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TRANSACTIONS

OF

THE FEDERATED INSTITUTION

OF

MINING ENGINEERS.

VOL. XII.—1896-97.

EDITED BY M. WALTON BROWN, SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

PRINTED BY ANDREW REID & CO., LIMITED, NEWCASTLE-UPON-TYNE.
1897.

ADVERTIZEMENT.

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TRANSACTIONS
OF
THE FEDERATED INSTITUTION
OF
MINING ENGINEERS.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

STUDENTS' MEETING,
HELD IN THE QUEEN'S HOTEL, LEEDS, AUGUST 5TH, 1896.

MR. T. H. COCKIN IN THE CHAIR.

BRYNCOCH COLLIERY ACCIDENT.

The **CHAIRMAN** proposed that the meeting should pass a vote of sympathy and condolence with the relatives of the workmen who had been killed and injured, with the agents, and with the owners of the Bryncoch pit, where an accident had occurred on the preceding day.

Mr. M. **WALTON BROWN** seconded the resolution, which was agreed to.

Mr. **ROSLYN HOLIDAY** read the following paper on "The Applications of Electricity in Mining Operations:"—

THE APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

By ROSLYN HOLIDAY.

In dealing with the applications of electricity to mining operations, the question is not what is it possible to apply electricity to, but to what uses can electricity be economically applied? There are hardly any uses to which power is transmitted by hydraulic, pneumatic, or mechanical agency to which electricity cannot also be applied. The vital point, however, which concerns the colliery proprietor is, whether electricity can be applied to the various purposes to which it is suitable, about a mine, without endangering the lives of men; and yet so that, at the end of the financial year, a lower working cost may be shown than if other modes of power-transmission had been used.

It will be the aim of the writer, if possible, to show where electricity may be used with advantage, in and about a mine.

In the first place, it would be well to enumerate the various purposes to which electricity can be and is applied, both on the surface and underground. On the surface it can be used for lighting, telephones, lighting miners' lamps, welding, driving pumps, hoists or elevators, sawing, lamp-cleaning, corn-crushing and hay-chopping, screening and washing machinery, also for driving machinery in mechanics' and blacksmiths' shops, and in some cases for traction.

Underground, electricity can be used for lighting, signalling, and for driving pumps, various systems of haulage, ventilators, also for driving coal-cutting and coal or rock-drilling machinery. In some instances locomotives electrically-driven are used.

Whether it is economical to use electricity for the above-named purposes depends to a very large extent on local circumstances. In by far the larger number of mines where electricity is used it is applied mainly to lighting, not many using it for power alone.

In the case of a large colliery where several seams are worked and also an adjacent brickworks, there may be (including arc-lamps) an equivalent of

600 to 800 16-candle-power lamps installed. Now these are very seldom all on at once, in fact from 6 to 8 a.m. and 4 to 5·30 p.m. during the winter months are about the only times when this occurs. Consequently, generating-plant is put down capable of dealing with the maximum load, but it is only running really efficiently during a few hours a day, for a few weeks in the year.

At such a colliery also there will be a number of small engines of various sizes in scattered positions. Each of these engines must have a certain margin of power to deal with any unusual load, whereas an engine works most efficiently when the brake horse-power most nearly equals the indicated horse-power.

If all the power could be supplied from one engine, then the margin allowed for unusual load would not be nearly as much as the total allowed on several small engines. Supposing electric motors to be used instead of the various scattered engines, then the same engines which are used for lighting could also be used for driving motors, and in this way they would get a day load.

This has been done at a large colliery in Yorkshire, and has been an unqualified success. Fig. 1 (Plate I.) shows load-curves at this colliery on January 29th and June 5th, 1896. The lower curves show the loads for lighting only, 60 units being the possible output. It will be seen that during the winter day, for seven hours, the load-factor, viz., the proportion of the actual to the possible output was about 0·130, while on June 5th for fifteen hours the load-factor was about 0·160. It is evident that if during the fifteen hours, more work could be found for the engines, it could be done without increasing the running cost, except, of course, for the extra steam used in proportion to the work done. On referring to the upper load-curves of Fig. 1, where both lighting and power are included, on June 5th for twelve out of the fifteen hours referred to, the load-factor was 0·593 instead of 0·160. By arranging in the winter, when the maximum lighting-load comes on, that certain machines, such as pumps, shall be stopped, the load-factor can be improved, and therefore such large engines would not be needed as would otherwise be the case if all the lights as well as the motors were run at the same time.

Another advantage of centralizing the power is, that in a central station triple-expansion engines could be installed large enough to deal with the total load without the cost being very much greater than that of a number of scattered small engines, which are very wasteful of steam, while the horse-power per pound of coal burnt would be considerably greater. In comparison with other systems of power-transmission, the efficiency, including attendance and repairs of an electric plant, is the most important consideration ; for in first cost it is, as a rule, the highest, and unless the cost of running it be less, or there is some other corresponding advantage, it is not worth while adopting it.

Some of the many advantages of the use of electricity are its adaptability to a variety of purposes, and its portability. The same power which is used for lighting at night can be used for driving motors in the day, or it can be used for welding, if necessary. The advantages of electric-welding for repair jobs, where there is already an electric plant, does not as yet seem to have been recognized by colliery managers. Many of the repairs, on which the greater part of the time is spent in getting the broken part from its place to the shop and back again, could be done *in situ* by connecting the small apparatus necessary to the nearest lighting main. This method of repairing is adopted by many engineering firms, though it is not much used at mines, where it would seem to be so eminently suitable. In the case of an existing mine, it would be essential that a very considerable reduction in working-cost could be shown in favour of electricity to make it worth while to discard the existing plant. The cost of such a change is often reduced by using the existing engines for driving the generator.

When an entirely new place is about to be started, the conditions are still more favourable to the application of electricity. It is often argued that electricity is only cheaper than steam or compressed air when the power has to be carried a long distance, and that for short distances it is much more costly.

If an engine, dynamo, and cables were put down to run one motor, say 600 feet distant, then, certainly, it would be far cheaper to carry a line of pipes, and put down an engine where the power was wanted. If, on the other hand, in the same engine-room an engine and dynamo were erected large enough to run six or seven motors from 6 to 20 horse-power, and at distances varying from 300 to 1,000 feet; and if, also, the lighting at night was done by the same engine and dynamo, it would then be found that the cost of running the motor 600 feet away would be less than that of the engine with its separate range of pipes. The attendance would be no more with the six motors than with one; and there would be much less trouble than with separate engines, as a good motor with carbon-brushes and the oil-cups filled twice a day needs no more attention. The motor-foundations can be made much lighter than those of an engine, and no time need be lost in tightening the belt, as the motor can be slid back while running.

A motor on a variable load, such as sawing, or on a light load, is more efficient than an engine. The power taken by the dynamo from the engine is in direct proportion to the flow of current, so that if a motor be stopped no power is being lost; whereas, if an engine be stopped, there is always condensation taking place in the steam-pipes.

In order to keep down the cost of attendance, the writer thinks that it would be advisable to have the fan engine-house and the electric generating-house all in one, so that the same staff would do for both. The cost for buildings would also be reduced, for the fan as well as the electric plant.

As to which is the best type of plant for a central station, there are considerable differences of opinion. Some engineers argue strongly in favour of the generator coupled direct to the engine, while others are just as much in favour of either belt or rope-driving. Local conditions must, to a great extent, guide the mining engineer as to which it would be best to use.

In the case of a large lighting-plant it is advisable to have a spare dynamo, though the plant need not necessarily be in duplicate; yet there should be a good margin, so that if a breakdown occurred to one machine the place would not be left altogether without light.

If the plant be also to be used for driving motors in the day, it would not be wise to depend on one engine only, which would be running day and night. For periods of very light load, such as Saturday and Sunday nights, a small generator coupled direct to an engine is very useful, and it should be arranged to run in parallel with the other machines.

Before purchasing the dynamos, the question which first presents itself is: what voltage shall be used? Until recently there was no really reliable lamp made, which would work with a voltage much above 110, but now good lamps are made working at 200 to 250 volts. The great advantage of this fact is that on a given size of wire twice as many lamps can be carried as was the case formerly with 100 volts.

For motors not very far from the generator, 200 volts is a very convenient figure, so that the same wires can be used for lighting and power. Where the power has to be carried a considerable distance the loss in the cables becomes a very serious item if a voltage of 200 be used. Voltages as high as 700 are used in mines, though from 400 to 500 is, on the whole, safer.

Fig. 2 (Plate I.) is an outline-plan of a plant which the writer designed and put down for the Ackton Hall Colliery Company, and is suitable for both lighting and power. In such a plant there are two vertical engines of 60 horse-power each: these drive from the flywheels two 30 horse-power dynamos *B B′* running at 200 volts for lighting. In line with the engine-shafts is a counter-shaft carrying a pulley, from which a belt drives a 60 horse-power dynamo *A*, running at 400 volts, for driving motors. At each end of the counter-shaft is a flexible friction-coupling capable of transmitting the whole power of either engine. These couplings can be thrown in or out of gear while the engines are running full speed, and work without any jar. Dynamo *C* is coupled direct to a 15 horse-power high-speed single-acting engine; this dynamo works at 200 volts, and it and the two dynamos *B B′* can be coupled in parallel.

By having the voltage of the power-dynamo just double that of the lighting-dynamos, in the event of a breakdown the two lighting-machines can be coupled in series, and so 400 volts is obtained between their outer terminals, to which the mains of dynamo *A* can be connected, and in addition either of the machines can be used for lighting (200 volts) at the same time. Under such circumstances, belt-driving seems preferable, as the same engines can be used for a double purpose, which would not be the case in a direct-coupled plant. To get the best advantage out of a plant like this, although the first cost is rather high, the engines must be compound condensing.

A type of generating-plant which is coming to the front just now is a steam-turbine coupled direct to a dynamo.

The writer has recently designed and put down a new plant in which there are two 500 volts generators of 200 horse-power each, coupled to two turbines. The total space occupied by these is only 15 feet by 10 feet, and no foundations are needed, the machines not being bolted down, but simply resting on rubber mats. The consumption of feed-water is very low with these machines, being 17 lbs. per indicated horse-power at half load, when condensing.

This plant has been erected to drive three systems of haulage in three pits, each driven by a 40 horse-power motor, and a large coal-washer in which there are three 80 horse-power motors. Coal-cutters will also be worked at nights.

After the engine and dynamo, the next most important factor in an electric plant is the motor. This should be of the best make, and with a margin of power above the ordinary load at which it is intended to be run. Like dynamos, there are three types of continuous-current motors, viz., shunt, series, and compound-wound.

Which machine is the best, altogether depends on the purpose for which it is intended. The compound-wound motor, when differentially wound, runs at a constant speed for all loads, but owing to its liability to be reversed when starting it is not much used. A well designed shunt-wound motor runs at a fairly constant speed with varying loads. Its drawback is that it will not start against a very heavy torque. The field-circuit should be closed first, and the magnets should be fully excited before the current is passed through the armature. Except in the case of very small motors a starting-resistance must always be used. Another point worthy of attention in a shunt-motor is, that if the field-circuit be opened a very high voltage is induced in the field-windings, and in the case of large motors it may be sufficient to break down the insulation. Provision should be made that, when the current from the generator is cut off from the field-circuit, there shall be a closed circuit through which the induced current can disperse itself. If this be done there will be no danger of damaged field-windings, and also the very vicious spark which damages the switch-contacts will be obviated.

The speed of a series-motor varies with the load, but the torque is greatest when starting, because the main current, going round both the field-windings and the armature, magnetizes them to the fullest extent. Series-motors are suitable where a heavy load has to be started, and when after starting the load is fairly constant.

Some of the uses for which a series-motor is suitable are pumping, coal-cutting, driving main-and-tail haulage, hoists, elevators, traction, as carried out in some mines in America, and in a few instances in England. They are also adapted for winding from shallow pits, as used in South Africa.

Shunt-motors are suitable for almost any work in which the load at starting is not great, and where the speed requires to be constant.

Just as in early days the steam-engine was set to pump water from the Cornish mines, so the first use to which mining engineers applied electricity, as a motive power, was the pumping of water.

Though pumping is not the kind of work in which electricity shows to the best advantage (except in the case of dip pumps), still the advantage of having a pair of cables and a column of pipes fixed in the shaft instead of a number of moving spear-rods was very evident to mining engineers.

Although while running, a Cornish pumping-engine, even in these days of triple and quadruple-expansion engines, is one of the most economical; still the moving parts are out of sight in the shaft, and repairs are awkward to deal with. With the electrically-driven pump, however, everything is easy of access.

In pumping from dip-workings, the chief gain in favour of electricity is its portability. The pump and motor can both be on one bed-plate, and the whole machine can be placed on a bogie, being moved forward as the water recedes, while at the same time cable is paid out from a drum.

As regards underground haulage, taken by itself, it would be very hard to find anything to beat in economy an engine on the surface driving a rope which is carried down the shaft. This system works remarkably well, and except for occasional breakages of the rope costs very little. This is an isolated plant which has to bear all its own capital charges, etc., while if the first cost were distributed over several other plants, the cost per ton of coal hauled to the pit-bottom would be reduced.

One other purpose to which electricity can be advantageously applied is the driving of underground fans. In a mine where the roads are very long the air-current is often extremely sluggish; while to increase the water-gauge at the fan would only cause greater leakage through the goaf and ventilating-doors, without very materially improving the ventilation. In order to improve the ventilation, a fan has been fixed at some collieries underground and driven by a motor. The fan being placed in the return air-way very materially assists the ventilation.

So far the writer has only dealt with continuous-current motors, and the question might be asked, would not alternating motors do as well or even better?

Where a continuous-current plant is going to be erected, the pressure at which it is to work must be very carefully thought out, as it cannot afterwards be altered—except by discarding the dynamos, motors, and lamps, and laying down new ones.

From multipolar dynamos, currents of two or three pressures can be obtained, though once fixed they cannot be altered. The pressure may be transformed by means of a rotary transformer, but owing to its cost and the fact that it has moving parts it is unsuitable for mining work. On the contrary, with an alternating-current, by means of a transformer in which there are no moving parts whatever, the pressure can be raised or lowered to suit the requirements of each case. Alternating machinery is more costly than continuous-current plant for the same power. Alternating motors have the disadvantage that most of them are not self-starting, and those that are will not start against a heavy load.

The great drawback to the use of electricity in mines, especially at the working-face, is the liability to sparking. No continuous-current motor has been made which has no sliding-contact, so that to render these machines safe, the expedient of completely boxing them in has been resorted to; but it is not satisfactory, as the commutator is just the part which is likely to give trouble, and therefore should be readily accessible.

There is an alternating motor of the polyphase type, in which there are no sliding-contacts whatever, and which is also self-starting against a considerable load. This machine, if electricity be used at the coal-face for cutting and drilling, is, in the writer's opinion, the most suitable one. It is not as efficient as some other forms, but it has the advantage of being safe. The application of electricity to coal-cutting is extending, though hitherto the collier seems to have reaped more benefit from it than the proprietor, as his hardest work has been done for him, and yet he gets very much the same pay.

If an engine or motor be used underground for pumping or haulage, it could also be used to drive a low-pressure polyphase generator for the coal-cutters. This is the only case, as machines are now, in which it is advisable to use an alternating current.

The question of cables is the next one to be considered. The size, of course, depends on the power to be transmitted, and the permissible loss in the cable. The chief difficulties to be overcome are the carrying of the cables down the shaft, in the first place, and, secondly, the way of supporting them along the roads. If the cables be supported on insulators at intervals down the shaft, then if pieces of coal fall down, the insulators are broken, the insulation is damaged, and it is not very long before electrolysis begins, and the cable is corroded away.

On the other hand, if the cables be embedded in wooden casing, fixed to the shaft-side, then the insulation must be high on account of the liability of corrosive waters to soak through the wood. Once the insulation begins to give way, there is endless trouble in localizing defects. Where the shaft is clear, owing to rope-conductors being used, the cheapest method in every way is to hang the cables from the top, unsupported anywhere else. The insulation need only be light, in fact, bare wire would do, only there would be the risk of the shaft-examiners getting severe shocks. With this method of suspension the support for the cable must be perfectly insulated. The writer uses a cast-iron oil insulator 6 inches long, carrying a bolt with an iron clamp at the end, to which the cable is clamped. When a cable is to be hung, the drum on which it is wound is placed in the cage free to revolve, the loose end is fixed in the clamp, the insulator is hung on the iron bar, which is its permanent support, and the cage is then lowered steadily, the wire unreeling as it descends.

A cable 1,200 feet long can be hung in twenty-five minutes, including the clamping, etc. Once fixed, these cables have not needed the least attention. There is nothing to catch falling coal, etc., and the insulation resistance of the shaft-cables is always the highest of any cables about the place. By this means the first cost is reduced, as a low-grade insulation can be used, the cost of hanging is very low, and the cost of maintenance is practically *nil.* If cables be run in pipes the cost is high, but the risk of any damage being done to them is very slight. Cables over 1,200 feet in length, to carry their own weight, should be armoured with galvanized iron wire. It should be understood that the cables are nowhere placed within 6 inches of the shaft side.

In carrying cables along the roads, if the roof and sides be good, they may be taken overhead. If the roof be bad it is best to bury them in wooden troughing.

For lighting wires which must be overhead, even if the roof be bad, they may be tied to the bars with light cord, so that in the event of a fall the cords will be broken, and in this way the wires often escape damage. For going long distances in-bye the concentric armoured cable is the best, though costly. If roof falls upon it, the outer and inner wires are nipped together, the fuses at the surface are blown, and in this way the risk of a flash in the mine is somewhat reduced.

As regards the use of fuses, many engineers object to them, and say that they go off when they are not wanted. A fuse should carry 50 per cent. above the normal current for a short time, but should be of such a length that if this be continued for some time the fuse gets hot and finally falls out.

All motor-circuits should have ammeters in the engine-room and in some cases at the motor also. As an instance of the use of an ammeter, the writer on looking one day at an ammeter of a 25 horse-power motor driving a three-throw pump noticed that it was taking 6 ampères more than usual; on sending for the man who had been down to it he was informed that the three glands had been tightened. This pump is 240 feet down a shaft, and is stopped and started from the engine-room; a man goes down morning and night to oil it. If a bearing gets warm, it shows on the ammeter. This pump has run for three years, and has cost nothing in repairs except for a new set of brushes for the motor.

Having considered the principal applications of electricity, some of the minor ones may be mentioned, viz., the lighting of miners' lamps, telephones, and signals used on the surface and underground. Several methods of lighting safety-lamps have been introduced: the advantages claimed being that the lamps need only be lighted when they are given out to the men, thereby saving oil. At a large colliery this would be a very considerable advantage. Electric signals are much quicker than pull-signals, and in deep pits, where fast winding is practised, the saving of time over the pull-bell is very considerable. Telephones are, perhaps, more conveniences than necessities, though at a large colliery much time may be wasted in going from one part of the works to another. In case of an accident to the cages, a telephone down the pit is very useful.

At a small colliery the enginewright, with moderate knowledge of the fundamental principles of electric machinery, will be able to do any small repairs. At a large colliery, it is advisable to have a skilled man who thoroughly understands the machines, who can also put in new lights, and keep things in order generally. For engine- and dynamo-attendants, the writer finds youths of eighteen or nineteen, trained on the place, better than older men, as they have fewer preconceived ideas about electricity; and, with a few books on the subject lent to them, they are not long before they are competent to take charge of a shift.

One very important point remains to be dealt with, and that is, the testing of machinery and cables. If ever the proverb about the stitch in time saving nine be true, it is in the case of electrical machinery. Although there is no instrument which can be fixed to a boiler to indicate the approximate thickness of the pipes, and show how far a leak may be away, yet a leak in a pipe shows itself at once when the pressure is on. With electrical plant it is different, as a leak does not make itself shown at once; in fact, perhaps not until there is a breakdown. With a proper testing-set, the insulation-resistance of the machines and mains can be measured; this should be done often, and the results kept in a book, so that it can be seen if a cable is becoming faulty, and the cause stopped. It may be said that the life of the plant, to a large extent, depends on constant testing for leakage.

In conclusion, the writer would urge that the mining engineer cannot alter the efficiency of engines, dynamos, and motors, and therefore it should be his aim, by the careful arrangement of the plant, to get a maximum of work done for a minimum expenditure. In good machines the combination of dynamo and motor should not involve a loss of more than 10 to 15 per cent. of the total power delivered to them, while there are many electrical installations of which the total efficiency is not 40 per cent., thus showing what scope there is for careful planning.

The **Chairman** said he was sure that the members had been interested in Mr. Holiday's paper. For taking power long distances, electricity was very valuable; but using it on the surface, as Mr. Holiday suggested, was very different. Setting the cost of the steam-pipes and engine against that of the dynamo and motor, there could be no saving of capital expenditure; and it would be a question whether the efficiency gained by using electricity and a high-class engine would be greater than the losses in the dynamo, cable, and motor. Mr. Holiday said that the loss should be 10 or 15 per cent., but as a rule these figures were exceeded. Mr. Holiday said that electricity was an efficient power in the case of variable loads, because the efficiency was greater; but, in the motors that he had seen, variation of the load caused sparking. He (Mr. Cockin) thought that there was a great future for the use of electricity for sinking purposes, as the steam-pipes were temporary, and could not be properly covered, so that a great deal of steam was lost. In coal-cutting they might think that compressed air would have a great advantage over electricity, as the electrical machines were heavier, more delicate, and were liable to sparking, and to give workmen shocks.

The Chairman then presented Mr. Holiday with the seven volumes given by the Institution as a prize for the paper.

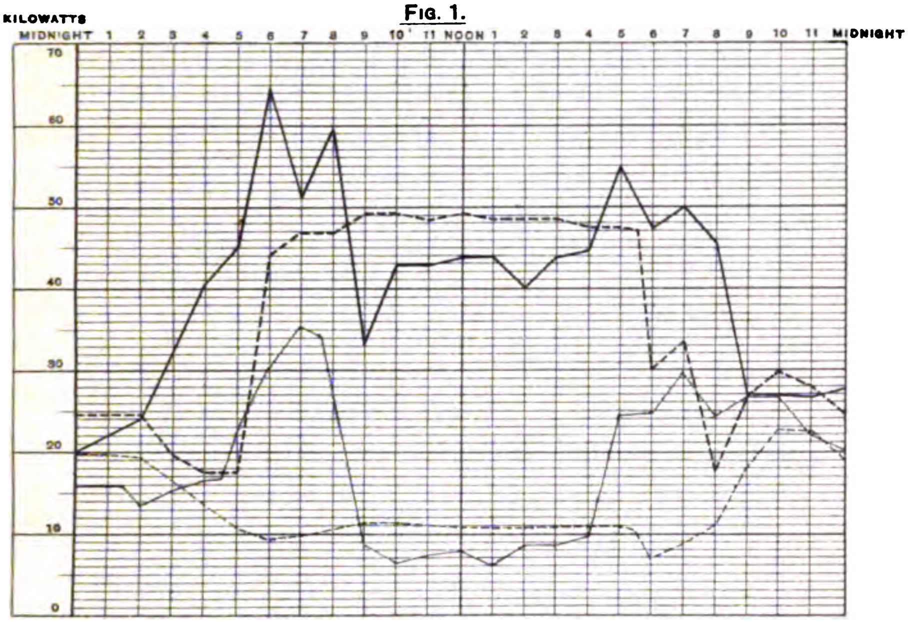
Mr. T. E. **Parrington** said Mr. Holiday stated that a current of 400 to 500 volts was safe, but he thought that anything over 300 volts was dangerous. Experiments showed that slight sparking had not caused explosion, but if the motor sparked badly, explosion occurred. One disadvantage of alternating motors was, that they always pulled up if they were slightly overloaded. Mr. Holiday advised the use of wooden troughing for carrying cables along the roads; but if a short circuit took place, the wooden troughing would take fire, and a fire in a pit was not altogether desirable. Mr. Holiday said he thought that telephones were more a convenience than a necessity; but he (Mr. Parrington) would use telephones in the pit sooner than any other form of electric plant. They were very necessary in communicating from one part of the pit to another,

The Federated Institution of Mining Engineers
Transactions 1896-7

VOL. XII PLATE I

To illustrate Mr. R. Holiday's Paper on "The Applications of Electricity to Mining Operations."

FIG. 1.



REFERENCES.

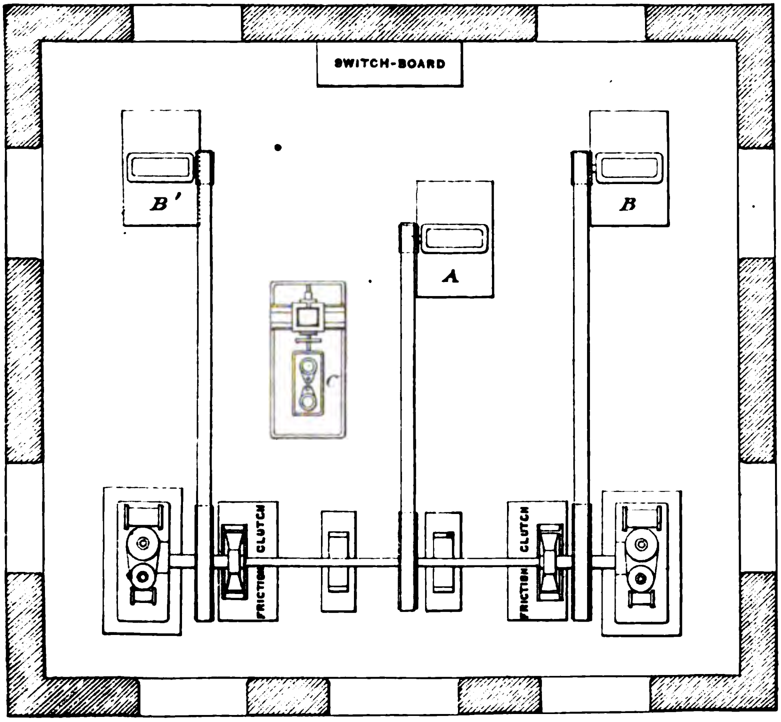
LOAD CURVES—LIGHTING ONLY.

———— JANUARY 29TH, 1896, LOAD-FACTOR, 0·300.
- - - - - JUNE 5TH, 1896, — LOAD-FACTOR, 0·226.

LOAD CURVES—LIGHTING & POWER COMBINED.

———— JANUARY 29TH, 1896, LOAD-FACTOR, 0·500.
— — — — JUNE 5TH, 1896, — LOAD-FACTOR, 0·444.

FIG. 2



and to the surface. Mr. Holiday said that the lighting of miners' lamps by electricity saved oil, and that lamps need not be lighted until given out to the workmen. In Durham, it was not usual to light safety-lamps; they were given out to the workmen, who generally lighted them.

Mr. W. R. **Bell** said that Mr. Holiday appeared to have had considerable experience in the use and application of electricity, yet he said that he would show where it might be used with advantage, if possible. He rather seemed to be in doubt whether electricity could be used with economy and efficiency as a motive power. Having an electrical engine, they must have a steam-engine to drive the generator; and if they only got from 40 to 60 per cent. of useful effect out of the electrical generator, it could not be economical to use electricity, considering the loss in the steam-engine, in the dynamo, etc. Mr. Holiday mentioned the use of an auxiliary fan in a return-airway to increase the ventilation; but with a machine which sparked, in a return-airway the results might some day be disastrous; and further, whether the ventilation was increased in the return-airways or in the shaft, there would be the same leakage through the goaf. Mr. Holiday said that electric signals were often used. Without a doubt that was the only improvement in which the disadvantages of electricity could be overcome.

The **Chairman** said that in Yorkshire they would not allow the workmen to light their own lamps, and they found electricity very useful for lighting lamps in the mine. They had not many pits in Derbyshire or Yorkshire where the introduction of a motor, if it did spark, would result in an explosion.

Mr. R. **Holiday** said that he intended his paper to meet the case of enquirers who asked whether putting a motor into a mine would be cheaper than an engine. An engine, motor, dynamo, and cables erected for one purpose alone would be more expensive than the ordinary method of applying power by means of an engine, but economy resulted where the plant could be used for many purposes. If a large dynamo was erected in the fan-engine room, 200 or 300 horse-power could be developed, and one attendant could look after the fan-engine and the electric plant. With a well-designed motor with carbon brushes, the work could be varied from half to full load, and the extra cost of attendance was practically *nil*. At Ackton Hall collieries, a number of motors varying from $\frac{1}{4}$ to 80 horse-power were in use: the attendants comprised one engineman, and a young man who went round to the motors once a day. It was not economical to erect a plant to work an isolated pump, but electricity was economical if one generating plant could be used to drive a number of motors of varying power. Ordinarily, for an isolated plant, electricity would be cheaper when it was not under 2,000 feet away; for a less distance than that, it did not pay. The great difficulty in working an electric-lighting station economically was that they had to have plant sufficient for the maximum demand, but for which there was no work during several hours of the day. Mr. Albion T. Snell, an authority on the subject, said that a colliery plant should possess a better load-factor than any other, as they could get both a day and a night load. With variable loads, a cheap motor could be used which would spark with a variation of 2 per cent. of the load; but, by paying a little more, a motor could be obtained which would not spark between half and full load.

The cost of engine, dynamo, cables, and motor was more than the cost of engine and pipes, but when, without greatly increasing the cost of the engine, they could run a large number of motors from that engine, the economy was considerable. The Chairman said he thought that there was a considerable opening for the use of electrical pumps in sinking shafts, but they would not be much more economical than the Bailey or Denaby pump, and it would not be economical to carry motors down with water continually dropping on them. For coal-cutting, the current should be transmitted at high-pressure, and transformed to low-pressure not far from the working-face, so that there should be no risk of shock. Mr. Parrington stated that a voltage over 300 was dangerous, but at Ackton Hall collieries, a pressure of 525 volts was used, and the young lads took the shocks and seemed to flourish, though there were circumstances in which 200 volts might be fatal. The commutator was the weak point in electrical machinery—the rubbing contact. If that could be avoided it should be done, but as yet it was not possible with continuous-current motors. He did not mean to say that electricity was *par excellence* the best power to use in a mine, and its application must, to a great extent, be guided by local circumstances. It was said that the alternating motor pulled up with variation of load: the ordinary polyphase motor did not pull up; it was like the series-wound motor which could start against a load, but it was not efficient above 15 horse-power. A machine of that size might be used to work a coal-cutter, but above that power they were not efficient. Mr. Parrington said that cables placed in wooden troughing would fire the wood if there was a short-circuit; but the cables should be placed in separate troughs so that there was no fear of short-circuit. He had no doubt that if telephones were more extensively used they would prove an advantage in mines. He had seen long rows of safety-lamps lighted in readiness for the workmen going down some time before they went down, and lighting by electricity really effected a considerable saving of oil. Mr. Bell said that he (Mr. Holiday) seemed to be in doubt as to whether electricity could be economically applied; but he had wished to show where, and under what circumstances, it could be economically applied.

The CHAIRMAN said he had yet to be convinced that it was a good thing to drive surface-machinery by electricity. Mr. Holiday seemed to argue that, having the plant, they must use it, but it might not be economical to use it if steam were wasted by doing so. He could not see that it would be wasteful to use electricity for working sinking-pumps. Mr. Holiday said that the water would destroy the cables, but could they not be protected?

Mr. R. O. BROWN said that he had seen protected cables in a shaft destroyed within a month.

The CHAIRMAN said that water falling upon steam-pipes was a very serious source of loss in sinking shafts.

Mr. T. E. PARRINGTON said that he had read of an instance where a man was standing on an iron tub which was wet; his head accidentally touched the cable, and he was killed, the voltage being only 250.

Mr. BELL said that in Durham the workmen left the bottom of the safety-lamp in the cabin at the mine, and took the top of the lamp home with them. When they returned to the mine, they got the bottom of the lamp and lighted it.

The CHAIRMAN moved, and Mr. F. G. PEAKE seconded, a resolution that a hearty vote of thanks be accorded to the Midland Institute of Mining, Civil, and Mechanical Engineers for arranging the present meeting, to the owners of collieries and works to be visited, and to the Council of the Yorkshire College.

The motion was agreed to.

STUDENTS' COMMITTEE.

With a view of furthering the arrangements for the ensuing Students Meeting, the following committee was appointed:—Mr. T. H. Cockin chairman; and Messrs. W. R. Bell, Robert O. Brown, Roslyn Holiday, E. McGowan, T. E. Parrington, and F. G. Peake.

Mr. R. HOLIDAY proposed a vote of thanks to the Chairman for his services.

Mr. T. HARGREAVES seconded the motion, which was agreed to.

The meeting was then closed.

The Ackton Hall and Micklefield collieries and the Yorkshire College were open for inspection during the course of the meeting on August 5th, 6th, and 7th, 1896.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
August 1st, 1896.

Mr. THOMAS DOUGLAS, Retiring-President, in the Chair.

The Secretary read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on July 18th and that day.

ELECTION OF OFFICERS.

The President appointed Messrs. J. T. Todd, R. F. Spence, W. R. Bell, L. Thursby, L. Austin, and W. E. Nicholson as scrutineers of the balloting-papers for the election of officers for the year 1896-97. These gentlemen afterwards reported the result of the ballot as follows: –

President.
Mr. George May.

Vice-Presidents.

Mr. W. Armstrong, Sen.
Mr. C. Berkley.
Mr. T. W. Benson.
Sir W. T. Lewis.
Mr. J. G. Weeks.
Mr. W. O. Wood.

Council.

Mr. Henry Armstrong.
Mr. W. Armstrong, Jun.
Mr. T. W. Asquith.
Mr. Henry Ayton.
Mr. W. C. Blackett.
Mr. J. R. Crone.
Mr. T. E. Forster.
Mr. T. Y. Greener.
Mr. A. C. Kayll.
Mr. C. C. Leach.
Mr. J. H. Merivale.
Mr. J. Morison.
Mr. H. Palmer.
Mr. M. W. Parrington.
Mr. A. M. Potter.
Mr. R. Robinson.
Mr. T. O. Robson.
Mr. R. L. Weeks.

The **Retiring-President** said, at the end of his term of office he might say that he was very much indebted to the Institute for giving him the honour of being President for the past two years. As far as he could, he had endeavoured to fulfil to some extent the duties of the position; he had been materially helped by the Council, in everything pertaining to the wellbeing of the Institute, and he knew that they would be equally prepared to help in the future. He was very glad that Mr. George May had been elected as his successor; he had known that gentleman for a very long time, and congratulated him on the appointment. He was sure that he would worthily fulfil the duties of President, and in resigning the chair to him it only remained for him to thank the members most heartily for their kindness during the past two years.

Mr. **George May** thanked the members for the honour that they had conferred upon him. He had great pleasure in proposing that a cordial vote of thanks be accorded to the Retiring-President, Vice-Presidents, Council, Treasurer, and Secretary for their services during the past year.

Mr. F. **Coulson** seconded the vote of thanks, and it was heartily adopted.

Mr. **Thomas Douglas**, in acknowledging the vote of thanks, said that he would do all he could to assist their worthy President in his new position.

The **Chairman** moved, and Mr. W. C. **Blackett** seconded, that a vote of thanks be given to the Scrutineers for their services, which was agreed to.

The **Secretary** read the Annual Report of the Council and of the Finance Committee as follows:—

ANNUAL REPORT OF THE COUNCIL, 1895-96.

The numbers of the members of various classes during a few recent years are as follows:—

	August 1st.		
	1894.	1895.	1896.
Honorary Members...	26	26	23
Members	624	717	767
Associate Members	53	67	78
Associates	68	67	83
Students	20	36	46
Subscribing Collieries, etc.	22	23	23
Totals	813	936	1,020

The members are to be congratulated on the continued increase in their numbers, which still, however, only slightly exceed the figures of a few years ago.

The class of Associates, consisting of persons occupying subordinate positions in engineering, has been very successful, and has tended to increase the membership roll.

An Excursion Meeting of the members was held at Wigan, on July 14th, 15th, and 16th, 1896, and the thanks of the Institute are due to Mr. Henry Hall, H.M. Inspector of Mines, Mr. John Knowles, Mr. Charles Cockson, and others, who made the excellent arrangements for the meeting.

The recently initiated meetings of Students have proved successful as to attendance, and one of the papers communicated has been printed in the *Transactions*.

The Council are endeavouring to make arrangements in order that papers of interest to Indian and Colonial members may be locally read and discussed, and it is especially desired that members will endeavour to ensure the success of these localized meetings. Mr. A. R. Sawyer has called two meetings in Johannesburg; but owing to concurrent disturbances no definite arrangements were made for their being continued.

The Council are pleased to congratulate the members on the success which has attended the formation of the Western Australian branch, and trust that members resident in India and the Colonies will be able to form similar local associations.

The Report of the Committee on Mechanical Ventilators is completed, and will be issued to the members during the course of the next few months.

Five volumes of the Sinkings and Borings (A to T) have been issued, and the remaining volumes will be published at early dates.

The additions to the library by donations, exchanges, purchase, etc., have been:—

Bound volumes	264
Pamphlets, reports, etc.	234
A total of	498 titles.

The library now contains 7,178 volumes and 1,261 unbound pamphlets. The card catalogue is now complete, and renders the books more readily accessible to the members.

The library (including the books and numerous engineering papers) is available to members from 10 a.m. to 5 p.m., and those residing at a distance may make use of the books by communicating with the Secretary.

A number of models have been lent, and others presented, to The Durham College of Science, where they will prove of use to mining students and others.

It will be seen by the list appended to this Report that several of the files of publications have been rendered incomplete by the neglect of members to return books to the library, and it is urgently requested that they search for and return the missing volumes.

The Wood Memorial Hall, Lecture Theatre, etc., have been kept in repair.

The arrangement with the Literary and Philosophical Society of Newcastle-upon-Tyne has proved of great advantage, by which the doorway between the adjacent libraries is opened daily, and the members of either society are allowed (on the production of a member's pass) to refer to the books in the library of either society.

A considerable reduction has been made in the prices of the *Transactions* and other publications of the Institute, and members are recommended to complete their sets before the stock is exhausted.

The Explosives Committee have concluded their investigations, and the results of their experiments and their recommendations are contained in the *Report* recently issued to the members. The Council have been in communication with the Secretary of State for the Home Department, as to the disposal of the plant, continuation of the experiments, etc., but the matter is still pending.

The Council felt that the services which Mr. A. C. Kayll had rendered to the Explosives Committee in preparing the *Report*, etc., deserved special recognition, and they accordingly presented him with a gold watch and chain and a cheque, as a token of the appreciation of the members.

Mr. J. H. Merivale has been re-appointed to represent the Institute at the Conference of Corresponding Societies of the British Association, for the Advancement of Science, at Liverpool, in September next.

The Federated Institution of Mining Engineers has now completed its seventh year, during which period General Meetings have been held at Stoke-upon-Trent, on September 18th and 19th, 1895; at Sheffield, on February 19th and 20th, 1896; and at London, on June 4th, 5th, and 6th, 1896. In addition, a meeting of the Students and junior members was held in this district on August 13th, 14th, and 15th, 1895, and the thanks of the members are specially due to the Committee who made the arrangements, and to all those who by their services contributed to the holding of an instructive and pleasant meeting.

Prizes of books have been awarded to the writers of the following papers, communicated to the members during the year 1894-95:—

"Sinking with Rock-drills." By Mr. Frank Coulson.
"The Effect of an Obstruction in the Air-way of a Mine." By Mr. T. L. Elwen.
"Magnetic Declination in Mines." By Mr. James Henderson.
"The Working of Hæmatite in the Whitehaven District." By Mr. J. M. Main.
"The Mining of the Softer Ores of Furness." By Mr. H. Mellon.
"Improvements in Brick-kilns." By Mr. R. W. Moore.
"The Extension of the Cumberland Coal-field, Southward and Northward under the St. Bees Sandstone." By Mr. R. Russell.
"Electric Transmission of Power." By Mr. Alexander Siemens.
"Saving of Life from After-damp, Smoke, or Fumes in Mines." By Mr. Simon Tate.
"Engineering Heliography, or the Sun-print Copying of Engineering Drawings." By Mr. B. H. Thwaite.
"British Guiana Gold-fields." By Mr. E. P. Wood.
"The Murton Coal-washer." By Mr. W. O. Wood.

The papers communicated to the members during the year have been as follows:—

"Haulage at Wearmouth Colliery." By Messrs. W. R. Bell and E. McGowan.
"Coal-cutting by Machinery." By Mr. William Blakemore.
"The Kent Coal-field." By Messrs. F. Brady, G. P. Simpson, and N. R. Griffith.
"The Resistances of Air-currents in Mines." By Mr. T. L. Elwen.
"A Compound Winding-engine." By Mr. William Galloway.
"The Causes of Death in Colliery Explosions." By Dr. J. S. Haldane.
"Some Aspects of Recent Colliery Explosions." By Mr. Henry Hall.
"The Quicksilver Mines and Reduction-works at Huitzuco, Guerrero, Mexico." By Mr. Edward Halse.
"Recovery of Bye-products in the Manufacture of Hard Coke." By Mr. John Jameson.
"The Whitehaven Sandstone Series." By Mr. J. D. Kendall.
"Shot-firing in Fiery and Dusty Mines." By Bergrat H. Lohmann.
"A Deposit found at Delaval Colliery, Benwell, Northumberland." By Messrs. Chas. J. Murton and Saville Shaw.
"Notes on the Explosion of Coal-dust." By Mr. W. J. Orsman.
"Notes on the Geological Features of the Coast of North Wales, from Liverpool to Menai Bridge." By Mr. C. E. De Rance.
"The Mode of Obtaining a True North Line." By Mr. A. L. Steavenson.
"Safety-explosives." By Bergassessor Winkhaus.

In conclusion, the Council urge the members to use their best endeavours to increase the membership, as the continued success of the Institute is entirely dependent upon its ability to meet the considerable expenses incurred by the connexion with The Federated Institution of Mining Engineers.

REPORT OF THE FINANCE COMMITTEE.

The total income for the year amounted to £2,474 13s. 9d.; deducting from this the sum of £93 18s., subscriptions of new life members; £126, subscriptions paid in advance; and £100 subscribed by the Coal Trade Associations to the expenses of the Explosives Committee—leaves £2,154 15s. 9d. as the ordinary income of the year, compared with £2,004 0s. 8d. for the previous year; showing an increase of £150 15s. 1d.

In accordance with the decision of the Council, the names of several members whose subscriptions were in arrear have been struck out of the list of members. The amounts written off in consequence are:—For current year, £45 3s. 0d.; arrears, £86 2s. 0d. The amount of subscriptions now in arrear, in excess of one year, is £32 11s. 0d.

The total expenditure amounted to £2,235 12s. 0d., an increase of £224 13s. 11d. The principal items contributing to this increase were:—The presentation to Mr. A. C. Kayll, in recognition of his valuable services in connexion with the Explosives Committee, £131 5s. 0d.; contributions to The Federated Institution of Mining Engineers, on the increased number of members, £22 3s. 11d.; and further costs involved in the preparation of the library index, £80 0s. 4d.

The period for which the investment with the River Tyne Commissioners was made having terminated during the past year, the sum of £1,500 became available for reinvestment, to which were added certain sums received for life-membership subscriptions. On the instructions of the Council, the sum of £1,400 was advanced to the Institute and Coal Trade Chambers Company, Limited, on mortgage at 3½ per cent., and £450 was expended in the purchase of shares in the same company.

T. DOUGLAS.
August 1st, 1896. J. L. HEDLEY.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND
FOR THE YEAR ENDING

			£ s. d.	£ s. d.
July 21st, 1895.				
To Balance at Bankers			685 7 10	
„ „ in Treasurer's hands			84 12 3	
„ Outstanding Amounts for Authors' Excerpts			4 16 8	
July 28th, 1896.				774 16 9
To Dividend of 7½ per cent. on 146 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for year ending June, 1896			219 0 0	
„ Interest on Investments with the River Tyne Commissioners			26 15 4	
„ Interest on Mortgage of £1,400 with Institute and Coal Trade Chambers Company, Ltd.			28 1 5	273 16 9
To SUBSCRIPTIONS FOR 1895-96 AS FOLLOWS:—				
577 Members	@ £2 2s.		1,211 14 0	
48 Associate Members	@ £2 2s.		100 16 0	
64 Associates	@ £1 1s.		67 4 0	
32 Students	@ £1 1s.		33 12 0	
82 New Members	@ £2 2s.		172 4 0	
19 New Associate Members	@ £2 2s.		39 18 0	
20 New Associates	@ £1 1s.		21 0 0	
13 New Students	@ £1 1s.		13 13 0	
			1,660 1 0	
To SUBSCRIBING FIRMS, VIZ.:—		£ s. d.		
3 @ £10 10s.		31 10 0		
3 @ £6 6s.		18 18 0		
6 @ £4 4s.		25 4 0		
10 @ £2 2s.		21 0 0		
			96 12 0	
To Subscriptions in Suspense...			10 10 0	
			1,767 3 0	
To 5 New Life Members			93 18 0	
			1,861 1 0	
Less—Subscriptions for current year paid in advance at the end of last year...			97 13 0	
			1,763 8 0	
To Arrears received			179 11 0	
			1,942 19 0	
To Subscriptions paid in advance during current year ...			126 0 0	2,068 19 0
To Sale of Publications				31 18 0
To Investments realized—River Tyne Commissioners ...				1,500 0 0
To Grant to Explosives Committee—				
Durham Coal Owners' Association...			75 0 0	
Northumberland Coal Owners' Association			25 0 0	100 0 0
				£4,749 10 6

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.

JULY 31ST, 1896.

July 28th, 1896.	£	s.	d.	£	s.	d.
By Printing and Stationery				233	18	1
„ Books for Library	48	10	4			
„ Prizes for Papers	17	17	0			
„ Incidental Expenses	62	7	2			
„ Postages	74	0	5			
„ Sundry Accounts	10	0	6			
„ Travelling Expenses	0	7	6			
„ Salaries	150	0	0			
„ Clerks' Wages	149	2	4			
„ Reporter's Salary	14	14	0			
„ Rent	95	12	8			
„ Rates and Taxes	22	10	6			
„ Insurance	4	0	7			
„ Furnishing, Repairs, etc.	55	14	2			
„ Coals, Gas, Electric Light, and Water	49	3	6			
„ Translation of Papers	4	0	0			
„ Library Card Catalogue	80	0	4			
„ Expenses of Meetings	24	13	0			
				862	14	0
By Explosives Committee	38	13	7			
„ Fan Committee	17	7	6			
„ Durham College of Science—Grant	50	0	0			
„ British Association Meeting—Delegate's Expenses ...	8	0	0			
„ Presentation to Mr. A. C. Kayll	131	5	0			
				245	6	1
By The Federated Institution of Mining Engineers—Subscriptions	894	16	5			
Less—Amounts paid by Authors for Excerpts ...	1	2	7			
				893	13	10
				2,235	12	0
By Investments—						
Institute and Coal Trades Chambers Co., Ltd.—12 Shares	450	0	0			
Do. do. Mortgage	1,400	0	0			
				1,850	0	0
By Balance at Bankers	575	17	8			
„ „ in Treasurer's hand	83	7	1			
„ Outstanding Amounts due for Authors' Excerpts ...	4	13	9			
				663	18	6

I have examined the above account with the Books and Vouchers relating thereto, and certify that, in my opinion, it is correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 1st, 1896.

£4,749 10 6

Dr. THE TREASURER IN ACCOUNT

				£	s.	d.	£	s.	d.
To 717 Members, 32 of whom are Life Members.									
685 685 @ £2 2s.							1,438	10	0
To 67 Associate Members, 5 of whom are Life Members.									
62 62 @ £2 2s.							130	4	0
To 67 Associates @ £1 1s.							70	7	0
To 36 Students @ £1 1s.							37	16	0
To 23 Subscribing Collieries							98	14	0
To 82 New Members @ £2 2s.							172	4	0
To 5 New Life Members							93	18	0
To 19 New Associate Members @ £2 2s.							39	18	0
To 20 New Associates @ £1 1s.							21	0	0
To 13 New Students @ £1 1s.							13	13	0
To Subscriptions in Suspense							10	10	0
							2,126	14	0
To Arrears, as per Balance Sheet 1894-95				291	18	0			
Add—Arrears considered irrecoverable, but since received				6	6	0			
				298	4	0			
Less—Struck off as irrecoverable—Arrears	86	2	0						
„ „ „ Current year	45	3	0						
				131	5	0			
							166	19	0
							2,293	13	0
To Subscriptions Paid in Advance							126	0	0
							£2,419	13	0

WITH SUBSCRIPTIONS, 1895-96. CR.

		PAID.			UNPAID.		
		£	s.	d.	£	s.	d.
By 577 Members, paid	@ £2 2s.	1,211	14	0	......		
By 108 „ unpaid	@ £2 2s.	......			226	16	0
685							
By 48 Associate Members, paid	@ £2 2s.	100	16	0	......		
By 14 „ „ unpaid	@ £2 2s.	......			29	8	0
62							
By 64 Associates, paid	@ £1 1s.	67	4	0	......		
By 3 „ unpaid	@ £1 1s.	......			3	3	0
67							
By 32 Students, paid	@ £1 1s.	33	12	0	......		
By 4 „ unpaid	@ £1 1s.	......			4	4	0
36							
By 22 Subscribing Collieries, paid	... ...	96	12	0	......		
By 1 „ „ unpaid	... ...	......			2	2	0
23							
By 82 New Members, paid	@ £2 2s.	172	4	0	......		
By 5 New Life Members paid	... ...	93	18	0	......		
By 19 New Associate Members, paid ...	@ £2 2s.	39	18	0	......		
By 20 New Associates, paid	@ £1 1s.	21	0	0	......		
By 13 New Students, paid	@ £1 1s.	13	13	0	......		
By Subscriptions in Suspense	... ...	10	10	0	......		
		1,861	1	0	265	13	0
Less—Struck off as irrecoverable	... ...	......			45	3	0
					220	10	0
By Arrears	... ...	179	11	0	32	11	0
By Subscriptions paid in advance	... ...	126	0	0	......		
		2,166	12	0	253	1	0
					2,166	12	0
					£2,419	13	0

GENERAL STATEMENT, JULY 28TH, 1896.

LIABILITIES.

	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	126	0	0			
„ carried over from previous year	2	2	0			
				128	2	0
Capital				8,621	15	1
				£8,749	17	1

I have examined the above account with the books and vouchers relating thereto, and certify that, in my opinion, it is correct. The Share Certificates and Mortgage Bonds have been produced to me.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 1st, 1896.

ASSETS.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	575	17	8			
„ in Treasurer's hands	83	7	1			
Outstanding amounts due for Authors' Copies...	4	13	9			
				663	18	6
146 Shares in the Institute and Coal Trade Chambers Co., Ltd. (at cost)	3,130	0	0			
Investment with the Institute and Coal Trade Chambers Co., Ltd., on Mortgage	1,400	0	0			
				4,530	0	0
(Of the above amount, £350 is due to Life Subscriptions Account, leaving £55 12s. not invested.)						
Proportion of Fan Committee Expenses—						
Midland Institute of Mining, Civil, and Mechanical Engineers	16	0	4			
South Wales Institute of Engineers ...	34	6	8			
				50	7	0
Arrears of Subscriptions	......			253	1	0
Value of Transactions and other Publications, as per Stock Account	......			1,052	10	7
Office Furniture and Fittings	450	0	0			
Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£8,749	17	1

The CHAIRMAN said that he was glad that the Students and Western Australian members had taken up the suggestion of the Council and arranged for meetings. He trusted these would be successful, and he was quite sure that they would considerably benefit the art of mining. He had hoped that there would have been a large increase in the number of Associates. It was, perhaps, unnecessary for him to refer to the benefits of membership of the Institute. The papers that had been read during the year were very diverse in their character, and comprised papers on every subject of importance to mining engineers, contributed by members resident in every part of the world. Several important subjects had engrossed their attention—particularly the question of coal-dust; and on that question he thought they had a good deal to learn. The members had recently received a very valuable paper from Dr. Haldane (he referred to the chemical part of the paper, more particularly) which had led the members to think over the subject, for it brought to their minds some fresh information with regard to gases. On the question of introducing electricity into mines, the difficulty with which they had to contend was the fear and dread of sparking, especially in mines giving off inflammable gases to a considerable extent. He did not believe, however, that there were any difficulties of this kind for which the knowledge of their scientific men would not find a remedy. He was certain that electricity was a coming power, and he was glad that it was being introduced into mines. He need not say that if it could be safely introduced either for locomotives underground or for the various machines brought to supersede labour, it would render most valuable assistance. He believed he was right in saying that the membership of the Institute was now larger than it had ever been in the past; but he thought it had not yet attained the magnificence, in point of numbers, that it would ultimately reach, and he hoped that the Institute would prove as useful in the future as it had done in the past. In conclusion, he had pleasure in moving the adoption of the reports of the Council and of the Finance Committee.

Mr. J. B. SIMPSON seconded the resolution, which was unanimously adopted.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The Chairman moved, and Prof. H. Louis seconded, a resolution that the following gentlemen be elected to represent the Institute on the Council of The Federated Institution of Mining Engineers for the ensuing year:—

Mr. Henry Ayton.
Mr. E. Bainbridge.
Sir Lowthian Bell, Bart.
Mr. T. W. Benson.
Mr. W. C. Blackett.
Sir B. C. Browne.
Mr. W. Cochrane.
Mr. J. R. Crone.
Mr. J. Daglish.
Mr. T. Douglas.
Mr. T. E. Forster.
Mr. W. Galloway.
Mr. J. Head.
Mr. J. L. Hedley.
Mr. A. C. Kayll.
Mr. C. C. Leach.
Sir W. T. Lewis, Bart.
Mr. James McMurtrie.
Mr. G. May.
Mr. J. H. Merivale.
Mr. H. Palmer.
Mr. T. O. Robson.
Mr. J. B. Simpson.
Mr. A. L. Steavenson.
Mr. L. Wood.
Mr. W. O. Wood.

The motion was agreed to.

Prof. H. Louis moved, and Mr. Thos. Wood seconded, a resolution that a cordial vote of thanks be awarded to the retiring representatives of the Institute on the Council of The Federated Institution of Mining Engineers.

The motion was agreed to.

The following gentlemen were elected, having been previously nominated:—

Members—

Mr. James Atherton, Mining Engineer, 13, Mawdsley Street, Bolton.
Mr. Francis J. Ede, Mining Engineer, Silchar, Cachar, India.
Mr. Edward Graham, Jun., Colliery Manager, East Howle Colliery, Ferryhill.
Mr. Edward Griffith, Colliery Manager, Brymbo Colliery, near Wrexham, North Wales.
Mr. James Patrick Howley, Director of the Geological Survey of Newfoundland, Museum, St. John's, Newfoundland.
Capt. Cecil Clement Longridge, Consulting Engineer, Leigh, Essex; and 3, Princes Street, London, E.C.
Mr. John Robinson, Mining Engineer, The Grange, Haydock, near St. Helens.
Mr. Richard Williams, Mining Engineer, California Gulley, Bendigo, Victoria, Australia.

ASSOCIATE MEMBERS—

Mr. **LESLIE HILL**, Calgary, Alta, Canada.

Mr. H. E. **NEAVE**, Manager, Lionsdale Estates, Limited, Carolina, Transvaal, South Africa.

Mr. **JAMES LINN SHERLAW**, Coolgardie Gold Syndicate, Coolgardie, Western Australia.

Mr. **LOUIS WILLS**, Mining and Mechanical Engineer, 29, Cornhill, London, E.C.

STUDENT—

Mr. **ARTHUR WELSH**, Mining Student, West Rainton, Fence Houses.

The **SECRETARY** read the following paper, by Bergassessor Winkhaus, on "Further Experiments with Explosives."

FURTHER EXPERIMENTS WITH EXPLOSIVES.*

BY BERGASSESSOR WINKHAUS.

I.—EXPERIMENTS WITHOUT STEMMING (APPENDIX A).

Since the publication of the first series of experiments† upon the behaviour of explosives, and especially of the so-called safety-explosives, towards fire-damp and coal-dust, a number of new safety-explosives have been introduced, and are being extensively used in coal-mining, both in Westphalia and in other districts. Experiments were also tried with these explosives under the conditions set forth in the writer's first paper on this subject, and the results obtained have been partly communicated already in the author's paper on safety-explosives.‡ These explosives were roburit I. and Cologne-Rottweiler safety blasting-powder, the most recent addition being the so-called neu-westfalit.

Experiments upon these newer safety-explosives have shown that roburit I., neu-westfalit, and kohlen-karbonit in unstemmed shots of 21·16 ounces (600 grammes) each would cause no ignition in an atmosphere containing 7 per cent. of fire-damp. Doubtless, however, there must be a difference in the degree of safety of these explosives, and it became of interest to determine this difference, so as to obtain comparative values of their degrees of safety.

There were two methods in which these comparative values could be obtained; one was to increase the charges until ignition ensued, and the other, to make the conditions of the experiments more severe, by experimenting in a more explosive atmosphere, that is to say, containing higher percentages of fire-damp. The first method could not well be used because the bore of the cannon was not adapted for taking larger charges, and also because the cannon would be too rapidly destroyed with such heavy charges. The second method was therefore selected, and the experiments were continued up to the most explosive and most easily ignited gaseous mixture with 9 per cent. of fire-damp. At the same time, an opportunity was thus presented of determining the effect of these highly-explosive mixtures upon the danger of ignition by the explosives employed.

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* Translated by Prof. H. Louis.

† *Trans. Fed. Inst.*, vol. ix., page 250. ‡ *Ibid.*, vol. x., page 337.

The arrangement of the apparatus, and the mode of conducting the experiments,* corresponded exactly to those employed in the previous series; the only change made was in the arrangement of the copper wires from the electric exploder, these being no longer run side by side along the wall of the gallery. One was now brought along the roof, and the other along the wall, to prevent any possible contact of the wires, or the production of an explosion by sparks caused by short-circuiting. Moreover, in experiments upon 9 per cent. mixtures of fire-damp, the charges were diminished by 1·76 ounce (50 grammes) at a time, until five consecutive shots no longer produced ignition of the explosive atmosphere. The explosives were all placed at the end of the borehole of the cannon (18·11 inches or 460 millimetres long) without any stemming whatever.

Explosives Employed.

In this series of experiments, gelatine-dynamit, which is not a safety-explosive, the four above-named explosives, and dahmenit A which belongs to the group of safety-explosives, were included. The composition of some has already been given, but for the sake of completeness that of all of them is here reproduced, according to the latest analyses made by Dr. Broockman, of Bochum, in the laboratory of the Westphalian Miners' Provident Society.

1. *Gelatine-dynamit*, from the Schlebusch dynamite-factory, contained:—

	Per Cent.
Blasting-gelatine (gun-cotton and nitro-glycerine)	65
Nitrate of potassium	26
Wood-meal	9

2. *Cologne-Rottweiler safety blasting-powder*, composed of:—

	Per Cent.
Nitrate of ammonium	91·9
Organic matter (containing 50 per cent. of carbon and 10 per cent. of ash)	5·8
Sulphur	0·9
Nitrate of barium	1·4

3. *Dahmenit A*, from the factory of the Castrop Safety-explosives Company, composed of:—

	Per Cent.
Nitrate of ammonium...	92·9
Naphthalene	4·5
Bichromate of potassium	2·6

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* *Trans. Fed. Inst.*, vol. ix., page 250.

4. *Neu-westfalit*, from the westfalit factory at Sinsen, composed of:—

	Per Cent.
Nitrate of ammonium...	89·6
Resin	5·0
Bichromate of potassium	4·9
Impurities	0·5

5. *Roburit I.*, from the roburit factory at Witten-on-the-Ruhr, composed of:—

	Per Cent.
Nitrate of ammonium ...	88·2
Dinitro-benzole	7·4
Manganese compounds (permanganate of potassium and manganese peroxide)	4·4

6. *Kohlen-karbonit*, from the karbonit factory at Schlebusch, consisting of:—

	Per Cent.
Nitro-glycerine	25·0
Nitrate of potassium ...	34·0
Rye-meal	38·5
Wood-meal	1·0
Nitrate of barium	1·0
Bicarbonate of sodium	0·5

The explosives used were taken from the magazines of neighbouring mines.

Results of Experiments with Coal-dust in the Absence of Fire-damp.

No ignition of coal-dust could be produced, even when the original cartridges of explosives, packed in paraffin envelopes,* were employed. The following were the heaviest charges that were used:—

	Ounces.		Grammes.	
1. Dahmenit A:				
Charges of	19·40	or	550	(Experiments 2 and 3, Table 3, Appendix A).
2. Neu-westfalit:				
Charges of	21·16	or	600	(Experiments 5 to 7, Table 4, Appendix A).
3. Roburit I.:				
Charges of	21·87	or	620	(Experiment 2, Table 5, Appendix A).
4. Kohlen-karbonit:				
Charges of	35·27	or	1,000	(Experiments 4 and 5, Table 6, Appendix A).

Results of Experiments with Explosive Mixtures of Fire-damp.

With the exception of Cologne-Rottweiler safety blasting-powder, all the safety-explosives showed themselves to be safe in mixtures containing 6 to 6½ per cent. of methane; the above-named safety blasting-powder ignited a 6½ per cent. mixture of fire-damp with a charge of 21·16 ounces or 600 grammes (Experiment 16, Table 2, Appendix A). In 7 per cent. fire-damp mixtures the following were safe:—

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* The Cologne-Rottweiler safety blasting-powder is packed in tin-foil cases. The influence of paraffined cases is discussed hereafter.

1. **Neu-westfalit:** Ounces. Grammes.
In charges of 21·16 or 600 (Experiments 13 to 16, Table 4, Appendix A).
2. **Roburit I.:**
In charges of 26·45 or 750 (Experiment 11, Table 5, Appendix A).
3. **Kohlen-karbonit:**
In charges of 29·27 or 830 (Experiment 8, Table 6, Appendix A).

Ignitions of the gaseous mixture were on the other hand produced by:—

1. **Cologne-Rottweiler safety blasting-powder:**
Ounces. Grammes.
In charges of 14·10 or 400 (Experiment 18, Table 2, Appendix A).
2. **Dahmenit A:**
In charges of 17·63 or 500 (Experiment 6, Table 3, Appendix A).

In the presence of 8 per cent. fire-damp mixtures all the explosives produced ignition, except kohlen-karbonit, as follows:—

1. **Gelatine-dynamit:** Ounces. Grammes.
With charges of 1·23 or 35 (Experiment 8, Table 1, Appendix A).
2. **Cologne-Rottweiler safety blasting-powder:**
With charges of 7·05 or 200 (Experiment 22, Table 2, Appendix A).
3. **Dahmenit A:**
With charges of 14·10 or 400 (Experiment 18, Table 3, Appendix A).
4. **Neu-westfalit:**
With charges of 14·10 or 400 (Experiment 22, Table 4, Appendix A).
5. **Roburit I.:**
With charges of 17·63 or 500 (Experiment 15, Table 5, Appendix A).

Kohlen-karbonit was tried in charges of 21·16 ounces (600 grammes) without producing ignition (compare experiments 12 to 15, Table 6, Appendix A).

Gaseous mixtures, with 9 per cent. of fire-damp, were ignited by the following minimum charges:—

1. **Gelatine-dynamit:**
Ounces. Grammes.
Charges of 0·35 or 10 (Experiment 12, Table 1, Appendix A).
2. **Cologne-Rottweiler safety blasting-powder:**
Charges of 1·76 or 50 (Experiment 26, Table 2, Appendix A).
3. **Dahmenit A:**
Charges of 3·53 or 100 (Experiments 25 and 27, Table 3, Appendix A).
4. **Neu-westfalit:**
Charges of 5·29 or 150 (Experiment 33, Table 4, Appendix A).
5. **Roburit I.:**
Charges of 8·82 or 250 (Experiment 20, Table 5, Appendix A).

Kohlen-karbonit was safe, even under these conditions, in charges of 21·16 ounces, or 600 grammes (compare experiments 20 and 21, Table 6, Appendix A), and is thus the only explosive which resisted all conditions of these experiments. This behaviour is only in part confirmed by the experiments of the Committee of The North of England Institute of Mining and Mechanical Engineers.* According to these, kohlen-karbonit was the only explosive that caused no ignition in fire-damp mixtures with or without coal-dust, whilst coal-dust alone in the absence of fire-damp was ignited by a charge of 2·50 ounces, or 71 grammes. This striking and difficultly explicable fact caused experiments 22 to 38 to be tried with smaller charges. It was not, however, possible to get an ignition of suspended coal-dust in the course of nine shots with charges of 4·40 ounces, or 125 grammes, or in the course of seven shots with charges of 8·17 ounces, or 90 grammes.

The previously determined fact that, in the case of safety-explosives of a very high degree of safety, the envelope of the cartridge, saturated with paraffin or ceresin,† ceased to have any influence on the danger of ignition was again demonstrated by these experiments. A comparison of experiments 27 and 35, Table 3 (Appendix A), with dahmenit A shows that ignitions were determined in 9 per cent. fire-damp mixtures, with charges of 3·53 ounces, or 100 grammes, whether wrapped in their paraffined envelopes or not, whilst 1·76 ounces, or 50 grammes, even in paraffined coverings, produced no ignition of the fire-damp mixture under otherwise similar conditions (compare experiments 28 to 32, Table 3, Appendix A). There was therefore no object in repacking the explosives for these experiments in paraffin-free envelopes, but the explosives were, on the contrary, tested in that covering in which they would be used in actual practice. In the case of neu-westfalit, the paraffined covering was taken off, because it is packed in double envelopes, forming so-called bag cartridges, and in using it instructions are given to take off the outer paraffined envelope before using the explosive.

With reference to the Cologne-Rottweiler safety blasting-powder, it must be added that, in the more recent experiments, it no longer showed that high degree of safety which the earlier trials assigned to it. In a 7 per cent. fire-damp mixture, ignition was produced by a 14·10 ounces or 400 grammes-charge instead of one of 21·16 ounces or 600 grammes. On analysis, the explosive showed no essential difference from the former figures. These unfavourable results caused tests to be made of the explosive in paraffined cases, by transferring it to empty paraffined roburit-envelopes, and, as experiment 27, Table 2 (Appendix A), shows, a coal-dust ignition was produced in the absence of fire-damp. The correctness of the more recent experiments is thereby confirmed.

* *Report of the Proceedings of the Flameless Explosives Committee.*

† *Trans. Fed. Inst.*, vol. ix., pages 262-266; and vol. x., page 344.

As will appear from the tables contained in Appendix A, the experiments in mixtures with high percentages of fire-damp were carried out in the absence of coal-dust, because the latter does not affect the liability to ignition; this appears from the dahmenit A experiments, 21 to 25, 26 and 27, and 28 to 32, Table 3, Appendix A. With charges of 3·53 ounces or 100 grammes, ignition was obtained in the 9 per cent. gaseous mixture with or without coal-dust, whilst with charges of 1·76 ounces or 50 grammes no ignition was produced under either conditions. This result corresponds with those previously obtained and already communicated to the members.

With reference to the temperatures of the gallery, it may be noted that these were somewhat higher than before. Their average was about 72 to 79 degs. Fahr. (22 to 26 degs. Cent.), but at times reached 86 degs. Fahr. (30 degs. Cent.), when frequent ignitions were produced at short intervals of time, and the walls of the gallery became considerably heated thereby. No especially unfavourable influence could, however, be traced to variations within these limits; a comparison of the various experiments will show that, under otherwise equal conditions, ignitions occurred at low temperatures, and were not produced at high temperatures, or *vice versâ.*

II.—EXPERIMENTS WITH DETONATORS.

Experiments with detonators were repeated in larger numbers, once it was determined that all kinds of detonators did not give equal security in explosive gaseous mixtures.

With Bornhardt detonators, 45 experiments in 9 per cent. fire-damp mixtures did not produce a single ignition. Of these 45 experiments, 5 were tried with No. 3 detonators containing 8·3 grains, or 0·54 gramme, of fulminate of mercury; 15 with No. 6 detonators containing 15·4 grains, or 1 gramme; 9 with No. 7 detonators of 23·1 grains, or 1·5 grammes; and 16 with No. 8 detonators containing 30·8 grains, or 2 grammes. The detonators were partly suspended freely in the gallery, and partly put into the bore of the cannon.

Experiments with electric detonators from another manufacturer gave less satisfactory results: 11 experiments with No. 8 detonators in a 9 per cent. fire-damp mixture gave 6 ignitions; 10 experiments with No. 6 detonators also gave 6 ignitions; 2 experiments with Nos. 6 and 8 detonators in a 7 per cent. fire-damp mixture also produced ignitions. These results have, however, no effect upon the danger of ignition of an explosive. In experiments with neu-westfalit, Nos. 11 to 14 (Table 4.,

Appendix A), and with kohlen-karbonit, Nos. 9 to 11 and 19 (Table 6., Appendix A), similar detonators were used without the explosive producing ignition of the explosive gaseous mixture.

Four experiments, each with Nos. 6 and 8 detonators, fired by means of fuzes, caused no ignition of a 9 per cent. fire-damp mixture.

It should be added that Bornhardt detonators were used in all the experiments with explosives, with the exception of the experiments above referred to.

III.—Experiments with Stemming (Appendix B).

The cannon that had been hitherto used, with a bore of 2·16 inches (55 millimetres) in diameter and 18·11 inches (460 millimetres) long, was found not to be suitable for experiments on stemmed shots, because it was important in these to imitate as closely as possible the conditions that obtain in practice. The cannon used for these tests was therefore made with a bore of 1·57 inches (40 millimetres), so that the safety-explosives used in mining in their original cartridges of 1·38 inches (35 millimetres) in diameter could easily be charged into it. The length chosen was such that it would take charges of 16 to 18 ounces (450 to 500 grammes) with lengths of stemming up to 6 inches (150 millimetres), for which purpose a length of 30 inches (750 millimetres) was found ample. The construction of the cannon was the same as that of the former one. It consisted of a core of 6·50 inches (165 millimetres) in diameter, in which was the borehole, and a shell of 19·48 inches (495 millimetres) in diameter shrunk on to it. The shell was made of tough, the core of hard, crucible cast-steel. The length over all of the mortar was 36·61 (930 millimetres). The mortar was placed near the floor of the drift in a recess in the face; but, on account of its greater length, it projected 5·91 inches (150 millimetres) beyond the face. In other respects its position was identical with that of the former cannon. The axis of the borehole intersected the roof of the drift at a point 32·81 feet (10 metres) from the face.

The internal arrangements of the gallery were as already described, both in the experiments with mixtures of fire-damp and in those with coal-dust.

The Experiments.

In the first place, the influence of the longer and narrower borehole upon the danger of ignition by the explosives tested had to be determined, as compared with the older construction of the mortar. For this purpose, a series of experiments was tried with two explosives used in each set of tests—namely, gelatine-dynamit and westfalit (old composition)—without the use of stemming, the explosive being always situated at the bottom of the borehole. The results of these experiments are reproduced in the annexed tables (Appendix B).

With reference to the effect upon coal-dust alone, of which material 122 cubic inches (2 litres) were invariably scattered over the first 16·40 feet (5 metres) of the drift measured from the face, whilst another charge of 122 cubic inches (2 litres) was suspended by means of the fan situated in the roof of the gallery, experiments 1 to 5 (Table 1, Appendix A) show that no ignition was produced by charges of 3·53 ounces (100 grammes) and 4·41 ounces (125 grammes) of gelatine-dynamit, but that it was regularly produced by 5·29 ounces (150 grammes); whilst with the old mortar, a coal-dust ignition could always be obtained with charges of 3·53 ounces (100 grammes). The influence of the longer bore was, therefore, one of considerable importance. On the other hand, in explosive mixtures of fire-damp no difference could be shown to exist: 1·41 ounces (40 grammes) of gelatine-dynamit caused ignition of a 7 per cent. mixture—a weight of charge which corresponds with that found in the older experiments.

With westfalit (old composition, containing 95 per cent. nitrate of ammonium and 5 per cent. of resin) in paraffined original cases, values were also obtained which did not differ from those previously obtained. Charges of 7·05 ounces (200 grammes) caused no ignition in an atmosphere of coal-dust alone.

The influence of the longer borehole upon the results obtained with gelatine-dynamit is probably due to the cooling effect of the longer walls of the borehole upon the flame thrown out by the explosive. In experiments with fire-damp mixtures, this influence was less noticeable, because the explosive atmosphere diffused into the borehole, and the flame produced by the explosive set up an explosion of the fire-damp mixture within the borehole. The results obtained with westfalit will not appear remarkable, if the fact be borne in mind that the coal-dust explosion is set up by the ignition of the gaseous products of the paraffin of the cartridge-case within the borehole.

Experiments with Clay Stemming.

The stemming used was soft clay made up into rolls, wrapped in paper, of the same diameter as the borehole, that is to say in the exact condition in which it is used in actual mining. The stemming was pressed firmly against the explosive with a wooden tamping-bar, but without force or blows. The greatest care was taken so that the stemming was always introduced quite uniformly into the borehole in the various experiments.

(1) *Experiments with Gelatine-dynamit and Clay Stemming.*—The length of stemming employed was 5·91 inches (150 millimetres); the coal-dust atmosphere was almost regularly ignited with charges of 8·82 ounces (250 grammes), but not with 7·05 ounces (200 grammes). To determine the influence of varying the lengths of stemming, experiments were tried with 3·94 inches (100 millimetres), 7·87 inches (200 millimetres), and 9·84 inches (250 millimetres) of stemming. With 3·94 inches (100 millimetres) of stemming a coal-dust ignition was produced with charges of 7·05 ounces (200 grammes), with lengths of stemming of 7·87 inches (200 millimetres), and 9·84 inches (250 millimetres), with charges of 10·58 ounces (300 grammes). The experiments therefore show that increased lengths of stemming augment the safety of the explosive, whilst decreased lengths diminish it.

In 7 per cent. fire-damp mixtures, with coal-dust present, the least charge of gelatine-dynamit that produced an ignition with 5·91 inches (150 millimetres) of stemming was 7·05 ounces (200 grammes). When the stemming was lengthened to 9·84 inches (250 millimetres) 7·05 ounces (200 grammes) charges no longer produced this result. The degree of security from fire-damp explosions was therefore proportionately higher, and the favourable effect of the longer stemming was also demonstrated.

(2) *Experiments with Gelatine-dynamit and Coal-dust Stemming.*—When fine dry coal-dust was substituted for clay-stemming, ignition of the coal-dust atmosphere was again produced by charges of 2·64 ounces (75 grammes), which amount also caused it without any stemming at all. When the length of stemming was increased to 9·84 inches (250 millimetres) ignition of the coal-dust was still caused by charges of 3·53 ounces (100 grammes).

(3) *Experiments with Westfalit and Clay Stemming.*—Westfalit (old composition) was included in the experiments, chiefly because it was desired to determine the effect of stemming upon the danger of explosion due to an explosive packed in paraffined cartridge-cases. It was found that charges of 15·87 ounces (450 grammes) of this explosive in its paraffined cartridge-case, and stemmed with a length of 5·91 inches (150 millimetres) caused an explosion in a coal-dust atmosphere, so that the injurious effect of the paraffin still continued in spite of the stemming. Fire-damp mixtures with 7 per cent. of gas could not, however, be fired

either by 17·63 ounces (500 grammes) without paraffined cases or by 14·10 ounces (400 grammes) charges in paraffined cases, whilst this explosive, under the same conditions, but unstemmed, produced ignition of the explosive gases with charges of 8·82 ounces (250 grammes) and 5·29 ounces (150 grammes) respectively.

Unfortunately, it was not possible to continue these experiments with higher proportions of gas up to 9 per cent. of fire-damp, because the mortar was destroyed after exactly 100 shots had been fired in it. The experiments recorded show, however, that both coal-dust and gas explosions can be produced with stemmed shots, but that an increased charge is then necessary. It must not, however, be supposed that figures can thus be obtained that are directly applicable to actual practice. Experiments with stemmed shots in an experimental gallery are carried on under conditions far less dangerous than those that may obtain in the mine; for actual facts are known in which dust-explosions have been produced in mining under far less dangerous conditions and with charges of gelatine-dynamit that have been found when stemmed perfectly safe in the experimental gallery.

Most important and most interesting is the determination of the fact that the very objectionable influence of the paraffined cartridge-case upon the danger of ignition by safety-explosives of a low degree of safety, like the older roburit, westfalit, and dahmenit, is not removed by stemming. All the more value must therefore be attached to the progress that has been made in explosives during the past year, so that the effect of this paraffin has been entirely removed in the case of most of the safety-explosives used in Westphalia, the degree of security of which has been markedly increased. The only explosive upon which this paraffin still retained an injurious effect was Cologne-Rottweiler safety blasting-powder, in which case the evil is avoided by the use of tinfoil in packing the powder.

IV.—EXPERIMENTS WITH WATER-CARTRIDGES (APPENDIX C).

The experiments shown in Appendix C were tried with gelatine-dynamit, so as to determine the effect of water-tamping upon the danger of ignition by explosives. The explosive in cartridges of 0·91 inch (23 millimetres) diameter, was inserted in waterproof paper-cases of 1·38 inches (35 millimetres) diameter, which were filled with water, as they are used in mining, so that it lay about 1·97 inches (50 millimetres) from the two closed ends, and was therefore surrounded on all sides by water. These water-cartridges were fired, lying horizontally upon blocks of wood in the explosion-chamber of the experimental gallery: some lying free, some being embedded in either dry coal-dust, dry sand, or damp sand, so that in the latter cases the lower ⅓ of the water-cartridge was surrounded, whilst the upper ⅔ of its circumference was free.

In 7 per cent. fire-damp mixtures, in the presence of coal-dust, charges of 17·63 ounces (500 grammes) caused no ignition. On the other hand in 9 per cent. mixtures, violent ignitions were produced with 8·82 ounces (250 grammes) with free-lying cartridges, and with cartridges embedded in coal-dust. With water-cartridges embedded in damp sand, 12·34 ounces (350 grammes) were safe, whilst 14·10 ounces (400 grammes) produced a gas ignition; with dry sand this was also produced with 12·34 ounces (350 grammes).

The effect of the damp sand is due to the circumstance that, by its use, the lower part of the cartridge of the explosive, which is protected by a thinner layer of water in consequence of its coming into contact with the case of the water-cartridge, is protected by the damp support on which it rests.

These experiments confirm the fact, already determined in other places, that water-tamping considerably increases the safety of an explosive.

APPENDIX A.

EXPERIMENTS WITH UNSTEMMED SHOTS.

REFERENCES: I, ignition N, non-ignition.

1. GELATINE-DYNAMIT.

Date of Experiment.		No. of Experiment.	Explosive.			Coal-dust.	Fire-damp.	Temperature of the				Results.
			Weight.		Cartridge Cases.			Gallery.		Coal-dust.		
1895.			Grms.	Ozs.			%	Fahr.	Cent.	Fahr.	Cent.	
Oct.	21	1	40	1·41	Original.	Nil.	7·00	48	9	..	..	I
,,	21	2	35	1·23	,,	,,	7·00	55	13	.	..	N
,,	22	3	35	1·23	,,	,,	7·00	53	12	..	..	N
,,	22	4	35	1·23	,,	,,	7·00	48	9	..	..	N
,,	22	5	35	1·23	,,	,,	7·00	52	11	..	..	N
,,	21	6	35	1·23	,,	,,	8·00	57	14	..	..	N
,,	22	7	35	1·23	,,	,,	8·00	39	4	..	..	N
,,	22	8	35	1·23	,,	,,	8·00	43	6	..	..	I
1896.												
April	7	9	25	0·88	,,	,,	9·00	57	14	..	..	I
,,	7	10	15	0·52	,,	,,	9·00	59	15	..	..	I
,,	7	11	10	0·35	,,	,,	9·00	79	26	..	..	N
,,	7	12	10	0·35	,,	,,	9·00	77	25	..	..	I

2. COLOGNE-ROTTWEILER SAFETY BLASTING-POWDER.

(*a*).—OLDER SERIES OF EXPERIMENTS.

1895.			Grms.	Ozs.			%	Fahr.	Cent.	Fahr.	Cent.	
June	1	1	525	18·51	Original tin-foil cases.	With coal-dust.	4·50	63½	17½	63½	17½	N
,,	1	2	524	18·48	,,	,,	6·50	64	18	63½	17½	N
,,	1	3	565	19·93	,,	,,	6·25	64	18	63½	17½	N
,,	1	4	560	19·75	,,	Nil.	6·50	64	18	..	..	N
,,	1	5	570	20·10	,,	With coal-dust.	6·75	66	19	66	19	N
,,	1	6	580	20·45	,,	,,	7·00	68	20	66	19	N
Aug.	19	7	550	19·39	Paper cases.	,,	6·50	64	18	71	22	N
,,	19	8	575	20·28	,,	,,	7·00	68	20	71	22	N
,,	19	9	600	21·16	,,	,,	7·00	68	20	71	22	N
,,	19	10	600	21·16	,,	,,	7·25	68	20	71	22	N
,,	19	11	650	22·92	,,	,,	6·50	61	16	71	22	N
,,	20	12	600	21·16	,,	Nil.	7·25	86	30	..	..	I
,,	20	13	600	21·16	,,	With coal-dust.	7·25	88	31	68	20	N
,,	20	14	600	21·16	,,	,,	7·25	88	31	68	20	I
,,	23	15	600	21·16	,,	,,	7·25	68	20	68	20	N

2. COLOGNE-ROTTWEILER SAFETY BLASTING-POWDER.—*Continued.*

(*b*).—MORE RECENT SERIES OF EXPERIMENTS.

Date of Experiment	No. of Experiment	Explosive.			Coal-dust.	Fire-damp.	Temperature of the				Results.
		Weight.		Cartridge Cases.			Gallery.		Coal-dust.		
1896.		Grms.	Ozs.			°/₀	Fahr.	Cent.	Fahr.	Cent.	
May 13	16	600	21·16	Paper cases.	With coal-dust.	6·50	64	18	53	12	I
,, 13	17	500	17·63	,,	,,	7·00	71	22	53	12	I
,, 13	18	400	14·10	Tinfoil cases.	,,	7·00	68	20	53	12	I
,, 13	19	300	10·58	,,	,,	7·00	68	20	53	12	N
,, 13	20	300	10·58	,,	,,	7·00	75	24	53	12	N
,, 13	21	200	7·05	,,	Nil.	8·00	68	20	..	..	N
,, 13	22	200	7·05	,,	,,	8·00	66	19	..	..	I
,, 9	23	150	5·29	,,	,,	9·00	66	19	..	..	I
,, 9	24	100	3·53	,,	,,	9·00	68	20	..	..	I
,, 13	25	50	1·76	,,	,,	9·00	53	12	..	..	N
,, 13	26	50	1·76	,,	,,	9·00	70	21	..	..	I
,, 13	27	400	14·10	Paraffined cases.	With coal-dust.	Nil.	70	21	53	12	I
,, 13	28	300	10·58	,,	,,	Nil.	66	19	53	12	N

3. DAHMENIT A.

1895.		Grms.	Ozs.			°/₀	Fahr.	Cent.	Fahr.	Cent.	
Sept. 4	1	400	14·10	Original.	With coal-dust.	Nil.	68	20	70	21	N
Oct. 16	2	550	19·40	,,	,,	,,	55	13	55	13	N
,, 16	3	550	19·40	,,	,,	,,	52	11	52	11	N
Sept. 4	4	500	17·63	,,	,,	7·00	68	20	70	21	I
,, 4	5	500	17·63	,,	,,	7·00	73	23	70	21	N
Oct. 16	6	500	17·63	,,	,,	7·00	62	17	55	13	I
,, 16	7	450	15·87	,,	,,	7·00	64	18	55	13	N
,, 16	8	500	17·63	,,	,,	6·50	62	17	55	13	N
,, 25	9	550	19·40	,,	,,	7·00	64	18	46	8	N
,, 25	10	600	21·16	,,	,,	7·00	62	17	46	8	I
1896.											
Mar. 10	11	500	17·63	,,	,,	7·00	75	24	50	10	N
,, 10	12	500	17·63	,,	,,	7·00	77	25	50	10	N
,, 10	13	500	17·63	,,	,,	7·00	77	25	50	10	N
,, 10	14	500	17·63	,,	,,	7·50	79	26	52	11	N
,, 12	15	500	17·63	,,	Nil.	8·00	86	30	..	..	I
,, 13	16	500	17·63	,,	,,	8·00	79	26	..	..	I
,, 13	17	400	14·10	,,	,,	8·00	86	30	..	..	N
Apr. 1	18	400	14·10	Repacked.	,,	8·00	77	25	..	..	I
Mar. 28	19	150	5·29	Original.	,,	9·00	62	17	..	..	I
,, 28	20	150	5·29	Repacked.	,,	9·00	78	25½	..	..	I
,, 28	21	100	3·53	Original.	,,	9·00	79	26	..	..	N
,, 28	22	100	3·53	,,	,,	9·00	79	26	..	..	N
,, 28	23	100	3·53	,,	,,	9·00	79	26	..	..	N
,, 28	24	100	3·53	,,	,,	9·00	82	28	..	..	N
,, 28	25	100	3·53	,,	,,	9·00	82	28	..	..	I
Apr. 17	26	100	3·53	,,	With coal-dust.	9·00	75	24	50	10	N
,, 17	27	100	3·53	,,	,,	9·00	75	24	50	10	I
,, 17	28	50	1·76	,,	,,	9·00	75	24	50	10	N
,, 17	29	50	1·76	,,	Nil.	9·00	64	18	..	..	N
,, 17	30	50	1·76	,,	,,	9·00	79	26	..	..	N
,, 17	31	50	1·76	,,	,,	9·00	77	25	..	..	N
,, 17	32	50	1·76	,,	With coal-dust.	9·00	75	24	50	10	N
,, 21	33	100	3·53	Repacked.	,,	9·00	79	26	53	12	N
,, 21	34	100	3·53	,,	,,	9·00	75	24	53	12	N
,, 21	35	100	3·53	,,	,,	9·00	64	18	53	12	I

4. NEU-WESTFALIT.

Date of Experiment.	No. of Experiment.	Explosive.			Coal-dust.	Fire damp.	Temperature of the				Results.
		Weight.		Cartridge Cases.			Gallery		Coal-dust.		
1896.		Grms.	Ozs.			%	Fahr.	Cent.	Fahr.	Cent.	
Feb. 20	1	500	17·63	Original paraffined cases.	With coal-dust.	Nil.	46	8	46	8	N
. 20	2	500	17·63	,,	,,	,,	46	8	46	8	N
. 20	3	500	17·63	,,	,,	,,	50	10	46	8	N
. 20	4	500	17·63	,,	,,	,,	50	10	46	8	N
.. 29	5	600	21·16	,,	,,	,,	57	14	50	10	N
.. 29	6	600	21·16	,,	,,	,,	57	14	50	10	N
Mar. 4	7	600	21·16	,,	,,	,,	77	25	50	10	N
. 2	8	600	21·16	Without paraffined case.	,,	,,	77	25	50	10	N
. 2	9	550	19·40	Original paraffined cases.	,,	6·00	61	16	50	10	N
. 2	10	550	19·40	,,	,,	6·50	59	15	50	10	N
.. 2	11	550	19·40	,,	,,	6·50	59	15	50	10	N
.. 2	12	550	19·40	Without paraffined cases.	,,	6·50	77	25	50	10	N
.. 2	13	600	21·16	,,	,,	7·00	77	25	50	10	N
.. 3	14	600	21·16	,,	,,	7·00	84	29	50	10	N
. 3	15	600	21·16	,,	,,	7·00	89	32	50	10	N
.. 4	16	600	21·16	Original paraffined cases.	,,	7·00	82	28	50	10	N
,, 5	17	600	21·16	,,	,,	8·00	75	24	50	10	I
,, 5	18	600	21·16	Without paraffined cases.	Nil.	8·00	82	28	..	..	I
,, 6	19	550	19·40	,,	,,	8·00	86	30	..	..	I
,, 6	20	500	17·63	,,	,,	8·00	86	30	..	..	I
.. 6	21	500	17·63	,,	,,	8·00	84	29	..	..	
.. 6	22	400	14·10	,,	,,	8·00	82	28	..	..	I
.. 7	23	400	14·10	,,	,,	8·00	88	31	..	..	N
,, 7	24	500	17·63	,,	,,	8·00	86	30	..	..	I
,, 15	25	300	10·58	,,	,,	9·00	77	25	..	..	N
,, 15	26	300	10·58	,,	,,	9·00	80	27	..	..	I
.. 15	27	250	8·82	,,	,,	9·00	66	19	..	..	N
.. 15	28	250	8·82	,,	,,	9·00	73	23	..	..	N
.. 20	29	250	8·82	,,	,,	9·00	86	30	..	..	I
.. 20	30	200	7·05	,,	,,	9·00	86	30	..	..	I
,, 22	31	150	5·29	,,	,,	9·00	64	18	..	..	N
,, 22	32	150	5·29	,,	,,	9·00	77	25	..	..	N
.. 22	33	150	5·29	,,	,,	9·00	79	26	..	..	I
,, 22	34	100	3·53	,,	,,	9·00	84	29	..	..	N
,, 22	35	100	3·53	,,	,,	9·00	82	28	..	.	N
,, 22	36	100	3·53	,,	,,	9·00	86	30	..	..	N
.. 23	37	100	3·53	,,	,,	9·00	77	25	..	..	N
,, 23	38	100	3·53	,,	,,	9·00	79	26	..	..	N

5. ROBURIT I.

Date of Experiment.	No. of Experiment.	Explosive.			Coal-dust.	Fire-damp.	Temperature of the				Results.
		Weight.		Cartridge Cases.			Gallery.		Coal-dust.		
1895.		Grms.	Ozs			°/₀	Fahr.	Cent.	Fahr.	Cent.	
Aug. 30	1	395	13·93	Original.	With coal-dust.	Nil.	62	17	62	17	N
Oct. 10	2	620	21·87	,,	,,	,,	61	16	55	13	N
Aug. 30	3	500	17·63	Repacked.	,,	6·50	62	17	62	17	N
,, 30	4	500	17·63	,,	,,	7·00	64	18	62	17	N
,, 30	5	550	19·40	,,	,,	7·00	64	18	62	17	N
,, 30	6	600	21·16	,,	,,	7·00	64	18	64	18	N
,, 30	7	600	21·16	,,	Nil.	7·60	66	19	..	..	N
,, 30	8	600	21·16	,,	With coal-dust.	7·00	66	19	64	18	N
,, 31	9	600	21·16	,,	,,	7·00	86	30	64	18	N
,, 31	10	600	21·16	,,	Nil.	7·00	86	30	..	..	N
Oct. 25	11	750	26·45	Original.	With coal-dust.	7·00	62	17	46	8	N
1896.											
Mar. 7	12	600	21·16	,,	Nil.	8·00	82	28	..	..	I
,, 7	13	500	17·63	,,	,,	8·00	86	30	..	..	N
,, 12	14	500	17·63	,,	,,	8·00	86	30	..	..	N
,, 12	15	500	17·63	,,	,,	8·00	86	30	..	..	I
,, 13	16	400	14·10	,,	,,	8·00	84	29	..	..	N
,, 13	17	400	14·10	,,	,,	8·00	80	27	..	..	N
,, 31	18	250	8·82	,,	,,	9·00	80	27	..	..	N
,, 31	19	300	10·58	,,	,,	9·00	75	24	..	..	I
,, 31	20	250	8·82	,,	,,	9·00	79	26	..	..	I
,, 31	21	200	7·05	,,	,,	9·00	82	28	..	..	N
,, 31	22	200	7·05	,,	,,	9·00	84	29	..	..	N
,, 31	23	200	7·05	,,	,,	9·00	79	26	..	..	N
,, 31	24	200	7·05	,,	,,	9·00	77	25	..	..	N
,, 31	25	200	7·05	,,	,,	9·00	77	25	..	..	N

6. KOHLEN-KARBONIT.

1895.		Grms.	Ozs.			°/₀	Fahr.	Cent.	Fahr.	Cent.	
Oct. 2	1	750	26·45	Original.	With coal-dust.	Nil.	62	17	62	17	N
,, 3	2	750	26·45	,,	,,	,,	77	25	77	25	N
,, 14	3	750	26·45	,,	,,	,,	57	14	52	11	N
1896.											
Mar. 18	4	1,000	35·27	,,	,,	,,	64	18	50	10	N
,, 18	5	1,000	35·27	,,	,,	,,	64	18	50	10	N
1895.											
Oct. 2	6	750	26·45	,,	,,	7·00	62	17	62	17	N
,, 14	7	600	21·16	,,	,,	7·00	57	14	52	11	N
,, 25	8	830	29·27	,,	,,	7·00	53	12	46	8	N
1896.											
Mar. 3	9	600	21·16	,,	,,	7·00	88	31	50	10	N
,, 3	10	600	21·16	,,	,,	7·00	86	30	50	10	N
,, 3	11	600	21·16	,,	,,	7·00	86	30	50	10	N
,, 6	12	600	21·16	,,	Nil.	8·00	84	29	..	..	N
,, 13	13	600	21 10	,,	,,	8·00	84	29	..	..	N
,, 13	14	600	21·16	,,	,,	8·00	86	30	..	..	N
,, 13	15	600	21·16	,,	,,	8·00	86	30	..	..	N
,, 20	16	500	17·63	,,	,,	9·00	89	32	..	..	N
,, 20	17	500	17·63	,,	,,	9·00	86	30	..	..	N
,, 28	18	500	17·63	,,	,,	9·00	84	29	..	..	N
,, 31	19	500	17·63	,,	,,	9·00	79	26	..	..	N
Apr. 17	20	600	21·16	,,	,,	9·00	84	29	..	..	N
,, 17	21	600	21·16	,,	,,	9·00	79	26	..	..	N
,, 10	22 to 31	125	4·40	,,	With coal-dust.	Nil.	64 to 66	18 to 19	52	11	N
May 1	32 to 38	90	3·17	,,	,,	,,	55 to 57	13 to 14	50	10	N

APPENDIX B.

EXPERIMENTS WITH STEMMED SHOTS.

References: I, ignition; N, non-ignition.

7. GELATINE-DYNAMIT, WITHOUT STEMMING.

Date of Experiment.	No. of Experiment.	Explosive.			Length of Stemming.		Coal-dust.	Fire-damp.	Temperature of the				Results.
		Weight.		Cartridge Cases.					Gallery.		Coal-dust.		
1895.		Grms.	Ozs		Mm.	Ins.		%	Fahr.	Cent.	Fahr.	Cent.	
Sept. 28	1	100	3·53	Original.	Nil.	Nil.	With coal-dust.	Nil.	59	15	59	15	N
,, 28	2	150	5·29	,,	,,	,,	,,	,,	59	15	59	15	I
,, 28	3	125	4·40	,,	,,	,,	,,	,,	64	18	59	15	N
,, 28	4	125	4·40	,,	,,	,,	,,	,,	61	16	59	15	N
,, 28	5	150	5·29	,,	,,	,,	,,	,,	61	16	59	15	I
,, 28	6	50	1·76	,,	,,	,,	,,	7·00	66	19	59	15	I
,, 28	7	40	1·41	,,	,,	,,	Nil.	7·00	66	19	..	..	I

8. GELATINE-DYNAMIT AND CLAY STEMMING.

1895.		Grms.	Ozs.		Mm.	Ins.		%	Fahr.	Cent.	Fahr.	Cent.	
Sept. 28	1	250	8·82	Original.	150	5·90	With coal-dust.	Nil.	66	19	59	15	N
,, 30	2	300	10·58	,,	150	5·90	,,	,,	82	23	59	15	I
,, 30	3	250	8·82	,,	150	5·90	,,	,,	86	30	59	15	I
,, 30	4	200	7·05	,,	150	5·90	,,	,,	89	32	59	15	N
Oct. 2	5	250	8·82	,,	150	5·90	,,	,,	64	18	62	17	I
,, 2	6	250	8·82	,,	150	5·90	,,	,,	72	22	62	17	I
,, 4	7	250	8·82	,,	200	7·87	,,	,,	50	10	50	10	N
,, 4	8	250	8·82	,,	150	5·90	,,	,,	61	16	50	10	I
,, 4	9	300	10·58	,,	200	7·87	,,	,,	62	17	50	10	I
,, 4	10	250	8·82	,,	200	7·87	,,	,,	72	22	50	10	N
,, 4	11	300	10·58	,,	250	9·84	,,	,,	66	19	50	10	N
,, 4	12	300	10·58	,,	250	9·84	,,	,,	66	19	46	8	I
,, 14	13	200	7·05	,,	100	3·94	,,	,,	61	16	52	11	I
,, 2	14	100	3·53	,,	150	5·90	,,	7·00	73	23	62	17	N
,, 2	15	150	5·29	,,	150	5·90	,,	7·00	70	21	62	17	N
,, 3	16	200	7·05	,,	150	5·90	,,	7·00	70	21	50	10	I
,, 3	17	150	5·29	,,	150	5·90	,,	7·00	79	26	50	10	N
,, 8	18	200	7·05	,,	250	9·84	,,	7·00	79	26	46	8	N
,, 8	19	200	7·05	,,	250	9·84	,,	7·00	79	26	46	8	N
,, 14	20	200	7·05	,,	150	5·90	,,	6·00	75	24	52	11	N
,, 14	21	200	7·05	,,	150	5·90	,,	7·00	75	24	52	11	I

9. GELATINE-DYNAMIT AND COAL-DUST STEMMING.

Date of Experiment.	No. of Experiment.	Explosive.			Length of Stemming.		Coal-dust.	Fire-damp.	Temperature of the				Results.
		Weight.		Cartridge Cases.					Gallery.		Coal-dust.		
1895.		Grms.	Ozs.		Mm.	Ins.		%	Fahr.	Cent.	Fahr.	Cent.	
Oct. 9	1	100	7·05	Original.	150	5·90	With coal-dust.	Nil.	55	13	55	13	I
,, 9	2	100	3·53	,,	150	5·90	,,	,,	62	17	55	13	I
,, 9	3	75	2·64	,,	150	5·90	,,	,,	70	21	55	13	I
,, 9	4	75	2·64	,,	250	9·84	,,	,,	70	21	55	13	N
,, 9	5	100	3·53	,,	250	9·84	,,	,,	66	19	55	13	I

10. WESTFALIT, WITHOUT STEMMING.

1895.		Grms.	Ozs.		Mm.	Ins.		%	Fahr.	Cent.	Fahr.	Cent.	
Sept. 30	1	400	14·10	Original paraffined cases.	Nil.	Nil.	With coal-dust.	Nil.	60	15	60	15	I
,, 30	2	350	12·34	,,	,,	,,	,,	,,	6	18	61	16	I
,, 30	3	300	10·58	,,	,,	,,	,,	,,	36	2	60	15	I
,, 30	4	250	8·82	,,	,,	,,	,,	,,	82	25	60	15	I
,, 30	5	200	7·05	,,	,,	,,	,,	,,	80	26½	60	15	I
,, 30	6	150	5·29	,,	,,	,,	,,	,,	86	30	60	15	N
,, 30	7	150	5·29	,,	,,	,,	,,	7·00	68	20	50	10	I

11. WESTFALIT AND CLAY STEMMING.

1895.		Grms.	Ozs.		Mm.	Ins.		%	Fahr.	Cent.	Fahr.	Cent.	
Oct. 4	1	400	14·10	Original paraffined cases.	150	5·90	With coal-dust.	Nil.	70	21	55	13	N
,, 4	2	442	15·59	,,	130	5·12	,,	,,	68	20	55	13	I
,, 4	3	450	15·87	,,	150	5·90	,,	,,	70	21	55	13	N
,, 4	4	447	15·76	,,	150	5·90	,,	,,	66	19	57	14	I
,, 8	5	450	15·87	,,	150	5·90	,,	,,	62	17	46	8	N
,, 8	6	450	15·87	,,	150	5·90	,,	,,	65	18½	46	8	I
,, 8	7	450	15·87	,,	150	5·90	,,	,,	72	22	46	8	I
,, 11	8	450	15·87	,,	150	5·90	,,	,,	64	18	50	10	I
,, 11	9	400	14·10	,,	150	5·90	,,	,,	64	18	50	10	N
,, 8	10	400	14·10	Paraffined cases removed.	150	5·90	,,	7·00	79	26	46	8	N
,, 10	11	450	15·87	,,	150	5·90	,,	7·00	62	17	55	13	N
,, 10	12	500	17·63	,,	150	5·90	,,	7·00	61	16	55	13	N
,, 10	13	250	8·82	Original paraffined cases.	150	5·90	,,	7·00	61	16	55	13	N
,, 11	14	350	12·34	,,	150	5·90	,,	7·00	61	18	50	10	N
,, 11	15	400	14·10	,,	150	5·90	,,	7·00	57	14	50	10	N
,, 11	16	344	12·13	,,	150	5·90	,,	7·00	64	18	50	0	N
,, 11	17	400	14·10	,,	150	5·90	,,	7·00	68	20	50	10	N

APPENDIX C.

EXPERIMENTS WITH WATER-CARTRIDGES.

12. GELATINE-DYNAMIT IN WATER-CARTRIDGES.

Date of Experiment.	No. of Experiment.	Explosive. Weight.		Coal-dust.	Fire-damp.	Temperature of the Gallery.		Temperature of the Coal-dust.		Results.	Position of the Water-cartridge.
		Grms.	Ozs.		°/o	Fahr.	Cent.	Fahr.	Cent.		
1895.											
Oct. 30	1	200	7·05	With coal-dust.	7·00	55	13	46	8	N	Lying free.
,, 30	2	300	10·58	,,	7·00	53	12	46	8	N	,,
,, 13	3	400	14·10	,,	7·00	64	18	46	8	N	,,
,, 13	4	455	16·05	,,	7·00	64	18	46	8	N	,,
,, 13	5	500	17·63	,,	7·00	50	10	46	8	N	Embedded in coal-dust.
,, 13	6	500	17·63	Nil.	7·00	64	18	..	..	N	Lying free.
,, 13	7	500	17·63	With coal-dust.	7·00	75	24	46	8	N	Embedded in coal-dust.
1896.											
Apr. 11	8	250	8·82	,,	9·00	61	16	53	12	I	,, ,,
,, 11	9	250	8·82	Nil.	9·00	64	18	..	..	I	Lying free.
,, 11	10	150	5·29	,,	9·00	68	20	..	..	N	,,
,, 11	11	250	8·82	,,	9·00	70	21	..	..	N	Embedded in damp sand.
,, 11	12	350	12·34	,	9·00	70	21	..	..	I	Embedded in dry sand.
,, 11	13	350	12·34	,,	9·00	66	19	..	..	N	Embedded in damp sand.
,, 11	14	500	17·63	,,	9·00	66	19	..	..	I	,, ,,
,, 11	15	400	14·10	,,	9·00	68	20	..	..	I	,, ,,
,, 11	16	400	14·10	,,	9·00	61	16	..	..	I	,, ,,

Mr. W. C. **Blackett** said that Mr. Winkhaus, like the Explosives Committee of the Institute, had made the mistake of using soft clay for stemming. He (Mr. Blackett) had always contended that it was not the best kind of stemming; and if the experiments were intended to be made under practical conditions, they should have used the same kind of stemming as was used in the mines in this district, viz., a sort of hard-setting seggar clay, or the like. If such stemming were used, and driven firmly into the hole, it would set there, and make the explosive do more efficient work. He was not surprised that no considerable difference in the degree of safety had been found when stemming with moist clay. Mr. Winkhaus slightly differed from the conclusions of the Explosives Committee with regard to stemming, for he said that his experiments tended to show that increased lengths of stemming did augment the safety of the explosive. The conclusion of the Explosives Committee was, that increased lengths of stemming—the soft stemming they used—did not greatly increase the safety of the explosive. No doubt, if a stemming with more grip on the sides of the hole, or cannon, had been used, the Explosives Committee would have come to a different conclusion.

It occurred to him (Mr. Blackett) that the conditions of the experimental galleries were more severe on the explosives than the conditions of the mine. In the first place, they absolutely enforced a blown-out shot, an occurrence somewhat unusual in the mine. He could not understand Mr. Winkhaus saying that the conditions in the experimental galleries were less dangerous than those obtaining in the mine.

Whether it was fair to assume that the experiments afforded comparative degrees of safety was open to some doubt. In one part of the paper, Mr. Winkhaus stated that, in the series of experiments, a number of shots (5) were fired consecutively, and if an explosive did not fire in five shots, it was considered safer than one which caused ignition in a smaller number of trials. This was not a fair assumption, as the experiments of the Explosives Committee showed that a large number of shots might safely be fired, and yet the next shot, made under apparently the same conditions, gave ignition.

Prof. H. LOUIS said that one point occurred to him in reading Mr. Winkhaus' paper, and it had been emphasized by what the previous speaker had said, and that was that he thought, in the present state of knowledge, they should deprecate the attempt to put explosives on a quantitative basis. He did not think their present knowledge was such as to warrant it; for example, it was found, by the experiments of the Explosives Committee, that a number of shots might be fired without causing an explosion, and another under apparently the same conditions would produce an explosion, consequently the present state of knowledge respecting the conditions necessary to determine an explosion was such that they were not warranted in attempting to put the subject yet on a purely quantitative basis. They wanted to know more than they actually did about the surrounding conditions. Whether the weight of explosive used was large or small, the temperature produced by its explosion must be the same, although the total quantity of heat was different. Earlier experimenters had attempted to ascribe the explosion of a fire-damp mixture purely to the temperature generated by the explosive employed, but modern research, amongst which the paper of Mr. Winkhaus may be included, did not corroborate this view, against which there was much to be said.

Mr. WINKHAUS wrote that Mr. W. C. Blackett pointed out that the stemming used for the stemmed shots did not correspond to that which was in every-day use. But his remark did not apply to the conditions prevailing in Westphalia; for, as might also be inferred, from the statement made in his (Mr. Winkhaus') paper, in Westphalia miners constantly used, for stemming, plastic clay identical in character with that used in the experiments. Regarding the further statement set forth in his (Mr. Winkhaus') paper, that the conditions under which experiments were conducted in an experimental gallery with stemmed shots were decidedly far different from those which were possible in the matter of risk belowground, he (Mr. Winkhaus) would point to the report of Mr. Georgi* in which it is stated that a coal-dust explosion was actually initiated by a shot stemmed with clay, the charge being only 5·29 ounces (150 grammes) of gelatine-dynamite. Two samples of air from the place of the disaster yielded mere traces of fire-damp, only 0·048 and 0·079 per cent. respectively. According to the experiments which he (Mr. Winkhaus) carried out, it was quite impossible under such conditions to produce a coal-dust explosion in the experimental gallery. With a length of only 6 inches of stemming, it required charges of 8·82 ounces (250 grammes) of gelatine-dynamite when no fire-damp was present, and 7·05 ounces (200 grammes) of gelatine-dynamite in the presence of 7 per cent. of fire-damp (Table 8, Appendix B).

The CHAIRMAN moved, and Mr. GEO. MAY seconded, a resolution that a vote of thanks be accorded to the author of the paper.

The motion was agreed to.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."†

Mr. JAS. MCMURTRIE (Radstock) said that he had given attention to the question of coal-dust as found in the collieries of Somersetshire. At one time he was of decided opinion that in the absence of fire-damp coal-dust was not a source of danger in mines. Inflammable gas had not been met with in the mines of Somersetshire for something like 100 years, and during that time there had not been an instance on record of a single explosion. He thought, therefore, that he was fully justified in concluding that coal-dust in the absence of inflammable gas was not an explosive substance, and he had ventured to give evidence to that effect before the Royal Commission on coal-dust. His faith had, however, been rudely shaken by circumstances which had taken place during the past three years. There had been two explosions in Somerset-

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* *Jahrbuch für das Berg und Hüttenwesen im Konigreich Sachsen, 1891*, page 1.

† *Trans. Fed. Inst.*, vol. viii., pages 227 and 593; vol. ix., pages 115, 206, and 274; vol. x., pages 38, 197, 492, and 503; and vol. xi., pages 175, 218, and 551.

shire during that period, and in the absence of proof of inflammable gas, most mining engineers had to come to the conclusion that these explosions were distinctly due to coal-dust alone. They were now acting to some extent on that opinion, as they considered that coal-dust was an actual source of danger. Mines were now being watered which previously were not watered ; roburite and other safety-explosives were being used ; special shot-firers were now employed—a thing practically unknown before; and mining engineers were now endeavouring in various ways to minimize the dangers known to exist. After the Timsbury explosion, by which seven lives were lost, a suggestion was made that it might not have been due to coal-dust but to the presence of carbon monoxide existing in some goaves, or as a product of shot-firing by ordinary powder. This theory was put before the coroner, and embodied in his enquiry. It was generally held, however, and the inspector had reported to the effect, that the explosion was due to coal-dust.

Mr. G. E. J. McMurtrie (Cinderford) said that the thanks of the members of the Institute were certainly due to the members of the Explosives Committee, who had so ably devised and carried out these extensive experiments. Their enquiry had done much good, even if it had only proved that the so-called flameless explosives were not yet what they were claimed to be, and that all produced more or less flame. It was stated that the experimental tube might be said to represent a gallery.* Could this be said of a tube 3 feet in diameter, when the general size of horse-roads was, probably, 6 feet by 6 feet, and of main haulage planes 10 feet or so by 6 feet ? Would not the area of the airway have some effect upon the results obtained ?

A table of equivalent weights of explosive for stemmed shots would be of considerable use, as it would afford reliable information as to the relative strengths of the explosives under these circumstances, and consequently their relative cost, which it was difficult to otherwise decide.

Did it follow that the relative results obtained, say from 1 ounce of each explosive used, would be the same for the greater weights required for ripping in the roof or floor ? Would not the weight affect the relative results ?

The statement that additional length of stemming was not an advantage,† appeared strange, and might possibly be due to the fact of the clay being damp and puddled.

The finding of the Explosives Committee that no high explosive ignited a gaseous mixture of pit-gas and air when stemmed was certainly

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* *Report*, page 9. † *Ibid.*, page 18.

reassuring; as was also the fact that bellite, roburite, and carbonite, did not ignite a gaseous mixture, with unstemmed holes, after twenty-five trials with each explosive. As blown-out shots were practically certain to occur occasionally, explosions were certainly less likely with these explosives should gas be present, and the shot-firer fail to properly examine the place.

The second and third conclusions of the first report draw attention to very important points, viz., (1) that these high explosives depend for their action on regularity in the proportion of ingredients used, and their thorough admixture; and (2) that these explosives alter in character with age. He (Mr. McMurtrie) understood that some of these explosives are built up on the basis that flame will be prevented—or, if formed, instantaneously put out—by the formation of some such gas as chlorine, or upon the assumption that the temperature of the gaseous products is so low as not to ignite pit-gas or coal-dust. If the mixture be incorrect, or has undergone transformation, clearly this cannot follow, even if it does at other times, which may be open to doubt, as the element of time is here all-important.

The danger of coal-dust has been more clearly shown by the experiments of the Explosives Committee, which have proved that, with blasting-powder only, ¾ lb. of coal-dust placed on frames, or ½ lb. in suspension, may, with a blown-out shot, cause a very violent ignition. That blasting-powder with coal-dust alone does cause ignitions, the explosions at Camerton and Timsbury have proved. Whether the carbon monoxide obtained by the ignition of the explosives played any part in the production of these explosions has yet to be proved: though, as Prof. Lewes has shown that, given a blown-out shot, coal-dust in the presence of carbon monoxide is explosive. This may be a possible explanation.

A series of experiments on the conditions necessary to such ignition would be of great interest, especially to those districts free from firedamp, as why such explosions only occurred at the very time when the advocates of the coal-dust theory required such evidence is a mystery, and points to the fact that, under many conditions of practice, even a blown-out shot in the presence of suspended dust would not cause an explosion. What these conditions are it is important to know, and it is much to be regretted that the propagation of a dust ignition was not included in the scope of the work of the Explosives Committee.

Had a series of experiments been made with different dusts to prove the effect which fineness of the dust, chemical composition and volatile matter contained in the dust, and dryness of the dust, had in causing dust ignitions, together with the amount of water required to thoroughly damp and render harmless the dust, the already valuable *Report* would have been greatly enhanced.

The result of the experiments with stemmed shots fired into mixtures of pit-gas and coal-dust in suspension, in which two shots only ignited the pit-gas and coal-dust, is reassuring, though open to the remark of the Explosives Committee, that an explosive which once fails in the safety test is liable to fail again.

So, also, are the experiments with carbonite and roburite with unstemmed shots fired into mixtures of pit-gas and coal-dust in suspension. In all, twenty-four experiments were made, and one roburite-shot only ignited the mixture; while the experiments with unstemmed shots fired into coal-dust in suspension, resulted in bellite, securite, ammonite, and carbonite, igniting the dust, are far from satisfactory, although roburite, ardeer-powder, and westfalit stood the test well.

The experiments, however, with explosives stemmed and fired into coal-dust in suspension, and coal-dust *in situ*, and with explosives unstemmed fired into coal-dust *in situ*, are most satisfactory.

It is much to be regretted that the funds necessary to carry out further experiments cannot be obtained from the Government, especially remembering the national importance of the coal industry, and the frequent loss of life from unexplained explosions.

The discussion was adjourned.

The meeting was then closed.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,
AUGUST 5TH, 1896.

MR. JAMES S. DIXON, EX-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. THOS. MCKAY, Brahmin Bararee Collieries, Bengal, India.
Mr. FRED. JOSEPH TRUMP, Rhymney Iron Works, Rhymney, Monmouthshire.

DISCUSSION ON MR. DUGALD BAIRD'S PAPER ON "THE DUTY OF PUMPING-ENGINES."*

Mr. D. BAIRD, replying to the discussion, said that Mr. Martin asked "what improvements on the present, or what change of type from the engines that he described, are necessary, so as to bring them up to the ideal standard of 100,000,000 foot-pounds of duty per cwt. of coal burned?"† This question, to do it justice, would require a detailed report on each of the five engines tested; which can scarcely be expected in this reply. Taking the engines, one by one, and making a few remarks about each, it will be seen how these engines could be improved, if not brought up to the duty of 100,000,000 foot-pounds. In order that these remarks may be properly understood it will be necessary to refer to the indicator-diagrams taken from the steam-cylinders of these engines.

The indicator-diagrams, Fig. 1 (Plate II.), were taken from the No. 1 engine, a single-cylinder (100 inches in diameter) bull condensing pumping-engine at Leven colliery, giving a duty of only 50,265,312 foot-pounds.‡

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* *Trans. Fed. Inst.*, vol. xi., pages 94 and 235.

† *Ibid.*, page 236. ‡ *Ibid.*, page 100.

The upper diagram (taken from the lower side of the piston) shows a terminal pressure of 20 lbs. per square inch above the atmosphere, and the whole of this valuable steam, at the end of each up-stroke, is passed straight into the condenser and destroyed: this terminal pressure is too great for economy. One way of remedying the loss would be to add another cylinder of the same size: the terminal pressure would then be about 5 lbs. per square inch, and the duty would be greatly increased, and possibly 80,000,000 foot-pounds would be reached. The lower indicator-diagram was taken from the upper side of the piston. This type of engine, having practically no expansion, should have very large cylinders if economy be desired.

Nos. 2 and 3 pumping-engines, at the Leven collieries,* are parts of the same underground installation, the one pumping water up to the other. The underground Davey differential pumping-engine, at the No. 1 pit, has two horizontal cylinders, each 36 inches in diameter, and two ram-pumps, which can be worked together, but are usually worked separately. The duplex pumping-engine, at the No. 2 pit, has two horizontal cylinders (22 inches in diameter) and two ram-pumps, which (as in all duplex pumping-engines) can only be worked together. Their collective duty is 41,360,000 foot-pounds; it should, however, be noted that these engines are underground and receive, like other underground engines, more or less wet steam. When the indicator-diagrams (Figs. 2, 3, 4, and 5, Plate II.) are examined and it is seen that the terminal pressures average 18 lbs. per square inch above the atmosphere, it will be acknowledged that the duty is not less than would have been expected. An improvement would ensue if these engines were compounded and supplied with superheated steam.

No. 4 pumping-engine, at the Durie colliery, is a Davey differential compound condensing vertical beam engine; the high-pressure cylinder being 33 inches in diameter, and the low-pressure cylinder 52 inches in diameter. It gives a duty of 69,705,890 foot-pounds.† This engine is of an economical type, and should yield a much higher duty: in this case the indicator-diagrams (Figs. 6 and 7, Plate II.) show that it is too small for its work, and that very little expansion is obtained in the high-pressure cylinder.

No. 5 pumping engine, at the Wellsgreen colliery, only gives a duty of 35,827,200 foot-pounds.‡ It is a compound condensing bull engine: one cylinder being placed vertically above the other, with a receiver between

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* *Trans. Fed. Inst.*, vol. xi., page 100.

† *Ibid.*, page 100.

‡ *Ibid.*, page 100.

the cylinders to hold the steam on its passage from the high-pressure to the low-pressure cylinder. The indicator-diagrams (Figs. 8 and 9, Plate II.) show that the steam is badly distributed; and that the full steam capacity of the low-pressure cylinder is exhausted into the condenser at the end of each stroke at a pressure of 19 lbs. per square inch. Another undesirable feature of this engine, as presently arranged, is that the high-pressure cylinder opens directly into the condenser, and this is a sure source of condensation of steam during the up-stroke.

Mr. Martin makes special reference to the priming of boilers.* There is no doubt that priming is dangerous and wasteful, and, if not mitigated, would affect the duty to a large extent. The writer has had experience of a locomotive boiler priming from the use of muddy water, and it was impossible to obtain more than half its duty until clean water was used. Of course, priming arises from various causes, but chiefly from the use of inferior water and too small boiler capacity, necessitating rapid evaporation; too much soda or boiler-composition will also cause priming. Mr. Martin also refers to feeding boilers with hot water: this is very economical if no grease or oil be allowed to mix with the water, as always occurs with open heaters. The practice of using a hot-water feed should become more general at collieries than it is at present.

The pumping of 600 gallons of water per minute up a slope mine against a vertical head of 2,100 feet is a heavy undertaking, and he would defer making any remarks as to the best system until the Moore hydraulic pump, which was being erected, was started and tested.†

In the case where the dead loss is 48 per cent. of the total water evaporated‡ there are considerable lengths of steam-piping on the surface, also 1,400 feet of pipes (7 inches in diameter) in the shaft and underground, the whole of which are covered by composition. Members should endeavour to find out the dead loss of their steam installation, and thereby the amount of blame for large consumption of steam will be allocated between the engines and the steam-piping.

Mr. Grant stated that for practical work the taking of indicator-diagrams from the engines was the proper way to obtain the duty of an ordinary pumping-engine.§ If Mr. Grant had said, that provided one had a set of indicator-diagrams from the engine when it was known to be in good order, that it was a good thing to take diagrams at regular intervals, and so be able to see how the engine was behaving, then he (Mr. Baird) would agree with him; but when Mr. Grant said that the

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* *Trans. Fed. Inst.*, vol. xi., page 237.

† *Ibid.*, page 236. ‡ *Ibid.*, page 237. § *Ibid.*, page 238.

duty could be got by simply taking indicator-diagrams, he (Mr. Baird) entirely disagreed with him. For instance, if an engine has long steam-ports and a large amount of clearance at the cylinder-ends (both of which tend directly to low duty) an indicator-diagram does not show either defect.

Mr. Muir drew attention to the fact that one pound of coal would not evaporate as much steam at a pressure of 80 lbs. as at 53 lbs. per square inch. That is so; but what it does evaporate at the higher pressure contains more units of heat. He also said that there would be a great difference in the efficiency of using steam at a pressure of 53 lbs. as against 80 lbs. per square inch. It is admitted that better economy can be got by using higher steam-pressure, provided that the engine is designed to use high-pressure steam; but the difference in the efficiencies at the pressures mentioned is only 0·6 per cent.

Mr. David Jackson (Old Cumnock) wrote that if a pumping-engine giving only 10,000,000 foot-pounds of duty, or about 22 lbs. of coal per hour per horse-power, be replaced by one giving 80,000,000 foot-pounds of duty, and consuming about 3 lbs. of coal per hour per horse-power, the difference between these two engines is 19 lbs., approximately, of coal per hour per horse-power. Assuming that the pumping-engine is of 200 horse-power, and works 12 hours per day, the resultant saving will be 7,430 tons of coal a year, worth (at 5s. per ton) £1,857. The efficiency desired is to pump the greatest volume of water for the coal burnt; but we are only putting ourselves in a false position if we adopt an evaporative efficiency of 10 lbs. with boilers giving only 6 or 7 lbs. Before we can receive the real benefit of the saving of coal from a pumping-engine which gives 80,000,000 foot-pounds of duty, we must have boilers capable of a high evaporative efficiency.

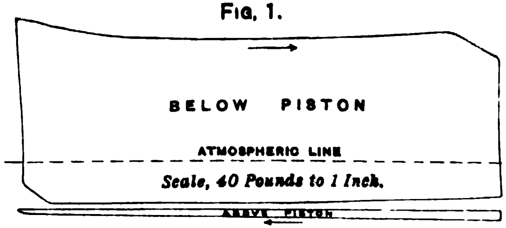
The Chairman said the popular idea was that coals were of little value at the pit-mouth. Every engineer was aware of the effect on the cost of working if a large proportion of the output was so consumed. Coal-masters did not raise coal for burning under colliery boilers, but for sale, and any economy that could be effected was most desirable from a national point of view.

The discussion was then adjourned.

To illustrate Discussion upon Mr. D. Baird's Paper on "The Duty of Pumping-Engines".

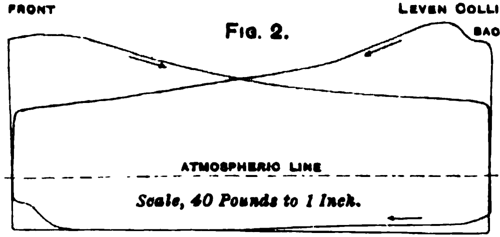
BULL PUMPING-ENGINE, LEVEN COLLIERY.

FIG. 1.



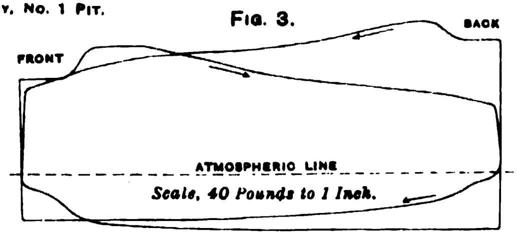
UNDERGROUND DAVEY DIFFERENTIAL PUMPING-ENGINE.
LEVEN COLLIERY, NO. 1 PIT.

FIG. 2.



LEFT-HAND CYLINDER.

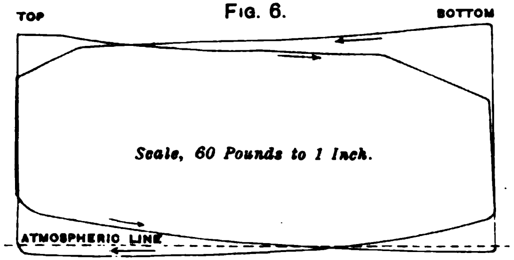
FIG. 3.



RIGHT-HAND CYLINDER.

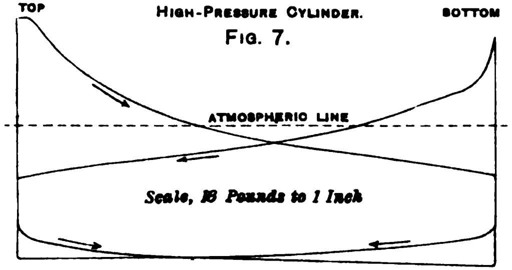
DAVEY DIFFERENTIAL COMPOUND PUMPING-ENGINE.
DURIE COLLIERY.

FIG. 6.



HIGH-PRESSURE CYLINDER.

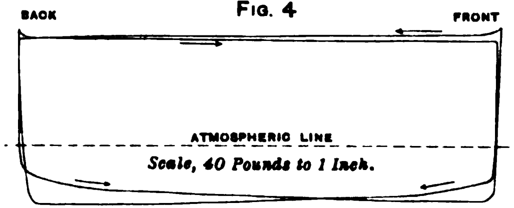
FIG. 7.



LOW-PRESSURE CYLINDER.

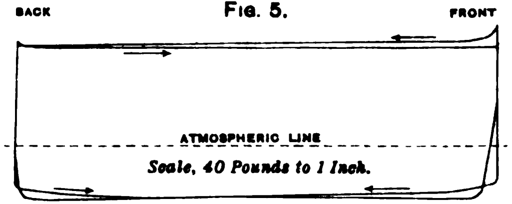
UNDERGROUND DUPLEX PUMPING-ENGINE.
LEVEN COLLIERY. NO. 2. PIT.

FIG 4



RIGHT-HAND CYLINDER.

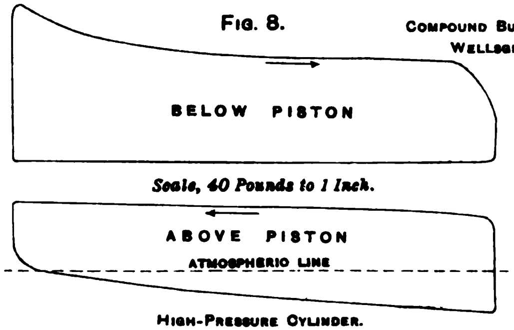
FIG. 5.



LEFT-HAND CYLINDER.

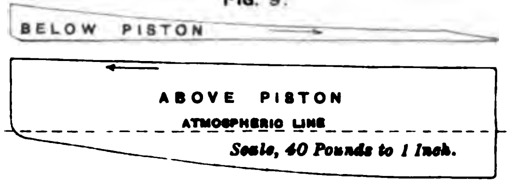
FIG. 8.

COMPOUND BULL PUMPING ENGINE.
WELLGREEN COLLIERY.



HIGH-PRESSURE CYLINDER.

FIG. 9.



LOW-PRESSURE CYLINDER.

Andw. Reid & Compy. Ltd. Newcastle on Tyne

DISCUSSION ON MR. BARROWMAN'S PAPER ON "THE HEALTH CONDITIONS OF COAL-MINING."*

The **Chairman** said that it must give great pleasure to the members that Mr. Barrowman had been able to bring out the fact so incontrovertably that coal-mining was not so unhealthy an occupation as many people were inclined to think.

Dr. T. G. **Nasmyth** (Cupar, Fife) wrote that Mr. Barrowman directed attention to the meagre statistics of the health and mortality of coal-miners in Scotland, and since his paper was written he had only been able to add a little to the information then given. In Dr. Arlidge's work on the *Diseases of Occupations* exception was taken to his opinion that phthisis was not a disease prevalent amongst miners to any extent, but Mr. Snell, who has directed much attention to the same subject, agreed with him. He had consulted many surgeons who have had extensive experience amongst coal-miners, and they all agreed with him that there was no disease peculiar to, or unduly prevalent amongst miners in Scotland. It was desirable, however, that this point should rest on a stronger basis than that derived from opinions, and he was at the present time preparing statistics which he hoped would provide this. Mr. Barrowman directed attention to the extraordinary uniformity of the temperature in mines. This was very clearly shown by the records of temperatures which he had prepared. Reference to the charts of these temperatures in the *Transactions*† would bear out this statement. Regarding mortality amongst miners, he had gone over the causes of deaths amongst eleven different classes of occupation in Fife and Clackmannanshire, and he found that out of 85 miners, 9 died from phthisis, and 7 from other tubercular diseases; 4 died from cancer, 22 from diseases of the respiratory system. Of these 85, the mean age at death was 45, and 27 per cent. of those who died were over 60 years of age.

Dr. **Grant** (Blantyre) said that he had always contended that a coal-miner was, as a rule, much healthier than most other workmen. An engineer, in spite of his working in better light than the miner, was doing so in a vitiated atmosphere, and, of almost any other occupation they might mention the same was true. It was also the fact that consumption was a rare complaint amongst miners, and he thought that

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* *Trans. Fed. Inst.*, vol. xi., page 240.

† *Trans. Min. Inst. Scotland*, vol. x., page 161, and Plate V.

Mr. Barrowman's paper plainly bore out that fact. He had been much struck with one remark in the paper, viz., that many of the miner's troubles were attributable to himself. As they were aware, he came up the pit half-clad and generally in a very warm condition. He had no protection, and the consequence was that he was very liable to respiratory troubles, especially bronchitis. Then, an old trouble, miners' asthma, was gradually dying out from the fact that they now worked in a much drier atmosphere than formerly. He remembered, when a student, a pathological specimen that was shown him was a miner's lung, which was black, like a piece of coal, and almost as hard. He had been struck with another remark in the paper, viz., that miners living in rural districts lived under healthier auspices than in a town. It was a fact, whatever else miners' houses were, that there was plenty of fresh air in them.

The discussion was adjourned.

DISCUSSION ON DR. HALDANE'S PAPER ON "THE CAUSES OF DEATH IN COLLIERY EXPLOSIONS."*

Dr. T. G. NASMYTH (Cupar, Fife) wrote that in Dr. Haldane's paper reference was made to the fact that in cases of poisoning by carbonic oxide, when the man was brought to cooler air he became much worse and might lose consciousness. The same thing happened in poisoning from choke-damp, and it was a belief amongst miners that the poisoned man should only be brought slowly into fresh air. He did not agree with this opinion, and considered that the poisoned person should be brought to the pure air as quickly as possible, even although unconsciousness ensued. Might not this state of unconsciousness be a provision of nature to secure two essential conditions to complete recovery, viz., complete rest and a recumbent position to enable the fluttering feeble heart to regain its power of contraction? In syncope, the patient was kept recumbent, and in poisoning with choke-damp there was a certain amount of syncope. Members of the Institute doubtless were aware of the practice in some districts of burying the sufferer from choke-damp in sand or moss. He had never heard any attempt at an explanation of this practice, but sometimes superstitious practices were capable of explanation by scientific reasons. Was it not possible that the burying of the person secured that rest in the horizontal position which was desired

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* *Trans. Fed. Inst.*, vol. xi., pages 502, 519, and 559.

and at the same time permitted only of a gradual introduction of air into the lungs, by the restraining influence of the weight of sand or soil on the chest? He would like to hear Dr. Haldane's opinion on this question. Everyone who had had experience of choke-damp in mines was aware of the great differences amongst men as regards their tolerance of it. Some were knocked down at once, and others were but little affected. As regards curative measures, he thought that, at all fiery pits and at all pits where stythe was found, cylinders of oxygen should be kept ready for use and the workmen should be instructed how to carry on artificial respiration until the arrival of a medical man.

Dr. **Robertson** (Hamilton) said that he was associated with his friend, Dr. Grant, at the Blantyre colliery explosion, and he had similar experience at the Udston colliery explosion. As regards most of the bodies which he examined—and he might say he examined every one which came out of the pit—the balance of his opinion was in favour of the fact that the men were killed by violence, and not by burning. He agreed with Dr. Haldane, and did not think that any of the men died from the effects of burning. They might have been killed by the violence of the explosion, or they might have got stunned and afterwards died from the effects of the after-damp. There might be a combination, but he found on referring to his notes of the Udston explosion that many of the deaths were clearly due to violence. Possibly the men had been blown down by the force of the explosion, and violently struck either with a stone or something in the pit, and got a blow upon the head which produced a sort of stun or concussion of the brain, and, before they had recovered, after-damp had caused their death. Members might very naturally put the question, "On what ground do you say so?" In the first place, he asked all the explorers to be sure and take note not only of how the men were lying, but where they were got, and he found, as a rule, that those that he certified afterwards as having died from violence had been found on their backs with their arms outstretched. Another point which he might also mention was that, as a rule, the surface of the bodies was very pale. The eyes were closed, and, on opening them, the eyeballs were very pale. The lips were pale also, as also the surface of the body, showing to his mind that the men had died, not from syncope, but from shock. Now, they knew perfectly well in the medical world that there was such a thing as death from shock, and he believed in the case of the Udston explosion, at any rate, a very large percentage of the men died from shock. He agreed entirely with what Dr. Haldane had said with regard to the burns. He did not think much harm was produced by burns. He believed that men who got slightly scorched would recover; and, at Udston colliery, several who were brought up immediately after the explosion, still alive, did recover. Some were far gone, being perfectly unconscious, and artificial respiration had to be resorted to. With others they adopted the old-fashioned plan of digging a hole in a field adjoining and taking the men over and holding their heads over the opened surface where the earth had been newly dug. What the virtue of this was, he did not know, but he knew that it had some effect in restoring animation.

He saw constantly in the newspapers that men were being fined for tampering with their safety-lamps and for the very pardonable offence of smoking. Well, miners could not take a smoke except at the expense of so many lives. Were there no means by which those men could be prevented from having the chance at all, either of opening a safety-lamp or of smoking? He said there was, and he thought it was the duty of colliery proprietors to carry it out, if in their power. His suggestion, which he made many years ago, was that there should be baths or lavatories in a shed at every mine, that every man should go to his work in his shifting-clothes, and that there should be a place in which each man could change his clothes, those he was to work in being carefully examined before he put them on. After he had got his clothing, and went down the pit, it was impossible for him to have a match or a pipe, or anything whatever whereby to produce an explosion. When he went up the pit at the end of his shift he would take off his working-clothes, have a bath, and be sent home a decent citizen. He thought that matter was worthy the attention of colliery proprietors, and he was perfectly satisfied that the cost would be trifling, and that it would remove one element of danger of explosions.

Dr. Grant (Blantyre) said that Dr. Haldane's paper was one of great interest to him personally, because his experience of colliery explosions had been rather unique, and he trusted few medical men would have the same experience. He had examined most of the bodies in the first explosion at Blantyre, when over 200 men were killed; in the second explosion, when 32 men were lost; and, again, together with his friend, Dr. Robertson, at Udston colliery, where the number of deaths was 76. The facts brought out by Dr. Haldane were interesting to him, for he noticed many of the symptoms he described, especially at the first Blantyre explosion. He thought that the great majority of the lives were lost through carbon monoxide, and a great number of the bodies had the reddish-blue appearance mentioned. Some, he had no doubt, died from shock, but he was perfectly satisfied that the great majority of deaths were due to carbon monoxide poisoning. About twelve hours after the first explosion at Blantyre colliery, three men were found alive in one of the main airways. They were burned, but the burns were superficial. Unfortunately, two of them died, but one recovered and was still alive. He thought these were the only three men rescued alive, except those who escaped when the explosion occurred. He agreed with the remarks of Dr. Haldane, that men suffering from carbon monoxide poisoning should be brought to the pure atmosphere slowly, and his theory was this, if they had been any length of time in the gas, they got an enfeebled heart, and a sudden access of fresh air caused syncope and death. He remembered, just after the second explosion at Blantyre, that they had another explosion through, he thought, a paraffin lamp being upset, and the pit was set on fire. He was standing by when one of the overmen descended to turn off a pumping engine that was in the shaft, in order to flood the pit with water; and, when he came to the surface again he suddenly fainted. As to the practice of miners holding a man's head over a hole in the ground while he was suffering from the effects of after-damp, he had seen it do a great deal of good. The same fact was recognized in some ironworks. He remembered having a talk with an iron-worker on the point, and was informed that birds sometimes fell to the ground after flying through the furnace gases, and they were in the habit of burying them in the sand until they recovered, showing clearly that there was something in the practice. The members were deeply indebted to Dr. Haldane for his paper, and he had no doubt that great good would result from the discussion.

The CHAIRMAN thought that Dr. Haldane had clearly demonstrated that carbon monoxide was the enemy they had to face after a colliery explosion, and it was for mining engineers and others connected with collieries to devise the best means of rectifying matters after an explosion had taken place. He was anxious that Dr. Haldane should give some explanation of the old habit of putting a man's face into fresh-cut turf to undo the effects of after-damp. One of his earliest reminiscences of mining—long before he imagined he would ever have anything to do with coal-mines—was going to the scene of an explosion, and seeing the explorers brought up the pit and subjected to this process, apparently with success. In regard to the question, "What should be done after an explosion?" it was most probable that all the lights in the workings would be put out; but if they were not, there was a difficulty that presented itself. Dr. Haldane now told them lights would burn in this gas. The general idea of miners was that the presence of carbonic acid and other gases would put out the lights; but this was not so. Therefore this was another obstacle in the way of men in the workings of a colliery finding their way out safely after an explosion took place. He had never been in such a situation, but he could well imagine, from what he had seen after an explosion, that he would be a very cool man who could sit down and consider what was best to be done under the circumstances. The natural feeling would be to make one's way to the pit-bottom. Most probably the best way was by the return air-course; but most of them must be aware how intricate and circuitous a path that was. Not one collier in a hundred could thread his way out by the return air-course to safety. Of course there might be chalk marks, as he had seen, to indicate how they should go, and which might be valuable if the lights remained. He thought the most practical and valuable suggestion Dr. Haldane had given the members was that of erecting stoppings to prevent the after-damp from getting into the working-faces. The material for this purpose would not always be available, but it might be provided, and there was generally brattice lying about which might be used for the purpose. He thought if men were cool enough at the moment it would be very well; but as he had said, at such a time the natural impulse would be to make for the pit-bottom by the accustomed road. Dr. Haldane had proved his case step by step, and it was for the members to consider the best means of meeting the difficulty when it arose. Of course, nobody expected that an explosion would take place in the colliery under his charge, and to provide vessels containing oxygen and things of that kind was like a man ordering his coffin before his death. Very few people would think of such a provision—the circumstances were so remote. He, however, thought it would be desirable to provide oxygen bottles in colliery districts, so that they might be applied in case of an accident. Probably Dr. Haldane had seen a description of a soldier at Aldershot who had been asphyxiated, and had a cylinder containing pure oxygen applied to his mouth, and it certainly had a very reviving effect, according to the account in the *Transactions*.* Dr. Robertson had raised a very interesting question, which had been often discussed along with that of baths and sanitation. He might tell him that it was a practice in some of the iron-ore-mines in Cumberland for the men to change their clothes at the end of their shift.

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* *Trans. Fed. Inst.*, vol. vi., page 533; and vol. vii., page 581.

Mr. J. B. **Atkinson** (H.M. Inspector of Mines, Glasgow) said that it was very desirable, both as regards the prevention of accidents in mines and for suggesting means for saving life after their occurrence, for scientific men like Dr. Haldane to come before the members with papers like that just read. Mining engineers who had had practical experience of explosions and knew the difficulties to be encountered in a mine wrecked by such an occurrence, could, in co-operation with scientific minds, devise means of rescue that neither alone might arrive at.

Dr. Haldane remarked that it came to him as an entire surprise that the presence of carbon monoxide was nearly always the actual cause of death in colliery explosions. This, so far as extensive explosions in dusty mines was concerned, was, however, pointed out as probable in *Explosions in Coal-mines*, by Mr. W. N. Atkinson and himself, it was only true of such explosions. It must be remembered that the great majority of explosions in mines were fire-damp explosions, usually burning one or two persons. In these cases death rarely occurred in the mine, but took place some days after, and might be due to internal inflammation, caused by breathing heated air. This was a point to which Dr. Haldane might usefully direct his attention. The history of a case of a miner burned by fire-damp was often as follows:—The man was reported as having received slight burns; he was taken home and appeared to be recovering; suddenly, however, he took a turn for the worse, collapsed, and died.

His (Mr. Atkinson's) attention was first called to the probability of carbon monoxide being present in the air after an explosion in a dusty pit by a mine manager informing him that after an explosion at Burradon colliery, Northumberland, one of the miners was found dead with his candle stuck in a piece of clay between his fingers; the candle had burned away and had burned the man's fingers. This fact showed that the miner had lost consciousness in an atmosphere which had not extinguished his candle, and pointed to the presence of some other deleterious gas than carbonic acid, or the absence of sufficient oxygen. The speaker had been present when persons had lost consciousness, or, at any rate, had lost the use of their limbs, when engaged in exploring a mine after an explosion, the safety-lamps in use burning meanwhile in the ordinary way.

While it appeared that the immediate cause of death was due to carbon monoxide, it was also probable that the injuries inflicted by burning and violence would, in the case of those victims in the direct track of the explosion, be sufficient, in most cases, to ultimately cause death.

He (Mr. Atkinson) did not agree with Dr. Haldane's remark that "it would seem that the after-damp left along the track of an explosion is so largely diluted with fresh air that more than enough of oxygen is left to support life."* It was probable that at the origin of a dust explosion there might be tongues of flame, as it were, but after the explosion was thoroughly established, it was probable that all the oxygen was consumed in the road, and there was evidence that even at the point of origin men could only move a few feet before falling unconscious. Again, if so much oxygen was left, why should carbon monoxide and not carbonic acid gas be formed?

Dr. Haldane suggested that an excess of dust might check the explosion at some points; this was improbable, judging from experience. It was probable that an excess of dust might prevent any ignition, say from the flame of a shot; in fact in the Hebburn experiments it was found that a small quantity of dust was more likely to be ignited than a large quantity, but this did not necessarily or probably hold with respect to an explosion thoroughly established. His (Mr. Atkinson's) picture of a dust explosion was a diaphragm of flame rushing along, preceded by a wave of air disturbing the dust and rendering the air black, the particles of dust being distilled in close proximity to the fresh air—here combustion was vivid, behind the flame there would be little or no oxygen but a mixture of nitrogen, carbon monoxide and carbonic acid gases, watery vapour, and the unconsumed products of distillation. No doubt as the heated gases in the road along which the explosion had passed contracted, air from the adjacent return air-ways or old workings would rush in through the shattered stoppings and air-crossings.

Dr. Haldane cited the case of fires found burning after an explosion in support of his view that "perhaps two-thirds of the mixture left along the roads is, on an average, pure air."† As pointed out in *Explosions in Coal-mines*, it was usually at the limits of an explosion that fires were found, that was, at points where fresh air was available to support combustion. He (Mr. Atkinson) was not acquainted with the particular circumstances at Micklefield, but it appeared to him quite possible that fresh air would come down the downcast shaft to supply the necessary oxygen to the paraffin flame referred to by Dr. Haldane.

The probability that an excess of coal-dust did not check an explosion was of great importance; with fire-damp and air the proportions of the two gases in the mixture required to exist within certain comparatively narrow limits in order to allow flame to pass, and in any case

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* *Trans. Fed. Inst.*, vol. xi., page 502. † *Ibid.*, vol. xi., page 508.

the fire-damp occupied a considerable volume of the roadway to the exclusion of air; with coal-dust it was different, on most dusty roads a large excess of coal-dust was present, and yet also the road was practically filled with air, and so far as his experience went this excess of dust did not check the passage of flame or diminish the violence of the explosion. If this be true, many roads in mines, in their normal condition, were capable of transmitting an explosion along their entire length by pure air and coal-dust. With fire-damp, the case was somewhat different, the issue of the combustible was variable, and unless under special circumstances a long length of road was not likely to contain the requisite mixture: such a mixture was much more probable to exist in the return air-ways, but it was not easy to point to the case of an explosion extending over a length of return air-ways, comparable to the lengths of intake air-ways often traversed by explosions.

With reference to the experiments in a boiler with a view to test the composition of after-damp, he (Mr. Atkinson) thought that it was a mistake to assume that what occurred on a small scale indicated what took place when a coal-dust explosion was thoroughly established in a mine. It was probable that all the air in the boiler was not consumed, but that fact did not justify the inference that the same result took place in a mine. He (Mr. Atkinson) had observed in several cases that a dust explosion starting on an intake air-way proceeded in each direction for about 250 to 300 feet before great force was exerted, and the conclusion was forced upon him that some change—it might be in the direction of detonation—took place in the speed or intensity of the combustion producing greater pressure. It was therefore his (Mr. Atkinson's) opinion that the phenomena observed at the start of a dust explosion were not a reliable guide to what occurred afterwards. Messrs. Mallard and Le Chatelier by reasoning from small experiments claimed that a coal-dust explosion could not extend itself for any considerable distance—a position which they would probably hardly take up now.

There was one point with respect to the physiological action of carbon monoxide to which Dr. Haldane had not referred, and as it was mentioned by one of the doctors who reported on the bodies of the victims in one of the Durham explosions, the writer ventured to recall it, this was the absence of *rigor mortis*, or stiffening of the body after death; it would be interesting to know if this was due to the action of carbon monoxide.

If it were not for the danger that might arise from moving fire-damp that had collected, consequent on the derangement of the ventilation by the explosion, over fires left burning in the track of the explosion, many mines would be more rapidly explored, and the ventilation restored by reversing the direction of the air-current, and proceeding inwards by the return air-ways which were often not damaged. This would also obviate the necessity of sweeping so much of the after-damp further into the mine to where survivors might be congregated. A paper was read before the members by Mr. Allardyce dealing with this matter from the point of view of an underground fire, and he described how a fan might be readily changed from an exhausting to a forcing fan.*

Dr. Haldane remarked that "the pressure during an explosion is probably not nearly so formidable as is sometimes assumed. So far as the writer is aware there is nothing in a colliery explosion remotely resembling the detonation of, say, a mixture of hydrogen or fire-damp with pure oxygen, and the greater part of the energy liberated by the combustion must be rapidly taken up by the large excess of coal-dust swept up by the blast."† With respect to the force or pressure exerted in a colliery explosion, it was his (Mr. Atkinson's) opinion that the principal mistake in the past had been the assumption that the explosion of a mixture of fire-damp and air in one part of the mine could cause destruction at a considerable distance from the place where flame had existed, or in other words that a blast from an explosion in one part of the mine could travel with violence to other distant parts. This idea no doubt originated owing to the ignorance of the fact that coal-dust and air could carry on an explosion, and it was assumed that the force of an explosion of a sudden issue of fire-damp at the face had extended itself along the intake air-way to the shaft, the true explanation being that coal-dust and air had exploded in the intake air-way. The force of an explosion of either fire-damp and air or coal-dust and air did not extend with violence many feet beyond the point where flame had existed. The only true ideas on the subject of the pressure during an explosion must be based on what was observed after an explosion, and there was no doubt that an explosion of coal-dust and air thoroughly established did exert considerable pressure. It was not possible to measure this pressure, but it was sufficient to blow out timber, displace stoppings, bend iron tubs, and strip the wood entirely off wooden tubs. At Usworth colliery, the smoke-box door of a tubular boiler was crushed in. At Elemore colliery, one of the cages hanging in the shaft was blown up sufficiently far to cause the cage in its descent to break the rope. No doubt Dr. Haldane was correct in stating that pressures such as those produced by the detonation of hydrogen and oxygen were not produced, but still considerable force was developed.

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* *Trans. Min. Inst. Scot.*, vol. xiv., page 80.

† *Trans. Fed. Inst.*, vol. xi., page 512.

An experience of seven and a half years in Scotland had confirmed him (Mr. Atkinson) in his views as to the influence of coal-dust in colliery explosions. During that time, no explosion had taken place in the East Scotland district in which coal-dust had played any part. All the explosions had been due to fire-damp and air—of the usual type—burning one or two persons, and in a few cases now and then doing no damage to the mine, and presenting no features difficult of explanation.

While stating that for so many years the explosions in the East Scotland inspection district had not been complicated by coal-dust, it was proper to state that there were collieries, particularly in the Hamilton district, where the necessary conditions existed for a sweeping dust explosion.

The SECRETARY (Mr. Barrowman) said that a most interesting paper had been published in the last number of the *Transactions* of the South Wales Institute of Engineers,* giving the experience of Mr. Getrych Davies, extending over a period of thirty years, as to the effect of after-damp on explorers and others who might go into it. Mr. Davies said :—

> A curious effect of after-damp is that, when a spirited man has worked until he feels weak, he becomes partly intoxicated and talkative. It is time then to return; and when such a man reaches pure air he is sure to fall unconscious.
>
> When going into after-damp, it is essential to ascertain whether the men could breathe easily through the nostrils. Unless they could do so, he considered them constitutionally unfit for the task, for he had found them unable to follow him . . . He attributed his saving one life at Dinas, and another at Park Slip, to breathing wholly through the nostrils.
>
> He had always done his utmost to send an unconscious man to fresh air; but at the same time he considered there was great danger in doing so, too suddenly, to a weak person.
>
> In exploring, there was very great danger in going downwards through a return air-way; as, when going downwards, a person did not feel his weakness– it was in going up-hill that a man felt it.

The Secretary, continuing, said that he had been told by a member that a party of three, who some time ago were examining the underground workings in a colliery near Baillieston, came upon after-damp and were very nearly overcome. They succeeded in getting out; and one of them took a drink, which caused him to vomit, and he got free of the effects much more rapidly than the other two. He mentioned this fact by way of eliciting opinion as to whether vomiting had any effect in relieving the effects of after-damp, or if the difference observed in this case was merely due to the gas having affected this person to the least degree of the three.

* Vol. xix., page 387.

Mr. M. **Walton Brown** (Newcastle-upon-Tyne) wrote that Dr. Haldane's suggestion as to the erection of stoppings or curtains, in order to keep back the after-damp, had been previously described by Mr. S. Tate in his paper on "Saving of Life from After-damp," etc.*

Dr. **Haldane**, in replying to the discussion, said, that in the first place, he must thank the members for their very kind reception of his paper. With regard to what Dr. Nasmyth remarked as to it being a good thing to bring a man straight to the fresh air in spite of the effects of cold, he could not say that he agreed with that opinion. He knew of several cases in which removal into cold air was immediately followed by collapse and rapid death, although in most cases the result was only temporary loss of consciousness. He believed that the bad effects were due to cold alone, and that, when cold was avoided, removal to fresh air was always beneficial. When a man suffering from after-damp was brought out of the mine, he should be thoroughly wrapped up.

With regard to Dr. Robertson's view that violence was the chief cause of death at the Blantyre and Udston explosions, it was of course possible that the circumstances may have been quite different there from what they were at the explosions which he himself had investigated, but his experience was clearly against the theory that violence was the cause of many of the deaths. At Tylorstown, there were only about four or five cases of death from violence; and at Micklefield there were none among the 46 bodies which he had examined, although two or three had received grave injuries. It was very desirable that the facts should be recorded by medical men who had had experience of different explosions, and particularly that the blood should be examined. It was not possible to tell the cause of death until the blood was examined.

Dr. Robertson had referred to the plan of holding the head of men affected by after-damp over newly-cut soil. This was a most curious plan, and was not confined to Scotland. He heard of it first in Wales, and then in the north of England, and he was much interested to hear of its existence in Scotland. He could not imagine what could be the origin of it, or what good it was expected to do. One suggestion which he had heard was that the miners believed that the result of placing the head in a hole would be to cause the heavy poisonous gases to escape by the mouth.

Mr. R. L. **Galloway** (Glasgow) remarked that the peculiar custom pursued in former times by the miners in this country for recovering

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* *Trans. Fed. Inst.*, vol. viii., page 189.

persons suffering from the effects of after-damp had perhaps been suggested by the treatment adopted in the case of the dogs at the Grotto del Cane, near Naples. Mr. Bradley, in his *New Improvements of Planting and Gardening*,* published in 1718, stated that the dog was quickly drawn out of the grotto and taken a short distance to the side of the lake, and his nose and mouth thrust in and rubbed in the mud and water, and proceeded to say that the practice of applying a fresh turf to the mouth of miners suffering from noxious gas "perhaps may be for the same reason that the mud being applied to the nose of the dog recovers him after he is drawn out of the grotto."

Dr. **Haldane**, continuing, said that he could not imagine that the earth had any effect, but probably the position of the body might have a good effect by increasing the blood supply to the brain. As to the reference of Dr. Grant to the birds in the ironworks, he should like to ask whether the sand in which the birds were placed was warm ?

Dr. **Grant** answered in the affirmative.

Dr. **Haldane** said that it was quite an intelligible explanation that the bird should be brought round in the warm sand. He had often seen the same effect of warmth in the case of other small animals rendered unconscious by poisonous gases. He was much interested to find that Dr. Grant had observed the colour of the bodies. This confirmed the idea that in most great colliery explosions the causes of death were very much the same. With regard to the Chairman's remarks about the use of oxygen cylinders, he would suggest as a practical plan that apparatus should be got for a number of pits. Probably, several might be kept in each district, and the medical men would know exactly where they were to be found. The soldier treated with such striking effects by Colonel Elsdale† with pure oxygen, was undoubtedly poisoned by the carbonic oxide contained in the coal-gas issuing from the balloon. The oxygen would act by rapidly expelling and replacing the carbonic oxide in the blood passing through the lungs, also by passing into simple solution in the liquid of the blood, and thus providing at once a supply of oxygen to the tissues. The convulsions described by Colonel Elsdale as accompanying the return of the man to consciousness were due to the after-effects of the want of oxygen caused by the presence of carbonic oxide in the blood, and would probably also have occurred had the man been brought round by the slower method of ordinary artificial respira-

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* Part iii., page 82.

† *Nineteenth Century*, vol. xxix., page 719; and *Trans. Fed. Inst.*, vol. vii., page 581.

tion. He (Dr. Haldane) entirely agreed with the conclusions arrived at by Dr. Thomson,* that pure oxygen would be useless in cases of suffocation by atmospheres vitiated simply by excess of carbonic acid, fire-damp, or nitrogen. In carbonic oxide poisoning, however, pure oxygen was undoubtedly of great service, if employed at once.

As regarded Mr. Atkinson's remarks respecting small explosions, he had never had any opportunity of seeing the effects of them. The deaths were, perhaps, more the result of burning than of after-damp. He had seen a great many cases of men who had been burned and who had recovered, although the epidermis had been taken off their hands and faces. Therefore, in many cases, the burning was not very serious; but there might be cases where the men had breathed air which was highly charged with steam, and which had a dangerous internal effect. He had looked out for these cases, but had not found them, and probably they could only be seen in small explosions. He noted that Mr. Atkinson was not inclined to agree that oxygen was left along the track of an explosion. His reason for saying that oxygen was left was simply the condition of the bodies of the men. Supposing that they had died in an atmosphere containing no oxygen, the appearances after death would have been different from what they actually were. He thought, however, it was quite possible that the oxygen might have been sucked in from the return air-ways and neighbouring roads. He did not think anything could decide this question but actual experiments. He quite agreed with many of the points that Mr. Atkinson had brought forward, and which, he thought, were very important; and he should like to say that he had obtained more information on this subject in the book on *Explosions in Coal-mines*, by Mr. Atkinson and his brother, than anywhere else. It was by far the best book on the subject. Another point to which Mr. Atkinson had referred was the absence of *rigor mortis*. He thought this was a mistake. It was often a long time before the bodies were recovered, and *rigor mortis* passed off when putrefaction occurred. Therefore, bodies that had been for some time in the workings had already passed out of *rigor mortis*. He had seen many cases of poisoning from carbon monoxide, and *rigor mortis* was always present, both in men and animals.

He thought that Mr. Davies' paper was a valuable one, and it gave a good description of the symptoms of poisoning by carbon monoxide. He particularly brought out the fact that men got much worse when they came suddenly into the fresh air. As to the effect of breathing

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* *Trans. Fed. Inst.*, vol. vi., page 526.

through the nostrils, he did not know how to explain that, unless it were that the nostrils kept out the soot and dust. Of course, the nostrils were wonderful filters for all sorts of particles, but they could not filter carbon monoxide, nor could a wet cloth do so. The cloth, however, would be very useful where hot air, or air loaded with sulphurous acid, had to be breathed.

Dr. GRANT asked whether the explanation might not be that there was less air taken up through the nostrils.

Dr. HALDANE said that was another possible explanation, but he would rather doubt that a man breathing through the nose breathed less air than one breathing through the mouth. Possibly he would not breathe so hard, and if that were so—if he breathed less air—he would not succumb so quickly. He meant that the result depended on the amount of gas absorbed, and that again depended on the amount breathed. As regarded vomiting, some persons seemed to think that vomiting relieved the symptoms of carbon monoxide poisoning, but it was not easy to see why it should. They did not get rid of any of the poison.

The CHAIRMAN said the members were very much indebted to Dr. Haldane for bringing this very interesting subject before them. Regarding the cause of death of so many victims of colliery explosions, it was for the members to consider what could be best done when these unfortunate occurrences took place. His own idea as to the hole in the earth always was that the position of the body had a good deal to do with the result, but from Dr. Haldane's remarks he thought another explanation was that the fact of the face being thrust into a hole no larger than what held it, thus excluding the air, might account for the whole thing. He proposed a vote of thanks to Dr. Haldane for his interesting and instructive paper, which was heartily accorded.

Dr. HALDANE returned thanks for the kind reception accorded him

The meeting was then closed.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING.

Held in the Mason College, Birmingham, October 12th, 1896.

Mr. J. H. COOKSEY, Retiring President, in the Chair.

The minutes of the last General Meeting and of Council meetings were read and confirmed.

The following gentlemen were elected:—

Members—

Mr. George M. Cockin, Heron Street, Rugeley.
Mr. Percy Nevill, Walsall Wood.
Mr. Samuel Richards, Mining Engineer, Camborne.
Mr. Charles T. Roberts, Mining Engineer, Salisbury, Rhodesia.
Mr. A. Tilly, Mining Engineer, Trewirgil, Redruth.

Students—

Mr. George B. Caulfield, The Mining School, Camborne.
Mr. George E. Crighton, Camborne.
Mr. James Wensley Gray, Athlone, Ireland.
Mr. Lawrence Holland, Brownhills.
Mr. Douglas B. Langford, Wellington Road, Camborne.
Mr. Harold A. Tute, The Mining School, Camborne.
Mr. J. Frederick Wells, The Mining School, Camborne.

The Annual Report of the Council, together with the Auditors' Report and the Balance Sheet, were read as follows:—

ANNUAL REPORT OF THE COUNCIL.

In submitting this report, the Council have pleasure in congratulating the members upon a successful year.

Twenty new members have been elected and 5 have resigned, so that the list embraces 151, as against 136 members at the end of last year.

The expenditure for the year was £178 0s. 9d., and the income £199 19s. 4d. The bank balance has consequently been increased by £21 18s. 7d., and now stands at £336 11s. 3d.

Mr. John H. Cooksey gave a very interesting inaugural address upon his election as President, and the following instructive papers have been read during the year:—

"A New Method of Starting and Stopping Electric Motors." By Mr. Henry Lea.
"Horse-feed." By Mr. F. G. Meachem.
"Poisoning of Horses by *Lathyrus Sativus*." By Mr. F. G. Meachem.
"Electric Power-plant at Haden Hill Colliery." By Mr. Isaac Meachem, Jun.
"Coal-mining in Assam, India." By Mr. George Turner.
"Underground Haulage at Cannock and Rugeley Collieries." By Mr. R. S. Williamson.

The Technical Education Committee, working in connexion with the Staffordshire County Council, has been the means of establishing two scholarships of £30 each, with maintenance allowance at discretion, for advanced students from the mining classes, and they have also continued to conduct the examinations.

The Institute has been put upon the list of the Corresponding Societies of the British Association for the Advancement of Science, and will receive the proceedings.

As announced in the last report, the Institute room in connexion with the Secretary's Offices, 3, Newhall St., Birmingham, is open to members: there they can inspect the *Transactions* of the following societies, together with other mining literature:—

Illinois Mining Institute.
Mining Society of Nova Scotia.
South Wales Institute of Engineers.
General Mining Association of the Province of Quebec, Canada.
British Society of Mining Students.
Institution of Mining and Metallurgy.
Manchester Geological Society.
Canadian Mining Institute.
New South Wales, Geological Survey.
Annales des Mines de Belgique.
Revue Universelle des Mines, de la Métallurgie, etc.
Chesterfield and Midland Counties Institution of Mining Engineers.
The North of England Institute of Mining and Mechanical Engineers.
The Federated Institution of Mining Engineers.

The presentation of books to the library would be very acceptable, and the Council would be particularly grateful for a copy of the Memoir on the South Staffordshire Coal-field, by the late Prof. J. Beete Jukes.

The Federated Institution of Mining Engineers still continues to grow in importance, and extend its influence, and there are now 2,301 members in connexion with the six societies comprised in it.

General meetings have been held in London, North Staffordshire, and South Yorkshire during the past year, and many valuable papers have been contributed, necessitating the publishing of the *Transactions* in two volumes.

These *Transactions* contain seventy-one papers upon Mining Engineering, Mechanical Engineering, Geology, Explosives, Lighting, and Ventilation, Electricity and its Applications, and other subjects, read during the year, at the meetings of The Federated Institution of Mining Engineers, and of the kindred societies; and there are in addition, numerous extracts from Foreign Transactions and Publications.

Your thanks are again due, and are hereby tendered, to the authorities of Mason College, for providing rooms for general meetings of members.

The success of the Institute is dependent upon a continued increase in the membership, as well as the contribution of interesting papers, and the Council strongly draw the attention of members to these points.

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1896. **Cr.**

	£	s.	d.
To Bank Balance	314	12	8
" Subscriptions Received	195	3	6
" Bank Interest	4	15	10
	£514	12	0

	£	s.	d.
By Subscription to The Federated Institution of Mining Engineers	79	2	0
" Secretary's and Reporter's Salaries	50	0	0
" Rent of Institute Room	15	0	0
" Gas Fittings, etc., in ditto	5	16	3
" Removing Bookcase from Mason College to Institute Room	1	4	6
" Mason College, Contribution towards fitting-up Engineering Museum	6	0	0
" Expenses of Secretary attending Council Meetings of The Federated Institution of Mining Engineers ...	5	10	6
" Postage Stamps, Wrappers, etc.	4	5	3
" Printing Circulars, etc.	6	15	0
" Binding Transactions	4	7	3
" Balance in Bank	336	11	3
	£514	12	0

BALANCE SHEET, 1895-96.

Liabilities.	£	s.	d.
Due to The Federated Institution of Mining Engineers ...	20	3	4
Balance	371	10	5
	£391	13	9

Assets.	£	s.	d.
Balance in Bank	336	11	3
Subscriptions due	55	2	6
	£391	18	9

Examined and found correct

DANIEL ROGERS.
WILLIAM H. WHITEHOUSE.

October 5th, 1896.

This is exclusive of considerably more than £100 worth of property, for which no credit is taken.

The Report was adopted, on the motion of the CHAIRMAN, seconded by Mr. JOHN WILLIAMSON.

The Report of the Auditors and the Balance Sheet for the past year were adopted.

ELECTION OF OFFICERS FOR 1896-97.

The SCRUTINEERS reported that the following gentlemen had been elected:—

PRESIDENT—Mr. R. S. WILLIAMSON.

VICE-PRESIDENT—Mr. W. H. WHITEHOUSE.

NEW MEMBERS OF COUNCIL.

Mr. E. J. BAILEY.
Mr. W. J. DAVIES.
Mr. J. LINDOP.
Mr. W. WARDLE.

Mr. R. S. WILLIAMSON, the newly-elected President, then took the chair, and delivered his inaugural address as follows:—

PRESIDENTIAL ADDRESS.

BY R. S. WILLIAMSON.

I thank you for the honour you have conferred upon me, in electing me as President of this Institute.

In accepting the position, I trust with your help that together we may increase the usefulness of the Institute. It has now, I think, become the established practice for the newly-elected President to lay before the members such matters from his own personal knowledge and experience as he thinks may be most generally useful and interesting to them, as some acknowledgment of the honour which he has received at their hands, in his election as their President for the year. I have found considerable difficulty in deciding on what subjects to address you, and have felt that the practice of so doing might be more honoured in this instance by its breach than in its observance.

It is interesting to find that mining engineers and colliery managers have advanced with the times, and by their skill and ingenuity are able, with greater difficulties—as regards increased depths, longer distances to the working-faces from the shaft-bottom, and increased restrictions as to blasting, lighting, etc.—to obtain an increased output ; the introduction of improved mechanical appliances has doubtless played an important part in this advancement.

When we consider the vast amount of capital invested, and interests involved in the mining industry, it is highly desirable that the working of mines should be conducted upon the most modern and economical lines. And we ought to congratulate ourselves upon being able, in connexion with our Institute, to compare notes, and gain experience from valuable papers read and discussed there.

I commenced my mining career in the year 1874, and on looking backward it is most gratifying and interesting to see the numerous improvements that have been made in mining, especially as regards the safety of those employed.

The mining engineer of to-day, to be up to date, and to be successful, must combine many other qualities than those of being a good pitman ;

he must have a good knowledge of mechanical engineering, electricity, etc.; and to enable him to carry out the numerous Acts of Parliament that come within his province he will find it, I think, necessary to go into the law.

The fatal accidents in proportion to the number of persons employed continue to decrease, not from the fact that mines are less dangerous to work, but from a higher standard of labour, supervision, and discipline. Respecting the greater safety of those employed above and below ground at collieries in this country, it may be interesting to make a comparison extending over a period of twenty years:—

	1874.	1894.
Quantity of coals raised, tons ...	126,590,108	188,277,525
Persons employed	538,829	705,240
Total separate fatal accidents ...	895	813
Ratio of persons employed for each fatal accident—		
Fire-damp explosions	12,246	32,056
Falls of roof and side	1,337	1,625
Miscellaneous accidents above and below ground	1,203	1,975

The table shows an increase of output in twenty years of 61,687,417 tons, and of 166,411 more persons employed. In the year 1874 the yield per head of persons employed was about 235 tons, and in 1894 it was about 267 tons.

To enable a colliery manager to carry out his duties in a satisfactory manner he should, first of all, have the confidence of his employers; enforce the strictest discipline, and be backed up by good and capable officials. Speaking of officials reminds me of the great advantages offered, at the present time, for the improvement of working-men, in the form of technical education; but I am afraid that many of the students who attend these classes, and should have in them the making of good officials, commit the instruction they there receive to memory, and fail to bring it into practical use. I regret that this has occurred in my own experience. For a good official we want practice and theory combined; and many of them are at a loss when it comes to the proper management of men. It is, however, gratifying to know that the officials of collieries—who are to a great extent responsible for the lives of those employed—appreciate their responsibility, and endeavour to do all in their power to secure the safety and welfare of the workmen.

Respecting the ventilation of the mine, with the appliances at our disposal, such a thing as deficient or defective ventilation should not be possible. Many years ago we were dependent to a very great extent upon the furnace, steam-jet, or waterfall for ventilating purposes, but now fans and engines, capable of producing large quantities of air with most excellent results, can be erected for a moderate sum.

After you have acquired the means of getting the air, comes the question of circulation ; this requires the careful attention of those concerned, as it is one thing to have the air, and another thing to apply it. The longwall system of working, which is now being largely introduced in the various coal-fields, offers advantages as regards ventilating. It is easy to ventilate, if the most essential points of having good intake and return airways, with judicious splitting of the air, be attended to. Some people are of opinion that if the air be taken into the workings, and put on to the face-of-work, it is quite sufficient. I maintain that, to comply with the Act, and for safety, all roads should be ventilated by driving or coursing the air up-and-down them ; and that wastes, fast-ends, etc., should be properly ventilated by throwing the air into them by brattice or other means.

In appointing persons to make the required inspections, care should be taken to select practical, properly qualified, and reliable men. Let their duties, as far as practicable, be properly defined on a printed form, signed by the manager, and the person appointed to make the inspection.

I think that the day is not far distant when the use of open or naked lights underground will be prohibited. Probably no portion of the mining community will feel the effects more than the southern portion of our coal-field. For my own part I should like to see the prohibition become law, as all workmen would then get properly educated to the use of safety-lamps, and a risk and liability would be removed.

Electricity will no doubt form an important factor in lighting, but at present the electric lamp is not sufficiently practical in form; and, again, all safety-lamps should indicate the presence of fire-damp and stythe. I am not aware that we have at present a reliable fire-damp or stythe-indicator, one difficulty would be that the amount of electricity used while testing with the indicator is greater than the amount required to heat the glow-lamp filament ; and there is the uncertainty of its action. My own experience goes to prove that a properly constructed Marsaut safety-lamp, burning good colza oil, cannot at present be superseded for general use underground.

When lamps are used underground, consideration should be given to the convenience of workmen, for relighting and locking, by having lamp-stations placed in the most convenient position, to prevent loss of time.

In the Coal Mines Regulation Act of 1896, additional power to prohibit the use of explosives in any mine is given to the Secretary of State. Numerous explosives are now being offered: and the results of a series of careful experiments are dealt with in the exhaustive and interesting report presented by Mr. Kayll to the North of England Institute of Mining and Mechanical Engineers.

No doubt explosives are too largely used, more particularly in seams, where a large percentage of round coal is not a necessity. In the present generation, there is a tendency on the part of the workmen to ignore the proper "under-cutting" or "over-cutting" of the coal, depending in many cases upon the explosive to do the work, much to the detriment of the owner and of themselves.

The use of explosives, forming as it does, so great an element of danger should, I consider, be subject to the most stringent rules, and if gas be known to exist, should not under any pretence be allowed.

With rapid winding and the use of mechanical haulage underground, electricity for signalling purposes is extensively used, when the cost of maintenance and efficiency of working is taken into consideration. The life of the old-fashioned pull-bell is now brought within measurable distance.

Timbering is an item requiring careful consideration from the points of view of safety, economy, care, and vigilance on the part of all concerned. In our own particular district, timbering is done generally on the working-face, etc., by the coal-getter or stallman, and, from careful observation, I consider that the system has many advantages, as, no doubt, our local workmen excel in this branch of their work. To carry out the Act satisfactorily, and for safe working I have found that considerable advantage ensued by giving each set of workmen printed instructions, stating clearly how, and at what distances the timber has to be set (whether required or not) on the working-face.

Most excellent results have been derived from the use underground of girders made either from steel or iron, instead of the usual wooden props and supports. In main and permanent roads, or return airways, girders possess many advantages, when they can be used with safety.

At the collieries under my charge, in case of extra heavy roof, it has been found advantageous to place girders alternately with wooden bars and trees. We must not forget, also, that in using iron or steel products, we are assisting an industry which largely supports the coal-trade.

The conditions of labour in almost all industries have undergone, and are constantly undergoing continuous modification and improvement, due principally to the ever-increasing uses to which mechanical appliances are being adapted. I am now more especially referring to the general working of mines. As far as labour-saving appliances are concerned, in some districts these have been largely applied.

The standing charges connected with coal-mines are so very great that any improvement calculated to reduce the cost of working is eagerly looked for. In my opinion, if mining associations and institutions would offer substantial prizes for labour-saving appliances for use in mines, improvements would still be made, and better results as regards working, reduced costs, etc., would be obtained.

In applying improvements, prejudice has to be overcome. I am myself convinced on one point, and that is, if we are to hold our own with our Continental competitors, we shall be compelled to give this question more attention. It would not surprise me to see coal imported into this country before long; in fact, we hear of coal from Belgium coming in now. I have it on the most reliable authority that coal is being got and sold in the United States of America for 3s. 9d. per ton, average selling-price, and at this price a profit of 6d. per ton is being made.

Foreign competition in coal is viewed by some with contempt, but unless we keep up with the times, as far as economical working is concerned, it will come sooner or later.

Coal-cutting by machinery has occupied the minds of those connected with collieries for years; large sums of money have been expended with disappointing results; but, having a convenient power like electricity at our disposal, I am convinced that satisfactory progress will be made in this direction before long.

The coals of our district being used largely for household purposes, makes their proper manipulation and sorting an important matter, and probably no district has to spend more per ton on this department than Cannock Chase. This sorting has necessitated an expenditure of a large amount of capital and the erection of extensive screens and picking-belts at many collieries, to compete satisfactorily with our neighbours.

Colliery machinery has been greatly improved, the tendency in erecting modern plants being not only strong and powerful machinery, but such as will give the best efficiency as regards fuel-consumption. I consider that in winding, hauling, air compressing, fan-engines, fans, etc., you should have a margin of at least 50 per cent. of surplus power.

Winding-engines have been adapted to the rapid and heavy winding, necessitated by going to greater depths. Quite recently we have had a description, etc., published in the *Transactions* of a compound colliery winding-engine. It would, however, appear that the results are not altogether satisfactory. I cannot but think that the winding-engine is the last of the various engines used at collieries from which good results are likely to be obtained by compounding. At any rate they should be condensing as well. To start and stop a compound engine, lifting a big load every 45 seconds, is not conducive to economy.

Ropes for winding and hauling purposes are made in a variety of forms of the very best qualities, and can now be obtained at a moderate cost. And under favourable circumstances and with proper treatment, the cost per ton on the quantity drawn works out to a mere decimal point.

I am afraid proper advantage is not taken in using ropes for hauling purposes. In many cases their adoption would mean a considerable saving.

Speaking of winding-ropes brings to my mind a circumstance which, with all our labour troubles, will never be repeated. I refer to the introduction of iron-wire winding-ropes at the Wingate Grange colliery, in the year 1843, and before the workmen would ride upon them, they had a strike of thirteen weeks' duration.

It is gratifying to know that endeavours are being made to still further prove the existence of coal in our own immediate district. I refer to the borings at Chartley on the north, Four Ashes on the west, and the proving of faults of considerable magnitude which have been looked upon as the boundary of the coal-field, on the southern and eastern points. The results will be anxiously awaited, and I think that we cannot do less than congratulate the parties interested on their enterprise, and wish them success in their undertakings.

We have a number of young and less experienced members, and to them, I feel sure, from my own past experience, that the *Transactions* offer practical examples and guidance, which are appreciated all over the mining world; and the desire to possess these is, I take it, the main cause of the ever-increasing strength of the various institutes comprised in The Federated Institution of Mining Engineers.

I feel that I have trespassed too long already on your patience—so long that I cannot but thank you for the attention with which you have listened to my address; and again I thank you for the honour of electing me your President.

A vote of thanks was given to the retiring President for his services during the past year.

On the motion of Mr. DUIGNAN, the Council and officers were cordially thanked for their services.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE STEPHENSON MEMORIAL HALL, CHESTERFIELD,
AUGUST 29TH, 1896.

MR. EDWARD EASTWOOD, TREASURER, IN THE CHAIR.

Mr. G. A. EASTWOOD and Mr. T. P. HEWITT kindly consented to act as scrutineers of the voting papers for the election of Officers for the year 1896-97.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

Mr. SYDNEY THORP BOAM, Assistant Manager, Whitwick Colliery, Coalville, Leicester.
Mr. FREDERICK CLENCH, Mechanical Engineer, Chesterfield.
Capt. HAROLD DEWHURST, Cork Artillery, Owner of Steatite Mines, Foxhall Park, Letterkenny, Co. Donegal.
Mr. PETER SINCLAIR HAGGIE, Mechanical Engineer, Gateshead-upon-Tyne.
Mr. BENJAMIN McLAREN, Colliery Manager, Portland House, Kirkby-in-Ashfield, Notts.
Mr. WILLIAM MAURICE, Electrical Engineer, Swanwick Collieries, Alfreton.

ALTERATION OF RULES.

The SECRETARY read the following proposed alteration of Article 1, Section VI., of the Rules, of which notice was given at the last General Meeting, April 4th, 1896, as recommended by the Council:—

There shall be three Ordinary General Meetings in each year, to be held in Chesterfield, unless elsewhere arranged for by the Council, in every April, August, and December, the meetings in April and December to be on the first Saturday in the month, at 2·30 p.m., and the date of the meeting in August, which shall be the Annual General Meeting, to be fixed by the Council. Anything in the rules affected by the foregoing intended alteration to be adjusted accordingly.

Mr. G. E. **Coke** (Nottingham), after considerable discussion had taken place, moved that the proposed resolution be referred back to the Council.

Mr. **Henry Stevenson** (Pinxton) seconded the proposal, which was put to the meeting, and carried unanimously.

The Annual Report of the Council was read as follows :—

ANNUAL REPORT OF THE COUNCIL.

The following is the usual comparative summary of the number of Members and the state of the finances in the past three annual statements, viz. :—

			Period 1¼ Years.
	1893-94.	1894-95.	1895-96.
Honorary Members ...	14	14	14
Life Members	10	10	9
Members	220	224	214
Associate Members ...	0	2	2
Associates	64	73	76
Students	28	27	34
	336	350	349
	£ s. d.	£ s. d.	£ s. d.
Cash Receipts	549 8 6	491 3 6	683 13 3
Cash Payments ...	551 17 1	495 8 11	537 13 10
Bank Balance	- 54 4 3	- 58 9 8	87 9 9
Invested Fund	533 6 8	533 6 8	533 6 8
	£479 2 5	£474 17 0	£620 16 5
Arrears considered recoverable at end of	1893-94.	1894-95.	1895-96.
	£28 12 6	£47 13 0	£52 16 0

Nine new Members (including 1 Student transferred), 1 Associate Member, 6 Associates, and 9 Students, have been elected during the year —total 25 (as against 28 last year).

The total retirements from all causes are 26 (as against 14 last year), viz.:—1 Life Member, 19 Members, 1 Associate Member, 3 Associates, and 2 Students.

There has been a net increase of 3 Associates and 7 Students; and a net decrease of 1 Life Member and 10 Members. Total net decrease, 1.

One Life Member, 3 Members, and 1 Associate Member have died during the past year, and are further referred to in Memoirs.

The total number on the roll of the Institution as for the year commenced August 1st, 1896, was 349.

The period included in the financial statement following, being from 25th March, 1895, to 31st July, 1896, *i.e.*, a year and a third very nearly, must be taken into consideration in comparing such lengthened period with the net years that preceded it. The subscriptions having been charged and paid *pro rata* show a corresponding increase.

The income of the past period was £192 9s. 9d. more than in the previous year, and £145 19s. 5d. in excess of payments.

The expenditure was £42 4s. 11d. more than in the previous year.

The arrears considered recoverable, as above, will probably be in great part realized during the coming year.

The formal agreement between the Town Council of Chesterfield and the Members of this Institution referred to in the previous Annual Report, as in preparation, was duly executed, and is being satisfactorily acted upon. One effect of the arrangement has been that the contents of the Museum of the Institution have been returned in most cases to the Donors or Lenders, and the residue has been presented to existing local museums. The sum of £28 has been received for the unused museum cases.

The Annual Meeting of The Federated Institution of Mining Engineers was held in September, 1895, at Stoke-upon-Trent. The other meetings were in February, 1896, at Sheffield (when the local arrangements devolved upon the Chesterfield Institution), and in June, in London.

Local meetings have been held in Warwick, on July 13th, 1895; in Chesterfield, October 12th; in Nottingham, December 7th; and in Derby, on April 4th, 1896.

The complete list of papers published in the *Transactions* of The Federated Institution of Mining Engineers since the Council's last report includes the following contributions from this Institution:—

"Presidential Address." By Emerson Bainbridge.
"Boring below the Blackshale Coal-seam at Apperknowle, near Sheffield." By G. E. Coke.
"Fencing-gates for Winding-shafts." By William Hay.
"The Geology of Warwickshire." By R. Smallman.
"Photometric Value of, and Notes upon, various Illuminants Used in Mines." By A. H. Stokes.

The Annual Meeting of The Federated Institution of Mining Engineers is fixed to be held at Cardiff on September 15th, 16th, and 17th, 1896.

ABSTRACT OF ACCOUNTS.

	INCOME.	£	s.	d.	£	s.	d.	£	s.	d.
194	Members at £2 2s. 6d.				412	5	0			
1	Do. at £1 11s. 6d. (short paid)				1	11	6			
7	Do. at 11s. (balance)				3	17	0			
2	Associate Members				4	5	0			
85	Associates and Students				114	15	0			
8	New Members and Entrances				25	8	0			
1	New Associate Member and Entrance				3	3	6			
14	New Associates and Students				20	5	0			
								585	10	0
312										
	Nine Members paid in advance, 1896-97				14	3	6			
	One Member do. 1897-98				1	11	6			
								15	15	0
								601	5	0
	Arrear Subscriptions received, 1894-95							21	3	6
								622	8	6
	Transactions and Excerpts sold							4	15	8
	Midland Railway Company's Debenture Interest ...							23	4	0
	Bank Interest							3	14	7
	Midland Institute—Share of Joint Meeting, September 27th, 1894							1	10	6
	Museum Cases							28	0	0
	Total Receipts ...							683	13	3
	Unpaid Arrears as per Subscriptions a/c				65	19	6			
	Do. 1894-95 Account	£18	15	0						
	Do. 1892-94 Do.	7	14	6						
					26	9	6			
					92	9	0			
	Irrecoverable				39	13	0			
	Net arrears to collect							52	16	0
								£736	9	3

Certificate of £533 6s. 8d. Midland Railway Company's 3 per Cent. Debenture Stock, and Policy of Assurance with Alliance Co. for £500, deposited in Bank.

PERIOD (1¼ YEAR, ABOUT) ENDING JULY 31ST, 1896.

EXPENDITURE.	£	s.	d.	£	s.	d.
The Federated Institution of Mining Engineers upon copies of Transactions, supplied at 17s. per Member:—						
Balance of Calls, 1894-95 (Vols. VIII. and IX.) ...	29	15	0			
Calls, 1895-96 (Vols. X. and XI.)	273	14	0			
Back Transactions on Payment of Arrears	10	0	0			
				313	9	0
Excerpts, Exchanges, etc.				14	15	4
Printing and Stationery, A. Reid & Co., Ld.	18	2	0			
Do. do., Bemrose & Sons, Ld.	13	5	7			
Do. do., W. Edmunds	1	13	6			
				33	1	1
Auditors				3	3	0
Reporting Proceedings				14	15	2
Fire Insurance				0	12	6
Postages, Parcels, and Telegrams				18	1	9
Travelling and Incidental Expenses				16	12	5
Fees at Meetings, Requisites, and Services				2	17	8
The Federated Institution of Mining Engineers Meeting, Sheffield, February, 1896				6	16	6
Secretary's Salary, Assistance, and Use of Office				108	2	2
Bankers' Charges				0	17	9
Legal Charges *re* Stephenson Memorial Hall				4	9	6
Total Expenditure ...				537	13	10
Balance from Last Year				58	9	8
Arrear Subscriptions				52	16	0
Balance as per contra				87	9	9
				£736	9	3

August 12th, 1896,

Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

DR. THE TREASURER IN ACCOUNT
PERIOD COMMENCING MARCH 26TH,

		£	s.	d.	£	s.	d.
233	Members, as per List, 1895-6, of whom						
9	are Old Life Members						
224	Members at £2 2s. 6d.	476	0	0			
	Less 8 paid in advance last year at £1 11s. 6d.	12	12	0	463	8	0
233							
	Nine Members paid in advance, 1896-7	14	3	6			
	One Member do. 1897-8	1	11	6	15	15	0
2	Associate Members				4	5	0
101	Associates and Students, as per List 1895-6, of whom						
1	Student is a Life Member.						
100	At £1 7s. 0d.				135	0	0
8	New Members and Entrances	25	8	0			
1	New Associate Member and Entrance	3	3	6			
15	New Associates and Students	20	5	0	48	16	6
24							
360					667	4	6
	Arrears per last Balance Sheet	47	13	0			
	Deduct Irrecoverable, not included in 1896-7	39	13	0	8	0	0
					£675	4	6

WITH SUBSCRIPTIONS, 1895-6. CR.

1895, AND ENDING JULY 31ST, 1896.

		Unpaid.			Paid.		
		£	s.	d.	£	s.	d.
194	Members at £2 2s. 6d.				412	5	0
1	Member do.	0	11	0	1	11	6
9	Old Life Members						
8	Paid in advance last year at £1 11s. 6d., of whom						
	Seven paid balance at 11s.				3	17	0
	One owes balance at 11s....	0	11	0			
21	Unpaid	44	12	6			
233							
	Nine Members paid in advance, 1896-7				14	3	6
	One Member do. 1897-8				1	11	6
2	Associate Members				4	5	0
1	Student is a Life Member						
85	Associates and Students at £1 7s. 0d.				114	15	0
15	Unpaid	20	5	0			
101							
8	New Members and Entrances				25	8	0
1	New Associate Member and Entrance				3	3	6
15	New Associates and Students				20	5	0
24							
360							
		65	19	6	601	5	0
	Arrears per last Balance Sheet	26	9	6	21	3	6
		92	9	0	622	8	6
	Irrecoverable	39	13	0			
	Arrears to collect				52	16	0
					£675	4	6

August 12th, 1896.—Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

Mr. M. H. **Mills** moved the adoption of the report. It was not necessary to say anything about the accounts, as they spoke for themselves.

Mr. C. R. **Morgan** seconded the resolution, which was carried *nem. con.*

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The **Secretary** said that the next business was the re-election of the present representatives of the Institution upon the Council of The Federated Institution of Mining Engineers for the year 1896-97. The present members were Messrs. E. Bainbridge, G. J. Binns, G. E. Coke, M. Deacon, H. Lewis, J. A. Longden, M. H. Mills, W. Spencer, and himself, *ex-officio*. No one else had been nominated.

Mr. W. D. **Holford** (Whittington) proposed the re-election of the gentlemen whose names had been read.

Mr. C. R. **Morgan** (Alfreton) seconded the motion, which was carried unanimously.

ELECTION OF OFFICERS—1896-97.

The scrutineers, who received the thanks of the meeting for their services, reported the result of the ballot as follows :—

President.

Mr. M. H. **Mills.**

Vice-Presidents.

Mr. G. J. **Binns.**
Mr. G. S. **Bragge.**
Mr. G. E. **Coke.**
Mr. H. R. **Hewitt.**
Mr. T. A. **Southern.**
Mr. R. **Thornewill.**

Councillors.

Mr. G. H. **Ashwin.**
Mr. P. M. **Chester.**
Mr. M. **Deacon.**
Mr. W. H. **Hepplewhite.**
Mr. C. R. **Hewitt.**
Mr. J. P. **Houfton.**
Mr. W. B. M. **Jackson.**
Mr. J. H. W. **Laverick.**
Mr. G. A. **Lewis.**
Mr. C. R. **Morgan.**
Mr. J. B. **Smith.**
Mr. H. **Walters.**

PAST-PRESIDENTS (*ex-officio*).

Mr. G. LEWIS.	Mr. A. BARNES.
Mr. J. JACKSON.	Mr. W. SPENCER.
Mr. J. A. LONGDEN.	Mr. E. BAINBRIDGE.
Mr. H. LEWIS.	

VICE-PRESIDENTS OF PREVIOUS YEAR (*ex-officio*).

Mr. A. G. BARNES.	Mr. W. D. HOLFORD.

TREASURER.

Mr. E. EASTWOOD.

SECRETARY.

Mr. W. F. HOWARD.

The President then took the chair and delivered the following address :—

PRESIDENTIAL ADDRESS.

By M. H. MILLS.

Let me first thank the members for the honour which they have done me by electing me as their President for the coming year. It is the rightful ambition of us all to gradually work our way step by step into the position wherein you have kindly placed me; for some years I gave considerable time to the work of the Institution, and more particularly to the federation of the various institutions under one head, the accomplishment of which has been such an advantage to all, and will no doubt gradually develop into one Institution of Mining Engineers for the empire, with its various branches working much the same as now. Lately I have left the more detailed work of the Institution in younger hands, feeling that it was a great mistake for any Institution to get into grooves of management, and for this reason I always hailed the advent of a new member of the Council with satisfaction.

I feel sure I may rely upon the same hearty support that the Council and Secretary have always hitherto given to our past Presidents, and I hope, when the term of my office comes to an end, that you will have no cause to regret having placed me in the chair.

It is not my intention in this address to give you a summary of what has been done in the mining world in the past, but rather to look at what is going on at the present time, and to endeavour to lead the younger members of the Institution, who are so soon to take our places, to study those subjects which appear to be most important to this district in the immediate future, and also to throw out some suggestions for papers.

Owing to the near exhaustion of the coal-seams lying within easy reach, it has become necessary to sink shafts to considerable depths, and I wish to bring more particularly before the members the various points that I do not feel have been sufficiently threshed out by members of our Institution.

All new mining undertakings have now to face heavy expenditure in deep sinkings and powerful machinery with more risk of the coal-seams not continuing of the same thickness or quality as they are found more to the rise. It is therefore necessary for lessees to secure larger areas of coal and longer terms of leases than formerly, and owners of property who are fortunate enough to have coal under their lands, but who do not own a sufficient area to induce lessees to sink for the one property alone, must join with their neighbours in granting such leases as will enable the lessees to successfully compete with other collieries. Owners of mineral property have, of course, as free a hand in dealing with their minerals as capitalists have in dealing with their money, and they must be expected to endeavour to make the best terms they can for the wares that they have to sell; I would therefore impress upon our younger members, and perhaps some of our older ones, the necessity for closer study of the various forms of leases, and I would urge them to make careful notes of all mining law cases, and so become thoroughly conversant with the many difficulties that occur in working under long leases. There is seldom difficulty in arranging terms of leases with men who have so studied the subject, but when one or both of the parties have not given time and close attention to the past working of leases and the whole matter is left in the hands of lawyers, then perhaps a very legal document may be drawn, but the result will be an unworkable lease and constant worry and annoyance entailed during its whole term.

I do not wish to take you through the terms of a lease, but should like to make one or two remarks on some of the more important parts when large areas and long terms are involved.

I should like to see more careful thought given to the question of sliding-scales for royalties, the royalty rising and falling with the average selling price of the coal upon which royalty has to be paid, and it appears to me that when large areas are taken on long terms it is advisable to have a sliding scale on the thickness of the seam as well. This dual sliding scale may appear complicated to some, but in practice it only means a little more trouble, and makes a fairer lease to both parties than one hard-and-fast royalty, which in my experience means a maximum with no minimum mentioned.

With regard to the fixed rent for large areas and long terms, I find that a rule of thumb is gradually becoming fixed for estimating the amount to be paid annually, which to my mind is entirely devoid of any reason whatever. The intention is that the colliery should be vigorously worked, subject, of course, to the many difficulties met with, and this alone must be the guide in deciding upon the amounts to be paid as a fixed or certain rent or minimum rent, as I like to call it.

I must say a few words upon the vexed question of wayleaves. I take it that when one property is necessary to another, in order to bring that other property into the market, then that property that so benefits by the permission of the other must expect to make payment for the advantages given, and lessees in acquiring leases over large areas must carefully consider and arrange these wayleaves in the first instance, and if they do not do so, then they have no right to complain of advantage being taken of their own carelessness. At the same time, when several estates have to be leased in order to make a sufficient area to warrant a colliery being established, then lessors cannot well, or to their advantage, press for wayleave rights.

There are one or two other points which I should like to mention, but fear I am rather lengthening out my remarks upon the subject, my only excuse being that I have had some experience in the matter, and it is not a usual one to be laid before you. I will, however, risk tiring you by adding that when long leases of large areas are necessary, it must not be expected, nor is it advisable, that the whole of the surface should be subject to the requirements of lessees. Lessees must consider what land they probably will require, and be content with power to take land at future times as required. Coal cannot be worked without men, and men require housing, but it is easy to settle on the site of a proposed village when the position of the colliery is arranged, and as the cottages are necessary to the colliery, and, in fact, form one concern, the same term of years is sufficient for the site of the cottages as for the site of the colliery.

One other point I desire to impress upon you is the mistake that is often made of granting leases up to lines of supposed faults, even should the fault be well known, as this practice has led to endless trouble in many cases.

I will now pass on to the more practical work of the mining engineer in deep sinking.

Before the desired area of coal has been decided upon it is necessary to consider the means of transport to the various markets, and this opens up a large field for further observation and invention, more especially in our district where the water-carriage of coal has been so neglected. I hope some of our members will give their attention to this, and let us have a paper upon the best means of conveying coal to foreign countries, so as to cause as little breakage as possible, and also at such a cost as will allow our coal-field to compete with Northumberland, Durham, Scotland, and South Wales. Surely it is possible to ship coal from Nottinghamshire and Derbyshire at a much less cost than we now pay, and I hope that it will fall to the lot of one of our members to show how this can be done to the advantage of all concerned.

Another paper that I should like to see, is upon the proper diameter for a deep shaft; there appears to be great difference of opinion on the subject, and I think that there is some fear of too large a diameter becoming usual, as it must be remembered that the new sinkings further east must pass through the overlying water-bearing measures, and great lengths of tubbing are sure to be necessary, so the stronger the shaft is the better, and the larger the diameter of the shaft the greater will be the expense in making the tubbing safe.

The construction of cage to be used in the shafts is another subject requiring more attention, and I invite a paper upon this. The present usual shape of the tops and bottoms of the cages is not, I think, all it might be for passing quickly through a strong current of air.

Passing on now to the machinery and boilers in use for deep sinking, there is scope for much ingenuity, as the consumption of coal at most collieries amounts to almost a scandal upon mining engineers of the day. As a rule they say that the value of the coal consumed is so small that it does not pay to have expensive systems for reducing the consumption, but I feel sure that if our members will give this their consideration they will do something to be proud of.

I now come to the possibility of a more convenient method of getting the coal by holing machinery. There is, I am sorry to say, a strong feeling on the part of the workmen against the use of machinery for this purpose, which savours much of the old war against machinery of any description, and brings one to wonder whether our elaborate system of free education is having the effect that it should on the strength and success of our country. Still the same old cry comes up, "if you introduce machinery to do our work you will not require our labour." Has this been so in the past? Has not the introduction of machinery in every case been to the advantage of the working classes, and made their labours more of mind and less of brute force, much to their moral and pecuniary welfare?

The selected leaders of the men should not allow their political duties to throw this subject into the shade; but should take upon themselves all the duties of leaders of men and boldly advise the wisest course.

From a practical experience of one of these machines in a thin seam of coal, I find there is much that is not satisfactory as yet, and I ask for a paper upon the various coal-cutting machines in use in the district.

I feel sure that a very useful service would be done by anyone having the opportunities of daily watching their work and noting the results.

Another matter to which I would invite your attention is compressed air and steam and rope *versus* electricity. I hope myself to give a paper upon the subject during my year of office, but do not propose to discuss the matter in an address which does not allow fair criticism to those upon whose corns I tread.

In concluding my address I will not apologize for its brevity, but must ask your indulgence for the meagreness of its contents, and can only say in excuse that it was quite recently that I was informed of the honour you desired to do me, and I had hoped that Mr. Smallman would have been able to accept the position, but for reasons we must all deplore he reluctantly was obliged to give up the privilege.

I now ask you to assist me in my year of office in the only way you can, that is by promising papers for our Institution, and I, on my part, promise to do all I can to improve the position and lighten the labours of those who are so manfully struggling through life in one of the most anxious and responsible positions that it has become the duty of man to fulfil.

Mr. C. **Sebastian Smith** (Shipley collieries) moved, and Mr. C. R. **Morgan** seconded, a vote of thanks to the President for his address.

The resolution was carried with acclamation, and duly acknowledged.

DISCUSSION UPON MR. GEORGE FOWLER'S PAPER "HOW A MINE MAY BE DRY BUT NOT DUSTY."*

Mr. A. H. **Stokes**, referring to Fig. 1 (Plate XI.), remarked that there was something like 1½ or 2 miles of workings without a difficulty in the way of faults, and that the structure of the coal-seam and strata was exceptionally favourable. He would like to know if any colliery manager had tried the idea suggested by Mr. Fowler in a blackshale or silkstone mine.

Mr. J. A. **Longden** (Stanton-by-Dale) wrote that, previous to the recent accident at Blackwell colliery, he was not a believer in the verdicts

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* *Trans. Fed. Inst.*, vol. xi., page 128.

given after numerous explosions, where the cause was stated to be ignited coal-dust, and possibly a blown-out or too heavily charged shot, and that there was no gas present. His opinion was no doubt induced by the exhaustive experiments which were made by the Chesterfield Coal-dust Committee, and in which he took part about twenty years ago. In consequence of the views which he held, he agreed to give evidence before the Coal-dust Commission, especially directing his remarks to the great difference there was between the relative inflammability of one dust and another. This was so clearly established at the experiments referred to, that he was sorry the question, which he considered a vital one, had not been ventilated, and he thought that testing apparatus ought to be available for any colliery manager to experiment with, and that it should be provided by Government free of charge. Mr. Fowler said that earthy dust was incombustible, and not in itself a cause of danger. He, no doubt, knew that the dust in flour-mills was the most dangerous of all—so much so that all modern mills are lighted by electricity, and no naked light is allowed—and it has been clearly shown that any dust, if fine enough, can, under certain conditions, be inflamed. The dust which exploded at Blackwell colliery was that nearest the pit-bottom, and, on a fast-running road, and this pointed to age and fineness as being two of the most important factors.

Mr. Fowler had, he thought, endless-chains or ropes at work, which moved the tubs slowly, and made no dust comparable with that produced on the main-and-tail, or other fast-running rope systems. Open-ended and over-loaded tubs were undoubtedly a great source of dust and consequent danger. Mr. Fowler estimated that the daily collection or deposit of dust from one of the main returns did not exceed 1 cubic foot from the roofs and sides. This estimate was very astonishing, and he thought that a current of 50,000 cubic feet of air per minute must carry away with it much road-dust of a fine nature. In a steep mine, with a soft coal which was constantly falling, the roads in the solid round the shaft-pillars would not retain any plaster, and it was these which had the greater amount of coal-dust upon them. The blackshale, or Silkstone, and the main, or Tupton, coal-seams required different treatment from the top hard, and to water them would mean to cause the road to lift to such an extent that the colliery would be closed. Mr. Fowler's paper was very interesting, and treated the subject in a novel way, and his suggestions, if adopted, might prevent a serious explosion.

The further discussion was adjourned.

DISCUSSION ON "THE YORKSHIRE AND NOTTINGHAMSHIRE COAL-FIELD," ETC., BY MR. W. S. GRESLEY;* "THE EASTERN LIMITS OF THE MIDLAND COAL-FIELD," BY PROF. E. HULL;† AND "THE SOUTHERN LIMIT OF THE NOTTINGHAMSHIRE COAL-FIELD," BY MR. G. E. COKE.‡

The **PRESIDENT** asked Mr. Coke whether anything further had been proved at the Ruddington bore-hole.

Mr. G. E. **COKE** said that there was nothing new in the boring that affected the question. He believed that they were boring in the Lower Carboniferous measures.

Mr. A. H. **STOKES** asked Mr. Coke whether he could tell the direction in which the strata were dipping in the bore-hole, and if so, whether he had any ready and easy mode of finding the amount of inclination and its direction? Whenever he had had anything to do with boring he had found great difficulty in deciding which way the strata dipped. The boring appeared to have reached the Lower Coal-measures; and, taking into consideration the information obtained from the other bore-holes, the indications appeared to denote that the southern limit of the coal-field was turning round toward the south-east. Did Mr. Coke think that there was coal under Peterborough, and that the coal district would extend south-eastward? With respect to the eastern extension of the Nottinghamshire coal-field, he did not know a single geological fact to show that coal did not extend to the county boundary of Nottinghamshire, probably to Lincolnshire, and possibly under the North Sea. With regard to the southern coal-field, since the papers were read the Hockley Hall Colliery Company had reached coal at Kingsbury, and found that the coal-seams came nearer together as they approached Whitacre Junction, proving them to be representatives of the Staffordshire thick coal-seam. He believed that at Hamstead colliery, near the Warwickshire county boundary, the thick coal-seam was fairly level, but breaking up; and present appearances pointed to there being no Silurian ridge as mentioned by Prof. Hull in his paper. He regretted that there was no clause in the Coal Mines Regulation Act requiring the details of borings to be

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* *Trans. Fed. Inst.*, vol. xi., page 143.

† *Ibid.*, vol. xi., page 9. ‡ *Ibid.*, vol. xi., page 339.

deposited at the Home Office, under similar regulations to plans of abandoned mines. Some people paid for bore-holes, and kept the information to themselves; it was different in the case which they were now discussing, as both the owner and mining engineer gave every information to the members, so that it might be known and discussed by experts in mining and geological research. They reaped a benefit by giving such information to the Institution.

The **President** said that the subjects of these papers were of extreme importance and interest to every one connected with these coal-fields, as their extension was an unsolved question. The bore-holes named told a very small part of the story; the rest was mere conjecture, and only helped them a little. Other bore-holes would be put down shortly, he had no doubt, which would solve the mystery by degrees. But there was a danger in forming theories from bore-holes, because the quality of the coal proved was not well defined. Unless the cores were exceptionally good, it was difficult to tell what bands of dirt were actually in the seam.

Mr. **G. E. Coke**, replying to the discussion, said that he could not be certain of the amount or direction of the dip; some cores appeared to indicate highly inclined strata, whilst in others the strata seemed to be horizontal, and he doubted whether it was possible to ascertain the gradient from cores of small diameter. He did not consider Peterborough within the limits of his paper. The bore-hole had proved that the coal-field terminated to the south near Ruddington, but the strike of the coal-seams appeared to be tending in a south-easterly direction, and whilst this continued it was probable that the axis of the coal-basin had not been reached. The Owthorpe boring was not published to the full depth reached, and he had assumed that the top hard coal-seam was reached from insufficient information. He hoped that Mr. Davey would see his way to allow the section to be published, as the knowledge could not injure his estate, whilst it might be beneficial to others.

The **President** proposed a vote of thanks to the writers of the three papers.

Mr. **Stokes** seconded the resolution, which was agreed to.

DISCUSSION UPON DR. J. S. HALDANE'S PAPER, "THE CAUSES OF DEATH IN COLLIERY EXPLOSIONS."*

Mr. A. H. **Stokes** said that the testing, recognition, and effect of carbon monoxide and carbon dioxide were subjects particularly interesting to all engaged in mining. Dr. Haldane made the remark that "He knows that in dealing with this very difficult subject he is handicapped by his want of knowledge of mining engineering, but he thinks that those who possess the requisite engineering knowledge are often nearly as much handicapped by want of knowledge of the medical side of the subject."† He quite agreed with Dr. Haldane; it was necessary to have some idea of the medical side of the subject. The old, antiquated way of treating a man suffering from inhaling carbon dioxide by digging a hole in the ground and putting the man's head in it was now succeeded by more humane and scientific treatment. It was very interesting to know that those curious insects, cockroaches, did not suffer, and it was a great pity that colliers could not command similar physical conditions. It was also curious to note that the mouse did suffer, and was the best indicator of the presence of carbon monoxide in air. It would be rather inconvenient, however, for every colliery manager to keep mice at his colliery and occasionally to take one into the pit to watch its movements; but he did not know if such animal-testing was necessary, because Dr. Haldane said that "only a practised observer could detect the outward signs of slight symptoms in a mouse, whereas correspondingly slight symptoms in a man might be very distinctly felt by the subject of them."‡ The effect of carbon monoxide on man was very quickly recognized, although probably if a man's attention were taken up with other business he might not quickly recognize his physical weakness until it had taken considerable hold upon him; but certainly when they did feel the effect their heads would begin to fail, their legs become weak, and unless there was some special object in front of them, they had better at once turn back. Whenever a man's head and legs began to fail him in a mine, "retreat" was the best and only safe course. What was the object of these tests? If it were to see how far they could go to rescue a fellow-man who lay helpless beyond, then he was sure the symptoms exhibited by a mouse would not prevent any man from running dangerous risks to save his

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* *Trans. Fed. Inst.*, vol. xi., pages 502, 519, and 552; and vol. xii., page 60.

† *Ibid.*, page 509. ‡ *Ibid.*, page 505.

fellow-workman, but if no life were at stake then a man's own physical condition should be his guide in the absence of more delicate tests. Dr. Haldane could not explain why "When a man who has absorbed much carbon monoxide reaches cooler and fresher air again he very often gets much worse, and may lose consciousness." * Dr. Haldane had here called attention to a curious fact, which some of those present could corroborate, but, like himself, could not explain. He had noticed that when a man was brought out into the fresh air he became unconscious: perhaps the temperature had something to do with it. It could not be the oxygen, because that was necessary for his recovery. Dr. Haldane proceeded to say that "the best remedy in carbon monoxide poisoning is the administration of pure oxygen." If that were so, he did not think that they could carry small cylinders of oxygen about the pit for the purpose of aiding the recovery of men. He thought that it would be better to bring the affected person out of the pit, because if the atmosphere in which a man was lying had been sufficient to lay him low by carbon monoxide poisoning, it would have that effect upon those attending him, and the sooner they got him removed the better. Then Dr. Haldane went into a little of the practical part when he said that "the work of temporarily restoring the stoppings, doors, etc., and so carrying the air inwards, would be much facilitated by using mice as indicators of the presence of after-damp." † The general practice after an explosion was to strive immediately to reach the injured and fallen men, and to restore the ventilation as quickly as possible, and all the points which Dr. Haldane had put before them—the practical points—were very well known to mining engineers. Their first object after an explosion was to restore the ventilation and carry the air-current with them. As regarded the rescue of men, there were very few present at that meeting who had not done things to save a man's life that they would not do in the ordinary course of mining, and probably they had been justified in their action. Although the mouse indication was practical, if they liked to keep mice, yet he thought it would be much better if Dr. Haldane could tell them a more scientific mode of testing for carbon monoxide. They had the safety-lamp for testing the presence of fire-damp, but a better test than mice was wanted for testing after-damp.

He congratulated Dr. Haldane upon the results of his investigations, and remarked upon the amount of labour and attention that he had given to the subject. He hoped that Dr. Haldane might be able at some future time to bring forward a simple and practical mode of ascertaining

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* *Trans. Fed. Inst.*, vol. xi., page 506. † *Ibid.*, page 511.

the percentage of carbon monoxide and carbon dioxide in the air-current of a mine. He advised all who were interested in the matter to obtain and study Dr. Haldane's official report upon the medical side of poisoning by carbon monoxide.*

Mr. C. **Sebastian Smith** thought that it would be very interesting if some of their medical friends would make suggestions as to how the effect of these gases could be got rid of. It was a very curious fact that a man poisoned with carbon monoxide should be apparently in a worse state when he was brought into the fresh air, and he could only guess at the reason. He thought that the man would have been equally as bad or much worse if he had been left in the poisonous air. The great thing was to employ artificial respiration to expel the impure air from the lungs by forcing pure air to take its place. The want of knowledge amongst colliers and ordinary people, and their not learning and thoroughly understanding how to produce artificial respiration, seemed a most unfortunate thing. He had an illustration of the want of that knowledge and its consequences a few months ago in the district in which he lived. An unfortunate collier, who was a good swimmer, was entangled in the weeds of a canal. There were several good swimmers in the neighbourhood, but at first they thought he was larking, and did not go to his assistance. When they saw he was really in danger they got him out of the water in an insensible condition, and were perfectly satisfied because his pulse was then beating ; they put his clothes on, and, having laced his boots, they discovered that the poor man was dead. There was no doubt that this life would have been saved had anyone present understood how to produce artificial respiration.

The **President** was of opinion that much information might be obtained from doctors, who might be induced to read papers and give their opinions upon the subject. From the little he knew of explosions in the North of England and at Clay Cross, he felt that what was required at an explosion must be done at once. Very often they found a man whose life might be saved if artificial means of respiration could be at once established, or if they had with them some oxygen for immediate administration, but if they had to take him a long way over falls he probably would be dead before they got him to the pit-bottom. Therefore, it showed how necessary it was that they should have well-organized lessons in ambulance work. There had been a great deal done in that direction, but perhaps a little more might be learnt from this paper.

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* *The Causes of Death in Colliery Explosions and Underground Fires.*

LIFTING A VERTICAL RISING MAIN BY EXPANSION.

BY WILLIAM HOWE.

An interesting application of steam has recently been twice made at the Clay Cross collieries* for the purpose of lifting a rising main. On January 25th, 1894, a branch pipe, the second from the bottom of a rising main 6½ inches in internal diameter and 720 feet in length, broke in the neck at the point A (Fig. 1, Plate III.), and it was necessary on account of the water in the mine to renew it with all possible speed at any cost. The fracture was temporarily repaired as early as possible to allow the pumps to work, but it was in so awkward a position that it could not be made to hold, and when pumping was resumed half the water escaped.

The author had three ideas about renewing the broken pipe, the first was to lift the main (which was approximately 30 tons in weight) by means of screws at the pit-top, with chains or ropes suspended from them hanging down either side of the main, and secured at or near the pit-bottom. Another plan was to lift it by means of screw or hydraulic jacks from the bottom, but he was very much averse to this, as in case of a jack failing the whole main would fall to the bottom, and loss of life would probably ensue. The third method was to take the pipes out from the top, and as the buntons were constructed and fixed in such a manner that the pipes could be easily taken out, it could be accomplished in forty-eight hours. It was therefore decided to adopt this plan, and arrangements were made accordingly.

However, on looking over some papers the author found a record of experiments that he had made a few years previously with regard to the expansion of steam-pipes in pit-shafts, and the idea occurred to him, why not empty the rising main, heat it by steam to expand it, then secure it in the pit-shaft, shut off the steam, and when contraction commenced it would be lifted from the bottom? The idea appeared feasible and perfectly safe, and, with the consent of the manager, Mr. Jackson, he immediately set to work to change the broken pipe by this method.

The first point that he considered was, at what height from the pit-bottom, it would be necessary to secure the main to allow of sufficient expansion and subsequent contraction to take out and renew the broken

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* *Engineer*, 1894, vol. lxxvii., page 112.

pipe; secondly, whether the flanges and bolts of the main would be sufficiently strong at that point to sustain the suspended load; and, thirdly, what means should be adopted to secure the main after it was expanded.

The main was supported laterally every 27 feet, it was free to move vertically, and was 720 feet long. From experience he knew that at 180 feet from the pit-bottom there would be an expansion of 2½ to 3 inches; the bolts, pipes, etc., were sufficiently strong to carry the suspended weight of 9 to 10 tons; and the brickwork in the shaft was particularly well adapted to fix in a bunton to carry the load, so he decided to secure the main at this point.

A pitchpine baulk 14 inches square was let into the brickwork 15 inches at each end close to the body, and 3 feet below the flange of a pipe in the main, and securely wedged in, as shown in Figs. 2 and 3 (Plate III.). A steam-pipe ½ inch in diameter, with a regulating-valve, was connected from the steam-pipes to the rising main at the pit-bottom. One pair of wooden, and two pairs of iron clamps to grip the main, and two cross buntons, one end of each to rest on the main buntons, and the other to rest on a pad in the brickwork behind the main, were got ready during the night, and by 8 a.m. of the following day all the tackle was fixed ready for changing the pipe. The clamps, as shown in Figs. 2 and 3 (Plate III.), were fixed loosely so as to waste as little time as possible, the pumps were stopped, the main emptied, and steam turned on, and in an hour's time the main had expanded 2½ inches at the point for securing the same. The author thinking this sufficient (though it would have expanded still more), had it thoroughly well secured by the clamps, and steam was shut off. The main being open at the top and bottom, immediately began to cool and contract, and in less than ½ hour the new pipe was introduced, steam again turned on until the main was sufficiently expanded to have the clamps taken off, steam was then shut off, and the connexion made to the pumps. The time from first turning on the steam, including changing the pipe and again starting the pumps, was only four hours, and not a single hitch occurred in the whole proceeding.

In another case, exactly the same method was adopted with a similarly successful result.

The process is simple, free from all danger with ordinary care, expeditious, and of much less cost than any other method known to the author, consequently he has taken the liberty of bringing it to the notice of the Institution thinking that it might be of service to the members under similar circumstances.

To illustrate Mr W. Howe's Paper on "Lifting a Vertical Rising Main by Expansion."

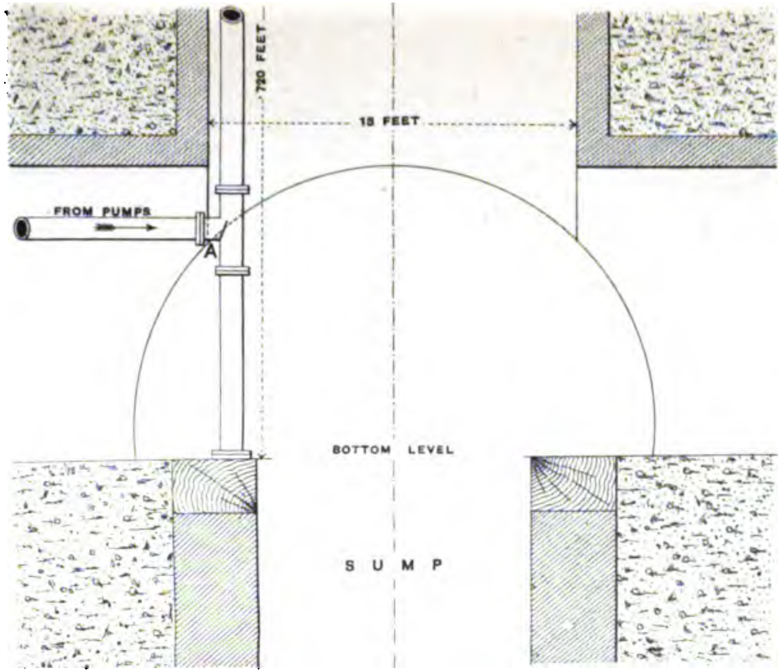

Fig. 1.

Scale, 6⅔ Feet to 1 Inch.

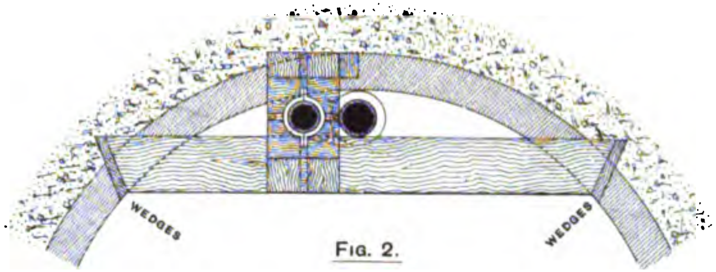

Fig. 2.

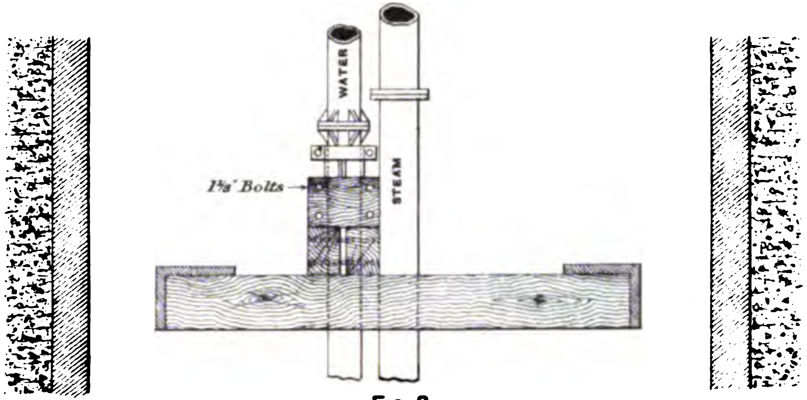

Fig. 3.

Scale, 4 Feet to 1 Inch.

Andw Reid & Compy Ltd Newcastle on Tyne

THE GYPSUM DEPOSITS OF NOTTINGHAMSHIRE AND DERBYSHIRE.

BY A. T. METCALFE.

The Nottinghamshire and Derbyshire gypsum deposits are of Triassic age. They occur in the Keuper series, which, as developed in these counties, consists, in descending order, of:—

Upper Marls,
Water-stones,
Basement Beds.

The Upper Marls are, both from a geological and economic point of view, the most important sub-division. They consist of thick beds of red and blue marls, with intervening minor bands of sandstone and deposits of gypsum. They make excellent bricks and tiles, and form a stiff soil, well adapted for orchards and grazing-land. The thinly bedded dense sandstones have been used for building purposes and for metalling roads for light traffic. Rock-salt, which occurs so abundantly in the Keuper series in other parts of England, is apparently altogether absent.

It is recorded in one of the memoirs of the Geological Survey that in some localities in North Nottinghamshire traces of gypsum occur at intervals in the Water-stones series. These traces, however, are very scanty, and, for all practicable purposes, it may be said that the gypsum deposits of Nottinghamshire and Derbyshire are confined to the Upper Marls. The beds of substantial commercial value, moreover, appear to be mainly in the higher portion of this subdivision.

Gypsum is hydrated sulphate of lime. It is normally white, but may be coloured grey or brown by an admixture of clay or bitumen, or yellow and red by being stained by iron oxide. It is found in various geological formations from the Silurian down to recent times. In its transparent crystalline state it is known as *selenite*. When it presents a finely fibrous opalescent appearance it is termed *satin-spar*. When resembling marble, extremely tough and massive, and capable of being sculptured, it is termed *alabaster*. When not in combination with water it is known as *anhydrite*. Anhydrite is liable at any time to absorb water, and so to pass into gypsum, increasing in bulk in the process.

Selenite is said to have been used by the ancients for some of the purposes for which we use glass. In *Chambers' Encyclopædia* it is recorded that at Petitcodiac, New Brunswick, there is a vein of nearly pure selenite 1 mile in length and 8 feet wide. In Nottinghamshire and Derbyshire, the writer has found selenite only in minute quantities. In cavities in the marls, where crystals have had ample room to form and to which water has had access, crystals of selenite can occasionally be found. Beds of ordinary gypsum sometimes are pierced by what the workmen call "wash-holes" or "watercourses," and the walls of these are commonly lined with selenite.

Satin-spar is abundant, and its brilliantly contrasting white bands and veins are a striking feature in many a scar or cliff facing the valley of the Trent. The veins run through the marls in all directions—vertically and horizontally—regardless of their bedding-planes, and cutting across them at every possible angle. East Bridgford has long been famous for its fine satin-spar, which there attains a thickness of 8 or 9 inches.

Alabaster is found at Chellaston; it is tough and massive, and when quite pure is of a brilliantly white lustre.

Anhydrite occurs in the centre of the beds of gypsum at Newark and other places.

The following is an analysis of a piece of ordinary Nottinghamshire gypsum:—

	Per Cent.
Sulphate of lime	77·37
Carbonate of lime	0·83
Oxide of iron	0·50
Siliceous matter	0·30
Moisture	21·00
Total	100·00

The mineral occurs in many varieties of form; in thick nodular, irregular beds or floors; in high spheroidal masses, or lenticular intercalations called "balls" or "bowls;" and in rows of "cakes" or smaller lenticular masses. The beds thin out and come in again on every hand, and may vary in thickness and quality within short distances. Pure white gypsum is found extensively, as also are admixtures in every proportion of gypsum and marl. The innumerable inosculations of minute veins of gypsum frequently bind beds of marl into extremely hard rock. This sometimes occurs immediately over the thick beds of gypsum, and the result is an excellent roof to the mine.

Where a large "ball" occurs, the marls above appear in some instances to have been more or less pushed up and rest in saddleback form over the "ball," as if the uplifting of the strata were due to the increase in bulk of the concretionary mass below. It has been suggested that these gypsum masses were at first masses of anhydrite, which having absorbed water and become expanded in consequence, have upheaved the marls. In the portions of the strata immediately surrounding a large "ball," gypsum sometimes appears to be altogether absent, as though it had been drawn away to form the "ball" by a concretionary process.

The "beds," "balls," and "cakes" of gypsum are saccharoid or amorphous. They are usually of a pure milky white, of a greyish tint or of a delicate flesh colour. They are frequently perforated by holes varying in size from that of a narrow pipe to openings many inches across. The walls of these "wash-holes" or "watercourses" usually have a wasted or ragged appearance, but occasionally, as before-mentioned, are lined with crystals of selenite.

The purest ordinary gypsum is known to the trade as "superfine." Other qualities in lessening order of value are known as "best," "pottery," "seconds," and "thirds." Coarse or impure gypsum is called "ball roots," "fundlers," or "offals." The terms "scawdey" and "foulstone" are applied to mixtures which, owing to the predominance of marl, are of no commercial value.

At Chellaston and Aston, the southern extremity of the district under consideration, the workable mineral lies practically in one bed or floor of from 10 to 15 feet in thickness. At Aston the men at work are enclosed, as it were, in solid gypsum: roof, floor, and sides being all gypsum. Unfortunately, the blasting operations begrime and discolour what would otherwise be the beautiful white surroundings. As we proceed north, the beds or floors are more numerous, but thinner, and with intervening strata of marls. The excellent quality, however, of the gypsum is fully maintained throughout the whole of the two counties.

The following is a generalized section of the strata exposed in the neighbourhood of Newark :—

	Feet.	Ins.		Feet.	Ins.
Tea-green marls	15	0	Red marls	1	0
Red and green marls	6	0	Gypsum, *Second White*	1	0
Red marls	10	0	Red marls	1	6
Balls of gypsum	5	0	Gypsum, *Third White*	1	0
Coarse gypsum	2	0	Red marls	2	6
Red marls	4	0	Gypsum, *Blue Rock*	1	0
Red marls and cakes	3	0	Red marls with cakes	1	6
Gypsum, *Grey Rock*	3	0	Red marls	4	0
Red marls with gypsum	4	0	Gypsum, *Fourth White*	1	0
Red marls with cakes	3	0			
Red marls	4	0			
Gypsum, *Top White*	1	0	Total	74	6

In thick beds, the upper portion is usually the purest; the bottom is commonly coarse, or "foulstone." A very thin coating of fibrous gypsum is commonly found above and below the beds. Mr. R. P. Cafferata, of Newark, who takes a scientific interest in his very extensive works, informed the writer that twenty-four hours after quarrying the bed of gypsum called "Blue Rock" (shown in the section), "free sulphur" appears in considerable quantity.

The deposits have considerable economical and commercial value. The tough, massive variety called "alabaster" is worked up into vases, statuettes, clock-frames, and other ornaments of considerable size. It is found at Chellaston, where it is known locally by the name of "Patrick," and commands a high price in the market. At Chellaston, a pulpit, font, and reredos, made of this quality, can be seen. The rock, when quite pure, is of a brilliant pearly-white lustre; but usually, owing to the presence of oxide of iron, it has a delicate tint, or elegant veins, stripes, or spots of a red colour. Ornaments made from this rock are sold largely at Matlock, and are commonly called "Derbyshire spar." An extensive trade in alabaster ornaments made from the Chellaston mineral has been done for many years. The parish has been largely undermined for this valuable variety, and on every hand can be seen sunken land marking the site of exhausted workings. The satin-spar of East Bridgford is worked up into beads and small ornaments, which have a peculiar play of light similar to "cat's eye." These small ornaments are chiefly made up in Derby; they are largely exported to America, where they receive gold-settings. The upper portion of the spar is more transparent than the lower; the lower is called in the trade the "root," and will not produce the best quality of ornament. Spar of the best quality has realized in the market £6 to £7 per ton. The rock has a kind of cleavage, and, to use the language of a workman at Derby, "it can be chopped like wood."

The ordinary gypsum has important uses. When heated to a temperature of about 175 degs. Fahr., gypsum begins to part with its combined water, of which it contains more than 20 per cent. This water is sufficiently driven off, and with the best results, at a temperature of about 230 to 250 degs. Fahr. When so burnt and ground to flour, gypsum possesses the valuable property of recombining with water and quickly setting from a thin paste into a solid mass. This property is lost if the mineral be exposed to too high a temperature, when it is said to be "dead burnt." The Nottinghamshire and Derbyshire gypsum is of sufficient purity to be admirably adapted for the manufacture of plaster of Paris, and every year thousands of tons are raised for this purpose, and also to form an ingredient in the manufacture of Keene and other hardened cements.

The process of production, as in operation at the works at Bowbridge Road, Newark, of the Vale of Belvoir and Newark Plaster Company, is as follows:—After the mineral has been got by blasting and the pick, it is broken up with wedges, and the blocks are carried along narrow-gauge steam-trams to the cleaning sheds. For the superfine quality every particle of red or blue marl outside or within the mass is chipped away. After being cleaned the blocks are burnt in ovens; afterwards they are passed under powerful steam crushers (edge-runners), and then taken by elevators into a mill, where they are ground to the finest powder. Finally, the flour is passed through sieves or dressers, and then filled into sacks, when it is ready to be despatched by railway-trucks to its destination. In many works the blocks of gypsum are first ground, and then dehydrated on hearths or pans heated by furnaces and flues underneath. Before the discovery of steam-power, gypsum was reduced to flour by flails—a very tedious process.

The chief works in Nottinghamshire are at Beacon Hill and Bowbridge Road, Newark, Orston, Barton, Thrumpton, Gotham, and Kingston; and in Derbyshire, at Chellaston and Aston. At Newark the mineral is obtained by quarrying; at the other places the workings are underground, being reached in most cases by a horizontal tunnel, but in some cases by a vertical shaft. Narrow-gauge tramways, worked usually by horses, run through the galleries, which, in some mines, extend in various directions for several hundreds of feet from the entrance. Pillars of rock or timber at intervals to support the roof, ventilation-shafts, doors to ensure proper circulation of air, and other features usual in mining quarters, are to be seen in the gypsum workings. As the level at which water stands in the gypsiferous districts is generally only a few feet from the surface, and as excavations are carried on to a considerable depth—in one case 135 feet—constant pumping operations are in some workings necessary to prevent flooding. This is, however, not always the case. In some mines the writer found the whole of the workings (owing to the impervious nature of the marls above) dry and even dusty, affording a pleasant contrast to the thick mud through which one has to thread one's way in other workings.

Among the many uses to which plaster of Paris made from gypsum is put may be mentioned the obtaining copies of sculptures and carvings, medals, engraved gems, and other objects. From it are made moulds for electro-deposits; it is used in stereotyping, in the production of glass, and of pressed and embossed pottery. Its most extensive use, however, lies probably in the finishing of internal plaster work, and in making cornice mouldings and other architectural enrichments in positions not exposed to the weather. Gypsum also forms a base in the manufacture of colours; it is used as a filling for all classes of paper; it is an ingredient in fictile ivory and imitation meerschaum; and it is said to be used in confectionery.

Another use to which gypsum is put is the Burtonizing of beer. It is well known that gypsum beds occur at Burton, and that the excellence of Burton beer is largely due to the presence of calcium sulphate in the water in its preparation. Mr. Molyneux in his *History of Burton-upon-Trent* calculates that 350,000 pounds of gypsum are annually imbibed in potations of Burton beer. The Newark breweries also have the advantage of being situate on the gypsiferous marls. The following comparative table of acids and bases contained in Burton water and water from one of the deep brewery wells of Newark, published in the official memoir of the Geological Survey, is of great interest:—

	Newark. Grains in an Imperial Gallon.	Burton. Grains in an Imperial Gallon.
Calcium	28·5553	24·4990
Magnesium	4·7820	4·2000
Sodium	4·1950	7·9146
Potassium	—	0·5060
	37·5323	37·1196
Sulphuric acid	65·9856	57·6542
Carbonic acid	4·4871	7·0600
Nitric acid	3·1940	—
Chlorine	3·5000	6·0270
	77·1667	70·7412

As gypsum is soluble, attempts have been made, with varied success, to add analogous salts, artificially prepared, to the water of districts not situate on gypsum-bearing beds. Large quantities of gypsum are purchased by brewers for this purpose. This addition, though doubtless very advantageous, does not effect perfect Burtonization; and on this subject one's mind cannot fail to be exercised at the sight to be seen in some of the great gypsum works of Nottinghamshire, of many thousand gallons of Burtonized water being daily pumped up from the beds, and allowed to run off without being applied to any special purpose.

Many small disused pits may be seen throughout the area of the Upper Marls. These were, in years past, opened solely or partially to get gypsum for making plaster floors. Plaster floors, however, are not now in favour, and, so far as there is a demand in that direction, gypsum has for some time past been practically superseded by Portland cement.

Blocks of gypsum which have been exposed to the weather or to the action of water in "wash-holes" are frequently (and especially when of a delicate flesh-colour) objects pleasing to the eye, and as such are in considerable request for the ornamentation of rockeries and aquaria.

The inferior qualities of gypsum are employed for agricultural purposes, the mineral being beneficial as a top-dressing for clover and other herbs. It is applied in the form of powder when the plants are moist with dew or rain.

Apparently there are no grounds for believing that the gypsum deposits of Nottinghamshire and Derbyshire are in any way whatever connected with volcanic agencies. Indeed, Sir Archibald Geikie says that no trace of British Mesozoic volcanoes has been met with, and that the vast interval between Permian and older Tertiary time (which includes the period during which these gypsum deposits were formed) was in Britain a period of total quiescence of volcanic activity.

After the Carboniferous Limestone age, great changes in physical geography are observable, and eventually the formation of the Triassic basins or inland seas. In these inland seas or salt-lakes, the gypsum deposits were probably formed by chemical precipitation in the following manner. Water that runs into such lakes has no escape in the form of outgoing rivers, and is evaporated by the air. But the various mineral salts derived from rocks and soils, and incessantly carried in solution into the lakes by entering streams cannot pass away by evaporation. They must remain behind, and in consequence the salinity of the lakes gradually increases. Common salt (sodium chloride) and gypsum (calcium sulphate) are two of the most important salts thus introduced. As the water of the lakes became more and more concentrated these substances were precipitated to the bottom, and there formed solid masses of salt and gypsum. The Dead Sea, the Great Salt Lake of Utah, and similar modern salt-lakes and inland seas assist us to understand how our gypsum deposits were formed.

Gypsum, being less soluble than common salt, is the first to be precipitated. Gypsum begins to be thrown down when 37 per cent. of the water containing it has been evaporated. Salt is not precipitated until

93 per cent. of the water has disappeared. It would seem therefore that on this side of the Pennine chain in the area occupied by the Keuper rocks of Nottinghamshire and Derbyshire the waters never became sufficiently saturated to allow of the precipitation of rock-salt. In the compact sandstones of the Upper Keuper Marls of Nottinghamshire and Derbyshire pseudomorphs of common salt are plentiful, and clearly indicate the salinity of the water of the ancient inland sea in which the Upper Keuper Marls were deposited.

THE DEPOSIT AT THE MILL CLOSE LEAD-MINE, DARLEY DALE, MATLOCK.

By CYRIL E. PARSONS.

Mill Close is an instructive example of a very rich lead deposit. The mine is situated in the Derwent Valley about 4 miles from Matlock Bridge.

The ore is obtained essentially from the top beds of the Carboniferous Limestone. The following is a section of the rocks in the locality:—

Millstone Grit.
Yoredale Shales, Sandstones, etc.
Cherty Carboniferous Limestone.
Toadstone.
Limestone.

Many rich deposits, having similar characteristics, have been worked in the same district.

The present workings penetrate down through the lower portion of the black bituminous shales into the top bed of limestone, where most of the ore is obtained. The mine is overlooked on two sides by steep hills of shale capped by Millstone Grit.

At the present day, there are four shafts in use: two for pumping, one of which is also used for hoisting on a small scale; one entirely used for hoisting; and another for ventilating purposes.

The workings are approached and carried on by three main levels (Fig. 1, Plate IV.).

South-west of the mine, by Wensley and Winster villages, the limestone crops to the surface, it dips to the east, and disappears underneath the shale and grit hills.

The deposit is a distinct fissure-vein intersecting the shale and limestone. In every case it is strongly marked, though irregular and characteristic of the limestone. The lead-ore does not contain silver in paying quantities. It is mined from the vein, its caverns, feeders, and flat veins. It will be convenient to describe each separately, as the ore occurs in each under different conditions with various peculiarities.

Vein.—The vein is a more or less vertical fissure. It bears a few degrees to the east of north along its course in the older workings, but in the more recent workings it tends to the west of north, but some of the older miners consider these to form different veins. It is vertical or hading to the east or west. One wall is generally well defined and marked with horizontal striæ or highly polished slickensides of steel-grained galena. It may vary in width from a few inches to 20 feet.

The old Mill Close shaft, at present not in use, enters the underlying bed of toadstone, a bed of lava contemporaneous with the limestone (Fig. 1, Plate IV.). Here the vein or fissure has faulted the beds 9 feet, but at the Lees shaft 2,610 feet to the north, no vertical fault exists.

Sometimes the vein dwindles to a simple fissure, further on it will perhaps widen out many feet and be filled up with a brecciated mass of limestone-rock with pieces of spar, cemented together by carbonate of lime. The spar was apparently derived from the vein itself, presumably formed in the vein, then broken off by attrition, resulting in an accumulation of breccia and horizontal striæ on the walls. We often find a banded structure, or it may widen out into a cavern.

The mineral bands or ribs are worth noticing. Generally, blende occurs next to the country rock, and in every case it seems to have been deposited first of all. On the blende, fluorspar is found, followed by massive opaque earthy barytes (cauk). This, again, will be encrusted with a rib of galena and crystallized calcite. Often a solid band of iron pyrites nearly a foot thick occurs in the centre. The lode with this banded structure may persist for some distance, and finally nip out or widen into a cavernous structure (Fig. 3, Plate IV.).

In places where the gangue contains cavities, the lead and calcite form splendidly crystallized masses of cubical galena and dogtooth spar. Fluorspar is very common, but seldom coloured. Here and there are stains of carbonate of copper. Small pieces of calamine are occasionally met with, evidently derived from the blende. Pink heavy spar, and black and white chert often appear associated with the ore under every condition. Great quantities of hydrous oxide of iron occur as a mud or powder due to decomposed iron pyrites in the cavernous parts of the vein. Pyromorphite is probably represented, coating other minerals in a thin yellow layer. In a few places, carbonate of lead is found in radiate crystals. Small pieces of white ore (cromfordite ?) much prized by the miners are sometimes procured. The minerals just described have all come under the notice of the writer.

Where feeders and strings join the vein, it widens out with rich deposits, and caverns may occur. Water charged with carbonic acid has found these veins or fissures a convenient course. The sides of the vein are thus eaten away. Blocks of limestone, loosened by natural jointing, fall in from the roof and top sides. These disintegrating agents have been mentioned by many writers in the formation of all the Derbyshire caverns. The nature of the rock might often decide the position of a cavern, by its hardness or degree of crystallization. The acuter the angle that the feeder makes with the vein the more it enriches it.

As beforementioned, the vein intersects the overlying shale and limestone below. Formerly the fissure might have intersected the Millstone Grit before it was disintegrated and worn away, but probably it existed only as a fault or imperceptible crack.

A good deal of ore has been obtained in the shale; but the further it penetrates that measure upwards the poorer and narrower it becomes, and the crystals of galena become smaller.

Hitherto the ore has been wrought exclusively in the cherty limestone, bounded above by the shale and below by the first toadstone-bed—in all about 156 feet thick. In Derbyshire, this measure has nearly always been considered the most productive.

Feeders.—The feeders are of all sizes, and enter the lode at every angle "making ore." They are subsidiary veins, and are often followed, proving productive to a considerable distance. Generally, they die out, and are unproductive at a slight distance from the main lode.

By following the feeders some of the largest caverns have been discovered. Only a fissure, as thick as writing paper, may exist: the miner driving on this, perhaps suddenly, breaks through into an enormously rich cavern that will provide work for years.

Caverns.—Caverns are found unexpectedly along, or branching off, the main vein on or from its feeders. Their shape is irregular. They may measure as much as 60 feet in many directions, several caverns often connecting with each other.

Most of the best ore is obtained from caverns. The floor is generally covered with small and large angular blocks of the country rock, with large crystals of dogtooth spar, lumps and blocks of cauk and galena, and other associates.

Iron pyrites is not so plentiful in the caverns as in the vein. Half of the cavern may be filled with fallen angular blocks intermixed with ore, and the ground is simply quarried. The blocks of limestone may be disintegrated, but not waterworn. In places, on the top of all this rubble, we find a fine black sediment of mud and hydrous iron oxide. The mud is often cracked and partially desiccated.

Before the water was drained off by the lower level and pumped away, the caverns and everything else were full of water. The roof is usually covered with incrustations of cauk, fluorspar, blende, masses of cubical galena (the cubes measure sometimes 2 inches across), and discoloured calcspars: the crystals of some of the dogtooth calcite will measure as much as 1 foot along their axes.

On surrounding ledges or cavities in the sides of these caverns, where no fallen rock has collected, we find the usual spars, galena, and associated minerals covered by mud as abovementioned. The galena seldom forms such fine cubes on the floor as on the roof.

Some fine crystallized specimens of different minerals may be obtained in some of the side cavities, as nodular cauk with a crystallized coating of iron pyrites (cromfordite?). A few rare and unique specimens of filiform hemimorphite have been obtained.

So far as ascertained, no cavity of any kind has been found which was not connected with a fissure.

It is common for layers of galena, etc., to penetrate horizontally from the caverns between the bedding-planes of the limestone-rocks, and gradually die out (Figs. 2 and 3, Plate IV.).

Flats.—Flats form generally more or less horizontal deposits. They occur along the bedding-planes of the limestone. Near the fissure or feeder they are most productive, and thin out to nothing as they recede from it.

Presumably here, as in other instances, water from the fissures has penetrated between the bedding-planes of the limestone, and eaten out an elongated, wedge-shaped cavity, the space being afterwards occupied with galena and other minerals.

The floor is generally irregular and undulating, rising or falling to or from the roof. After a time it rises to meet the roof and cuts out gradually all the ores.

The roof generally remains more regular in accordance with the bedding-planes of the limestone above. Irregular cavities are found in the flats.

The miner usually, in working these flats follows a fissure or leader, that may be in itself totally unproductive, but has evidently enriched the flat by its proximity.

While dealing with flats we will introduce the subject of "way-boards," or beds of clay formed contemporaneously with the limestone. These wayboards are well known in the district. They are generally beds of grey clay about a foot thick, with limestone above and below them. The old miners are well acquainted with them according to their characteristic appearances, and name them.

An example can be seen in the cliffs between Matlock Bridge and Matlock Bath, tilted to an angle of about 45 degs.

In the 42 fathoms level of Mill Close mine there is a wayboard that exerts a distinct influence upon the mineral deposit (Fig. 2, Plate IV.). This wayboard resembles others in the district. On the top of it, about Lees shaft, there is 1 inch of bright coal; sometimes the coal is only represented by a little dark bituminous matter, or even this may be absent. The underlying clay is darker near the coal, and becomes grey lower down. The coal is not the least altered by the intersecting vein. This wayboard changes in character in different places, the coal may die out or the clay become thicker, etc. At the Warren Carr shaft, 891 feet from Lees shaft, this wayboard forms a bed fully 3 feet thick.

This interstratified bed of soft clay seems to have checked the uprising solutions holding various minerals in suspension, a flat of unusual richness appearing to be the result. It continues for a greater distance and the ore is more evenly distributed than in the case of the other smaller flats. The roof is very regular and bounded by the wayboard. The floor is uneven and irregular, in striking contrast to the roof above. The same minerals are found as in the caverns.

In an old disused working from the 42 fathoms level, the wayboard crops out. Here we find clay, somewhat dry, forming a heap as it crumbles down on the floor. Intermixed with the heap is a mass of silky white crystals of alum (alumogene?). In the more exposed and looser clay, the crystals are very white and silky, but below the outside covering the alum occurs in small particles, having a greenish colour. The decomposition of iron pyrites is probably the cause of the presence of alum, while the discoloration may be due to traces of copper in the pyrites.

Fire-damp.—Many years ago, before the mine was so efficiently worked, fire-damp gave rise to a great deal of trouble. The overlying black Yoredale Shales are very bituminous and emit a great deal of gas. The far end of the 42 fathoms level is in this shale, and blowers of gas are common: it may be heard coming out resembling a singing kettle. Long ago the blowers were ignited, and used to give light for the men at their work.

In working, the miners consider the smell of gas indicative of ore; probably because the vein is richest where it is full of cavities, so that gas can accumulate.

The miners have many other indications of ore, but these are mainly erroneous; for instance, the "old men" firmly believed that whistling underground would frighten ore away.

The mine is now so well ventilated that any danger that might arise from fire-damp is removed, and naked lights can be used with perfect safety, except in a few places that are marked and carefully fenced. In such places safety-lamps only are used.

In coal-mines we are acquainted with "creep," where the floor, owing to the enormous weight exerted by the surrounding rocks, grows up and raises the roadway.

A strong fissure through the Yoredale Shales is not likely to remain unaffected by this phenomenon, and would naturally close together and exclude ore-bearing solutions under the influence of the surrounding pressure.

The limestone below, however, would resist this tendency, whereas water would readily attack it and open up inviting cavities for the deposition of ore.

Toadstone would not be so liable to "creep." The wayboards, however, from their clayey nature, would certainly be affected, and this would account for the richer deposit generally found beneath it in the 42 fathoms level.

Prof. C. Le Neve Foster quotes instances of quicksilver deposits. It seems that in very many cases, as at Ekaterinoslav in Southern Russia, and California, the quicksilver has deposited itself in sandstone directly beneath a covering of shale. He says:—"It seems as if the impermeable clay had arrested and directed the course of the ore-bearing solution as it ascended." These conditions may account for the top limestone being richer than the lower measures.

In many places round Winster, Elton, and neighbouring villages, the limestone occurs at the surface, and is rich in galena and other minerals. In earlier geological ages these portions were covered by shale, which has since been worn away.

Upon reference to the geological map of the district it will be noticed that in the district round Mill Close, up the valleys to Winster, and towards Wensley and Elton, etc., very numerous veins are marked, and

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Vol. XII Plate IV.

To illustrate Mr C. E. Parson's Paper on "The Deposit at the Mill Close Lead-mine."

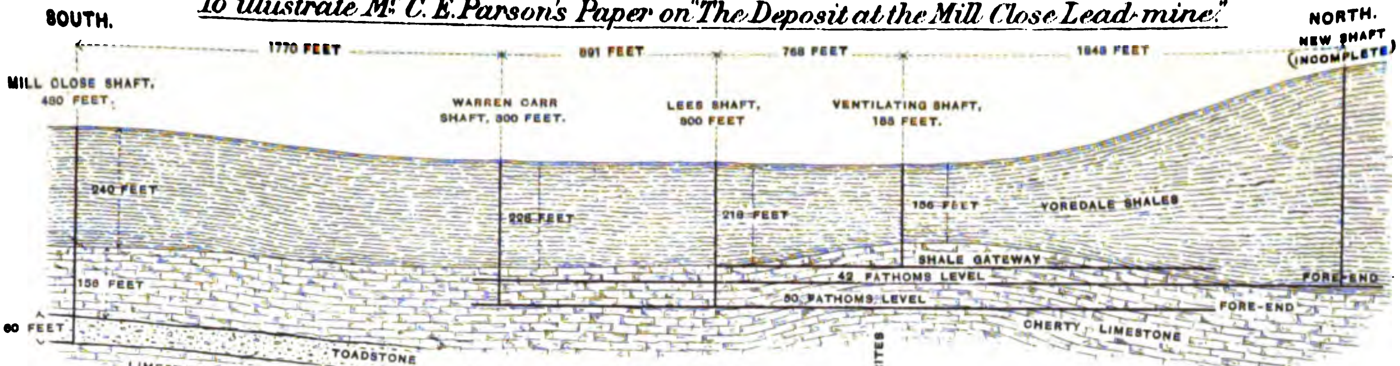

Fig. 1.—Section of Mill Close Lead-Mine.

Horizontal Scale, 800 Feet to 1 Inch.

Vertical Scale, 400 Feet to 1 Inch.

Fig. 2.—Section of Vein.

THE BLACK PORTIONS REPRESENT LEAD-ORE

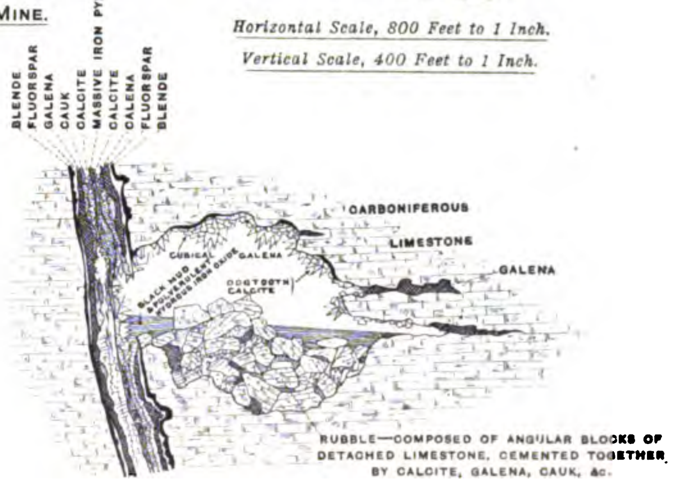

Fig. 3.—Section of Cavern and Vein.

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they seem more or less to tend in two directions, as north and south, east and west, roughly speaking, and to exist in parallel groups, often intersected by others. They appear to be, locally, areas of disturbance. The veins themselves are often faults.

It may be that some faults shown in the geological map on the Millstone Grit, if followed in depth below the Yoredale Shales into the top limestone, would become productive lead lodes.

This country affords evidence of volcanic conditions in the beds of toadstone and volcanic vents mentioned by Sir Archibald Geikie in the discussion of a paper by Mr. H. H. Arnold-Bemrose before the London Geological Society on "The Microscopical Structure of the Carboniferous Dolerites and Tuffs of Derbyshire."* At Matlock we have warm springs still existing; these may be due to their deep-seated origin.

Undoubtedly, underlying the shale, there are still many rich deposits resembling that of Mill Close, and it is to be hoped that in course of time, with improved methods and better prices, Derbyshire may again become one of the prominent lead-mining centres.

The writer is very much indebted to Mr. A. M. Alsop, and wishes to thank him and others who have assisted and given him a great deal of information in connexion with the Mill Close lead-mine.

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* *Quarterly Journal of the Geological Society of London*, 1894, vol. l., page 603.

PIT-TOP SAFETY-FENCING.

BY SIMEON WATSON.

The pit-top safety-fencing described in this paper is used while men are being sent into and withdrawn from the mine.

The New Hucknall colliery shaft is 1,200 feet deep, and 655 men and boys require to be sent down and withdrawn from the mine daily.

Each cage has three decks, and 10 men ride upon each of the top and middle decks, making a total of 20 men to be lowered or raised at one time. Formerly, only 12 men were so carried, and in bad weather, when men were frequently late in arriving in the morning, all of them were not able to descend the pit before the coal-drawing commenced; thus it often happened in times past that many had to return home, losing their day's work, to the disadvantage of both workmen and employer.

With the view of remedying this inconvenience, the management decided to increase the number of men and boys carried upon the cage at one time from 12 to 20, as above-mentioned. Mr. Stokes, H.M. Inspector of Mines, acquiesced in this proposal if an arrangement of fencing arms *B*, *B*, as shown in Fig. 1 (Plate V.), were provided and put into operation. This arrangement having been erected, the whole of the men are now sent into and withdrawn from the mine in 40 minutes, without hurry or inconvenience. The alteration has given satisfaction, not only to the pit-men, but also to the enginemen and banksmen, and may be described as follows:—

The banksman at the middle-deck is considered to be the head-banksman, and is placed in charge of the pit-top. When men are about to enter the cage, he lifts up the balanced lever *A*, raising the fencing arms *B*, *B*, *B*, to the open position at *E*. Ten men then enter the cage on the top-deck and 10 on the middle-deck. The assistant banksman at the top-deck landing, when his men have entered the cage, and are ready for lowering, signals to the head-banksman at the middle-deck. Then the head-banksman, when his men have entered the cage and are ready for lowering, pulls down the lever *A*, bringing the fencing arms *B* for each deck into their horizontal position, afterwards giving the signal to the engineman, and the men are lowered into the pit. This operation is

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To illustrate Mr. Simeon Watson's Paper on "Pit-top Safety-fencing."

Vol. XII Plate V.

FIG. 1.—FRONT ELEVATION.

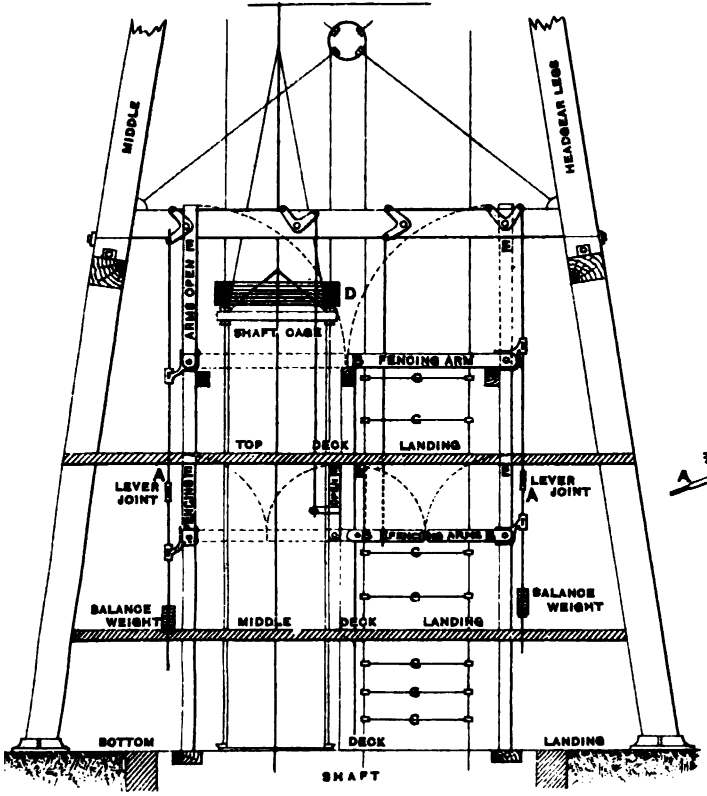
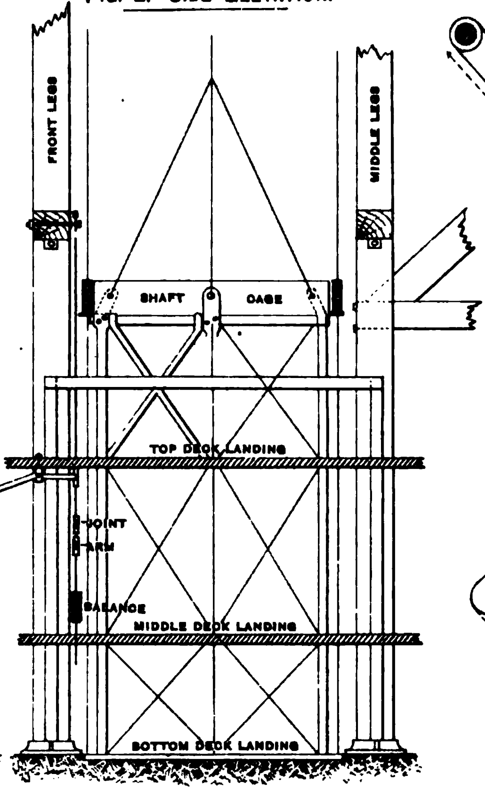


FIG. 2.—SIDE ELEVATION.



Scale, 7 Feet to 1 Inch.

Scale, about 7 Inches to 1 Inch.

FIG. 4.

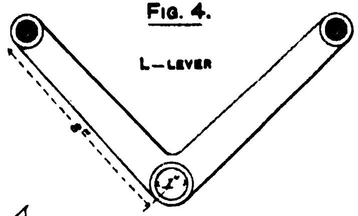
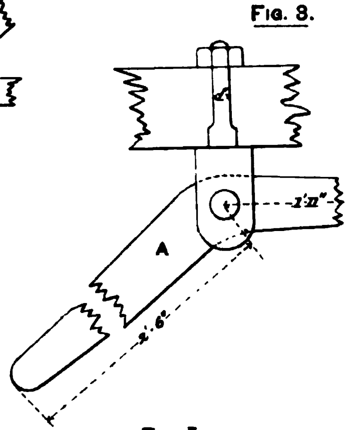


FIG. 3.



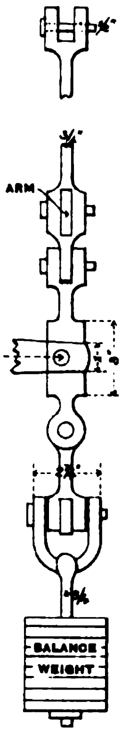


FIG. 5.

JOINT OF PROTECTION-BARS

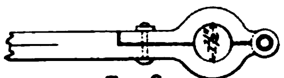


FIG. 6.

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Vol. XXI Plate XIII.

repeated at each trip while men are being carried. The fencing arms are not worked during coal-drawing, but only while men are being raised or lowered.

The advantages of this arrangement are, that the men can be raised or lowered more quickly, and that this can be done more safely by one man, *i.e.*, the head-banksman having full command of men getting on or off the cage. As will be seen in Figs. 1 and 2 (Plate V.), he closes the entrances to the cage at both decks, before giving the signal to the engineman, thus preventing men from getting on or off the cage, after the signal has been given; otherwise it was feared that through some misunderstanding an accident might have occurred in carrying men on the two decks, at the times of getting on or off the cage.

The ordinary fencing *C* for the pit-top while coal is being drawn is shown in Fig. 1 (Plate V.). This consists of iron protection-bars, 1 inch in diameter, placed in front of the opening of the shaft, and the cage coming up the shaft through the pit-top, gathers the bars up, as shown at *D*, and, descending, leaves the bars again in their horizontal positions *C*.

The enlarged drawings (Figs. 3 and 4, Plate V.) show the details of the L-levers, the handle *A* for working the fencing arrangement, etc., and (Figs. 5 and 6, Plate V.) the joint of the protection-bars.

MEMOIRS OF DECEASED MEMBERS.

Mr. ECKLEY BRINTON COXE was born in Philadelphia, on June 14th, 1839: graduated in 1858 from the Pennsylvania University, and after a post-graduate course in the Mining Department of that Institution, spent several years abroad studying at the École des Mines at Paris and at the Mining Academy at Freiberg. Born to the inheritance of wealth, in land and mines, he presented an illustrious instance of the complete utilization of the advantages which wealth can give to a young man, when it does not demoralize and weaken him by taking from ambition and industry the pressure of necessity. No student desperately seeking the means of livelihood ever worked harder than Mr. Eckley B. Coxe; and when, after his thorough preparatory training, he entered into active life, he was speedily recognized as the foremost of American mining engineers.

In April, 1871, he united with Mr. Richard P. Rothwell and Mr. Martin Coryell to sign the circular letter which led to the organization at Wilkes-Barre, in May of that year, of the American Institute of

Mining Engineers. For six out of the first seven years thereafter, he was a vice-president; in 1878 and 1879 he was elected and re-elected president, and after the latter date he served four years in two terms as vice-president again. His ability was recognized in the American Societies of Civil and Mechanical Engineers, of which he was a member, and of the latter of which he was elected president in 1893. But it may be fairly said, without offence, that his most affectionate interest was centred in the American Institute of Mining Engineers, which he had helped to found. His presidential addresses and numerous papers in the Transactions of that society evince not only his professional ability but also his interest in scientific and technical education. This was shown also by his maintenance at Drifton for many years of a technical school for the education of miners. He and his brothers deserve the high praise of not only exhibiting in the collieries under their management models of mine engineering and machinery, but also offering in the dwellings, gardens, artesian-wells, library, reading-room, schools, churches, and other appliances of comfort and improvement provided for their employees, models of enlightened philanthropy.

In connexion with the Geological Survey of Pennsylvania and the State investigations into the waste of coal mining, he rendered efficient service. The latter subject was one to which he gave much attention, and in the study of which he expended much money as well as time. In recent years, he devoted himself ardently to the idea of diminishing the commercial waste of anthracite, by effecting the economical utilization of the smaller sizes. His inventions and publications in this direction are of high value. He had been for years and was at the time of his death a trustee of the Lehigh University.

He died May 13th, 1895, of pneumonia, after a very brief illness.*

He became a life member of this Institution on April 14th, 1877.

Mr. Richard Elihu Dickinson was born in Liverpool, on April 16th, 1849. He was apprenticed in Liverpool to a shipping house which is now merged in the White Star Line, and received a good commercial training. His tastes being however essentially mechanical, he gave himself up to the study of engineering, both theoretically and practically.

In 1871 or 1872 he commenced business as an engineer and iron-founder at the Cleveland Engine Works, Birkenhead, as Messrs. R. E. Dickinson & Co. Whilst he had these works, he became connected

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*Condensed from Memoir by Mr. R. W. Raymond in the *Transactions of the American Institute of Mining Engineers*, vol. xxv., page 446.

with some Portuguese mines, and was resident abroad for a while erecting the necessary machinery.

His attention was early called to steam power in connexion with tramways, and he built a considerable number of locomotive cars that were used in Dublin, Wigan, and elsewhere; the characteristic of the engines lay in the absence of smoke, and the small consumption of fuel. Mr. Dickinson closed the Birkenhead works and removed to the Saville Street Engineering Works, at Sheffield, carried on in close connexion with the Clay Cross Co., with a view specially of constructing steam tramcars. At Sheffield he was greatly interested in the manufacture of steel as well as general engineering work, and on a company (in which the late Mr. Daniel Adamson was largely interested) being started at Barrow-in-Furness, Mr. Dickinson was offered and accepted the management. He stayed there until 1887, when he took the management of the steel and ironworks department of Messrs. Palmer's Shipbuilding and Iron Co., Ld., at Jarrow-upon-Tyne. Here he erected several large steel-smelting furnaces, and a bar-mill, which is one of the best in the kingdom. In 1891, he removed to Bradford, and became managing director of the Bowling Iron Co., Ld., a position which he retained until his death, which took place on May 12th, 1895, after a very brief illness.

Mr. Dickinson was a man of great ability, indomitable perseverance, and high courage. With a thorough consciousness of his own ability and ever ready to give a strong opinion *pro* or *con*, he was unobtrusive and modest in demeanour, and had his constitution been as strong as his indomitable will, and his life been spared, he would undoubtedly have taken a prominent position in the engineering world.

He was a member of the Iron and Steel Institute, of the Institution of Mechanical Engineers, and of the Institution of Civil Engineers. He became a member of this Institution on February 17th, 1892.

Mr. **HERBERT FLETCHER**, of the Hollins, Bolton, was born at Bolton, on April 25th, 1842. After being educated at the Windermere Grammar School, he went to Messrs. Hick, Hargreaves, & Co., Soho Ironworks, Bolton, to study mechanical engineering; and also learnt surveying under Mr. Elias Dorning, of Manchester. From 1862 to 1868, he managed, for his father, the Clifton and Kearsley collieries, near Manchester, and from 1868 the Ladyshore colliery, near Bolton. He succeeded his grandfather and uncle in the post of mineral adviser to the Duke of Buccleuch at Burnley, and was consulting engineer at the Atherton collieries, near Bolton, until 1874. Besides designing many practical improvements in small appliances for coal-pits, he adopted the method now used at Ladyshore colliery of packing the goaf, as the coal was extracted, with material from all parts of the mine instead of sending the latter to bank, and brought down for that purpose cinders and other available refuse, the object being to take the weight as it came on, better than by props or chocks, and to leave no space for the accumulation of gas. He was an early convert to the opinion that coal-dust was an important factor in mine-explosions, and adopted the practice of watering dusty roads. For the last fifteen years he worked hard to abate the nuisance of smoke arising from boiler-fires. He adopted a mechanical furnace of the coking kind, and for many years his chimneys have been practically smokeless; and steam has been raised with the maximum of economy from refuse coal from the colliery, for which no reasonable price could be obtained. In these furnaces he made many improvements. For some years past he had devoted much attention to the general question of smoke-abatement, and spent much time in collecting information for a report to the Smoke Abatement Society, with the object of showing conclusively the merits of the different methods of boiler-firing, and proving that the mechanical furnace was the most economical in utilization of both fuel and boiler-space, and that the kind of furnace which made the least smoke was financially the most economical. He was a member of the Bolton Town Council and of the Lancashire County Council. He was also a member of the Institution of Mechanical Engineers. His death occurred near Bolton from failure of the heart, on September 16th, 1895, at the age of 53 years.

He became a member of this Institution on August 13th, 1881.

Mr. GEORGE WILLIAM TURNER was born at Clay Cross on January 11th, 1842. In 1854 he commenced as clerk under the Clay Cross Company, and after a few years he went to Moira, in Leicestershire, to study mining engineering. Afterwards he became a clerk at the Oakerthorpe coal and ironworks, and subsequently returned to the Clay Cross Company, under whom he succeeded his father (Mr. Benjamin Turner) in the position of overground colliery superintendent. In 1877, upon the opening out of the Alma collieries, the property of his father-in-law, the late Mr. Thomas Holdsworth, he became their general manager, and at Mr. Holdsworth's death the owner. He took an active part in public local affairs, and was universally respected. He died at his residence, the Farm, Northwingfield, on May 5th, 1896.

He became an associate member of this Institution on December 1st, 1894.

The meeting was then closed.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

Held at the North Stafford Hotel, Stoke-upon-Trent,
September 28th, 1896.

Mr. E. B. WAIN, President, in the Chair.

The minutes of the previous General Meeting were read and adopted.

The following gentlemen, having been previously nominated, were elected:—

Associate Members—

Mr. **Horace Edward Brothers**, Analytical Chemist, Park Terrace, Tunstall.
Mr. W. J. **Heppell**, Agent and General Manager, Cwmaman Colliery, Aberdare, South Wales.
Mr. **Edgar** W. **Waine**, Coal Master, Werrington, Stoke-upon-Trent.

Associate—

Mr. **Robert Hill**, Underground Manager, Norton Collieries, Smallthorne, near Burslem.

COAL MINES REGULATION ACT, 1896.

The **President** called attention to the Act to Amend the Coal Mines Regulation Act of 1887. The most important features of the new Act were those which provided specially that the Home Secretary might make special rules as to explosives, and decide the explosives which might be used. He might also make special rules as to the watering or efficient damping of the mine or any ways or places therein. He (the President) thought that these special rules would be made in accordance with the principal Act, and in case of dispute the matter might be referred to arbitration. Another clause provided that workmen in such an arbitration were given power to nominate some person to appear on their behalf, and they might be charged a portion of the costs of the arbitration. There were also provisions as to more accurate plans of the workings and also of abandoned workings. Another important matter was the sixth clause, by which the Secretary of State was given power, on being satisfied that an explosive was, or was likely to be, dangerous, to prohibit its use. In that case he took it that the Home Secretary had absolute power without any arbitration or reference whatever.

Mr. W. N. **Atkinson** (H.M. Inspector of Mines) said that the President had pointed out in sections 1 and 6, the most important provisions of the new Act, but these were sections which referred to the future more than the present. The Act came into force as soon as it was passed, August 14th, 1896, and there were certain other sections requiring the immediate attention of the colliery owners and managers. Section 3 referred to the plan and manner of working. The plan kept in pursuance of section 34 of the principal Act must show the position of the workings thereon with regard to the surface and the position and direction of every known fault or dislocation of the seam with its vertical throw. On the majority of existing plans the surface-marks were shown; the faults were shown on all plans, although not some of the smaller faults, nor the vertical throw.

The **President** asked whether it was intended that all buildings, fences, and surface-marks must be shown on the working-plans?

Mr. **Atkinson** said that he was not in a position to give a legal opinion on that point, but he should say not. It did not refer to every surface-mark, but only sufficient to show the position of the workings with regard to the surface. Then section 4, referring to the abandonment of a mine, was of immediate application, requiring an accurate plan of the mine or seam—either the original working-plan or an accurate copy by a competent draughtsman—to be sent to the Home Secretary within three months of abandonment. The inspection before the commencement of work extended to all working-places in which work was temporarily stopped.

Mr. J. **Richard Haines** said it meant that every district of a mine must be clear whether it was at work or not.

Mr. **Atkinson** believed as a rule that was done.

Mr. T. E. **Storey** said that was the rule in North Staffordshire where any working-place was standing.

Mr. H. R. **Makepeace** (H.M. Inspector of Mines) mentioned that the original Act said "every part .... in which workmen are to work." He had known instances, where a place had not been inspected, and the explanation had been given that it was not a "working-place," as it had been fenced. In well-managed collieries such places were examined, but cases had occurred where they had not been examined because they were fenced, and not intended to be worked. He thought that this section required the inspection of each place, though it might be fenced.

The PRESIDENT said the exact wording of the Act was that "a competent person . . . shall . . . inspect every part of the mine situate beyond the station . . . in which workmen are to work or pass during that shift."

Mr. W. N. ATKINSON understood that the new Act extended to places where workmen might not have to work.

Mr. J. R. HAINES thought that there would be no objection to it.

Mr. W. N. ATKINSON then directed attention to sub-section 2 of section 5, which provided that "A safety-lamp shall not be used in any mine or part of a mine by any person employed therein unless it is provided by the owner of the mine, and no portion of any safety-lamp shall be removed by any person from the mine while the lamp is in ordinary use."

Mr. J. C. CADMAN remarked that this section would not apply to mines in North Staffordshire, where the colliery owners were the owners of the safety-lamps.

Mr. H. R. MAKEPEACE said that at many mines in South Wales the lamps belonged to the men. In Northumberland and Durham, the men took the tops of their lamps home and cleaned them.

Mr. W. N. ATKINSON considered that the section was a very important one, and was generally carried out in this district. He then read sub-section 3 of the same section, providing that only clay or other non-inflammable substance should be used for tamping, and that it should be provided by the owner of the mine.

The PRESIDENT said that if there was no natural clay in the mine it must be provided. He had been accustomed to sending clay down to a fixed place, where the men could obtain it when required.

Mr. STOREY said that if there was no clay in a pit the owner must provide it.

Mr. H. R. MAKEPEACE observed that if there was nothing but black bituminous shale, which contained inflammable matter, that would not be available, and proper clay for tamping should be sent down the pit by the owner of the mine. Then it was a question where a line should be drawn as to what was available for tamping, and what was not. Some materials used for tamping would come under the category of inflammable substances.

Mr. J. R. **Haines** said that there was no doubt it would be advantageous to use clay for tamping, because with it many explosives produced better results.

The **President** next referred to clause 2, sub-section 1, of clause 4, which provided that the accuracy of a plan after the abandonment of a mine must be certified " so far as is reasonably practicable, by a surveyor or other person approved in that behalf by an inspector of mines." That must mean that the surveyor must be a qualified person.

Mr. W. N. **Atkinson** said that he scarcely understood the meaning of the clause. He was afraid that there would sometimes be difficulty in finding a competent person.

Mr. J. R. **Haines** read clause *a*, sub-section 1, section 4, and said that if they took a town plan it might show the boundaries, but they could not show every working under every block of houses.

Mr. A. M. **Henshaw**, referring to section 3 of the new Act, requiring a plan to show the position of the workings with regard to the surface, and the position, extension, and direction of every known fault or dislocation of the seam, with its vertical throw, said that the levellings of underground workings should be written on the plan; it was the practice at many collieries, and a desirable one.

Mr. J. J. **Prest** observed that there were clauses in the Act which required to be brought before the men employed in mines, and it ought to be published in sheet form and posted up at each mine.

The **President** thought that the members must wait until they saw what suggestions were made as to the new special rules before proceeding any further.

Mr. W. N. **Atkinson** said he had no doubt that there was a desire to draft special rules applicable to all districts.

The **President** said that if one set of special rules were applied to the United Kingdom they would form practically an amendment of the Act by the Home Secretary and not by Parliament.

The meeting was then closed.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE FIRTH COLLEGE, SHEFFIELD, SEPTEMBER 26TH, 1896.

MR. G. BLAKE WALKER, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated.

MEMBERS—

BERGRATH BEHRENS, Chief Director, Hibernia Colliery, Herne, Westphalia.
Mr. CYRIL FRANK JACKSON, Mining Engineer and Surveyor, Crigglestone, Wakefield.
Dr. SCHULTZ, Principal, Mining School, Bochum, Westphalia.
Mr. WILLIAM SCOTT, Colliery Manager, Thornhill Collieries, Dewsbury.

ASSOCIATE MEMBER—

Mr. WILLIAM DERBY, Chemical Engineer, 4, Cross Street, Manchester.

STUDENT—

Mr. JOHN WHITEHEAD MAW, Mining Student, Oaks Collieries, Barnsley.

The President delivered his Inaugural Address on "The Education of Mining Engineers" as follows :—

THE EDUCATION OF MINING ENGINEERS.

PRESIDENTIAL ADDRESS.

BY GEORGE BLAKE WALKER.

My first duty is to thank you for the honour which you have done me in electing me to the presidency of the Midland Institute for the present year; and, in thanking you, to assure you that I shall endeavour, to the utmost of my power, to make my year of office a useful one to the Institute. I hope that in this I may rely on the cordial co-operation of the members.

The industry with which we are all connected, and in whose prosperity we are all so deeply interested, is passing through a time of trial and difficulty, the causes of which are various and complex, and the remedies for which are problematical and obscure. The coal trade of Great Britain, which formerly had no rival, is now hard pressed in the race, and the unquestioned supremacy which this country once possessed is hers no longer. Science is making rapid strides in all branches of industrial enterprise, and science being cosmopolitan, gives to all nations equally the benefits of discovery and experience.

In the Presidential address* which he delivered last year to the Federated Institution of Mining Engineers, Mr. W. N. Atkinson pointed out that the output of coal in the United States of America would soon have exceeded that of the United Kingdom, and that Germany, France, and Belgium, in the ten years from 1884 to 1894, had increased their production of coal by 29 millions of tons, or 31 per cent., whereas in the same period the output of the United Kingdom had only increased by 27 millions of tons, or 17 per cent.; the production of the three countries being, in 1894, two-thirds of that of this country. Mr. Atkinson urges that, in view of the changing conditions, the increasing physical difficulties to be surmounted, and the more and more severe competition which we have to meet, "it is more than ever requisite that, to be successful, the mining engineer should have a very efficient training both in the practical and scientific knowledge of his profession."†

The opinion which Mr. Atkinson so strongly urged is one which I have myself held, and for which I have worked for many years past. I

* *Trans. Fed. Inst.*, vol. ix., page 299. † *Ibid.*, page 307.

think there is no subject of more pressing importance for the consideration of such an Institute as that to which we belong, and I therefore propose, with your permission, to make the education of mining engineers and colliery officials the subject of the remarks which it is my privilege to address to you to-day.

We are, I fear, somewhat apt in this country to set a less value on scientific attainments in business pursuits than is reasonable, because we rightly attach very great importance to practice and experience. Were it a choice between a scientific and a practical knowledge of mining, there could, of course, be no question as to which of the two we must prefer, and the mere student, however well read, is virtually useless without a thorough practical experience; but, although we are all agreed about this, I venture to think that at the present day, and under existing circumstances, the continued progress and prosperity of the coal trade of this country depends on our raising the standard of scientific attainments to the level of that of our foreign competitors. The problems of surmounting constantly increasing difficulties, and at the same time reducing the cost of the article produced and of so producing it as to give it the greatest possible value, the preservation of life and health at greater depths and under more trying conditions, are ever presenting themselves under new and exacting forms; and in the struggle for life those only will eventually survive who can most successfully bring to their aid the resources of science and highly trained ability.

If we glance at the statistics of the coal-production of the world, we shall find that no country has made such strides in the development of her coal resources as Germany. Yet Germany has by no means easy conditions to account for her startling progress. On the contrary, the conditions have been distinctly unfavourable and difficult, and it has only been by means of a large measure of engineering skill, and the clever adaptation of means to ends, that the result which has been so strikingly successful has been obtained. *

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* Wherein lies the real secret of Germany's strong and unceasing commercial advance? Prof. William Ramsay has forwarded to the *Times* a letter by Prof. Ostwald, which throws a great deal of light on the subject. The secret of the Germans, as revealed by Prof. Ostwald, is the close connexion between theory and practice in scientific education. The teaching of science in Germany has as its constant aim the detection of properties of matter which may possess an industrial value, and the detection of these properties is promptly followed by their application. Our students are not less able or less industrious than their German rivals, but they are inclined to be too exclusively practical, and as a result too conservative. There is no branch of trade in which Germany has entered more successfully into competition with us than the chemical industries, and these are a typical instance of the difference between the two national systems. The number of men, to begin with, who are investigating with a view to practical advance in these industries is far larger in Germany than in England; those who are engaged in the work in

There is unquestionably more appreciation of the value of a good technical training in Germany than at home, and no one can fail to be struck with the enthusiasm with which it is sought for by the miners themselves. When recently visiting the Mining School at Bochum, in Westphalia, I was told that in the year 1894 there were 646 applications for admission to the Mining School by working miners and mechanics, notwithstanding the fact that these men would have to attend at the school for four hours every day, in addition to doing their ordinary work. Out of this large number, there were places available for only 120 students, who were selected by examination. It is to be feared that a similar proof of earnest desire to acquire knowledge could not be adduced in our own country, where, indeed, there is the greatest possible difficulty in getting students to attend even a single night a week during the winter time. No doubt, progress is being made as the result of the efforts of the County Councils to provide technical instruction in mining as in other trades. I am able to say, from my experience as an examiner, that there is an advance in the knowledge acquired in the various local classes, which are carried on by the West Riding County Council during the winter months, and the lectures which are given at Sheffield and at Leeds on Saturdays, and at Barnsley on Wednesdays, are attended by a considerable number of earnest and intelligent young men ; but, after all, what is two hours a week in comparison with the systematic daily course of instruction which is provided in Germany, and which, as I have already said, is so eagerly taken advantage of ?

The question of the relative value to be assigned to practice and theory in the industrial arts is one which has often been and still is debated, but there never was a time when it was of greater importance to realize the true bearings of these two sides of fruitful knowledge than now. I think the experience of everyone will confirm me when I say that, though in the abstract most men will admit that practice and theory must go hand-in-hand, yet in everyday life we hear a great deal of nonsense talked on the subject, betraying a confusion of ideas, which to

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Germany are, moreover, better adapted to their object by their former training. The same may be said of almost every trade in which Germany competes with us. There are few trades which are not built on a scientific basis, and it is in recognition of this scientific basis and in unwearied efforts to construct a new and improved edifice upon it, that Germany holds such advantages as she can fairly claim. The advantage is not confined to the experts, the workers themselves, thanks to a superior system of technical education, handle their materials with knowledge and intelligence. The only way in which we can cope with German progress in this matter is by imitating German methods. Better technical education, more readiness to progress, and a scientific training which will be of greater aid in producing industrial developments, are the first means to be employed if we are in future to preserve our commercial supremacy.

a great extent obscures the real point at issue. I think our time will not be wasted if we try to focus our ideas, and make clear to ourselves what is the true end and object of scientific knowledge in connexion with callings such as mining, in which empiricism must, by the necessities of the case, always be a very important, if not a preponderating factor.*

The navigation of the sea was in early times an art which was necessarily untechnical, in the sense that the sailors relied on their own observation and experience, and had almost no recourse to scientific methods. The result was that, in the course of their voyages, they scarcely dared to venture out of sight of land, and navigation was consequently very much restricted. When, by degrees, they obtained a little assistance from astronomy, and learnt to steer a course by observation of the stars, they made a step in advance; but it was not till the invention of the compass that they could venture far upon the trackless ocean with security. At the present moment, the navigation of ships requires a very considerable amount of special scientific training; and, even with the assistance of the national observatories, and the use of delicate instruments of precision, considerable mathematical calculations are necessary to determine the position of a ship upon the ocean from day to day. But, by means of this scientific knowledge, the carrying trade of the world is conducted with almost absolute certainty and punctuality; and in spite of wind and weather, of fog and darkness, our ships perform their voyages with the precision of a railway-train. But it may be doubted whether, if the requirements of mankind had been satisfied with the primitive seafaring methods of antiquity, all these improvements and these scientific attainments would have come to pass. We can imagine some old ship's captain saying, "I don't believe in all this book-learning, I never had it, and I've sailed the seas these

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* An eminent manufacturer on Tyneside wrote to the *Newcastle Daily Chronicle* of October 24th, 1896, as follows:—

"The only technical education which is possible, on a pedagogic basis, consists in giving a foundation, the deeper and broader the better, in the sciences which underlie the technical work. Of this sort of technical education we cannot have too much, or too much encourage an appreciation of its value, or too much assist by all the means in our power the growth and capabilities of those institutions which supply it.

There is no denying that in this sort of education we have always been behind the Germans. We have not had as good opportunities for getting it, and as a people we have lacked, and still largely do lack, the proper appreciation of it. Of late years we are making rapid advances as regards the means of obtaining scientific training, and the value, and even necessity of it, are coming to be more and more appreciated. Assuredly, no busy technical specialist can ever be anything but greatly benefited in his work by having been well instructed in the science of his business, and trained in scientific methods, before he had to put his nose to his own particular grindstone. In the hands of such men our industries would not suffer any deterioration—they would rather advance and throw out new branches."

sixty years and more. Let a boy learn to handle a rope and reef a sail, and he'll be all right; but the book-learning will only take the manliness out of him." I say, we can understand such language, because we often hear something very much like it in connexion with mining, but we think it very foolish all the same. Still, the analogy may help us to see our own position a little more clearly. Mining in the last century was like the navigation of ancient times; it was distinctly unscientific and empirical. The coal was worked at shallow depths, but the dangers and inconveniences of the calling of a miner were a thousand times greater than they are to-day under far greater difficulties. I believe that in the shallow ironstone-mines of this district the ventilation was so bad that "black spit," or miner's phthisis, was a general complaint. It is now practically unknown, though the descendants of those men have to work in far deeper mines, perhaps at the distance of 1 or 2 miles from the shafts.

Mining nowadays is pursued, is made possible, by the invention of the safety-lamp, quite as much as navigation was made possible by the invention of the compass. And perhaps there is not in the whole history of invention a more striking case of a purely scientific discovery, obtained in the best scientific method, which was at the same time so truly and essentially practical, as the wire-gauze cylinder of Sir Humphry Davy.

I have said that the mining of the last century was like the coasting voyages of the ancients; the mining of the day seems to me, with your pardon, hardly so far advanced as an art as the ocean navigation of to-day.

We had for the first half of this century, the coal-mining and (to a great extent) the manufacturing industry of the world to ourselves. Europe plunged in war, crushed by the military tyranny of the first Napoleon, and bound down by the slowly-falling fetters of mediæval feudalism, was hampered in the race, and in consequence Great Britain became the workshop of the world. We had, too, great natural advantages. Our seams of coal were thick and of fine quality, and they were almost level and conveniently disposed for cheap and easy mining. Everything was in our favour, and consequently against the foreigners in competition with us. We gloried in our commercial pre-eminence, and attributed it to the genius and the shrewd practical common-sense of the British race. Far be it from me to undervalue these qualities, they are among the most priceless things that we possess; but they do not suffice us to-day. Nothing is, indeed, more forced upon our attention at the present moment than the extreme difficulty with which British trade is now maintained, and the rapid strides with which other countries are gaining upon us.

An excellent opportunity of gauging the rate of American progress in iron and coal is afforded by the issue, which has just taken place, of two interesting and important documents, namely, the summary authorized by the Treasury of the United States, giving the imports for the fiscal year ended June, 1896, and *The Production of Coal in 1895*, issued by the division of Mineral Resources of the Geological Survey. The imports of iron and steel manufactures amounted to 370,546 tons in 1896, and to 325,037 tons in 1895; while the imports of iron-ore amount to 776,285 and 262,205 tons respectively. The exports of iron and steel manufactures thereof, for the fiscal year 1896, are valued at 41,159,422 dols. (about £8,231,884), against 32,000,989 dols. (about £6,400,197). These figures show a very great increase in the United States exports of iron and steel, and of manufactures of iron and steel in the fiscal year 1896, as compared with the fiscal year 1895. Even in 1895, the export under this head was greater than at any previous period. It is noticeable that these results have been obtained without the aid of reciprocal agreements. The total amount of coal raised in the United States in 1895 was 193,117,530 tons, of which 135,118,193 tons represent bituminous, and 57,999,337 tons anthracite coal. The value is placed at 197,799,043 dols. (about £39,559,808).

It is in no spirit of pessimism that I allude to this unpleasant fact; it is rather in order to appeal to that shrewd practical common-sense, to which allusion has already been made. Great Britain can boast the greatest names, not only in science, but in practical invention. The countrymen of Newton, of Cavendish, of Faraday, of Watt, of Stephenson, and of Wheatstone need not fear to fall behind in the race, if they only realize the gravity of the situation, and set themselves to meet it with the dogged determination said to be characteristic of the British race.

The first thing to be done is to look facts straight in the face, and to allow neither pride nor prejudice to prevent us from seeing them as they are. We are still resting in the comfortable belief that things are much as they used to be in the time when Great Britain had the coal trade and the iron trade nearly to herself. Although we have been told that this is not so till we are forced to believe it, for the most part it is a "faith without works," and we go on as if it were true. Next, the trade of the country has received, and is still receiving, staggering blows from the great strikes of late years, of which the most terrible and disastrous were the London dock strike of 1889,* and the great Midland Counties coal strike of 1893.

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* The shipping trade of Hamburg has now surpassed that of Liverpool, and Antwerp is dangerously near doing so also.

Both these civil wars have inflicted permanent injury upon our trade; and, unfortunately, there are no signs that the working classes have learnt any wisdom from them. Ignorance is the great difficulty and danger here, and the only hope we can entertain is that before it is too late, those who guide the sheep-like toilers of this land will learn the vital necessity of conserving the trade of the country for their own sake, instead of wasting their strength in quarrelling with their partner the capitalist, as "a house divided against itself cannot stand."

Another fact we have to face is that pleasure and amusement have a far stronger hold on our young men in England than they have among their competitors abroad. This is an evil which I fear is growing. No one would wish to deny to young men healthy and rational amusement, and it will be an evil day for Great Britain when her sons are not keen for manly games. But when amusement becomes the chief object in life ; when employment is regarded as a necessary drudgery to be got through in the shortest possible time, and with the least possible trouble ; when scarcely any interest is taken in doing work well, or in turning out the best possible articles ; then, indeed, there is a serious, nay a fatal symptom ; and, if it be not cured, British trade must inevitably decline, and ultimately perish. Parliament has voted considerable sums of money to provide for the instruction of the industrial classes in the technical science of their trades. But the old saying, "You may take a horse to the water but you cannot make him drink," has been only too applicable to the efforts which have hitherto been made to confer these benefits upon the mining population of this district. So much, indeed, has this been the case that I believe the West Riding County Council have been compelled to consider whether they were justified in expending such large sums of public money with such very qualified results. Abroad we do not find the same indifference. There, as I shall tell you presently, there is great earnestness and enthusiasm in the acquirement of technical knowledge. The foreigners' abilities are not inferior to our own. But they assign to sports and pastimes a place secondary to the main business of life, and do not enthrone football and horseracing in the seat which should be reserved for the calling by which they are to live.

And lastly, notwithstanding the provision which Parliament has made for technical education in recent years, we are all still far behind other countries in the systematic courses which are essential to the real training of men who are to take up the battle of this country with its competitors, and bring it victorious out of the struggle. And it is just in this particular matter that the opportunity and duty of our Institute will be found. It is for us, who represent the brain of the mining industry in this great county of Yorkshire, to bestir ourselves; to make clear, first to ourselves and then to others, what it is that is necessary in order to be at least the equals of our commercial rivals; to dissipate the errors which abound as to the educational equipment which is needful for young mining engineers who are growing up amongst us, and who will have to carry on the battle after us. We must stimulate these last to realize the seriousness of the struggle in which they are about to engage; we must urge them to take the fullest possible advantage of such educational opportunities as we at present possess; and we must endeavour by all the influence we can command to bring pressure upon the public authorities to get our systematic scientific and technical mining instruction extended and improved. This is, in my opinion, one of the most useful things that this Institute can set itself to do, and it is for this reason that I have selected it as the subject of the present address.

In order to make the enquiry as useful and practical as possible, I propose first to consider:—(1) What are the objects which we should strive to secure in the education of the mining engineer? (2) What are the present means of instruction in our own district? (3) Similar institutions abroad. And (4) what are the extensions and improvements in our own systems of education which we should endeavour to promote?

1. Our Present System and What we should Aim at.

There are three classes to whom instruction in technical mining is important:—The mining engineer, the colliery official, and the ordinary workmen. But the latter, only requiring such general instruction as will make him more intelligent, and enable him to follow his calling with greater safety to himself and his fellow-workmen, is amply provided for by popular lectures and simple treatises on mining.

With the official it is different. It is most desirable that he should have a sound and accurate knowledge of the scientific laws and phenomena with which he is daily brought into contact, in order that he may not only conduct the operations of the mine with safety, but may have an intelligent comprehension of the object of the instructions of the manager of the mine, which it falls to him to carry out. As mines become more extensive and machinery more general, as new motive forces, such as electricity, are brought into requisition, or new substances, such as safety-explosives, are used, it becomes most important that the under-manager, the deputy, or whatever else he may be, should know something of the principles on which the action of his appliances depends, for so only can reasonable economy and safety be assured. Such men should have, as a matter of course, a far more thorough course of instruction than they have hitherto had, and managers should insist on candidates for positions of responsibility passing through an adequate course of instruction.

But time will not permit of my dealing very fully with the technical education of colliery officials, as I wish to devote myself more particularly to that of mining engineers, and the superior class of colliery managers.

Mining students in this country do not usually receive a satisfactory technical education. As a rule, they go through the ordinary middle class school-course (which frequently now professes to give a certain amount of instruction in scientific subjects, but in the majority of cases such instruction is of no practical value whatever). When the boy leaves school he is usually articled to a mining engineer, who probably undertakes, under the articles of apprenticeship, to teach him the "business and calling of a mining engineer and colliery manager." The way in which this promise is redeemed varies according to the character and disposition of the two parties to the bargain; but it is not, and cannot be, an altogether satisfactory system. The mining engineer probably has his hands very full, and the spare time which he may have in an evening is only given to instructing his pupils at very great self-sacrifice and under great difficulties. Besides, not one man in twenty is gifted as a teacher, and when a man in middle life feels that in some respects his own knowledge is a little rusty, he shrinks from entering on a course of lessons which might occasionally land him in an embarrassing difficulty with a pupil fresh from school. As a result, the apprenticeship resolves itself into an opportunity for a pupil to spend a certain number of years about a colliery and pick up what he can. The men with whom the learner is habitually thrown are the officials, frequently men of but little education, who, though practically acquainted with the daily round of pit-work, are apt to be prejudiced and possessed of erroneous notions about many things, so that the student may get quite as many wrong notions as right ones. As time goes on he obtains perhaps a subordinate post, and eventually something of a more responsible kind; but his training has been on no enlightened basis, and he lives merely to carry on the traditions and customs which have been handed down in the colliery or neighbourhood where he has served his time.

An apprenticeship in the office of a consulting mining engineer is not much better, and is rather apt to foster in the student a disposition to cocksureness and to consider himself a superior person, a character to which he can lay no claim. Now, both these trainings are invaluable in their place, but they are only parts of a thorough course of education, and not a complete course in themselves.

The art of colliery management may be summed up under these three heads:—(*a*) To work your pit safely; (*b*) to work your pit economically; and (*c*) to make the very best of the article you produce.

To do each of these things as well as they can be done involves a very considerable amount of scientific knowledge, but it is particularly in the last that the pecuniary reward of special knowledge is to be reaped. To secure the first, the Government has organized and has enacted legislation; the second is always being pursued, sometimes more, sometimes less intelligently; as to the third, the general ignorance and supineness are astonishing and deplorable.

In the old days, our forefathers left two-thirds of the coal in the earth to support the roof; in these days, we make of two-thirds of the output of our mines a second or third-rate article. We understand something of the art of cheapening production; we have much to learn of the art of making the most of the coal when it is produced.

I am not for a moment contending that a colliery manager must be an "admirable Crichton," and combine in himself the expert knowledge of all the sciences; but I do maintain that he should know enough of these to be able to form an intelligent opinion on the various problems which are connected with his calling, and be able to judge in what direction success is likely to be obtained, even if he has to fall back on an expert in some branch of science to work out the solution.

The subjects in which a mining student should be trained may be summarized as follows:—(1) The art and practice of mining; (2) physics (mechanics, pneumatics, hydrostatics, electricity, heat, etc.); (3) chemistry (the elements of inorganic chemistry and the organic hydrocarbons); (4) geology (physiological and lithological); (5) machine construction and drawing, steam, and the steam-engine; (6) electrical engineering; (7) surveying; and (8) mining jurisprudence. And in each of these respects he should have a thorough, not a superficial, grounding.

I need not stop to remind you of the enormous development in the use of machinery in connexion with mining operations, and the great strides which have been made in the economical use of steam and the saving of fuel, which is, in these hard times, of great importance, even at collieries. Seven per cent. of the output used to be considered a reasonable quantity of fuel to be consumed at a colliery for steam-raising, but there are collieries to-day which obtain all their steam from the utilization of waste-gases from coke-ovens, and compound and condensing engines are being more generally used. Then, in electricity we have a new power, which is certain to be of enormous importance in the mining of the future; but it is a power which ought never to be used without a thorough knowledge of its principles and action, for its ignorant use underground is undoubtedly fraught with very great danger. These are typical cases of practical subjects with which every colliery manager ought to be thoroughly conversant; so instructed, indeed, that he will not be in the hands of the engine-builder or electrical engineer, but will himself possess clear and correct ideas of what the design and construction of the machinery should be, which he proposes to employ to accomplish any given object in the most satisfactory and most economical manner.

A knowledge of the elements of physics is perhaps, of all branches of science, the most essential, for it enters into every department of a colliery manager's work.

2. OUR PRESENT EDUCATIONAL FACILITIES.

As I am addressing only members of the Midland Institute of Mining, Civil, and Mechanical Engineers, I confine myself to mentioning those colleges providing a mining course which would be likely to be made use of by students within the Midland district. There are, of course, other colleges in various parts of Great Britain where technical mining instruction is given, but it would swell the bulk of this address too much to attempt to deal with all of them.

(1) THE ROYAL SCHOOL OF MINES, which now forms part of the Royal College of Science, London, is intended to give students a thorough training in the general principles of science, followed by advanced instruction in mining and metallurgy.

The course lasts three years, and the fees amount to about £75. The laboratories are magnificent, and laboratory work constitutes a leading feature in the course of instruction. Hitherto, however, the Royal School of Mines has devoted its teaching more to the department of metalliferous than to that of coal-mining; and probably, unless there should hereafter be a considerable development of coal-mining in Kent, it will continue to be of little value, so far as the northern coal-fields are concerned.

(2) THE DURHAM COLLEGE OF SCIENCE, NEWCASTLE-UPON-TYNE, offers a somewhat complete course. It requires the attendance of the student at least three days a week,* and the programme is as follows:—

First Year.—Mathematics, chemistry, physics, mechanical drawing, and chemical and physical laboratories. *Second Year.*—Geology (with field work), junior engineering, mineralogy, mechanical drawing (advanced), technical electricity and electrical laboratory, and metallurgical laboratory (for assaying of ores and fuels). *Third Year.*—Mining, metallurgy, dressing of minerals (for metal-mining certificate), elementary organic chemistry (for coal-mining certificate), and mine-surveying.

Here, certainly, is a very excellent programme, but it is so extensive that I venture to doubt if three days a week are sufficient to cover so much ground, unless two other days are devoted to laboratory work. The theory and practice of mining occupies two hours a week; mine-surveying, three hours; the engineering class, four hours a week; and mechanical drawing, two afternoons in the week.

We have in the county of Yorkshire two technical colleges which give instruction in mining, the Yorkshire College, Leeds, and the Firth College, Sheffield. Both are anxious to promote mining instruction; but as yet the encouragement that they have received has not been enough to justify them in providing more than a provisional programme in this particular department.

(3) THE YORKSHIRE COLLEGE, LEEDS.—The coal-mining course occupies two years, and includes courses of lectures on mining engineering, chemistry, and geology. The first year course includes one lecture a week during the first term on the chemistry of coal-mining, and another on the geology of coal-mining. During the second and third terms there is a longer lecture once a week on the theory and practice of coal-mining, mining engineering, and colliery management. The second year course is entirely devoted to mining engineering, and there is a course of ten to twenty lessons in surveying.

Although not organized as part of the recognized coal-mining course, it would certainly be possible for students, devoting their whole time to attendance at the lectures at the Yorkshire College, to take a course very nearly corresponding to that already quoted at The Durham College of Science. But, to the best of my belief, mining students do not avail themselves of the classes outside the special mining course, and what real educational benefit is to be expected from two hours' instruction a week?

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* See Prof. H. Louis' remarks, *Trans. Fed. Inst.*, vol. xii., page 162.

No doubt it does give the student some insight into the rationale of mining methods, but as to educating him in the sense in which foreigners understand the term, it is a mere delusion.

(4) FIRTH COLLEGE, SHEFFIELD.—The mining instruction given at this college is divided into two sections:—(1) An advanced course; (2) an elementary course. The advanced course is intended to give scientific instruction to articled pupils, who are unable to devote more than two days in the week to attendance at the college. The course extends over three years. Where, however, students can devote their whole time to attendance at the college, additional lectures and laboratory work can be arranged for in connexion with the regular college classes. The subjects of instruction are as follows:—

First Year.—Mathematics, mechanics, chemistry, chemical laboratory, steam, geology, and engineering drawing and design. *Second Year.*—Mathematics, mechanics, chemistry in its special application to coal-mining, engineering, engineering laboratory, electricity, physical laboratory, and principles of mining. *Third Year.*—Mathematics, elements of civil engineering, steam, electrical engineering, engineering laboratory, mine-surveying, and mining. In addition, it is intended to commence a course on metalliferous mining, with instruction in assaying.

The elementary course is spread over two years, and is intended for colliery officials who are unable, by reason of their employment, to attend classes at the college during the week. The classes are held during four hours on Saturday afternoons, and at the end of the course certificates are presented to those who have satisfactorily passed the examinations in all the courses of instruction. Instruction is given in:—

First Year.—Mechanical drawing (2 hours), practical mining (1 hour), chemistry, ten lectures (1 hour), and mechanics, twelve lectures (1 hour). *Second Year.*—Mine-surveying (2 hours), practical mining (1 hour), and steam and steam-engine (1 hour).

Practically the same courses are given under the joint auspices of the Yorkshire and Firth Colleges at Barnsley, and by the Firth College at Derby.

Local Popular Lectures.—These lectures consist of popular courses given in the mining villages of the West Riding during the winter months (October to March), by special lecturers from the Yorkshire and Firth Colleges. Fifteen courses are given each year, viz.:—Five by the Yorkshire College, Leeds, and ten by the Firth College, Sheffield. The courses given by the Yorkshire College consist of twelve lectures each, comprising three lectures on the chemistry, and three on the geology of coal-mining, with six lectures on the theory and practice of mining.

The lectures undertaken by the Firth College consist of five courses, of eleven lectures each, on practical mining, and five, of ten lectures each, in which either the chemistry of the mine gases or the elementary applied mechanics are taken.

In the past the object aimed at in these lectures has been to arouse among the mining population an interest in elementary scientific knowledge in connexion with them, and with this view the endeavour has been made to attract large numbers; in future it is hoped that the classes will be (though possibly smaller) composed of students who are prepared regularly and diligently to pursue the course of study, and present themselves for examination at the conclusion of the courses.

The West Riding County Council provide the funds for the elementary and local lectures in their division of Yorkshire, and the Derbyshire County Council do the same in that county.

3. FACILITIES IN FOREIGN COUNTRIES.

France.

The countries nearest to us, and with which we are most directly in competition, are France, Belgium, and Germany, and in giving some account of the systems of technical education provided in these countries, we shall have an example of each of three systems pursuing lines somewhat dissimilar from each other in detail, but which all differ very markedly from the mining technical instruction given in this country, both in the subjects on which greatest stress is laid, and in the length of time which is devoted to their study. It would seem that in Belgium, an extraordinary value is assigned to the acquisition of a very thorough general scientific foundation, particularly in the branch of mathematics, which is carried to a high point. In France, great importance is also assigned to mathematics, but great stress also is laid on the various branches of physics. In Germany, the instruction is of a singularly practical description, and accords more with my own ideas of what it is desirable that we should strive to imitate.

I am aware that Prof. Merivale has in a previous paper (read before the North of England Institute of Mining and Mechanical Engineers)* reviewed the work which is being done all over the world in the direction of technical mining education, but in endeavouring to cover the whole field he has necessarily been unable to fully deal with the particular points which I wish to bring under your special notice on the present occasion.

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* *Trans. Fed. Inst.*, vol. v., page 623.

NATIONAL SCHOOL OF MINES, PARIS.—The National School of Mines is placed under the control of the Ministry of Public Works, and its object is to train engineers for the Government service; also to give instruction to students desirous of obtaining the diploma of *ingénieur civil des mines*, and to become engineers and managers of mines, metallurgical works, railways, and chemical factories. Engineer students *(élèves ingénieurs)* are taken exclusively from amongst the highest pupils of the Polytechnic, and are nominated by the Minister. Day students are admitted by competition, the examination being conducted by a special commission.

The special course lasts three years. Preparatory courses lasting one year have been arranged, to allow of young men who have not passed through the Polytechnic acquiring the special instruction. The preparatory course includes:—(1) Geometrical analysis, and descriptive geometry, with its applications; (2) mechanics; (3) physics, thermodynamics, electricity, etc.; and (4) chemistry (particularly of the metals).

The system of instruction comprises practical mining, metallurgy, analytic mineral chemistry, industrial chemistry, mineralogy, palæontology, geology, applied geology, machine construction, electricity, political economy (industrial), mining legislation, and German and English languages. The practical work consists of:—Chemical research (and specially analysis of minerals and metallurgical products) work in mineralogy and petrology, the laying out of works and mining operations, the winning and working of mines, machine design, and plan making.

At the termination of each year excursions are arranged into the mining districts.

Students who do not obtain 55 per cent. of the possible marks at the examination which takes place at the end of each year are dismissed. At the end of the course students who have obtained not less than 65 per cent. of the possible marks obtainable during the three years obtain the diploma of *ingénieur civil des mines.*

THE SCHOOL OF MINES, ST. ETIENNE, is also under the direction of the Ministry of Public Works. It is intended for the training of engineers and managers of collieries and metallurgical works. Foreign pupils are received. The instruction is free, but students are required to provide themselves with the necessary books and instruments.

The course extends over three years, and is specially directed to the working and treating of minerals. With this view it gives instruction in the winning and working of mines, applied mechanics and machine construction, and railway technology, applied electricity, metallurgy, mineral analysis, mineralogy, geology, legislation, and political economy.

The college work includes work in the laboratory, design (in line and colour) of machines and metallurgical apparatus, schemes for laying out mines, design of machinery, surveying above and below ground, and visits to mines and works.

The system of instruction in the school is divided into two parts—instruction in the school and the excursions. The excursion takes place after each of the two last sessions, and pupils are required to send in reports on the mines and works that they have visited.

Admission to the school is obtained after competitive examination in July of each year. Candidates are required to pass in arithmetic, algebra, geometry, rectilinear trigonometry, analytical geometry of two and three dimensions, descriptive geometry, physics, and chemistry. Those who obtain the highest number of marks in the admission examination obtain the vacant places in the school.

Foreign students are admitted on the recommendation of the ambassador of their country, provided they pass an examination showing that they are able to take advantage of the course.

THE SCHOOLS FOR MASTER MINERS, at Alais and Douai, are intended for the instruction of the subordinate officials in mines.

At Alais, students pass six months at the school, and six months in the mines. At the school: November, December, February, June, and July; and in the mines: March, April, May, August, September, and October. Pupils reside at the school. The instruction is free, but the cost of board and lodging is £16 per annum. Working miners only are received from 18 years of age and upwards, who have worked not less than 18 months in a mine. Foreign students may be admitted at the discretion of the Ministry of Public Works. Admission to the school is obtained after competitive examination. Diplomas and certificates are issued at the end of the course to students who obtain 65 per cent. and 55 per cent. respectively of the possible marks. The course lasts two years.

At Douai, the students are admitted at 16 years of age. They must have worked in a mine one year, or longer for older workmen. Here, also, the students are boarded. The instruction extends over two years. It includes:—(1) Reading, writing, and orthography; (2) elementary mathematics; (3) machine design, planning, and surveying; (4) elementary physics, chemistry, mineralogy, geology, and practical mining. These subjects are treated in a simple way so as to be suited to working men. In the intervals of instruction the students learn practical smith-work and fitting-work as practised at collieries. At certain times every year the lessons are suspended, and the pupils are sent to work in the mines, where explanations are given them by the managers, deputies, and foremen. At the end of the course they are examined, and diplomas and certificates are awarded according to merit.

It should be observed that in all cases students in France devote the whole of their time to college training for three years in the superior grade, and for two years in the lower grade. There is nothing analogous to our once-a-week lectures during the winter months. The education obtained must necessarily be of an altogether different character from that which we try to give, if, indeed, we can seriously regard our technical mining lectures as an educational system at all.

Belgium.

Mining being the most important of the Belgian industries, we should expect that special attention would be given to it by the government, and we find that this is the case. The chief school of mines is that at Liége, but there is also a mining department in the University of Brussels, and a special School of Mines at Mons, besides numerous practical schools throughout the country for the education of the official class.

LIÉGE.—The institution at the University of Liége of a course of instruction intended for students wishing to enter the service of the state, or to undertake the management of mines, dates from 1825, but a few years ago it was entirely reorganized. A special department of Arts and Manufactures and of Mines has been created, with the power of granting degrees. These degrees comprise the superior one of *ingénieur civil des mines*, an inferior degree of *candidat*, and certificates of capacity for those students who do not aspire to the higher grades.

Candidates for the degree of *ingénieur civil des mines* have, before admission to the School of Mines at Liége, to pass an examination before a board, composed of the professors of the university, in languages, history, and geography, and the various branches of mathematics. It does not include any examination in practical mining, and the largest number of marks are assigned to languages, but a very considerable knowledge of mathematics is necessary even for this preliminary examination.

The course prescribed lasts three years, and at the end of each year there is an examination which deals with a different series of subjects. That of the first year comprises:—Applied mechanics, machine construction, industrial physics, analytical chemistry, and especially the analysis of mineral substances, and mineralogy and the elements of palæontology. The second year's examination deals with:—The construction and application of machines, industrial chemistry, geology, practical mining, metallurgy, and industrial architecture. The third year's examination includes:—Surveying, railway construction, electricity and its industrial applications, practical mining (advanced), metallurgy (advanced), industrial architecture (advanced), commercial and industrial geography, political economy, and mining jurisprudence. For the lower degrees the subjects are somewhat similar, but, naturally, are not so advanced.

HAINAULT SCHOOL OF MINES, MONS.—This school, situated in the midst of the great coal-field of Southern Belgium, was founded in 1837 by the provincial council. In the introductory preface to the prospectus of this school the following interesting passages occur:—

> At that period (1837), the greater part of the industrial enterprises of our country were directed by men often very intelligent, but who had only received a purely practical knowledge of their business, and who could not bring to bear an enlightened judgment as to the value of the improvements of which the various industrial processes were susceptible as human knowledge advanced and improved methods in the processes of production were introduced.
>
> The ease with which all the young people who have left our school have obtained situations in our great industries has given the most positive proof that the provincial council of Hainault have satisfied a real and pressing need in establishing this school, and no effort has been spared to render the instruction of the young people attending the course as complete as possible.
>
> Thus it is that the instruction, which was at first for two years, was extended first to three, and afterwards to four years, in order that the new developments of industrial science might be adequately studied. The necessity of scientific preparation for every one who wishes to devote himself to industrial operations is now sufficiently demonstrated; indeed, it is needless to insist on the absolute necessity of this condition. Latterly, the number of foreign students, French, German, Russian, Polish, etc., who have followed, and who still follow, the course of this establishment, proves that its reputation has extended far, and that its services rendered to young people who have studied here are appreciated in other countries than Belgium.

It is noticeable that among the enumeration of foreign countries, Great Britain does not appear, an evidence of how completely we are out of harmony with opinions prevalent as to mining training on the Continent.

The following table will best give an idea of the course of study at the Mons School of Mines :—

Days.	Hours.	First Year.	Second Year.	Third Year.	Fourth Year.
Monday	8-10	—	Political Economy	—	Practical Railway Construction
	10-12	Exercises	Drawing	Industrial Chemistry	Industrial Chemistry
	2-4	Mechanics	Assaying (2 to 5)	Laboratory	Laboratory
	4-6	Exercises		—	—
Tuesday	8-10	Drawing	Applied Physics	Applied Physics	Railway Construction
	10-12	General Chemistry	Drawing	Practical Mining	Mechanics
	2-4	Descriptive Geometry	Stone Cutting and Carpentry	Stone Cutting and Carpentry	Laboratory
	4-6	Exercises	Exercises	—	—
Wednesday	8-10	—	Assaying	Machine Construction	Practical Mining
	10-12	Exercises	—	Metallurgy	Metallurgy
	2-4	Mechanics	Machine Construction	—	Laboratory
	4-6	Exercises	Exercises	—	—
Thurs.	8-10	Drawing	Exercises	Practical Railway Construction	Essays
	10-12	General Chemistry	Building Construction	Practical Mining	Geology Field-work
Friday	8-10	Elementary Physics	Mathematics	Railway Construction	—
	10-12	Drawing	Mineralogy	Mechanics	Practical Mining
	2-4	Descriptive Geometry	Mechanics	Electricity (2 to 6)	Building Construction
	4-6	Exercises	Exercises	—	—
Saturday	8-10	Analytical Geometry	Drawing	Political Economy	Machine Construction
	10-12	Elementary Physics	Mechanics	Geology Field-work	Practical Mining
	2-4	Exercises	Machine Construction	—	Electricity (2 to 6)

In addition to those above described, there are numerous schools of lower grade for the instruction of colliery officials.

Germany.

Mining schools in Germany have existed for several centuries, but the present system of education given in the mining district of Dortmund dates from 1861. In that locality there exists a fund called the Westphalian Mining Fund, which originally had as its object the relief of the relatives of those who were incapacitated or lost their lives from accidents in mines, but which is now to a considerable extent available for other purposes. It amounts at the present time to about £5,000 a year, but as this would be insufficient in itself to carry on the thorough system of instruction which is now provided, it is supplemented by contributions from all the collieries in the district by a voluntary rate of 0·2 pfennig per ton on coal raised. This is only 0·024d., but it produces about £4,000 a year, and contributions from other sources bring up the amount available for the purposes of the fund to £12,500 a year.

Instruction is given in two ways, as in our own district. In each of the important mining towns there are evening classes open to all miners free of charge; where, following up the excellent elementary education given in the schools, young men of the age of 18* are passed through a two years' course, which includes arithmetic, drawing, practical mining, mining law, and other kindred subjects. When a student enters for these classes, he is bound to attend them regularly and for five nights in the week. The number under instruction during the present year (1896) in these classes is about 460. It is evident that the work done is of an entirely different kind from the popular lectures which are given in certain mining centres in South Yorkshire one evening in the week, and where the attendance of the greater number of the learners is very irregular.

MINING SCHOOL, BOCHUM.— The most important work, however, which the Westphalian Mining Fund conducts is the Mining School at Bochum. In the present buildings (which are about to be superseded by a handsome new college) there is only room for 300 students, but when the new buildings are completed this number will be greatly increased. The object aimed at in this school is not the training of the higher class of mining engineers, and those who will have the general management of large concerns, but that of those who are candidates for subordinate positions; particularly under-managers, overmen, deputies, and enginewrights; although provision is also made for the education of the class which would correspond to our certificated managers. Of the higher education which is necessary for employment under government I shall speak presently.

The school includes lecture-rooms, a fine geological museum, a chemical laboratory, and a museum of models as well as special rooms for drawing and surveying classes. The staff of professors includes :— The principal, professors of mining, of chemistry, of geology, of mathematics, and of physical science; and teachers of surveying, of machine-construction, and of drawing.

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* It is a condition that candidates for these classes must have worked for two years in or about a mine.

The work is divided into three branches :— (1) a lower class ; (2) an upper class ; and (3) a surveyors' class. The lower class consists of persons who have already served four years in a mine, and who have for the most part completed their term of military service, and who have resumed their duties at the collieries. The hours of instruction are so arranged that men can attend the morning classes when their work is on the afternoon shift, and the afternoon classes when they are on the morning shift. Thus the morning class begins at 7·30 a.m. and goes on till 11 a.m. ; the afternoon class begins at 4·15 p.m. and goes on till 7·45 p.m. The total number of hours which a student in the lower class must attend at the school is 24 per week, and the course lasts for two years, with the exception of twelve weeks' holiday in each year. In the upper class, the numbers are smaller, and the students are men who have either passed through the lower class, or have given evidence of educational qualifications which enable them to take up this work, which is more advanced than in the lower class. They devote their whole time to the school (36 hours a week) and the course lasts for a year. There is also a special year's course for instruction in surveying.

The subjects taught in the lower class are as follows :—Drawing, plan-making, and mechanical drawing ; mathematics ; mechanics and machine-construction ; surveying ; practice of mining ; mineralogy and geology ; physics and chemistry; mining law ; and book-keeping.

The time-table on the following pages will afford an idea of the course of study at the Bochum Mining School.

It is needless to say that the students who have passed through a two years' course of instruction at the Bochum Mining School—and who are, it must be remembered, working men—leave it with a very thorough mining education ; a better education, probably, than is possessed by many young Englishmen who have had the advantage of a public school education, and who have been articled pupils. But these men look no higher than the subordinate positions in the collieries. Where, however, the subordinate officers of a mine are men of this stamp, it is evident that the whole of the operations must be conducted with an intelligence and knowledge which are wanting in men who have not had such educational advantages.

Such being the educational equipment required for the subordinate positions in collieries, it may be supposed that a high standard is prescribed for those who are to occupy the highest and most responsible posts, whether as servants of the state in the capacity of inspectors or managers of the state mines, or in private employment as the general

MINING SCHOOL, BOCHUM.—(a) FROM APRIL 1ST, 1896.

Hours.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
(1) SURVEYORS' CLASS.—SESSION 1894-5.						
7·30 to 9 9·15 to 11 — 11·15 to 1	Mathematics Surveying & Plan-making	Mathematics Mining Law Mineralogy	Geology Stratigraphical Geology German	Practical Surveying	Mining Mathematics —	Practical Surveying
(2) UPPER CLASS.—SESSION 1894-5.						
7·30 to 9 9·15 to 11 11·15 to 1	Mining Mathematics Drawing	Mining Drawing	Geology Mechanics and Machine Construction Mining	Mathematics Mining Law Physics	Surveying	Chemistry Mining Mechanics and Machine Construction
(3) LOWER CLASS. DIVISION A.—SESSION 1894-6.						
4·15 to 6 6·15 to 7·45	Mining Natural Science	Drawing	Mining Mathematics	Drawing	Mining Mathematics	Mechanics Mining
DIVISION B.—SESSION 1894-6.						
4·15 to 6 6·15 to 7·45	Mathematics Mining	Natural Science Mining	Drawing	Mining Mathematics	Mechanics Mining	Drawing
DIVISION C.—SESSION 1893-5.						
7·30 to 9·30 10 to 11·15	Mining Natural Science	Mining Surveying	Drawing	Mathematics Mining	Mechanics Mining	Mathematics Book-keeping
DIVISION D.—ENGINE-WRIGHTS' CLASS. SESSION 1893-5.						
4·15 to 6 6·15 to 7·45	Drawing	Mensuration Book-keeping Mining	Mathematics Natural Science	Mathematics Mining	Drawing Mechanics and Machine Construction	Mechanics and Machine Construction Natural Science

MINING SCHOOL, BOCHUM.—(*b*) FROM OCTOBER 21ST, 1895.

Hours.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
(1) UPPER CLASS.—SESSION 1894-5.						
7·30 to 9	Mining	Mining	Geology	Mathematics	Surveying	Chemistry
9·15 to 11	Mathematics	Drawing	Mechanics and Machine Construction	Book-keeping		Mining
11·15 to 1	Drawing		Mining	Physics		Mechanics and Machine Construction
(2) LOWER CLASS. DIVISION A.—SESSION 1894-6.						
7·30 to 9·30	Mining	Mathematics	Drawing	Mathematics	Mining	Surveying
10 to 11·30	Natural Science	Mining		Mining	Mechanics and Machine Construction	Book-keeping
DIVISION B.—SESSION 1894-6.						
4·15 to 6	Mathematics	Drawing	Natural Science	Surveying	Mathematics	Mechanics and Machine Construction
6·15 to 7·45	Mining		Mining	Book-keeping	Mining	Mining
DIVISION C.—SESSION 1895-7.						
7·30 to 9·30	Mathematics	Surveying	Mining	Drawing	Mathematics	Drawing
10 to 11·30	Mining	Mechanics and Machine Construction	Natural Science		Mining	
DIVISION D.—ENGINE-WRIGHTS' CLASS. SESSION 1895-7.						
4·15 to 6	Drawing	Mathematics	Mathematics	Mathematics	Drawing	Natural Science
6·15 to 7·45		Mining	Mining	Natural Science	Machine Construction	Mechanics and Machine Construction

managers or chief engineers of important collieries. The government officials are numerous, and the state possesses collieries of its own, but it seems to be the general custom for young men who desire to reach the higher rank of mining engineers to qualify by passing through the routine prescribed by the state, even if they do not intend eventually to take any public post.

The course pursued is as follows :—A youth possessed of a certificate that he has passed the final examination at a higher state school makes application at one of the head mining-offices *(ober-bergamt)* for enrolment as a candidate for state employment in the mining department. Besides his school certificate, he must present a medical certificate of health, and testimony as to good character. If accepted, his technical education is taken in hand by the state, and he is henceforward under the direction of the *ober-bergamt.* He is called a mining student *(bergbaubeflissener).* His training consists of :—The practical course; the academic course ; and the technical and business preparation.

(1) *Practical Course.*—The first year is devoted to becoming practically skilled in mining handicrafts. And here, we may notice, that in Germany a high value is attached to practical knowledge. The following extract from a ministerial circular proves this: the minister writes :—" The one-year course *(lehrzeit)*, when properly utilized, should give the mining student such practical experience as will fit him for pursuing his academic course with profit," and he adds: one of the inspectors reports that " the opportunities afforded the young people are often neglected; the actual practical work, acquaintance with the smaller appliances and arrangements of the mine, are reduced to a minimum, and many students think that they have done more than enough when they have learnt how to bore and charge a hole, or take a hand in the working-places, by way of helping the collier; but a regular observance of the regular working hours is considered out of the question, and many students regard actual manual work as unnecessary." " In such a case," writes the minister, " the oversight of the authorities is to blame, and more strictness must be observed in future."

Here we have a very practical, not to say a severe, interpretation of the way in which young men aiming eventually at occupying positions of high responsibility, and commanding the expenditure of large amounts of capital, should lay the foundation of their theoretical knowledge by acquiring a thorough grasp of the actual manual operations which their workpeople have to perform.

(2) *Academic Course.*—A three years' course of university study is required for the acquisition of theoretical knowledge in mathematics,

natural science, mining law, and political economy, as well as in mining engineering. Of this period, at least three years must be passed at an university, and there are certain universities where special instruction is given in these subjects to meet the requirements of mining students, for example, Aachen, Berlin, Bonn, and the mining schools at Clausthal and Freiberg. It is not so much required that students should attend lectures as that they should qualify themselves to pass with credit the special examinations which are held every half-year in the following subjects enumerated in the official rules:

A. Mineralogy and geology, including petrology; inorganic chemistry and chemical analysis; physics; mathematics, viz.:—(*a*) pure mathematics to analytical conic sections, functions, etc.; (*b*) applied mathematics, statics, and mechanics of solid, liquid, and gaseous bodies (special value is set on readiness in working out practical problems, the use of logarithms, and practical geometry); the elementary principles of law, with special reference to mining law; and political economy.

B. Mining engineering, blast-furnace practice, prospecting, chemical technology, surveying, and machine-construction.

Students who pass the examination at the close of their studies at the university receive a certificate from the examination commission, which, when presented at the *ober-bergamt* of the district in which the student is registered, entitles him to be enrolled as a *berg-referendarius*, a term for which I can hardly suggest an English equivalent (probationer?). Students who pass the examination with distinction may be recommended by the examining commission to the ministry of public works for a premium or travelling scholarship. The students who fail in their examination have a second opportunity, but if they fail in the second examination their names are removed from the list of state candidates.

(3) *Technical and Commercial Training.*—Students who have been registered as *berg-referendarien* receive further training, which is divided into a technical and a commercial branch. The technical training includes all the operations incidental to collieries, ironworks, and salt-mines, as well as practical surveying. The commercial training comprises the general management of collieries, ironworks, and salt-mines, the business transacted in the offices of the inspectors of mines, and in office work and book-keeping, and the special calculations required in connexion with these undertakings.

The course extends over three years, of which at least nine months must be spent in the offices of a colliery, ironworks, or salt-mine, six months with an inspector, two months with a chartered surveyor, and nine months at the head mining-office (*ober-bergamt*).

When this period is completed, a second examination takes place. On this occasion the *berg-referendarius* has to produce:—A certificate frcm the chiefs under whom he has been trained; a certificate from the military authorities that he has completed his military service; a list of the principal reports, memoirs, or essays and notes of travel; and in addition: (*a*) original drawings of the plan of a mine; (*b*) section of a mine, showing the methods of winning the minerals; (*c*) a surface-arrangement of a colliery, ironworks, or salt-mine; and (*d*) a drawing of a large engine, or the mechanical appliances at a mine. The examination which follows is both written and *viva voce*, and consists partly of essays written by the students, on selected themes such as—a treatise on some branch of political economy or mining law; on some technical mining subject; or a report on some department of mine management.

The *viva voce* examination is to be specially directed to ascertain whether the candidate has acquired an intelligent knowledge of the subjects which he has been studying, and whether he is able to practically apply what he has learnt.

I have dealt with this part of my subject at great length, but not, I think, at greater length than it deserves. I have endeavoured to bring our as forcibly as I can the essential difference between the systematic instruction open to mining students in France and Germany, and the deplorable state of things in this matter at home. I now turn to the last section of my subject—

4. How is our Mining Educational System to be Improved?

(1.) The first thing that we have got to do is to persuade both the parents and the rising generation of students that the present sham technical instruction must give place to something more thorough and far-reaching. Here is our main difficulty. Many parents think that they cannot afford to send their sons to a technical college for three years, as well as five years to be spent in probation in or about a mine. As to this, I would point out that: No young man can now expect to become a colliery manager under twenty-five years of age; if, therefore, he were to begin his technical education at seventeen and spend three years at a college, he would still have five years left to be spent at the colliery. Better still would it be if the course were taken thus:—Two years at a colliery; three years at a technical college; two years in a colliery (underground); and one year at a colliery (in the office).

A youth who went through such a training would be certain to be turned out a thoroughly competent man, capable of eventually filling the highest posts, and it would be a course quite equal to those in France and Germany.

(2.) The second thing is to get the same recognition for college training from the government in settling the qualifications for candidates for colliery manager's certificates as that which obtains in France and Germany. I feel sure that this is a matter which requires only to be duly represented in the proper quarter to be acted upon. The present Home Secretary (Sir Matthew White Ridley) is well acquainted with coal-mining matters, and would receive any representations from the mining institutes in a sympathetic spirit. Our local members of parliament (one of whom has been a large benefactor of the Sheffield Technical School) would certainly lend their assistance.

(3.) The Yorkshire and Firth Colleges should be asked to arrange courses at least as complete as those of the Durham College of Science. I feel sure that they are ready and willing to do this if any pupils can be induced to come. Mining engineers who have pupils might do much to start this work by advising some of their pupils to suspend their pit-work during the college sessions, and devote their whole time to systematic study.

(4.) We must enlist the county councils in the work that we want to do. They have been feeling their way in this matter of technical education. They have been generous, and will continue to be so if only they can be satisfied that they are getting value for the money which they grant for mining purposes. Assuming for the moment that only the present amount is available, the county council would certainly receive with every consideration recommendations from this Institute as to how the money could be spent to the best advantage. Whenever it was seen that more money was necessary to the proper carrying on of the work it would be forthcoming. In this matter of funds the colliery proprietors would also, no doubt, give a helping hand. They are not less patriotic than their *confrères* across the water, and if they saw a well-organized system of mining education short of funds they would not be backward in helping it. And in so doing they would feel they were investing money to great advantage. As I began by saying our trade is hard pressed, our opponents are strong and vigorous, to hold our own we must neglect nothing that can aid us in the race, and in equipping our future engineers and managers for the struggle we shall be spending our money in the best possible way.

And now I have done. This address has far exceeded the limits that I proposed to myself when I commenced it. I would gladly have made it shorter, but I could not do so without omitting something worth considering. Let me ask you to think the matter out earnestly. It is a serious question—a vital question. It is a case of our sleeping while our competitors are wide-awake.

I think that it is clearly the duty of an institute such as ours to seriously consider the question in all its bearings; to set itself above prejudice and custom, and to take, in the interests of our common country, an enlightened view of the conditions under which British commercial prosperity depends. If the general opinion of all civilized peoples is opposed to ours on such a subject as this, we may well have misgivings as to the wisdom of the course which we have hitherto pursued; and if we have become convinced that a more complete scientific education is now essential for our mining students, if we are to keep abreast of the progress of the world, we must sedulously endeavour to promote the changes which are necessary to secure this. I believe the moment to be opportune for the successful prosecution of this work. The only thing wanting is an appreciation of the true state of affairs, and a determination on our part to put mining education on a sounder footing. No more useful work can be done by this Institute, and I commend it to your serious attention.

Mr. C. H. Cobbold, after thanking the President for his address, said that no one could have lived during the past twenty years without recognizing that we were slowly getting behind Continental countries in technical knowledge, and when they saw the practical work in technical mining instruction done here and abroad they noticed the disparity all the more. What they had to deal with at the present time was not so much the method of carrying out technical work—that could be safely left to the various colleges and institutes—but the way to put pressure first upon those who were to benefit from the education—the workman, the under-manager, and the mining engineer. If there were a demand for technical education, the colleges instead of having to ask people to attend would be besieged (as they were abroad) by applicants for technical education. One means of bringing that demand into operation would be for mining engineers when they employed anybody above the class of deputy to give preference to anyone who had attended any of the mining classes. The moment there was any advantage to be gained by having gone through a course of technical education there would be no need to seek for candidates. The difficulty at present was that there was no demand for the candidate who had gone through any one of the mining courses. Practical knowledge was the thing that was looked for mostly, and men would hardly go to the mining classes if they were paid to do so. The Firth College, last year, had a fairly complete syllabus of lectures but the classes were neglected, and it was with difficulty that mining students could be found to attend. Again, this year, a complete course of lectures had been arranged, but until there was a demand for men who had gone through a college course the classes would be badly attended.

Mr. JOHN GERRARD said he was quite sure that, in putting Mr. Walker into the presidential chair, the members had put the right man into the right place. In the work he had put before the Institute for some time past he had given full proof that if he did anything he did it thoroughly. Much consideration was being given to this subject which was one of the most pressing matters of the day, and the practical information given by Mr. Walker was of great value. Whilst it was true that Germany, France, and Belgium had rapidly increased their production, it was also true that Great Britain was in the front rank with regard to the production of coal. It was not much to be wondered at that the increase of production had been so rapid in Germany, Belgium and France, and they could not expect to continue to supply coal to those countries as they had done in the past. They must look for markets other than those of Belgium, Germany, and France, though undoubtedly they had sent, and were sending, a large amount of coal to those countries. But having said that Great Britain was still in the front rank as a coal-producer he was not going to minimize the importance which they ought to apply to mining education. Along with scientific training, practical experience, was, he thought, absolutely necessary. It would hardly be thought desirable to put in charge of an important mine a man fresh from college, however scientific he might be. As to how technical or mining instruction should be conveyed in the higher and in the elementary branches, Mr. Walker's valuable address would stimulate them to consider, and he thought there would be a practical outcome. As to the workmen he must confess that, when they had had 7 or 8 hours down a pit, and had travelled home and had a thorough wash and refreshment, they next wanted rest. He was not surprised at young fellows, having to be at the pit at 6 a.m. and getting home at 5 or 6 p.m., being indisposed to take a long railway journey to secure technical instruction. He was not speaking for them entirely, but he submitted that something might be said in their favour. He proposed a vote of thanks to Mr. Walker for his interesting address.

Dr. Hicks (Firth College, Sheffield) said that technical instruction had been studied very thoroughly in Germany. He did not think that they could hope, if it were desirable, though he did not think it was desirable, that they could get young men after spending 5 or 6 hours in the pit each day to give 4 hours a day to college instruction. He did not think that they could transfer the German system to England. The point where the German system was so good was the systematic way in which they went about their work. It was a weakness they found in technical instruction everywhere in Great Britain. The men who came—it did not matter whether workmen or others going to be managers and directors afterwards—all that they wanted to do was merely to be able to carry out just the things that they were obliged to do in the ordinary routine of their work. If they were to hold their own, managers and engineers ought to have a much fuller and more scientific knowledge, not of all branches of science, but a full knowledge of the sciences connected with their occupations. They might forget the details, but they would have got into the ways and methods of investigation, and they would have got to know that on some points certain things were known, and would know where to find them when they required them. As far as Firth College was concerned, they had done what they could for some years to provide instruction in coal-mining. They had been conscious that it was useless to try to go in for a complete system of three years' study of coal-mining. For the last four or five years, since they had had the aid of the county council, their classes had been successful. The work done had been very good, but it was altogether inadequate, compared with what ought to be done. They had tried to arrange more advanced classes, but although they had had these courses on their calendar for one or two years they had had no applications. This year they proposed a slight modification, and he hoped that that might be the beginning of articled pupils attending two days a week for three years at the college. As to practical education, it was hopeless to ask yet for the whole of their time. What he should say would be—a certain number of years given in the pit, then college for two or three years, giving their whole time to work there, and a final year in the pit. The work they did at college then would be illuminated by the needs which they had already discovered in the pit. They would afterwards go back to the pit for a certain number of years further, when the knowledge obtained would ripen. The course that they were now proposing was a new development, and—in the course of twenty years—might lead to a more advanced course of preparatory training of two or three years.

Mr. **JNO. LONGBOTHAM** seconded the resolution proposed by Mr. Gerrard, and suggested that the discussion be adjourned.

Mr. **R. A. HADFIELD** said that he had travelled abroad perhaps more than some present during the last few years, and had seen the want of some systematic method of taking up technical education in metallurgy. He thought that in Germany they had an aptitude for these things, and this country would have to work up to their level. Mr. Walker had taken the sensible way of going over to see what had been done. He had the great advantage of being able to speak German, and to understand what he saw in a way which many of them would fail to do. There again Germany set an excellent example. How it was he did not know, but nine out of ten people abroad were able to converse in other languages than their own, and that gave a great advantage in the way of reading all the best English technical journals. They had a newspaper devoted to that kind of work, and in his own line they followed all the English investigations most carefully. They had no paper of that character on this side of the Channel. He had suggested to the council of the Iron and Steel Institute the desirability of obtaining fuller information as to continental technical publications. Britain could not hope to monopolize the trade of the world. The increase during the last ten years had not been at the same ratio as some countries of which they heard so much, but they began at zero, whereas this country had already a large trade. At the same time he should not like for a moment to minimize the great importance of paying attention to the subjects touched upon by Mr. Walker.

Prof. **H. LOUIS** (Durham College of Science, Newcastle-upon-Tyne) wrote that Mr. Walker had raised a good many interesting and important points in his address; with much of what he said he (Prof. Louis) was heartily in accord, though he ventured to differ from Mr. Walker on some points. It was only on the latter that he need say anything, and in doing so he would confine himself strictly to coal-mining, and would divide the subject into the two heads of the training of engineers and the training of officials and working miners. He did not separate the two latter classes, because he held that their method of training should be identical, and that those among the working miners whose abilities were superior to those of their fellows, and who, therefore, benefited more fully by this training, would and ought naturally to rise and fill the posts of the various colliery officials. This was, indeed, the general system in this country, and was, in his opinion, a better plan in every way than the continental method of making three grades of men from the outset.

Turning, firstly, to the education of mining engineers, he ventured to think that Mr. Walker's list of subjects* was not quite perfect. He would object to the omission of mineralogy, and above all of mathematics, and he held that one or two foreign languages, ambulance work, and book-keeping or accountancy should all form part of a complete curriculum. In order of time, he would place the art of mining last and not first, because no real progress could be made with it before the sciences that underlie it, such as chemistry, physics, geology, etc., had been mastered.

Mr. Walker was good enough to endorse the course which the Durham College of Science offered, and he ventured to think that his praise would be less qualified if the wording of the calendar, which he quoted, had been more unmistakable. He did not for a moment suppose that three days a week sufficed for the ordinary student. Three days' attendance a week was the minimum that qualified a student to sit for his examinations, but as a matter of fact his mining students worked, and had to work hard, six days a week. One day was given up to that important subject field geology, and another day was a short day, but yet much more than three days a week had to be devoted to college work, exclusive of home-reading. In the third year, all the work was concentrated on three days a week, in order to enable a student to put in three days a week at the pits. The object of this arrangement was to meet, as far as may be, the provisions of the Coal Mines Regulation Act (1887), which insisted on five years' work in the pits before a certificate could be granted. As was mostly the way in this country, we had to struggle to advance our art in opposition to legislation, instead of receiving any assistance from it. He was most emphatically of the same opinion as Mr. Walker, that if the law allowed, say two years, passed at a recognized mining college to count instead of the same time in the pit, we should hear far less of our scientific inferiority to other nations, but as long as the law looked upon scientific training as a useless

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* *Trans. Fed. Inst.*, vol. xii., page 141.

incubus, our undoubted inferiority in this respect would continue to handicap us in the race. Let them contrast the attitude of our government towards the scientific training of mining engineers with that of the governments of continental nations, and there would be no need to look for any supposed inferiority in our mining colleges as compared with theirs.

He (Prof. Louis) might add that, with respect to the Durham College of Science mining course, he found that Mr. Walker's view (if he understood him properly) was not correct, and that a majority of the students did take the full course. The course of sixty mining lectures was really a course on the theory of mining only, and in it he mainly endeavoured to teach students how the sciences, which they had already studied, were applied to solve the various problems that confronted the mining engineer. He always took the knowledge of these preliminary sciences for granted. Again, in mechanical drawing, only the theory was taught, because it was assumed that the student would have plenty of practice in the drawing-office whilst serving his apprenticeship.

He (Prof. Louis) now came to another point of much importance: he held it to be utterly impossible for any college in the world to turn out mining engineers or mine managers. College training must be supplemented by apprenticeship or its equivalent. He agreed fully with Mr. Walker that apprenticeship without scientific training would not suffice to make a good mining engineer, but he was equally emphatic on the converse of this proposition. The much-lauded practical German course of college training did not, so far as his experience went, turn out practical engineers. He had, for instance, seen a graduate of a German school very doubtful as to which way to turn a nut in order to tighten it; give him pencil, paper, and plenty of time, and he could work it out quite correctly, but put a spanner in his hand and he was quite as likely to turn it the wrong way as the right. He felt sure that this could not be the case with a young man who had gone through his apprenticeship (as understood in this country) properly. At the same time, he held that continental nations had an immense advantage over us in their forced military service, which taught them to become handy, practical, smart, and self-reliant, and above all enforced the essential lesson that all must learn—who aspire to command men—that of unquestioning obedience.

Of all methods of teaching mining, he liked the American method best, but then they gave four years as a rule to their college course, and four years was none too much for so complex and manysided a subject. Nevertheless, he repeated that no college training alone could make a mine manager; even if he could leave the college with all the requisite scientific and technical knowledge, he would still have to learn to control his workmen, and, more important still, to control himself.

He might add that he did not follow Mr. Walker's reasoning,* where he pointed out that Englishmen did not attend the Hainault School of Mines. Surely this fact could be fairly interpreted as showing that they obtained what they wanted in their own country.

His (Prof. Louis) ideal course for training a mining engineer would be as follows:—Leave school at the age of 16 or 17 years, with a sound knowledge of elementary science, mathematics, and, at any rate, one foreign language; attend college courses in pure science for two years, devoting each long vacation to what the Americans term "summer schools" at some mining district (not his own); in the third year divide his time, half at the college, attending special courses on mining subjects, and half at the pits; then two, or, if possible, three more years of apprenticeship should follow. This would bring the aspirant to about 23 years of age, when he ought to have no difficulty (if the law were suitably altered) in passing an examination as colliery manager, even more searching than the present one. He did not think it a good plan for the student to go underground before he had received his scientific training, although he was aware that there was something to be said for this practice. A young man was better fitted physically to stand the work if he was a little older, and he was better equipped mentally to understand what he saw; moreover, he was generally less capable of applying himself to hard scientific reading if he had been used to the physical exertion that pit work entailed for a couple of years before coming to college.

With respect to the training of working miners and colliery officials, he did not think that Mr. Walker distinguished clearly enough between technical instruction and technical education. However deficient our miners might be in the latter, he ventured to assert that in the former they more than held their own. He had seen miners at work in most quarters of the globe, and had no hesitation in saying that in manual skill, and physical and technical ability, our British miners were hard to beat. They were backward, it was true, in scientific knowledge and knowledge of principles, but many of them were working hard to make up their deficiencies.

At the Durham College of Science, there was a Saturday class of some sixty miners and mine officials, sent chiefly by the county councils of

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* *Trans. Fed. Inst.*, vol. xii., page 149.

Northumberland and Durham, who were doing capital work in this direction. He was now engaged in an endeavour to devise for this class a complete course of systematic education in the various sciences that underlie their art. He had no need to provide for these men (any more than he held that we need provide for mining students) anything like technical instruction, such as, *e.g.*, how to hew, to drill, to cut timber, or anything of the kind. What they needed was technical education in scientific principles, and that he hoped to provide for them in a very complete form.

It must not be forgotten that the coal trades associations of Northumberland and Durham subscribed towards maintaining the efficiency of the mining instruction at the Durham College of Science, which in that respect might be compared on a small scale to the Bochum Mining School, supported by the Westphalian Coal Mining Fund. When mining colleges in this country received the same official recognition from government that was enjoyed by those in Germany, as was wisely suggested by Mr. Walker should be the case, he saw no reason why the Durham College of Science, for instance, should, in any way, either in numbers of mining students or in the quality of the training provided, fall short of its continental rivals; more especially if the coal miners' unions could be induced in their own best interests to combine with the coal trade associations to provide the necessary funds, as was being done in Westphalia, to enable as many as choose from all ranks of miners to benefit by the teaching that could be thus provided for them. Unfortunately in this country we were too much used to find legislative enactments bar the way of scientific progress, and he only hoped that Mr. Walker's address might induce some of the leaders in all ranks of coal-mining to bestir themselves as he suggested.

The PRESIDENT said he supposed that the members would agree with the proposal of Mr. Longbotham that the discussion on his address be adjourned. He was much obliged for the kind remarks made by the various speakers, and he hoped that the subject might fill their thoughts a little while and bring about some improvement in a system of education which left much to be desired.

The meeting was then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, OCTOBER 10TH, 1896.

MR. GEORGE MAY, PRESIDENT, IN THE CHAIR.

The **Secretary** read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on September 26th, and that day.

The **Secretary** reported the proceedings of the Council of The Federated Institution of Mining Engineers.

The following gentlemen were elected, having been previously nominated :—

Members—

Mr. J. S. **Chambers**, Mining and Mechanical Engineer, Little Italianshaja No. 5, St. Petersburg, Russia.

Mr. **John Macintosh Donald**, General Manager, Bantjes Consolidated Mines, Ltd., Florida, S.A.R.

Mr. **Erne Hewlett**, Mining Engineer, Ammanford, South Wales.

Mr. T. J. **Richards**, Mining and Consulting Engineer, Glamorgan Exploring Syndicate, Coolgardie, Western Australia.

Mr. **William Saint**, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester.

Mr. **Gilbert Pitcairn Simpson**, Mining Engineer, 5, Belsize Park Gardens, London, N.W.

Mr. **Thomas Michael Thackthwaite**, Civil Engineer, Beechfield, Farnham Royal, Bucks.

Mr. **John Webster**, Mining Engineer, 83, Lombard Street, London, E.C.

Mr. **William Fischer Wilkinson**, Mining Engineer, P.O. Box 267, Johannesburg, S.A.R.

Mr. **Harry Page Woodward**, Mining Engineer, c/o Messrs. Bewick, Moreing, & Co., Coolgardie, Western Australia.

ASSOCIATE MEMBER—

Mr. **GEORGE THOMAS KENNEDY**, Professor of Chemistry, Geology, and Mining, King's College, Windsor (Hants Co.), Nova Scotia.

STUDENTS—

Mr. **HENRY SHERRATT TOMLINSON**, Mine Engineering Student, Wingate, R.S.O.

Mr. **HAROLD E. WHITE**, Mining Student, Esh Vicarage, Durham.

The SECRETARY read the following paper by Bergassessor Winkhaus, on "The Danger of Employing Safety-fuzes for Blasting in Fiery Mines."

THE DANGER OF EMPLOYING SAFETY-FUZES FOR BLASTING IN FIERY MINES.*

BY BERGASSESSOR F. WINKHAUS.†

For the past eighteen months, so called "safety-fuzes" and "safety-igniters" have been employed in the mining district of Westphalia, in order to ensure greater security in blasting in fiery and dusty mines. The object of this safety-fuze is to prevent the fuze from burning through sideways and throwing out sparks, as happens with ordinary Bickford and guttapercha fuzes: this object is attained by covering the core of powder, not with jute or india-rubber, but with several layers of cotton thread, and afterwards passing the fuze through liquid tar or a bath of colouring-matter in order to make it still more impervious.

The igniters that have been chiefly used are those of Norres and Roth; the principle of both of these consists in lighting the fuze inside a metallic cap, which is nipped on to the end of the fuze, and which is supposed to stifle the jet of flame thrown out when the fuze is lit. In the Norres igniter, a small percussion-cap is used to light the fuze, and is exploded by a wire placed inside the metal cap. A part of the flame-jet from the fuze can, however, strike through the hole pierced in the cap for the passage of the wire, and can thus ignite fire-damp, as has been shown by experiments in gaseous mixtures containing 6 and 9 per cent. of fire-damp. The cap must therefore be enclosed in a wooden hood when the wire is withdrawn.

In the Roth igniter, a small glass bulb filled with sulphuric acid and a pill composed essentially of a mixture of sugar and chlorate of potassium are enclosed in a metal capsule closed at one end. When the glass bulb is broken, the action of the acid on the pill produces a tolerably sharp flash of flame, which ignites the powder-core of the fuze. It is essential that this igniter shall be very carefully nipped on to the fuze and completely enclose it, otherwise the flame of the igniter is apt to escape between the cap and the fuze, and may cause ignition of fire-damp.

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* Translated by Prof. H. Louis.

† Communications from Bergrath Kaltheuner, of Gelsenkirchen, have been embodied in this paper.

The employment of these methods of ignition has, however, been found dangerous in several respects.

In seven known cases, in which 1 miner was killed and 8 others more or less severely injured, the shot exploded at the very moment that the igniter was fired or a few seconds afterwards. Investigation of all these accidents showed that there had been no negligence on the part of the workmen. In every case, tarred safety-fuzes, 40 to 50 inches in length, were used, and they were fired in six cases by Norres, and in one case by Roth igniters according to the printed instructions. The cause of these ignitions can, according to all appearances, only be that the fuze suddenly burnt through its entire length. The assumption that such burning through could be caused by absence or deficiency of the core of the fuze is not admissible owing to the method of manufacture that is employed. After a series of investigations initiated by the owners of the Consolidation pits, near Schalke, and continued in the experimental drift of the Westphalian Miners' Association, the following phenomena must rather be regarded as indicating the cause of these accidents.

If a piece of the black tarred safety-fuze with double cotton covering (manufactured by Messrs. Bruckner and Zschetsche, Minden) be ignited and then nipped at any place with a pair of pliers about ½ inch wide and provided with grooves, the pressure being maintained until the core has burnt past the nipped portion, the fuze almost invariably bursts open below the nipped spot with a loud report and with the projection of sparks. At times a longer or shorter piece of the fuze is thus exploded and then it continues to burn quietly. Not unfrequently, it would be observed that the explosion involved the whole of the yet unburnt end of the fuze, about 40 inches long, when a violent detonation would be accompanied by sparks flying out along the whole length of the fuze, as also from its end, so that the flame had suddenly traversed the entire length of 40 inches of fuze. The same phenomenon can be produced by pressing the burning fuze against the floor with the foot. It is essential that the pressure shall be continued even after the powder core has burnt past the nipped spot, so that the hollow space produced inside the fuze by the burning of the core shall be again closed. If this be not done, the fuze continues to burn quietly. For example, the fuze could not be made to explode by nipping it between two planed surfaces of cast-iron by means of bolts; but an explosion was immediately produced when the iron surfaces were drawn up more tightly after a portion of the fuze had burnt away, so that it was closed up completely behind the burning portion.

When these experiments were repeated with a fuze covered with gutta-percha, this invariably burnt through immediately behind the nipped spot with the projection of a few sparks; no explosion, was, however, observed. When the fuze consisted of an inner jute covering with a firm outer covering of tarred cotton (manufactured by the Tongauer Company), explosions again took place below the nipped spot, but were limited to a local rupture of the fuze accompanied by sparks and report. The fuze of the same makers, with double covering of cotton tarred and covered with talc, however, burnt through up to a length of 47 inches.

The above described phenomena furnish an explanation of the production of explosions of fuze. Two classes of fuze may be distinguished, one in which the burning of the core does not destroy the outer covering, and the other in which the covering partly burns away with the core. With fuzes of the first kind, as the core burns away, a hollow tube is formed which allows the gases formed by the burning of the core to escape outwards, that is to say by the already burnt end. If this tube be now closed, as happens when the fuze is nipped as above described, the products of combustion are prevented from escaping; they, therefore, collect in the burnt out portion of the fuze until the pressure generated overcomes the resistance of the envelope and bursts the latter, accompanied by the phenomena of an explosion. If the resistance of the walls be too great, the explosion extends to the unconsumed portion of the core, which at once explodes and flashes out violently. This explanation shows why long ends of fuzes only exploded when fuzes with stout cotton covering were tested, whilst in the case of fuzes with the weaker jute covering, merely local explosions were produced.

With fuzes of the second class, where the covering is partly burnt and destroyed, such explosions cannot be caused, because the gases evolved from the powder can escape freely through the damaged covering.

In the practical employment of fuzes, this distinction between the two kinds must be still much more strongly accentuated. Here the fuze is firmly encased, for the whole or the greater part of its length, in the stemming. In fuzes with indestructible covering, there is only the tube, left by the burning of the core, available for the escape of the gases. The obstruction of this must, therefore, be doubly dangerous with such fuzes, because the stemming prevents the fuze from bursting laterally; and if the obstruction in the rear cannot be overcome, the flame must break through forwards, causing the charge to explode at once. Of course, a number of quite especial circumstances must coincide for such an occurrence to take place, otherwise, considering the thousands of shots that are fired every day, there would be a still greater number of such accidents to record. It is, however, certain that the accumulation of the products of combustion within the fuze is favoured by firmly affixing a Roth or Norres igniter. In the trials in the experimental gallery, it was not found possible to cause explosions of fuzes by simply nipping on such igniters; but explosions must occur whenever the back part of the fuze is sealed inside the igniter by the powder dust and the tar of the fuze covering. That such a case is not impossible is proved by a communication from the management of the Consolidation Colliery Company, to the effect that, after numerous trials, they had succeeded in producing an explosion of fuze on firing it with a Norres igniter.

The effect of the igniter is also indicated by the fact that the great majority of accidents occurred with the Norres igniter, and one only with a Roth igniter; the reason being that the Norres igniter must be most carefully nipped on to the fuze to avoid a misfire, while the Roth igniter does not really require to be nipped on in order to light the fuze with certainty. Of course, as already pointed out, it loses in the latter case its properties as a safety-igniter, owing to the flames escaping sideways from it.

Other circumstances, however, may also close completely the core-passage inside the fuze. If, for instance, a fuze is squeezed either by a large piece of stone in the stemming, or by being kinked inside the bore-hole, that spot might become closed completely by the residue from the powder, as would seem to be indicated by the following circumstance. A miner, who was aware of the possibility of the flame in the fuze striking through, although it had not been demonstrated at that time, attempted to secure himself by making a knot in the projecting end of the fuze, which was about 18 inches long. According to his statement, which seems quite worthy of belief, in this case the shot exploded when the fire inside the fuze must have got as far as the knot, or "at the outside" of, the stemming. Here, then, a stoppage had been produced by means of the knot.

Accordingly, the use of fuzes with very resistant coverings, that are not destroyed by the burning of the core, must be looked upon as a source of danger; and, in the writer's opinion, there is such danger in the use of all fuzes in which explosive phenomena can be produced by compression, as above described. Even the employment of those fuzes in which the phenomena are only local, appears hazardous. Only those fuzes can be considered secure against sudden firing which are partly destroyed when the core is burnt, because with these a great part of the space occupied by the fuze is free for the escape of gas, so that compression can entail no risk. As a matter of fact, no accident of this kind has ever happened, as far as the writer knows, with fuzes covered with gutta-percha—in spite of these being so widely used. At the same time, there are objections to these fuzes: the quantity of gas evolved when they are burnt, as also its penetrating odour, are disagreeable accompaniments. Moreover, this class of fuzes is subject to the other danger of not being quite safe in fiery mines.

While safety-fuzes with a resistant covering may be looked upon as quite safe as regards fire-damp explosions, when the flame thrown out by them is stifled by a suitable safety-igniter, this perfect safety does not exist in the case of gutta-percha covered fuzes, as the following experiments have proved.

In a number of experiments, about 130 feet of fuze were burnt inside the explosion-chamber of the experimental gallery,* which was filled with a 9 per cent. fire-damp mixture, in such a way that both ends of the fuzes were outside the gallery or that one end was lit inside it by means of a safety-igniter. Further experiments were tried with 65 feet lengths of fuzes, which were slightly kinked at intervals of about 3 feet. The explosive mixture was never fired. A fuze, 26 feet long, sharply kinked at 20 points, and thus partly damaged, caused an explosion of the fire-damp mixture after burning for seven minutes, say at about the twelfth kink. The total time of burning of a 26 feet length of fuze is about eleven to twelve minutes.

In similar experiments with safety-fuzes, the gas was never fired, and whilst these fuzes appeared almost unchanged after they had burnt through, the guttapercha fuzes always broke into a number of separate pieces. It may be concluded from these experiments that there is no fear of firing a fire-damp mixture by sparks thrown out from the sides of a guttapercha fuze so long as the piece projecting from the shot-hole is uninjured. If, however, it be damaged it can fire a fire-damp mixture just as well as by the flame projected from the end, when it is lit.

The fuze is thus damaged even when a Norres or a Roth igniter is nipped on to it, and it has actually been observed that a quantity of sparks are emitted and the fuze is sometimes torn off completely below the compressed spot when the fuze is lit. Although in a number of

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* *Trans. Fed. Inst.* vol. ix., page 250.

experiments, it was not found possible thus to fire an explosive fire-damp mixture, this phenomenon indicates that the employment of igniters that require nipping on to the fuze would therefore seem not to be free from risk. Attempts have been made to meet this danger by making the tubes of the igniters so long that they project into the stemming. The sparking of the fuze is thus also prevented. This is, however, only possible when the depth of the shot-hole is such that the length of the projecting end of fuze is less than that of the igniter. Damage to the fuze may be avoided by using the Kost* or the Hohendahl† igniters, both of which cover the end of the fuze only whilst it is being lit. Then, again, there is the danger that the miner may take off the igniter before the fuze has ceased to throw out flame.

In fiery mines, the degree of safety attained in using safety-fuzes must, in the main, depend upon the skill and trustworthiness of the miner employed.

In order to avoid the dangers connected with the lighting of fuzes, Dr. Roth has attempted to dispense with fuzes altogether by his method of determining the explosion of shots by the injection of gases or liquids into the cartridge. This method does not, however, appear to have been adopted in practice.‡

The Jarolimeck "water ignition,"§ which is described as "a method for the central explosion of shots by means of a chemical reaction, in which the water used for stemming penetrates through the porous covering of the special detonating-cartridge till it reaches a certain part of it made of caustic lime, and re-acts upon this, developing sufficient heat to ignite the charge of a detonator, with a simultaneous increase in volume," has the same object, namely, to dispense with the fuze. This method has not been as yet adopted in Westphalia; the same may be said of the Tirmann percussion-igniter‖ and the Lauer friction-igniter,¶ the construction of which may be assumed to be known.

A method of firing shots which is most reliable, and in England especially very extensively used, and which at the same time affords the highest degree of security against explosions of fire-damp, is electric ignition, to which a few closing remarks may be devoted.

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* German patent, No. 43,690. † German patent, No. 86,569.

‡ *Trans. Fed. Inst.*, vol. x., page 95. § German patent, No. 80,954.

‖ *Trans. Fed. Inst.*, vol. xi., page 609.

¶ *Report of the French Commission on the Use of Explosives in Mines.* Translated by Messrs. W. J. Bird and M. Walton Brown, page 153.

Electric igniters are divided into low-tension igniters, the charge of which is fired by a wire brought to a red heat by the electric current, and high-tension igniters, in which the detonating charge is fired by a spark between the ends of two wires buried in it. The former has the advantage that the tension required for ignition is so low—about 2 volts—that there is no danger of fire-damp being ignited by sparks forming at portions of the conductors that are not insulated. The objection is said to be that there are too many miss-fires. In England high-tension igniters are, therefore, chiefly used; these are fired by means of small, extremely handy, and very light magneto-electric machines. These machines consist of closed boxes, with a carrying-handle and removable crank, of dimensions 7 inches by 6 inches by 6 inches, or 7 inches by 5¾ inches by 4 inches, and weighing 7 or 8 lbs. They produce sparks with a tension of about 180 volts.

The author found these in use at every mine that he visited in a tour through the British coal-fields. They were said to be most reliable, and miss-fires with them were all but unknown. In the experiments with explosives conducted by the North of England Institute of Mining and Mechanical Engineers, for instance, such a machine was employed, and in their reports, in spite of the great number of experiments, only two miss-fires are recorded due to defective detonators.

In order to test the trustworthiness of this form of machine, one was obtained for the experimental gallery at Schalke, from the Roburite Explosives Company, Limited, of Gathurst, near Wigan. Unfortunately it was found impossible to get from German makers detonators that could be fired with it, because the German makes of electric detonators contain a less sensitive charge, that can only be fired by a very high-tension spark, such as is produced by frictional electrical machines. These machines are, however, too bulky, and too unhandy in practice. The smallest size, to be obtained from the Nobel Dynamite Company, of Vienna, is 9 inches by 9 inches by 4 inches, and weighs 7 lbs. According to the statements of German makers of detonators, it is a very difficult matter to manufacture sensitive detonators for magneto-electric machines; on the one hand, because it is difficult to make them uniform, and, on the other, because the charge must be made so sensitive that their transport is attended with danger. The writer is not able to judge whether the difficulties of producing these detonators are really so great, but in his opinion a method of ignition which has been employed most extensively in Great Britain, with the best results, ought also to be applicable in Germany. The use of electric ignition is made very much easier in Great

Britain, because the shot-firers, who fire all the shots in dangerous mines, as they do in Westphalia, only carry the electrical machine, the cable, and the detonators, the miner having charge of the explosive. In Germany, on the contrary, the shot-firer is also loaded with explosives; the introduction of machines as small, as light, and as handy as possible, is therefore of double importance.

The fear that even electrical ignition may not be quite free from danger in fiery mines, because, if the connexion with the main cable be badly made, sparks may strike across outside the shot-hole, is not, in the writer's opinion, justified. This danger can be completely avoided by making the insulated wires of the detonator and the corresponding insulated wires of the conducting cable of different lengths; the non-insulated ends of the wires would then be so far apart that it would be impossible to bring them dangerously close together.

In addition to its almost absolute safety from fire-damp explosions, electric ignition has the further great advantage, that accidents due to shots being fired too soon or too late are completely prevented.

The PRESIDENT said that Mr. Winkhaus' paper brought strongly before their minds the danger arising from the use of so-called safety-fuzes; it also showed them that the electrical method of firing shots was much the better system. The writer appeared to be satisfied that the system of shot-firing in use in Great Britain was better than that in use in Westphalia.

Mr. A. L. STEAVENSON said that the paper was valuable, inasmuch as it called attention to what might appear a small matter, but which on any occasion might be of vital importance. The moral seemed to be: don't use fuzes, but, where ordinary igniting is not possible, then use electrical firing. In coal-mines, there might always be gas (notwithstanding the most careful inspection), and there was always a certain amount of coal-dust, and under the circumstances electrical shot-firing seemed to be much the best.

Mr. T. E. FORSTER said that the writer appeared to conclude that the experience in this country had been in favour of high-tension electricity for shot-firing. Experience at the Wallsend sinking, in the presence of water, etc., had proved that high-tension fuzes had in a great number of instances failed, and he thought that low-tension fuzes were more satisfactory.

Mr. M. WALTON BROWN remarked that in the experiments made by Mr. Foggin and himself, low-tension fuzes were ordinarily employed, without a single miss-fire.*

Mr. A. L. STEAVENSON said that the principal defect of high-tension fuzes was the occurrence of occasional miss-fires; but there was no danger unless the workman dug out the charge and damaged himself. In the mines under his charge he had told the men that when it was necessary to fire a second shot the owners would pay the cost.

Mr. F. S. PANTON said that in the case of the Hebburn experiments only two miss-fires occurred with high-tension fuzes. When such a case happened, another charge with a detonator was placed on the top of the first charge and both shots were exploded simultaneously.

Prof. H. LOUIS said that the members should distinguish between the ordinary high-tension generally referred to in this country, which is produced by electro-magnetism and the high-tension mentioned by Mr. Winkhaus produced by frictional machines. He (Prof. Louis) had formerly had some experience with frictional machines, and found them very unreliable. When Mr. Winkhaus was visiting this district, a few months ago, he appeared to be rather averse to electrical firing; no doubt, that view had reference to frictional electricity, and it was satisfactory to know that he had altered his opinion after seeing electro-magnetic detonators in general use. He had seen low-tension detonators used in America, but the results did not seem to be very satisfactory; he had not, however, had any experience with them himself.

Mr. W. COCHRANE thought it was very indefinite to say that one was using high-tension detonators, and that another used low-tension detonators. He thought they might ask the author to state precisely what he meant when he said that high-tension detonators were chiefly used in England.

Mr. M. WALTON BROWN pointed out that Mr. Winkhaus stated that low-tension detonators were fired with a tension of about 2 volts, and that high-tension detonators required a pressure of about 180 volts.

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* *Trans. Fed. Inst.*, vol. ii., page 85.

Prof. **Louis** remarked that the terms "high-tension" and "low-tension" referred to the system of detonators: low-tension meant that a connecting wire was heated to redness to cause ignition, and high-tension referred to ignition by sparks passing from wire to wire.

Mr. T. E. **Forster** agreed with Prof. Louis' definition. Low-tension detonators were more satisfactory, as they could be tested before use with a galvanometer. High-tension detonators could not be tested.

Mr. F. **Winkhaus**, replying to the discussion, wrote that, in his paper, he distinguished between electric igniters: the glow-igniter and the spark-igniter. By glow-igniters are meant those by which the detonator is ignited by means of a wire brought to a red-heat by means of a current of low tension (about 2 volts); and by spark-igniters those by which the ignition of the detonator is caused by a spark which springs across two wire-ends fixed in the detonator (requiring an electric spark of about 180 volts tension). He might add that German detonator manufacturers have succeeded in manufacturing spark-igniters, which can be ignited by means of an exceptionally small and handy electro-magnetic apparatus of about 5 inches cube, and, as a consequence, the electric firing method had become gradually established in the Westphalian mining district. The results obtained up to the present time with this igniting method were very satisfactory, miss-fires rarely if ever occurring.

The **President** moved a vote of thanks to Mr. Winkhaus for his valuable paper.

Mr. G. B. **Forster** seconded the motion, which was cordially adopted.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

The SECRETARY read the following further correspondence with the Secretary of State for the Home Department, respecting the use of the plant erected at Hebburn for testing explosives to be used in mines:—†

NEVILLE HALL,
NEWCASTLE-UPON-TYNE,
February 28th, 1896.

SIR,—In view of the importance of the question of the use of explosives in mines, and the prominence that is likely to be given to it in the future, the President and Council of this Institute venture once more to draw your attention to their letter of July 12th, 1895, in which your notice was respectfully directed to the experimental station erected by the North of England Institute of Mining and Mechanical Engineers at Hebburn. The testing-plant has been seen by several members of the Royal Commission on Explosions from Coal-dust in Mines, who expressed their strong approval of its value, and as this plant is still in existence, it is suggested that some arrangement might be made for its continuance as a testing-station for mining explosives.

The North of England Institute of Mining and Mechanical Engineers (the senior mining institute in this country) has always devoted itself to objects that might tend to the safe development of mines, and to the preservation of life; it has made costly experiments and researches in many directions, notably in those tending towards the improvement of the ventilation of mines, the relative security of safety-lamps, the efficiency of mechanical ventilators, the dangers arising from coal-dust, etc. The results of these experiments and researches have been admittedly of great value to the mining industry, and having been recorded in the *Transactions*, are available for reference by mining engineers resident in all parts of the United Kingdom and throughout the entire world, in every quarter of which members of this Institute are to be found.

The experiments at the Hebburn explosives testing-station with flameless explosives for use in coal-mines have extended over a very lengthy period of time; and apart from the personal expenses of the mining engineers who have voluntarily given their services, the expenditure has been borne entirely by the Institute and its subscribers. The Council of the Institute feels that it is not justified in further encroaching on the funds of the society for the benefit of the mining community generally; for the same reason the Council cannot expect or ask professional men to continue their gratuitous services in connexion with similar experiments; and it would appear desirable that in the future some recompense should be made to those who are called upon to give their valuable assistance.

It is therefore urged that the Government should make a grant, with the view of avoiding the discontinuance of these useful experiments, and in that case the Council venture to suggest that the apparatus should be retained by the Institute,

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* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593; vol. ix., pages 115, 206, and 274; vol. x., pages 38, 197, 492, and 503; vol. xi., pages 175, 218, and 551; and vol. xii., page 51.

† *Trans. Fed. Inst.*, vol. x., page 38.

which is prepared to undertake any further experiments with explosives as suggested by the Secretary of State. The Council would arrange that reliable engineers should conduct the experiments, if the Government would contribute an annual sum towards the maintenance of the plant and other consequent expense, and pay the necessary charges attendant upon its working for each day that such experiments were made by request of the Secretary of State.

The Council is in a position to make favourable terms as to the rent of the ground, for the provision of natural pit-gas (an unlimited supply being afforded by the courtesy of the proprietors of the Hebburn colliery), and for the manual labour of those who have been connected with the apparatus from the time of its erection, a period extending over four years.

If the Institute be able to retain the station at Hebburn, the apparatus, when not required for Governmental purposes, may possibly be used for other experiments, as directed from time to time by the Council of the Institute.

Should this proposal not receive your favourable approval, the Council will be glad to comply with any suggestions that you consider desirable, as they respectfully submit that it is of vital importance that the Hebburn explosives testing-station should remain available for future experiments.

It may be that no similar grants have been made to any of the mining institutes of this country in the past, but the importance of the subject has constrained this Institute to communicate with you with the view of avoiding an occurrence which could not fail to be a calamity to the whole of the mining community.

The Council have pleasure in forwarding herewith two copies of the Third and Concluding Report of the Committee.

I have the honour to be, Sir,
Your obedient Servant,
M. Walton Brown,
Secretary.

The Secretary of State,
Home Department, Whitehall, London, S.W.

Whitehall,
April 1st, 1896.

Sir,—With reference to your letter of February 28th last, urging that a grant should be made by Government, with a view to avoiding the discontinuance of the experiments conducted hitherto by the North of England Institute of Mining and Mechanical Engineers at the Hebburn explosives testing-station, I am directed by Secretary Sir Matthew Ridley to state that in the Coal Mines Regulation Amendment Bill, which is to be introduced in Parliament this session, he intends to deal with the use of explosives in mines; and that, as soon as the Bill is passed, the question as to what part should be taken by the Government in the testing of explosives will be considered, but that until that time has arrived it will be impossible to give any definite answer to the suggestions of the Council of the Institute.

Sir Matthew Ridley gladly takes this opportunity of recognizing the important work done by the Institute, and feels sure that, if required, he may count upon receiving from it all the aid that can be afforded.

I am, Sir,
Your obedient Servant,
Henry Cunynghame.

The Secretary to the North of England Institute
of Mining and Mechanical Engineers,
Newcastle-upon-Tyne.

Neville Hall,
Newcastle-upon-Tyne,
October 10th, 1896.

Sir,—With reference to my previous letters of July 12th, 1895, and February 28th, 1896, and to your replies of July 22nd, 1895, and April 1st, 1896, respectively:—

Provisions as to the use of explosives in mines having been included in the Coal Mines Regulation Act of 1896, the Council of this Institute feel that the time is appropriate for the establishment of a permanent testing-station, where any explosive which "is or is likely to become dangerous" may be tried under conditions approaching the actual methods of use in mines. The same plant would be equally available for testing new explosives produced from time to time.

In the letter of February 28th, 1896, the President and Council drew your attention to the experimental plant erected by this Institute at Hebburn-upon-Tyne; and as it is still in existence, they would again respectfully suggest that some arrangement might be made for its permanent retention as an explosives testing-station.

The President and Council now ask that you should consider their proposals, with a view to a grant being made to the Institute by the Government in order to avoid the absolute discontinuance of the experiments on explosives conducted by the Institute in this district.

The Council will be pleased to adopt any suggestions that you may make upon the question, but would respectfully urge that the experiments should be continued under the charge of reliable mining engineers.

The valuable results already obtained may be gathered from the reports forwarded to you with my previous letters.

I have the honour to be, Sir,
Your obedient Servant,
M. Walton Brown,
Secretary.

The Secretary of State,
Home Department, Whitehall, London, S.W.

The Secretary read the following paper by Mr. H. W. Hollis on "A Spring-coupling for Winding or Hauling-ropes":—

A SPRING-COUPLING FOR WINDING OR HAULING-ROPES.

By H. W. HOLLIS.

It is probably within the experience of every mining engineer that the necessity for frequent renewal or reversal of winding and hauling-ropes is an important item in the working costs of a colliery. The writer is consequently justified in assuming that an appliance such as that which he is about to describe, which has for its object the prolongation of the working life of ropes moving under heavy strains, will not be without interest to the members.

It will be admitted without question, that when a heavy body previously at rest is set in motion by a rope, or when a heavy body in motion is stopped by a rope, the moment of most severe strain upon the rope is the moment when motion commences in the first case, and the moment when motion is arrested in the second case; in other words, it is the inertia or the momentum of the body moved by the rope which causes the most severe strain upon a rope. This fact was strongly forced upon the writer's attention about four years ago when watching the working of one of the 10 tons hydraulic cranes at the Tudhoe ironworks. These cranes are worked by wire ropes, driven by hydraulic pistons, of which there are five on each crane, for supplying the movements of raising and lowering, jibbing round and racking in and out of the load carried. When the cranes were first started, great trouble was experienced with the ropes which swing them round. These ropes broke constantly, and when they did not break they were pulled out of their sockets. This damage always occurred at the moment of either starting or stopping the jibbing round; and on one occasion when the writer saw the rope break on stopping the crane swinging round with a 6 tons ingot at the end of the jib, traversing a circle of 22 feet radius, he realized how enormously the strain upon the rope was increased at the moment of starting and stopping the motion, and it occurred to him that if he could convert that sudden strain into a gradual one, without appreciably varying the working length of the rope, it would get rid of what was a very serious difficulty. He accordingly designed the spring-coupling, which is illustrated in Figs. 1 and 2. In place of the rigid attachment previously adopted, one of these couplings was put in at each end of the jibbing rope, and from that time no further trouble was experienced.

Fig. 1 is an elevation of one form of spring-coupling or attachment, and Fig. 2 is an end elevation of the same. The coupling or attachment in the form shown in Figs. 1 and 2 consists of a pivoted frame composed of two end-plates *a a′*, one or both of which may be formed or provided with a hook. The end-plates are connected to the side-plates *b b′*, by means of links *c*, which are pivoted to both of these plates. The side-plates *b b′* are normally held apart by means of a spring *d*, through the centre of which passes loosely a rod *e*, one end of which is secured to the side-plate *b*, while the other end passes loosely through the opposite side-plate *b′*.

FIG. 2.

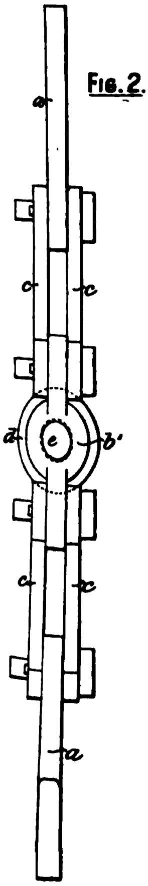
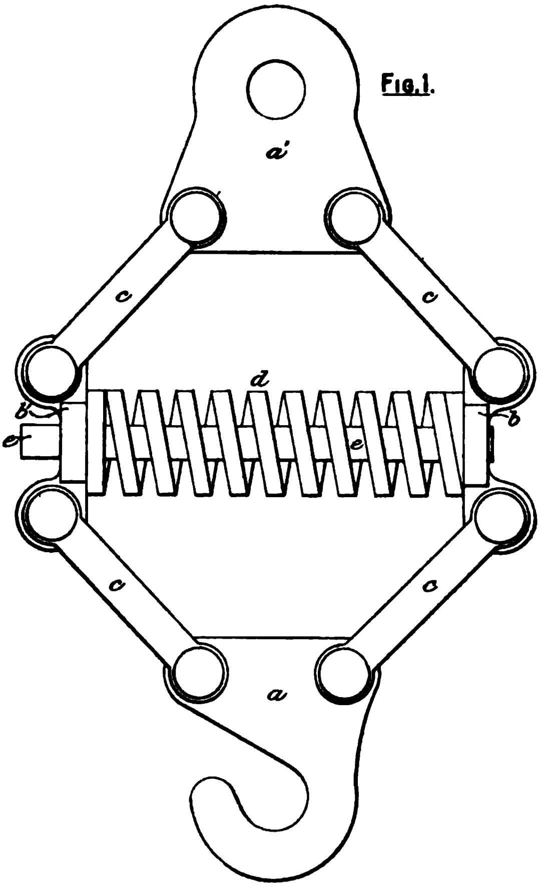


FIG. 1.



It will be seen that, whenever any sudden strain is placed upon the end-plates of the spring-coupling, the side-plates separated by the spring approach each other, and thus compress the spring. As the strain increases, the resistance of the spring to compression becomes greater, and the compressing power of the links becomes less, so that a condition of equilibrium is rapidly attained. If the spring were to break, the spring-coupling might still act in the manner intended, and in the event of a portion of the spring falling out, the spring-coupling would still act as a rigid connexion.

The adoption of these spring-couplings upon the cranes, having been so satisfactory as almost to warrant the writer in saying that they made the difference between failure and success in these important machines, he was desirous to ascertain what would be the result of their application to winding ropes.

A spring-coupling was applied to the west-side cage at the West Thornley colliery furnace-shaft, on June 2nd, 1894. The west-side rope had then been running for 5½ months, and in April, 1896, after the spring-coupling had been in use for 23 months, the rope was in excellent condition, and had drawn during that period 105,000 tons of coal, in addition to changing the workmen and boys.

It would appear that the life of a winding-rope will be increased very considerably where spring-couplings are used; and possibly, in addition, the cage-hangers, chains, bolts, and shackles will have a longer life.

Mr. A. L. STEAVENSON said that the appliance seemed to be a very useful addition to winding-ropes, but he did not know how it could be used for hauling. He himself had for some time adopted an arrangement of flat rubber discs, enclosed in a box, for relieving the strain of the lift of a winding-engine.

Mr. G. B. FORSTER said that he had used indiarubber below the bearings of the winding-pulleys. They lasted a number of years and were very effective in increasing the life of the ropes: being placed under the pulleys, there was no danger of any accident from breakage. If Mr. Hollis' arrangement were adopted in addition to a safety-hook above or below it, more height would be required between the flat-sheets and the pulleys. The use of such an arrangement was not so necessary in the case of hauling-ropes, although the rope would last much longer when kept tight at one tension. He had a haulage-road worked by an endless rope kept tightly strained, and the ropes were found to last much longer. The number of tons drawn by the rope was stated in Mr. Hollis' paper, but it was not stated what quantity was drawn by a similar rope before the spring-attachment was adopted.

Mr. F. R. **SIMPSON** said that a spiral spring-arrangement, somewhat similar to that which Mr. Steavenson had described, seemed to work very satisfactorily at some collieries in the Midland district. The springs were of such a strength that on replacing full tubs by empty ones in the cage at bank, the recoil was sufficient to slightly raise the cage, and allow the keps to be withdrawn without the usual delay.

The **PRESIDENT** moved, and Mr. G. B. **FORSTER** seconded, a resolution according a vote of thanks to Mr. Hollis for his paper.

The **SECRETARY** read the following "Notes on the Venterskroom Goldfields, South African Republic," by Mr. H. B. Bunkell:—

NOTES ON THE VENTERSKROOM GOLD-FIELDS, SOUTH AFRICAN REPUBLIC.

By H. B. BUNKELL.

The writer having had occasion to inspect properties near Venterskroom on the Vaal river (Fig. 1, Plate VI.) begs to place before the members of the Institute some of the results of his inspection. From a number of cross-sections, he has made a typical or ideal section (Fig. 2, Plate VI.). A glance at the section, naturally induces anyone acquainted with the Witwatersrand formation to draw comparisons between the two.

Dip.—The beds near Venterskroom dip towards the south, but an examination along an east-and-west line shows that the formations dip sometimes to the north and sometimes are vertical.

To the south the Vredefort, granite is encountered, and there is no hope of finding these beds occurring again in that direction as a syncline.

About 30 miles or so to the north-west, however, at Buffelsdoorn, the Table Mountain Series is found, and further north the Malmesbury Series. Both of these can be traced from the Witwatersrand: their dip is about south-east, and directly towards Venterskroom. This leads one to believe that a cross-section from Venterskroom through Buffelsdoorn would show a syncline of the two above-named series.

The Venterskroom beds would thus form the southern fringe of the syncline, and their proper dip should be to the north-west more or less, namely, in the direction of Buffelsdoorn.

The following is the order of occurrence of the beds at Venterskroom:—

1. Vredefort Granite.
2. Malmesbury Series.
3. Table Mountain Series.
4. Amygdaloidal Dolerite.
5. Black Reef Series.
6. Dolomitic Limestone.
7. Gatsrand Flagstones, etc.
8. Coal-measures.

(1) Vredefort Granite needs little description.

(2) The schists and quartzites of the Malmesbury Series are almost exactly the same as those found in the Malmesbury Series of the Witwatersrand. Here are found the typical Hospital Slates with contorted and curved laminæ and thin seams of jaspery quartz, the latter being

most noticeable in the beds nearest to the granite. No very great stretch of imagination is therefore required to liken the quartzites on the southern side of this series to the Du Preez quartzites of the Rand; and further to liken the quartzites lying on the northern edge of the schists to those known on the Rand as the Troyville quartzites.

Between the Malmesbury Series of Venterskroom and the Vredefort Granite there is a considerable amount of basaltic rock. This rock can be traced for many miles without interruption, but varies of course in thickness. At Palmietfontein in the Orange Free State, just opposite Brakfontein (marked *Q* on Fig. 1, Plate VI.), this basaltic rock occurs in greater quantity, forming a large hill.

In one instance, the basalt appears to have broken through the granite, somewhat as represented in the section (Fig. 2, Plate VI.). It is quite possible that this rock is in some way connected with the tilting-over of the beds at Venterskroom. The writer noticed also that the granite on Koppieskraal farm (marked *S* on Fig. 1, Plate VI.) had formed itself into a ridge running parallel to the bedded formation, and appeared as if it had been acted on by some force which had caused a slight upheaval.

Between the Malmesbury and the Table Mountain Series at Venterskroom a considerable thickness of diabase occurs, forming an unmistakable dividing or datum-line. This also occurs on the Witwatersrand, although not so noticeable as in the hilly country at Venterskroom.

(3) This series is similar to the Table Mountain (or main reef, etc.) Series of the Rand. It has been argued that the main reef line of this series is missing, caused probably by a slide or overlap.

The writer in his numerous investigations failed to find any proof of this argument, more particularly taking into consideration the dip of the strata. On the other hand, there is much more probability of the Elsburg or more recent beds being covered over by the Dolerite Series. This possibility would, in the writer's opinion, account for the missing member of the Table Mountain Series.

A closer examination shows the existence of three distinct groups of reefs or beds of conglomerate, classed by the writer under their local names as follows :—

Group A.—
  Acme or Odin reef.
  Red or Meisters reef.
  North or Jumbo reef.
  Another unnamed reef.

Group B.—

- An unnamed reef.
- Yellow or Roos reef.
- Myrtle reef.
- Other thin beds.

Group C.—

- Stink reef.
- Gordon black seams.
- Two-feet reef.
- Springbok or Brown reef.
- Great western reef.
- Leach or Amazon reef.
- Other leaders.

Group D.—

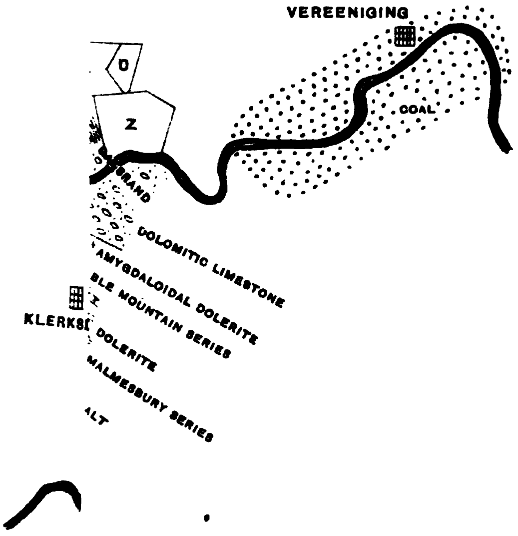
- The missing line of reefs (presumably covered by dolerite).

Remarks.—The similarity of the Venterskroom formations to those of the Rand is very striking, more particularly in regard to their arrangement into groups.

With regard to the similarity that exists between group *A* and the main reef series of the Rand the following evidence is adduced:—(1) The proximity to the dividing-line between the Malmesbury and the Table Mountain Series; (2) the limited number of reefs in the series; (3) the red sandstones, underlying group *A*; (4) the correct position by measurement from groups *B* and *C*; and (5) the actual existence of gold with occasional good assay results.

With regard to the similarity between group *B* and the bird reef series of the Rand, the following evidence is adduced:—(1) Their correct distance from groups *A* and *C*; and (2) the similarity of appearance between the yellow reef and the bird reef.

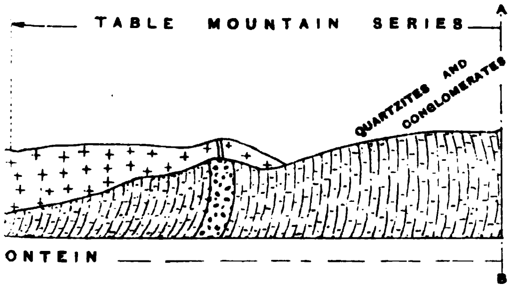
With regard to the similarity between group *C* and the Kimberley series of the Rand, the following evidence is adduced:—(1) The correct distance from groups *A* and *B*; (2) the great number and size of the reefs; (3) the similarity of the rock taken from the Leach shaft to that of the Kimberley reef, more particularly noticing the striated pebbles, chloritic talc pebbles, and chlorite; (4) the existence of sandstone, with thin seams of oxide of iron, panning gold in places, and similar to the Gordon reef of the rand; and (5) the existence of gold in certain beds.

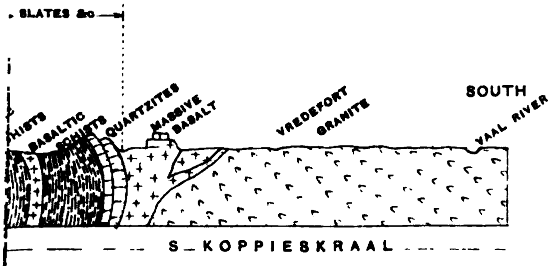


REFERENCES TO FARMS.

A	KROMDRAAI
B	NOOITGEDAACHT
C	TIJGERFONTEIN
D	ROODERAND
E	LEEUWFONTEIN
F	BUFFELSKLOOF
G	KOEDOESLAAGTE
H	KOEDOESFONTEIN
I & K	BUFFELSHOEK
L	RIETFONTEIN
M	MODDERFONTEIN
N	BRONKHORSTFONTEIN
O	BRAKFONTEIN
P	WITTEKOPFONTEIN
Q	BRAKFONTEIN
R	RIETPOORT
S	KOPPIESKRAAL
T	OORSEETJESFONTEIN
U	ZEEKOEFONTEIN
V	DITTO
W	VAALFONTEIN
X	ROOIDRAAI
Y	WELTERREDEN
Z	KAALPLAATS

...ape Roods to 1 Inch.





300 Cape Roods to 1 Inch.

North of Eng...

The writer was told that a shaft sunk through the dolerite had intersected a banket bed. This bed is probably one of the reefs of the missing Elsburg series or group *D*.

(4) The Amygdaloidal Dolerite is similar to that which occurs on the Rand overlying the Elsburg Series. It exists at Venterskroom in its correct position as compared with the Rand beds, always assuming that the Elsburg Series underlies it.

(5) The Black Reef formation is found in its proper place, as compared with the Rand beds, near Lindique, underlying the dolomite and overlying the dolerite.

(6) The Dolomitic Limestone next occurs in its proper position, as compared with the Rand beds.

(7) Portions of the Gatsrand Flagstone formation next occur near Lindique in proper position as compared with the Rand beds.

(8) The Coal-measures are found overlying the Dolomite at Stillfontein, near Klerksdorp and Vereeniging, on the Vaal river.

Prof. Louis said that this paper, like several others published recently on the geology of South Africa, made the mistake of arriving at important geological conclusions on very slight evidence. Where the beds extended over tens and sometimes hundreds of miles and the stratification was very much broken up and difficult to recognise, the most careful and accurate surveys were necessary before they could arrive at anything like definite geological conclusions. There were parts of Great Britain on which the best geologists had been working for years without definite results, and he was convinced that many parts of the Transvaal were at least as puzzling; the author's object was to make out the identity of his "group *A* " at Venterskroom with the main reef series of the Rand, and in doing this he relied for his datum-line on a " considerable thickness of diabasic rock." When an eruptive rock was taken as a datum-line, confusion and error would necessarily ensue, and the case was still worse when the author had to assume the existence of a line of reefs for his purpose.

He (Prof. Louis) deprecated in the strongest possible manner such premature attempts on correlation founded on unsatisfactory geological evidence. He had examined the coal-measures in the district, and so far as he could judge in the very short time at his disposal they appeared to be of Carboniferous age.

The PRESIDENT moved a vote of thanks to Mr. Bunkell for his paper, which was cordially approved.

The meeting was then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

STUDENTS' MEETING,

Held in the Wood Memorial Hall, Newcastle-upon-Tyne,
October 10th, 1896.

Mr. G. P. CHAPLIN in the Chair.

DISCUSSION ON MESSRS. W. R. BELL AND E. McGOWAN'S PAPER ON "HAULAGE AT WEARMOUTH COLLIERY."*

The **Chairman** asked whether the tub-wheels were made of steel, and whether they were kept in use after "flats" had formed on them?

Mr. W. R. **Bell** replied that the tub-wheels were made of steel, and he had never known a "flat" to form on them. If the rim was broken, the wheel was immediately replaced by a new one. Chilled iron wheels were used at one time: the first supply was very serviceable, but the second supply was brittle, and their use was discontinued.

The **Chairman** said that the practice of placing boilers at the shaft-bottom was not to be recommended. If the mine was gassy, it would be dangerous to take the air for the boilers from the return air-currents. If boilers were used underground, it was desirable to supply the air direct from the intake air-currents. It was preferable to place the boilers on the surface, and to send steam down the shaft in pipes to the engine.

Mr. W. R. **Bell** said that the Wearmouth pits were not gassy, and there was no danger in passing the return-air over the boiler-fires. He could not agree with the Chairman's opinion that it would be better to send the steam down the shaft. The depth of the shaft was nearly 1,800 feet, and condensation would be considerable and could not be made up by economy in surface-working.

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* *Trans. Fed. Inst.*, vol. xi., page 221.

Mr. H. W. **Middleton** enquired as to the duration of the haulage-ropes, and as to the distance apart at which the rollers were placed; whether the tail-rope was carried altogether on or above the ground; whether the full set ran down from different sides of the incline; and what was the radius of the curves on the engine-planes.

Mr. W. R. **Bell** replied that the life of the ropes varied greatly: a new rope in one case lasted only three and the next rope twelve months. The tail-rope was always carried near the ground. The incline in the A pit or north maudlin seam had a double line of rails, which ran together into a single line at the top and bottom. The incline in the east maudlin seam had three rails, except at the pass-bye, so that the inside wheels of the full tubs ran on the same rail as the inside wheels of the empty tubs. The incline in the south-west maudlin seam had a single line of rails, except at meetings. The radius of the curves varied according to the angle of the places. If the angle was sharp the radius was small, but if it was an obtuse angle the radius could be larger. The rollers were placed the same distance apart on the main-rope side and on the tail-rope side, being about 30 feet between each two rollers.

Mr. R. R. **Simpson** asked whether the battens were of larch or Scotch fir; what was the increased cost of laying the roadway with battens; and whether repairs were often needed or not? Also, whether any appliance was used for preventing the rail from moving longitudinally, such as a small notch for the spike cut out of the base of rail. Whether the tubs were made of wood or iron, what was their weight, and how they were lubricated? In changing the ropes, it would seem that time would be saved if the sockets were arranged so as to be opposite the branches when the set was at the shaft, and changing done at that time. By the means suggested, two stoppages would be saved, and this was no small matter when time was an object.

Mr. W. R. **Bell** said that the battens were of Baltic redwood and the sleepers of Scotch fir, both being creosoted. It was almost an unknown occurrence for the sets of tubs to run off the way, and the repairs were not nearly so great as in the case of the bridge or chair-rail. It was hardly possible to feel the joints of the rails when laid on longitudinal battens. He had never known the rails to move longitudinally, and no means were adopted to prevent it. The tubs were mostly made of wood, but in the last tubs which had been built in the colliery-shops the bottoms were made of iron, and they were belted on the parts where they would break soonest if they caught anything. The tubs weighed about one half of the weight of coals carried; therefore, for 9½ cwts. of coal the tubs weigh about 4¾ cwts. The iron bottom added a little to the weight, making them nearly 5 cwts. The tubs were lubricated in the old-fashioned method: a man at bank greased the tubs with a stick when in the kick-up. As to the time of changing the ropes, it might actually be arranged that the ropes could be changed when the set was at the shaft, but in some cases this was not done (it was in others). The advantage of changing the ropes at the offtakes was that if none of the landings were ready, the set need not stand at the shaft, but could be taken in-bye and the ropes changed to the first landing out of which a full set was run.

The **Chairman** asked whether the outer rail was raised in going round curves. From the necessity of using full tubs to steady the sets at the moderate speed of 10 miles per hour, it might be suspected that the roadway was not kept in good order.

Mr. W. R. **Bell** said that the outer rail was slightly raised at the curves, but it was very slight. Some of the students had seen the roadways, and he would leave them to judge whether they were kept in order. He might also remark that 6,637 tubs of coals had recently been brought out from the landings to the shaft in a day.

Mr. R. O. **Brown** asked whether the main-ropes were used for tail-ropes after a certain time.

Mr. W. R. **Bell** said that the ropes were changed from main to tail-ropes, or *vice versa*, after a time. On the A pit or north engine-plane, the tail-rope performed the heavier work, and in this case the new rope was always put on the tail-rope side. On the south-west engine-plane, the tail-rope of one set was the main-rope of the next set; and as the road was very even and almost level, the strain was constant and equal. The life of the rope on this plane averaged about nine months. On the east engine-plane, the rope was first used as the main-rope and then as the tail-rope.

Mr. **Brown** asked why the outside rail was raised higher at the curves? Should not the inner rail be raised to resist the pull of the rope?

Mr. **Bell** said that it was the opinion of the managers at Wearmouth that it was better to raise the outer rail.

Mr. R. O. **Brown** said that at Elswick colliery, on a heavy gradient, the inside rail was raised in a curve, which was not skeated, and of about 130 feet radius.

Mr. H. W. **Middleton** said that at Trimdon Grange colliery the inner rail was raised on curves.

Mr. R. R. **Simpson** said that at Towneley and Stella collieries the rails were placed level, and the curve was skeated with deals.

Mr. W. O. **Tate** said that at East Hetton colliery, with a 132 feet curve, the rails were placed level, and no skeating-deals were used.

Mr. W. R. **Bell** said that at Wearmouth colliery, after passing round a curve, the rails were in some cases bent, so that the rope as soon as it got past the bend went into the centre between the rails, and so on to the rollers.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT, OCTOBER 19TH, 1896.

MR. E. B. WAIN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected :—

MEMBERS—

Mr. **WILLIAM BARBER**, Colliery Manager, Halmerend, Newcastle, Staffordshire.

Mr. **ARTHUR BERRY NOWELL**, Colliery Manager, Assam Railway and Trading Company, Upper Assam, India.

Mr. **EDWARD BLAKELEY SMITH**, Civil Engineer, Etruria, Stoke-upon-Trent.

ASSOCIATE MEMBER—

Mr. **JAMES L. BAKER**, P.O. Box 1161, Johannesburg, Transvaal.

STUDENT—

Mr. **WILLIAM TELLWRIGHT**, Sneyd Colliery, Burslem, Staffordshire.

The report of the Council was read as follows :—

ANNUAL REPORT OF THE COUNCIL.

The Council of the Institute have pleasure in presenting their Annual Report. During the past year the usual General Meetings have been held, at which valuable papers have been read and discussed on the following subjects :—

"The Rocket Oil-engine." By Mr. T. H. Armstrong.

"Modern Coal-tipplers." By Mr. J. J. Prest.

"The Use of Petroleum in Safety-lamps." By Mr. E. B. Wain.

"The Woodworth System of Progressive and Automatic Cut-off Gear for Winding-engines." By Messrs. B. Woodworth and W. G. Cowlishaw.

Meetings of The Federated Institution of Mining Engineers have also been held in North Staffordshire, South Yorkshire, London, and Cardiff during the past year, at which papers, comprising 71 in number, upon nearly every subject appertaining to mining and engineering, have been read and discussed, the details being contained in the Seventh Annual Report of the Council of The Federated Institution of Mining Engineers.

The number of members on the register at the end of the past financial year was as follows:—

Life Member	1
Honorary Members	6
Ordinary Members	120
Associate Members	3
Associates	37
Students...	16
Total	183

being an increase of 3 upon last year's list; 6 new members have been elected during the year, viz., 3 ordinary members, 1 associate member, 1 associate, and 1 student; 2 have resigned. One, the late Mr. Thomas S. Strick, has been removed by death. It is with deep regret that we refer to this melancholy disaster, and herewith tender our deepest sympathy to his family. He was cut off in the discharge of his duty in the very prime of life.

The Council trust that a greater interest will be taken in the future of the Institute, and that all members will make an effort to attend the meetings, contribute papers, and take part in the discussions.

Mr. J. BLAIKIE moved, and Mr. JOHN HEATH seconded, the adoption of the report, which was carried unanimously.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee have pleasure in reporting that the income for the past year shows an increase, as compared with the preceding year, of £118 15s. 8d., the receipts in 1894-5 from all sources being £204 11s. 4d., and in 1895-6 £323 7s.

The expenditure has been £58 14s. 9d. below the income of the year.

Arrears still continue to form an important item in the balance-sheet, notwithstanding every effort that has been made to reduce them.

The PRESIDENT said it was satisfactory to know that the balance was almost £60 more than it was a year ago, and that there was now in the bank £138, besides other assets.

Mr. J. LOCKETT moved the adoption of the report, which was seconded by Mr. JOHN H. COLE and carried unanimously.

ELECTION OF OFFICERS, 1896-7.

PRESIDENT.

Mr. JOEL SETTLE.

VICE-PRESIDENTS.

Mr. JAMES C. CADMAN. | Mr. HUGH R. MAKEPEACE. | Mr. J. J. PREST.

TREASURER.

Mr. H. M. MAKEPEACE.

SECRETARY.

Mr. J. RICHARD HAINES.

COUNCIL.

Mr. W. N. ATKINSON.
Mr. JOHN HEATH.
Mr. A. MAYON HENSHAW.
Mr. GEORGE P. HYSLOP.
Mr. JAMES MADDOCK.
Mr. GEO. A. MITCHESON.
Mr. JOHN NEWTON.
Mr. CHAS. E. DE RANCE.
Mr. FREDK. SILVESTER.
Mr. WILLIAM STATHAM.
Mr. THOMAS E. STOREY.
Mr. BENJAMIN WOODWORTH.

Mr. SETTLE, on taking the chair as President, delivered the following address :—

PRESIDENTIAL ADDRESS.

By Mr. JOEL SETTL .

Allow me to thank the members sincerely for electing me President of this Institute, and I can only say that every endeavour on my part shall be used to merit the confidence reposed in me.

The Institute had not increased its membership of late years, and it was very desirable that each member should endeavour to introduce new members, and, if possible, to make the Institute of more interest by contributing papers.

It had been under discussion on several occasions that it would be of great advantage if we had a habitation of our own where we could meet and deposit books, maps, models, and specimens of interest. This subject appeared worthy of our best consideration, and might be best attained in combination with other interested societies, and we might not unreasonably look for some assistance from the coal and iron-masters of this district.

It was difficult to touch upon any question which had not been considered ; therefore, this address might not prove so interesting as it might otherwise be, but it would no doubt be of interest to commence with the working principles of a colliery in general.

Engines.—Winding-engines should be of the highest possible workmanship, not too large for the required amount of work to be done, with the best automatic steam shut-off arrangement, with steam and foot-brakes so as to afford all facilities possible for assisting the enginemen, who had great responsibility of life in winding workmen up and down the pit. And generally their work required the best facilities, on account of the large amount of work which had actually to be done. There was nothing more important to engines than supplying them with dry steam, which could be done by erecting a steam-receiver, to give a regular supply of steam, or an extractor, to accomplish the same result.

Boilers.—It was a most important point that high-pressure boilers should be worked to obtain the best results and effect economy in fuel. Where possible, an economizer or some other method should be used to heat the feed-water to a high temperature ; this would prevent, in a great degree, contraction and expansion of the boiler-plates, and give a longer life to the boiler, and also effect a great saving in labour and fuel.

Headgears.—Headgears should be fixed so as to give as long a life to the winding-ropes as possible; and in all cases detaching-hooks should be fixed so as to prevent loss of life and damage to property.

Centralization of Work.—Often we see several collieries belonging to the same firm a few hundred feet apart, and each colliery was equipped to deal with its own production, whereas by drafting all the coal to one centre great economy could be effected in most cases.

Coking.—Where the coals were of a bituminous character, coking-plant should be erected, and the gases utilized for generating steam. This system had the effect of reducing the consumption of coal, and provided a profitable use for slack.

Screening.—One of the most important factors at a colliery were the screens, suitable to make coals of such size as suited the trade requirements of the district. The best system was the shaker-screen with or without travelling-belts, as might be required, to enable the coal to be perfectly cleaned. By such means the selling price of the coal would be increased, and most satisfaction afforded to the customers.

Coal-washing.—There had not yet been an efficient washer erected at a reasonable cost to deal with North Staffordshire coals. The coal contained from 12 to 15 per cent. of dirt, and at the present time the washed slack was of very little more value than unwashed slack, and it was very questionable whether washing was of any benefit where anything like a reasonable price could be obtained for unwashed slack. In any case it was essential that the coal washed should be of a bituminous character, as so much small fine slack or smudge was produced.

Electricity.—Electricity had made rapid strides during the last few years, and had given great aid for lighting and conveyance of power, and under favourable conditions had a very great future.

A recent application, for relighting miners' safety-lamps with electricity without opening them, removed the risk of the lamps being unlocked in the mine, and the possibility of the lamp not being properly put together after relighting. Under proper regulations the system seemed commendable in economy and safety.

Passing on below ground among the first things which demanded attention were:—

Horses.—Every manager of a mine should see that his horses were well cared for, well stabled, kept clean, their harness well fitted, and that the drivers used the greatest kindness to them at all times.

Butty System.—The butty system was prevalent in this county, and although the butties were men of stability and reliable in themselves, yet it must be considered that they placed themselves in a certain position to get coals at a less price than they received from the proprietor to enable them to work to a profit. They also ran certain risks at times to draw more coals, which was not conducive to the safe working of a colliery. The chief objections to the butty system were:—(1) The butties would continue their contract so long as it paid them, but when it became a loss, they would fail in interest, and eventually gave it up, except at an increased rate. (2) The management was not in direct touch with the men who were employed under him. (3) It had the effect of making management of collieries easy, and caused the same to get into a loose way. (4) The interest of the butty was sometimes opposed to the true interests of the colliery owner.

Ventilation.—The time had arrived when the ventilation of a mine should not depend upon a furnace, but mechanical ventilation. Furnaces were dangerous to work when placed near a coal-seam, and in cases of serious accidents they were not able to cope with cases of emergency, and should the air be charged with gas there was danger in most cases.

The advantages of mechanical ventilating-appliances placed upon the surface were so numerous that it would take a paper of great length to enumerate them.

It was imperatively necessary that the ventilation be split reasonably into districts, particularly in cases of mines subject to spontaneous combustion, so that any one district could be closed without affecting others.

Gob-fires.—As there were several mines which were subject to spontaneous combustion and which gave great trouble to the management of those mines, probably a few words upon this subject would be of interest.

Mines which gave the most trouble and were most liable to spontaneous combustion were those which had a hustle or carbonaceous shale above or underneath the coal-seam; and great care should be exercised in the working of such seams, whether they had ever had gob-fires in the seams or not. In such seams, the goaf should not have too much ventilation passing through, as it induced spontaneous combustion, and waste-goafs were better sealed off with stoppings to prevent such support from being given.

It might be thought that such goafs would form gasometers in the colliery, but such was not the case, as gases were well known to be harmless unless mixed with certain proportions of air.

It was astonishing how small a quantity of gas given off from an open goaf would contaminate the ventilation of a district and give rise to great thought and trouble to the management.

I see nothing whatever to alter my opinion expressed in my paper on gob-fires[*] as to the fundamental principles to be observed, as follows :—

(*a*) Do not try to work out too large a district at once.

(*b*) Districts should be worked out as quickly as possible, and sealed off when finished, whether they had taken fire or not.

(*c*) Leave sufficient support of coal so as not to disturb sealed-off districts.

(*d*) Preparatory or temporary stoppings should always be erected.

(*e*) The quality of gas given off from a goaf should be carefully noticed.

(*f*) Note any change in temperature from the goaves.

(*g*) Do not pass more ventilation through a district than was sufficient to keep the working-places and gob-edges free from gas.

New Mines Act.—Besides the question of safety-lamps in section 5, part 2, the most important questions dealt with in the Act were those relating to the use of explosives, and the watering or efficient damping of the mine or any ways or places therein.

This Act gave the Secretary of State absolute power to prohibit the use of any explosive, which, in his opinion, was, or was likely, to become dangerous. With regard to explosives, there was now a widespread opinion that gunpowder was the most dangerous explosive for use in fiery and dusty mines, and although its use had been abandoned to a great extent, it was probable that its use would be further restricted by order of the Secretary of State. In view of this probability, it behoved colliery managers to ascertain which was the best, so called, safety-explosive for use in his particular mine.

With reference to coal-dust, the watering or efficient damping thereof appeared to be a question awaiting solution, and it might be disputed in some places whether it was practicable to deal with it by water or any other method to render it harmless. It must be borne in mind that there were several seams where watering would be ruinous. The system of watering with pipes appeared to have been more developed in South Wales than in any other district, but as yet the experience was not sufficient to show that the desired result had been attained.

Ambulance.—Work of great value was constantly being done in the mines of this district by the members of the St. John's Ambulance

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[*] "Spontaneous Combustion in Coal-mines," *Trans. Fed. Inst.*, vol. v., page 10.

Association. A number of classes were held last winter, under the auspices of that Association and this Institute, at which ambulance instruction specially fitted for persons employed in mining was given. It was hoped that these classes would be continued throughout this winter, and that the ambulance brigade, which was nearly 200 strong in this district, would be extended to each colliery or group of collieries in North Staffordshire.

Commercial.—Questions of wages and prices and the commercial management of collieries, although of the greatest interest and importance to members of the Institute, hardly came within the field of its operations, for which reason I would only say with reference to these subjects that I thought the best course was to try and increase the selling price of coal rather than to endeavour to reduce wages.

For this purpose greater co-operation is required on the part of colliery-owners, who should combine to maintain prices instead of undreselling, and so reducing prices. There were only a limited number of proprietors in the district who produced gas-coal, and some two years ago, seeing that a depression had set in and we were competing keenly for the various contracts, the producers met to arrange a uniform price or allow all the gas-coal to pass through a central committee to deal with the same, composed of all the producers. This object was not accomplished, and we are still going on in the same old groove, and prices are lower than ever and the financial position worse.

North Staffordshire Coal-field.—Many of the existing collieries in North Staffordshire would either be exhausted within the next twenty years, or their output of coal would have to be got under greater difficulties than was the case at the present time. There were several large pounds of water in the coal-field which would constitute more serious difficulties and dangers to mining in the future. For instance, the deeper measures in the Chatterley district were of unknown wealth, but at the present time it was waterlogged; it would eventually have to be dealt with, and a central pumping-plant erected for dealing with the water.

Mr. W. Y. CRAIG, in proposing a vote of thanks to the President for his address, said he was sure that everyone present would endorse what had been stated by Mr. Settle with reference to the arrangements for the productive department of mining. There were some of the topics to which he had referred which deserved careful consideration, especially with regard to the closing of goaves and dealing with gob-fires. Gob-fires were not only a great danger to the workmen of a colliery, but they saddled the colliery proprietors with heavy expenditure. He (Mr. Craig) had been engaged in the management of mines in North Staffordshire for more than thirty-five years, and had dispensed with butties for the simple reason that that system kept apart the employer from the workmen; it was a sort of inconvenient obstacle to that touch which should always exist between employer and workmen. He was quite sure that if the recommendations of the president were attended to, the result would be to conduce to the safety of the workers, and to the advantage of the colliery owners and all concerned.

It was essential that the commercial department of a colliery, to which the President had alluded, should be so managed as to prevent the glutting of the markets and the consequent irregularity of production, because the safety of collieries was jeopardized by irregularity of working. The president had called attention to the fact that there had been efforts put forward by colliery owners to keep up the prices of coal. He thought some thorough organization was necessary in order to accomplish that most desirable object. There was always a tendency on the part of some to break rules after arrangements had been made. He (Mr. Craig) had himself suffered seriously in consequence of men not adhering to the understanding arrived at.

For a considerable time the trade had been the reverse of profitable. Why? Not because there was any great defect in the productive department, for they knew that the production had been increasing year by year. Nevertheless, the prices were such as to leave scarcely any margin on the right side between the productive cost and the selling price. It was a case in which some well-considered plan should be acted upon—some organization that would meet the circumstances. It should be something that would fasten people and cause them to adhere to what was devised after due consideration. There were three parties actively interested in the coal trade—the producing capitalists, the producing workmen, and the consuming public. The object should be to give a reasonable profit to the capitalists, such wages as would maintain the workmen in respectability, and enable the public to get their coal at such prices as would allow the consumers of coal to carry on their operations, upon which so much depended. This object was not secured at present. There was something wanted which would prevent that spasmodic competition which pulled down prices and created irregularity and loss. The existing state of things was this, that each man sold what he could and got as much as he could, the general market being lost sight of. There was a demoralizing system which created in the mind a desire to gain, if one could, at another's loss. There ought to be a syndicate of such a character as to control to a certain extent this competitive system; that the same should be so elastic that it would not stop any market here, nor prevent the export of coal to other countries. Every coalowner should have the power to work his colliery to the best advantage, at the least cost, and with the greatest safety. But, in order that he might do so, he ought to be sure that he would get his coal sold at satisfactory prices. If there was a syndicate having a branch in every coal district, managed by a board of directors, all merging to one general head, it would, while allowing sufficient liberty to suit circumstances, prevent individual competition, and give every producer a chance to get for coal what it was worth in the general market. It would prevent the eternal conflicts between employer and workmen, and it would give the consumer a certainty that he would get his coal at a fair price.

Mr. W. N. **Atkinson** seconded the proposition, which was carried unanimously.

Mr. J. **Blaikie** moved, and Mr. C. E. **de Rance** seconded, a vote of thanks to Mr. Wain for his past services as president.

Mr. **Wain**, in reply, said that he was glad to see the Institute in a better position financially now than when he first took office.

CLOWES-REDWOOD GAS-TESTING APPARATUS.

Prof. **Clowes** (Nottingham) exhibited the Clowes-Redwood portable testing-apparatus for the detection and estimation of carbon monoxide in air. He explained, with the aid of lantern-slides, the construction of the apparatus, and said that it was not brought out primarily for use in mines, though it might be readily adapted to that purpose. It was intended to test for coal-gas and water-gas in closed places into which these gases might possibly escape, such as electric culverts. In the course of his remarks, he said that a method of testing for the presence of carbon monoxide had been described by Dr. Haldane, namely, the mouse test, with which they were doubtless familiar.* It

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* *Trans. Fed. Inst.*, vol. xi., page 505.

consisted in carrying a mouse in an open cage, and watching how the mouse comported itself. If the mouse showed signs of the presence of carbon monoxide, a man would have ample opportunity of escaping, since the mouse was affected in the twentieth part of the time required for affecting the man.

The safety-lamp, with hydrogen attachment, which he (Dr. Clowes) exhibited was made of aluminium, and was much lighter than the old one. In fact, the old one when fully charged weighed 4 lbs. 14 ozs., and this weighed 2 lbs. 7 ozs. By means of the standard hydrogen flame, in this lamp, the presence of 0·20 per cent. of carbon monoxide in the air was indicated by an ½ inch cap: this proportion of the gas was that at which danger commenced when the air was breathed. The hydrogen gas-testing safety-lamp was therefore a portable apparatus which served for the detection of carbon monoxide in a coal-mine. It only served this purpose, however, when other combustible gases were known to be absent, since every combustible gas yielded a cap over the hydrogen flame, and these caps were not distinguishable one from another. The newer form of portable apparatus, however, was a stationary hydrogen flame contained in a brass cylinder, which was provided with a glass front for the perception of flame-caps. The cylinder was supported at a height convenient for inspection by mounting it on a camera-tripod. The air to be examined was then pumped over the flame in a continuous current through a flexible rubber tube connected with the base of the cylinder by compressing a valved rubber ball. The indications were similar to those given by the safety-lamp, but the apparatus presented the advantage of enabling the test to be made without the necessity of entering and breathing the poisonous atmosphere, as the india-rubber tube could be extended to a distance from the testing-apparatus, and serve to bring in the gas for the test.

Mr. W. N. **Atkinson** said that, although it did not appear to him that the apparatus would be serviceable underground, it would still be of great advantage in places where it could be used. The hydrogen gas-testing lamp, he considered, was a great boon to miners. It gave in a simple, practical form an instrument for detecting such a minute quantity of fire-damp as ¼ per cent. There was a decided want of a portable indicator of carbon monoxide. The only known test was by observing the effect on a mouse or other small animal, and that was not altogether a satisfactory test, although he believed it had been used in cases of gob-fires. Many people could not be convinced of the dangerous nature of anything which they could not see. They did not appreciate danger until it was present in such a form as to disable them; but if they saw a mouse lie dead in a cage, they would understand that there was danger to themselves.

Prof. **Clowes** said that they had a meeting at Nottingham on Saturday, and a statement was made there, which was said to have come from Dr. Haldane, that it required an expert to see the effect produced on the mouse, by inhaling air containing carbon monoxide.

Mr. **Atkinson** said that he was present when a mouse was taken into the atmosphere of a mine, and it was left for ten minutes. At the end of that time it was almost dead; but it was taken into fresh air and revived. Then it was taken a little further into the poisonous atmosphere, and when brought out ten minutes after it was dead. Although he and others were in the poisonous atmosphere for twenty minutes, they were not seriously affected; but they could plainly see the effects on the mouse before it was dead.

The annual dinner took place the same evening, Mr. Joel Settle presiding.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, OCTOBER 24TH, 1896.

MR. G. B. WALKER, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBER—

Mr. THOMAS LIONEL SHAW CARRINGTON, Mining Engineer, Sheffield.

STUDENTS—

Mr. LIONEL CLINTON MAITLAND, Mining Student, 78, Brunswick Street, Sheffield.
Mr. REGINALD B. WOOD, Mining Student, Wincobank, Sheffield.
Mr. WILLIAM ARMLEY WOOLER, Mining Student, Thurgoland Vicarage, Sheffield.

DISCUSSION ON MR. BRYAN DONKIN'S PAPER ON "POWDERED COAL FOR FIRING STEAM-BOILERS: WEGENER AND OTHER SYSTEMS."*

The PRESIDENT said that Mr. Bryan Donkin's paper raised points with regard to the use of coal-dust as fuel which were, he thought, novel to many of the members. It described the use of coal so finely powdered as to go through holes $\frac{1}{80}$ inch in diameter—in fact, somewhat similar to the fine dust which adhered to props, doors, sides, and ledges in pits, where it was dry and dusty. They knew that in case of an explosion, coal-dust rapidly ignited and produced intense heat and flame. By the contrivances Mr. Donkin described, and particularly by the Wegener system, this fine coal-dust was used to produce very excellent results in boiler-furnaces. They knew that the object of burning fuel under a boiler was to produce gases formed by a mixture of oxygen with

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* *Trans. Fed. Inst.*, vol. xi., page 321.

the carbon contained in the coal, and by combustion producing heat. The more finely divided the coal, the more quickly the necessary combination would take place. Mr. Donkin showed that the boiler-efficiency with finely powdered coal-dust was as high as 78 per cent., whilst the efficiency with the boilers fired with nut-coal was only 54 per cent. Moreover, an analysis of the gases resulting from combustion showed a higher percentage of carbon monoxide than was usual, consequently producing a more intense heat; and, finally, the whole of the smoke was consumed. The members had a great deal of small coal at their disposal, and as pits got deeper coal was apt to get more dusty. If any of these contrivances for burning fine coal-dust powder could be brought into use it might very much improve the value of small coal, which at present was almost valueless.

Mr. H. B. NASH asked what was the cost of grinding the coal.

The PRESIDENT said that Mr. Donkin put it at from 9d. to 1s. a ton.

Mr. NASH asked whether the coal should be very pure. Mr. Donkin said that coal should be paid for according to its heating properties and not according to weight.

Mr. CHURTON said he was thinking of the danger of using coal-dust such as that which sometimes caused explosions in mines. It occurred to him, if the coal-dust was to be propelled into the furnace, whether it might convey the heat and cause a disastrous explosion in the main bulk.

Mr. NASH said he did not think explosion would take place, because the combustion of the fine dust was only caused through its being completely surrounded with air.

The PRESIDENT said that the heat of the furnace-lining caused the combustion of the coal.

Mr. NASH said that the flame could not flash back, because the coal-dust was in a compact mass in the pipes.

The PRESIDENT said that Mr. Donkin stated: "No doubt long exposure of the coal to the atmosphere might diminish its calorific value, but they were obliged to use it fairly dry, so that the question did not arise in practice." Generally speaking, the results of the experiments were satisfactory for in Berlin the coal had been stored for months and always burnt well.

Mr. **St. John Durnford** asked whether coal or smudge was used to start the fires.

Mr. **T. W. H. Mitchell** said that the experiments had not lasted long enough to determine the maximum quantity of ash which could be burned with the powdered coal. Mr. Donkin said that—

> The only similar fuel they had tried was gas-coke, and that did not ignite easily, and required to be mixed with a certain amount of bituminous coal. Gas-coke often contained 15 to 30 per cent. of dirt, and yet they burned it, not in powder, but in the ordinary system with forced blast. To burn all kinds of low-class fuels, economically was very advantageous.

Mr. **R. Routledge** said that with sufficient boiler-room, one could use very small coal, such as duff (worth from 1s. 3d. to 1s. 6d. per ton), which went through $\frac{3}{16}$ inch sieve. Better results would be obtained if a mechanical arrangement was in use.

Mr. **Nash** said that Mr. Donkin used coal worth 5s. 6d. a ton, and spent 9d. a ton on grinding, while Mr. Routledge used duff worth 1s. 6d. a ton. The question was whether the difference of results between duff at 1s. 6d. a ton and ground coal at 6s. 3d. a ton showed any benefit. Could they get three times the benefit for the difference of the cost?

Mr. **St. John Durnford** said that another advantage was a smokeless chimney.

Mr. **Nash** said that a smokeless chimney could be obtained if they fired gently instead of forcing it.

The **President** said that the statement was that there was a gain of 20 per cent. in the boiler efficiency.

Mr. **Nash** said if they only got 20 per cent. greater efficiency and spent 300 per cent., the saving at the tap would run away at the bung-hole.

Mr. **Churton** said that if coal-dust worth 1s. 6d. per ton could, by spending 1s., be made worth 3s. a ton, there was a margin of profit.

Mr. **Nash** said that if Mr. Donkin used a high percentage of round coal of good quality they, firing with the same stuff without grinding, might get probably better results at less expense. It might show good results when he got good coal, but when he used bad coal, such as they used at collieries usually, he might not get as good results out of the dust with dirt in it as he did with the good coal.

Mr. B. Donkin, replying to the discussion, wrote that some of the advantages of powdered coal firing as compared with large coal were :—Absence of smoke after the fire-brick lining had become hot, continuous and automatic fuel-supply, less dependence upon the stoker, more perfect combustion, more easy regulation of the exact quantity of air required and of steam generated, saving in cost of labour, economy of coal, no grate or grate-bars, no fire-doors, higher furnace-temperature, and increase of boiler efficiency, from 5 to 25 per cent. With boilers having an efficiency of about 55 per cent., the gain in efficiency would be greater than in those having 75 per cent. The only extra cost was that of grinding the coal, which would vary according to the locality and quantities required, but might be taken at 9d. to 1s. per ton. It was necessary to line the flues of Cornish or Lancashire boilers with fire-brick in order to ignite the powdered coal on its entrance, as there was no grate and no store of glowing fuel as usual. The hgih temperature of the lining kindled the coal as it entered. This lining required a little repair from time to time. In water-tube boilers no special lining was necessary, many working without.

The question was often asked whether there was no liability to explosions with this finely powdered coal. Nothing of the kind had ever occurred either in Germany, England, or France. Some 30 to 40 boilers were now regularly at work on this system.

In the discussion, the prices of coal quoted per ton were approximately those at the pit-mouth, but by far the larger quantity of coal used to produce steam was not burned at the pit-mouth, but in all the towns and cities all over England. This might be taken at about double the prices mentioned. In London, refuse small coal could be bought at from 9s. to 12s. per ton, but this varied with seasons and the market. Colliery boilers had generally a very low heat efficiency, say 50 to 60 per cent., as the gases usually escaped at a high temperature. It would, undoubtedly, be to the advantage of each colliery to have one boiler with which to try experiments on waste and other coals, always measuring the quantity of water evaporated by a good type of piston meter. If collieries would send him (Mr. Donkin) samples, carriage paid, of fine powdered coal, he would be happy to test them. "Good" or "bad" coals were mentioned in the discussion, but these were indefinite terms, and had no definite meaning. The dimensions of the pieces (anything between ½ inch and 2 inches), and the calorific value should always be given, and the latter was easily obtained now.

The discussion was adjourned.

DISCUSSION ON MR. G. FOWLER'S PAPER ON "HOW A MINE MAY BE DRY BUT NOT DUSTY."*

Mr. H. B. **Nash** said that Mr. Fowler, speaking from the point of view of a Nottinghamshire colliery manager, argued that it was cheaper to make the sides of his roads smooth and to whitewash them, and to gather up the coal and dust. He should like to see Mr. Fowler's system tried in a Yorkshire mine. Mr. Fowler said that it would cost £5,000 or £6,000 to damp his own pit, but he could deal with the dust in the manner described in his paper for £500 or £600 at the Cinderhill colliery. He smoothed the walls, plastered all fissures, and whitewashed over all, so that dust would not lodge. He used bars and props, which, apparently, he also whitewashed. The cost was absurdly low, but every one knew that the maintenance of the roof, etc., in Derbyshire and Nottinghamshire cost very little, compared with Yorkshire.

Mr. E. W. **Thirkell** said it appeared to him that the most dusty places about a pit were on the surface, about the screens, and at the bottom of the downcast shaft. He was arranging to use a series of water-sprays in the downcast shaft, a few feet down. On a windy day, dust from the screens went down the shaft in clouds, and his intention was to lay the dust, or to saturate it with water, so that at the pit-bottom it would drop on the sump-boards, instead of being carried by the air-current into the mine.

Mr. W. **Scott** said that another of the fruitful causes of dust was the high speed of the haulage.

Mr. **Thirkell** said that where there was a main-and-tail rope with trains going 10 or 12 miles an hour, with an energetic air current meeting it, a considerable amount of dust was produced.

Mr. **Nash** said that was Mr. Fowler's argument, and he stated that by making the sides of the airways smooth as the walls of a house the dust could not adhere. It fell to the floor and it was an easy matter to remove it, at very little expense.

Mr. **Thirkell** said that it was not an easy or cheap matter to thoroughly remove the dust. He suggested that it should be swept in a reasonable manner from the sides, damped on the floor, and removed in tubs. Several members who had tried water-sprayers, found that the

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* *Trans. Fed. Inst.*, vol. xi., page 128; and vol. xii., page 98.

water injured the electric-cables. The moisture got in to the side and roof, and though it might not cause damage for some time, at length the effects began to be felt in falls of roof and sides, which made them regret having used the sprayer. If too much water was used, the floor lifted also.

Mr. NASH said that Mr. Fowler made the sides and the top smooth, so that he could easily bring the dust out of the pit.

Mr. MITCHELL said that with a view of testing the point Mr. Fowler had prepared two portions of roadway, 1,500 feet in length, where the roof and sides were smooth, covered with plaster where necessary, so that the dust could not collect. The cost of plastering had been 1½d. per square foot, and other points had been smoothed at a cost of 1d. per square foot.

Mr. CHURTON suggested that it would be possible to sweep away the dust in certain portions, and thus form isolated sections, which would prevent an explosion being propagated for any considerable distance. It would be a great expense to sweep a colliery from one end to the other, or to make the sides clean throughout.

Mr. R. ROUTLEDGE said that if a section was well watered the explosion would not travel past that length.

Mr. THIRKELL said that that fact had been demonstrated over and over again.

The PRESIDENT said that the advantage of such a precaution was proved at Seaham colliery.

Mr. R. ROUTLEDGE said that the advantages had been proved at Altofts colliery also.

Mr. G. FOWLER thanked the members for their appreciative criticism of his paper. He considered that all mining questions were primarily financial, and his object in writing the paper was, in the first place, to compare Mr. Haarman's method with his own from that point of view. The endeavour to make mining as safe as possible did not clash with the primary condition laid down; for, if all mines were under the same necessities for their security, the relative costs of coal-mining would vary but little. He might add that the cost of making smooth roadways at Cinderhill colliery was intentionally over-stated. His method of treatment by no means presented the difficulties that suggested themselves. The natural surfaces left by the fractures of rock-roofs and sides were often smooth, and could be easily smoothed; and the act of sweeping with a common broom "down the wind" was very easy. In a large pit raising 400 tons per day, roads, more than a mile long, were swept over at a cost of £10, including both the intake and return airways. He might also point out that this method of treatment was suggested only for application on main roads, or possibly on sections of main roads. He also suggested that pack-walls, roughly plastered or laid in mortar, would frequently conduce to the maintenance of the roads. He also desired to express his adhesion to Mr. Thirkell's suggestion as to the necessity of preventing the dust from the screens passing into the mine. Where screens were situated closely adjacent to the top of the downcast shaft, they were certain producers of dusty main roads; and he was of opinion that the water-sprays suggested by Mr. Thirkell might in such cases be of service.

The discussion was adjourned.

DISCUSSION ON MR. G. B. WALKER'S PRESIDENTIAL ADDRESS ON "THE EDUCATION OF MINING ENGINEERS."*

Mr. L. T. O'Shea (Firth College, Sheffield) wrote that, not only the members of the Midland Institute of Mining Engineers, but mining engineers generally, owed Mr. G. B. Walker a debt of gratitude for laying before them so exhaustive a digest of the subject.

We in South Yorkshire have, for the last six years, been dealing with the subject of elementary mining education, and are now advancing a step further in providing for the educational wants of the mining engineer. It was of great advantage, therefore, at the start to have the opportunity of looking into the systems of education of foreign neighbours, and of examining their results to see how far we can profit by their experience, and what it was desirable to copy in order to place mining education in this country on a sound and satisfactory foundation.

There was one feature which had struck him (Mr. O'Shea), and one, he thought, of primary importance, namely, the thoroughness of the scientific training of the mining student abroad. Whilst he was fully trained in the practice of mining by attendance and working in the pit, he was, at the same time, compelled to receive a thorough instruction in the elementary and higher branches of all those sciences which find appli-

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* *Trans. Fed. Inst.*, vol. xii., page 132.

cation in the art of mining. As a consequence, the mining engineer abroad was a man who thoroughly understood the theory, as well as the practice, of all his operations, and, above all, was fully alive to the progress of science, and was able to judge for himself the advantages or disadvantages of the modern inventions which affected his calling. Engineers thus trained were able to push, and did push, their industry into the front rank.

He believed that in the future only those engaged in great industries would succeed who were able to use to the greatest advantage the resources of science, not only in dealing with the primary commodity, but in the treatment and recovery of all of the attendant bye-products; and the engineer who had the best scientific as well as practical training would be the one to do this.

He thought that we could not do better, in the first instance, than copy our neighbours abroad in establishing a sound scientific training for mining engineers. It was not the want of practical knowledge in which we were deficient: it was the want of scientific training that we deplored. He would not for one moment advocate any reduction in the practical training of a mining engineer; but he did urge that it was necessary to strengthen this by a scientific training, which should be thorough and not superficial.

But whilst advocating this aspect of the question, he would like to emphasise what Mr Cobbold had already said. The initiative must come from mining engineers, and he felt sure, from his experience of mining education in South Yorkshire and Derbyshire during the last six years, that if active and sympathetic interest in this matter was shown by those in authority, it was possible to start and carry out a system of training for mining engineers which would help them to compete with their neighbours and maintain their stand in the front rank. Mr. Walker's paper, and Mr. Cobbold's remarks, showed that amongst the members of the Midland Institute, this active and sympathetic interest existed.

Mr. Walker had compared the enthusiasm of the German student with that of our own; his comparison was true and just; still enthusiasm could be cultivated, and for years in Germany everything had been done to foster and encourage education. The state insisted that only engineers who had passed through a most severe training, theoretical and practical, should enter its employment, and whilst laying down a curriculum to be followed for the training of its own employés, it encouraged and recognized independent educational efforts. Highly trained engineers thus controlled the German mining industry; they fully recognized the advantage of having men similarly trained around them, and consequently they encouraged the coming generation to follow in their footsteps. Now, with such hearty co-operation from mining engineers at home, and some recognition from our authorities, he thought we should find that the enthusiasm so evident in Germany would come to us. He heartily supported Mr. Walker's suggestion that the government should be approached, and asked to recognize the time spent by mining students in following properly organized collegiate courses of study during the period of their articles. And how could this be done better than by this Institute and the other branches of The Federated Institution of Mining Engineers uniting with the educational establishments providing mining instruction to form a deputation on the subject to the Home Secretary? The earnestness of mining engineers would then be evident to the authorities, and he believed that the seeds of enthusiasm would then be sown. His (Mr. O'Shea's) remarks had extended to far greater length than he intended, but before he concluded he would like to refer to some remarks made by Mr. Cobbold, which struck him as likely to lead to some misunderstanding as to the facilities for the training of mining engineers in South Yorkshire, for he felt sure that that gentleman would be the last to depreciate any efforts which were being made in this respect. He felt sure that Mr. Cobbold would be pleased to hear that there was a course at Firth College for the training of articled pupils which followed on somewhat similar lines to those of the course at the Durham College of Science at Newcastle-upon-Tyne. The scheme of this course had been in existence since last year, but owing to want of the proper circulation of the information concerning it (which had now been remedied) actual work had only commenced this year.

The deep interest which he took in this subject must be his excuse for the length of his remarks, but he could not let the opportunity pass without emphasizing his sense of its importance.

The **President** said that he should like the Institute to identify itself with him in taking up this subject. If he was right in interpreting the feelings of the members of the Institute, they were just as sensible of the importance of this matter as he was himself. He had spoken to no member of the Institute who had not expressed cordially and heartily his desire that the Institute should take some steps in the matter of raising the standard of education of the young men who were entering upon their articles, and who were hereafter to be the colliery managers of the district. The members should come to some conclusion as to what they thought was desirable, and having arrived at that they could give effect to it. There were many points on which there might be a good deal of difference of opinion. It might be that they need not trouble themselves with carrying matters to such an extent as they did on the continent in connexion with the higher branches of scientific education, but that was a matter of degree.

Mr. T. W. H. Mitchell said that Mr. O'Shea hit the nail on the head when he spoke of the want of enthusiasm on this question. They had had small classes at Barnsley in connexion with the Yorkshire and Firth Colleges. Considering the large opportunities afforded, very few had accepted until quite recently. When the classes started in Barnsley, the fees for three likely young men to attend for the first year were provided free, and it was hoped that having had the first year's course paid they would follow up the second, but not one of them attended for the second year, simply because they had to pay a shilling a lecture for what was really a college education. If, whenever they had young men who seemed likely to read, they encouraged them to go to these classes they would be doing what Mr. Walker wished. There was ample opportunity afforded at Leeds, Sheffield, and Barnsley for an education which a good many of the older members would have been glad to have had afforded them in years gone by. It was for those who had not had this opportunity to urge young men to the education they could have if they would take it. All he could do was to thank Mr. Walker for his paper, and ask the members to help him in bringing this question forward in their district, and to urge young men to accept the opportunities given to them at the various centres of learning.

Mr. Thirkell said that several of the members who had young men with them, or in connexion with the collieries where they were, were in a difficulty when they were asked to set them in a proper groove. They had prospectuses offering subjects which the youths should study, but to get exactly what they required in one year had been a difficulty. A different procedure would have to be adopted with such pupils from that for students who had to earn their living whilst seeking to improve themselves, and he was glad that the colleges were providing a course to meet such cases. He was sorry that enthusiasm for scientific training was at such a low ebb, but he thought a good deal could be done if the manager at every colliery would make the lectures thoroughly known, and try to induce young men about the pits, deputies, and overmen to attend the classes.

Mr. Jos. L. Routledge remarked that in an opening address at one of these schools he said that he did not see why a working collier, after a course of five years' training at these schools, should not be able to obtain a first-class certificate, and a working collier did, in five years, obtain a first-class certificate, and was now in an under-manager's position. His experience of science classes was that there must be a great amount of enthusiasm in the teacher which must be infused into the scholars. If the teacher was unsympathetic or lectured over the heads of his pupils they lost interest and did not attend the classes. He had eight or ten workmen, deputies and others, under him attending the mining classes in connexion with the Leeds Mechanics' Institute, but he did not think that they would go to the Yorkshire College if asked. The fees would be prohibitive, and there would not be that interest taken in them which was taken in them at the present time. If members induced young men and youths under them to attend science classes, it was as much as they could do. If those in position as teachers would do their part, and the committees in connexion with them, it would be better for the country altogether.

Mr. St. John Durnford said that the paper went further than the last speaker's remarks, and showed what the Firth and Yorkshire Colleges were striving to do. They wanted to emphasize as much as possible the fact that there was a course for articled pupils to mining engineers at each of these schools, altogether independent of the evening classes which could be attended at local centres such as Barnsley and Leeds. If articled pupils could leave the colliery two days a week to attend lectures at the Firth College, or at the Yorkshire College, there was a course at each from which they would derive considerable benefit. The fact of these pupils attending this course, as had been stated by H.M. inspector of mines for the district, would not disqualify them from counting their time, given in for their certificate examination, as spent at the colliery. No doubt the classes to which Mr. Routledge had alluded were excellent things, but Mr. Walker had pointed out that the Belgians, Germans, and French went a great deal further than that, and insisted not only on attendance at evening classes, but required attendance at a course lasting two or three years. If they could get the owners of coal-mines to insist on having young men about them who had gone through an University education, even though it might be more costly than the present mode of educating young men, they would have accomplished a great deal towards getting the scientific requirements they wished for. Again, if mining engineers would take good care to appoint and have about them young men who had been to similar colleges, that again would go a long way towards putting them on a level with, if not superior to the continental schools of mines. With regard to the mining classes at Barnsley, two students of his had to leave Featherstone at two o'clock, and did not get back until ten, to attend the lectures; so that it was not an easy matter for them to attend.

Mr. **Stephenson** said that it would be a good thing if some competent person could give aspirants some line to follow. If Mr. Walker would suggest how far they should go in chemistry, and what particular parts of geology and physics should be taken, it would be helpful.

Mr. H. **Bonser** said he had no doubt that the mining population would thank the President for his paper, which excited the interest of every one. He asked the members to consider the condition of the workmen abroad and the rate of wages, and Mr. Walker to name the ideal colliery whose surface-arrangements were superior to those of this country. He should also like a comparison of their arrangements underground. He believed that they were suffering from a habit of self-depreciation. He had been abroad and seen many collieries. The men were under military rule, and were of a better class, but if one colliery could be mentioned to compare with those of Yorkshire for safety and comfort of the workmen, he should be pleased to see it.

Mr. H. B. **Nash** said that mines abroad were in many cases owned by government or by large associations, who would only employ engineers who had passed very high examinations. In England, if they had to possess this scientific training, few of those who were successful managers of large collieries would be able to get through. The men in charge of English collieries were men who had risen to a position, not as scientific men, but as practical men. Whilst admiring the spirit and enthusiasm which the foreigner put into his work, he agreed that they had equally as good men at collieries as any they had abroad, or ever would have. He agreed that with a scientific training a practical man must be the best man. The difficulty was to infuse sufficient enthusiasm amongst young men to interest themselves in science classes. Without sympathetic teachers they could not have enthusiastic learners; and a great difficulty was that the teachers had attained such a high scientific ground that they could not descend to the student's level and teach him how to grasp the subject. If they could bring themselves to the level of the deputies and colliers, talk in their language, and explain details, they would get more enthusiastic students.

Mr. W. A. RITSON said that time spent in study abroad did not count for the certificate examination, but it ought to do so. Two of his friends had practically wasted two years in consequence of this default.

The PRESIDENT said that he had no wish to depreciate Englishmen in comparison with foreigners. He believed that given equal or even inferior facilities, the English colliery manager would equal or even surpass his foreign competitor, but they were giving the foreigner a long start. Replying to Mr. Bonser's remark, he mentioned the Shamrock III. and IV. collieries of the Hibernia Company—the plant was magnificent, the labour-saving arrangements very elaborate—everything was carried out as the English railway-companies were accustomed to carry out engineering works. There were also the Zollverein collieries and the Cologne Company's collieries. The officials of the German collieries were as highly or more highly paid than those of this country. It would be a most excellent thing if a visit of the Institute could be paid to Westphalia—notwithstanding the difficulties of language, they might obtain many useful hints. With regard to the training of articled pupils he did not think that he could define how far they should study a subject. The courses now arranged at the colleges would give the students instruction as far as they could reasonably go in the time. With regard to the suggestion that there was a lack of careful help on the part of the teachers, with greater experience on the part of the teachers, there had been a great improvement in that respect, and of late that cause of complaint had been entirely removed. There was a great amount of zeal on the part of the teachers, and if there was any want of help in that direction it rested with the students not asking for it.

Mr. H. BONSER asked whether it was fair to institute a comparison with the men in charge of collieries abroad—how many of them were officers who in case of war would be drafted from the collieries to lead the defence? What chance had the ordinary workman to attain to these highly-paid situations? Though they had grand arrangements on the surface, most of the money was spent on the pit-top—there was little below. In this country, with a simple top, they had a grand colliery underground.

The **President** said that a workman in Germany had every chance to rise, and he pointed to the mining school of Bochum described in his paper, from which young men were frequently chosen to take responsible positions in the collieries. The chief officials of the mines were not men actually connected with the army, and could not be called upon to take command of troops, except, possibly, in the very remote possibility of the *landsturm* being called out.

The discussion was adjourned.

The meeting was then closed.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE ROOMS OF THE SOUTH WALES INSTITUTION OF ENGINEERS,
CARDIFF, SEPTEMBER 15TH, 1896.

MR. G. A. MITCHELL, RETIRING PRESIDENT, IN THE CHAIR.

The SECRETARY read the Annual Report of the Council as follows:—

THE SEVENTH ANNUAL REPORT OF THE COUNCIL.

The Council, in presenting the Seventh Annual Report to the societies forming The Federated Institution of Mining Engineers, is pleased to congratulate the members upon the success that has attended the working of the Institution.

The objects of the Institution are:—To promote a more general recognition of the status of mining and metallurgical engineering as scientific professions; to supply information to the Government upon the practical requirements of legislation affecting these professions; and to promote the advancement of the sciences of geology, mining, metallurgy, engineering, and their industrial applications, by the interchange of opinions, by the reading of communications from members and others, and by discussions.

The *Transactions* comprise the papers read at the meetings of the Federated Institutes, and at the two General Meetings held in each year, in the various mining districts of the United Kingdom, and at one held in London. In addition, a meeting of Students is held annually, when an approved essay is read upon a selected subject. These considerable advantages could not otherwise be obtained, except at greatly increased cost, by individual subscriptions to each of the institutes.

The influence of the Institution, as representing mining engineers in their entirety, would become more effective, and the value of its *Transactions* would be greatly enhanced, if it included all the societies interested in mining, metallurgy, and their allied industries. The Council would therefore urge members who may be interested in other kindred societies to use their influence in favour of federation. The members can also materially advance the prosperity of the Federated Institutes by using every endeavour to extend their membership.

The Institution now comprises six societies :—The Chesterfield and Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil, and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The following table exhibits the progress of the Institution since its formation on July 1st, 1889 :—

Year.	No. of Members.	No. of Non-Federated.	Totals.
1889-90	1,189	50	1,239
1890-91	1,187	9	1,196
1891-92	1,415	19	1,434
1892-93	1,533	19	1;552
1893-94	2,068	123	2,191
1894-95	2,210	109	2,319
1895-96	2,301	81	2,382

The status of the membership has been carefully considered, and all of the Federated Institutes have now adopted a classification of their members in accordance with Bye-law 8 B of the Institution as follows:—

The members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students:—

(*a*) Each Ordinary Member shall be more than twenty-three years of age, have been regularly educated as a mining, metallurgical, or mechanical engineer, or in some other branch of engineering according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an engineer; or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an engineer for at least five years.

(*b*) Each Associate Member shall be a person connected with or interested in mining, metallurgy, or engineering, and not practising as a mining, metallurgical, or mechanical engineer, or some other branch of engineering.

(*c*) Each Honorary Member shall be a person who has distinguished himself by his literary or scientific attainments, or who may have made important communications to any of the Federated Institutes.

(*d*) Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

(*e*) Students shall be persons who are qualifying themselves for the profession of mining, metallurgical, or mechanical engineering, or other branch of engineering, and such persons may continue Students until they attain the age of twenty-five years.

General Meetings have been held in North Staffordshire, in South Yorkshire, and in London, and the members are to be congratulated upon the value of the papers communicated, and the accompanying discussions.

A Students' meeting was held in the North of England in August, 1895, under the auspices of the North of England Institute of Mining and Mechanical Engineers. The meeting proved very successful, and the reading of the prize essay on "The Prevention of Accidents in Mines," by Mr. Austin Kirkup, was followed by an interesting discussion.

The thanks of the Institution have been conveyed to the gentlemen who kindly allowed their works and collieries to be visited by the members during these meetings.

The Council have awarded prizes to the authors of the following papers, printed in the *Transactions* for the year 1894-95:—

"The Magnetic Survey of Great Britain." By Prof A. Rücker.
"Investigations on the Composition, Occurrence, and Properties of Black-damp." By Messrs. John S. Haldane and W. N. Atkinson.
"Canals." By Mr. Lionel B. Wells.
"Electric Transmission of Power." By Mr. Alexander Siemens.

Presidential addresses have been delivered during the year to the members of The Federated Institution of Mining Engineers by Mr. G. A. Mitchell; the Chesterfield and Midland Counties Institution of Engineers by Mr. Emerson Bainbridge, M.P.; the North Staffordshire Institute of Mining Engineers, by Mr. E. B. Wain; and the South Staffordshire and East Worcestershire Institute of Mining Engineers, by Mr. John H. Cooksey.

The *Report* of the Proceedings of the Flameless Explosives Committee of the North of England Institute of Mining and Mechanical Engineers has been issued, and the Council have made arrangements by which it can be procured by members of the Institution.

The following papers have been communicated on mining engineering:—

"Haulage at Wearmouth Colliery." By Messrs. W. R. Bell and E. McGowan.
"Coal-cutting by Machinery." By Mr. W. Blakemore.
"Gold-mining in the Hauraki District, New Zealand." By Mr. Henry M. Cadell.
"The Indian Gold-fields." By Mr. A. G. Charleton.
"Electric Coal-cutting on Longwall Faces." By Mr. T. B. A. Clarke.
"Notes on Mining in Portugal." By Mr. Robert Fisher.
"The Gobert Freezing Process of Shaft-sinking." By Mr. A. Gobert.
"Fencing-gates for Winding-shafts." By Mr. William Hay.
"The Prevention of Accidents in Mines." By Mr. Austin Kirkup.
"Gold-mining in Nova Scotia." By Mr. F. H. Mason.

"Methods of Closing the Tops of Upcast Winding Shafts." By Mr. Alexander Reid.

"The Use of Steel Girders in Mines." By Mr. E. Thompson.

"Coal-mining in Assam, India." By Mr. George Turner.

"Underground Haulage at Cannock and Rugeley Collieries." By Mr. Robert S. Williamson.

The papers on mechanical engineering include:—

"The Rocket Oil-engine." By Mr. T. H. Armstrong.

"The Duty of Pumping-engines." By Mr. Dugald Baird.

"Coal-cutting by Machinery." By Mr. W. Blakemore.

"The Woodworth Progressive Cut-off Gear for Winding-engines." By Mr. W. G. Cowlishaw.

"Powdered Coal for Firing Steam-boilers: Wegener and other Systems.' By Mr. Bryan Donkin.

"A Compound Winding-engine." By Mr. W. Galloway.

"Road Locomotives." By Mr. John McLaren.

"Electric Welding." By Mr. T. Scott-Anderson.

"Lead and Lap of Winding and other Engines." By Mr. Hargrave Walters.

"The Woodworth System of Progressive and Automatic Cut-off Gear for Winding-engines." By Messrs. B. Woodworth and W. G. Cowlishaw.

"Adjustable Piston-rings." By Mr. H. Wormald.

The following papers have been read upon geology:—

"The Kent Coal-field." By Messrs. F. Brady, G. P. Simpson, and N. R. Griffith.

"Gold-mining in the Hauraki District, New Zealand." By Mr. Henry M. Cadell.

"The Indian Gold-fields." By Mr. A. G. Charleton.

"Boring below the Blackshale Coal-seam at Apperknowle, near Sheffield." By Mr. G. E. Coke.

"Southern Limit of the Nottinghamshire Coal-field." By Mr. G. E. Coke.

"The Southern Ayrshire Coal-fields." By Mr. Robert W. Dron.

"Notes on the Sinking of the No. 1 Pit at the Ackton Hall Colliery, with Special Reference to the Thinning Out of the Silkstone and Beeston Coal-seams." By Mr. H. St. John Durnford.

"Notes on Mining in Portugal." By Mr. Robert Fisher.

"The Yorkshire and Nottinghamshire Coal-field: Geological Suggestions relative to its Eastward Extension beneath the Permian and Secondary Strata into Lincolnshire." By Mr. W. S. Gresley.

"The Quicksilver Mines and Reduction-works at Huitzuco, Guerrero, Mexico." By Mr. Edward Halse.

"The Eastern Limits of the Midland Coal-field." By Prof. Edward Hull.

"The Whitehaven Sandstone Series." By Mr. J. D. Kendall.

"Geological Description of the Gold-mines of the Transvaal (Witwatersrand, Heidelberg, and Klerksdorp Districts)." By Prof. L. de Launay.

"Gold-mining in Nova Scotia." By Mr. F. H. Mason.

"Economic Minerals of the Province of Ontario, Canada." By Mr. Wm. Hamilton Merritt.

"Notes on the Geological Features of the Coast of North Wales, from Liverpool to Menai Bridge." By Mr. C. E. De Rance.
"The Depth to Productive Coal-measures between the Warwickshire and Lancashire Coal-fields." By Mr. Chas. E. De Rance.
"The Gold-fields of Matabeleland." By Mr. F. G. Shaw.
"The Geology of Warwickshire." By Mr. R. Smallman.
"Coal-mining in Assam, India." By Mr. George Turner.

The following papers have been written on the use of explosives, coal-dust, etc.:—

"How a Mine may be Dry but not Dusty." By Mr. George Fowler.
"The Causes of Death in Colliery Explosions." By Dr. John S. Haldane.
"Some Aspects of Recent Colliery Explosions." By Mr. H. Hall.
"Shot-firing in Fiery and Dusty Mines." By Bergrat H. Lohmann.
"Notes on the Explosion of Coal-dust." By Mr. W. J. Orsman.
"Photography in the Technology of Explosives." By Mr. Alfred Siersch.
"The Roth Method of Firing Shots." By Mr. George Blake Walker.
"Safety Explosives." By Bergassessor Winkhaus.
"The Blasting Efficiency of Explosives." By Bergassessor Winkhaus.

The papers on lighting and ventilation comprise:—

"The Resistances of Air-currents in Mines." By Mr. T. L. Elwen.
"Investigations on the Nature and Sources of the Suffocative Gas met with in Wells: together with Further Observations on the Black-damp of Coal-mines." By Dr. John S. Haldane.
"Photometric Value of, and Notes upon, Various Illuminants used in Mines." By Mr. A. H. Stokes.
"The Use of Petroleum in Safety-lamps." By Mr. E. B. Wain.

The subject of electricity and its applications, signalling, etc., comprise:—

"Telephonic Communications in and about Coal-mines." By Mr. A. W. Bennett.
"Electric Coal-cutting on Longwall Faces." By Mr. T. B. A. Clarke.
"Electrical Machinery for Mines." By Mr. Rankin Kennedy.
"Electric Power-plant at Haden Hill Colliery." By Mr. I. Meachem, Jun.
"Precautions Necessary in the Use of Electricity in Coal-Mines." By Mr. H. W. Ravenshaw.
"Electric Welding." By Mr. T. Scott-Anderson.

The following papers have been written on mechanical coal-cutters:—

"Coal-cutting by Machinery." By Mr. W. Blakemore.
"Electric Coal-cutting on Longwall Faces." By Mr. T. B. A. Clarke.

The miscellaneous papers comprise:—

"The Health Conditions of Coal-mining." By Mr. James Barrowman.
"Mechanical Roasting of Ores." By Mr. Horace F. Brown.
"Barometer, Thermometer, etc., Readings for the Year 1895." By Mr. M. Walton Brown.

"The Quicksilver Mines and Reduction-works at Huitzuco, Guerrero, Mexico." By Mr. Edward Halse.

"Recovery of Bye-products in the Manufacture of Hard Coke." By Mr. John Jameson.

"Obituary of Joseph Mitchell." By Mr. G. J. Kell.

"The Treatment of Timber for Use in Mines." By Mr. Robert Martin.

"Horse-feed." By Mr. F. G. Meachem.

"Poisoning of Horses by *Lathyrus sativus*." By Mr. F. G. Meachem.

"A Deposit found at Delaval Colliery, Benwell, Northumberland." By Messrs. Charles J. Murton and Saville Shaw.

"Coal-washing Plant at the Wirral Colliery, Neston, Cheshire." By Mr. James Platt.

"The Mode of Obtaining a True North Line." By Mr. A. L. Steavenson.

The foregoing lists, comprising 72 papers, demonstrate the varied nature of the papers contributed to the *Transactions* during the year. Many of the papers and the accompanying discussions refer to subjects of both general and special interest, and the Council hope that the members will send in their communications as liberally as heretofore.

The "Notes of Papers (163) on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications" have been continued, and should prove of interest and value to the members.

The bulk of the papers has necessitated the *Transactions* being printed in two volumes (Vols. x. and xi.), and the Council hope that the arrangement will be received with satisfaction by the members.

BOOKS, ETC., ADDED TO THE LIBRARY.

Annales des Mines de Belgique, vol. i., Nos. 1 and 2.

Australian Mining Standard, vol. xi., Nos. 355-369, 371-373; vol. xii., Nos. 374-397.

British Association for the Advancement of Science Report of the Sixty-fifth Meeting, held at Ipswich, September, 1895, octavo, 884 pages.

British Society of Mining Students, Journal, vol. xvii., parts 5 and 6; vol. xviii., parts 1-4.

Brooks, George, Industry and Property, crown octavo, 255 pages.

Canadian Mining Review, vol. xv., Nos. 2-5

Chater, Joseph, The Indian Coal-Mines: Is Legislation necessary to Regulate their Working? 1885, octavo, 17 pages.

Chewings, Dr. Charles, Geological Notes on the Coolgardie Gold-fields, 1896, octavo, 16 pages.

Collins, Henry F., Quicksilver Mining in the District of Guadalcazar, State of San Luis, Potosi, Mexico, octavo, 30 pages.

Corthell, E. L., American Society of Civil Engineers, Resumé of Correspondence from Engineering Societies Relating to Establishing closer International Relations, 8 pages.

Cory Brothers, British Coal Trade and Freight Circular, July 31, 1895, to June 30, 1896.

Engineering and Mining Journal, vol. lx., Nos. 4-26; vol. lxi., Nos. 1-26; and vol. lxii., Nos. 1-3.

Foreign Office Report, No. 1638, Japan, Report for the Year 1894 on the Trade of the Consular District of Hiogo.

Franklin Institute, Journal, vols. cxxxix., cxl., cxli; and vol. cxlii., part 1.

Geological Survey of New South Wales, Records, vol. iv., No. 4; and vol. v., No. 1.

Hall, Henry, and Joseph S. Martin; The Schalke (Gelsenkirchen) Explosive Testing Station, Westphalia, foolscap, 6 pages.

Handbook of British North Borneo, Compiled from Reports of the Governor and Officers of the Residential Staff in Borneo, 1890, octavo, 184 pages.

Hull, Prof. Edw., Artesian Boring at New Lodge, near Windsor, Berkshire.

—, Observations on the Geology of the Nile Valley and on the Evidence of the Greater Volume of the River at a former period.

Institution of Mining and Metallurgy, Transactions, vol. iii., part 3.

Kuntze, Dr. Otto, Geogenetische Beiträge, 78 pages.

Longridge, Capt. C. C., The Holloway-Longridge Process of Extracting Gold from Antimony Ores, etc., 32 pages, and plate.

Lewes, Vivian B., Service Chemistry, being a Short Manual of Chemistry and its Application to the Naval and Military Services, second edition, octavo, 558 pages.

Michigan Mining School, Catalogue of 1892-94; Announcements 1895-96.

—, Prospectus of Elective Studies, May, 1895.

Mines and Quarries, 1895, Summaries of Statistics relating to the Mines and Quarries in the United Kingdom of Great Britain, etc., obtained by H.M. Inspectors of Mines.

New Zealand, Papers and Reports relating to Minerals and Mining, 1896, foolscap, 451 pages.

Ontario Bureau of Mines, 1st, 2nd, 3rd, and 4th Reports.

Pape, Hermann, The Self-Ignition of Coal-Cargo, and How to avoid it, octavo, 16 pages.

Perkins, H. J., Notes on British Guiana and its Gold Industry, 1895, foolscap, 23 pages.

Report of the Observatory Committee of the Royal Society for the Year ending December 31, 1895.

South Wales Institute of Engineers, Transactions, vol. xix., parts 5 to 8.

Stetefeldt, C. A., Can Organic life Exist in the Planetary System Outside of the Earth? octavo, 11 pages.

—, The Lixiviation of Silver-Ores with Hyposulphite Solutions, with Special Reference to the Russel Process, second edition, 210 pages, and plates.

Storrie, John, Roman Iron-making at Ely Race-course, octavo, 5 pages.

Suess, Prof. Ed., The Moon as seen by a Geologist.

Thomas, J. J., Westmorland Slates, Their Geology, Chemistry, and Architectural Value, 1896, octavo, 22 pages.

Wadsworth, M. E., The Michigan Mining School.

Ward, Thomas H., The Indian Coal-Mines Reviewed, 1885, octavo, 8 pages.

Woodward, H. P., Mining Handbook of Western Australia, second edition, 1895, 216 pages and plates.

EXCHANGES.

Annales des Mines de Belgique.
British Association for the Advancement of Science.
British Society of Mining Students.
Franklin Institute of the State of Pennsylvania, U.S.A.
*General Mining Association of the Province of Quebec, Canada.
*Illinois Mining Institute, U.S.A.
Institution of Mining and Metallurgy.
*Manchester Geological Society.
*Mining Society of Nova Scotia, Canada.
New South Wales, Minister of Mines.
*Revue Universelle des Mines, de la Métallurgie, etc.
South Wales Institute of Engineers.

* No publications received during current year.

July 31st, 1896.

The Local Institutes in Account with The Federated Institution of Mining Engineers, for the Year Ending July 31st, 1896.

Dr.	No. of Members.		Balance due at the beginning of the year.	Amounts falling Due during the Year.			
	Federated.	Non-Federated.		Calls made during the year.	Excerpts.	Transactions, Reducing Plates, etc.	Totals.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	324	...	10 2 2	275 8 0	4 3 7	13 3 4	302 17 1
Midland Institute of Mining, Civil, and Mechanical Engineers	253	...	2 11 1	215 1 0	4 3 4	7 13 4	229 8 9
Mining Institute of Scotland	413	81	6 2 11	391 11 0	15 1 1	10 3 4	422 18 4
North of England Institute of Mining and Mechanical Engineers	1,026	...	1 7 4	872 2 0	22 18 1	16 9 4	912 16 9
North Staffordshire Institute of Mining and Mechanical Engineers	163	...	22 5 5	138 11 0	2 12 6	5 13 4	169 2 3
South Staffordshire and East Worcestershire Institute of Mining Engineers...	109	...	77 11 2	92 13 0	0 11 8	5 10 4	176 6 2
Totals... ...	2,288	81	120 0 1	1,985 6 0	49 10 3	58 13 0	2,213 9 4

Cr.	Amounts Paid during the Year.					Balance due at July 31st, 1896.
	Balance from previous year.	Calls.	Excerpts.	Transactions, Reducing Plates, etc.	Totals.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	10 2 2	273 14 0	4 3 7	13 3 4	301 3 1	1 14 0
Midland Institute of Mining, Civil, and Mechanical Engineers	2 11 1	214 4 0	4 3 4	7 10 0	228 8 5	1 0 4
Mining Institute of Scotland	6 2 11	391 11 0	13 10 10	7 13 0	418 17 9	4 0 7
North of England Institute of Mining and Mechanical Engineers	1 7 4	843 4 0	22 18 1	16 6 0	883 15 5	29 1 4
North Staffordshire Institute of Mining and Mechanical Engineers	22 5 5	114 18 0	...	0 6 8	137 10 1	31 12 2
South Staffordshire and East Worcestershire Institute of Mining Engineers	77 11 2	55 5 0	0 5 2	1 0 0	134 1 4	42 4 10
Totals... ...	120 0 1	1,892 16 0	45 1 0	45 19 0	2,103 16 1	109 13 3

Dr. THE TREASURER IN ACCOUNT WITH THE
FOR THE YEAR

July 31, 1895—		£ s. d.	£ s. d.
To Balance at Bank		607 15 8	
" " in Treasurer's hands		38 13 8	
			646 9 4
To Subscriptions for year ending July 31, 1895—			
Federated—			
Chesterfield and Midland Counties Institution of Engineers		9 7 0	
Midland Institute of Mining, Civil, and Mechanical Engineers		1 14 0	
North of England Institute of Mining and Mechanical Engineers		1 7 4	
North Staffordshire Institute of Mining and Mechanical Engineers		14 16 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers		58 4 6	
			85 8 10
To Subscriptions for year ending July 31, 1896—			
Federated—			
Chesterfield and Midland Counties Institution of Engineers		273 14 0	
Midland Institute of Mining, Civil, and Mechanical Engineers		214 4 0	
Mining Institute of Scotland		351 1 0	
North of England Institute of Mining and Mechanical Engineers		843 4 0	
North Staffordshire Institute of Mining and Mechanical Engineers		114 18 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers		55 5 0	
			1,852 6 0
Non-Federated—			
Mining Institute of Scotland			40 10 0
To Local Publications and Authors' Copies—			
Chesterfield and Midland Counties Institution	1894-95.	1895-96.	
of Engineers	0 14 2	4 3 7	
Midland Institute of Mining, Civil, and Mechanical Engineers	0 17 1	4 3 4	
Mining Institute of Scotland	3 19 7	13 10 10	
North of England Institute of Mining and Mechanical Engineers	......	22 18 1	
North Staffordshire Institute of Mining and Mechanical Engineers	4 19 5	......	
South Staffordshire and East Worcestershire Institute of Mining Engineers	......	0 5 2	
The Federated Institution of Mining Engineers	7 14 9	3 6 9	
	18 5 0	48 7 9	
			66 12 9
Carried forward			£2,691 6 11

FEDERATED INSTITUTION OF MINING ENGINEERS. **Cr.**
ENDING JULY 31, 1896.

	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
July 31, 1896.												
By Printing—												
Transactions, Vol. V., printing	0	9	6									
				0	9	6						
„ „ VIII., printing	1	6	3									
„ „ VIII., plates	2	0	3									
				3	6	6						
„ „ IX., printing	445	13	10									
„ „ IX., plates	176	13	9									
				622	7	7						
„ „ X., printing	410	7	0									
„ „ X., plates	119	3	7									
				529	10	7						
„ „ XI., printing	89	4	7									
„ „ XI., plates	27	3	8									
				116	8	3						
							1,272	2	5			
Excerpts, Vol. VII.				0	16	6						
„ „ IX.				56	8	6						
„ „ X.				57	3	4						
							114	8	4			
Circulars							24	0	8			
Proofs of Papers for General Meetings							14	3	11			
										1,424	15	4
By Addressing Transactions, etc.							19	5	0			
„ Postages—Circulars				19	11	7						
„ „ Correspondence				12	10	4½						
„ „ Transactions				175	6	1						
							207	8	0½			
„ Stationery, etc.							23	5	9			
„ Insurance of Transactions							2	0	0			
„ Binding—Library				1	4	2						
„ „ Sundries				0	14	6						
„ „ Transactions...				40	6	4						
							42	5	0			
„ Reporting General Meetings							10	16	0			
„ Expenses of General Meetings							4	0	4			
„ Incidental Expenses							7	15	7			
„ Petty Cash							7	9	6			
„ Salaries, Wages, etc.							475	7	8			
„ Indexing Transactions							7	10	0			
„ Travelling Expenses—Secretary				39	18	6						
„ „ „ Treasurer				11	10	0						
							51	8	6			
										858	11	4½
Carried forward										£2,283	6	8½

Dr. THE TREASURER IN ACCOUNT WITH

	£ s. d.	£ s. d.	£ s. d.
Brought forward			2,691 6 11
To Sales of Transactions, etc.—			
	1894-95.	1895-96.	
Chesterfield and Midland Counties Institution of Engineers	0 1 0	11 3 4	
Midland Institute of Mining, Civil, and Mechanical Engineers	......	2 0 0	
Mining Institute of Scotland	2 3 4	1 3 0	
North of England Institute of Mining and Mechanical Engineers	......	12 6 0	
North Staffordshire Institute of Mining and Mechanical Engineers	2 0 0	0 6 8	
South Staffordshire and East Worcestershire Institute of Mining Engineers	19 6 8	......	
Members, etc.	......	75 16 9	
	23 11 0	102 15 9	
			126 6 9
To Reducing Plates—			
	1894-95.	1895-96.	
Chesterfield and Midland Counties Institution of Engineers	......	2 0 0	
Midland Institute of Mining, Civil, and Mechanical Engineers	......	5 10 0	
Mining Institute of Scotland	......	6 10 0	
North of England Institute of Mining and Mechanical Engineers	......	4 0 0	
North Staffordshire Institute of Mining and Mechanical Engineers	0 10 0	......	
South Staffordshire and East Worcestershire Institute of Mining Engineers	......	1 0 0	
	0 10 0	19 0 0	
			19 10 0
To Advertizements			472 10 10
			£3,309 14 6

THE FEDERATED INSTITUTION OF MINING ENGINEERS.—*Continued.* **Cr.**

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward							2,283	6	8½
By Advertizements—Agreement Stamps	0	13	6						
„ „ Commission	147	1	4½						
„ „ Printing	1	12	0						
„ „ Sundries	0	3	6						
				149	10	4½			
„ Prizes, Vols. VIII. and IX.	20	0	0						
„ „ Students', Vol. X.	5	0	0						
				25	0	0			
„ Translations of Papers				3	10	0			
„ Abstracts of Foreign Papers, Vols. IX. and X. ...				91	5	0			
„ Barometer Readings, etc.				6	18	0			
„ Calendar				13	1	6			
							289	4	10½
							2,572	11	7
„ Mining Institute of Scotland, amount refunded for Excerpts				......			5	3	7
„ Balance at Bank				683	0	3			
„ „ in Treasurer's hands				48	19	1			
							731	19	4
							£3,309	14	6

Liabilities.

	£ s. d.	£ s. d.
Sundry Creditors—		
Advertizements Paid in Advance	18 0 0	
Printing, etc.	720 0 0	
Postage of Transactions	80 0 0	
Abstracts of Foreign Papers	60 0 0	
Barometer Readings	8 0 0	
Prizes for Papers, Vols. X. and XI.	20 0 0	
Index, Vol. XI.	6 0 0	
		912 0 0
Balance of Assets over Liabilities		968 4 11
		£1,880 4 11

I have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in my opinion it exhibits a correct view of the affairs of the Institution.

I have accepted the assets "Transactions in stock" as valued by the Officials of the Institution.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
September 11*th*, 1896.

ENGINEERS.—BALANCE SHEET, JULY 31, 1896.

Assets.

	£	s.	d.	£	s.	d.
Balance at Bank	683	0	3			
„ in Treasurer's hands	48	19	1			
				731	19	4
Subscriptions Unpaid, Year ending July 31, 1896—						
Chesterfield and Midland Counties Institution of Engineers	1	14	0			
Midland Institute of Mining, Civil, and Mechanical Engineers	0	17	0			
North of England Institute of Mining and Mechanical Engineers	28	18	0			
North Staffordshire Institute of Mining and Mechanical Engineers	23	13	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	37	8	0			
				92	10	0
Excerpts Unpaid—						
Mining Institute of Scotland	1	10	3			
North Staffordshire Institute of Mining and Mechanical Engineers	2	12	6			
South Staffordshire and East Worcestershire Institute of Mining Engineers	0	6	6			
Members	0	18	1			
				5	7	4
Transactions Sold—						
Midland Institute of Mining, Civil, and Mechanical Engineers	0	3	4			
Mining Institute of Scotland	2	0	4			
North of England Institute of Mining and Mechanical Engineers	0	3	4			
North Staffordshire Institute of Mining and Mechanical Engineers	1	16	8			
South Staffordshire and East Worcestershire Institute of Mining Engineers	4	0	4			
				8	4	0
Reducing Plates—						
Mining Institute of Scotland	0	10	0			
North Staffordshire Institute of Mining and Mechanical Engineers	3	10	0			
South Staffordshire and East Worcestershire Institute of Mining Engineers	0	10	0			
				4	10	0
Advertizements unpaid				295	15	0
				1,138	5	8
Transactions in Stock				741	19	3
				£1,880	4	11

The Chairman (Mr. G. A. Mitchell) regretted that all the mining institutes of the Kingdom were not yet federated; but he thought that the members might hope for the time when The Federated Institution of Mining Engineers would include all.

ELECTION OF OFFICERS.

The Secretary announced the following elections of officers by the Council:—

President.

Mr. Lindsay Wood.

Vice-Presidents.

Mr. J. B. Atkinson.
Mr. W. N. Atkinson.
Mr. E. Bainbridge, M.P.
Sir Lowthian Bell, Bart.
Mr. W. Cochrane.
Mr. J. Daglish.
Mr. J. S. Dixon.
Mr. T. Douglas.
Mr. J. T. Forgie.
Mr. W. J. Hayward.
Mr. George Lewis.
Sir William Thomas Lewis, Bart.
Mr. George May.
Mr. M. H. Mills.
Mr. Geo. A. Mitchell.
Mr. J. Nevin.
Mr. A. Sopwith.
Mr. E. B. Wain.
Mr. G. B. Walker.

Treasurer.

Mr. Reginald Guthrie.

Auditor.

Mr. John G. Benson.

Mr. Jas. McMurtrie (Radstock) proposed that a cordial vote of thanks be accorded to Mr. Mitchell for his able presidency of the Institution. It had not been his own fortune to attend many of the meetings during the past year, but from what he had observed he was sure that the retiring President had acted with great ability and dignity during his term of office.

Mr. W. N. Atkinson (Newcastle-under-Lyme), in seconding the vote of thanks, said that Mr. Mitchell had displayed in his occupancy of the presidential chair an ability, a courtesy, and a demeanour which had obtained the hearty admiration and respect of the members.

The vote of thanks was heartily adopted.

Mr. G. A. Mitchell expressed his sincere thanks to the members for their kind appreciation of his discharge of the duties of President. He was afraid that there had been many faults in the manner of his conduct in the chair; but he was sure that they were ready to overlook them. He had experienced great pleasure in the discharge of his duties; he had felt the responsibility, he had also felt the honour of having his name handed down among the list of illustrious men who had been presidents of this institution. His only regret at this time was that he was not to be relieved of the duties of the chair that day. It was usual for the new president to take the chair at the September meeting after his election, but Mr. Lindsay Wood was unable to be present. Mr. Lindsay Wood was well known amongst mining engineers, and he had great pleasure in introducing him as his successor, in his absence.

STUDENT'S ESSAY.

The SECRETARY reported that the Council had presented to Mr. Roslyn Holiday the prize offered to students, for his paper on "The Applications of Electricity to Mining Operations."

Mr. W. D. WIGHT read the following paper on "Anthracite Coal-breaking and Sizing Plant at Glyncastle Colliery":—

ANTHRACITE COAL-BREAKING AND SIZING PLANT AT GLYNCASTLE COLLIERY.

By W. D. WIGHT.

While the production of anthracite coal in the United States of America had rapidly increased, until the output in 1895 had reached the enormous total of 58,000,000 tons, South Wales anthracite-deposits had been comparatively neglected, and the trade for this quality of coal had languished.

Out of an approximate area of 1,000 square miles in the South Wales coal-field, it was estimated that no less than 410 square miles contained numerous seams of anthracite-coal of excellent quality, and of more than average thickness.

The official returns for 1895 gave the total output of this coal-field as 33,040,114 tons of coal, out of which anthracite amounted to only 1,761,186 tons, being the largest quantity recorded up to that date; but this was greatly disproportionate to its area.

There are no exceptional mining difficulties to contend with in developing the anthracite-coal of the South Wales district, but on the contrary immense tracts may be reached by day-drifts. Upon the north-western edge of the larger portion of the coal-field there is a range of some 35 miles along which seams of this quality crop out, in addition to which, in the smaller detached portion of the coal-field in Pembrokeshire, the outcrop runs for about 45 miles.

This slow development can be explained only by the circumstance that, in the past, the purposes to which it had been applied in this country were very limited. The use of large anthracite-coal in blast-furnaces has almost been abandoned, and the trade has been confined to malting and lime-burning. It is only in very recent years that anthracite colliery owners generally have awakened to the fact that it is possible to create a trade for their coal for domestic purposes, if it be supplied to the consumer in such a condition that it can be burned with facility.

A great proportion of American anthracite-coal is prepared for household use, and the collieries in the United States have for many years past been fitted with extensive breaking-plants, in order to reduce the lumps of coal to such sizes as may be found suitable for the market.

It is difficult for those who have not had experience with this class of coal to understand that, although of the finest appearance and purest quality, yet it is nearly impossible to burn it in the ordinary grates usually found in dwelling-houses, but with specially prepared grates it can be burned with economy and efficiency.

It would appear that anthracite burns only on the surface, and that, in order to ensure active combustion, the proportion of surface to a given bulk of coal should be greater than in the case of bituminous coal. It is necessary, also, that the pieces should be of fairly uniform size, so as to allow of the air having free passage through the mass, and hence the close sizing adopted. Slow combustion is essential, for if it be attempted to burn large pieces by means of a fierce draught, the coal is liable to decrepitate and fall through the grate in a partly-burnt condition.

Stoves are now made with special appliances to meet the requirements of anthracite-fuel; and for convenience and efficiency, together with economical results, this method of house-warming will compare favourably with any other. The benefits to the community, especially in great cities, arising from the use of an absolutely smokeless combustible must not be lost sight of.

Experience has shown that the size of coal usually called "nuts" is the most suitable for domestic stoves, and the plant which has been erected at Glyncastle colliery, to be described and illustrated in this paper, has been designed to manufacture this size, the remaining sizes being only incidentally produced.

The analysis of the Glyncastle coal is as follows:—

	Per Cent.
Carbon	91·67
Hydrogen	3·93
Oxygen	1·87
Nitrogen	0·44
Sulphur	0·77
Ash	1·32

The situation at Glyncastle colliery, from the circumstance of the pits being at a much higher level than the railway-sidings, permits of the trams being brought over gangways from the mountain-side to the top of the building without the aid of elevators, and the coal gravitates through the machinery to the trucks, the height of the erection from rail-level on siding to tram-rail on tippler being 46½ feet (Plates VII. and VIII.).

As it is not always desired to break the coal, facilities had to be afforded to load large coal when wanted, to accomplish which a long shute is placed in direct line with the tippler and colliers' screen, conveying the large coal directly to the waggon. The greater part of the sizing-screens and the picking-belt are arranged in a parallel line 12 feet to one side, the coal passing by means of inclined shutes in this direction (Fig. 1, Plate IX.).

Tippler.—A revolving side-tippler being considered the best type both for economy in labour, despatch, and careful treatment of the coal, enquiries were made of numerous makers as to their designs. It was found almost without exception that side-tipplers were made with an uniform speed of revolution, and those in which it was attempted to give a variable motion either failed to do so in a manner suitable to the requirements of tipping, or introduced mechanical complications which were not desirable.

When carefully looked into, it will be found that the discharge of coal in a side-tippler, even with a volute-shute to modify the flow of coal from the side-plate, takes place only during one-eighth part of the revolution. If it be desired to tip, say once in 32 seconds, then the whole of the coal will be emptied in the short space of 4 seconds. This is too rapid to efficiently screen upon a fixed-bar screen and with the heavy lumps of Welsh coal the shocks and breakage caused thereby would be detrimental. The trams in use at Glyncastle colliery carry an average weight of 35 cwts. of coal, and it will at once be seen that to discharge such a mass upon a screen in 4 seconds would subject the coal and machinery to excessive violence.

Having failed to get a satisfactory tippler, the one about to be described has been designed, and it has answered the requirements with a marked degree of success (Figs. 4, 5, and 6, Plates IX. and X.).

This tippler revolves in a theoretically perfect manner, the full tram being turned slowly during the discharge of coal, and when empty returned quickly to economize time. It commences at a medium speed which decreases to an extremely slow motion as the coal begins to discharge, continues very slowly during discharge, but immediately this is completed a greatly accelerated speed is attained, which gradually slows down again as the tippler completes its revolution.

The mechanism by which this is achieved is a novel and curious combination of two crank-pins *A* and *B*, and a connecting-link *C*, which is placed at one end of the tippler, either below the tram as shown on the diagrams, or above at the empty end, as may be the more convenient.

The driving crank *B*, curved to clear the tram wheel when passing from the tippler, is driven by a belt-wheel at *E* from the main shafting at a uniform velocity through a worm *F* and worm-wheel *G*, which gives the required reduction of speed. The tippler-ring *H* carries a pin *A*, the relation of which to the centre of the tippler constitutes the second or following crank. The crank-pins *A* and *B* are connected by a link *C*.

It will be seen that the turning of the driving-crank *B* drags after it the tippler, which is free to rotate on the four rollers *J* upon which it rests. The resulting motion of the tippler can be best understood by reference to the diagram (Fig. 6, Plate X.), each division of which marks an equal period and may be assumed to be seconds. The first 11 seconds are occupied in inverting the full tram until the coal lies upon the side-plate at an angle ready to be discharged. At the eleventh second, the coal commences to fall upon the screen and continues to do so until at the twenty-sixth second the whole is emptied. Very rapid motion then commences with the empty tram, one-half the revolution being completed in 4 seconds, with gradually reducing speed, the two last periods being occupied in quietly bringing the tippler to rest.

It will thus be seen that the coal is being emptied during $\frac{15}{32}$, or almost $\frac{1}{2}$, of the time, as against $\frac{4}{32}$, or $\frac{1}{8}$, of the time of revolution, with a uniformly revolving machine. By differently proportioning the lengths of the cranks and link, any desired variation of the speeds can be produced, but those described have been found suitable for the purpose. A simple starting- and automatic stopping-gear places the arrangement under complete control.

This form of tippler has special merits when applied in connexion with cleaning-belts. Its application would, in many cases, dispense with the necessity for distributing-belts, or, where they are used, would, in a marked degree, increase their efficiency. By virtue of the time saved with the quick return of the empty tram, this tippler will deal with a larger quantity than those of the ordinary type, with less breakage of the coal.

Colliers' Screen.—The custom of the district by which the collier is only paid upon large coal, which passes over a bar-screen of certain dimensions, with spaces of 1 inch between the bars, necessitated the introduction of this screen. The coal which passes through the bars is weighed in the machine known as a "Billy Fairplay," and is dealt with as afterwards explained (Figs. 1 and 2, Plates IX. and X.).

Cleaning-belt.—A belt, 14 feet in length by 4 feet in width, receives the coal from the screen, and enables any large pieces of foreign matter which might injure the breakers to be removed (Figs. 1 and 2, Plates IX. and X.).

Large Coal Screen.—A short fixed bar-screen, with 3½ inches spaces, is introduced at the end of the cleaning-belt, and serves the double purpose of making the large coal of exceptional size and of avoiding the passage of the smaller-sized coal through the first coal-breaker when making broken coal only. The coal passing through these bars falls down an inclined shute to the first Klein screen (Figs. 1 and 2, Plates IX. and X.).

At the end of the large-coal screen is a hinged flap, covering or leaving open the entrance to the first coal-breaker. When it is desired to load large coal, this flap is lowered and forms a part of the bottom of the shute which conducts the large coal to the waggon, the inclination of the shute being just sufficient to permit of the coal sliding quietly down.

Coal-breakers.—The proper form of machine for breaking the coal was a matter which received much consideration. Opinions as to the correct type differed considerably, and each design had warm advocates, whose arguments it was impossible to controvert without the results of actual competitive tests with the same quality of coal, and these were not obtainable.

Among the various breakers which have been introduced in South Wales may be mentioned the following:—(*a*) Revolving picks depending upon centrifugal force to strike the coal; (*b*) stone-breakers with hinged jaws having corrugated teeth on the faces; (*c*) inverted conical basins, fitted with revolving internal cones, the working surfaces being serrated, like the domestic coffee-mill; (*d*) two opposite faces, studded with spikes reciprocating horizontally, the coal falling between the spiked faces as they advance and recede from one another; (*e*) pairs of deeply-fluted cylinders revolving in opposite directions, arranged with the projections of one cylinder working into the depressions of the other cylinder; and (*f*) pairs of spiked cylinders, revolving in opposite directions, arranged with the spikes of one cylinder working into the interspaces of the other. This last type is the one adopted at Glyncastle colliery, as it gave the best promise of breaking the coal with the smallest production of inferior sizes.

First Coal-breaker.—The first breaker is used for the purpose of reducing the larger pieces of coal, a considerable proportion of which exceed 1 cwt. and occasionally reach upwards of 3 cwts., to such a size as can be dealt with in the second breaker.

This machine consists of two cylinders, *A* and *B*, each 4 feet in length by 2½ feet in diameter, studded with spikes as shown in Figs. 7 and 8 (Plate X.), the spikes being alternately 3 inches and 4½ inches in length. The holes in which the spikes are fixed are slightly tapered, the spikes being turned to a tight driving fit. In each cylinder there are 435 spikes of each length, or 1,740 in all, in this machine.

A driving pulley, *C*, is attached to one of the axles, and transmits its motion to the other cylinder through a pair of toothed wheels, *D*. The whole of the parts are entirely enclosed in an iron casing. The speed at which the cylinders are driven is 100 revolutions per minute, which gives the teeth approximately the same rate of motion as that acquired by the coal in dropping upon them.

The coal from the first breaker passes through an inclined shute to the first Klein screen, where it mingles with the coal which has passed through the large-coal screen (Figs. 1 and 2, Plates IX. and X.).

First Klein Screen.—The coal now undergoes a preliminary sizing, whereby all that will pass through 3 inches square holes is separated and forwarded directly to the next sizing-screen, the larger pieces going to the second breaker. This screen is fixed horizontally, but owing to its peculiar swinging action it has the power of working the coal forward. An essential feature in its motion is the fact that each point of the screen describes the same oval curve.

The coal on the screen commences to rise quickly in a line of flight at the beginning of the first half-revolution of the crank or eccentric (see direction of arrows in Fig. 12, Plate X.). Having reached the summit of its path, the second half-revolution of the crank gives the screen a slow downward and retrograde motion, receding from the material which has been thrown forward to fall at another point of the screen, when it is again jerked forward. The upward motion of the screen is about 2½ times as fast as its downward motion. The path traversed by the material at each stroke is in proportion to the size and position of the curve adopted.

Fig. 12 is a diagram of the motion, and Figs. 9, 10, and 11 (Plate X.) are drawings of the screen. The triangular crank-piece *C*, on the driving-shaft *B*, is attached to the screen-frame at *A*. At *D*, this crank-piece is suspended by links from the bearings *F*. As a result of *D* being suspended, *A* describes an oval curve the shape of which depends on the position of points *A*, *B*, *D*, and *F*. In order to transmit this same oval motion to all points of the screen, a parallelogram is adopted: *A*, *D*, *D'*, *A'*; *D'* being suspended from a bearing, *F'*, and connected to the screen at *A'*. The points *D* are hung by means of the links *E* from the bearings *F*, and are connected by the tie-rod *H*. *J*, *J* are connecting rods between *H* and *H'*, and *H' H'* are connected to the frame of the screen by means of suspension rods, *K*. The whole arrangement is fixed to the frame *N*.

Second Coal-breaker.—This breaker is used for the purpose of reducing such coal as failed to pass through the 3 inches holes in the first Klein screen, to the size of nuts. It is similar in construction to the first breaker but smaller, the cylinders being 18 inches in diameter by 2½ feet in length, and the spikes, numbering 242 in each cylinder, are 3 inches in length.

Second Klein Screen.—This screen, which is 16 feet in length and 3½ feet in width, receives the coal which passed through the first Klein screen and the last breaker. It is here that the coal is sized for cobbles and first and second nuts. These are delivered on to the picking-belt, all the smaller coal falling into the elevator-hopper.

Picking-belt.—This belt is of the usual description, 4½ feet in width and 80 feet in length, divided longitudinally for cobbles, first, and second nuts. The nuts are swept off each side opposite their respective waggon-ways, and the cobbles are discharged at the end of the belt (Figs. 1 and 2, Plates IX. and X.).

The small coal extracted by the colliers' screen, and known as "Billy" coal, is not allowed to pass through the sizing-screen although it contains a proportion of nuts, because experience shows that this coal contains too many stones to be effectually cleaned by picking. It is, therefore, conveyed by an Archimedian screw from the billy-shute directly to the elevator-hopper.

Coal-washery.—For the purpose of treating the coal below nut size, *i.e.*, such as passes through a ¾ inch square hole, an additional plant has been erected adjoining the main building. In this the coal is separated into three further sizes: beans, peas, and duff (Figs. 1 and 3, Plate IX.).

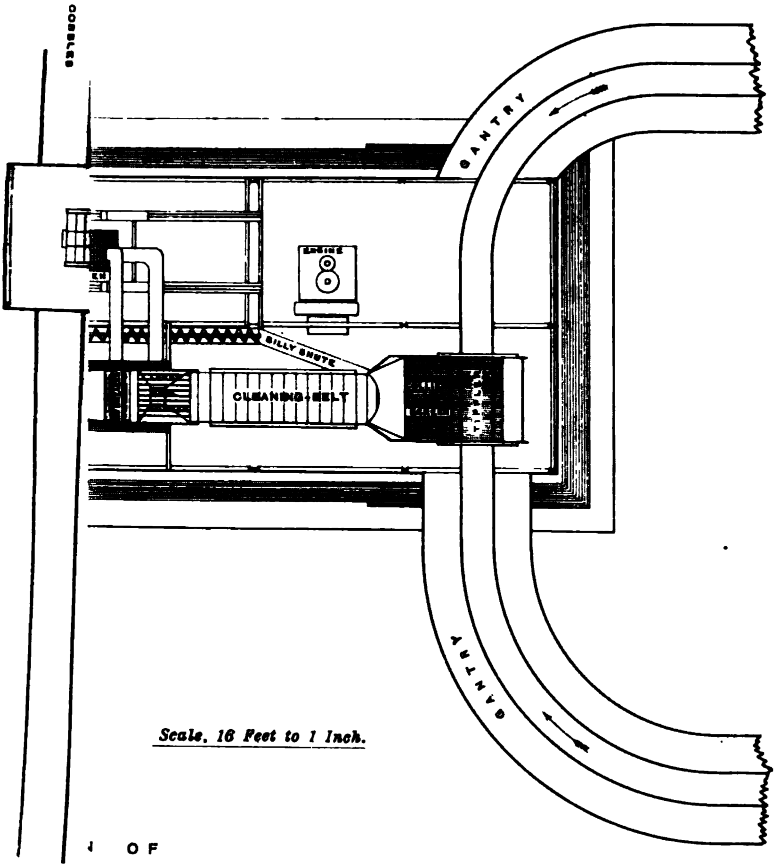
An elevator, 50 feet in height, lifts from the hopper, into which all the smaller coal has been conveyed, and discharges upon a vibromotor

To illustrate Mr. W. D. Wight's paper on "Anthracite Coal-Breaking and Sizing Plant," etc.

Glyncastle Colliery.

Siz

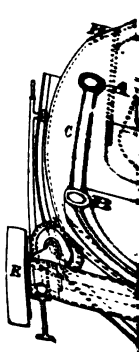
" Sizing-Plant at Glyncastle Colliery."



Scale, 16 Feet to 1 Inch.

OF

PLANT



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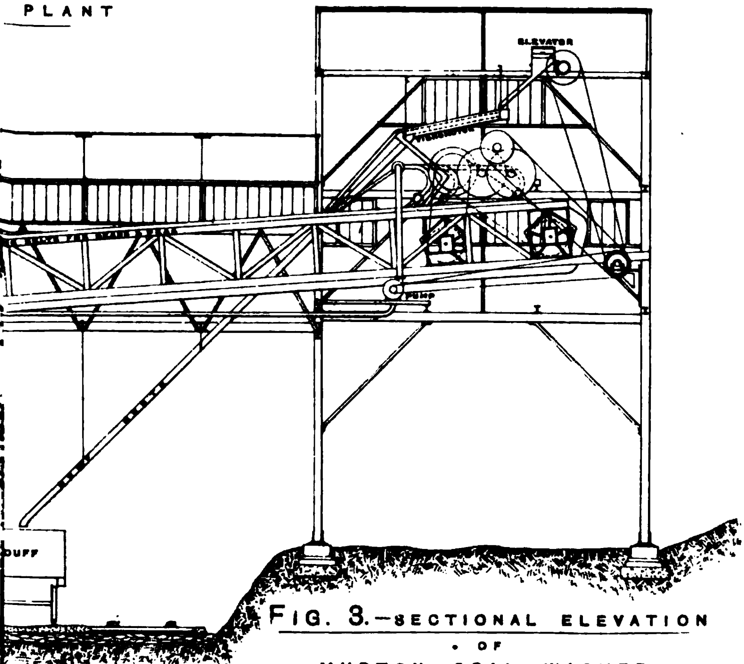
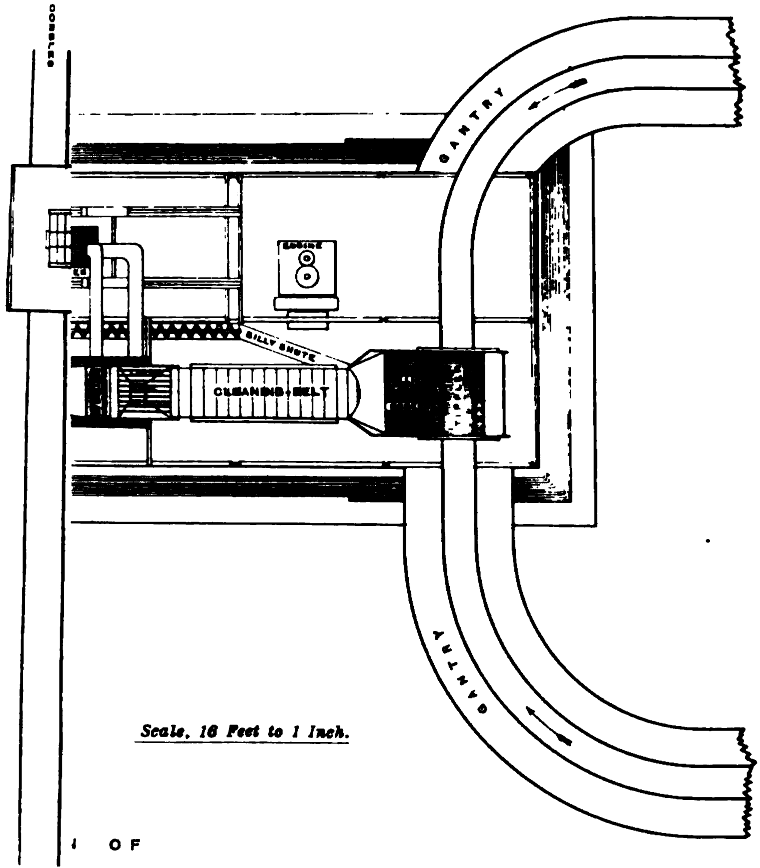


Scale, 16 Feet to 1 Inch.

FIG. 3.—SECTIONAL ELEVATION OF MURTON COAL WASHER.

"Sizing-Plant at Glyncastle Colliery."



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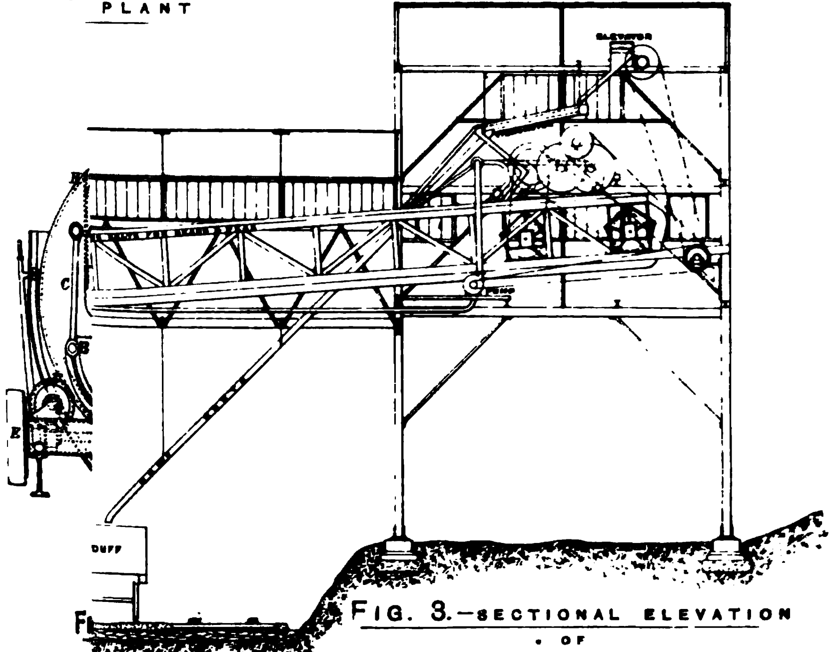

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FIG. 3.—SECTIONAL ELEVATION OF MURTON COAL WASHER.

Scale, 16 Feet to 1 Inch.

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Sizing-Plant at Glyncastle Colliery."

Vol. XII Plate X

11.

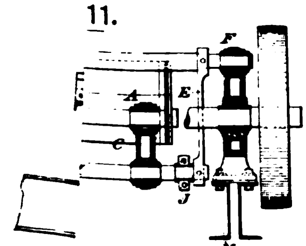
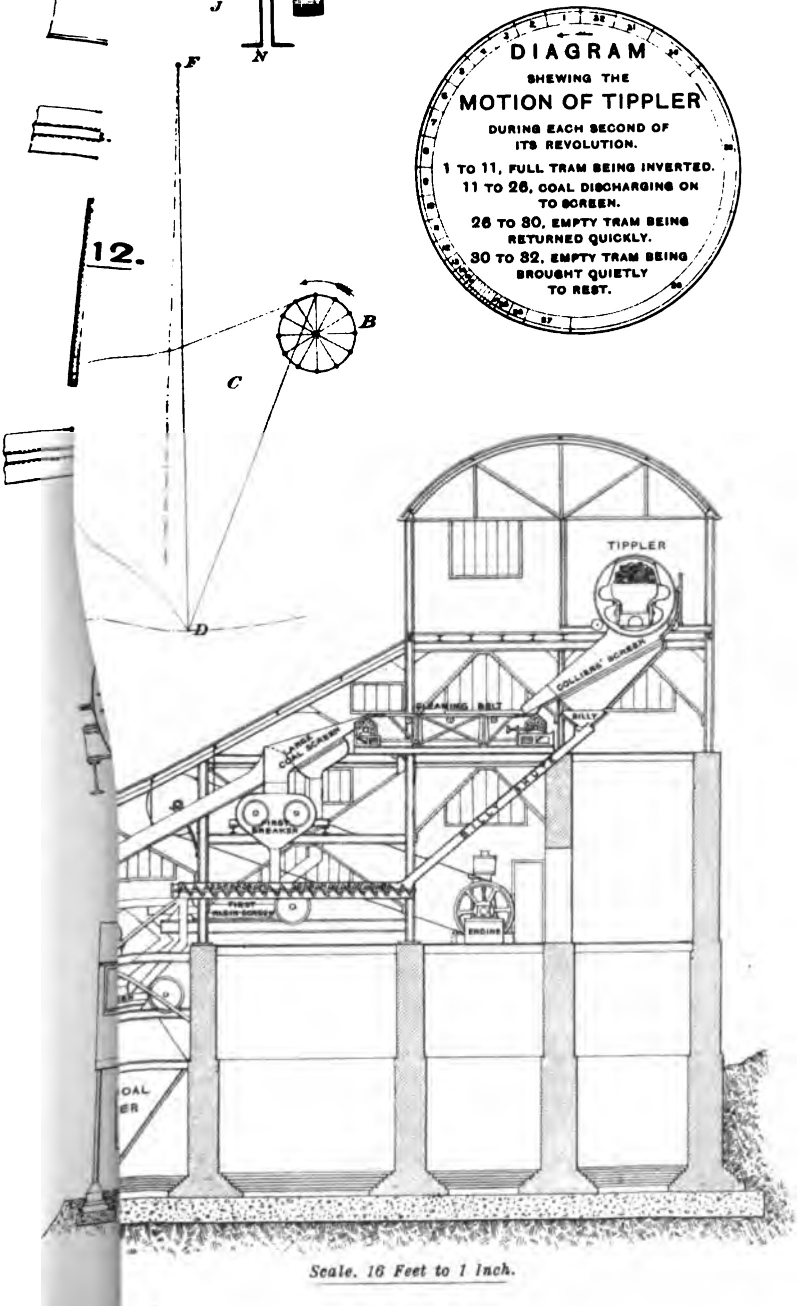


Fig. 6.

12.



Scale. 16 Feet to 1 Inch.

screen with double perforated plates, which sizes it into three different qualities. The beans and peas are then cleaned in a Murton coal-washer and emptied into bunkers, where they dry ready to be filled into waggons. The duff falls down a shute to the trucks.

The vibromotor screen and the Murton coal-washer having recently been described in the *Transactions*,* it is unnecessary to give any explanation of their action.

The motive power to work the whole installation is obtained from a Babcock and Wilcox water-tube boiler working at a steam-pressure of 120 lbs. per square inch, supplying a Tangye-Archer compound-engine with high-pressure cylinder 10 inches in diameter, and low-pressure cylinder 16 inches in diameter, each of 10 inches stroke, running at 180 revolutions per minute, to which is attached a Babcock and Wilcox exhaust-steam feed-water heater. A main line of shafting is carried through both buildings from which the various machines are driven.

The buildings are constructed of steel girders, framed together and covered with corrugated iron sheeting (Plates VII. and VIII.).

The sizes of coal which are made are as under:—

Large coal is what passes over bars with 3½ inches spaces between.
Cobbles pass through 3 inches square holes and over 2¼ inches square holes.
First nuts ,, 2¼ ,, ,, ,, 1¾ ,, ,,
Second nuts ,, 1¾ ,, ,, ,, ¾ ,, ,,
Beans ,, ¾ ,, ,, ,, ⅜ ,, round holes.
Peas ,, ⅜ ,, round holes ,, $\frac{3}{16}$,, ,,
Duff ,, $\frac{3}{16}$,, ,,

These sizes can be varied to suit market requirements.

Mr. MORGAN W. DAVIES (Swansea) said that this being the first occasion at which the breaking and classification of anthracite-coal in this country had been the theme of open discussion at the hands of experienced engineers, it was needless to observe that many specially interesting points must arise and the wider the scope of the discussion the more valuable and advantageous must be the information elicited and the experiences recounted thereon. The subject of coal-breaking and sizing was one in which he (Mr. Davies) had been keenly interested for many years, and he believed that one of the earliest attempts at its solution on a practical scale was an installation designed by himself

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* *Trans. Fed. Inst.*, vol. xi., page 55, and vol. ix., page 42.

for the Gwauncaegurwen collieries, then under the direction of the late Mr. Thomas Cooper of Rotherham. The arrangement provided only for the classification of the coals that had already passed through the main or colliers' screen, and so successful was it in its operation that the demand for properly-screened nut coal so far outgrew the production that the colliery company had to resort to breaking large coal in order to supply the demand. Various types of breakers were employed, all in a more or less experimental stage, until the installation of a very extensive and complete plant designed by Mr. W. Galloway which was in satisfactory operation to this day. During that time many other collieries had realized the necessity of breaking and sizing the coals, and at the present moment there are several extensive plants in operation doing very efficient work.

Different coals in the process of breaking give widely different results, having regard more especially to the quantity of small coal produced in the form of peas and duff. In order to minimize this breakage, considerable attention must be paid not only to the form of breaker and screen employed but also to the working speeds, and, in the case of the screens, to their angles of inclination. Speaking generally, the coal should be broken in gradations by the employment of two, three, or more breakers set successively to closer gauges, and jig or vibrating-screens produce less waste and act more satisfactorily in the separation of large and small nuts from the peas and duff than cylindrical revolving-screens; but for the separation of the peas from the duff, the cylindrical revolving-screen is incomparably the better arrangement.

Col. Brown carried out, in the anthracite coal-fields of Pennsylvania, U.S.A., a series of careful experiments to determine the waste caused by breaking by hand, by machinery, and by screening through circular screens, and he gives the following figures :—

	Per Cent.
Waste made by breaking by hand down to egg size, with small hammers and screening by hand	6·28
Extra breakage caused by running the same through the cylindrical screen	4·00
Breaking by rolls, and screening through cylindrical screens	15·27

From the above table, it is evident that the difference between breaking by rolls and breaking by hand is only 5 per cent., after deducting the loss of 4 per cent. produced by passing the coal through the cylindrical screen. It would have been very interesting if Mr. Wight had given in his paper the relative proportions of the different categories of coal produced by the sizing-screens as compared with the quantity of large or through coal dumped into the breakers over the initial screens.

The question of cost of treatment was also an important one, and any reliable figures bearing on the subject would be much appreciated.

There was one statement in Mr. Wight's paper to which he was sorry to take exception, and that was where he said that it was nearly impossible to burn anthracite-coal in ordinary grates but that with specially prepared grates it could be burned with economy and efficiency. As a matter of fact, anthracite-coal could and was being regularly burned in almost every variety of grate, and no difficulty attached to its burning, but to those inexperienced in its use it was slow to kindle. There were large districts where nothing but anthracite-coal was being used, and it constituted the fuel of cottage and mansion alike, giving out an exceptionally bright and cheerful fire; but on grounds of economy and high efficiency it was *par excellence*, a stove coal.

Mr. J. A. **Longden** (Stanton) said that the arrangement of the tippler described in the paper seemed to be well-designed, and especially adapted for large loads. The trams were said to contain 35 cwts., but if the same principle were applied to smaller tubs containing only 8 or 10 cwts., as was the custom in the Midland districts, a considerable number of tipplers would be required in order to deal with a large output. Perhaps the writer could give some idea as to the duration of the spikes of the breaker, and as to the practical working of the vibromotor screen.

Mr. **Oliver Sheppard** (Bridgend) said that the general arrangement might be divided into the breaker, the screen, and the tippler. The tippler appeared to meet one great difficulty— that of obtaining a satisfactory variable motion. He had not seen the tippler at work, but if it did what it was said to do, it would be a great acquisition for any colliery.

From his (Mr. Sheppard's) experience in designing plant for treating anthracite-coal, he was inclined to think that the process of reduction from large coal to nuts was not sufficiently gradual. To reduce a large block of say 1 cwt. to the size of nuts, which would pass through a 1¾ inches screen, by two processes, must be a violent method, and produce a large quantity of small and duff coal of little value. It would have been advantageous to have added at least one more breaker with the spikes further apart, in order that the larger pieces of coal might be reduced more gradually. He had himself adopted this method in one plant, putting in three sets of breakers; in the first set, the points of the teeth were about 6 inches apart; in the second set, they were about even with each other; in the third set, they were closer together, and all the points were more or less adjustable. At most collieries, it was thought undesirable to break the best coal, and at the end of the ordinary billy screen another screen was placed with movable bars. It was a fact that large anthracite-coal commanded a ready sale. The coal broken into nuts was of a size from 6 to 8 inches, and as it had not to be reduced from the great bulk to nuts, two breakers in that case were sufficient. The spikes of the breaker usually lasted a long time, unless the bed of coal contained a considerable quantity of iron pyrites not exposed until the coal was broken. In the breaker described in the paper, it seemed to him that there would be great difficulty in renewing the spikes when a breakage did occur. He thought it was disadvantageous that the cylinder should be cast in one piece and the spikes driven into tapered holes; if they broke off level with the cylinder it would be almost impossible to extract the shank. Some manufacturers made the rollers in sections, and he ventured to think that this was an advantageous arrangement.

He quite agreed with Mr. Morgan Davies that the shaking-and-vibrating screen was the best for separating the two sizes of nuts—French and Germans they were generally called; but coals below ¾ inch were better screened in revolving screens, provided they were of sufficient size. There seemed to be rather more mechanical complication than was necessary in the Klein screen. He had fitted up a screen with a somewhat similar motion at an anthracite colliery. The hangers usually attached to the back end of the screen were attached to the connecting-rods of the screen, at about one-third of their length from the end, the effect being that the back end of the screen had an oval motion, while the front end moved backwards and forwards.

The picking-band was divided into three compartments, but it seemed evident that anyone could not efficiently pick cobble coal when separated by part of the band; it would be almost impossible to pick second nuts and cobbles on that band, because one could not get close to them, and he thought that it would be found preferable to have a separate band for each kind of coal. Mr. Wight would probably say that the Glyncastle anthracite-coal contained very little dirt requiring picking out. He was pleased to see that Mr. Wight recognized the great importance of washing the billy coal; it was almost impossible to pick out the dirt by hand, as the coal contained so much rubbish.

Mr. W. N. **Atkinson** (Newcastle-under-Lyme) said that there seemed to be a very marked difference of opinion between Mr. Wight and Mr. Davies as to the capabilities of ordinary grates for burning anthracite-coal. Were the grates proposed for use of the nature of closed stoves or open fires? In this country we were so wedded to large open fires—the most extravagant method for burning coal that could be devised—that this consideration would largely influence the use of anthracite. Anyone who had spent a few days in London during a fog would strongly advocate the use of anthracite-coal in all large towns.

Mr. R. **Beith** (Llanelly) said that Mr. Wight, in the introduction to his paper, made a comparison between the United States anthracite output and that of South Wales. When the members considered the enormous quantity of anthracite-coal raised in the United States during the past year, amounting to 50,000,000 tons, while 410 square miles in the Principality of Wales only produced 1,750,000 tons, it was certainly an assurance that anthracite had been neglected here. When members made that comparison they could not but admit that the Americans knew more about anthracite-coal than we did. Many years ago America erected most extensive and expensive coal-breaking and sizing plants for the preparation of anthracite-coal, and introduced grates, stoves, and boilers with fire-bars fitted to burn anthracite-coal properly and profitably. Seeing that there was so large an area of anthracite-coal at home, it was time that coal proprietors should push anthracite-coal into the proper channels of use. He questioned whether duplicating the breakers would decrease the percentage of small coal, and, if the breakers in use at Glyncastle were kept properly in order, whether they would give the smallest percentage was a question he would like to put to Mr. Wight. The writer said that the type of breaker which he had erected gave the best promise of producing the smallest quantity of inferior sizes. Could he, at the same time, give them the percentage of breaker small, as this was an important point in breaking anthracite? He might also advise as to the distances between the cylinders of the breaker, so as to obtain the largest quantity of No. 2 Germans and No. 2 French nuts, for these sizes realized the best prices. The working of coal-screens, whether jiggers or revolving, produced a certain amount of small coal, and experiment could only determine which of these screens would produce (after the coal passed through the breakers) the smallest percentage of breaker small. Could Mr. Wight give the percentage of small coal so produced?

Mr. D. A. **Louis** (London) asked whether the motion of the Klein screen did not produce a large amount of small coal? The motion was different from that of the jigging-screen and different from that of the revolving-screen, and therefore the proportion of small coal produced would be interesting information.

Mr. **Hort. Huxham** (Swansea) said that for the sake of convenience, rather than proper sequence of thought, he would take the points as they arose *seriatim* in Mr. Wight's interesting paper.

In the first place, he was inclined to think that a closer acquaintance with the anthracite district of South Wales would lead the writer to modify his statement that "immense tracts may be reached by day-drifts." * It was true that the outcrop of the coal-seams extended for many miles, but the larger portion of the coal had already been worked on the outcrop, and considerable areas were seriously affected by disturbances, the strata being much contorted by numerous anticlinal and synclinal lines. By far the larger portion of the coal available in the future would have to be won by pits.

With regard to the use of anthracite-coal in ordinary grates, he could not agree with the writer that "it is nearly impossible to burn it in the ordinary grates." † It was no doubt difficult to satisfactorily burn anthracite-coal in open grates with cast-iron sides and backs and with feeble draught, chiefly because of the rapid radiation of heat from the iron, and this difficulty would equally apply to many other classes of coal. In grates constructed with firebrick sides and backs, as they had been since olden times in the anthracite-coal districts, and were now very generally made in an improved form with fireclay slabs for dwelling-houses throughout the country, anthracite coal would burn cheerfully and make an excellent fire, and if the front bars of the grate were vertical instead of horizontal, so much the better. It was, however, important to remember when burning anthracite-coal, under any conditions, that the old-fashioned habit of poking the fire must be discarded, as otherwise the coal would disintegrate and the fire go out. All that was needed was merely to keep the bottom bar clear of ashes for the admission of air, and a bright and cheerful fire would always be maintained. He (Mr. Huxham) had had an experience of over forty years in the use of the coal, and he had never had any difficulty in burning good anthracite.

The statement of the writer that "slow combustion is essential, for if it be attempted to burn large pieces by means of a fierce draught, the

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* *Trans. Fed. Inst.*, vol. xii., page 238.

† *Ibid.*, page 239.

coal is liable to decrepitate and fall through the grate,"* might apply to the coal dealt with at the colliery at which the plant described in the paper had been erected, but he thought that on further enquiry the writer would find that such an observation hardly applied to the true anthracite-coal of South Wales, which would burn with forced draught at an intense white heat with but very slight decrepitation, and with practically no decrepitation if the coal be gradually heated (as all coal should be) when so used. If, however, the forced draught be sufficiently powerful to lift the coal on the grate, as might sometimes be the case, then disintegration of the coal was mechanically produced, just as if the fire had been poked, and not from the effect of the intense heat. For very many years, anthracite-coal was used for iron-smelting at some of the ironworks in South Wales, and it was not an uncommon occurrence to find pieces of the coal, which had passed down through the blast-furnace, come away with the slag, charred on the outside, but internally retaining the perfect fracture, bright lustre, and unaltered appearance of true anthracite-coal, showing that the intense heat had not been sufficient to decrepitate the coal. Then again, anthracite-coal was used almost universally under the steam-boilers at the anthracite collieries with great success, both with natural and with forced draught.

With regard to the use of stoves, the inference to be drawn from the insertion of the word "now" in paragraph 3,† was that stoves were quite a modern appliance; but, in point of fact, stoves for burning anthracite-coal have been in use for very many years in the United States, where the production of anthracite-coal for last year was over 50,000,000 tons, a large portion of which was used for domestic purposes, and where a vast experience had been acquired over a long course of years as to the best form of stoves, in respect to which improvements had from time to time been gradually made with very excellent results. These stoves, and copies on the same principles made elsewhere, have been of recent years introduced into this country, and on the Continent, for burning anthracite-coal.

With respect to the plant described in the paper, he (Mr. Huxham) observed that the large coal, when not passed through the breaker, was allowed to slide down an iron shoot some 64 feet in length, and with an inclination of about 16 inches in the yard, from the belt at the bottom of the colliers' screen direct into the railway-waggon. Even with the shoot kept full of coal, the friction and breakage on such a very great length of shoot must be considerable; and it seemed to him that it would

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* *Trans. Fed. Inst.*, vol. xii., page 239. † *Ibid.*, page 239.

have been advisable to have adopted a creeper, or conveyor-belt, which might easily have been made self-acting, for lowering the coal gradually into the waggon with but very slight breakage.

He (Mr. Huxham) thought that the side-tippler, with variable speed of discharge and return, introduced by the writer, was a much desired improvement on the usual form, and that it would save breakage and discharge the coal more uniformly over the colliers' screen.

With reference to the several types of coal-breakers, there was no doubt considerable divergence of opinion as to their respective merits. The one adopted by Mr. Wight was, however, very largely used in America, and experiments there on an extensive scale had proved its efficacy when properly proportioned to the size of the lumps of coal dealt with; but this was also proved, under similar conditions, to be the case with pairs of deeply toothed cylinders, arranged so that the projections of the one cylinder worked opposite the depressions in the other cylinder. It seemed to him (Mr. Huxham) incongruous to pass lumps of coal, varying in weight from 1 to 3 cwts., through the same breaker, as the action of the spikes or teeth (as the case may be) upon the maximum sized lump adapted to their size or capacity, would be very different from the tearing and scraping action on a lump of coal too large for the spikes or teeth to grip at the first contact—to say nothing of the undue strain thrown on the spikes or teeth. He had always seen the larger lumps first broken down by hand to the size adapted to the breaker; and unless that were done, or a separate breaker provided for the unusually large lumps, there would be an excessive percentage of small coal made. It was impossible, with a rotatory action, to avoid this conclusion.

From the description in the paper, and so far as he could see in the diagrams, there did not appear to be any regulator to control the feed of coal on to either of the screens. He took it as an axiom that one of the most important principles of mechanical coal-screening was to feed the screen regularly, and this especially applied to vibrating plate-screens.

With regard to the form of screen adopted, he thought that there was less small made by using an ordinary vibrating plate-screen, properly hung and adjusted at a suitable slight inclination and requisite speed for the sizes of coal to be dealt with, than with a Klein screen, and with less strain on the cranks or eccentrics, and with a smaller number of bearings to be kept in order.

Then, as to the form of the holes in the plate-screens, he was curious to know why square holes had been adopted instead of circular holes. The square hole had, of course, a greater perimeter than the circular one, and at the same speed of vibration would produce a larger percentage of small from friction and breakage; besides which, the sizing of the coal would be very much more regular with circular than with the square holes, for, with a 3 inches square hole, for instance, the sizing would only in part depend on the dimension of the side of the hole, but also on the diagonal of the square, or, practically, 4¼ inches. This sizing, of course, was not of so much importance in the first screen, which was designed to take off the larger lumps to pass through the second breaker, although it regulated the maximum size of the cobbles on the second screen; but it was of material importance in sizing the smaller sizes on the second screen.

There was one point about which he was not clear. Mr. Wight stated that the billy coal was not allowed to pass through the sizing-screen No. 2, because it contained too many stones. Then the washing-plant was described as dealing only with such of the billy coal as passed through the ¾ inch vibromotor-screen, and no mention was made of what was done with the nuts, or that portion of the billy coal which passed over the ¾ inch screen; perhaps the writer would kindly explain what became of it.

He (Mr. Huxham) would have been glad if the paper had stated what quantity of coal the breaker and plant could deal with per hour. He thought that the interest and value of the paper would also be much enhanced if the writer would state the results of passing, say, 100 tons of coal, as produced from the colliery, over the colliers' screen and through the breaker and screening-plant and washery, giving (1) the percentage of billy coal from the colliers' screen, and (2) the percentages of cobbles, nuts, washed beans, peas, and duff produced for the market. And if he could state the cost of the installation, and the cost per ton in dealing with the 100 tons throughout the process, it would further add to the value of the paper.

Mr. G. E. J. McMurtrie (Cinderford) wrote that the coal-breaking and sizing plant at Glyncastle colliery appeared to be very complete, and Mr. Wight was to be congratulated on his paper. There were, however, one or two points on which additional information was desirable. The special tippler certainly appeared to be a distinct improvement on those driven by toothed gearing or by chains, inasmuch as the variation in its speed gave a slow discharge of the coal and a quick return of the empty tram. The inclination of the large coal shute appeared unnecessarily steep, and, in his opinion, a fall of 1 in 3 would have been found sufficient. While it was difficult to beat the endway jigger at a slight inclination for thorough screening, if the Klein screen avoided the shock or vibration inseparable from the jigger it had this advantage. Mr. Wight did not state what quantity of coal this screen could deal with per day of 8 hours, but as, from the description, the coal had apparently to go uphill during part of every revolution or stroke, and was level when at rest, it clearly could not pass the amount that a jigger at a slight inclination would comfortably pass, viz., 500 tons per day. Moreover, the Klein screen would appear to require more power to drive it under these circumstances. The width of the picking-belt for first nuts, cobbles, and second nuts, viz., 4½ feet, seemed very little to clean three qualities, unless the band travelled fast or very little of these sizes was made. His experience certainly had been that it was better to wash coal from 1½ inches downwards, rather than to hand-pick it by the dry method, as boys were unreliable. A little more information as to the action of the vibromotor-screen would be valuable, such as its size and weight, the inclination of the screen, what quantity of coal it could screen in 8 hours, what size of coal it could deal with, what weight of coal was put upon it at any one time, and what advantage, if any, it possessed over the ordinary revolving riddle.

Mr. W. D. WIGHT, replying to the discussion, said that he had not had sufficient experience in the working of this plant to enable him to give the percentages of the different sizes of coal. Furthermore, even if he did know, he was not sure that it would be of very much value, for each quality of coal from each different colliery would vary to a considerable extent, and what held good at one colliery might not do so at another, even a short distance away. Mr. Davies and Mr. Huxham considered that it was possible to burn large anthracite-coal in ordinary grates. In reply to that, he might say it had been the endeavour of anthracite coal-owners to persuade the British public that this could be done; but they had failed to do so. To say that the thing was impossible, and not practicable, was perhaps drawing lines rather too fine; but they wanted to put the coal into such a state as to find purchasers for it, which they had hitherto failed to do. One member said that the tippler was not suitable for small loads, because it would not despatch the work. But this tippler could be driven as fast as any tippler, and if it dealt with coal more gently when driving slowly, it should do so relatively when driving fast. The number of broken spikes in the breaker was very, very few. He could not give the life of the spikes, because they had not yet worn any out. So far as he had been able to judge, the vibromotor-screen was a most excellent screening-appliance, probably the best for small sizes that had been brought out within his knowledge. He was satisfied that two breakers were able to deal with the coal fairly satisfactorily. If wide breakers were erected they need not be multiplied to the same extent as narrower machines. He had given consideration to the segmental breaker recommended by Mr. Sheppard, and concluded that it would not be found satisfactory. All the segments were placed on one axle, and seeing that they together weighed about 1½ tons, he judged it better to remove the spike in position rather than remove segments. The spikes were tapered, with the view of allowing them to be easily withdrawn. Mr. Sheppard criticized the arrangement by which the cobbles were placed in the centre of the picking-band, and anticipated his reply to that, namely, that the quantity of foreign matter required to be removed was excessively small, and was of a large size, easily seen and easily picked out.

Proper grates for burning anthracite were being introduced into the anthracite district, and by firms in London: they were modelled on the types used in the United States and on the Continent. To show the extent to which they had been adopted on the Continent, he might say that in recent years one firm had sold in Paris alone 70,000 stoves, so that if the great city of London were to take to burning anthracite-coal there would be a large quantity of stoves required. In order to ascertain the proportion of small coal produced by the respective screens it would be necessary to re-arrange the entire plant; but they could ascertain the quantity of small coal produced in the whole process, and, commercially, that was all that concerned them.

Mr. Huxham referred to the burning of large anthracite-coal by other collieries further west. It was within his (Mr. Wight's) knowledge that certain of these collieries had to purchase bituminous coal for use on their locomotives; even with the draught of the locomotive anthracite-coal could not be burned. The process of burning in a blast-furnace was gradual, and he did not think that the argument that anthracite did not decrepitate therein had any bearing on the use of the coal in ordinary fire-places. Mr. Huxham took objection to the use of an inclined shoot for loading large coal, but the shoot was kept full of coals, and had traps to let it down gently; and the great length of the shoot was not objectionable when the coal was dealt with in that way. It might be desirable to load large coal directly from the screen into the waggon, but it would require a separate plant to be erected for that special purpose.

Mr. Huxham also said that he did not observe any arrangement of regulators, but he (Mr. Wight) explained in his description of the apparatus that the tippler acted practically as a regulator. He was surprised that Mr. Huxham should have raised the question of the difference between pieces of coal of 3 cwts. and of 1 cwt., for he knew as well as himself that the pieces of coal in South Wales varied to an enormous extent, and no one would erect a different breaker for every different size of coal. The first breaker would deal with the very largest pieces without any preliminary dressing or splitting of any kind: all went into and were broken by that breaker. He had no particular partiality for square as against circular holes; the former were adopted, but in any case the size would have to be proportionate, so as to pass the same size of coal. With regard to the nuts in the billy coal, this might possibly be dealt with in the future, but up to the present it had not been thought desirable to complicate the process for the sake of dealing with it. If it were desirable, it would be an easy matter to erect another screen to take the nut coal out of the billy coal. The plant could deal with 60 tons of coal per hour.

The Chairman, in moving a vote of thanks to the writer of the paper, said that some of the members who took part in the discussion appeared to think that Mr. Wight should have described many other arrangements. He had described the various arrangements of the plant under his charge in a clear and satisfactory way, and had given his reasons for adopting it. He (Mr. G. A. Mitchell) was particularly pleased with the tippler; if its practical working was satisfactory, it would be extensively adopted.

The vote of thanks was unanimously adopted.

Mr. Wm. Galloway read the following paper on "Secondary Haulage":—

SECONDARY HAULAGE.

By W. GALLOWAY.

It is now nearly thirty years since the committee of The North of England Institute of Mining and Mechanical Engineers issued their Report on Underground Haulage.* That report dealt with four systems of haulage: endless-chain; endless-rope, with single tubs moving slowly; endless-rope, with trains moving rapidly; and main-and-tail-rope. It was one of the most valuable contributions that had ever been made to the literature of mining, and it had helped to spread a knowledge of the subject of underground haulage by mechanical means all over the world. The committee dealt only with the subject of conveying large quantities of coal from one point to another at distances of many hundreds of feet apart, and were consequently able to show certain marvellously low costs per mile-ton.

But in every mine a secondary system of haulage was necessary—namely, that which served the purpose of collecting the coal from the working-places into a siding, from which it might be conveniently taken away by one or other of the systems referred to in the committee's report; and conveying the empty waggons, which were brought to the siding, back to, and distributing them amongst, the working-places. This operation was usually carried out by boys, men, ponies, or horses. It involved taking single waggons part of the way, at least; and for this reason, as well as because delays of one kind and another were inevitable, it was necessarily more expensive per ton per unit of distance than the primary haulage on important horse-ways or engine-planes.

If the total cost of haulage in a mine for any given time be divided by the total output of coal for the same period the average cost of haulage is obtained, and the average cost of one mine can be compared with that of another. The comparison is not, however, of any particular value unless the conditions and the distances are alike in both cases. The committee dealt with the question of large quantities and long distances in a very careful and exact manner, and there seemed to be hardly anything left to say on that part of the subject; but, so far as the writer could

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* *Trans. N.E. Inst.*, vol. xvii.

gather, the question of collecting and distributing had nowhere received the same kind or degree of attention, although he believed it would be found, on enquiry, that it was deserving of the closest scrutiny.

In the case of long engine-planes or horse roadways, in which a primary system of haulage is carried on, there is a fixed point at each end. The distance between the two points is known, and the cost of haulage per unit of distance can at any time be ascertained by dividing the wages and other expenses by the number of tons conveyed in a given time. In the case of haulage from the faces to a siding, there is only one fixed point, or collecting-siding, and the faces are always moving farther and farther away from it. Moreover, no two faces are, as a rule, at the same distance from the collecting siding. Under these circumstances, it is necessary to ascertain the following particulars before we can arrive at the true cost per ton per unit of distance of the haulage from any particular district of faces to a collecting siding:—

1. The distance of each face from the siding.
2. The number of tons of coal sent away from each face within a given time.
3. The aggregate amount paid for haulage in the district in question during the same period.

The distances may be best ascertained by direct measurement at the commencement and conclusion of the period, or, if it be very short, one measurement will suffice. The quantity of coal sent away from each face within the period, as well as the wages paid for haulage in the district, may be taken from the pay book, and the period itself should obviously be made to coincide with one or more ordinary pays. Where horses or ponies are employed, the cost of feeding them, providing harness, renewals, grooming, etc., should all be taken into account.

In the year 1894, while No. 1 pit of the Llanbradach collieries, near Cardiff, was being opened up in the little rock coal-seam, the writer ascertained the cost of haulage twice in this way—viz., for the weeks ending January 27th and September 22nd. The seam of coal is on the average about 3 feet thick, and in the course of driving the principal headings about 3 feet of floor is cut to make a height of 6 feet. Consequently, there was from one-third to one-half as much rubbish as coal hauled during the periods under consideration. The haulage was done exclusively by means of small self-contained semi-portable engines worked by compressed air, designed originally by the author, and made for him by Messrs. Thornewill & Warham, of Burton-upon-Trent, who also designed the valve-gear. Each engine has two drums, 2 feet in diameter by 10 inches wide between the cheeks, and can be used as a tail-rope engine when required. Some of the ropes were ⅜ inch and some ½ inch in diameter. Each mine-waggon weighs about 12 cwts. when empty, and carries on an average 2 tons of coal. The general inclination of the seam is about 1 in 24. Between the two dates named, two of the fore-winning headings were driven through downthrow faults of 15 and 20 feet respectively, with gradients of 1 in 4 and 1 in 5, to explore the seam on the other side, and two other headings were going to the dip. The workings were also divided into a number of small detached districts just outside the shaft-bottom pillar (1,200 feet square), and they were enlarging gradually as the headings extended further and further away from the shaft. The whole of the workings were carried on by a double-shift, so that each small engine required two sets of attendants. The situation at the time the costs were taken was, therefore, by no means an ideal one.

The construction of the hauling engines is shown in the drawings, Figs. 1, 2, and 3 (Plate XI.) being side and end elevations and a plan respectively. A box with four sides, *M M*, but with neither top nor bottom, and consisting of four plates of sheet-iron riveted to angle-iron corner pieces, constitutes the frame. The cylinders, *A A* are fixed outside, and the drums are placed between the longest sides and parallel with them. *B* is the driving-shaft, *C C* pinions, *D D* spur-wheels, which form also the outer drum-cheeks, *O O* the inner drum-cheeks, *E E* clutches, *F F* clutch-levers, *G G* foot-brakes, *H* reversing-lever, *L* handle of compressed-air valve, and *P* flange for connecting a knee-piece attached to a length of flexible hose. The frames are provided with two simple axle-bearings. The complete engine can be mounted on two pairs of ordinary mine-waggon wheels and taken into the cages and along the roadways as easily as an ordinary mine-waggon. A branch from the compressed air-pipes is extended by means of a flexible hose 1½ inches in diameter and 10 or 12 feet long, to a small sheet-iron receiver 6 feet long by 2 feet in diameter placed horizontally in a recess. This receiver is furnished with a pressure-guage, a pipe extending from near its bottom up through its upper side, and provided with a stop-cock for allowing condensed water to be blown out, and two stop-cocks with 1½ inches openings for connecting it on the one side to the branch from the compressed air-pipes, and on the other side also with a flexible hose to the hauling-engine. The hauling-engine may either be dismounted from its wheels and placed on the floor with a prop in front of it or it may remain on its wheels.

The following are the results obtained on charging the whole of the wages against the coal hauled :—

For the week ending January 27th, 1894—

Number of yard-tons	727,500
Output of coal	2,025 tons.
Average distance for one ton	359 yards.
Wages paid for hauling	£23 11s 11d.

Wages cost for 359 yards = 2·796d. per ton.

For the week ending September 22nd, 1894—

Number of yard-tons	1,715,487
Output of coal	2,981 tons.
Average distance for one ton	575 yards.
Wages paid for hauling	£45 0s. 4d.

Wages cost for 575 yards = 3·642d. per ton.

A rough-and-ready way of arriving at the cost of secondary haulage per ton of coal where horses are employed to transport the coal from the faces to collecting-sidings, is to divide the average output per day by the number of horses at work in the mine, so as to ascertain the average number of tons per horse per day. The writer has done this for a very large number of mines in South Wales, and has found that the number of tons per horse varies from a minimum of 8, except in the second case mentioned hereafter, to a maximum of 25 tons. This quantity is in addition to the rubbish brought out to the collecting-siding and sent to the surface or carried from one part of the workings to another. In a considerable number of cases where primary haulage by mechanical means is employed, the writer has found that the average number of tons of coal transported from the faces to the collecting-sidings, in addition to the rubbish hauled by the same horses, does not exceed 10 tons per horse.

Take an instance of a colliery of the first magnitude in South Wales with an output of 345,000 tons a year of large and small coal, with mechanical haulage on the main headings, a thick seam of coal, a good roof, no faults, and very moderate gradients. The following is the exact cost of secondary haulage for one year :—

	£		d. Per Ton.
Wages	9,364	...	6·51
Feeding horses	2,753	...	1·91
Harness	402	...	0·28
Amortization of horses	390	...	0·27
Totals	£12,909	...	8·97

In another instance in which the proprietors of a colliery instructed the writer to make an exhaustive examination into the costs, he found that the cost of hauling coal and rubbish by means of horses from the faces to a collecting-siding at an average distance of about 500 yards amounted to rather over 1s. 3d. per ton of coal. The quantity of rubbish handled amounted to about one-third of the gross output. Many of the roadways were situated to the dip of the collecting-siding, but the gradients were not severe. However startling these figures may appear to be, the writer is aware that they are by no means abnormally high.

Taking 7s. per day as the average cost of a horse, driver, attendants, and all other charges, including amortization, Fig. 4 (Plate XI.) will give a clear idea of the cost per ton according to the number of tons hauled in a day. This diagram is intended for reference only in the case of secondary haulage for short distances, say, for an average of 300 to 500 yards.

In instances which have come under the notice of the writer, he has found that the cost of collecting and distributing by means of workmen partly in level roadways, partly in rise roadways with gradients which require considerable effort to push the empty tubs up to the faces, and extending to an average distance of 200 to 300 yards, amounts to about 1d. per ton per 60 yards. It stands to reason that the longer the distance the less is the cost per ton per unit of distance, as there are fewer stoppages and delays.

The question is a vital one for many collieries. Notwithstanding its importance, however, it is generally most difficult to ascertain the cost of secondary haulage. The various items which are chargeable to this service are usually mixed up in the cost-sheets and pay-books with other things with which they have no connexion from the point of view now under consideration: for instance, some of the wages are charged amongst those of men who work on the surface; some amongst those who work underground; horse-feeding and harness are included with stores; in some cases part of this service is carried out by the colliers, and no account is taken of this indirect cost in estimating the total cost; in other cases men or boys are specially paid to do part of the work while horses or ponies do the remainder.

Thus it happens that when one enquires what is the cost of secondary haulage at any given colliery, he is met with the answer that the colliers do it for nothing (there could be no greater fallacy); or that no one can form any idea; or the costs of primary and secondary haulage are mixed up in such a way that the one cannot be separated from the other; or part of the cost is given and the remainder is omitted. These statements are not what they ought to be. The services should be kept perfectly distinct, thus :—

1. From faces to collecting-sidings.
2. From collecting-sidings to pit-bottom.
3. Winding, including cost of hitchers, banksmen, enginemen, proportion of steam and stores, repairs and renewals.
4. Screening, including all wages paid for handling the coal, screening, picking, and loading into waggons.

The writer hopes that some of the members of the Institution will follow his example and face the problem by giving the true costs of secondary haulage for the whole of the workings of a pit and not merely for one or more favourable districts. Opinions and guesses are obviously apt to be deceptive, and should therefore be carefully avoided in dealing with a problem of this kind which is susceptible of an exact solution.

Mr. H. Richardson Hewitt (Derby) wrote that the subject of secondary haulage was a very important one, and one which appeared to be somewhat neglected. A great deal could be done in the first setting out of the workings, so that it could be arranged for all loaded trams to gravitate to a central station whence the main haulage-system was working. When this could not be done, the compressed-air engines mentioned by Mr. Galloway would be found of very great service; but, of course, that implied the erection of an air-compressing plant at the surface, and unless the system was extensive, or the plant was required for other purposes, it would entail a great outlay. He (Mr. Hewitt) knew of one colliery where twelve or fourteen such engines were at work as secondary haulage, and where horses were not used at all, while other engineers preferred electricity as the secondary power. It appeared to him, that 0·50d. per ton for wear-and-tear of ropes on a road 300 yards long was somewhat high, and might probably be caused by the drums being so small as 2 feet in diameter.

Mr. James McMurtrie (Radstock) said that it was very useful to draw attention, as the writer had done, to one of the smaller economies which were apt to be lost sight of. Engineers were apt to turn their attention to the main systems of haulage, and to overlook the small economies, which were scarcely of less importance. He drew attention to the report of The North of England Institute of Mining Engineers

FIG. 2.

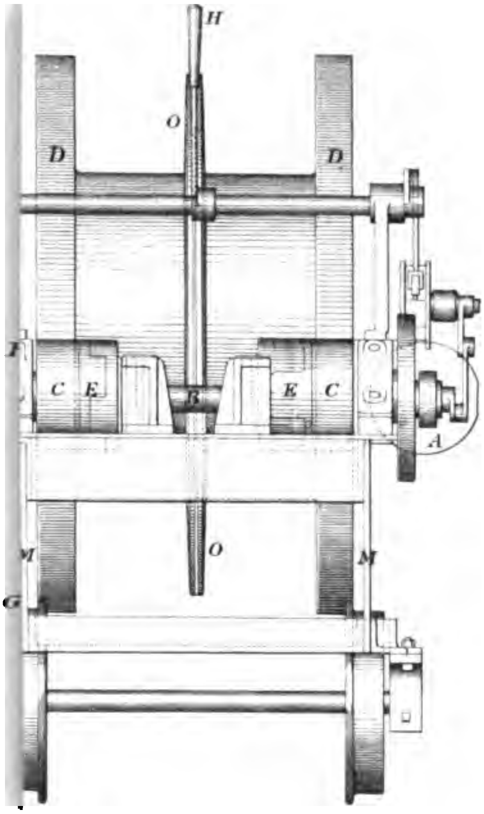
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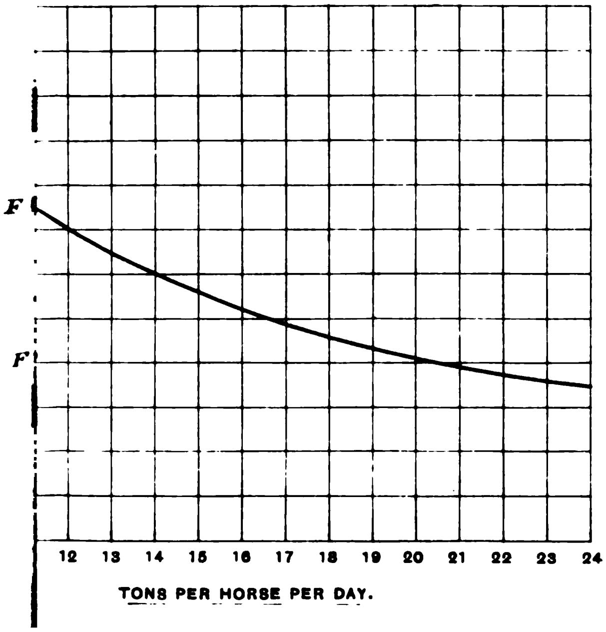
FIG. 4.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TONS PER HORSE PER DAY.

on the subject of mechanical haulage, which he considered most valuable; and if copies were yet to be had, he would recommend its perusal by students of the present day. Mr. Galloway appeared to have made out a case for economy in secondary haulage; and although the saving per ton was not very great, it was great enough to deserve the attention of all mining engineers. He believed that a similar attempt had been made in South Wales, where the seams were moderately inclined, by using an endless-chain, the loaded trams running down one stall while the empty trams were pulled up to the other stall, and in that way an attempt had been made to work this secondary haulage by a cheaper method than had hitherto been done.

Mr. J. A. **Longden** (Stanton) said that the committee of The North of England Institute of Mining Engineers, in their report upon haulage, came to the conclusion that the endless-chain was the most economical system of mine-haulage, but he thought their experience at the present time was that the endless-chain was not the most economical system. The cost of haulage underground, in the cases brought before their notice by Mr. Galloway, referred to tubs containing 2 tons each of coal. In the Midland counties, where the tubs only carried 10 cwts. of coal, it meant pulling four tubs in the place of one, and consequently great difference in the cost of haulage. Another item in favour of Mr. Galloway's method was, that at that particular colliery the seam dipped 1 in 24. In steep mines, the economy of haulage appeared to increase according to the steepness of the seam. He took it that in this case there would be as much dirt drawn as coal. If that were so, the figures should be divided by 2, and the 3d. would be reduced to 1½d. per ton.

Mr. **Galloway**—One-third should be allowed, reducing the cost to 2d. per ton.

Mr. **Longden**, continuing, said that he knew collieries in the Midland counties where the cost was 2½d. per ton, including all labour from the face of the coal until it was put on the cage ready to be sent out. The work was done by contract, a system which ensured economy. He would like to draw the attention of members to a most excellent article on "Coal-mining," by Mr. Galloway, which appeared in the handbook to *Cardiff*. The article was extremely valuable, and he had pleasure in adding his testimony to its worth.

Mr. W. N. **Atkinson** (H.M. Inspector of Mines, Newcastle-under-Lyme) said that there was one minor point in connexion with secondary haulage which was worthy the attention of all persons interested in the cheap production of coal, and that was with regard to the rails and tubs used for the purpose. He believed that considerable economy might be effected by the provision of better rails and more perfect tubs. The number of times that tubs were thrown off the rails, in coming from the face to the siding, must in some cases entail a large amount of extra work, and it would not only reduce the labour, but the facilities for getting a larger quantity would be increased, if the rails were laid in a more workmanlike fashion and the tubs were of better construction.

Mr. G. E. J. McMurtrie (Cinderford) enquired whether Mr. Galloway could define when the early form of secondary haulage (which he presumed in every case must be by horses) ought to be replaced by engine-power? He (Mr. McMurtrie) would suggest that as soon as three horses could be replaced by the addition of an engine, economy ensued. He supposed that the best system of haulage at the present time in South Wales consisted of endless-rope, where the roof would allow of it, and where the Nottingham system of longwall was worked, inside the main engine-plane, it was usual to use small subsidiary engines, bringing the coal from two or three main levels and headings to the principal siding; inside that again, he supposed in every case horses would be used—in the case of thicker seams from the face of the stalls, and in thinner seams from the bottom of the stalls. He was resident in the Forest of Dean, where many thin coal-seams were worked, and after Mr. Longden's statement he was almost afraid to give the cost—so far as he had worked it out on the lines indicated in Mr. Galloway's paper. While he was able to get at the yard-tons of coal, he had omitted the amount of dirt, though this was considerable, for he could not get at the actual places where the dirt had come from. He had taken out the cost of haulage in two cases; for the twenty inches coal-seam at one pit, and for the lowrey coal-seam at the other. In the case of the lowrey coal-seam, the coal was brought by horses to a siding at the top of an incline 300 yards long and dipping 6 inches to the yard. This incline delivered the coal to the engine-plane siding, whence it was taken by two hauling-engines a distance of some 1,600 yards to the shaft. The gradient of the seam was about 1 inch to the yard in favour of the horses. In the case of the twenty inches coal-seam, horses conveyed the coal to the top of a short incline, 80 yards long, whence, together with other coal, it was dropped 90 feet down a staple-pit and was then taken by a horse for a short distance to the main siding. In the case of the lowrey coal-seam, he had long urged the replacing of some of the horses by a small semi-portable hauling-engine, and in the case of the twenty inches coal-seam, although the colliery was an old one, he thought that a system of mechanical haulage ought to be adopted.

Taking the figures for a fortnight, of 7 working days, the results for the lowrey coal-seam were :—

Number of yard-tons	1,449,680
Output of coal, tons	1,214
Average distance for one ton, yards	1,194
Wages paid for haulage	£15 9s. 3d.

Cost of hauling 1,194 yards, 3·05d. per ton.

The figures for the twenty inches coal-seam were :—

Number of yard-tons	1,481,136
Output of coal, tons	1,441
Average distance for one ton, yards	1,028
Wages paid for haulage	£23 14s. 6d.

Cost of hauling 1,028 yards, 3·95d. per ton.

Taking 300 yards as a standard of comparison, the costs per ton became :—

	Lowrey Coal-seam. d.	Twenty Inches Coal-seam. d.
Wages	0·80	1·16
Cost of horses	2·61	3·58
Ropes, practically *nil*	—	—
Cost of hauling coal, 300 yards ...	3·41	4·74

The disparity between the horse and labour costs in the above table was most marked.

Mr. J. S. MARTIN (H. M. Inspector of Mines, Bristol) said that it had hardly been made sufficiently clear that at the colliery referred to in the paper, the haulage was done entirely by machinery, and that there were no horses underground. The circumstances of haulage there, and at the collieries such as Mr. McMurtrie referred to, and other collieries in the Midland Counties, where the tubs only carried 10 cwts. of coal, were so totally different that it was difficult to see how a comparison could be made. It would be more interesting for comparison if the actual cost of secondary haulage could be obtained from collieries in South Wales, where the haulage was necessarily all done from the face, either by horses or mechanical power, in consequence of larger trams being used than in other mining districts. In his opinion, further application of machinery to secondary haulage in South Wales would in many cases be advantageous. As he had not got the necessary information at his command he could not say how it would work out, but those employed in the management of the collieries might be able to give the relative costs. It appeared to him that a combination of the system introduced by Mr. Galloway at Llanbradach colliery, together with haulage from shorter distances by horses, might in older mines with bad roofs or floors, be found more efficient than either separately.

Mr. J. A. LONGDEN (Stanton) said that the 2½d. per ton to which he referred represented labour cost only; if the cost of horses were included, it would be necessary to add about ¾d., making a total of about 3¼d. per ton.

Mr. GEORGE ELCE (Lancashire) said that in the particular collieries with which he was connected, the tubs only carried 4½ to 5 cwts. of coal. He did not know how collieries might be situated in South Wales, but it seemed to him that the principle should be the same, and that they should take the main haulage as near as possible to where the coal was got. If ever he ventured to have the haulage much more than 100 yards or 150 yards from where the coal was got, the costs soon increased not by 1d. but by 6d. or more. He did not quite understand in Mr. Galloway's paper why, when a pit was set out, it should not be so arranged that the mechanical haulage could be taken to such a point in relation to the working-places that gravity would bring the coal to the haulage-station. If the mine was flat, the main roads should be so arranged, in spite of the large amount of money to be spent in making them so, that no long distances would be involved, and if the seam was inclined, so that they could fall by gravitation, the cross-roads should be arranged for machine haulage. In Lancashire, the coal was let down by trip-and-trip or endless-ropes.

Mr. T. FORSTER BROWN (Cardiff) said that there was one objection to what was stated by the last speaker with regard to South Wales. In his experience, none of the haulage-roads became settled until the face was probably 250 yards from any given point, and therefore it would hardly be practicable to carry the permanent haulage-ways nearer than 250 or 300 yards from the face. He sympathized with Mr. Galloway as to adopting some means of reducing the cost of haulage from the face to the nearest point of contact with a main haulage-way; but he doubted whether Mr. Galloway had solved the problem, for the cost, by his system, seemed to be rather extravagant. He (Mr. Forster Brown) could not at that moment quote the cost of horse-haulage, but he questioned whether the North of England haulage-system by ponies cost anything like the figures given in the paper as the cost by Mr. Galloway's method.

Mr. **Alfred Chambers** (Eastwood) said from a considerable experience of coal-working he found that they must have concentrated haulage and rapidity of working. The roadways required to be maintained in excellent condition, if the haulage was effected by any other system than horses or ponies. In order to avoid the use of horses near the face in one pit, short lengths of rope were used, and when the tub reached the main haulage-way the clip was knocked off, and the tub was attached to the main haulage-system. When the roadway became settled, the permanent haulage-system was shifted towards the working-face.

Mr. **M. Deacon** (Alfreton) said that where single ropes were worked, and the dip of the mine was sufficient to cause the empty train to work by gravity, mechanical haulage, under ordinary conditions, was cheaper than horse-haulage, but where the mine was fairly level it might be difficult to determine whether a secondary system of mechanical haulage would be materially cheaper than horse-haulage. At the present moment, he was arranging for the establishment of two systems of secondary haulage (one by compressed air and the other by electricity), where the gradients were not heavy and the cost of horse-haulage was about an average under similar conditions. Before he decided to establish mechanical haulage, he ascertained the cost of horse-haulage on the particular gradients with which he had to deal, and he found that the average cost from the face to the nearest pass-byes (360 to 400 yards) varied from 1s. 5d. to 1s. 9d. per ton-mile. These figures were at first rather astonishing, when compared with long engine-haulages which worked out at 2d. to 2½d. per ton-mile. He came to the conclusion that, in this case, there was room for the establishment of a system of secondary haulage, either by single rope or by tail rope, and he was adopting the tail-rope system on a small scale. The engines which he proposed to utilize would be fixed at the pass-byes nearest to the main mechanical haulage, and would haul from every stall to these pass-byes. Reducing the figures given in the paper, those for the distance of 359 yards worked out to 1s. 1¾d. per ton-mile, and for the distance of 575 yards to 11¼d. per ton-mile: so that if his own figures, as to cost of horse-haulage, were anything like correct, and the gradient did not exceed 1 in 50 against the load, there appeared to be a very fair margin for economy; in the case of the 359 yards' distance 3¼d., and in the other 5¼d. per ton-mile. In mechanical haulage there was the additional advantage that when a pit was not working owing to shortness of orders, strikes, or otherwise, the plant would cost nothing to maintain beyond interest and depreciation, whilst horses would have to be fed and attended to. Mr. Galloway had probably introduced a subject of greater importance to the members of the Institution than they might think, but the paper would have been of still greater value if he could have given them the cost of horse-haulage in the particular mine and under the particular conditions to which he had applied the secondary haulage that he had described.

Mr. J. S. **Dixon** (Glasgow) wrote that the subject of Mr. Galloway's paper was of very great importance. In addition to the comparison between different collieries as suggested by Mr. Galloway, one between the various sections of any pit would also be very instructive. When circumstances admitted, his practice had been to reduce the lengths of secondary haulage, so that no such lengths as Mr. Galloway mentioned in his paper required to be treated, and this could be done in such a working as he described with an inclination of 1 in 24—if moderately free from troubles.

At Bent colliery, Hamilton, for nearly twenty years, there had been in operation a system, by which the haulage moved in a quadrilateral course, the roads being so arranged that the rope passed within a short distance of the working-faces. The rope passed along one way, then in a direction parallel with the working-faces, and then returned by another way to the pit-bottom. This system was specially applicable to pillar-and-stall workings, with a clean field and moderately uniform gradient, but it had also been applied in longwall workings. If the faces, either advancing or returning, be kept in line, the haulage could be advanced every second stall, so that the distance of the secondary haulage was often only a few feet.

Mr. W. **Galloway**, replying to the discussion, said that he quite agreed with Mr. W. N. Atkinson as to the necessity for laying the rails properly in mines, and also of having well-constructed tubs; in this district (South Wales) more especially there was great room for improvement in the construction of the tubs used in mines.

Mr. Elce remarked that it was necessary to make use of gradients as much as possible; they all knew the advantage of doing what he recommended in that respect. In the places referred to in the paper, faults interfered with the regularity of the dip, and the haulage was not effected under the most favourable circumstances.

Mr. Forster Brown made a remark which Mr. Deacon afterwards answered by stating the results that he had obtained on taking out the cost of haulage in the same way as he (Mr. Galloway) had done. He might say that his own attention was seriously directed to the subject a number of years ago, when he had occasion to find out the cost of haulage in a steam-coal colliery, referred to in the paper, and to his surprise he found that hauling coal by means of horses a distance of about 500 yards cost 1s. 3d. per ton.

In reply to Mr. Richardson Hewitt, he desired to say that the diameter of the drums was amply large enough for the ropes employed, and that the excessive wear-and-tear was due to the fact that the system was quite new in the district, and that the officials, not being fully alive to the importance of details, had not taken sufficient care to drive the roads absolutely straight, and to put in friction rollers between the rails and at the bends where required. If this had been done, the cost of ropes might have been reduced by one-half.

He had seen the admirable system of haulage at Bent colliery ten or twelve years ago, and he had laid out the workings in the seam in question with the object of applying the same arrangement to the pillar-and-stall workings; but at the time the observations were made everything had to be sacrificed to increasing the output, as the colliery was only being opened up, and it was therefore impossible, under these circumstances, to wait until headings 900 or 1,200 feet long had been driven before commencing to work the stalls. The secondary haulage was, therefore, effected under adverse circumstances; but, even such as it was, it would obviously bear comparison with any other system that had come under his own notice, or been mentioned, during the discussion.

The following comparison between the cost (for the week ending September 22nd, 1894) of the system he had introduced at Llanbradach colliery, and the cost of pony-putting as practised in the county of Durham and elsewhere, would be instructive In order to make the comparison complete, it was necessary to reduce the wages actually paid to the standard by deducting the 23¾ per cent. which was paid above the standard rates at that time, leaving the nett amount of £36 7s. 6d. It was also necessary to take some account of the quantity of rubbish hauled simultaneously with the coal, as this would necessarily have to be paid for under any system of haulage that might be adopted.

The writer can, however, only vouch for about 300 tons of rubbish hauled during the week in question, viz.:—

Quantity Tons.		Distance Yards.		Yard-tons.
150	...	870	..	130,500
50	.	630	...	31,500
100		300	..	30,000
		Total	. ..	192,000

He therefore proposes not to take into account any rubbish that accrued from other sources.

The quantities hauled thus become :—

	Tons.		Yard-tons.
Coal, as before	2,981	...	1,715,847
Rubbish	300	...	192,000
Totals	3,281	...	1,907,847

From this statement, it followed that the average distance hauled was 581 yards.

The standard rates for pony-putting, the cost of ponies, and the average earnings of pony-putters paid at a colliery in the county of Durham, were supplied to the writer by Mr. H. F. Bulman. They appear to accord very fairly with the figures quoted by Mr. Longden and Mr. Deacon during the discussion, and to supply a complete answer to the remarks made by Mr. T. Forster Brown.

A.—COST OF WORKING :—

Llanbradach Colliery.

	Tons.
Quantity of coal hauled	2,981
Do. rubbish hauled...	300
Total	3,281
Average distance	581 yards.

	£	s.	d.
Wages of engine-boys and riders	36	7	6
Ropes	5	0	0
Coal (duff) 60 tons, at 2s. 6d.	7	10	0
Stoking and boiler management	3	10	0
Enginemen's wages (air-compressor)	1	1	0
Stores, oil, etc.	2	10	0
Repairs	3	0	0
Total cost	£58	18	6

or 4·310d. per ton.

The costs of ropes, coal, stores, and repairs, were carefully examined by Mr. J. R. Glass, the mechanical engineer of Llanbradach colliery. The price charged for duff coal was somewhat above what was actually obtained for it at the time. The wages of the men who attended to the air-compressor were divided equally between that engine and two other engines in the same building, to which they also attended. The stoking and boiler-management was a proportion of the wages actually paid, reduced to the standard wage; and the wages of engine-boys and riders have been already dealt with above.

County of Durham.

Pony-putters' standard for 130 yards, 11½d. per score, and for every additional completed 30 yards 1d. per score. A score contains 8 tons of coal. The average wage of a pony-putter is 2s. 7½d. per day, and the cost of a pony 1s. 10d. per day. The average number of tons hauled to a distance of 581 yards by each pony-putter in a day's work would therefore be 9·60, and the cost 5·572d. per ton.

The relative costs are therefore:—

System.	581 Yards. d.	1 Mile. s.	 d.
Small engines	4·310	1	1·056
Pony-putting	5·572	1	4·879
Difference in favour of small engines	1·262	0	3·823

The writer has no hesitation in saying, as the result of his own observations, that a comparison of secondary haulage with horses and men with higher wages than pony-putters would be found to be still more in favour of the small engines. He might state also that he had lately heard from the engineer of some of the largest collieries in South Wales who took the trouble to enquire into the subject, that secondary haulage by means of horses was costing from 1s. 8d. to 2s. 8d. per ton-mile in the collieries under his supervision.

B.—Cost of Installation :—

The whole of the working cost of the air-compressing plant had been charged against the haulage of coal and rubbish in the little rock coal-seam for the week ending September 22nd, 1894, for the simple reason that very little use was being made of compressed air for other purposes at that date. But when we consider charges made on capital account, with the object of comparing them with the corresponding charges incidental to other systems of secondary haulage—say, by means of ponies or horses—then the potential power of the plant on the one hand, and of the ponies or horses on the other, must be taken into account, and the charges apportioned accordingly.

During the week ending December 15th, 1894, the quantity of coal hauled by small engines at this colliery was:—

	Tons.	Cwts.
Little Rock coal-seam	4,062	16
Steam coal-seam	997	16
Total	5,060	12

The distance hauled in the former case was necessarily greater than 581 yards, as the workings had been advancing during three months dating from September 22nd. In the latter case, however, it would not average more than, perhaps, 130 yards, as the coal was then being obtained from headings in the shaft-pillar. In addition to these quantities of coal, a certain amount of rubbish was hauled in each seam. Compressed air was also supplied for the following purposes:—(*a*) Six small pumps, working intermittently; (*b*) three small ventilating engines, working continuously; (*c*) smiths' fires on the surface; and (*d*) jets occasionally used for ventilating. The number of small hauling engines in the little rock coal-seam was twenty, and in the steam coal-seam eight.

If, therefore, we assume that the proportion of the available power of the air-compressing plant required to effect the haulage in the little rock coal-seam during the week ending September 22nd, 1894, amounted to one-half of the whole of the available power, we are probably well within the mark.

The number of ponies required to do the same work, taken at 9·6 tons per day each, would have been 57.

The cost of the air-compressing plant was approximately as follows:—

1 Boiler (30 feet by 8 feet) and buildings ...	£700
Air-compressing engine	1,550
Foundations	150
Erecting	60
Proportion of engine-house	150
2 Receivers at surface (old boilers)	200
Steam and air-pipes	700
Sundries	200
Total	£3,710

The proportion of the cost of plant for the little rock coal-seam was therefore :—

One-half of £3,710	£1,855
20 Small hauling engines	1,800
20 Receivers underground	260
Total	£3,915

Assuming that this plant required to be wholly renewed at the end of twenty years, a sinking fund must be created by setting aside such a sum annually as will amount to its total original cost at the end of the period. If interest at the rate of 5 per cent. per annum be allowed upon the sinking fund the annual charge required to create the fund amounted to 3 per cent. of the capital. Again, if interest at the rate of 5 per cent. per annum was allowed upon the capital considered simply as an investment, then these two charges—3 per cent. and 5 per cent. —added together amounted to an annual charge of 8 per cent., which included both interest and amortization, viz., £3,915 at 8 per cent., or £313 4s. the amount required.

Mr. Ernest Boissier, veterinary surgeon, who has just published an elaborate memoir on the subject of horses employed in mines,* stated that the average life of a horse employed underground was five years. It might also be assumed that the harness required to be renewed every five years. Knowing the character of the gradients to be surmounted in several places in the little rock coal-seam at Llanbradach colliery, at the period under consideration, the writer was satisfied that neither hand-putters, ponies, nor horses could have done the whole of the work, even if mine-wagons of suitable weight and capacity had been supplied to suit the strength of one or other of these agents. Where hand-putters required helpers, pony-putting became cheaper than hand-putting ; where ponies were too light, horses must be substituted ; and where horses could not ascend the gradients, engines must take their place.

So far as the writer had been able to ascertain up to the present time, pony-putting was a cheaper method of effecting secondary haulage than horse-putting when the conditions were such that ponies could do the work without distress. He had therefore chosen to compare the cost of secondary haulage by means of small engines with that of pony-putting rather than with that of horse-putting, although he was aware that if he had made the comparison with the latter method he would have been able to make out a much better case in favour of the small engines.

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* "Cheval de Mine." *Bulletin de la Société de l'Industrie Minérale*, 1896, vol. x., page 295.

Assuming, however, that 57 ponies could have done the work, the capital required for their purchase, together with that of their harness, would have amounted to the following sum:—

57 Ponies at £14	£798
57 Sets of harness at £2	114
Total	£912

The annual charge required to create a sinking fund to repay this sum at the end of five years, allowing interest as in the last case at the rate of 5 per cent. per annum, was 18 per cent. of the capital; and if interest at the rate of 5 per cent. per annum was allowed upon the capital, then these two charges—18 per cent. and 5 per cent.—added together amounted to a total annual charge of 23 per cent., which included both interest and amortization. And for £912 at 23 per cent. per annum, a sinking fund of £209 15s 2d. was required.

The cost of stables underground and granary aboveground for this number of ponies might be taken at £400, and an annual charge of 8 per cent. upon this sum (as in the case of the air-compressing plant) required £32 a year. We had therefore:—

	£	s.	d.
Ponies and harness	£209	15	2
Stables and granary	32	0	0
Total	£241	15	2

This amount left a balance of £71 8s. 10d. a year in favour of ponies, which, for an output of 3,281 tons a week, amounted to 0·100d. per ton. We had already seen that the difference in cost of working was 1·262d. per ton in favour of the small engines, so that, after subtracting 0·100d. per ton, there still remained 1·162d. per ton, which, at the same output, gave £826 per annum, or sufficient to pay interest at the rate of 21 per cent. upon the capital of £3,915 invested in the air-compressing plant, in addition to the 5 per cent. allowed above.

The air-compressing plant and the motors actuated by it were much more elastic, as regarded their capability for doing more work, than either ponies or horses. This was shown by the fact that the twenty small engines in the little rock seam hauled 4,062 tons 16 cwts. of coal, besides rubbish, during the week ending December 15th, 1894. These engines had never been all worked up to their full capacity, so that, in comparing their capital value with that of fifty-seven ponies, as above, they had been placed at a considerable disadvantage.

The air-compressing plant itself was of the wasteful type usually employed about collieries, and probably did not give more than one-half to one-third of the useful effect of such engines as those now working at the great air-compressing establishment at the Quai de la Gare, Paris. The air employed in actuating the motors in the little rock coal-seam was forced through pipes 3 inches in diameter, the larger pipes intended for their supply not having been erected at the time the observations were made. A large amount of air was undoubtedly lost by leakages at various points as well as wasted in the workings. Lastly, the motors were by no means perfect, and were capable of very great improvement.

If, however, in spite of its clamant imperfections, this plant could earn an income at the rate of 21 per cent. per annum upon the capital invested in it, as compared with the least expensive system of secondary haulage by means of living agents that could possibly have been brought into competition with it, there was reason to think that the day was not far distant when mechanical appliances would be exclusively employed in secondary haulage wherever the quantity of mineral to be moved and the distance to be traversed were of any appreciable importance.

It was simple enough to say that pony-putting would not, as a rule, be carried on to an average distance of 581 yards. But even with pony-putting the circumstances must govern the case. At Llanbradach colliery, with which the comparison had been instituted, there were five main headings going in different directions, from each of which a proportion of the output was obtained. It would have been impossible to concentrate the output into any one of them at a distance of, say, 300 or 400 yards, and to haul the whole of the coal from that point to the bottom of the pit by means of a single engine and a small staff of men. It must also be borne in mind that the shaft-pillar was 400 yards square; that the seam was on the average only 3 feet thick within the area worked at that time; that the colliery was in process of being opened out; that two downthrow faults, one of 15 the other of 20 feet, had been crossed; that every effort was being directed towards increasing the output so as to reduce the cost per ton on the establishment expenses which were necessarily very large in a colliery of that magnitude; and, lastly, that the output from that seam, which was only begun on March 11th, 1893, had been pushed up to 4,062 tons for the week ending December 15th, 1894. There was, therefore, neither time nor opportunity available for the adoption of the excellent, although obvious, suggestions made by Mr. H. Richardson Hewitt, Mr. Elce, Mr. J. S. Dixon, and others.

He (Mr. Galloway) believed that the figures he was now able to produce proved to demonstration that the system in use at Llanbradach colliery was not only the cheapest method of secondary haulage that could have been adopted under the circumstances of that colliery, but was the cheapest under any circumstances. He had lately seen the same system in operation at one of the Glamorgan Coal Company's collieries under the management of Mr. W. W. Hood, he was glad to hear Mr. Deacon say that after careful enquiry he intended to adopt it, he observed that Mr. Hewitt knew of a colliery where it was in operation, and he thought that as soon as the other members of the Institute had time to enquire into the costs in their own cases they would be disposed to view the subject in a somewhat different light from that in which it appeared to some of them at first.

The following table illustrated the difference between the cost of secondary and primary haulage :—

SYNOPSIS OF THE COST OF CONVEYING MINERALS BY VARIOUS AGENTS IN MINES.

1.—IN OR NEAR THE WORKING-PLACES.

	System.	Agents.	Unit of Weight.	Day's Work.	Cost per Day.			Cost per Ton-mile.	
			Lbs.	Yard-tons.	£	s.	d.	s.	d.
a	Carrying on the back	Man	120	330	0	3	8	19	6·60
b	Wheelbarrow ...	,, ...	200	540	0	3	8	11	11·40
c	Sledge	,, ...	200	600	0	3	8	10	9·00
	2.—SECONDARY HAULAGE. CONVEYING SINGLE WAGGONS FROM THE WORKING-PLACES TO A COLLECTING-SIDING.								
d	Hand-putters ...	Boy	550	1,610	0	2	0	2	2·30
e	Horse-putters ...	Man and horse	2,800	6,864	0	6	6	1	8·00
f	Pony-putters ...	Lad and pony	896	5,577	0	4	5·5	1	4·879
g	Hand-putters ...	Man	896	5,252	0	3	8	1	2·740
h	Small engines ...	Lad and boy	4,480	15,721	0	9	9·6	1	1·056
	3.—PRIMARY HAULAGE. CONVEYING TRAINS OR AN UNINTERRUPTED SUCCESSION OF SINGLE WAGGONS FROM A COLLECTING-SIDING TO THE BOTTOM OF THE SHAFT.								
k	Horses	Man and horse	—	105,600	0	6	6	0	1·300
l	Endless rope ...	Engine & men	—	376,107	2	0	4	0	2·267
m	,, ,, ...	,, ,,	—	354,048	1	5	5	0	1·520
n	Tail rope	,, ,,	—	1,015,308	3	8	1	0	1·417
o	Endless chain ..	,, ,,	—	626,439	1	7	0	0	0·911

The quantities in *a*, *b*, *c*, and *d* systems are taken from the *Cours d'Exploitation des Mines*, by Prof. Haton de la Goupilliere; *k* is from Callon's *Lectures on Mining*, and is reckoned at 8 tons, carried 7½ miles per day on a very good road at least 1,000 yards long; *e* is the more favourable of the two examples of horse-haulage in South Wales, mentioned above; *f* and *g* are on the authority of Mr. H. F. Bulman, and are calculated for a distance of 581 yards, so as to be comparable with *h*, which is the Llanbradach example (hand-putters are, of course, inapplicable, except under very favourable conditions); *l* to *o* are some of the examples given in the Report on the Haulage of Coal published by the North of England Institute of Mining and Mechanical Engineers in 1869; but the cost of maintaining roadways and waggons has been excluded, as it did not appear in any of the other examples. In the five examples taken from French authors, the wages of men and boys and the cost of a horse had been assimilated to the corresponding wages and cost in this country.

As regards the dimensions and capacity of mine-waggons, he would quote the following criticism of Mr. R. Broja, a German mining engineer:—

> While in the salt-mines of Germany with plenty of room underground, and in the coal-mines of Upper Silesia, in seams of 6 to 25 feet thick, we are satisfied to continue to use mine-waggons with a capacity of ½ ton, the ordinary capacity of the waggons used in the Pennsylvanian anthracite mines is from 2½ to 3 tons. Capable American mining engineers who are acquainted with German mines find it inexplicable that larger waggons, with their undeniable advantages, have not been introduced into these mines years ago. By the choice of the more advantageous large waggons the whole anthracite mining industry of Pennsylvania has attained its singular and magnificent development* . . . .
> 15,650,000 tons in 1870, and 58,126,345 tons in 1895.†

He (Mr. Galloway) had employed electricity for driving pumps and ventilators underground, and he had seen it in operation in several applications of main-and-tail-rope haulage, and in the electric endless-rope system of haulage at Bolsover colliery. He regarded it as well adapted for continuously running motors. It did not seem to be equally suitable where there was frequent starting, stopping, and reversing, and therefore, up to the present time, he preferred compressed-air motors for secondary haulage.

As to the relative cost of electricity and compressed-air, he referred the members to the two works named below,‡ from which it would be seen that compressed-air was produced as cheaply as electricity for actuating motors when sufficient care was bestowed upon the design and construction of the engines and motors.

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* *Der Steinkohlen Bergbau in den Vereinigten Staaten von Nord-America*, 1894, page 21.

† *The Mineral Industry*, 1895, page 125.

‡ *Studien über Kraftvertheilung*, Berlin, 1892, by Mr. A. Riedler. *On the Development and Transmission of Power from Central Stations*, 1894, by Mr. William Cawthorne Unwin.

So far as he was aware there were no data in existence from which the cost of secondary haulage by means of electric motors could be ascertained. But the following figures which he had extracted from a paper by Mr. Robert Robertson on the "Electrical Haulage at Earnock Colliery,"* served to throw some light upon its cost when employed in primary haulage. Unfortunately, the author of the paper did not state in exact terms the quantities of coal hauled from the various distances given, but by taking an average distance of 725 yards (viz., the mean of 800 and 650 yards) for the maximum quantity in the ell coal-seam and the maximum distance and quantity in the main coal-seam, the figures were as follows:—

	Tons.	Yards.	Yard-tons.
	60	495	29,700
	340	725	246,500
	200	445	89,000
Totals	600	609	365,200

	£	s.	d.
Wages per day	4	0	6
Coal and stores per day	2	0	0
Total	6	0	6

Or 2·410d. per ton, or 6·964d. per mile-ton.

This result was not very encouraging, even if they assumed that the wages paid were considerably higher than the standard rate.

In conclusion, he differed entirely from those members who suggested the use of horses at first and small engines afterwards, as he had shown by quoting the actual costs in each case that the small engine by itself was able to do the whole of the work both better and cheaper than the horse or pony, more especially where the mine-waggons were large and capacious.

His object in writing the paper was to obtain exact figures, and to induce members to go into the matter for themselves and ascertain the actual cost of secondary haulage.

The CHAIRMAN said that the members were very much indebted to Mr. Galloway for bringing this paper before them. It was desirable that they should have figures on the subject from actual experience. He had pleasure in proposing a hearty vote of thanks to Mr. Galloway for his paper.

The motion was unanimously adopted.

The following paper, by Mr. W. D. Wight, on "Automatic Variable Expansion-gear applied to Balanced Slide-valve Winding-engines," was taken as read:—

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* *Proceedings of the Institution of Civil Engineers*, 1895, vol. cxxi., page 47.

AUTOMATIC VARIABLE EXPANSION-GEAR APPLIED TO BALANCED SLIDE-VALVE WINDING-ENGINES.

BY W. D. WIGHT.

Though far from being a recent introduction, the application of expansion-gear to winding-engines has not met with that large share of appreciation and adoption which its admitted economy would appear to merit. This is not a very difficult matter to account for, as there are few forms of expansion-gear which meet the somewhat exacting requirements of winding-engines, and, in addition, they necessitate deviations from the usual designs of winding machinery and introduce complications which have deterred many engineers from availing themselves of this means of saving expense.

The principal expansion-gears in use have been described in a paper read by Mr. Maurice Deacon,* in which it will be noticed that the Cornish or double-beat valve is an essential feature of the most perfect forms.

The advantages possessed by an ordinary slide-valve over the Cornish valve in admitting of the use of lead and compression, without which any engine running at more than a very slow rate is put under a great disadvantage, and in its better resistance to wear and superior tightness are fully recognized. The lack of compression, owing to the use of Cornish valves, entails great loss of steam in the clearances, amounting in engines of this class to a very considerable proportion of the total steam supplied.

The gear, described in this paper, was designed to provide with slide-valves an automatic cut-off as perfect as can be attained by the use of Cornish or even Corliss valves; the valves themselves, whilst retaining all the advantages of slide-valves, being so well balanced that they require no more power to operate them than properly proportioned double-beat valves (Figs. 1, 2, 3, 4, and 5, Plate XII.).

The main-valve *A* is of the slide-valve type with a balance-plate *B* on the back to relieve the pressure of steam. It is preferably made wedge-shaped in section, so that the steam may be applied to the top and the bottom of the valve, except for the two strips of metal upon which it

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* *Trans. Fed. Inst.*, vol. vii., page 672.

slides. The wide end of the wedge is placed downwards. The area exposed to steam underneath the valve is greater than the area of the top of the valve, so as to perfectly balance it. The valve is extended beyond the face of the ports, and steam-passages are carried through it, to allow the cut-off valves *C*, *C*, to encircle the main-valve.

The expansion-valves, of which there are two *C*, *C*, upon each main-valve, are simply hoops around the main-valve and sliding upon it, having the power to close the steam-passages through the main-valve.

The motion of the valves, by means of the gear, may be described as follows:—The main-valve is actuated by a spindle *E*, *F*, attached to an ordinary link motion, but for the purposes of the expansion-valves the spindle is carried through the back end of the valve-chest. Each cut-off valve has a separate spindle *D*, *G*, and these are connected to the main-valve spindles through toggle-joints *K*, *L*, or a short connecting-rod hinged in the middle, one end *F* of the toggle being rigidly connected to the main-valve spindle, and the other *D* to the cut-off valve spindle.

It will be seen that, so long as the toggle is straight, the main and expansion-valves will move to and fro together, with the steam-port in the main-valve open; but when the joint is bent, the pressure of steam in the valve-chest, acting upon the area represented by the section of the expansion-valve spindle, will drive outwards the cut-off valve, and thereby close the steam-passage at that end of the main-valve. The straightening of the joint to allow of admission of steam upon the next stroke is accomplished by the main-valve spindle carrying its end of the toggle back until the two rods forming the joint are in line. In order that this may be satisfactorily accomplished, it is necessary to prevent the cut-off valve spindle being driven too far back, or the joint would not straighten, and this is provided for by a volute spring within a dash-pot *H*, which cushions the shock of the expansion-valve when closed by the steam, and holds its spindle until the main-valve spindle returns far enough—to straighten the toggle-joint.

A small air-valve is attached to the dash-pot to give free access to the air to fill the dash-pot.

The tripping of the expansion-valve is accomplished by a projection forming part of one of the toggle-joint levers coming into contact with a stop, the position of which is regulated by a governor set to the required speed.

It will be understood that during steam admission the joint is always straight, and during expansion it is always bent.

Fig. 6 (Plate XII.) is a reduced indicator diagram, taken from a

To illustrate Mr. W. D. Wight's Paper on "Automatic Variable Expansion Gear Applied to Balanced Slide-Valve Winding-Engines."

WIGHT & WILD BALANCED SLIDE AND CUT-OFF VALVES, WITH AUTOMATIC CUT-OFF GEAR.

FIG. 1.

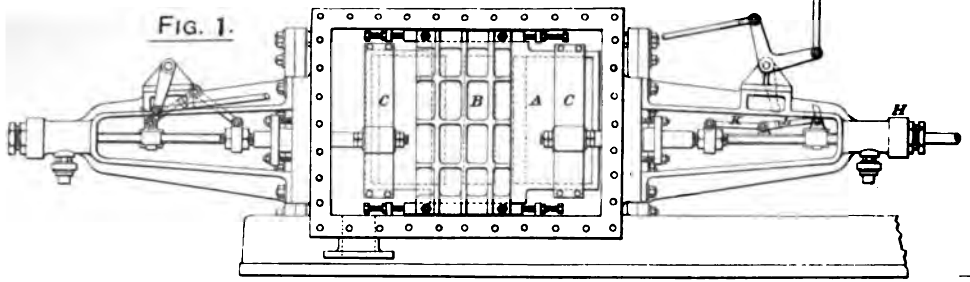
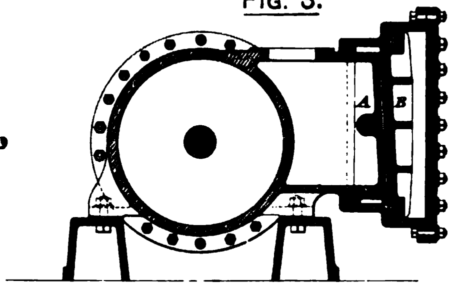


FIG. 3.



Scale, 21 Feet to 1 Inch.

FIG. 2.

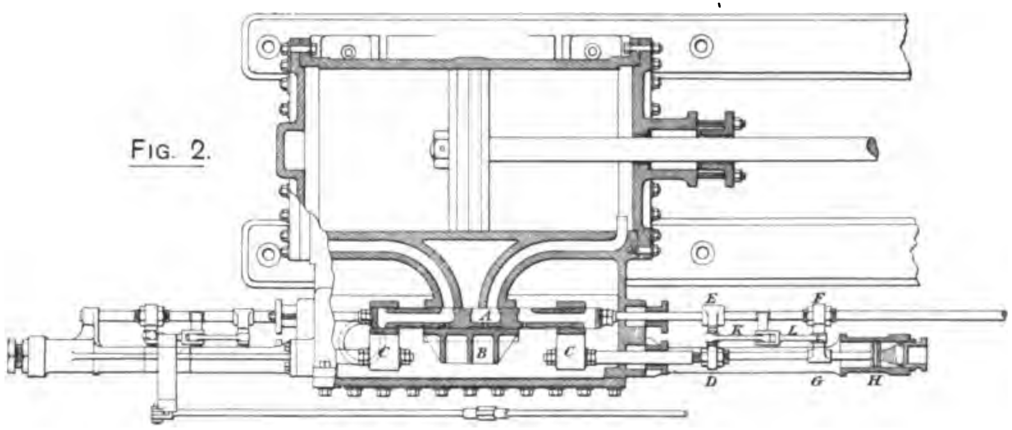
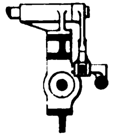


FIG. 4.



SECTION THROUGH TRIP GEAR.

FIG. 5.

SECTION THROUGH CUT-OFF VALVE.

FIG. 6.

SCALE, 1/48

And^w Reid & Comp^y L^td Newcastle on Tyne.

winding-engine, showing that the expansion was varied according to the load and speed, and that even in a winding-engine the speed could be controlled with certainty.

Among other advantages it is claimed that the valves, having all plane faces, are capable of adjustment; the valves, being balanced, the wear is infinitesimal; there are no additional eccentrics required for the expansion-valves; the cut-off is independent of the engineman, but his control is not complicated or interfered with; the governor adjusts the steam to the work it has to do, maintaining the engine at a constant velocity so soon as the desired speed has been attained, by cutting off the steam earlier at each succeeding stroke as the load lessens; and, lastly, one of the most prolific sources of loss of power in quick-running winding-engines is overcome, as the back pressure is inconsiderable, even when the engine is making a wind of 25¼ revolutions in 27 seconds, including the acceleration and retardation accompanying the starting and stopping of the engine.

Although the application of the valve-gear described in the paper is to a winding-engine, the arrangement is equally suitable for other engines.

Mr. M. Deacon (Alfreton) wrote that he did not quite agree with Mr. Wight in his remarks that expansion-gear necessitated deviation from the usual designs of winding-machinery, and introduced complications. There were certain classes of automatic gear which might be fitted to existing winding-engines without any material alteration of the engines, and with very little additional gearing. No doubt the balancing of slide-valves was a great advantage, but it was questionable to his mind whether, even then, this type of valve was equal to the Cornish drop-valve, inasmuch as the wire-drawing, which invariably resulted with slide-valves, could not be overcome, notwithstanding the fact that the valve was balanced. The balancing simply overcame the objectionable loss of power which occurred in the working of unbalanced valves.

Mr. Hugh Bramwell read the following paper on "The Compound Winding-engine at the Great Western Colliery Company's Tymawr Pit: with Notes on its Comparative Steam Economy":—

THE COMPOUND WINDING-ENGINE AT THE GREAT WESTERN COLLIERY COMPANY'S TYMAWR PIT: WITH NOTES ON ITS COMPARATIVE STEAM ECONOMY.

By HUGH BRAMWELL.

Mr. T. Forster Brown, in his notes on the South Wales Coal-field, prepared for the use of the members of the British Association in 1891, stated that a compound winding-engine was about to be erected at the Great Western colliery.

The engine was completed and commenced raising coal in August, 1892, and has worked continuously and satisfactorily since that date. Being one of the few compound winding-engines in this country, the writer proposes giving some particulars of its design, and of its efficiency compared with winding-engines of a more usual type.

Before so doing, it may be stated that a compound winding-engine worked for a number of years at Allhallows colliery, Cumberland, but being of limited power, it was superseded by an ordinary horizontal engine, and converted into an underground hauling-engine. Since the erection of the Tymawr engine, a very similar engine has commenced work at one of the Astley and Tyldesley collieries, Manchester, some particulars of which were given by Mr. Maurice Deacon in his paper on the "Use of Expansion-gear as applied to Colliery Engines."* Mr. W. Galloway, of Cardiff, has also erected and started a compound winding-engine at the Llanbradach colliery of the Cardiff Steam Coal Company: he has described this engine in a paper communicated to the North of England Institute of Mining and Mechanical Engineers.† Abroad, both on the Continent and in the colonies, compound winding-engines are becoming more common, a noted example being the large vertical inverted engine, built by Messrs. Simpson & Co., of London, for the De Beers Mining Company.

The Great Western colliery winding-engine was erected after enquiries had been made relative to the working of a similar engine in Belgium, which was specially examined. The detailed designs of Messrs. John Fowler & Co. were finally accepted.

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* *Trans. Fed. Inst.*, vol. vii., page 672. † *Ibid.*, vol. xi., page 207.

The following are brief particulars of its dimensions:—Horizontal type, twin compound, two cylinders, one on each side of the drum. High-pressure cylinder, 32 inches in diameter; low-pressure cylinder, 48 inches in diameter; stroke of each cylinder, 5 feet; double-beat Cornish equilibrium-valves; high-pressure cylinder, steam-valves, 8 inches in diameter; exhaust-valves, 10 inches in diameter; low-pressure cylinder, steam-valves, 12 inches in diameter; and exhaust-valves, 13 inches in diameter. Average working boiler pressure, 120 lbs. per square inch. Plain cylindrical drum, 18 feet in diameter; pulleys, 18 feet in diameter, supported on lattice-girder frame. The working load comprises cage, chains, etc., 3 tons 8 cwts.; two empty trams, 17 cwts. 3 qrs. 12 lbs.; coal, 2 tons 10 cwts.; and rope, 26 lbs. per fathom, 2 tons 18 cwts. 4 lbs., forming a total weight of 9 tons 13 cwts. 3 qrs. 16 lbs. The depth of shaft is 1,440 feet. The time of winding, 50 seconds. The maximum speed of winding in shaft (approximate), 60 feet per second.

Both of the cylinders are steam-jacketed. The steam from the high-pressure cylinder passes into a receiver, before entering the valve-chest of the low-pressure cylinder. The piston-rods are packed with Faull metallic packing.

The engine is controlled by steam reversing-gear, fitted with an oil-cataract, the motion of the valves following the engineman's handle.

Alongside of the handle of the main steam stop-valve, is a special handle for operating a valve for the admission of high-pressure steam into the low-pressure cylinder valve-chest, in order to assist the engine at starting. Under ordinary working conditions, the use of this valve is unnecessary. It is, however, occasionally made use of, in order to turn the engine over the centres, and at starting should the steam-pressure be low.

The valves are actuated by short rockers: Figs. 1 and 2 (Plate XIII.) being elevations of the gear on the high and low-pressure cylinders respectively. The steam-valves are arranged to trip and drop, so as to admit of expansive working. The steam-valves on the high-pressure cylinder are under the control of a heavy governor, which brings the cut-off into action, and varies it according to the speed of the engine. The valves are also arranged so that they may turn automatically on their seats, and thus equalize the wear round their circumference.

The bed-plate of the engine is of wrought-iron, in the form of riveted box-girders, to which are bolted the cast-iron cylinders, motion-bars, and bearings.

The drum has 8 cast-iron bosses, and cast-iron brake-wheels on each side, connected together by wrought-iron arms and stays. The barrel is of steel-plate, lagged with wood. There are two vertical lever-brakes, capable of being worked either by foot or by steam, at the engineman's pleasure. In ordinary working the steam-brake is not used.

The centre of the pulley-wheels is 60 feet above the landing-level, the angle of lead of the ropes being 52 and 61 degs. for underlap and overlap ropes, respectively. The wheels have cast-iron bosses and rims, with wrought-iron arms, and are made in halves for ease in transport, and to avoid internal strains in casting. For the latter reason the bosses are split vertically as well as horizontally. Special care was taken in bolting the rims and bosses together, the joints being made with sheet lead.

At present, improved crucible-steel ropes, 5¼ inches in circumference and weighing 26 lbs. per fathom, are in use. Their average life has been 20 to 24 months. These ropes are to be replaced by best improved plough-steel, plated ropes, 4¾ inches in circumference, weighing 22 lbs. per fathom, and having a breaking strain of 100 tons, or 15 to 20 tons in excess of that of the present ropes. The weight of the ropes in the shaft is at present unbalanced, the arrangements at the pit-bottom for hanging a counter-balance rope under the cages being incomplete. The cages are double-decked, carrying one tram per deck, the shaft being too small to allow of any other arrangement. The cage-floors tilt to facilitate changing of the tubs.

By the adoption of lighter ropes and a counter-balance rope, it is estimated that the time of running will be reduced to 40 seconds. The fact that the shaft is an upcast, with covers for the cages to lift at each winding, is somewhat against quick running.

The engine is under easy control, and no difficulty whatever has been experienced in working; it has been worked with the automatic expansion-gear on the high-pressure cylinder, both in and out of action. With a steam-pressure of 120 lbs. per square inch, there is little, if any, difference in the time of running, whether with or without the expansion-gear. If the gear be adjusted to come into use at too low a speed, the drop of the valves, when cutting-off, has a tendency to make the ropes sway in the shaft; but this is not experienced under ordinary working conditions.

Owing to the distance of the engine from the boilers (450 feet), and the high-pressure of the steam, considerable trouble was experienced with cast-iron steam-pipes. Fracture of the flanges was not uncommon, and these, in several instances, revealed internal honeycombs. The joints were also most difficult to keep tight, notwithstanding the use of combined copper-and-asbestos rings. The whole of the cast-iron pipes have, however, been replaced by mild steel tubes, having wrought-iron flanges solid-welded on to them. The flanges are provided with as many bolts as can be worked into them. There has been practically no trouble with the steam-pipes since this change.

The engines have been indicated at intervals, and Figs. 3 and 4 (Plate XIII.) are representative diagrams.

Steam Economy.—So many circumstances enter into the total efficiency of a winding-engine, that it is somewhat difficult to make reasonably accurate comparisons.

To arrive at the steam economy of the engine only, all such elements as:—Quality of fuel used, evaporative efficiency of the boilers, length and nature of the steam-pipes, momentum of weights to be set in motion other than parts of the engine itself, the more or less perfect balancing of the ropes, the friction of the moving bodies other than that of the engines, and possibly others, should be eliminated. Some of these cannot be altogether excluded, and for practical purposes, the steam indications of the engine must be relied on, with a view of comparing the steam-consumption per indicated horse-power, exerted in each case.

With the object of comparing the efficiency of the Tymawr compound engine with others of a different type, the writer has made observations on the working of examples of three classes of modern winding-engines, viz.:—

(1) A large high-class horizontal winding-engine working without expansion.
(2) The same engine, but with its variable automatic expansion-gear in use.
(3) An exceptionally efficient large winding-engine with variable automatic expansion-gear.
(4) The Tymawr compound winding-engine with variable automatic expansion-gear.

In each example, the engine has been indicated continuously throughout the winding, and each stroke approximately timed. The weights of steam used and the horse-power exerted during each revolution have been calculated from the diagrams.

Reduced drawings of the continuous diagrams from the Nos. 1, 2, and 4 engines are shown in Figs. 5, 6, 7, and 8 (Plate XIII.).

The difference between working with full steam strokes, throughout the wind, and working expansively was well shown in Figs. 5 and 6 (Plate XIII.). The enormous economy of steam due to expansive working was apparent to the eye. The writer may here say that the engine from which these diagrams were taken was erected in 1875, it had raised an average output of 1,000 tons per day since that time, and that no repairs whatever had been done to the valve-gear.

The results obtained from the writer's observations were given in the following table, which recorded the average steam economy of each engine during the time steam was on in each wind :—

No.	Description of Winding-engine.	Time Steam on each Winding.	Weight of Steam used each Winding.	Average Indicated Horse-power while Steam was on.	Steam Used per Hour per Indicated Horse-power
		Seconds.	Pounds.	Horse-power	Pounds.
1	Hetty pit, winding-engine, without expansion-gear .. .	26	375	695	74
2	Hetty pit, winding-engine, with expansion-gear	26	228	686	46
3	High-class winding-engine, with expansion-gear	40¼	306	734	37
4	Tymawr pit, compound winding-engine, with expansion-gear ...	31⅛	144	650	26

No doubt, a winding-engine designed purposely to work without expansion would probably show somewhat better results than example No. 1, as the exhaust-valves in this case were altogether too small for working with full steam strokes, and there was consequently excessive back-pressure. This was, however, a fault which was almost always found in winding-engines, working without expansion.

The difference in economy between examples Nos. 2 and 3 was due to the fact that in the latter case the ropes were more perfectly counterbalanced, and the expansion-gear admitted of an earlier cut-off.

The Tymawr winding-engine, although working under very disadvantageous conditions, owing to the entire want of counterbalancing of the ropes, proved itself to be very economical. The engine did not get up to its speed until after 6 full steam strokes, the cut-off in the high-pressure cylinder coming into action at the seventh stroke, and even then the maximum cut-off obtained was only ½. With proper counterbalancing, the writer was confident that 4 full steam strokes would be sufficient to attain the required speed, and that the gear could be fixed to cut off at a maximum of ¼ stroke instead of ½ stroke.

The above figures were useful as comparative results only, being all derived from the same basis. They must not, however, be compared with the results from regular running mill or other engines. They covered in each case the whole period of starting and getting up speed, when the use of the steam was necessarily extravagant. It was only after the engines had attained their maximum speed that reasonably economical working could be expected.

The diagram given (Fig. 9, Plate XIV.) showed the consumption of steam per indicated horse-power for each stroke throughout the winding in each example, and from it, it would be seen, that the maximum economy attained at any one stroke in each case was as follows :—

	Lbs. of Steam per Hour per Indicated Horse-power.
1. Hetty pit, winding-engine, without expansion-gear, 1st stroke ...	52·15
2. ,, ,, with ,, 12th ,, ...	32·80
3. High-class winding-engine ,, ,, 7th & 8th ,, ...	24·72
4. Tymawr pit, compound winding-engine, with expansion-gear, 7th stroke	19·39

In conclusion, the writer wishes to express his indebtedness to Mr. Panton, Silksworth, for the loan of his continuous indicator, and to Mr. Davison, Mechanical Engineer, Great Western colliery, for his care in using the same.

APPENDIX.

Table Showing the Consumption of Steam per Hour per Indicated Horse-power for Each Stroke of the Several Engines Referred to.

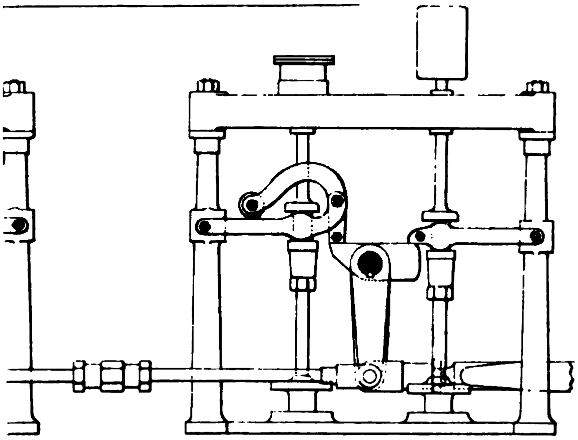
No. of Stroke.	No. 1.		No. 2.		No. 3.		No. 4.	
	Without Expansion.		With Expansion.		With Expansion.		Compound and with Expansion.	
	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.
		Pounds.		Pounds.		Pounds.		Pounds.
1	Steam, full stroke ...	52·15	Steam, full stroke ...	47·14	Steam, full stroke ...	46·53	Compound, steam, full stroke in high pressure cylinder	33·18
2	„	56·09	„	58·86	„	51·16	„	27·79
3	„	54·56	„	66·35	„	54·04	„	32·91
4	„	56·35	„	68·73	„	58·16	„	30·28
5	„	69·35	„	73·06	„	60·15	„	30·41
6	„	70·04	Steam, cut off at ½	39·13	Steam, cut off at ¼	24·88	„	30·47
7	„	70·04	„ ½	40·71	„ ¼	24·72	Compound and steam, cut off on first cylinder at ½	19·39
8	„	89·16	„ ½	39·13	„ ¼	24·72	„ ½	19·51
9	„	77·87	„ ½	40·15	„ ¼	25·04	„ ½	19·90
10	„	88·70	„ ½	40·15	„ ¼	25·53	„ ½	20·35
11	„	84·09	„ ½	38·33	„ ¼	25·53	„ ½	20·80
12	„	90·43	„ ⅖	32·80	„ ¼	25·53	„ ½	21·12
13	„	97·88	„ ⅖	33·09	„ ¼	25·53	„ ½	21·35
14	„	102·53	„ ⅖	33·09	„ ¼	26·51	„ ½	21·58
15	„	107·11	„ ⅖	33·09	„ ¼	26·51	„ ½	21·96
16	„	94·66	„ ⅖	33·09	„ ¼	26·51	„ ½	22·46
17	Steam, shut off	—	Steam, shut off	—	„ ¼	26·51	Steam, shut off	—
18	„	—	„	—	Steam, shut off	—	„	—
19	„	—	„	—	Steam, against	—	„	—
20	„	—	„	—	„	—	„	—
21	„	—	„	—	„	—	„	—
22	„	—	„	—	—	—	Steam, against	—
23	—	—	—	—	—	—	„	—
24	—	—	—	—	—	—	„	—
25	—	—	—	—	—	—	„	—
Means* ...		74	—	46	—	37	—	26

* The mean results take into account the duration in seconds of each stroke.

Mr. W. Galloway (Cardiff) said that Mr. Bramwell, in his otherwise admirable paper, had omitted to take full advantage of his opportunities by giving the consumption of steam for each engine per actual horse-power hour; and to him (Mr. Galloway), as a seeker after information on

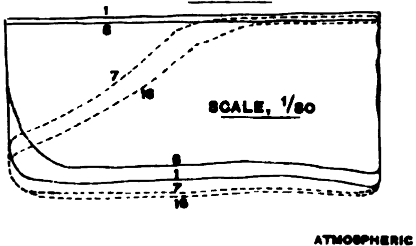
FIG. 2.

ON LOW-PRESSURE CYLINDER.



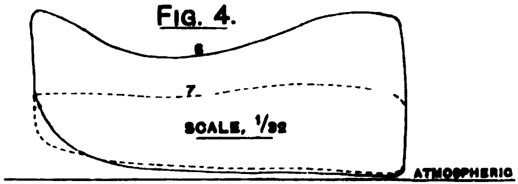
Scale, 2 Feet to 1 Inch.

FIG. 3.



HIGH-PRESSURE CYLINDER.

FIG. 4.



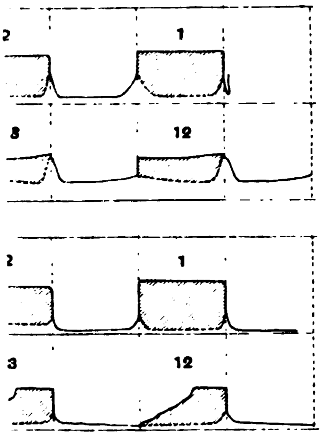
LOW-PRESSURE CYLINDER.

REFERENCE.

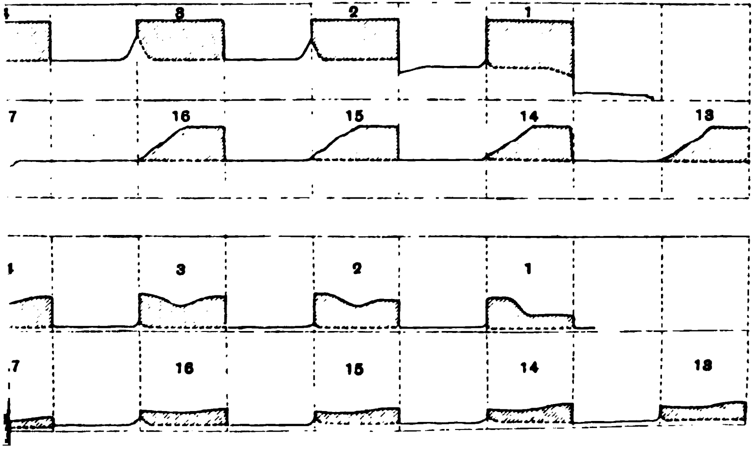
FULL STEAM STROKES SHEWN THUS _________

EXPANSION STROKES " " — — — — —

FIGURES REPRESENT THE NUMBER OF THE STROKE.



M. HIGH-PRESSURE CYLINDER.



APPENDIX.

TABLE SHOWING THE CONSUMPTION OF STEAM PER HOUR PER INDICATED HORS POWER FOR EACH STROKE OF THE SEVERAL ENGINES REFERRED TO.

No. of Stroke.	No. 1.		No. 2.		No. 3.		No. 4.	
	Without Expansion.		With Expansion.		With Expansion.		Compound and with Expansion.	
	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.	Conditions, each Stroke.	Steam Used per Hour per Indicated Horse-power.	Conditions, each Stroke.	Steam Used per Hour per Indicated
		Pounds.		Pounds.		Pounds.		Pound
1	Steam, full stroke ...	52·15	Steam, full stroke ..	47·14	Steam, full stroke ...	46·53	Compound, steam, full stroke in high pressure cylinder	33·18
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4	,,	56·35	,,	68·73	,,	58·16	,,	30·28
5	,,	69·35	,,	73·06	,,	60·15	,,	30·41
6	,,	70·04	Steam, cut off at ½	39·13	Steam, cut off at ¼	24·88	,,	30·47
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12	,,	90·43	,, ⅖	32·80	,, ¼	25·53	,, ½	21·12
13	,,	97·88	,, ⅖	33 09	,, ¼	25·53	,, ½	21·35
14	,,	102·53	,, ⅖	33 09	,, ¼	26·51	,, ½	21·58
15	,,	107·11	,, ⅖	33 09	,, ¼	26·51	,, ½	21 96
16	,,	94·66	,, ⅖	33·09	,, ¼	26·51	,, ½	22·46
17	Steam, shut off	—	Steam, shut off	—	,, ¼	26 51	Steam, shut off	—
18	,,	—	,,	—	Steam, shut off	—	,,	—
19	,,	—	,,	—	Steam, against	—	,,	—
20	,,	—	,,	—	,,	—	,,	—
21	,,	—	,,	—	,,	—	,,	—
22	,,	—	,,	—	—	—	Steam, against	—
23	—	—	—	—	—	—	,,	—
24	—	—	—	—	—	—	,,	—
25	—	—	—	—	—	—	,,	—
Means* ...		74	—	46	—	37	—	26

* The mean results take into account the duration in seconds of each stroke.

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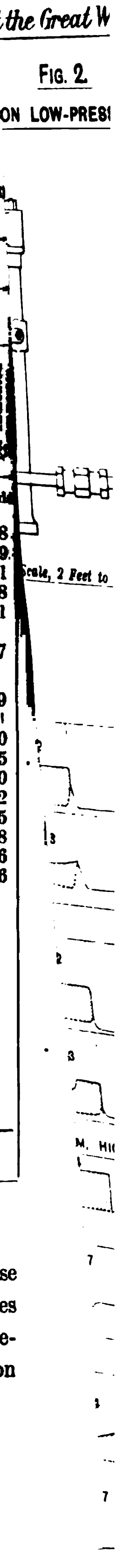

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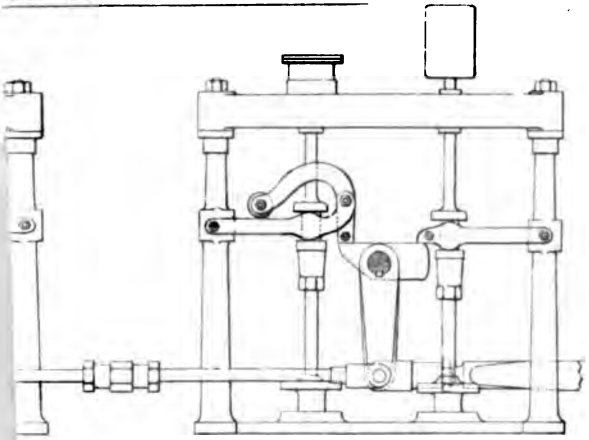
FIG. 2.

ON LOW-PRES

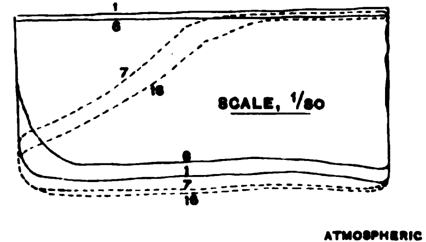
FIG. 2.

ON LOW-PRESSURE CYLINDER.



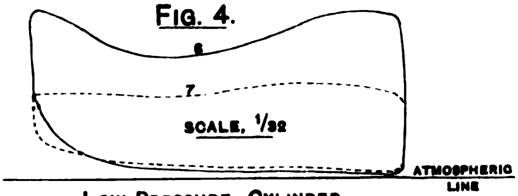
Scale, 2 Feet to 1 Inch.

FIG. 3.



HIGH-PRESSURE CYLINDER.

FIG. 4.



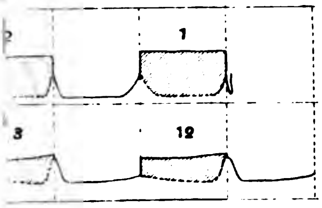
LOW-PRESSURE CYLINDER.

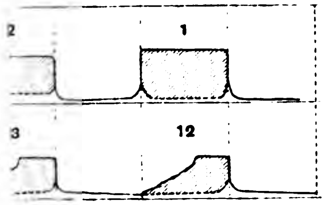
REFERENCE.

FULL STEAM STROKES SHEWN THUS————

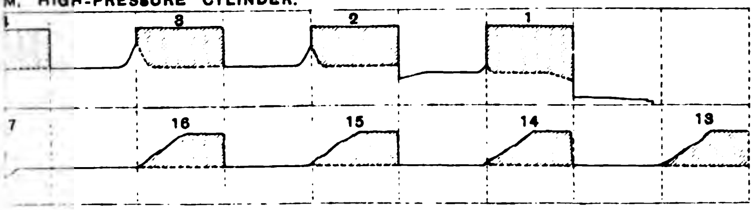
EXPANSION STROKES " " – – – –

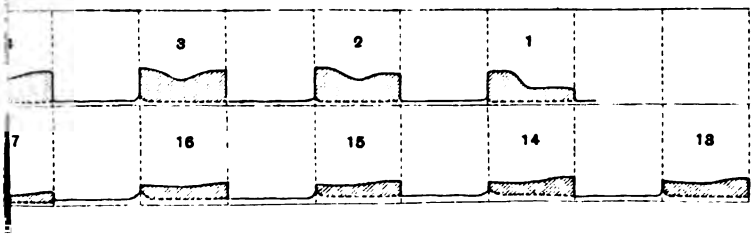
FIGURES REPRESENT THE NUMBER OF THE STROKE.





M, HIGH-PRESSURE CYLINDER.





The Federated Institution of Mining Engineers.
Transactions 1896-7

Vol. XII Plate XIV

To illustrate Mr. Hugh Bramwell's Paper on "The Compound Winding-Engine at the Great Western Colliery &c."

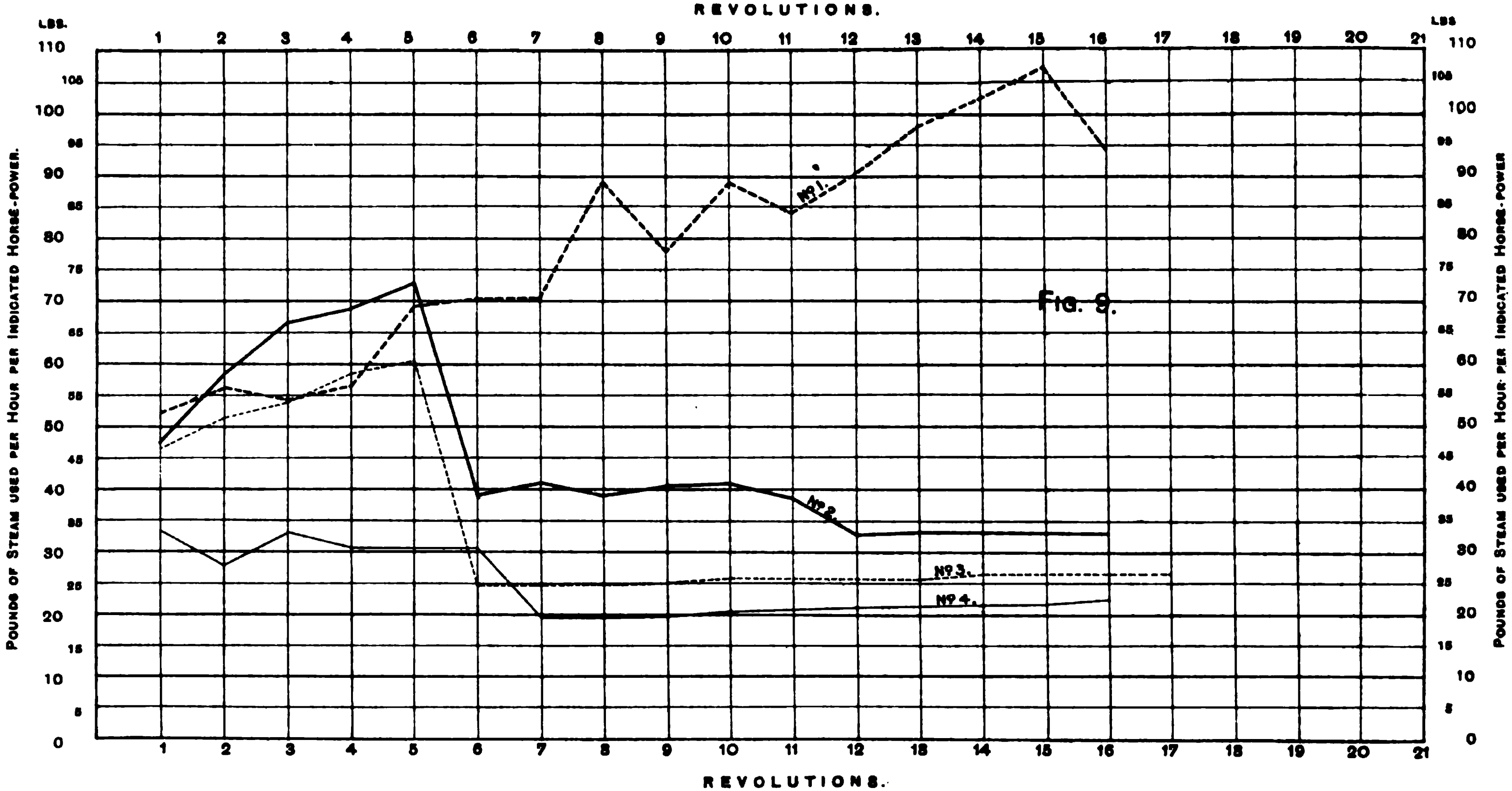


Fig. 9.

Reference - - - - - - No. 1 Great Western Colliery Company, Hetty Pit, Winding-Engine, working without Expansion-Gear.
——— No. 2 Do. do. do. working with Expansion-Gear.
- - - - - No. 3 Large High-class Winding-Engine .. .. working with Expansion-Gear
——— No. 4 Great Western Colliery Company, Tymawr Pit, Winding-Engine, Compound, and working with Expansion-Gear

the subject, the addition of these details would be exceedingly gratifying, as it would give the means of comparing the work of the various engines referred to by Mr. Bramwell with those brought forward by himself in a paper on "A Compound Winding-engine."* It should also be mentioned whether, in the three first examples, the winding-ropes were flat or balanced; if flat, what were the initial and final diameters of the coil, the depths from which winding took place, and the useful working-loads raised in each winding?

Sufficient data were given in the paper to enable a comparison to be made between the Tymawr pit-engine and the various winding-engines referred to by himself (Mr. Galloway). Amongst the winding-engines referred to in both papers, the palm must be accorded to the Tymawr winding-engine, for the present at least; and he (Mr. Galloway) ventured to think, that with the evidence now before them, the members would be disposed to consider that a fair case had been so far made out for the use of compound winding-engines in preference to simple engines, with or without expansion-gear, notwithstanding the slight additional complications which the application of expansion in more than one stage involved. It would be well, however, if the members, instead of comparing the consumption of the winding-engines, whose performances had been recorded in these papers, with those of Corliss and other continuously running engines with high-class cut-off gear and condensation, were to turn their attention homewards and to give the actual results obtained with winding-engines in ordinary practice. They would be astonished at the results; and considering that each additional pound of steam required not only so much boiler space, boiler building, chimney, grate-area, coal, and labour, he (Mr. Galloway) thought that an effort should be made to introduce economy into a service that had hitherto been apparently neglected. The work done by a winding-engine was quite different from the work done by a constantly running mill-engine for example, and it had long been his opinion that winding-engines were exceedingly wasteful of steam.

Mr. M. **Deacon** (Alfreton) said that he was somewhat surprised at the comparison between the winding-engine working without expansion-gear and of the second working with expansion-gear. The difference seemed to be very large, and much more than he had been accustomed to find from practical experiments, and he thought that perhaps it could not all be due to saving in steam. They could not consider that the difference in the measurements of indicator-diagrams was repre-

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* *Trans. Fed. Inst.*, vol. xi., page 207.

sentative of saving of steam, for they had to deal with the fact that in the case of the expanded steam the walls of the cylinder became reduced to a lower temperature than in the case of high-pressure steam, thus causing the cylinders to cool down, and in their turn to produce a certain amount of condensation on the re-admission of live steam at the opposite end of the cylinder. He thought all experiments of this description should be accompanied by a comparison of the actual quantity of coal consumed by the boilers; and if Mr. Bramwell had ascertained the quantity of fuel used over a sufficient length of time he would probably have found that the saving of fuel was nothing like what was shown in the table to be due to the saving in steam. Without for a moment professing to give an exact opinion as to the actual saving of fuel, he should say that if the figures given in the paper were divided by 2, the product would more nearly represent the saving in fuel than the recorded figures.

Mr. L. B. **Atkinson** (Cardiff) said that it appeared to him to be entirely fallacious to calculate the steam required by an engine from indicator-diagrams, but if a proper measurement had been made it would probably have told rather more in favour of the compound engine than of the engine working with expansion-gear. So far as indicator-diagrams were concerned, there should be no difference in the steam used by a single or compound engine, working with the same total range of expansion. The difference which did exist would be due to the inital condensation being less in the compound engine owing to the first cylinder not being cooled as much. It would be interesting to know, in the case of the two engines, the actual range of expansion through which the steam was carried. Assuming it to be the same in both cases, he would expect to find from the actual steam-consumption that the compound engine would appear to less advantage than the figures given in the paper showed. It must be obvious that engines which were standing between each winding in the way that compound winding-engines did, could not be expected to work with a total expenditure of coal per horse-power per hour of 2·5 lbs.; if they did so the result was an exceedingly good one. He did not say that compound engines were not better than single engines, but from the figures given in the paper it was possible to run away with exaggerated notions of the economy of those engines.

Mr. B. **Woodworth** (Fenton) wrote that the most surprising part to him was that such a late admission of steam as 50 per cent. of the full stroke was obtained by the use of the ordinary tripping-gear actuated by the governors. In his own experience he had never found tripping-gear giving more than 25 to 30 per cent. of the full stroke, while in the case of both the Tymawr and Hetty winding-engines the cut-off took place at practically half-stroke in both cases. The results of the steam-consumption were very good for winding-engines; if the main valves were adjusted to give an admission of 85 to 90 per cent. in full-gear further improvement would take place, and if the balanced-rope arrangement were added under the cages or in a modified form so as to leave the cages and sump clear (if the latter be practicable), then a cut-off at half-stroke in the low-pressure cylinder would materially increase the efficiency of the engine. With the relative weights of dead and paying-loads given, it would be more practicable to only partially balance the ropes on account of the extra lift required in landing with a fully balanced arrangement. The best proportions would be a matter of calculation, and would vary as the loads were simultaneously or alternately hooked on and landed. In order to secure the maximum of efficiency, the expansion-gear should not wait for full speed to be attained before coming into action, but it should be brought into operation as early as practicable. With his own system of progressive cut-off gear, he could apply it to the third revolution of the winding, under any conditions of working with which the engine in full gear could freely start, and the working range of cut-off point could range from 65 to 25 per cent. during the progress of each winding, and all the movements were automatic.*

Mr. H. **Bramwell**, replying to the discussion, said that Mr. Galloway asked why in the comparison made the indicated horse-power was taken instead of the actual horse-power of the load lifted. Unless the comparison was so made, it would be difficult to compare any two winding-engines, because their conditions of work were so different. For instance, the Tymawr winding-engine, with a totally unbalanced rope, could not be compared with the Hetty pit winding-engine, which had a partially balanced rope. He therefore thought it best in this particular case to base his comparisons on the indicated horse-power instead of on the actual work done. Attention had been drawn to what appeared to be an excessive saving of steam by the use of expansion-gear on the winding-engine (examples Nos. 1 and 2), but on looking at the diagrams the reason for the saving would be seen in this instance. The exhaust-valves were totally

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* *Trans. Fed. Inst.*, vol. x., page 470.

insufficient to pass the steam out of the cylinders without excessive back-pressure, and the use of the expansion-gear almost increased the speed of the winding. Mr. L. B. Atkinson suggested that the economy shown in the table appended to his paper was due more to the saving of cylinder-condensation. He (Mr. Bramwell) avoided altogether taking into account anything beyond the mere indicated horse-power of the engine. He was unable to make a comparison by a measurement of water and coal consumed with any reasonable chance of accuracy, so he had to fall back on the question of indicated horse-power in each case. The Hetty pit winding-engine was erected in 1875; he thought that it had worked an average of 280 days a year since, raising on an average 1,000 tons of coal per day, and he believed that there had been no repairs to the gear during that period. The Tymawr winding-engine had only worked for a few years, and there was a little wear in places on the gear; it was very slight, and so far there had been no trouble with it.

Mr. J. A. LONGDEN (Stanton) said that some years ago he had an opportunity of testing a Guinotte expansion-gear engine, with two cylinders each 32 inches in diameter; when the gear was in work four boilers were required, but when out of work, five boilers were used. This method was only a rough-and-ready way of arriving at a comparison—it might be termed a stoker's method, but the result was obtained after running for many months. He had had a curious experience with automatic cut-off gear, during the last twelve months: a blowing-engine was erected with a steam-cylinder 60 inches in diameter, and a blast-cylinder 100 inches in diameter. This engine had been working with cut-off gear: the continuous working of a blowing-engine was different to the intermittent running of a winding-engine, and the brasses of the automatic-gear had been almost worn through in twelve months. With large slide-valves like that necessary on a cylinder 60 inches in diameter, the amount of surface requiring lubrication was very large, and the lubricant was not easily applied. He would like to ask Mr. Bramwell if he had had any trouble with trip-valves? He had a fan-engine working with trip-valves, and he was rather surprised the other day to find that whilst twelve months ago the indicator-diagrams showed an equal duty on each side of the piston, the next time it was taken (twelve months afterwards) he found that one side was doing all the work and the other was doing none. It appeared to him that the economy of any valve-gear depended to a great extent on the frequency with which indicator-diagrams were taken, and subsequent adjustment of the valves. It was necessary to keep the trip-valve in good working order—it was not sufficient to leave it to the sole care of the engineman or mechanic. He had great pleasure in proposing a vote of thanks to Mr. Bramwell for his paper.

The motion was unanimously adopted.

Mr. W. Galloway read the following paper on "The Principal Pumping-engine at Llanbradach Colliery":—

THE PRINCIPAL PUMPING-ENGINE AT LLANBRADACH COLLIERY.

By W. GALLOWAY.

The two shafts at Llanbradach colliery are 165 feet apart: the upcast is 17 feet in diameter and 1,710 feet deep; the downcast is 20 feet in diameter and 1,752 feet deep. The former was sunk to its final depth before the latter was begun. Both shafts passed through the lower half of the Pennant Sandstone Series of the South Wales coal-field, and encountered altogether 894 feet or thereabouts of hard rock with numerous water-bearing fissures. The principal beds of rock lie between the surface and a depth of 600 feet, and by far the greater proportion of the water was met with in this part of the sinkings. A second bed of rock, 192 feet thick, also containing water, was passed through between the depths of 870 and 1,062 feet.

In sinking the upcast shaft, two Worthington pumps, both obtained from the Worthington Pumping Company, New York, were established in chambers specially excavated on one side of the shaft, at depths of 642 and 1,110 feet respectively. They were supplied with steam from the surface through the same column of pipes, 4 inches in diameter, and they raised the water to the surface through the same column of pipes, 6 inches in diameter. The first pump had a capacity of 12,000 gallons an hour, the second of 8,000 gallons an hour; and the one actually raised about 6,000 gallons, the other about 4,000 gallons an hour, day and night continuously. The speed of each pump was regulated by means of a float in the pump-well, such as will be described hereafter in the paper.

In sinking the downcast shaft, a wide fissure was met with in the rock at a depth of 400 or 450 feet, which produced water in such abundance as to make it necessary to replace the upper Worthington pump by another capable of pumping 30,000 gallons an hour. This water passed down through a bore-hole in the bottom of the shaft into a heading which communicated with the lodgment in the upcast shaft, situate at a depth of 600 feet, and thence down through 4 inches pipes to the well of the pump, condensing the exhaust-steam in a jet-condenser on its way down.* As

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* *Transactions of the South Wales Institute of Engineers*, 1889, vol. xvi., plate 41.

the sinking proceeded, the water gradually increased up to 70,000 gallons an hour. Pumping was temporarily abandoned, the upcast shaft was allowed to fill with water to within 600 feet of the surface, and the water was raised by the winding-engine, by means of two tanks each with a capacity of 1,000 gallons. When the downcast shaft had been sunk to a depth of a little over 600 feet, and had reached suitable ground below the water-bearing rock, a thick wall of brick and cement was built in it, which tubbed back the greater portion of the water, and there then remained only 24,000 to 25,000 gallons an hour from all sources above the level of the upper pump.

As there was no suitable ground at this level in which a lodgment of sufficient capacity could be excavated, the writer recommended that the water should be conveyed down to the little rock coal-seam at a depth of 792 feet, and that a first class triple-expansion pumping-engine should be erected at that point, and this arrangement was accordingly carried out.

The little rock coal-seam is about 3½ feet thick at the hanging-on place in the upcast shaft, and it has a very hard and strong rock roof about 15 feet thick. Fig 1 (Plate XV.) shows the positions of the shafts, together with the headings and airways communicating with them. *A* is the pump-chamber. The lodgment is at some distance to the dip as shown, its position having been determined by the existence of one of the boundaries of the property near the shafts. The dotted line which connects the pump-chamber to the lodgment shows the position of the channel which connects the latter to the well of the pump. Fig. 2 (Plate XV.) is a plan which shows the pump-chamber, the pump, the shaft, and the roadways along which coal is brought to it, the girders upon which the pipes rest at this level, the pipes themselves, and the cages. Fig. 3 (Plate XV.) is a sectional side elevation through the pump-chamber and the shaft. Fig. 4 (Plate XVI.) is a sectional elevation through the pump-well looking towards the pump, and Fig. 5 (Plate XVI.) is a sectional elevation through the shaft looking towards the entrance of the pump-chamber.

The pump was designed and constructed by Messrs. James Simpson & Co., London, to the requirements of the writer. It is a triple-expansion direct-acting Worthington engine of the following principal dimensions:—

	Inches in Diameter.
High-pressure cylinders	13
Intermediate ,, ...	18½
Low-pressure ,, ...	30
Pump-plungers	9½

And all of 2½ feet stroke.

The normal speed of the steam-pistons and water-plungers is 140 feet per minute, and the pump is capable of raising 750 gallons of water per minute to a height of 800 feet with an effective steam-pressure of 120 lbs. per square inch.

The exhaust-steam is led directly into a Ledward ejector-condenser situate behind the low-pressure cylinders. The plungers are made of gun-metal, and are packed externally, the plunger-rods of delta-metal, and the valves of gun-metal faced with leather, and falling upon gun-metal seats. The valves are arranged in separate pot-shaped valve-boxes, and are pressed downwards by delta-metal springs.

All the other parts of the work were designed by, and carried out under the instructions of, the writer.

The whole of the water accruing from both shafts above the level of 600 feet is collected into an annular lodgment 12 feet wide, concentric with, and immediately outside of, the walling of the shaft. That is to say, this lodgment has a diameter of about 40 feet, and the shaft passes down through its centre. It is 7½ feet deep, and can contain about 60,000 gallons of water. A column of pipes, 4 inches in diameter, *a*, Figs. 2, 3, and 5 (Plates XV. and XVI.), extends from the bottom of this lodgment down to the entrance of the pump-chamber, whence a branch passes into the chamber and is connected to the top of the Ledward condenser behind the pump. The water escaping from the bottom of the condenser flows back to the pump-well through the pipe *e*, which lies in a channel under the floor of the pump-chamber.

The water is raised from the well through the suction-pipe *f*, and after passing through the pump is forced into the rising main *c*, which is 10 inches in diameter, and extends up to the surface. The pipes forming the lower 60 feet or so of this column are of cast-iron, and the remainder are of wrought-iron.

The steam is brought from the boilers at the surface through pipes *b*, 4 inches in diameter, which pass the entrance to this chamber and extend down to the lower pump at 1,110 feet. A branch pipe b^1 conducts part of it to the high-pressure cylinders. The fourth column of pipes *d*, 6 inches in diameter, extends from the lower pump up to the surface.

The three columns of pipes, *a*, *b*, and *c*, are carried by cast-iron supports *g*, which rest on the pit-walling at one end and on a girder built of wrought-iron plates and angle-iron at the other. The girder is capable of carrying a weight of 50 tons. The cast-iron supports consist of two pieces bolted together, and enclosing the pipe between them. Each pipe so supported has a special flange cast on it for this purpose.

A thin sheet of lead is placed between the last-mentioned flanges and the supports, with the object of providing slightly plastic seats to the columns.

There are other columns of pipes in the same division of the shaft for conveying compressed air into the workings, as well as copper wires for electric lighting, but they have been omitted from the drawings as they are not essential to the description of the pumping installation.

The flow of the water from the upper lodgment can be regulated or stopped altogether by means of the stopcock *w* just above the condenser. The quantity of steam supplied to the high-pressure cylinders is regulated automatically by the float *h*, which actuates the lever *k*, and through it a simple and efficient throttle-valve *l*. When the valves of the pump are examined the water is retained in the rising main by closing the valve *m*, and when pumping is resumed the overflow-valve *o* is opened, so as to allow the pump to fill the valve-boxes and to return the superfluous water into the well. After this is done the pump is stopped, the valve *o* is closed, *m* is opened, and pumping is proceeded with. There are two air-vessels, one *p* for the suction the other *q* for the rising-main. The height of water in the latter is shown by a glass gauge. There are also three gauges fixed on a board at a convenient height on one of the walls of the chamber showing the steam-pressure, the vacuum, and the pressure of water in the column. Access is gained to the well through circular cast-iron manholes *r* built in the arches which constitute the floor of the chamber above the well. The rod which connects the float *h* to the lever *k* passes through a central opening in the lid of one of these manholes. The circular opening *s* (Fig. 3, Plate XV.) in one side of the well shows the commencement of the conduit which connects the well to the lodgment in the seam.

The roof of the chamber is a strong, hard rock which stood without support when first excavated, but iron joists resting on the side walls were afterwards placed under it for greater security. The floor is of concrete, smoothed over with a layer of cement. Ventilation is provided by means of a current of air which comes directly from the downcast shaft, is carried over the empty tram-roadway *u* (Fig. 1, Plate XV.) by a small air-crossing, and passing up through three chimneys in the end-wall of the chamber escapes near the roof through the three openings *t*, *t*, *t*. Lighting is effected by means of four 16 candle-power incandescent lamps fixed on each side of the chamber, and a portable electric lamp enables the various parts of the pump to be examined more closely. It is almost needless to add that the walls and roof of the chamber are whitened, so as to make it as light as possible.

When this pump was first started it was required to pump as near as may be 24,000 gallons of water an hour during the whole twenty-four hours, but as time went on the quantity gradually decreased to 21,000 or 22,000 gallons an hour. The whole of the water condensed in the steam-pipes and cylinders, together with the water from the Ledward condenser, goes into the well, so that all the heat brought by the steam from the boilers except the portion that escapes by radiation and is consumed in doing work, is accumulated in the water which is pumped. The temperature of the water coming to the pump was 54 degs., and the temperature of that arriving at the surface was 71 degs. Fahr. at the time the writer made his observations.

In the *Steam Engine** by Mr. D. K. Clark, the results of testing a compound condensing steam-engine by thermal analysis are given as follows :—

	Units.	Units.
1. Total heat carried into the cylinders ...	—	141·26
2. *a* Heat absorbed by the injection-water ...	113·10	—
b Heat retained by the condensed steam...	7·95	121·05
3. Heat consumed in doing work and lost in external cooling	—	20·21

The proportion of the total heat which reappeared in the condenser was therefore :—

$$141{\cdot}26 : 121{\cdot}05 = 100 : 85{\cdot}7 \text{ per cent.}$$

Supposing the same proportion of heat to have been lost in the same way in the case of the Llanbradach pump then the total quantity of heat required to raise 1 pound of water to a height of 800 feet was :—

$$85{\cdot}7 : 100 = 17 : 19{\cdot}84 \text{ units.}$$

The pump was doing about one-half the work of which it was capable, and must therefore of necessity have been consuming a larger quantity of steam per unit of work than it would do were it working up to its full capacity.

The pressure of steam in the pipes between the regulating-valve and the high-pressure cylinders was only 75 to 76 pounds, the vacuum was on the average 26 inches.

The total amount of heat required to raise 1 pound of water from a temperature of 71 degs. to a temperature of 319·4 degs. Fahr., which corresponded to the absolute pressure of (75 + 14·7) 89·7 lbs., and to evaporate it at that temperature was about 1,040 units.

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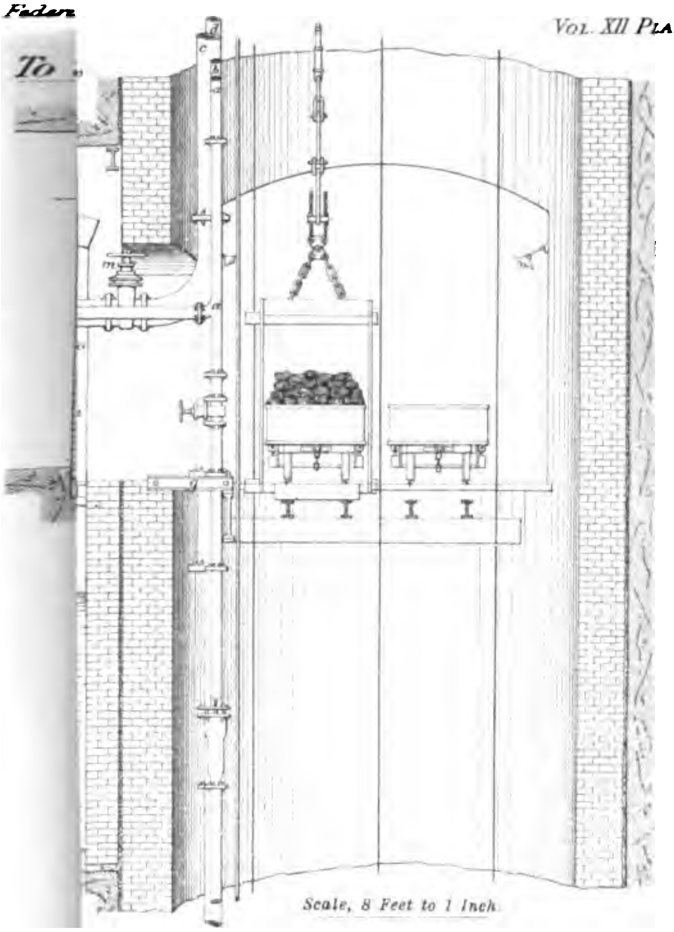
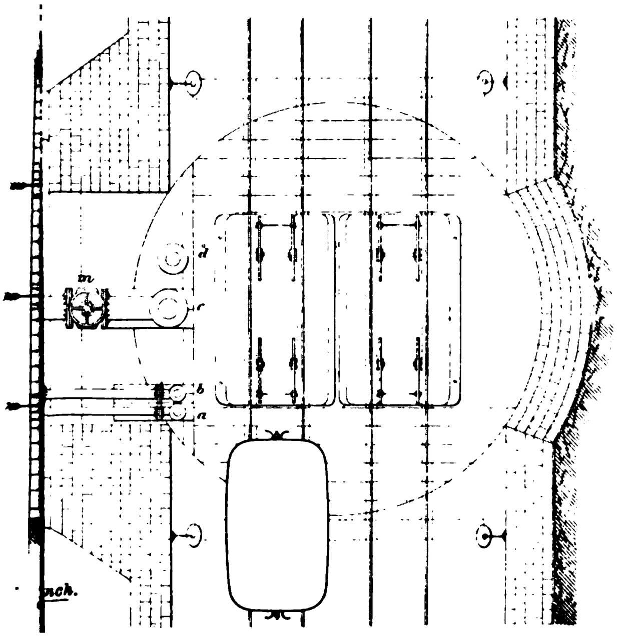
* Vol. ii., page 603.



Scale, 8 Feet to 1 Inch.

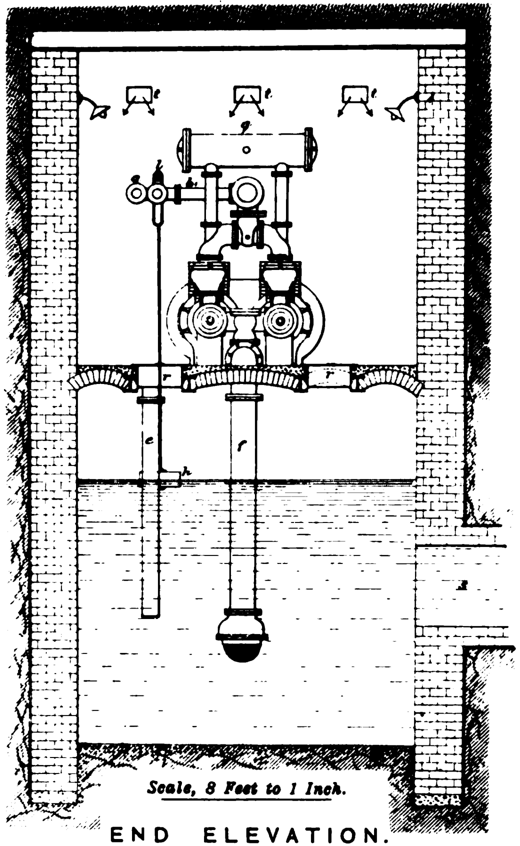
G. 3. SIDE ELEVATION.



nch.

To illustrate Mr. W. Galloway's Paper on "The Principal Pumping Engine at Llanbradach Colliery."

FIG. 4.



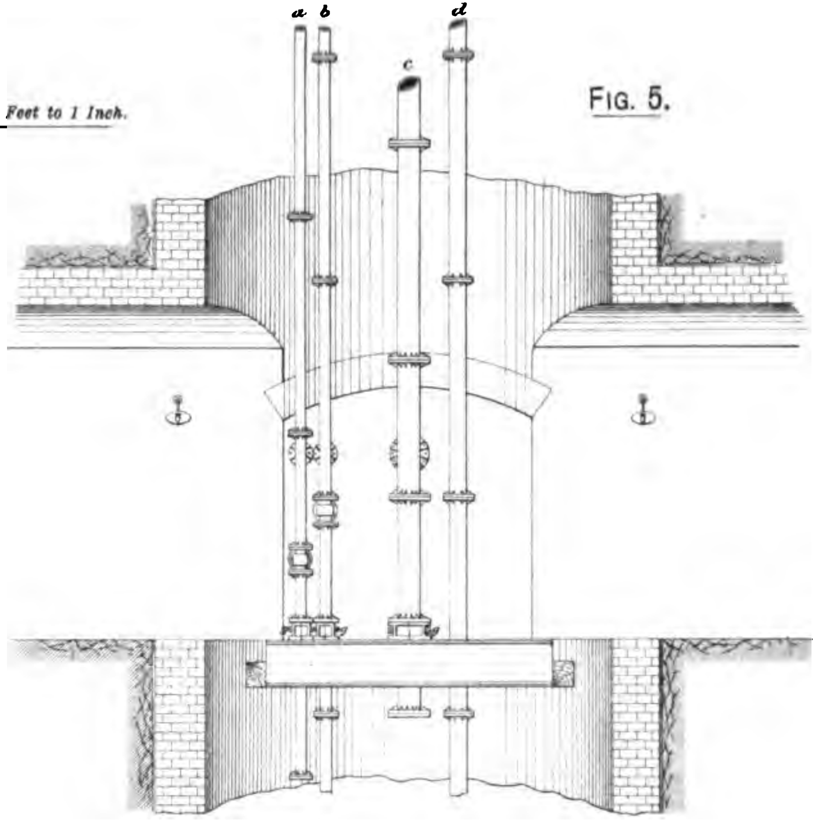
Scale, 8 Feet to 1 Inch.

END ELEVATION.

SECTION THROUGH WELL.

FIG. 5.

Scale, 8 Feet to 1 Inch.



SECTION THROUGH SHAFT

Andw Reid & Compy Ltd Newcastle on Tyne

The work of 1 pound of steam in this pump, working under the conditions described above, was therefore approximately—

19·84 : 1,040 = 800 : 41,935 foot-pounds.

This represents the work actually performed by the pump under ordinary conditions.

Mr. H. AYTON (Newcastle-upon-Tyne) wrote that he had perused with interest the paper by Mr. Galloway on the pumping arrangements, as applied to the sinking and draining of the Llanbradach colliery, as he was at present engaged in the re-opening and unwatering of the Wallsend colliery. He noted that at Llanbradach colliery the upcast shaft was first sunk with an underground Worthington pump, employed to raise the water to the surface, and that the first one was placed at a depth of 642 feet, although the principal water-bearing beds of rock were met with down to within 600 feet from the surface. It would be interesting to learn from Mr. Galloway how the water-feeders were dealt with before the pump was installed. The second pumping-engine was placed some 468 feet below the first, but on sinking the downcast shaft, owing to meeting a feeder of water beyond the capacity of the pumps, with which, he presumed, it was connected, the water was allowed to rise to within 600 feet of the surface, thereby drowning the pumping-engines in the upcast shaft. Another pumping-engine of the same type was subsequently erected at a depth of 792 feet. The rising main consisted of pipes 10 inches in diameter, all of wrought-iron, with the exception of the lower 60 feet, which were made of cast-iron; it would be of interest if the author would state why this arrangement was adopted, and if he would describe the joints used in both sections of pipes. He had no doubt whatever that the Worthington system of pumping was very good, as the engine running at a much higher speed than the old-fashioned engine fed the rising main by smaller but more rapid injections of water, and by so doing produced a much steadier flow, and thus minimized to a great extent shocks, which were always a source of danger at the lower end of a heavy column of water. He did not see, however, that these pumping-engines, when too large to stand in the shaft itself, or to be lowered as the sinking advanced, were adapted to sinking operations, and even when applied to permanent work they, like all other underground engines, were more or less liable, when a sudden influx of water took place, to become drowned, and unable to deal with the water at a time when most required.

Mr. J. A. **Longden** understood that Mr. Galloway had not been able to ascertain the boiler-power necessary for working the pump by itself. Would it not be possible to make the necessary experiments on a Sunday or other day when the pit was idle? If the results could be obtained, they would add materially to the value of the paper.

Mr. W. **Deacon** asked Mr. Galloway to describe the cement-walling used for keeping back the water.

Mr. W. **Galloway** said that the method of dealing with the water-feeders in the upcast shaft before the pumps were put in position was communicated to the members of the South Wales Institute of Engineers.* The water which accrued from the sides of the shaft down to within 50 or 60 feet above the bottom was diverted into a large tank—part of an old steam boiler—which rested on a beam at one side of the shaft, and was lowered from time to time as the shaft was deepened. Two wire-rope guides extended from the bottom of this tank to the top of the head-gear, whence they passed over pulleys and returned to the ground-level, where they were wound upon the drums of hand-crabs. The guide-ropes could thus be lengthened as the tank was lowered. Another smaller tank, which was raised and lowered by a small compound condensing winding-engine, worked between the guide-ropes, and was filled when it dipped into the larger tank, and emptied automatically at the surface by means of an arrangement of levers described in the paper.

The water which accrued between the fixed tank and the bottom of the shaft was dealt with by means of a pneumatic water-barrel, invented and applied by the writer for the first time in this sinking. The first pneumatic water-barrel used had a capacity of 600 gallons, but subsequently a larger one with a capacity of 800 gallons was employed. It was filled in 30 to 40 seconds by creating a vacuum in its interior, and was raised by the main winding-engine to the surface, where it was emptied in 30 seconds by lowering it into a water-trolley of the ordinary type run over the top of the shaft for the purpose. These means were found sufficient to deal with the water in the upcast shaft until the chambers for the pumps had been excavated and the pumps established and set to work. The pumps were not otherwise employed while sinking was proceeding.

The upper flange of each water-pipe had a groove a little over 1 inch wide and about $\frac{3}{16}$ inch deep, in which an indiarubber ring of similar dimensions was placed. The lower flange of each pipe had a cor-

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* *Transactions*, 1888-89, vol. xvi., pages 107 and 268.

responding projection which rested upon and compressed the indiarubber ring. None of these joints had ever given any trouble. On the other hand, several of the wrought iron pipes, 10 inches in diameter, situated between the bottom of the column and a height of 45 feet above, it burst open along the line of welding soon after they were put in and cast-iron pipes were substituted for them with the same kind of joints as those above described.

He (Mr. Galloway) might mention that the old Worthington pump, having a capacity of 30,000 gallons of water per hour, was erected in the chamber *v* (Figs. 2 and 3, Plate XV.) after the Simpson pump had been set to work and now acted as a reserve pump to the latter. It was connected to the same system of water and steam pipes; its supply of steam was regulated by the same float; and its exhaust steam was condensed in the same way as in the Simpson pump. But it had been omitted from the drawings, together with its connexions, so as to simplify the description of the Simpson pump, which was the object of the paper.

Since the sinking was completed, no sudden influxes of water have occurred, and if they had, the two pumps could deal with them up to more than three times the normal quantity.

The walling was done in two or three ways in the shaft, as several sections of cement-walling were used for keeping back the water. In one instance there was a ring of cement behind a lining face of brickwork. In the case of the largest quantity of water, the brickwork was built without a special ring of cement. One ring of bricks was built a little lower than the rings in front of and behind it; the space was filled with liquid cement, and the bricks were pushed into it. About a year after the brickwork was finished, a hole was bored into one of the wooden plug-boxes, and it was found that the pressure was 160 lbs. per square inch. The shaft was 20 feet in diameter. Although the whole of the water was not kept back, about 45,000 gallons an hour were kept back by that particular range of brickwork.

The method of raising the water during the early stages of the sinking had been described in the *Transactions* of the South Wales Institute of Engineers,* and he (Mr. Galloway) proposed shortly to submit a paper to this Institution describing the methods whereby the large feeders were dealt with before the water-tight walling was built.

In reply to Mr. Longden, he was sorry that he was not now in a

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* Vol. xvi., pages 107 and 268.

position to make the necessary experiments to ascertain the boiler-power necessary for working the pump by itself.

The **President** moved that a vote of thanks be accorded to the writer of the paper.

Mr. **Walcot Gibson** (Cardiff) read the following paper on "The Geology of Africa in relation to its Mineral Wealth" :—

THE GEOLOGY OF AFRICA IN RELATION TO ITS MINERAL WEALTH.

By WALCOT GIBSON.

INTRODUCTION.

Within the last few years Africa had taken an important position among the gold-producing countries of the world, and this had led to the rapid opening up of the continent.

South of the Zambesi river, immense tracks are being made accessible to the miner and prospector by the enterprise of the Chartered Company. North of the Zambesi river, the African Lakes Company are winning for us an extensive area around lakes Nyassa and Tanganyika. Germany is actively engaged in making the best of her East African colony, and the British Government has commenced a railway from the coast to Uganda. When this railway is completed, which is promised in three years' time, the most difficult and inaccessible portions of Central Africa, which have hitherto remained *terra incognita* to the prospector, will be brought within reach.

A great deal of valuable information on the geology and mineral products of Africa lies scattered through various pamphlets and journals. With the likelihood of such large portions of the continent being soon rendered accessible to travellers and mineral prospectors, a brief sketch of the general order of succession of the strata may be serviceable. A collection of the known geological facts is certainly of use in pointing out in what formations and in what localities the strata are likely to contain minerals, as well as being able to show which are the formations that are unlikely to yield any.

In the following geological sketch, the author has attempted to piece together the facts accumulated by various observers, and to show the prospects that they hold out of the continuance of the African mining industry and of its future development. In dealing with so vast an area, nothing but broad general outlines can be attempted, nor can these be taken as more than approximations to truth, for the knowledge of African geology is in an extremely elementary and imperfect stage.

The chief authorities on African geology are :—Messrs. Lenz, Zittel, Rolland, Pomel, Lyons, Gumbel, Cornet, Blanford, Hull, Russegger, Schweinfurth, and Sandberger, for North and West Africa; and Messrs. Von der Decken, Thomson, Drummond, Von Höhnel, Ehlers, Livingstone, and Gregory, for East Africa.

Among the numerous authors on South African geology, the following may be considered as having contributed the most important papers:—Messrs. Alford, Baines, Dunn, Draper, Green, Griesbach, Jeppe, Molengraaf, Rubidge, Sawyer, Stow, Sutherland, Schenck, Struben, and Tate.

An important treatise on the Transvaal by Dr. Schmeisser was published last year in Germany. Prof. Futterer, in an elaborate work, has dealt with the gold districts of Africa generally. Prof. Emmons, also, has a paper on the Transvaal gold-fields in the *American Geologist*,* Prof. L. De Launay in the *Annales des Mines*,† and in the *Transactions* of The Federated Institution of Mining Engineers‡ has dealt fully and systematically with the Transvaal gold-bearing beds. Messrs. Goldmann, and Hatch and Chalmers have also published accounts of the gold-fields of the Transvaal, but chiefly from a commercial point of view.

In the present paper a brief outline-sketch of the leading geological features of the continent will first be given. The various rock systems, in chronological order so far as yet ascertained, and the minerals that they contain, will afterwards be discussed in greater detail.

BRIEF SKETCH OF AFRICAN GEOLOGY.

A glance at the geological map of Africa (Plate XVII.) shows that by far the larger portion of the continent as yet known is composed of metamorphic crystalline rocks. A broad zonal belt of these rocks stretches from near Cape Verde on the west to Cape Guardafui on the east, and divides Africa geologically into a northern and southern portion. This zone of rocks sinks to the north beneath the sands and Quaternary deposits of the Sahara Desert, and rises again southward into the high tableland of Central and South Central Africa, to emerge again from beneath the Palæozoic deposits of the Cape around Cape Town.

Unlike the same rocks in Europe generally, these crystalline rocks do not constitute the axes of the main mountain-ranges from which newer deposits dip, but represent an old and vastly denuded floor, on which newer rocks have been laid down—for the most part horizontally. These

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* March, 1896.

† 1896, vol. ix., page 5.

‡ *Trans. Fed. Inst.*, vol. xi., page 378.

newer rocks are of marine origin in Northern Africa and around the borders of the continent, but are of lacustrine or terrestrial origin in the interior and in South Africa.

On the old platform of schistose rocks, and after it had suffered intense denudation, immense piles of volcanic material were poured out from fissures and large vents. The snow-clad Kilima-njaro (19,600 feet) and Kenia (18,370 feet) are among the finest examples of African mountains with this origin, while Mount Elgon, Mount Chibcheragnani, and hosts of smaller volcanoes, stud the central plateaux of Eastern Africa.

The sedimentary rocks, deposited on the eroded edges of the crystalline rocks, are of various geological ages. In South Africa, rocks from Silurian (Malmesbury beds) to Upper Karoo (Permo-Triassic) cover great areas, the strata of the Karoo formation spreading in vast horizontal sheets over Cape Colony, Natal, and the Transvaal. Sandstones and shales, apparently of Karoo age, also occur in the Congo basin, around Lake Tanganyika, Lake Bangweolo, and on the East Coast of Africa, and again in Abyssinia, while the lower portion of the so-called Nubian Sandstone may also, in part, be of Karoo age.

In the central portions of the Sahara, and in the Atlas, rocks of Silurian and Carboniferous age occur.

Of newer rocks there is the great fringe of strata of Secondary and Tertiary age in North Africa and Egypt, while strata of the same ages border the East Coast, Madagascar, Natal, and run up the West Coast to join a border of rocks of the same ages coming round from Morocco.

Besides the sedimentary rocks, a large portion of the continent is occupied by rocks of igneous origin. These occur either as vast sheets of lava, as in South Africa and Abyssinia, or as great piles of volcanic material, as in East Central Africa. The sedimentary rocks of all ages, as well as the subjacent metamorphic rocks, are pierced by innumerable dykes of nearly every kind of igneous rock, from extremely acid to ultrabasic in composition.

In describing the geology of Africa it is most convenient to commence with South Africa, as here the relation of the strata to each other is best displayed, and has been more fully worked out, though certainly not to the extent that the mineral wealth they contain justifies. Sooner or later a mineral survey of South Africa will have to be seriously undertaken, in order to arrive at some approximation as to the extent and distribution of the mineral-bearing districts. South Africa and this country would have everything to gain by a Government Geological Survey, as such a survey, being made independently of any personal interest, would tend to reassure the investing public and convince it that the mineral wealth of South Africa is very great.

At present the credit of South Africa as a mineral-producing country is based on the output of gold and on reports made chiefly for a body of directors, where the main end is the flotation of a company. This survey is all the more important at the present time, when constantly-recurring political troubles also shake the confidence of the people of this country.

The diagram-section (Plate XVIII.) from Cape Town to Johannesburg gives the general succession of strata in South Africa. For the details of this section the author is indebted to the researches of Messrs. Green, Sawyer, Molengraaf, and others, with the exception of the northern portion, which is mainly the author's own interpretation of the order of succession of the strata.

METAMORPHIC ROCKS OF SOUTH AFRICA.

It will be seen that the gneissose platform underlying the pre-Carboniferous and Silurian rocks of Cape Colony appears again around the little town of Vredefort. The rolling country north of Johannesburg and the hills around Pretoria, Barberton, and in the Lydenburg district are also largely composed of gneissose and schistose rocks and quartzites. Further north, gneisses and schists cover a large extent of country as far as the Zambesi river. There is little doubt that all these crystalline rocks of South Africa belong to the same metamorphic complex. They are the granites that figure in so many geological sketch-sections of South Africa, being not infrequently, but quite erroneously, represented as the cause of the tilting of the sedimentary deposits overlying them.

The rocks composing the metamorphic complex chiefly consist of sheared basic igneous rocks of very varied types, being also crossed and recrossed by several systems of later dykes of both acid and basic varieties.

In some localities in the northern Transvaal and in Rhodesia, quartzites are developed on a large scale, and massive quartz-veins are not uncommon, though it has not been made clear how much of the quartzites of the northern Transvaal belong to the metamorphic series, and how much to the banket formation of the Rand. In places, the quartzites and quartz-veins are auriferous.

In several localities, the crystalline schists are themselves auriferous, but it is in the territory of the Chartered Company, according to the reports of several competent observers, that they become richest in minerals.

In Mashonaland, there are reported to be 42,000 square miles of gold-bearing country, the gold occurring in schistose rocks of igneous origin. Mr. A. R. Sawyer states that in Mashonaland the gold occurs in five belts, in almost unbroken parallels for 400 miles. Pockets are said to occur, but shoots are not uncommon. In places, the ore runs 5 ounces over the plates.

The pre-historic workings in Mashonaland are considered, if taken at the low average yield of 10 dwts. per ton, to have produced gold to the value of £1,600,000.

Crossing the metamorphic rocks are a series of dykes of diorite, which Mr. Alford has shown contain gold. It will be important to ascertain whether these gold-bearing igneous rocks are of Karoo, post-Karoo, or pre-Karoo age, and to find out if it be a definite set of dykes with a general trend that is auriferous. So far as is yet known, it is not common in the Transvaal for dykes newer than the metamorphic rocks to contain gold. On the Rand, there has been found no connexion between the richness in gold of the several conglomerate-bands and their proximity to igneous masses or dykes.

Silver, tin, copper, cobalt, and iron ore are also reported to occur in the metamorphic areas, though no one has yet made it clear whether these minerals occur in the metamorphic rocks themselves or in beds of later age folded in with them or only in connexion with intruded masses of igneous rocks. In this and most other cases, it should be borne in mind that the stratigraphical geology of South Africa is extremely complex, and that all observations with the conclusions drawn from them must be received cautiously.

METAMORPHIC ROCKS OF CENTRAL AFRICA.

North of the Zambesi river, metamorphic rocks cover vast areas around Lake Nyassa, Lake Tanganyika, and the two Nyanzas, besides forming a wide tract near the coast, called the Nyika, which divides the interior of East Africa from the coast. From what the author saw of these rocks between Mombasa and Uganda, and from specimens from Tanganyika and other portions of Central Africa, the metamorphic rocks north of the Zambesi river appear to be generally of a more acid type than those of South Africa, though, as in South Africa, they are pierced by numerous dykes of acid and basic varieties. The method of travelling in East Africa by means of large caravans, in the years 1891 and 1892, did not allow much time for prospecting, nor could the caravan be delayed on the march to enable one to prospect. A little panning in the evenings, and a hunt round was all that could be attempted. The author does not therefore feel in a position to form any opinion as to the mineral wealth of East Africa. The absence of minerals in the metamorphic rocks of East Africa cannot be definitely stated till a closer inspection of the ground has been undertaken, a feat impossible till the Uganda railway is completed.

At present, no minerals have been yielded by the metamorphic rocks of Central Africa north of the Zambesi river, and the natives do not possess any knowledge of the occurrence of gold in East Africa. In the Bura hills and at Kenani in East Africa, crystalline limestones form part of the metamorphic series, and will, no doubt, be found to be a useful source of lime.

METAMORPHIC ROCKS OF NORTH AFRICA.

Gold is reported from Abyssinia and from the upper reaches of the Nile. The Somalis of the Jub river report the occurrence of the precious metal. In all these cases, the author thinks that the gold will ultimately be traced to the crystalline rocks.

Further north, in the Etbai and Abyssinia, the crystalline rocks occur. Here there are stated to be two series, with a great unconformity between them. It is the older set of rocks that appears to be metalliferous. Mr. Floyer has done much to develop and draw attention to the mineral resources of this part of Africa, wherein very ancient gold and emerald mines occur, as well as large quarries in ornamental stones.

Gold occurs in Morocco and along the chain of the Great Atlas. Indeed, this portion of Africa is known to be very rich in many kinds of minerals, some occurring in metamorphic rocks, others in rocks of sedimentary origin.

Rocks of the metamorphic series crop out in many places in the Sahara, and the southern limit of these little-known regions is known to be bounded by crystalline rocks, from which rocks of Palæozoic age dip to the north. The author is not aware that much has hitherto been done to ascertain whether the junction of these two sets of rocks yields any minerals. The natives of Timbuctu and Sokoto have long used gold-dust as a trade article, the source of which has not been made very clear.

METAMORPHIC ROCKS OF WEST AFRICA.

The metamorphic rocks of West Africa have not as yet yielded any minerals, except in Namaqualand and Damaraland; but it is an open question how much of the gold in the modern conglomerates and laterite of the West Coast is derived from the crystalline rocks, and how much from the Palæozoic rocks abutting against them, or whether the gold is entirely of geyser origin.

It is thus seen that the metamorphic rocks of Africa show indications of containing many valuable and precious minerals. Our knowledge is very scanty, very incomplete, and frequently unreliable, nor is it safe to speculate widely on the few known and imperfect data at hand; but there is certainly a promise that the metamorphic rocks, which compose so large an area of our African possessions, are not so barren of minerals as would appear at first sight.

ROCKS NEWER THAN THE METAMORPHIC SERIES IN SOUTH AFRICA.

Table Mountain Sandstone.—Returning to South Africa, a set of highly cleaved and contorted strata are found resting on the metamorphic series. These are the Malmesbury Schists, and are of Silurian age. On these rests the Table Mountain Sandstone, which is of very doubtful age, but of great thickness. Essentially a sedimentary deposit of great thickness, it forms nearly the entire mass of Table Mountain.

Bokkeveld and Zwaartebergen Quartzites.—Further north in the Zwaartebergen mountains the Table Mountain Sandstone is succeeded by the Bokkeveld Beds and Zwaartebergen Quartzites. These two formations are intricately folded together, and probably represent strata of Devonian and Carboniferous ages, while folded in with them are possibly rocks of very various ages.

Among the quartzites, Mr. A. R. Sawyer has detected certain conglomerate-bands similar to those found in the Banket formation of the Witwatersrand. From the complex of rocks in the Zwaartebergen mountains the same observer records the occurrence of *Spiriferi* of Carboniferous species. The author of this paper has already stated his reasons before the Institution* for not taking the presence of this fossil as indicating more than the age of the particular band of rock in which it occurred. Experience in many parts of the world has taught the lesson of extreme

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* *Trans. Fed. Inst.*, vol. ix., page 370.

caution in assuming or inferring the age of groups of strata occurring in folded regions. The unravelling of the stratigraphical succession in the Zwaartebergen mountains can only be accomplished by minute and careful mapping. Conclusions arrived at from hasty examinations of isolated districts are next to worthless. Nothing short of prolonged investigation in the region, and careful mapping of the strata, would enable one to speak decisively of the true succession of the rocks in these complicated regions. It is the story of the Southern Uplands and North-west Highlands over again, the true history of which is even now far from being solved, after years of patient labour by the most celebrated geologists. But the author thinks that it is in the Zwaartebergen mountains that a great deal of the geological history of South Africa from the period of the Table Mountain Sandstone to that of the Karoo lies written in bold characters, and in a country admirably adapted for geological investigation. At present the writer on South African geology is compelled to follow in the steps of the old, patient observers who worked so hard and so enthusiastically, and who performed so much of real value. Their conclusions are certainly more trustworthy than those arrived at by the theorists who seek to establish an identity in age of all South African conglomerates with the auriferous deposits of the Rand.

Dwyka Conglomerate.—Following the upward succession established by Mr. Dunn and others, the next division of rocks is the Dwyka Conglomerate. This formation lies unconformably on the Zwaartebergen Quartzites, and, is in turn, succeeded conformably by strata of Karoo age. The last-mentioned group will be dealt with later on, when the coal-bearing beds of South Africa are discussed.

The Dwyka Conglomerate is one of the best marked and most remarkable formations in South Africa. It forms an excellent base to all the overlying formations, and, being well developed in Cape Colony and Natal, has received much attention. The varied assortment of boulders forming the main mass of the conglomerate have been attributed to glacial action by several geologists, while others have assigned them a volcanic origin or consider them as part of an ordinary sedimentary deposit.

As long ago as 1872, Mr. Dunn considered the Dwyka Conglomerate to be of glacial origin, and in this conclusion he was supported by Mr. Stow and Dr. Sutherland. Prof. Edgeworth David has recently brought forward conclusive evidence to show that conglomerates in Australasia of the same age as the Dwyka and of a somewhat similar character, are of glacial origin. This is in accordance with the origin attributed to the

Talchir group, the Salt Range group, and boulder-beds of Bap in Western Rajputana, in India, by Dr. Blanford and other observers. Since, on palæontological grounds, the Dwyka Conglomerate of South Africa is homotaxial with strata of similar composition in Australasia and India, whose glacial origin is unquestioned, it seems reasonable to suppose that the Dwyka also is due to ice-action.

For the student of South African geology, the correct determination of the origin and age of the Dwyka Conglomerate is important, because at a first glance at a geological map of South Africa it would be natural to consider the famous Witwatersrand Banket formation as some modified form of the Dwyka Conglomerate. If the Dwyka be of glacial origin this does not appear so reasonable, for the Banket formation occurs over very wide areas and is made of a variety of rocks that cannot possibly be considered to be of glacial origin. In lithological composition, the Dwyka Conglomerate and the Banket Conglomerates are also widely different. The Dwyka contains pebbles of various kinds of rocks, while the pebbles of the Banket are almost exclusively composed of quartz.

The Banket.—The Banket formation of South Africa is assuming a very great commercial importance, much has been written about it, and many guesses as to its age and origin have been brought forward. The character of the formation is now so well known as to need little further description. It will only be necessary to draw attention to some points in the stratigraphy that have recently been described.

One of the most important discoveries of late is that of a thick band of dolomitized limestone overlying the black reef series and of an apparent unconformity of the black reef series of conglomerates to the main reef and its associated beds.

The delimitation of this limestone is due to the researches of Dr. Molengraaf, Mr. Draper, and Mr. Struben. Messrs. Draper and Struben have been able to detect by means of this band of limestone the presence of some portion of the Witwatersrand formation in areas far removed from the typical locality of Johannesburg.

Mr. Struben, in a recent map, represents outcrops of the Banket formation over the entire continent south of the Zambesi. His descriptions, however, are so vague—and no attempt is being made by him to separate the various sedimentary deposits of South Africa or to assign to the conglomerates any definite position, even within wide limits, in the sequence of South African strata—that his arguments cannot be followed. There is even a possibility of his having identified limestones of Cretaceous, Silurian, Carboniferous, and Devonian ages, with the dolomite associated with the auriferous sediments of the Transvaal.

Neither Mr. Draper, Mr. Struben, nor Dr. Molengraaf, have grasped the amount of mechanical deformation that the Banket formation has suffered, nor has anyone yet made out the true succession or age of the Witwatersrand Beds. Thus, the quartzites and shales north of Johannesburg are stated by Messrs. Draper and Struben to underlie the main reef series, and are used by these observers to trace the outcrop of the main reef where this is hidden beneath surface-deposits. Dr. Molengraaf considers that there is an unconformity between the quartzite-and-shale group and the main reef series. The author of this paper considers that the junction is a faulted one, but does not profess to say what is the true relationship. The quartzites and shales may be either above or below the main reef, or merely bands occurring on many horizons in the Banket formation. It is certainly not safe to argue that certain conglomerates outside the Rand area are portions of the main reef series, because they are underlain or overlain, according to the view of the particular observer, by certain quartzites and shales which appear similar to those that apparently underlie the main reef, near Johannesburg. In the present state of knowledge, it is impossible to state definitely what is the true sequence on the Rand. This will, perhaps, be possible when the several bands of quartzites, shales, and conglomerates, are laid down on an accurate topographical map on a scale large enough to show the major divisions of the strata.

In 1893, the author of this paper stated his conviction that the strata on the Rand were thrust over each other, or at least along the northern margin of the Johannesburg gold-field.* He sees no reason for altering this opinion. Indeed, fresh evidence of the thrusting over each other of the various strata is met with each year. Thus, Prof. De Launay, in the *Annales des Mines*,† states that 70 per cent. of the faults are overfaults. Messrs. Hatch and Chalmers, in their book on the *Gold-mines of the Rand*, give diagrams of the local reduplication of the conglomerates by overfaulting. If the dips in the bore-hole sunk to the south of the Simmer and Jack mine are to be trusted, the section shows further evidence of complication existing through overfaulting. Thus the following dips are met with in depth from the surface:—60, 50, 47, 35, 45, 44, 27, 23, 13, and 15 degs. These dips are inconsistent with a flattening out of strata arranged in a simple synclinal fold, but easily explained by overthrusting.

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* *Trans. Fed. Inst.*, vol. vi., page 124.

† 1896, vol. ix., page 5.

The age of the Banket formation must also for the present be left an open question. It is certainly newer than the metamorphic series, but older than the upper portion of the Karoo. To any portion of the geological scale between these limits it can be assigned. In the Transvaal, the Banket formation is the only sedimentary deposit between the Upper Karoo and the metamorphic rocks. Wherever the base of the series is seen, it is found to rest on the metamorphic rocks. In Cape Colony, several thick formations of known geological ages lie between the Karoo and the metamorphic rocks. To which of these formations the Rand beds belong has still to be ascertained.

If the black reef series and the dolomite be unconformable to the main reef series, the discovery of specimens of Carboniferous fossils at Vereeniging shows no more than the age of the dolomite in which they occur. It is not safe to say that the Witwatersrand beds are of Lower Devonian age if there be this marked unconformity between the Banket formation and the dolomite.

It is also impossible, in the absence of fossils in the Witwatersrand Beds, to correlate them with strata occurring so far off as the Cape, even though beds of somewhat the same lithological composition as the Banket formation occur in the Table Mountain Sandstone Series.

The table of strata accompanying this paper (Appendix A) shows the correlation of the strata in South Africa according to the several authorities, but it must be considered as only provisional.

The Banket formation crops out in the Potchefstroom and Klerksdorp districts, and in one or two localities in the Orange Free State bordering on the Vaal river. In all these districts the strata are thrown into gentle folds. Around Vredefort, these folds are very sharp and shallow.

North of Johannesburg, some portion of the Banket series crops out, and forms the Megaliesberg range of mountains. Mr. Struben also considers that there are broad outcrops of the formation in Matabeleland and Mashonaland, but his arguments are not conclusive.

In Zululand, Messrs. Daulton and Paulson, in 1893, reported the occurrence of strata, similar to those of the Banket formation, on the Tussenbye farm, on the British Zululand border. The strata lie at angles of 5 to 12 degs. There is said to be a sharp division between the sandstones and conglomerates. The hanging wall alone carries gold; pannings of 14 dwts. 10 grs. per ton have been obtained.

These conglomerates and sandstones have been taken to be of the same age as the Rand deposits, but their identity with the Banket formation has yet to be proved. It must be remembered that in Cape

Colony gold is found in strata of Karoo age, and as the Karoo formation also contains bands of conglomerate (Enon Conglomerate) indistinguishable from those of the Rand, the age of the auriferous conglomerates of Zululand cannot be settled by petrological or mineralogical data.

Mr. Struben, in one of his sections, shows the auriferous conglomerates of Zululand conformable to the Karoo and coal-bearing strata. If this be correct, the Banket of Zululand and Natal cannot possibly be the same as that of the Rand, for in the Transvaal there is no doubt about the marked unconformity of the coal-bearing strata to the Witwatersrand conglomerates.

In the Potchefstroom and Klerksdorp districts, also, the coal-bearing strata rest almost horizontally on the folded sandstones and conglomerates of the Rand formation.

North of the Zambesi river, no Banket beds have as yet been detected anywhere in Africa. The Banket of the West Coast is of more recent origin.

Palæozoic Rocks of North and West Africa.—On the West Coast of Africa, in French Sudan and French Congo, Palæozoic rocks of undetermined age occur. They are described as consisting of quartzites and schists, resting on metamorphic rocks. Large areas in the Sahara are composed of Palæozoic rocks of Silurian and Carboniferous ages, and probably of other Palæozoic formations. The strata dip north off the Palæozoic rocks to form a basin in the centre of the Sahara. This region is too uninviting for prospectors, but it is just possible that the Palæozoic rocks of North Africa will yield petroleum among other minerals.

Karoo Beds of South Africa.—The Dwyka Conglomerate forms the base of the most extensive series of sedimentary deposits in South Africa. These constitute the Karoo formation, which is of Lower Mesozoic age, judging from palæontological evidence.

In the Orange Free State and around Kimberley and on the Karoo desert, the strata are thrown into gentle folds or lie nearly horizontal. They consist of sandstones, shales, and conglomerates. In the vicinity of the Kimberley diamond-pipes, the sandstone appears to be converted into quartzite.

In Natal, these strata cover great expanses of country, and the Drakensberg mountains are chiefly composed of sedimentary rocks of Lower and Upper Karoo ages, with their associated contemporaneous and intrusive lavas.

The upper portion of the Karoo or the Stormberg Beds contain thick deposits of coal. These are being extensively worked in the Transvaal and in Natal.

The existence of coal in South Africa of course adds largely to the prosperity of the country. It is to be hoped that high-class steam-coals will be discovered. At present the chief workable seams of coal are of inferior quality, when compared with the best Welsh steam-coals. They yield a very large amount of ash. The coal on the Oliphants river is, however, of fair quality and is largely used on the Rand.

Outside the typical areas in South Africa, strata of unquestionably Karoo age are found, in some localities bearing thin beds of inferior coal. In Mashonaland, on the upper reaches of the Zambesi, sedimentary rocks with workable coal-seams occur. The same set of sediments is found near the mouth of the Zambesi, but only thin layers of coaly matter and plant-beds have been recorded.

Karoo Beds North of the Zambesi River.—Around Lake Nyassa, Lake Tanganyika, and Lake Bangweolo, sedimentary rocks of unquestionable Karoo age have been found. The identification of some fossil shells of Karoo species renders their age certain. As yet no workable coal-seams have been detected, though shaly coals and coal-smuts have been found.

On visiting East Africa, the author was struck with the resemblance of the sandstone-grits underlying the Jurassic deposits of Mombasa, to the strata of the Karoo formation in South Africa. Fragments of coal were detected, but no signs of coal-seams or underclays. No fossils were found and none are reported to occur, so that at present there is only a striking lithological resemblance to the Karoo Beds. In the sandstones and grits of Mesara, near Mombasa, thin veins of argentiferous galena occur.

In Abyssinia, the Adigrat Sandstone of Dr. Blanford may possibly be of Karoo age, as suggested by Dr. Hull; and it is also possible that the lower portion of the Nubian Sandstone may be of Karoo age and perhaps also coal-bearing.

In the Congo basin, in Namaqualand, and in a few other far distant and isolated places, sandstones and grits have been said to occur which appear from descriptions to correspond in lithological composition and in their lacustrine origin to the Karoo formation of South Africa.

North of Lake Bangweolo, there is no direct evidence of the existence of strata of Karoo age, but looking at the great spread of strata of undoubted Karoo age from lat. 5 to lat. 33 south, it is always advisable for the traveller to bear in mind the possibility of strata of this age occurring in North Africa and Central Africa and of their proving to be coal-bearing.

Igneous Rocks of Africa.—In connexion with the Karoo formation the igneous and volcanic rocks of Africa may be fitly mentioned.

It was with the Karoo formation that the chief volcanic activity of Africa was ushered in. This has continued down to the present day, though now manifested in only a feeble manner, while everywhere on the continent the vast monuments of spent volcanic forces are admirably preserved.

A very large portion of South Africa is threaded with dykes and overflowed by vast sheets of basic lavas, while necks and old vents are extremely common. To the latter class, the Kimberley diamond-pipes belong. In South Africa, the igneous rocks are chiefly of Karoo or post-Karoo age, but igneous rocks of pre-Karoo age are not uncommon. Many of the dykes cutting the Witwatersrand beds are certainly of pre-Karoo age, for they have undergone a great mechanical deformation, which does not affect the Karoo beds.

In South Africa, it is a question still open for debate, how far the gold in the Banket Beds is due to the presence of igneous rocks, or how much is original, and if any is due to volcanic activity in the neighbourhood of the auriferous sediments. Mr. Alford has shown that some of the igneous dykes (diorites) are auriferous, and as long ago as 1854 Mr. Rubidge described the occurrence of gold in trap-dykes intersecting the Karoo formation of South Africa.

The volcanic rocks of Central and North Africa are of later age than those of South Africa. Many of the great extinct volcanoes of Central Africa are comparatively of recent date, while some are still active, and others apparently only dormant.

Except in South Africa, the igneous and volcanic rocks have not shown any indications of being metalliferous. The natives of Chagga on Kilima-njaro, and of Kavirondo on the north-eastern shores of Lake Victoria Nyanza, obtain an iron ore, which is very easily worked in a charcoal fire, from dykes of ultra-basic rocks.

Looking at the immense amount of volcanic activity displayed in the regions of Lake Naivasha, Lake Rudolf, and Lake Baringo, it is possible that asphalt-deposits will some day be found to exist in these regions of East Central Africa.

POST-KAROO FORMATIONS.

The formations of newer date than the Karoo are not of much mineral importance. In North Africa, very large areas are covered by rocks of Cretaceous and Tertiary ages. In the Atlas, the strata are intensely folded, but on the Sahara they form very gentle synclines. As a possible water-supply for Egypt and the towns in the interior of North Africa they are worthy of consideration.

Cretaceous rocks fringe the East Coast of Africa, and occur in Natal, Madagascar, and again on the West Coast. Consisting of limestones and shales, they are a future source for lime and cement.

SURFACE-DEPOSITS.

In dismissing the geological formations of Africa, a word or two may be said about the surface-deposits. The strata of very large portions of the Continent are concealed beneath very thick deposits of red sand and laterite. On the Gold Coast, the laterite is auriferous.

In other parts of Africa, the red surface-sand sometimes contains thin bands of impure ironstone, but as a rule the deep deposits of sand are unremunerative and are often a great hindrance to the prospector.

The dry regions of North, Central, and South Africa contain surface-deposits of minerals, and the salt-lakes yield good, clean salt in addition to natron.

Near the eastern shores of Lake Albert Nyanza, Captain Lugard records deposits of salt around a small lake-margin. Dr. Barth has made known the salt-deposits of Bornu, Sokoto, and Gandu, as well as the natron-lakes of Badamuni and Fogha. Nitrates are said to occur on the N'giri plain, north of Kilima-njaro, while the natives of East Africa use a salt-deposit consisting of sulphate and carbonate of soda, obtained from the plains on the northern flanks of Kilima-njaro, to mix with their tobacco.

MINERAL STATISTICS.

In conclusion, it may be interesting to give a few statistics of the present value of the chief mineral deposits of Africa. First, taking the gold output in monetary value for the year 1893 :—

1. North-east Africa	Nil.
2. North-west Africa	£30,000
Senegambia	30,000
Guinea Coast...	200,000
3. Equatorial and South Africa	5,600,000
Total	£5,860,000

Taking the output since 1880, the following table shows the rat increase, almost entirely due to gold won from the main reef series the Rand:—

	Ounces.		Ounces.
1880	96,452	1887	92,85
1881	96,452	1888	217,69
1882	96,452	1889	415,38
1883	34,658	1890	478,30
1884	40,188	1891	686,93
1885	66,969	1892	1,067,62
1886	69,543		

In 1893, the Transvaal alone produced the following output of gold

	Ounces.
Rand	1,478,477
De Kaap	67,497
Lydenburg	29,329
Klerksdorp and Potchefstroom	24,407
Klein Letaba	6,587
Malmani	1,719
Vryheid	21
Total	1,608,037

If 74,285 ounces are added, as yielded by other parts of Africa, gold output for 1893 is 1,682,322 ounces.

In 1894, the output of the Transvaal gold-fields amounted 2,024,159 ounces.

These figures are sufficient to show that Africa has become a g factor in increasing the gold output of the world.

Taking the annual output of coal for South Africa, the following t gives the amount for 1895:—

Transvaal	1,152,206 tons valued at	£516,215
Natal	,,	62,946

Of other minerals, Namaqualand produced copper in 1894 value £284,800.

The annual output of diamonds at Kimberley is valued at £3,000,000. In 1894, they were valued at £3,013,578 while in 1 the diamonds exported from South Africa were valued at £3,906,992.

It is thus seen that Africa is producing minerals and precious st that, on an average, are valued at £10,000,000 per annum.

APPENDIX A.—CORRELATION OF STRATA IN SOUTH AFRICA.

Schenk.	Penning.	Dunn.	Molengraaf.	De Launay.	Gibson.
Stormberg Beds	High Veld Beds	Coal-measures	Coal-bearing formation	Karoo	Karoo
	Kimberley Beds	Upper Karoo			Dwyka Conglomerate
		Kimberley Shale			
		(Uncon	formity)		
Kap formation	Klip River Series	Lydenburg Beds	Gatsrand formation	Gatsrand formation	Zwaartebergen Quartzites
	Dolerite Series		Malmani formation	Megaliesberg Beds and Dolomite	Bokkeveld Beds
	Witwatersrand Beds		(Unconformity)	(Unconformity)	Table Mountain Sandstone
			Boschrand Beds	Black Reef Series	Witwatersrand Beds (age very uncertain)
			Diabase	Klipriversberg Amygdaloid	
			Witwatersrand Beds	Bokkeveld Beds (wanting in Transvaal)	
				Witwatersrand Beds—Table Mountain Sandstone	
				Quartzite and shales	
		(Uncon	formity)		
Swazi Schists.	Cape Valley Beds	Namaqualand Schists	Older Schist formation	Malmesbury Beds	Malmesbury Schists
		(Uncon	formity)		
	Schists and gneiss	Schists and gneiss	Gneiss, schist, and granite	Granite and gneiss	Metamorphic rocks

APPENDIX B.—LITERATURE.

The following list contains the more important works on African geology:—

Alford, C. J., *Geological Features of the Transvaal, South Africa*, London, 1891.

—, "Geological Features of the De Kaap Gold-fields," *Mining Journal*, 1889, vol. lix., pages 453 and 475.

—, "Witwatersrand Gold-fields, their Geological Features," *Mining Journal*, 1889, vol. lix., page 1141.

—, "Geology of Witwatersrand District," *The Witwatersrand Mining and Metallurgical Review*, 1890, vol. i., page 1.

Bain, A. Geddes, "On the Geology of Southern Africa," *Transactions of the Geological Society*, 1852, second series, vol. vii., pages 175-192.

Barth, H., *Reisen und Entdeckungen in Nord und Central Africa in den Jahren* 1840-53, 5 volumes, Gotha, 1858.

Blanford, H. F., "On the Age and Correlation of the Plant-bearing Series of India, and the former Existence of an Indo-Oceanic Continent," *Quarterly Journal of the Geological Society*, 1875, vol. xxxi., page 519.

Blanford, W. T., *Observations on the Geology and Zoology of Abyssinia*, 8vo, London, 1870.

Bunkell, H. B., "Notes on the Venterskroom Gold-fields, South African Republic," *Trans. Fed. Inst.*, vol. xii., page 186.

Capello and Ivens, *From Benguela to the Territory of Jacca: A Description of a Journey into Central West Africa*, London, 1882.

Cornet, Dr. Von, "Die Geologischen Ergebnisse der Katanga Expedition," *Pet. Mittheil.*, 1894, page 131.

Decken, Von Der, *Reisen in Ost Afrika*, Leipzig, 1869, etc.

Draper, D., "The Occurrence of Dolomite in South Africa," *Quarterly Journal of the Geological Society*, 1894, vol. l., page 561.

Dunn, E. J., *Report on the Stormberg Coal-fields*, Cape Town, 1878.

—, *Report on a Supposed Extensive Deposit of Coal Underlying the Central Districts of the Colony*, Cape Town, 1886.

—, *Geological Sketch-Map of South Africa*, 2nd edition, 1887.

—, "Mode of Occurrence of Gold in the Transvaal Gold-field," *Geological Magazine*, 1885, page 171.

Emmons, S. F., "Geology of the South African Republic," *The Journal of Geology*, Chicago, 1896, vol. iv., No. 1.

Floyer, —, *Etude sur le Nord Etbai entre le Nil et la Mer Rouge*, Le Caire, 1893.

Futterer, Dr. Karl, *Afrika in seiner Bedeutung für die Gold-produktion*, Berlin, 1895.

Gibson, W., "The Geology of the Gold-bearing and Associated Rocks of the Southern Transvaal," *Quarterly Journal of the Geological Society*, 1892, vol. xlviii. page 404.

—, "Geology of the Southern Transvaal," *Trans. Fed. Inst.*, vol. vi., page 124.

Goldmann, C. S., *The Financial, Statistical, and General History of the Gold and other Companies of the Witwatersrand*, London, 1892.

Green, Prof. A. H., *Report on the Coals of Cape Colony*, 1883.

—, "A Contribution to the Geology and Physical Geography of the Cape Colony," *Quarterly Journal of the Geological Society*, 1888, vol. xliv., page 239.

Gregory, Dr. W., *The Great Rift Valley*, London, 1896.

Griesbach, C. L., "On the Geology of Natal, in South Africa," *Quarterly Journal of the Geological Society*, 1871, vol xxvii., page 53.

Gümbel, —, "Beiträge zur Geologie der Goldküste in Afrika," *K. Bayr. Akad. d. Wissenschaften*, 1882, vol. xii., page 170.

Gurick, Dr. G., "Ueberlick über den geologischen Bau des Afrikanischen Kontinents," *Pet. Mittheil.*, 1887.

Halse, Edward, "Some Banket Deposits of the Gold Coast, West Africa," *Trans. Fed. Inst.*, vol. ii., page 69.

Hamilton, J. P., "Notes on the Natal Coal-fields," *Trans. Fed. Inst.*, vol. iii., page 874.

—, "Witwatersrand Gold-field, Transvaal, South Africa," *Trans. Fed. Inst.*, vol. iii., page 857.

Hatch and Chalmers, *The Gold Mines of the Rand*, London, 1895.

Jones, Prof. T. R., "The Mineral Wealth of South Africa," *Proc. Imp. Col. Inst.*, 1887.

—, "Notes on some Fossils from the Devonian Rocks of the Witzenberg Flats, Cape Colony," *Quarterly Journal of the Geological Society*, 1872, vol. xxvii., page 28.

—, "Geology and Mineral Products of South Africa," *Mining Journal*, 1886, vol. lvi., page 771.

Last, —, "On the Society's Expedition to the Namuli Hills, East Africa," *Proceedings of the Royal Geographical Society*, 1887, vol. ix., page 467.

De Launay, Prof. L., "Les Mines d'Or du Transvaal," *Annales des Mines*, 1896, vol. ix., page 5.

—, "Geological Description of the Gold-mines of the Transvaal," *Trans. Fed. Inst.*, vol. xi., page 378.

Lenz, O., "Zur Geologie der Goldküste in West Afrika," *Verhandl. d.k.-k. Geol. Reichsanstalt*, 1878, vol. xii., page 119.

—, "Geological Notes on Western Africa," *Geological Magazine*, Dec. 11, vol. vi., No. 4, April, 1879.

Liddell, J. M., "The Witwatersrand Gold-field," *Trans. Fed. Inst.*, vol. iii., page 447.

Lyons, Captain H. G., "On the Stratigraphy and Physiography of the Libyan Desert of Egypt," *Quarterly Journal of the Geological Society*, 1894, vol. l., page 531.

Molengraaff, G. A. F., "Beitrage zur Geologie der Umgegend der Goldfelder auf dem Hoogeveld in der Südafrikanischen Republik," *Neues Jahrbuch für Min., etc., Beilage*, 1894, vol. ix., page 174.

Penning, W. H., "Sketch of the Gold-fields of Lydenburg and De Kaap in the Transvaal, South Africa," *Quarterly Journal of the Geological Society*, 1885, vol. xli., page 569.

—, "A Contribution to the Geology of the Southern Transvaal," *Quarterly Journal of the Geological Society*, 1891, vol. xlvii., page 451.

—, "Sketch of the High-level Coal-fields of South Africa," *Quarterly Journal of the Geological Society*, 1884, vol. xl., page 658.

Redmayne, R. A. S., "The Geology and Coal-deposits of Natal," *Trans. Fed. Inst.*, vol. iv., page 553.

Reunert, Th., *Diamonds and Gold in South Africa*, London, 1893.

Rolland, G., "Sur l'Histoire Géologique du Sahara," *Comptes Rendus Acad. Paris*, December 22, 1890.

—, "Sur le Terrain crétacé du Sahara septentrional," *Bull. Soc. Géol. de France*, 1881, 3rd series, vol. ix., page 508.

—, "Mission Trans-Saharienne. Géol. et Hydrol," *Annales des Mines*, 1880, vol. xviii., page 152.

Rubidge, R. N., "On Some Points in the Geology of South Africa," *Quarterly Journal of the Geological Society*, 1859, vol. xv., page 195.

—, "On the Occurrence of Gold in the Trap Dykes Intersecting the Dicynodon Strata of South Africa," *Quarterly Journal of the Geological Society*, 1854, vol. xvi.

Rugg, R., *New Map of the Matabele Goldfields and Portuguese Territory*, London, 1893 and 1894.

Russeger, J., *Map of Palestine and Egypt*, 1842.

Sawyer, A. R., *The Gold-fields of Mashonaland*, London, 1892.

—, *Report upon the Geology and Mineral Resources of the Division of Prince Albert and surrounding Districts*, Cape Town, 1893.

—, "Mining at Kimberley," *Trans. N. Staff. Inst. Min. and Mech. Eng.*, 1889-90, vol. x., page 74.

—, "The South African Coal-field," *Trans. N. Staff. Inst. Min. and Mech. Eng.*, 1889-90, vol. x., page 161.

—, "The Northern Extension of the Witwatersrand Gold-field," *Trans N. Staff. Inst. Min. and Mech. Eng.*, 1889-90, vol. x., page 124.

—, "Remarks on the Banket Formation at Johannesburg, Transvaal," *Trans. Fed. Inst.*, vol. ix., page 360.

Schenk, A., "Die Geologische Entwickelung Südafrikas," *Peterm. Mitth.*, 1888, vol. xxxiv., page 225.

—, "Über Transvaal und die dortigen Goldfelder," *Verh. Ges. f. Erdkunde*, Berlin, 1888.

—, "Vorkommen des Goldes in Transvaal," *Zeitschr. d. Deutsch. Geol. Ges.*, 1889, vol. xli., 8573, 81.

—, "Über die Goldfelder Süd-Afrikas," *Verh. Naturh. Ver.*, Bonn, 47, 11, 1890, Corr; bl. 1, 66-70.

Schmeisser, Dr., *Ueber Vorkommen und Gewinnung der nutzbaren Mineralien in der Südafrikanischen Republik (Transvaal) unter besonderer Berücksichtigung des Goldbergbaues*, Berlin, 1894.

Shaw, F. G., "Auriferous Conglomerates of the Witwatersrand," *Trans. Fed. Inst.*, vol. v., page 169.

—, "The Gold-fields of Matabeleland," *Trans. Fed. Inst.*, vol. xi., page 29.

Shaw, Dr. J., "On the Geology of the Diamond-fields of South Africa," *Quarterly Journal of the Geological Society*, 1872, vol. xxviii., page 21.

Stow, G. W., "On some Points in South African Geology," *Quarterly Journal of the Geological Society*, 1871, vol. xxvii., page 497.

—, "On the Diamond-gravels of the Vaal River, South Africa," *Quarterly Journal of the Geological Society*, 1872, vol. xxviii., page 3.

—, "Geological Notes upon Griqualand West," *Quarterly Journal of the Geological Society*, 1874, vol. xxx., page 581.

Struben, F. P. T., *A Geological Sketch-Map of Africa, South of the Zambesi*, 1896, with Pamphlet, London, E. Stanford.

Suess, —, *Antlitz der Erde*, 1885.

Sutherland, Dr., "Note on the Auriferous Rocks of South-eastern Africa," *Quarterly Journal of the Geological Society*, 1869, vol. xxv., page 169.

—, "Notes on an Ancient Boulder-clay of Natal," *Quarterly Journal of the Geological Society*, 1870, vol. xxvi., page 514.

Tate, R., "The Age of the Nubian Sandstone," *Quarterly Journal of the Geological Society*, 1871, vol. xxvii., page 404.

—, "On Some Secondary Fossils from South Africa," *Quarterly Journal of the Geological Society*, 1867, vol. xxiii., page 139.

Thomson, J., "To Lake Bangweolo and the Unexplored Regions of British Central Africa," *Proceedings of the Royal Geographical Society*, 1893, page 117.

—, *Through Masai Land*.

Zittel, Carl von, "Beiträge zur Geologie und Palæontologie der Libyschen Wüste,' *Palæontographica*, 1883, vol. xxx., part 2.

Prof. H. **Louis** (Newcastle-upon-Tyne) enquired how Mr. Gibson had fixed the age of the Gold Coast conglomerates, as no fossils were found on the Gold Coast, and very little of the country was known, and that little was covered with swamps and dense jungle. Even the relation of the conglomerate-beds to the quartz-reefs mined at Akankoo, Gie Apantoo, and other places was unknown, whilst the relation of the laterite to the underlying rocks was far from clear, consequently he would like to know how he had arrived at his rather dogmatic statement as to the age of those rocks. The West Coast conglomerate was different from that of the Rand, it carried no pyrites in depth, and the cementing-material was all crystalline quartz, with ilmenite and hœmatite or magnetite, none of the minerals known on the Rand, such as chlorite, etc., being present. The formations were mineralogically quite different, and, in the absence of fossils, he would like to know by what data their respective ages could be determined.

Mr. R. A. S. **Redmayne** (Seaton Delaval) wrote that he was glad to find that Mr. Walcot Gibson believed that a geological survey of South Africa was much needed, as he had frequently advocated such. It would, he felt sure, be attended with most useful and far-reaching results, and would amply repay its cost. He suggested that it should be geological as well as mineral. Before, however, such a geological survey as we have of the British Isles could be made, an accurate and detailed topographical survey would be required, and such does not exist, of the colony of Natal at least, where merely the primary triangles were taken some years ago and the survey discontinued; the writer experienced great inconvenience when in Natal for want of reliable and detailed surveys, which he had ultimately to make for himself.

Mr. Gibson stated, speaking of the gold-fields of Mashonaland, that "in places, the ore runs 5 ounces over the plates," an admirable result when compared with other gold-mining districts where the ore is mined from quartz-veins as opposed to banket-reefs, and one which was more than borne out by Mr. F. G. Shaw, who in his exhaustive report to the St. Helens Development Syndicate gave much higher results for various parts of the Chartered Company's territory.

One of the chief and first difficulties that beset the student of South African geology was the hopeless and chaotic state of the classification of the various deposits—there was not one but several classifications. The writer endeavoured * to correlate the Natal series with the late Prof.

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* *Trans. Fed. Inst.*, vol. iv., page 559.

Green's division of the Cape Colony rocks. One of the principal labours of any geological survey of South Africa would be the compilation of a working classification.

There could be little doubt but that the Dwyka Conglomerate was of glacial origin. It was however badly termed in Natal "the Boulder Clay," and, as the writer had remarked elsewhere, this was not a happy term for a Palæozic group. Dr. Sutherland, whom Mr. Gibson mentioned in this conjunction, said in his paper on the *Geology of Natal:*[*] "In the present state of geological knowledge the deposition of this formation cannot be accounted for except by references to glacial action. . . . The great Scandinavian drift is precisely the same in mechanical composition as the boulder clay of Natal." There were many signs of glacial action. The included fragments of rocks have the appearance of being smooth and polished by attrition.[†] He would like to ask Mr. Gibson if whether he thought that this deposit might be regarded as representative of a part of the true Carboniferous system. There was a somewhat similar deposit in the North of England underlying the Carboniferous Limestone of Cross Fell which was termed Basement Beds.

In composition, the Banket Beds of the Rand and the Dwyka Conglomerate are entirely different, and, as Mr. Gibson said, lithologically in nowise resembled each other, the former being a sedimentary and the latter a glacial deposit.

Mr. Gibson mentioned Messrs. Daulton and Paulson as having "reported the occurrence of strata, similar to those of the banket formation, on the Tussenbye farm, on the British Zululand border," in 1893. "These conglomerates and sandstones," he adds, "have been taken to be of the same age as the Rand deposits, but their identity with the banket-formation has yet to be proved." The strata, he said, dip at angles of 5 to 12 degrees, and the hanging-wall alone carries gold, pannings of 14 dwts. 10 grs. having been obtained. As these deposits are of some moment, and are likely to come into much greater prominence in the near future, he might perhaps be excused if he went into the question in some detail. In the year 1891, when in the Colony of Natal, his (Mr. Redmayne's) attention was called to this property which is spelled "Tusschenby," and is situated in the extreme south-eastern corner of the district of Vryheid, in the Transvaal, close to the Zululand border, and about 4 miles south of the White Umvolosi river. The country is very hilly, not to say mountainous. The country rock is, generally, a series of sandstones, shales, and quartz-conglomerates, which

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[*] Page 118. [†] *Trans. Fed. Inst.*, vol. iv., page 557.

are in some places conformably overlain, first by talcose and arenaceous shales, then by jaspery and ferruginous shales, and finally by sandstone. The beds of quartz-conglomerate, or "banket reefs" are in all essential particulars identical with those of the Rand, and dip at angles varying from 4 to 15 degrees. The beds all carry gold and pyrites, though not necessarily in paying quantities. These reefs are exposed in a creek in Tusschenby. The third reef from the top (there are only three exposed), where exposed on the southern side of the creek, contained 24 to 25 dwts. of gold to the ton. This reef averaged 38 inches in thickness. The property is now, or was, a short while since, being worked.

The intrusive igneous rocks which intersect and cut up the coal and banket-formations are chiefly greenstone. He had noticed that they did not appear to appreciably fracture or disturb the beds on either side. These dykes are common in all gold and coal-producing districts of the Transvaal and Natal, and were found at Tusschenby occurring precisely as they do on the Rand. They are evidently of later origin than the sedimentary rocks which they intersect, as in many instances they flow between and over them.

He would like to ask Mr. Gibson whether the bog iron-ore or limonite so very common all over the colony of Natal is the same thing as the red sands and laterite which he classified under "Surface-deposits."

In conclusion, he considered that Mr. Walcot Gibson had written a very able paper, which seemed to him a step in the right direction towards a proper and comprehensive geology of South Africa.

Mr. H. M. CADELL said that the paper was one of great interest, and there was also a valuable list of literature on the subject in the appendix to the paper which was of considerable importance. The geological structure of South Africa and also of Western Australia, with which he was better acquainted, was in many respects similar to various parts of Scotland. Unfortunately in Scotland they had not found diamonds or gold in important quantities. On a recent occasion he had remarked, on seeing a driving through a volcanic neck in one of the oil-shale mines in the Lothians, that it was just the kind of thing they had in Kimberley, and diamonds ought to be found there. Possibly at some future date he might be able to bring a paper before the Institute on a discovery of diamonds in Scotland! He cordially agreed with Mr. Gibson that the relationship of these rocks would never be satisfactorily determined until competent geologists had examined the ground in detail. It was only by very careful and detailed work by competent geologists that the structure and relationships of the rocks could be properly made out, and South Africa was such a vast country that it was not yet possible to speak with certainty on its general geological character.

Mr. WALCOT GIBSON said that the map (Plate XVII.) attached to his paper looked small, but it was not compiled without a great deal of trouble. He had had to examine over 700 books and maps in order to obtain the necessary information.

He had not assigned any very definite age to the Banket of the West Coast. Where fossil evidence failed, the age of beds in Africa could sometimes be settled by their relationship to the volcanic eruptions of pre-Karoo and post-Karoo ages.

He did not think that the Dwyka Conglomerate could be correlated with the Carboniferous basement-beds of the North of England. He had used the term "laterite" in a very loose way to include many kinds of superficial deposits which had not been definitely described.

As regards a geological survey of South Africa, he (Mr. Gibson) certainly believed that a properly equipped geological survey was much needed. The attempts at a survey previously made have proved abortive, owing to the fact that the chief object of a geological survey was not fully understood. To be of any practical use, the survey must be sufficiently equipped to settle, first of all, the true sequence of the strata in South Africa, and afterwards should be given time enough to map out the limitations of the coal-fields and gold-fields, and to ascertain their more important geological structures. The survey must be as complete as circumstances allow, and it were better left undone than undertaken in a half-hearted manner. He thanked the members for the kind way in which the paper was received, and hoped that it would prove of use to African travellers.

The PRESIDENT moved a vote of thanks to Mr. Gibson for his interesting paper, and the resolution was unanimously adopted.

The following paper by Captain C. C. Longridge on "Mining in Northern Argentina" was taken as read:—

MINING IN NORTHERN ARGENTINA.

By Captain C. C. LONGRIDGE.

1. *Physical Character of the Country, etc.*—Northern Argentina embraces the two provinces of Jujuy and Salta. The former is the smallest of the Argentine provinces. Extending to the frontier of the republic, it is bounded on the north by Bolivia, and on the south, east, and south-west by the province of Salta. In order of importance, this latter province ranks seventh in the republic. It takes the form of a half-moon; and, as already described, borders Jujuy on three sides.

The climate of both these provinces is dry and healthy, intermittent fevers occurring only in the lower portions of the land. The contour of this part of Argentina is that of a general ascent towards the north. Drawing a line east and west through the town of Salta, the altitude thereabouts is some 3,000 feet above sea-level. Thence it gradually rises until, at the Bolivian frontier, it attains 10,000 to 12,000 feet above the level of the sea.

2. *Number and Nature of the Mines.*—Early in the present year, the writer was commissioned to inspect and report on certain mines in the two provinces. But during a tour of four months, including a mule journey of 1,200 miles among the mountains up to the Bolivian frontier, many opportunities were afforded for a brief inspection of other mines, and for the formation of an opinion as to mining prospects generally in Northern Argentina.

Roughly speaking, and as might be expected, the bulk of the mines are located in the numerous mountain-ranges and spurs that intersect these provinces. The Official Memoir on Mines in the Argentine Republic (*Mémoire Général et Spécial sur les Mines, la Métallurgie . . . dans la Republique Argentine*, by H. D. Hoskold), published in 1889, showed that there were in that year 182 mines known and registered in the province of Salta, and 103 mines in that of Jujuy, without counting a number that had been abandoned. Since then many fresh mines have been opened.

As an illustration of the mineralogical character of these mines, it may be said that at the period in question the department of Poma counted 62 silver, 9 gold, 3 copper, 3 bismuth, and 3 argentiferous galena mines; that of San Carlos had 6 gold, 17 silver, and 5 copper mines; in the department of Molinos there were 5 gold and 19 silver mines; in Cachi, 1 silver mine; in Vina, 5 silver mines; in Chicoana, 1 marble, 1 Roman cement, and 1 steatite mine; in Santa Victoria, 1 gold and 5 silver mines; in Iruya, 2 gold, 2 silver, and 3 copper mines; in Rosario de la Frontera, 2 iron mines; in Metan, 2 lignite mines; in Campo Santo, 1 copper mine; in the department of Rosario de Lerma, 2 silver mines; and so on.

It would unduly lengthen this paper to include tabular statements of the assay-values of the ores in the several mines. But they are such as to leave no doubt that the whole of these provinces are prolific in valuable ores of lead, copper, and silver; and probably few, if any, parts of the republic are richer in mineral wealth. In one mine inspected by the writer, seven 40 to 50 lbs. samples, taken fairly across the vein, waste as well as clean ore being included in the sample, gave a mean assay of 127·5 ounces of silver, with about 4 per cent. of copper to the ton. But there are published assays of silver ore with 1,776 ounces of silver, native copper with 91·26 per cent. of copper, and argentiferous lead ore with 50 per cent. of lead to the ton. As regards gold ores, the writer is scarcely at liberty to give information, and therefore draws attention rather to the bulk of the mines at present known, namely, those of silver, copper, and lead, in regard to which the question of most practical or commercial importance is this: can these mines be profitably worked?

3. *Mining in the Past.*—As to the past, Mr. H. D. Hoskold, Director-General of the Argentine Government Mining Department, had stated that:—

> It is to be regretted that extravagant expenditure, inefficient management, and, in too many cases, bad faith, have characterized the mining history of the Argentine Republic, and that but very few companies have succeeded in obtaining a fair, remunerative, and constant profit on the capital invested in their mining and metallurgical operations. But this condition of things has not resulted so much from the unproductiveness of the mines selected, as from an entire want of practical knowledge and energy, and inability in enforcing the application of economical principles to the various classes of work, as well as ignorance of the language, laws, and customs of the country. The natives do not understand mining as an industry.* . . .

A very pregnant judgment, from an expert with more than half a century of experience in the mining history of the country, and one that the writer can confirm from personal observation. The result of

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* *Trans. Fed. Inst.*, vol. iii., page 445.

the incompetence and dishonesty here referred to has been to discredit mining as a pursuit, and to give birth to a saying among North Argentines that "Our cattle are our mines." In other words, the natives now prefer the easy life of the *estancia* to the toilsome labour of the mine, and the old mining spirit created and fostered by the Incas and the Spaniards has, in a measure, died out, and with it the mining industry of the country.

4. *Natural Difficulties.*—Apart, however, from the baneful effects of ignorance and maladministration in the past, there are undoubtedly certain natural difficulties in North Argentine mining—namely, scarcity of fuel and water, and high cost of transport. From the towns of Jujuy and Salta, there is regular and through communication by railway with the ports of shipment, Rosario or Buenos Ayres; but above these towns transport is less easy—roads, in the English sense of the term, are few and far between; tracks, such as they are, in sections, at least, are impassable for vehicles, and in many places mules alone can be relied on for transport to and from the mines. As regards water, very many of the mines in Northern Argentina are not well supplied. Of course, nearly every mine, when it attains a little depth, collects water, and this can often be utilized for steam-power. Springs and streams are fairly numerous, but the prospector has to be cautious in accepting local information as to the existence of such sources. The phrases "mucha agua" and "bastante agua" are, by the Argentines and Indians, constantly applied to small pools or streams sufficient for the watering of mules or the filling of camp-kettles, but altogether inadequate for mining purposes. The term "rio," also, is very misleading, the word being continually used of the merest rivulets, and of watercourses that, in the dry season, are frequently devoid of water; this word, therefore, when used by natives, or in mining maps and reports, should not be accepted as necessarily implying the existence of even a small perennial water-supply. On the whole, it may be said that while some of the mines will have to be worked by mule-power, or by petroleum engines, a very large number have sufficient water for steam-power; whilst others—the most favoured—have sufficient water-supply for all purposes, including the generation of electric power. Ore-dressing and concentration will, in a large number of cases, have to be performed by hand-picking and by mechanical concentrators. For this work labour is cheap, men's wages being 1s. 4d. per day, women and children receiving less. Moreover, as will presently appear, fine crushing and close concentration are not here of so much importance.

As to the question of fuel, in a large number of cases the only supply available at the mines is:—*Tola:* a light brushwood, fairly plentiful; *añagua:* somewhat stouter than *tola*, but less plentiful; *espinillo:* a light prickly brushwood, not very abundant; *yareta:* a sort of grass root, tolerably abundant; and *turba:* an inferior peat. The average price for any of these fuels is about 50 cents (8d.) per 100 lbs. delivered at the mines. The consumption of *tola* or *yareta* may be reckoned at 10 lbs. per indicated horse-power per hour. It goes without saying that such fuel is unsuited for smelting purposes.

5. *Mining in the immediate Future.*—It must be remembered that the two provinces are highly mineralized, and the ore is in many cases so rich, even at comparatively superficial levels, that it can be exported and sold at a profit, in spite of the cost of crude and expensive methods of mining, and the heavy charges of carriage to Europe. Now, crude and costly methods of ore-winning disappear before modern and skilled management, while the cost of transport is in part already in progress of diminution, and in the major part is on the eve of elimination. The railway, which has been built as far as Jujuy and Salta, has now been surveyed far beyond this limit. The Argentine government are alive to the importance of completing the track, which is to constitute the international route between Argentina and Bolivia; and this line, the first section of which, there are grounds to believe, will be speedily commenced, will pass through the heart of the mining district. In the meantime, on representations made to the President of the Republic by the writer and others, greatly reduced rates over Government railways have been granted for the carriage of mining machinery and stores, and a sum of public money has been given for the immediate completion of a cart-road to one of the principal mines in the province of Salta. There is little doubt that this work, now in active operation, is but the first of a number of other similar works.

With these increased facilities for transport, the cost of carriage from the mines to Salta and Jujuy will be greatly lessened. But the more costly portion—namely, the expense of rail and sea-carriage to Europe—is, it has been said, on the point of removal, for it has been practically decided to smelt and treat the ore in the country, leaving only the rich matte or pig-metal to export at an insignificant cost. The advantages of this course were so evident, and the saving to be effected so great, that the writer having formed this opinion, applied for and obtained, in conjunction with another gentleman, a ten years' concession for establishing smelting and ore-treating works. The opening of these works will, it is obvious, entirely alter the commercial aspect of North Argentine mining. In place of European markets, a local mart for all classes of ore will be established. Numerous mines, therefore, that would not, or would scarcely, have paid to work when the mineral had to be exported, will yield satisfactory profits now that the ore is to be freed from the incubus of several thousand miles of transit. The miner, too, will no longer be under the necessity of resorting to the irregular, extravagant, and limited exploitation that attends the picking of mineral sufficiently rich to bear the cost of carriage to Europe, and the leaving unworked the poorer grades of ore. Henceforth he will be enabled to attack the main body of his ore, following a regular system of winning, with decreased mining expenses and largely increased output. Moreover, fine crushing and close concentration being a positive disadvantage to the smelter, the miner will be relieved from the chief need for an abundant water-supply, and can work in districts where the supply is very limited. In a word, the establishment of smelting-works, by providing a local market, where fair prices can be obtained, must revolutionize the prospects of mining in Northern Argentina.

But will the smelter be able to pay the miner a fair price for the ore? In other words, are the physical conditions of the country such that the business of smelting and ore-treating can be economically conducted? Well, in the first, place, it should at once be said that it is not proposed to establish smelting-works for individual mines. The altitude at which the majority of the mines are placed, as well as the scarcity of water and suitable fuel, prohibit such a course. Moreover, small works of this kind could never compete in economy with a large central establishment. The question, therefore, is, can a site be found with all the conditions required for economical smelting on a large scale?

To one personally unacquainted with the country, it might seem desirable to erect the works at Salta, the capital of the province, and the terminus of railway-communication with Jujuy, and with the ports of shipment. This, however, is not altogether practicable, as metallurgical works of an adequate character require an ample supply of water. Such a supply is not to be found either at Salta or in the immediate neighbourhood. The water of the river Arias or Salta is neither suitable for power purposes nor available for use, as it is already mostly taken up by water-rights for irrigation purposes, and in the dry season but little water passes the town. That at the neighbouring San Lorenzo is quite insufficient. Another stream, the river Mojotoro, passes within 5 miles of Salta; but is, in the dry season, almost entirely drained for irrigation.

Again, apart from this local deficiency of water there is a lack of timber for fuel, and a still more serious objection that would result from the works themselves. Both calcining and smelting originate noxious gases having a very injurious effect on vegetation. It is, therefore, more than probable that the erection of such works near the town and its cultivated land would lead to endless complaints, accompanied by heavy claims for damages. The only rational and economical manner of utilizing these destructive fumes would be the manufacture of sulphuric acid, but this would somewhat complicate and increase the cost of the plant at the works.

Although Salta, therefore, is not a convenient spot, a very suitable site does exist somewhere lower down the Ferro Carril Central y Norte. Here there is water and fuel in abundance. A river runs close to and parallel with the railway; and, measured in May, gave a sectional area of 200 square feet, with a mean velocity of 376·7 feet per minute, representing a flow of 75,340 cubic feet of water per minute. The fall, roughly estimated, was about 1 in 20. The site, therefore, is provided with an ample and efficient water-supply for all purposes, power included.

Land which, unlike that at the higher altitudes, is here thickly timbered, can be secured at a reasonable price, and works could be erected close to a station, goods being delivered by a short siding. The ground also is suitable for a terraced plant.

Fuel, which throughout the province is wood, is here abundant. That most suitable for the purpose is obtained from several kinds of *typa*, *cevil*, *algarroba*, and *quebracho*. Firewood from the above woods is sold at 1·50 to 1·70 pesos, say 2s. 2d. the cubic metre or 7s. 4d. the cord, usually mixed wood, stacked in billets of 3 to 6 inches in diameter. For boiler use, 1½ cords of good, dry, hard wood such as *cevil*, *algarroba*, and *quebracho* is equal to one ton of good bituminous coal. For such purposes, therefore, the use of wood is equivalent to the consumption of coal at 11s. 2d. per ton.

For calcining in heaps or stalls, even cheaper wood could be used. Most sulphide ores, in such cases, will not stand the heat generated by a thick bed of sound, dry, hard wood, so that it frequently happens that a less costly variety of wood answers the purpose better. A large proportion of the bed therefore may be made up of old railings, logs, gnarled and knotted trunks, and such sticks of cordwood as are daily thrown out from wood-burning boilers and calcining-furnaces as too crooked and mis-shapen to enter a contracted fireplace. Decayed and refuse wood of this description will usually cost half to two-thirds of the price of sound fuel, or say 5s. 7d. to 7s. 5d. per ton. For calcining purposes nothing can excel wood as fuel; its long, hot, non-reducing flame being peculiarly suited to the requirements of the process. For calcining, about $1\frac{2}{3}$ cords of hard, or 2 cords of soft wood are commonly considered equal to 1 ton of fair bituminous coal.

In blast-furnace work, an admixture of wood has certain notable advantages. On the one hand, a great deal of sulphur is burned off by the wood, thereby allowing the use of a greater proportion of sulphide-ore in the charge, thus reducing the work and cost of calcination. On the other hand, the use of wood causes a rise in the grade of the matte. "I have many times," says Dr. Peters, "used wood in 2 feet lengths to replace a portion of the coke in the blast-furnace, though merely to tide over a time when coke was scarce. I have invariably noticed a decided rise in the grade of the matte when smelted with wood." Mr. H. Lang, when matting silver ores in a 36 inches cupola at Mineral, Idaho, U.S.A., using a charge of 950 lbs. and 110 lbs. of Connellsville coke, found that by replacing half of the coke by 135 lbs. of firwood, cut from dead and apparently dry trees, the mixture produced as high a smelting temperature as all coke. "Whence I infer," says he, "that the smelting effect of a given weight of wood is to that of the same weight of coke as 11 to 27, or 1 to $2\frac{5}{11}$." Assuming, therefore, that a cord of wood (3,200 lbs.) sawn and delivered at the furnace cost 10s. (thus allowing a large margin for contingencies), while coke, at the very outside price of 45s. per ton at Rosario, comes to 85s. per ton at the furnace, the use of wood plus coke over coke alone would reduce cupola fuel from 85s. to 50s. per ton, made up as follows:—1,120 lbs. of coke at 42s. 6d. and 2,349 lbs. of wood at 7s. 6d. Thus, relatively speaking, the price of blast-furnace fuel is reasonable. But it is not even necessary to resort to blast-furnace smelting. Reverberatory smelting may be adopted, and, for this, wood is excellent firing. For such work 2 cords of dry mountain-oak, such as *quebracho*, which lasts well and gives a hot flame, are about equal to $1\frac{1}{2}$ tons of ordinary coal. An ordinary furnace of this description, smelting say 20 tons of cold ore per 24 hours, will burn about 7 to 8 tons of fair coal or say 11 cords of dry hard wood per 24 hours, equivalent to 5s. 6d. per ton of cold ore. If hot calcines are used, there is a gain of 23 per cent., so that for hot ore the cost of wood fuel is reduced to about 4s. 3d. per ton, allowing for contingencies the same addition as before to the price of wood.

For copper-refining, no better fuel than wood exists, as its freedom from sulphur and other impurities, and its long, pure, non-reducing flame peculiarly fit it for the purpose.

As salt for calcining is cheap and abundant, whilst fluxes and refractory stone are obtainable near at hand, it is evident that nothing is wanting to ensure successful and economical smelting, the more so as all power for crushing, hauling, lighting, blast, etc., can be obtained from water-power at hand. But economical smelting means ability to pay good prices for ore, or a ready and fair market—one of the essential conditions for profitable mining in North Argentina.

The following paper by Mr. J. Bergeron on "Possible Extensions of the Coal-fields of France" was taken as read:—

POSSIBLE EXTENSIONS OF THE COAL-FIELDS OF FRANCE.*

By J. BERGERON.

The study of coal-deposits, so far as it has been carried by geologists and engineers, and particularly by the writer's colleague, Mr. Fayol, has settled in no uncertain fashion the relationship between these deposits and the folds of the earth's crust. For, whatever may be the particular origin of the coal, it is always deposited in a depression or trough due to a ridging-up of the terrestrial surface. The knowledge of the general direction followed by these folds is of especial interest to engineeers, as it may serve to guide them in their researches.

Fifteen years ago, the theoretical ideas of Baron Élie de Beaumont still exercised paramount influence, and it was admitted that the earth-movements which resulted in the formation of mountain-chains had taken place along straight lines. Mountain-systems, on this hypothesis, were made up of an assemblage of all such heights or ridges as have the same direction or strike. But the great Professor Suess, of Vienna, in a series of remarkable memoirs† which may be regarded as epoch-making in geological science, has enunciated the question of uplifts in altogether different terms. In his view, and in that of his pupils and followers, a mountain-system is the sum total of all the folds which were produced contemporaneously. The idea of strike or direction is regarded as quite subsidiary : that of age is of primary importance.

Taking into account merely the epoch of uplift of mountain-chains, these may be classified into four, three of which alone are easily recognizable in Europe. The most ancient of these three is the result of the folding of the Silurian strata before the deposition of the Devonian. The Silurian beds thus thrust up on end formed the coast-line of the Devonian sea by whose agency they were denuded away. Thence resulted a detritic shore-formation which in Britain (on account no doubt of its colour) was called the Old Red Sandstone. This borders the first chain and overlies unconformably all strata whose deposition took place before that time. The name of Caledonian system was given to this first fold,

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* Translated by L. L. Belinfante, B.Sc.

† See in particular his work *Das Antlitz der Erde.*

as it was discovered for the first time in Scotland, where it now helps to form the Grampians. But other small chains belonging to the same period have been found showing the same unconformities in bedding (this determines geologically the age of uplift) in Ireland and in Wales, in Scandinavia (where the Scandinavian Alps form an eastern chain) while in the far west of North America the Green Mountains represent the corresponding western chain. All that is now visible* of this Caledonian system is restricted to the north of Europe and America (Fig. 1, Plate XIX.).

Then at the end of the Primary epoch another uplift took place. It began to make itself felt at the dawn of the Carboniferous era and ended only in Permian. It resulted in the formation of an orographic system termed by Prof. Suess the "Variscan chain" (the Varisci were an ancient tribe who dwelt in Saxony and Bavaria), and dubbed by Mr. Marcel Bertrand "Hercynian chain" (from *Hercynia silva* or Harz) because it includes the Harz among its secondary chains. As it is better known by the second name, that alone will be used in the following pages. The small Hercynian chainlets now visible in Europe are numerous; they are concentrated to the south of the Caledonian chain, and are chiefly found in Central Europe. A glance at Fig. 1 (Plate XIX.) will show their distribution and the geographical massif to which they appertain. In France, they form the mountain-groups of the Ardennes, the Vosges, Brittany, and the Cotentin, the Central Plateau, the Maures, and the Esterel. Some fragments remain in the Pyrenees and the Alps, but they are of minor importance when compared with the earth-movements which subsequently took place in the very same areas. Other Hercynian secondary chains are to be found in America, as, for example, in the Alleghany Mountains.

The Hercynian system is of extreme importance from an industrial point of view, as it is within its area that the principal coal-fields are met with: those of Saxony, Bohemia, and the Ruhr; the Franco-Belgian basin, the English basins, and those of the Central Plateau of France, etc. The study of these Hercynian folds may then provide us with some clue as to the possible extension of coal-fields, and to that aspect of the subject we shall presently revert.

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* In the accompanying small map of Europe (Fig. 1, Plate XIX.) of the small chains which together go to make up the great mountain-ranges, only such have been shown as are visible in Europe and Northern Africa. But these small chains extend beneath the sea and beneath sediments which were laid down subsequently to their uplift. When a more recent chain includes fragments of an older chain, as in the case of the Pyrenees and the Alps, these have been omitted for the sake of clearness.

The third chain, known as the Alpine chain, began to uplift itself at the close of the Eocene period. At that time, too, the Pyrenees rose between the Central Plateau of France and the equivalent tableland or Meseta of Spain. Then followed in Oligocene ages, a series of folding and sagging, but it was not till the close of the Helvetian and Tortonian epochs that the great Alpine fold was ridged up into higher relief than is now the case. It is true that already at the time of the uplift of the Hercynian chain some folds had been produced in the Pyrenean and Alpine areas, the intervening troughs being filled up in the case of the former by the Rhune and other coal-fields, and in the case of the latter in the Mure basin, etc. But the present structure of these regions is due by the main to the Tertiary earth-movements, and thus they belong in reality to the Alpine system. This includes a vast number of smaller or secondary mountain-chains, which, taken altogether, present a rather irregular configuration. In Europe, they are grouped all around the shores of the Mediterranean: then they strike across into Asia, where they form the Himalayas, etc. This "Alpine" system includes the most elevated mountain-areas in the world. Going from east to west, it includes in Europe the following chains:—The Caucasus, the Carpathians, the Alps, the Apennines, the Pyrenees, and the Betic Cordillera. To it also belongs the range which borders the Mediterranean in Northern Africa.

All these chains, whatever may be their age, and to whatever mountain-system they may belong, present invariably the same structure: an alternation of protruding and re-entering folds formed by the same strata, in other words, to adopt the terms used by geologists, an alternation of anticlinals and synclinals. These folds are more acute, more strongly marked, the younger the mountain-chain of which they form part. This is an immediate consequence of the time-duration of the destructive agencies due to atmospheric phenomena. To take an example, the Alpine system being of less remote age than the Hercynian, will have been exposed for a shorter period of time to the action of erosion: wherefore its ridges will make a bolder relief, and the general facies of the folds will be more easily discernible. It is not proposed here to enter upon the study of the different varieties of folds which may be produced in a mountainous region, but, for the clearer understanding of what will be said at a subsequent page concerning the structure of the Franco-Belgian coal-field, it may be as well to devote a little attention to some of the features which characterize the Alpine system. These features, owing to the excellence of the available sections, are of easy interpretation. The writer refers here to the domes and to the overfolds and overthrusts.

The anticlinals do not always form a crest-line situated at the same altitude: sometimes the ridge is high, sometimes low. The same statement applies to the synclinals, the line drawn through their lowest portions being far from invariably horizontal. Indeed sometimes this line runs through a ridge, and an anticlinal is found to have been thrust up in the middle of a synclinal. Such a fold as this is termed a dome. Moreover, the line of strike of one series of folds is always practically normal to the line of strike of another series of folds.

At times mountain-chains, subsequent to their uplift, have been subjected to lateral pressure such that some of the folds have been thrust over on to the remainder of the chain: we then have the phenomenon of overfolds or overthrusts. In some cases, moreover, not only has the fold been turned over but the anticlinal has slid over the synclinal (Fig. 2, Plate XIX.), and one of the limbs of the anticlinal has thus been abnormally drawn out. The result is that the overfold is not complete in all its parts, it is only made up of a portion of its constituent elements, and the contact of the overthrust portion with the component strata of the synclinal being abnormal, there appears to be a fault along the line *ab* (Fig. 2, Plate XIX.). This is what may be termed a fold-fault or thrust fault.

If the unit, made up of the sheared fold and the underlying synclinal, be subjected to more folding, the termination of the anticlinal will reappear in a synclinal formed of more recent strata (Fig. 3, Plate XIX.). Then on all sides, save in its topmost portion, the terminal part of the overthrust anticlinal will show abnormal junctions. Moreover, if we suppose that denudation has shaved off all the uppermost beds, so that it becomes impossible to detect the characteristics of an overthrust anticlinal, the observer will merely be able to infer the presence of a remnant of overfold isolated by a series of faults.

To return now to the Hercynian ranges of France. We shall confine ourselves to those of the Ardennes, Brittany, the Central Plateau, and the Vosges, and shall leave out of account the Maures and Esterel mountains, the Alps and the Pyrenees, as they are not yet sufficiently known from the point of view here selected.

If we look at a geological map of France, we shall see that the massif of Brittany* is traversed by three great belts striking generally north-west and south-east. That these are synclinals is shown by the arrangement of the strata which border on them. The synclinals are made up of limestones and shales with a marine fauna characteristic of the Lower Carboniferous formation. Nor does each of the depressions in reality correspond to a single synclinal. Often and often each one of them is occupied by several folds, which would seem to show that, even if the sediments were deposited in one great depression, there was at a later period a series of plications, part of the effects of which has disappeared by means of denudation. But whatever may be the constitution of these belts one thing remains certain—they correspond to depressions filled up with Carboniferous strata.

The northernmost belt runs through the roadstead of Brest, Châteaulin, Vitré, and Laval, describing a convex curve towards the north. Westward this depression is filled up with Devonian strata, which are, however, soon overlapped by Carboniferous, and it is this formation which covers most of the area. As mentioned above, several folds of subsidiary importance may be detected in this depression. In one of them, at St. Pierre la Cour, a small coal-field belonging to the Stephanian horizon, is worked.†

The second depression, its course marked by Devonian and Carboniferous deposits, strikes through Plogoff, Quimper, Plouay, and Ancenis. It is situated south of the previously described depression, and forms an arc, the convex portion of which, though not very prominent, is turned northwards. Coal-fields are more numerous in this fold ; such are the basins of Plogoff, Quimper, and a little north of it that of Kergogne, all three being of Stephanian age.

The third and southernmost fold corresponds to the synclinal occupied by the Vendée coal-fields. It starts from the neighbourhood of Guérande, and strikes through the Lake of Grandlieu, Chantonnay, and St. Maixent. Carboniferous deposits are rare; but here we find the coal-fields of St. Laurs, Faymoreau, Vauvant, and Chantonnay. The first-named is said to be of Culm age, while the others belong to

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* From the geological standpoint, the Brittany massif includes, besides Armorica, a portion of the Cotentin. In the latter district are situated the Littry and Plessis coal-fields, but it is not proposed to devote attention to these, because the synclinals which they occupy end up in the Channel, and therefore such indications as might be obtained regarding the prolongation of the folds would be of no practical utility.

† The Carboniferous formation includes three stages or great horizons ; at the base is the Dinantian, with marine fauna or the Culm with terrestrial facies ; above this comes the Westphalian, and topmost lies the Stephanian. The two last-mentioned are, in Western Europe, without doubt of purely terrestrial facies.

the Westphalian system. As to the Chantonnay coal-field, it is overlain by Jurassic strata which continue to mark the fold up to St. Maixent.

The following are characters which are common to all these folds: they are deflected from north-west to south-east, and are indicated by fragments of Coal-measurès.

If, now, we turn to consider the *massif* of the Central Plateau, it will be found that it includes a series of folds whose general direction is much more difficult to follow than in Britanny. For, while in that province they form continuous bands, here they are detached fragments completely isolated one from the other. The deposits whereby their identity is determined are either Dinantian limestones and shales or orthophyric tuffs,* or a combination of all these rocks. In many cases they are exclusively Coal-measure deposits or else capped by Permian strata.

In these folds of the Central Plateau, three groups may be distinguished (see map, Fig. 6, Plate XIX.) as follows:—(1) The western group, which includes all the patches of Carboniferous west of a great disturbance that strikes obliquely (along the line *A B*) across this region of France; (2) a middle group including all such fragments as mark the disturbance or lie east of it; (3) and an eastern group, easily recognizable from the fact that it is astride of the eastern border of the Central Plateau.

Western Group.—The northernmost belt is made up of the Carboniferous areas of Ajain, Damerol, Chambon, Chat-Cros, near St. Julien, La Genète (Creuse), and Bregeroux, near Château-sur-Cher. Not a trace of Coal-measures has been observed in this synclinal, which consists of Dinantian limestones and shales associated with tuffs.

Next, we come to the Ahun coal-basin striking north-north-west and south-south-east. This seems to correspond exactly to a synclinal situated amid crystalline rocks. To this same fold must, doubtless, be assigned the patches of tuff lying north-west of the coal-basin.

These two synclinals of Chambon and Ahun appear to converge towards the north-west, but data for determining with certainty their relationship are still to seek. If our surmise be correct they would connect up with a single fold of the Breton massif.

The small coal-fields lying west of Aubusson and in the neighbourhood of Bourganeuf appear to form part of one and the same synclinal sharply deflected westward. But as there is some doubt, considering

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* Volcanic outbursts accompanying the extrusion of the orthophyres.

the few data available, as to whether they really belong to one and the same synclinal or to two distinct synclinals, it has been deemed sufficient to indicate the position of these basins on the accompanying map (Fig. 6, Plate XIX.) without defining more precisely the fold or folds to which they belong.

The Brive coal-basin certainly belongs to a synclinal striking north-west and south-east. The basin of Terrasson or Cublac (which makes a pair with that previously described, but south of a great belt of Permian that separates them) belongs either to the same synclinal as that of Brive (the axial portion of this synclinal being concealed beneath the Permian) or to a second fold parallel to the first. This position is one that recurs in many districts of the Central Plateau, as will be seen farther on. But in no case has it been possible to settle the question as between one single fold and two folds.

The small basin of Argentat south-east of Tulle, judging from the aspect of the crystalline and phyllitic rocks which surround it,* belongs to a synclinal juxtaposed upon that of Brive. There is, then, in this region a group of folds striking north-west and south-east.

It is to one of these folds that we must ascribe the little coal-field of St. Perdoux; perhaps it continues the fold which comprises the Brive basin. In any case the fold which includes it is limited to the eastward by the great disturbance of which mention has already been made, and which becomes a fault in the district of Figeac, south-east of St. Perdoux.

All these folds of the western group, more or less strongly characterized by the sediments which fill them up, are orientated in a north-west and south-easterly direction, like those of Brittany. Wherefore the idea that the folds of the two regions continue each other, despite the apparent interruption due to the presence of the Secondary deposits which cover them in the Straits of Poitou, has long impressed itself on the mind. This hypothesis is of vast theoretical importance; but when from the practical point of view, one attempts to find out where it is best to put down a boring for the purpose of striking the concealed Carboniferous folds, the hypothesis carries with it so much uncertainty regarding the exact location of these synclinals that it seems to lose very much of its value.

Happily the study of the course followed by the more recent beds superposed upon the older strata enables the writer to predict the position of the last-named. From the studies first initiated by Mr.

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* *Bassin houiller et permien de Brive* (Coal-measure and Permian Basin of Brive), by Mr. Mouret, with geological map.

Godwin-Austen in England, and followed up in France by Messrs. Hébert, Marcel Bertrand, and G. Dollfus, it would appear that earth-movements take place on practically the same spot at successive epochs. The sea may have invaded a large area, an entire district, and, perhaps, leave sedimentary deposits on heights which at one time stood above the waters; but on fresh earth-movements taking place, these have occurred just where others did at preceding epochs, and the sediments which had been laid down horizontally, are destined to be thrust on end in their turn. It is hardly necessary to add the reservation that, when the series of upheavals have resulted in the formation of mountain-chains, this law is subject to modification.

The preceding considerations have shown us that, if in a particular district it is indeed possible to recognize on the surface folds, or rather undulations of later date than even post-Carboniferous deposits, for that very reason the observer will find some indication of the course followed by the subjacent Carboniferous folds. The manner of plotting out these undulations, not to be confounded with the surface-relief due solely to erosion, has been explained over and over again by Messrs. Bertrand[*] and G. Dollfus,[†] and it is useless to repeat the explanation here.

The method was first applied to the search for the north-westerly prolongation of the Nord coal-field synclinal, as will be shown farther on. But, by following the same method, one would be enabled to see what is the course followed, beneath the Secondary deposits, by the folds present in the Britanny massif.

Thus it is that in the province of Maine, Mr. Marcel Bertrand[‡] has ascertained that the folds which have affected the Secondary deposits, and continue, or rather correspond to, the more ancient folds, no longer follow the north-west and south-east course familiar to us in the Brittany massif. This must hold good, also, of the subjacent older folds, which turn eastward and even north-eastward, before being again deflected to the south-east. Moreover, in this same Maine district, the folds do not all follow the same course; the axes of the folds describe curves which make their actual direction oscillate by more than 45 degs. around their mean value.[§] In the north, the folds are generally directed eastward, while in the south they strike north-east. The work of Mr. J. Welsch has confirmed these observations;[||] and he draws up a map of the folds that affect the Second-

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[*] *Bull. Soc. Géol. France*, series 3, vol. xx., page 118.

[†] *Bull. Serv. Carte Géologique de France*, vol. ii., page 116.

[‡] *Op. cit.*, page 138. [§] *Op. cit.*, page 139.

[||] *Bull. Soc. Géol. France*, series 3, vol. xx., page 440.

ary deposits in the Straits of Poitou. He has been enabled to demonstrate that a Jurassic synclinal follows upon the ancient synclinal of Vendée, passing through St. Maixent, La Mothe-St.Héraye, Vanzay, and Civray. Similarly, the Plogoff-Ancenis synclinal is, doubtless, prolonged by a Jurassic synclinal ranging south of Loudun, then striking east and west it appears to be finally deflected north-eastward, and ranges through Dange and St. Hippolyte.

The changes in the direction of the folds of the province of Maine, mentioned by Mr. Bertrand, are perhaps recognizable in the synclinals striking north of Poitiers, while those ranging south of that city probably retain a north-west and south-east strike. Unfortunately, the data available concerning the older strata on the western border of the Central Plateau are not of themselves sufficient to determine the continuity of the folds. It may well be that the fold of Chambon joins up with that of Ancenis, while the fold of Brive is similarly connected with the Vendée fold. The probability is great, but it is only a probability. Under these circumstances it is quite conceivable that beneath the Secondary deposits masking the older folds lie hidden synclinals filled up with Coal-measures.

Before bidding farewell to the Straits of Poitou, we must follow Mr. J. Welsch* in taking note of three folds at right angles to those recognized in the Jurassic strata. Two out of the three are synclinals, one of which ranges through Couhé, Poitiers, and Jaulnay, the other through Civray, Sommières, Gençay, and Leugny. No outcrop of the older deposits that fill up these folds being known, it is, of course, impossible to assert whether or no Coal-measures are to be found in them.

Middle Group.—Let us now return to the great disturbance which cuts obliquely (along the line *A B*) the whole Central Plateau. We see that the folds situated on the east no longer strike north-west and south-east, but are differently orientated—some ranging almost due east-and-west, others north-east and south-west. We see, then, that the folds change in character from this disturbance onwards; and the latter would, indeed, appear to coincide with the line along which all the Carboniferous folds have been deflected. Working along this line, then, orogenic energy produced its maximum effect; thence, too, derives the fault which traverses the Central Plateau. It was probably started, like the folds which originated it, during the Carboniferous epoch, for it is marked by a whole

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* *Op. cit.*, page 444.

series of coal-basins. It is possible that the disturbance did not originally correspond with a fracture, and was merely a depression at right angles* to the folds of the Central Plateau. At all events, there is a fault visible in nearly all the coal-basins; it is also met with in the area lying between Decazeville and Cordes, north-east of Albi. Whether it be a fold or a sagging along a great belt of strata—indeed, of whatever nature it may be—the disturbance was none the less in existence in Carboniferous times. At the present day, going from north to south, one comes successively upon the basins of Noyant, Le Montet, Mont-Marault, Saint Gervais, Pontaumur, Bort, Mauriac, and Pleaux; but still farther south one meets with patches of Coal-measure sandstone at St. Christophe, south-east of Pleaux, in the western environs of La Capelle-Viescamp, Pers, etc. These isolated patches must have been at one time all connected together; they all date from the latest Carboniferous stage—*i.e.*, from the Stephanian.

West of the basins of Le Montet and Mont-Marault one meets with those of Commentry and Montvicq; these still correspond to a synclinal originally striking north-east and south-west, which has been subjected to torsion in the manner described by Mr. de Launay.† It is practically in parallel alignment with the great disturbance first described, and was probably formed at the same time. For that reason it has been classified here with the middle group.

The same statement holds good of the coal-fields of Maulne and Estivarielle, situated on the right bank of the Cher, and aligned along a north-and-south direction. In the neighbourhood of these deposits the crystalline schists are puckered up into folds striking north-east and south-west. It is possible that the basins are connected with a great north-and-south depression which took place in the Montluçon area, at the time of the formation of the great Noyant-Pleaux channel. This depression may well have been prolonged northwards below the Jurassic strata of the Paris Basin. The same statement is possibly applicable to the Commentry-Montvicq and Noyant-Pleaux folds, but no positive affirmation can be made hereanent, as this portion of the Central Plateau is traversed by numerous faults, and is not at all of easy interpretation.

Supposing that we follow the great Noyant-Pleaux trough, south of the last-named village we no longer meet, near the fault which reappears on the parallel of Figeac, with any other coal-basin than that of St. Perdoux, already mentioned, lying to the westward. Then, farther south, and still west of the fault appears, on the parallel of Najac, a frag-

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* Mr. Marcel Bertrand, *Revue Générale des Sciences*, 1894, page 671.

† *Bull. Soc. Géol. France*, series 3, vol. xvi., page 1045.

ment of Coal-measures made up of shales and sandstones with plant-impressions characteristic of Stephanian rocks. This patch certainly seems to correspond to a depression striking north-west and south-east, but it soon disappeared towards the north-west, below the Permian and the Jurassic. On the other hand, it is limited eastward by the great fault which brings the crystalline rocks higher up than the Coal-measures. Certain it is, however, that the Najac synclinal, with its contained Coal-measures, must have continued to the east amid the crystalline rocks, just as it extends to the west below more recent strata.

East of the Noyant-Pleaux trough occur folds which, as previously mentioned, have an orientation different from that of the folds in the western group.

The northernmost fold of all in the central group is dotted with Carboniferous patches principally made up of orthophyric tuffs. It comprises the following areas: that situated north of Manzat; a second south-west of Gannat; finally, a third at Cusset, near Vichy. All, moreover, are orientated roughly south-west and north-east. But, south of the Cusset outcrop, one still meets with a series of small patches of Carboniferous which mark the western lip of a great fault that cuts obliquely across the Forez district and is known as the Forez fault (line *C D* on the map, Fig. 6, Plate XIX.). They run down south-eastward all along the fracture, and thus reach the level of a great fold striking north-north-east still occupied by Carboniferous, and ranging south of Roanne. They are so disposed along this great fault as to suggest shearing, as if the Manzat-Cusset fold and that south of Roanne had only formed one, and as if, in consequence of a dislocation the western portion had got displaced northward. The fold lying south of Roanne will be adverted to farther on.

Still east of the great Noyant-Pleaux trough, Coal-measure basins are met with whose relationship to the folds of the Central Plateau is not especially clear. Such are the basins of Brassac, Brioude, and Langeac, arranged along a line striking roughly north and south, but each individually striking in a different direction. Perhaps these are the mere fragments of Coal-measure deposits which at one time occupied the bottom of the Limagne basin. This, indeed, like the lower valley of the Loire, would appear to be an orthogonal* synclinal of Carboniferous age, including Coal-measures. Whatever conclusion may be arrived at in this respect, it is certain that in Tongrian time these two basins sank

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* Mr. Marcel Bertrand, *loc. cit.*

down along several faults diagrammatically shown by the lines *E F* and *G H* on the map (Fig. 6, Plate XIX.). The depressions thus produced were filled up with Tertiary sediments, subsequently denuded away at some localities, such as Brassac, Brioude, and Langeac. The traces of petroleum met with in Limagne are due, according to some authors, to the distillation, at the contact with Tertiary eruptive rocks, of coal-seams lying deep down in the old Carboniferous folds; but the borings put down in Limagne do not appear to confirm this hypothesis.

In following the eastern border of the Noyant-Pleaux trough, one reaches the coal-basin of Decazeville. This is bounded on all sides by faults, and it is no easy matter to recognize the particular type of fold to which it belongs. Nevertheless, it most likely extends farther eastward. Thus, if we examine the edge of the belt of Jurassic rocks which stretches between Capdenac and the Causses of the Aveyron, we shall find that many patches of Coal-measures crop up between the Jurassic and the crystalline schists. Those of the northern border are grouped around St. Geniez and along the Lot Valley, wherefore they are known as the St. Geniez or Lot Valley basins. They are limited southward by faults which bring down the Permian, or even the lower horizons of the Middle and Lower Jurassic, against the Coal-measures. The patches on the southern border have been much studied, and are now even worked at Bennac, Gages, Bertholène, and Le Méjanel. Most are banked up against the crystalline schist massif of the Palanges, and they are often designated by the name of the Palanges basins. They are bounded northwards in just the same way as those previously described are bounded on the south, that is, by faults. These patches, on whatever side they may be with reference to the Jurassic belt, all present such characteristics that they must undoubtedly correspond to the borders of basins far more extensive than those now outcropping; wherefore the Coal-measure strata, most probably, are prolonged on either side towards the axis of the belt. But it is hardly allowable to conclude therefrom the existence, deeper down, of one large basin covering all the breadth comprised between the Coal-measure patches, and having the same thickness as the Decazeville basin, which it does, perhaps, continue. There may well be in this region two series of parallel basins, similar to the parallelism already described in the case of the Brive-Terrasson basins.

Looking to the fact that, east of the Noyant-Pleaux trough, the strike of the folds is deflected towards the north-east, it seems possible that the Decazeville basin, with its assumed easterly prolongation, is itself merely the prolongation of the Brive-Terrasson fold in one part of its course—where it takes an east-and-west strike before turning north-eastwards.

Following the great trough, we find on the east the Carmaux basin, situated in the Céron Valley, which runs north-west and south-east. The Coal-measures crop out in the south-east and disappear north-westward, beneath the Permian and Tertiary rocks, coming again to the surface with the same strike at La Guépie. We are, then, here in presence of a series of deposits which correspond to a synclinal fold striking north-west and south-east; that is, following the same direction as the other deposits, already described, belonging to the western group of the Central Plateau; but this series lies east of the trough, and it is not known to be continued beyond the western edge of the great fault.

Still farther south, we come upon the little coal-basin of Réalmont. This is cut up by numerous faults, in such wise that it is impossible to determine the features of the synclinal to which the basin belongs; nevertheless it is seen that the surrounding Cambrian strata have a general north-easterly and south-westerly strike, whence one may infer, with some show of probability, that such also is the strike of the synclinal. In the district of Réalmont numerous faults cause the repetition of junctions of the more or less metamorphosed Cambrian with the Coal-measures and the Permian. Westward, outcrops of Cambrian make their appearance from beneath the Tertiary. It seems probable that still farther west we should meet with Carboniferous.

East of Requista, on the borders of the Tarn Valley, are a few isolated patches of Coal-measures, which disappear eastward beneath Permian and Jurassic rocks. The writer has not been able to ascertain of what fold they formed a part: are they the continuation of the Carmaux fold or of the Réalmont fold? One thing alone is certain, as already said, they disappear eastward beneath more recent deposits.

The Graissessac basin does not fill up a synclinal, but a depression, lying between two ancient massifs or domes. One of these corresponds to the gneissose massif of the Montagne Noire, the other to a vast sheet of microgranulite which makes up the Mendic. This depression has been filled in much the same fashion as the other coal-basins of the Central Plateau; that is, by detrital matter drifted down from the surrounding mountains. It has an east-and-west strike, and disappears eastward beneath the Permian. According to the evidence obtained from the old borings put down in the eastern portion of the basin, the Permian has here an enormous thickness, and the Coal-measures were not struck, even at a depth of 2,300 feet. It is possible that this basin, which does not lie in a fold, is more irregular than the others, and joins up eastward with a synclinal striking north-east and south-west, passing through Le Vigan, where Coal-measures crop out. In that case, however, instead of looking to the east for its continuation, as has always been done up to the present, we should look north-eastward, beneath the Secondary strata, which are developed in great thickness south of Le Vigan.

On the southern edge of the Montagne Noire appears the coal-basin of Neffiez, which occupies (if we may judge from the strata that are seen at the outcrop) a synclinal striking north-east and south-west, as do all the folds of this mountain-massif. The entire southern portion of the basin disappears beneath Permian and Jurassic formations. But this fold would appear to be continued north-eastward and to join up with that of the Gard coal-field.* In point of fact, the present writer's researches in the Montagne Noire have proved to his satisfaction the continuity of the folds in the ancient rocks of this area with those of the Cévennes. If this be so, the Coal-measures which disappear north-eastward from Neffiez beneath a vast thickness of more recent strata should reappear in the Gard, some 45 miles away to the north-east.

If we turn to the geological map of France, we see that all these folds of the Cévennes run up towards the north throughout the south-eastern portion of the Central Plateau. And thus it is that the Neffiez-Alais synclinal turns northward towards Privas, as may be inferred from the general trend of the Secondary strata along the borders of the ancient massif.

The Prades basin, bounded north and south by two faults striking north-east and south-west, probably coincides with the prolongation of one of the folds of the eastern group or the middle group, but in the present state of knowledge regarding the lie of the strata in the Causses area, it is idle to attempt to settle this point.

Eastern Group.—If we follow the eastern border of the Central Plateau, we find several folds occupied by well-known coal-basins, and these constitute the Eastern Group.

First of all comes the St. Etienne coal-field, the most considerable of all those of the Central Plateau. Mr. Termier has, however, recognized

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* The Gard or Alais coal-field is at present divisible into two areas: that of La Grand'Combe on the west, and that of Bessèges on the east. The massif of ancient rocks forming the Rouvergue divides one from the other. Prof. Grand' Eury's researches have, however, proved that this massif was upraised after the deposition of the earlier Coal-measures in the basin. Originally there was but one synclinal, the one to which we are now directing our attention, and the uplift of the Rouvergue was contemporaneous with the formation of the basin. Similar earth-movements, sometimes attended with dislocation, have been noted in a great number of basins.

several other synclinals grouped around that of St. Etienne,* which have a very marked tendency to converge towards the north-east with a northerly deflection. On the accompanying map (Fig. 6, Plate XIX.) the writer has indicated only the two synclinals in which Coal-measures have been found. The fold occupied by the St. Etienne coal-field is continued on the left bank of the Rhône, where it crops out south of Ternay and Communay. It is to this fold also that the Coal-measures, struck deep down east of Communay and Chaponnay, very likely belong. The outcrops on the left bank of the river are, however, not so very numerous, the strata disappearing beneath the Tertiary and Pleistocene or Quaternary deposits, in such a manner that it is extremely difficult to follow on this side of the Rhône the folds mapped by Mr. Termier on the other side. According to this geologist, the Coal-measure patches of Chonas, La Poipe, Les Guillemottes, and Serpaize belong to a second synclinal (that which on the map passes through Vienne), which is believed to have been struck by a boring between St. Pierre de Chandieu and Toussieu. The Chamagnieu coal-deposit is supposed to form part, either of the second synclinal much expanded, or of a third synclinal which strikes through Sarras, and in which the presence of coal had not hitherto been recorded.

All these folds are prolonged eastward, but it is impossible to ascertain what becomes of them under the younger sedimentaries of the Rhône Valley—especially whether they are continued into the Southern Jura.

The basin of Ste. Foy l'Argentière, which lies more to the northward, occupies yet another synclinal, as may be inferred from the arrangement of the surrounding strata. But this fold seems to be bent northward before disappearing beneath the Secondary and Tertiary strata of the Saône Valley. The numerous faults which on this side border the Central Plateau have brought about considerable changes in the general character of the fold; and, if the latter be continued north-eastward, it is highly probable that the Coal-measures occur in it as mere broken patches.

On the parallel of Mâcon are seen outcrops of orthophyric tuffs, corresponding to the eastern termination of that synclinal, the presence of which has already been noted south of Roanne. The synclinal in question is made up of a plexus of folds, the general strike of which is north-east, south of Roanne; then, from Tarare onwards, they are bent up northward, taking a north-north-easterly direction, approximatively parallel to the Saône Valley. Dinantian strata mainly, and in particular

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* *Bull. Service Carte Géol. France*, vol. i., page 1.

the orthophyric tuffs, fill up the synclinal. Here and there on the tuffs rest little patches of Coal-measures[*] whose general alignment seems to be across the direction of the folds, and this is the case also with the faults which cut up the Dinantian strata into separate fragments or patches. These faults have all coincided in deflecting the main fold from its original course and bending it towards the north. It disappears amid the patches of Jurassic rocks which in the Saône Valley border the Central Plateau.

We may here pause to observe that the folds which run south of the St. Etienne coal-field are all deflected northward, and appear to converge[†] towards the continuation of the basin which, in the part known to us, follows a north-east and south-westerly direction. It would seem, then, that all these folds join together and pass through an ancient area of depression lying between the Jura and the Alps. North of the St. Etienne coal-field, as we have just seen, the folds of Ste. Foy l'Argentière and Roanne have undergone a deflection which has brought them into parallelism with the southern chain of the Jura. This is a deflection dating from the time of the formation of the Jura and the uplift of the Alps, in other words, from the Miocene; and the earth-movements by which it was caused were sufficiently powerful to plicate even the middle region of the Central Plateau. Under these circumstances, the Coal-measures, if there be any beneath the more recent sedimentaries which occupy the Saône Valley or in the above-mentioned depression between the Jura and the Alps, must be in a very fragmentary and dislocated condition.

The coal-fields of Le Creusot and Blanzy are situated north and south of a great Permian belt that strikes north-east and south-west, on each side of which, moreover, are other basins of far less consequence. This belt has been usually considered as formed by a synclinal, whose axial portion occupied by Permian has sunk down, while the edges are, in all probability, those of the Coal-measure basin laid bare by erosion. But Mr. Delafond[‡] interprets the evidence otherwise. According to him, there were two synclinals, one to the north and one to the south, and a part of each of these synclinals was dragged downward with the sinking middle portion. However that may be, we may regard this belt as corresponding to a synclinal which is prolonged westward and includes the Bert basin. Still farther west, however, from the previously-

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[*] *Geological Map of France*, scale $\frac{1}{80000}$: sheet Roanne.

[†] *Annales de Géographie*, Mr. Deperet, vol. iv., page 432.

[‡] *Bull. du Service de la Carte Géologique de la France*, vol. ii., page 57.

mentioned fault of Forez onwards, all trace of it is lost. Its continuation in a north-easterly direction is quite unmistakable; it joins up with the Coal-measure basins lying south of the range of *ballons* of the Vosges. Its course is further indicated by the small Palæozoic massif of La Serre, lying between the Saône and the Doubs. In 1873, north of this outcrop of ancient rocks, a boring struck the crystalline rocks at a depth of 400 feet, after passing through Trias and Permian. Mr. Trautmann* observes, however, that this boring had been located much too near the axis of the outcrop, which is, in reality, an anticlinal, and the Coal-measure basin must be looked for further north. The Vosges basins included within this fold are those of Ronchamp and Roppe, the strata of which dip towards the massif of La Serre and disappear beneath the Jurassic.

Further north yet, along this eastern edge of the Central Plateau, we meet with the basins of Igornay and Epinac, whose lie is much the same as that of the Creusot and Blanzy basins. We may consider all these as belonging to one great area of depression—that of Autun—parallel to the depression to which attention has been previously directed. Eastward it terminates, after passing beneath the Secondary rocks, in the small basins of Villé and St. Hippolyte, between Champ-de-Feu and the mountains of Ste. Marie-aux-Mines in the Vosges. South-westward the continuation of the fold is lost amid a series of faults of Tertiary age, which correspond with the eastern boundary of the great depression of the Loire Valley.

The Coal-measure basin of Decize forms an isolated patch outside the Central Plateau ; it appears amid the Jurassic, and has been regarded as the westerly continuation of the Autun fold† deflected northwards alongside a fault by Tertiary earth-movements. Recent research by Prof. de Launay‡ has shown that this basin occupies a synclinal striking nearly due east-and-west, then deflected south-westward before it rejoins either the Noyant-Pleaux trough or the Commentry-Montvicq fold. Under these circumstances we should feel bound to admit that all that portion of the Central Plateau which lies west of the Forez fault has been similarly displaced northward, and we might suppose that the Noyant-Pleaux trough is connected with the Creusot-Blanzy fold by

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* *Bassin Houiller de Ronchamp* (Coal-measure Basin of Ronchamp), page 113.

† Mr. Munier-Chalmas : information communicated verbally.

‡ "Le Massif de Saint-Saulge et ses Relations avec le Terrain houiller de Decize" (The Massif of St. Saulge and its Relationship to the Coal-measures of Decize), *Bull. Serv. Carte Géol. France*, vol. vii., page 183.

means of the Bert basin. This view finds support in the fact to which attention has already been drawn, namely, that the Carboniferous belt of Manzat-Cusset is sheared and drawn out alongside the Forez fault.

Under these circumstances, the great depressions in the Central Plateau, pointed out as being orthogonal folds, would be nothing of the kind; they would constitute merely the continuation of the folds of the eastern group. This being so, there would be no occasion to search for their prolongation outside the Central Massif. Taking into consideration the generally simple features of the folds in most of the Hercynian chains, the writer thinks that it is extremely improbable that the folds of the Central Plateau are arranged in the particular way described, and he continues to think, as does also Mr. Marcel Bertrand,* that we cannot regard these synclinals as anything else but orthogonal folds.

The small coal-basin of Sincey, in the Morvan district, ranges east and west, but we are in possession of few data as to its general aspect. If it be continued eastward it disappears rapidly beneath the Secondary strata of Burgundy, which are, be it observed, highly faulted in this area.

It may be that the Côte d'Or Straits correspond with an orthogonal fold whose deeper portions are occupied by Carboniferous rocks, but of this we have no available evidence.

If, now that we have directed our attention in turn to the Carboniferous synclinals of Brittany, the Central Plateau, and the Vosges, we look at them as a whole, we shall see that the folds of these several Hercynian chains are in a general way connected one with the other. Striking first of all north-west and south-east, they take in the east a north-easterly and south-westerly course, and describe a series of V's whose width of aperture varies with the position of the synclinals. The writer has contented himself with marking on the map (Fig. 6. Plate XIX.) such synclinals as are known to be filled up with Carboniferous deposits, since these crop out in the emerging massifs. The data which they furnish from the point of view of the search for coal are more precise, and consequently we are more keenly interested in tracing them out. But there are other synclinals whose existence may be inferred in the ancient massifs from the general trend of the strata, and these, containing no Carboniferous deposits in their visible portions, have not been marked on the map. They all disappear westward beneath the Secondary deposits of the Paris Basin, of the Straits of Poitou, and of the Aquitaine

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* "Les Lignes directrices de la Géologie de la France" (The Directing Lines of the Geology of France), *Revue Générale des Sciences*, 1894, vol. iv., page 671.

basin, eastward beneath the Secondary and Tertiary formations of the Straits of Côte d'Or and the Rhône Valley. Nevertheless, we must not forget that they do exist, and it is just possible that they may one day reveal, at varying depths, there where they are covered by more recent sedimentaries, a precious hoard of coal.

In the northern portion of France that Hercynian chain, which corresponds to the Ardennes, the Eifel, the Hundsrück, and the Taunus, is marked by two great depressions filled up with Coal-measures. First of all, we have the Sarre basin in the south. Looking at the general lie of the Secondary strata which cover this coal-field, one can feel little doubt that it is continued westward into the Paris Basin. Truly, it strikes north-east and south-west; but, taking into consideration the great rapidity of its dip towards the Paris Basin, as shown by borings put down in Lorraine, it must lie there at a very great depth. Nor have we any indication as to the course which it follows after its disappearance beneath the Secondary rocks.

The Franco-Belgian coal-basin lies north of the ancient massif of the Ardennes; its course is, in fact, parallel with the whole of this Hercynian chain, and it forms to the east the Ruhr basin. As it passes into Holland, it disappears beneath more recent sedimentaries; but it has been struck again by means of borings, and some changes in its general features have been noted thereby. To these we need devote no attention here, as the facts which have recently come to light in Dutch Limburg are of no service to us in the study of the Franco-Belgian basin, upon which we are just now intent.

The outcrops in Belgium, the workings and borings in France have enabled observers to recognize that the basin which, in its eastern portion, strikes north-east and south-west takes a due east-and-west course between Namur and Mons, and, then, after a temporary deflection between Valenciennes and Douai, follows a north-west and south-east strike. But from Fléchinelle, in the Pas de Calais, onwards, no trace of Palæozoic rock is known to occur till we reach Hardinghen and Ferques in the Boulonnais. We are then confronted by two questions. What course does the Coal-measure fold take between Fléchinelle and Hardinghen? Is it really the same fold that passes through both localities? In order to solve these problems Mr. Marcel Bertrand has applied the principle of superposition of folds previously set forth by him. But in this area of the provinces of Artois and Boulonnais, an additional complication is imported into the problem by the great number of folds which occur in the Jurassic and Cretaceous rocks. Nevertheless, Mr. Bertrand * has arrived at this conclusion, that the Boulonnais forms a dome, and that the prolongation of the Coal-measure synclinal of the Pas de Calais runs north of the aforesaid dome. This being so, the little Coal-measure patch of Hardinghen is, indeed, the continuation of the Coal-measures seen at Fléchinelle, as had been inferred beforehand, although not proved. Moreover, the synclinal before it reaches Hardinghen is several times deflected, if we may judge by the folds observed in the overlying strata. After following a north-westerly course as far as Covecque it is deflected so as to take a north-north-east direction up to Remilly. Thence it resumes a north-west and south-easterly course with some undulations, especially on the parallel of the Palæozoic outcrop of Ferques.

We might well be tempted to correlate this fold with one of the coal-basins of southern England. A boring undertaken at Dover in 1890, which has resulted in the discovery, not only of Carboniferous strata, but of coal, lends great probability to such a correlation. Despite this, however, the attentive study of the known plications, both in England and in France, fails to confirm the hypothesis. As far back as 1855, Mr. Godwin-Austen had enunciated the theory of superposition of folds, and, applying it to the Somerset coal-field, he concluded that the Coal-measure synclinal ranging north of the Mendip Hills must also range north of the North Downs, which constitute a massif of Secondary strata, following on the anticlinal of ancient rocks of the Mendip Hills. Mr. Godwin-Austen's hypothesis has been abundantly justified by the result of the Dover boring; and, applying the theory to the French shore of the Straits, we should infer that the Dover fold must come to light on the parallel of Calais. But that is just what it does not do; far from that, the continuation of the fold of the Nord and Pas de Calais basin passes through Cape Gris-Nez; whence we must conclude that the folds of the English and French coal-fields are not mutually continuous.

On the other hand, an old boring put down in the neighbourhood of Calais is said to have struck Coal-measure sandstone, while another boring has quite recently, so it is said, come upon the Devonian. The data available with regard to this Coal-measure synclinal are as yet too scanty to enable us to draw any conclusion from them.

Mr. Bertrand, while endeavouring to follow up in the Boulonnais, the fold of the Franco-Belgian coal-basin, devoted some attention to the lie

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* *Annales des Mines*, 1894, series 9, vol. v., page 569, and Plate XI.; and *Trans. Fed. Inst.*, vol. v., page 106.

of the strata. The researches of many observers, and particularly those of Prof. Gosselet,[*] in the Ardennes and the Franco-Belgian basin, have shown that the last-named corresponds to a synclinal bounded on the south by an anticlinal, the occurrence of which is soon made manifest—this being the fold or ridge of Condros. As the result of thrusts coming from the southward, this anticlinal was overfolded on to the Coal-measure synclinal. Overfolding was accompanied by shearing; the base of the fold was unable to follow the projecting portion, and the Palæozoic rocks, such as the Silurian, Devonian, and Dinantian, which constitute the fold were so sheared that they in part disappeared. The result of this was an abnormal junction, a fault-fold; which precisely accords with the explanation given on a previous page (Fig. 2, Plate XIX.). Moreover, folding took place after this shearing, with this effect—that the extreme end of the overlapping patch occupies a depression, as shown in Fig 3 (Plate XIX.).

We may now proceed to a more detailed study of the basin. Mr. Briart,[†] manager of the Bascoup mines, has called attention to the occurrence in the neighbourhood of Landelies and Fontaine l'Évéque of an overlapping patch, which not only includes Devonian and Dinantian, but also the productive Coal-measures resting upon coal. The whole of these form an inlier, now isolated in consequence of erosion having lopped off that part of the overlapping patch which joined up the extremity of the overfolded anticlinal with its basal portion. This is precisely the same class of phenomenon as that to which reference was made on a previous page in discussing the systems of folds in mountainous regions. The beds are arranged as shown in Fig. 4 (Plate XIX.);[‡] this is a diagrammatic section, the right-hand portion of which illustrates the lie of the beds in the Landelies and Fontaine l'Évêque area.

A mere glance at a geological map would lead us to infer that we are here dealing simply with an anticlinal intervening between two Coal-measure synclinals. Going farther west, the strata continue to confirm that impression. It would appear that on the parallel of Boussu rises a Palæozoic anticlinal ridge separating two Coal-measure synclinals—on the north lies that of Condé-Jemmapes, which is prolonged westward, and on the south that of Dour, which appears to be limited about Quiévrechain

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[*] *L'Ardenne*, and numerous papers in the *Annales de la Société Géologique du Nord*.

[†] "Géologie des Environs de Fontaine l'Évêque et de Landelies" (Geology of the Neighbourhood of Fontaine l'Évêque and Landelies). *Annales de la Société Géologique de Belgique*, 1894, vol. xxi., page 35.

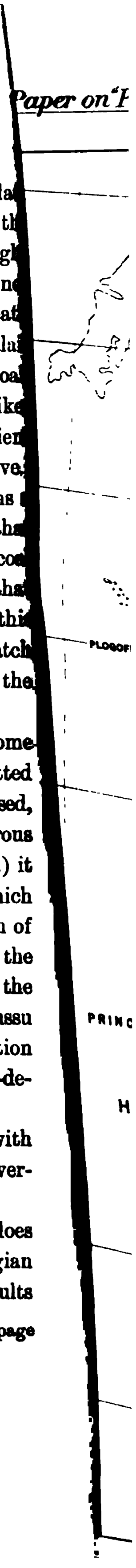
[‡] From Mr. Bertrand, *Annales des Mines*, series 9, vol. v., plate x., Fig. 4.

by the northward deflection of the older formations (Fig. 5, Pla XIX.*). But Mr. Briart's observations suggested to Mr. Bertrand† th idea that the Palæozoic rocks of Boussu, Valenciennes, etc., were broug into their present position by means of an overfold, and that they are n the bottom part of a basin, but rather an overlapping patch, beneat which should occur not only a considerable portion of the Pas de Calai and Nord Coal-measure basin, but also a double thickness of coa Under these circumstances, the bottom part of the basin, which strik across Dour, lies much farther south than the outcrops of the ancie strata towards Douai and Valenciennes, would have led one to believe; the difference is a matter of 3 miles or so. This area would then, as whole, present the conditions illustrated in Fig. 4 (Plate XIX.), and th being so, the peculiarity of the Nord basin in failing to supply gas co from the higher horizons—whereas farther east, the Mons basin holds tha variety of coal, and farther west the Pas de Calais basin does also—thi peculiarity would be explained by the fact that the overlapping patc conceals the higher coals of the basin, but fails to do so in regard to the lower coals, which alone skirt this patch on the north.

This method of interpreting the facts helps us in understanding some other characteristics of the Franco-Belgian basin. It was fully admitted that a succession of faults had been produced, some normal, some reversed, so as to explain the presence of Devonian and Lower Carboniferous strata amid the Coal-measures. On referring to Fig. 4 (Plate XIX.) it will be seen that it only requires a fault-fold (corresponding to that which is called the great southern fault), together with a simple undulation of the strata as a whole, in order to understand the abnormal junction of the Silurian, Devonian, and Lower Carboniferous series with the coal in the undulating portion: this had been known under the name of the Boussu fault. Then, farther, to the right in the same figure, we see the junction of the Lower Coal-measures with higher strata: this is the Cran-de-retour of the Nord miners.

It is believed that this overlapping patch diminishes *pari passu* with the northward deflection of the basin. Nevertheless, traces of overfolding are said to be still observable at Hardinghen.

Perhaps it may be admitted that Mr. Bertrand's interpretation does not quite fit in with all the observations made in the Franco-Belgian basin, and thus Mr. Chapuy‡ records the undoubted existence of faults



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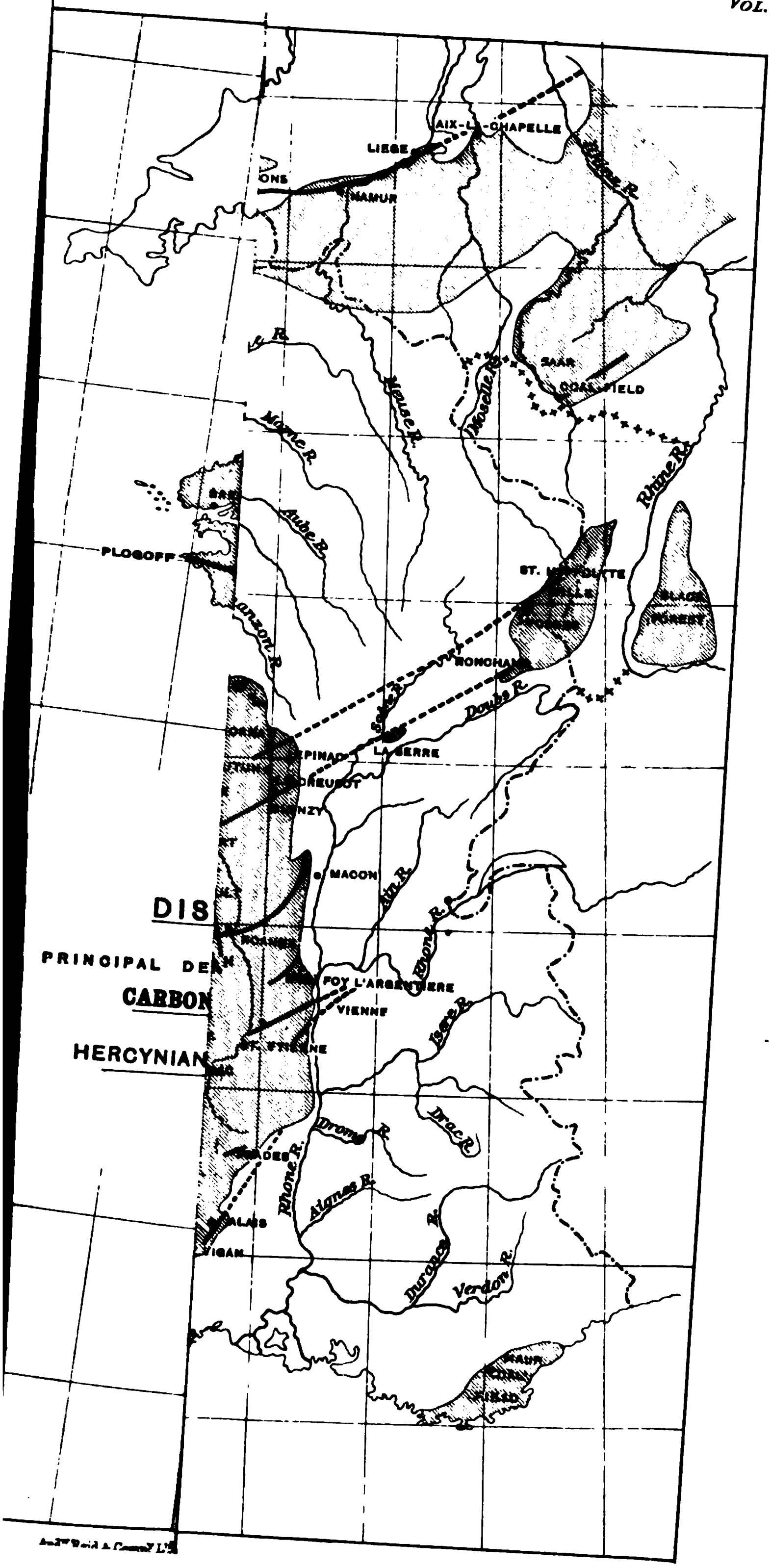
* Copied from Mr. Bertrand's figure, *Annales des Mines*, series 9, vol. v., page 605, Fig. 6.

† *Annales des Mines*, series 9, vol. v., page 569.

‡ *Annales des Mines*, series 9, vol. viii., page 192.

Paper on "Poss



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which cut the basin near its centre, and depress to some extent its southern portion. This being so, we could not consider the basin in its present structure as a single sheared fold. The absence of gas-coals in the Nord basin appears to admit of no doubt, whether we agree or not with the explanation previously discussed; and, whatever we may think concerning these points of detail, the fact that a part of the basin is overlapped by a patch of Palæozoic rocks is undeniable. It is just possible that the basin does not extend so far south as Mr. Bertrand seems to think, but this is a point which can only be settled by long and arduous research.

The consumption of coal in France being greater far than the production, there is good reason for extending existing workings and multiplying new ones. The facts and hypotheses set forth in the preceding pages may not always furnish infallible indications as to the localities where it would be advisable to put down new workings, but they may at all events give useful guidance: thanks to them indeed, encouraging results have been attained by recent searches for coal. For these reasons the writer has thought it well to bring them to the notice of mining engineers.

Mr. JAMES McMURTRIE (Radstock) said that he had read with great pleasure this valuable paper on an interesting and far-reaching subject—not confined to the shores of France. Having been engaged, long ago, by the Royal Coal Commission in working out the facts in Somersetshire, he had taken a deep interest in the views held by Mr. Godwin-Austen as to the probable existence of a buried coal-field in the South-east of England, forming a connecting-link with the coal-fields of France and Belgium. The present paper by Mr. Bergeron, as well as a former paper by Mr. Bertrand,* extended still farther Mr. Godwin-Austen's views, which, briefly stated, were that, just as in South Wales and Somersetshire, there was an elevation of the older rocks forming an anticlinal, to the north of which there lay a number of coal-fields; and as on the Continent there was a similar, and even more pronounced uplift, with a similar range, and with valuable coal-basins lying to the north of it, so in the intermediate area there probably existed a similar state of things, although both the anticlinal and the Coal-measures adjoining it had alike been buried beneath newer formations.

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* *Trans. Fed. Inst.*, vol. v., page 106.

The subsequent borings at Dover had abundantly proved the correctness of Mr. Godwin-Austen's views; and when the present sinkings there were completed, they might expect to see a development which would greatly change the aspect of affairs in the South-east of England.

As regards the present paper, those only who were well acquainted with the geology of France could follow Mr. Bergeron's theory in all its details. It was difficult for others to grasp and to discuss the many upheavals of the older rocks therein referred to, with synclinal valleys between, in some of which coal had been found, and in others it might be expected; but of the broad principle which the paper advocated, he (Mr. McMurtrie) entertained no doubt, viz., that ancient lines of elevation had often been followed by recurrent upheavals and depressions, and that a study of the surface-rocks would often give a clue to the configuration of the older formations which lay beneath.

It was well known that in the south of Europe and on the western coast of South America there were lines of disturbance which had been in a state of activity in the earlier geological ages, and in which movements were continued down to the present time; and what had happened in cases within their personal knowledge had probably occurred often in the past. But they must not place too much reliance on this theory, apart from surrounding circumstances, for the mere fact of a slight synclinal in recent formations did not necessarily imply the existence of a coal-field beneath. Mr. Godwin-Austen had gone upon safe ground, for he had a well known anticlinal visible in the older rocks of England, pointing towards a similar uplift in the older rocks of France, and he was guided by evidence in the overlying strata within the intermediate area when attempting to connect the two. This was the true geological method, and events had justified it.

The success which had attended this generalization, and the present paper by Mr. Bergeron, raised a question whether the same idea might not be worked out further in England to the east of the known coal-fields. In Somersetshire, the possible coal-areas were two in number, viz., in the eastern extension of the synclinal basin to the north of the Mendip range, and in the synclinal basin to the south of it; but what of the country to the east of the Midland coal-fields, partly dealt with in the paper lately read by Mr. Coke? He looked forward to the further discussion of that paper for information on the subject.

Prof. **EDWARD HULL** (London) wrote that he had read Mr. Bergeron's essay on the "Possible Extensions of the Coal-fields of France" with much interest. It formed a very fitting sequel to those essays on similar subjects which have already appeared in the *Transactions* of the Institution. He gathered from it that the Carboniferous formation had once had a vastly greater extension over the area of France than it had at present, or would have were all the Mesozoic and Tertiary formations stript from off its surface. This we were all aware of as regards the coal-basins or troughs of Northern France and Belgium; but there was much regarding the inferred extensions of the troughs of Brittany and the central and eastern parts of France which to him, at least, was quite new. The wonderful system of plications to which the strata of the Franco-Belgian coal-formation had been subjected, had long been recognized as belonging to the Hercynian system, the direction of which was approximately east to west. This system, traceable, as Mr. Bergeron showed, from the Ruhr across Belgium and the North of France, passed under the English Channel and the South of England to South Wales, and was grandly developed in the South of Ireland and amongst the mountains of Kerry. Some years ago, he (Mr. Hull) showed that the geological age of this system could be exactly determined as being post-Carboniferous and pre-Permian; a period of long duration during which in the North of England a vast amount of Carboniferous beds was disturbed and denuded away, in consequence of which the Permian beds were found resting unconformably on various members of the Carboniferous system down to the very base. Mr. Bergeron showed that the flexures of Brittany with their easterly extensions belonged to this same period. But he also showed that these north-west to south-east flexures passed towards the east of France into south-west to north-east directions veering north. Now, in the British area, there was evidence to show that the north-and-south flexures of the Carboniferous strata, such as those of the Pennine chain, were of later date than those ranging approximately west to east, namely, post-Permian and pre-Triassic; and he would suggest that the northerly orientation of the flexures in France might be due to movements of later date than those having a west-to-east, and are referable to an epoch succeeding the Permian but preceding the Triassic. The formation of isolated troughs, or basins, in the Carboniferous beds might be explained by the intersection of two systems of flexures, transverse or approximately perpendicular to each other, accompanied and followed by denudation of the strata. In this way he believed that the coal-basins of England have in the main been formed as he had shown, many years ago, in his evidence before the Royal Coal Commission; and it seemed very probable that the same process applied to those of France and Belgium, as it was known that the Triassic sandstones of the Vosges (Grès des Vosges) and those of Permian age were unconformable to each other; implying disturbances and denudation between their respective geological periods.

The **Chairman** proposed that the thanks of the members be accorded to Mr. Bergeron for his valuable paper, and this was agreed to.

Mr. J. **Bergeron** (Paris) wrote that he was very pleased that his paper had proved of interest to the members of the Institution, and had pleasure in acknowledging their cordial vote of thanks.

Mr. John Yates' paper on "The MacArthur-Yates Process of Gold Extraction: Dry Crushing, with Direct Amalgamation and Cyanidation," was taken as read:—

THE MACARTHUR-YATES PROCESS OF GOLD EXTRACTION: DRY CRUSHING, WITH DIRECT AMALGAMATION AND CYANIDATION.

BY JOHN YATES.

Few metallurgical processes which existed 400 years ago have come down to the nineteenth century without material alteration either as to plant or method. Of these, the process of extracting gold from its ores by means of gravitation-stamps and amalgamation is one of the most interesting and important. Georgius Agricola in his *Vom Bergwerck*, published in 1557, gives an illustration of a stamp-mill then in use, and except in the materials used and the proportions adopted it differs in no important feature from the Californian mill of to-day. Stamps and amalgamation have held the field for four centuries against all comers, not because this is a perfect method of gold-extraction or even a near approach thereto, but because its proposed rivals were even less perfect.

Next to the quality of the reef, there is nothing about a mine so productive of grumbling as the expense of the stamp-mill, and the unsatisfactory nature of its returns.

The faults of the ordinary amalgamation-process are well known. The great weight of the plant, the power and amount of fuel required, together with the great quantity of water needed and the very heavy first cost are some of the drawbacks attending its use. The percentage of gold which it extracts is seldom high, and often, after a ruinous outlay and much trouble, its only return is to yield a fraction of the gold in the ore.

What is wanted is a plant of moderate cost giving a high extraction, and which can be run economically with but little water or fuel. By supplementing the treatment in the stamp-mill by the MacArthur-Forrest cyanide process, the desired extraction has been approached, but the whole process as thus carried out with its stamps, pans, settlers, etc., is needlessly cumbrous, and an expensive and laborious method of doing that which can now be performed in a much simpler manner.

The accompanying sketches (Figs. 1 and 2, Plate XX.) show the MacArthur-Yates process, which approaches modern requirements, and promises, by reason of the little water needed, to go far towards removing the grave difficulty at present experienced in the recovery of gold in Western Australia and elsewhere. The process is one of combined amalgamation and cyanidation. The plans appended illustrate an 100 tons per day plant. This plant consists of four barrels, with amalgamating apparatus, six 100 tons leaching-vats, three solution-sumps and three extractor-boxes, etc., together with the necessary gearing, piping, etc.

The ore is dry-crushed by any suitable machinery, that being preferable which produces the most uniform product. A three-stages crushing-plant, such as is shown on the plans, will be found suitable, the respective stages being (*a*) rock-breaker in headgear at shaft, (*b*) reciprocating fine-crushers, and (*c*) rolls. The mesh to which the ore must be reduced depends to a great extent upon the character of the ore, but 400 meshes per square inch will in many cases be found to give good results. The crushed ore is raised by elevators to the barrels, these being 6 feet long by 4½ feet in diameter internally, and their shafts, which pass through them, support the amalgamating apparatus, consisting of a light rectangular iron frame, so designed as to be free to rotate on the shaft, and carrying two rectangular amalgamated plates of corrugated copper.

The large aperture of the barrel, together with the movable frame, affords free access to the plates for removal and renewal, it being possible to take out a set of plates after a run, and replace them by others ready dressed in three or four minutes. The amalgamated-surface exposed by the two plates amounts to 29 square feet. The frame carrying the plates is so adjusted on the shaft as to yield to the pressure of the ore on the plates at the moment of starting, and permit of both plates being brought to the aperture, and thus within easy reach for manipulation. The barrels discharge into casings, and the pulp is conveyed thence to one of the six leaching vats, where the ore is subjected to an ordinary percolation treatment.

Such is the efficiency of the corrugated plates, that about one hour's agitation will, with many ores, result in a satisfactory extraction by amalgamation, the charge then being passed to the vats.

The method of working is as follows:—After freshly-dressed plates have been inserted in the frame, ore and cyanide of potassium solution, in the proportion of 2 to 1 respectively, are charged into the barrel together, the amalgamated plates being vertical. When the barrel has received its full charge of 2½ tons of ore and 1¼ tons of cyanide solution of suitable strength, the charging aperture is closed, a tight joint being secured by means of a rubber washer.

[illegible]

The [illegible] minute [illegible] of the [illegible] off, and [illegible]

The [illegible] mated plates [illegible] wedges, and [illegible] dressed being [illegible] From the [illegible] percolation-[illegible] whole of the [illegible] treatment in [illegible]

From the [illegible] main, the ordinary [illegible] being that the ore is [illegible] view of securing [illegible] and thus raising [illegible] economy of power is [illegible]

The ore receives a [illegible] there is consequent [illegible] compact mill, the [illegible] and the superintend[illegible]

The wear-and-tear [illegible] practice, and the [illegible] mated plates are placed [illegible] manner, and then dressed [illegible] extractor-boxes are cleaned [illegible] venient.

The ore being treated [illegible] of acidity in it by atmospheric [illegible]

Special attention is called [illegible] to which the ore is subjected after [illegible] must necessarily have on the [illegible] ores a yield of 90 per cent. of [illegible] percentage which is seldom reached [illegible] plant.

In order that the ore may remain under the [illegible] as possible, the filtering of the washes should [illegible] apparatus, which may take the form of either an [illegible]

Another feature of this plant is that it may be run as an ordinary percolation-plant independent of the barrels, the vats having a capacity suitable for treating 100 tons of ore per day by this method. This point will commend itself to the management of those mines where stocks of tailings already exist, and where batches of ore suitable for simple cyanide treatment are found.

On the Witwatersrand gold-fields, where the mining and treatment of gold ores is being carried out on an enormous scale, the present approved practice consists of three stages, (*a*) the stamp-mill with amalgamation, (*b*) cyanidation of clean sands, and (*c*) treatment of slimes. With the MacArthur-Yates process the same result can now be attained with one plant. The new process also has the advantage in costs. For equal capacities, the initial cost of the proposed plant, complete with crushing machinery, would be less than the combined cost of a stamp-battery, cyanide plant, and slimes plant. The running expenses would vary according to the conditions. Under some circumstances they would approach those of present practice, but in many cases they would be much less. This estimate is made without taking into consideration the considerable economy effected in water.

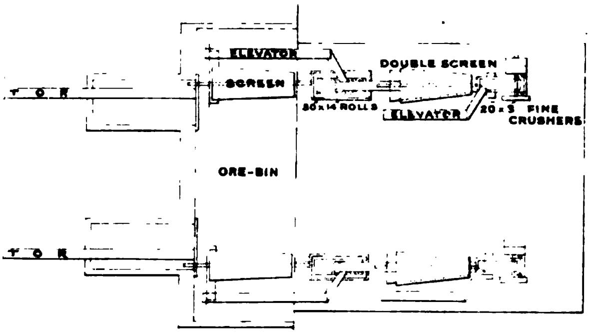
A frequent source of worry and expense in working stamps is the water-supply. No one credits stamp-mills with economy of water; they seldom require less than 150 cubic feet of water per ton of ore crushed, all of which, as a rule, after being used, runs to waste: for it is highly desirable that the water supplied to a stamp-battery should be clean, a dirty supply having a deleterious effect on the amalgamated plates. In the MacArthur-Yates process only a small initial stock of water is required, and this can be used over and over again, the loss being only from 15 to 20 per cent., this being carried away by the tailings, evaporation, etc. The solution is kept clear by the filtration in the vats, and owing to the presence of the cyanide of potassium, the plates are kept bright and at their maximum efficiency. The stock of solution, therefore, only requires replenishing to the extent of one-fifth of the quantity of ore crushed—a most important consideration where water is scarce.

The water-charge attending some of the stamp-batteries in Western Australia is returned at 10s. per ton of ore crushed, the large volume of water needed by the stamps (at least four times the quantity required by the MacArthur-Yates process) affording great opportunities for loss. In an 100 tons per day MacArthur-Yates plant only about 100 tons of solution per day are dealt with, of which not more than 20 tons are lost.

·ith Direct Amalgamation and Cyanidation."

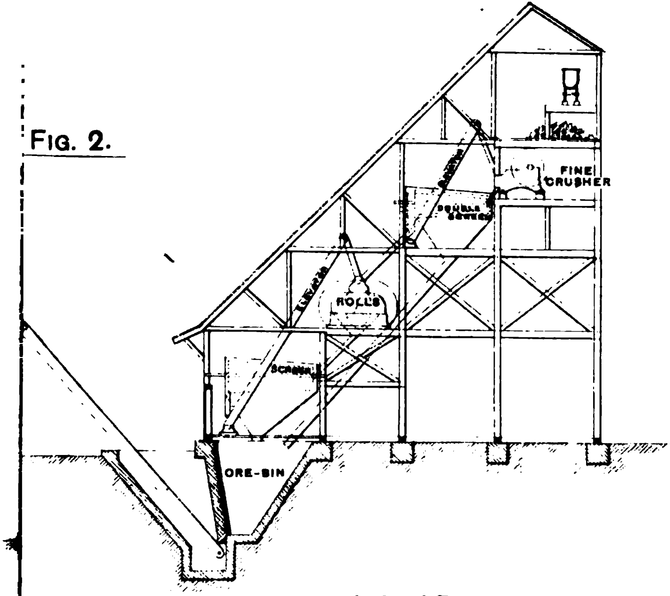
Scale, 24 Feet to 1 Inch.

Fig. 1.



Note.—The Breaker is situated in the Headgear at the Shaft.

Fig. 2.



Scale, 24 Feet to 1 Inch

Compared with the stamp-mill, the McArthur-Yates plant would pay for itself in a comparatively short time, on the item of water alone, under such circumstances.

A McArthur-Yates plant was recently constructed for Western Australia, and trials were conducted with one of the barrels in the presence of several prominent mining and metallurgical men, and Messrs. Tatlock & Brown, independent experts. A three hours' run with gold ore, assaying 7 ozs. 19 dwts. 21 grns. per ton, gave an extraction of 99·2 per cent. estimated on the value of the tailings, which assayed only 1 dwt. 7 grns.

Too much stress cannot be laid on the high extraction obtainable by this process when it is remembered that a yield of even a few extra pennyweights per ton, either by an improvement in the quality of the ore or in the method of extraction, often means all the difference between a paying and a non-paying mine.

In conclusion, the plant is worthy of consideration owing to its moderate cost; it will give a high extraction at an economical rate; and, whilst it will treat ores under ordinary conditions very advantageously, it is peculiarly suitable for districts where water is scarce.

Prof. H. LOUIS (Newcastle-upon-Tyne) wrote that it was difficult to estimate in advance the value of a new process before it had been practically tried; nevertheless, in this case, there was a considerable quantity of practical experience to guide members in comparing the MacArthur-Yates process with that of milling in the stamp-mill. It might be fairly assumed that the two processes differed only after the quartz had passed through the rock-breaker, whilst the cyanide process was the same for both. The 100 tons plant here described was equivalent to a 20 heads mill of 1,000 lbs. stamps, which would readily reduce 100 tons per 24 hours to an even finer mesh than the rather coarse screen specified in the paper. In the stamp-mill, crushing and amalgamation were performed in one operation, and were continuous; in the MacArthur-Yates process they formed two separate operations, and the amalgamation was discontinuous, the latter being a somewhat objectionable feature.

An investigation of the horse-power required in the two processes would give the following results:—From a long series of investigations, and after indicating a number of engines and other motors driving stamp-mills, he had no hesitation in fixing the indicated horse-power required to drive 20 heads of 1,000 lbs. stamps at rather under 40 horse-power, say about 38 horse-power, or, roughly speaking, the stamp-mill would crush 2½ tons of average quartz in 24 hours per horse-power (excluding rock-breaker). Turning now to the MacArthur-Yates process:—The power required for crushing would be: for the fine crusher, to crush 100 tons in 24 hours, about 15 horse-power; for Krom rolls to crush 40 tons, supposing the other 60 per cent. to be fine enough to pass the screens, about 12 horse-power; two screens, elevators, belting, etc., say 3 horse-power, or the total power required for crushing about 30 horse-power. The power required for amalgamating, that is to say, for driving the four amalgamating-barrels, might be roughly estimated: the barrel itself would probably weigh about 1 ton, and the charge being 3¾ tons, there would be a mass weighing about 5 tons to be kept in rotation at 15 revolutions per minute. From trials with smaller barrels, he would expect that it would take 3 to 4 horse-power to drive each of those barrels, or, say, 14 horse-power for the four; so that he estimated the power-consumption of the MacArthur-Yates process at about 44 horse-power per 100 tons crushed, or very considerably more than that of the stamp-mill. The above figures have been taken as far as possible from actual practice, the power-consumption of the stamp-mill being exactly known, and that of most of the elements composing the MacArthur-Yates process being very approximately known. He did not think that his figures would be found far out in actual working, and he had no doubt that this new process was very wasteful of power as compared to the stamp-mill.

Hitherto all attempts at amalgamating in rotating amalgamators had been failures, and it remained to be seen whether this new machine would fare any better.

The most serious objection, in his opinion, which of course applied to all dry-crushing methods, was the fact that a very small proportion of the ore raised in the world was suitable for dry-crushing. Any ore could be crushed wet, *i.e.*, in a stream of water, but for an ore to be crushed and screened dry it must be thoroughly dry, even a few percentages of water, especially in the case of clayey ores, rendering screening impossible. As far as his experience went, there were very few ores that were fit for dry-crushing as raised from the mine; some would be got in dry countries, such as Western Australia, but even there the permanent water-level must be reached before very long, and all ore below that level would require artificial drying before it could be screened dry.

The result quoted in the paper was of but little practical use, 8 oz. ore being rare in practical gold-mining. A process that left 1 dwt. 7 grains in the tailings was obviously not suitable for low-grade ores, such as were being largely milled to day. If it be thought that he was taking too pessimistic a view of the prospects of this new process, he could only say that he had seen scores of devices that were intended to replace the stamp-mill adorning the scrap-heaps of mines in all parts of the world, and that this consideration alone dictated the utmost caution in examining new gold-extraction processes.

Mr. H. M. CADELL (Bo'ness) said that there were one or two points on which it was very difficult from the description given to understand the working of the process—he could not understand, for instance, how the amalgamating arrangements inside the barrel were worked. One advantage of the process seemed to be that it dispensed with stamps. The essential part of the process, so far as he could make out, was the treatment with cyanide of potassium inside the revolving barrel. There was one paragraph in which the author said, "another feature of this plant is that it may be run as an ordinary percolation-plant, independent of the barrels;"* but as the barrels were apparently an essential part of the process, their disuse would completely destroy its special character. The writer said that a 3 hours' run had been made, giving an extraction of 99 per cent., but they would have liked to have heard the results of a 3 or 4 months' run. The idea was good, because the action of the cyanide of potassium on the quicksilver kept the mercury clean, and enabled it to amalgamate more easily with some ores. It was premature to pronounce any opinion upon the process until it had been more worked.

Mr. D. A. LOUIS (London) agreed with the previous speaker that the information in the paper was incomplete, not alone, however, as regards the apparatus employed, but also in reference to the material. As far as this point was concerned, it would seem that the process was intended to cover the whole range of gold-bearing materials, for there was no statement to the contrary in the paper, and this was a ridiculous position to assume, inasmuch as no process at present known could treat all gold ores, and certainly the one described would not; the author should state what kind of ore he treated to obtain a 99 per cent. extraction. In such

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* *Trans. Fed. Inst.*, vol. xii., page 364.

cases as these gold-processes, which were produced in very great numbers, a man should be precise in describing and proving his process, otherwise people were led astray. Taking the integral parts of the present process, which it was claimed would reduce, amalgamate, and cyanide ore direct with one plant, it was a strange fact that so far the combination of amalgamation and cyaniding in one apparatus had not proved successful, and if the process implied the use of several apparatuses, then it was in the same position as many other processes; for dry-crushing was a common practice, in successful use even before wet-crushing, hundreds of years ago; the use of a barrel for amalgamation was also as old as the hills, and the rest of the apparatus was that of the MacArthur-Forrest process. The success of the latter process rested in the fact that the inventors showed precisely how to get the gold out of certain ores, and unless a process did that one could not form a satisfactory judgment as to the value of the process. The present process might, perhaps, be a very good one, but not on the face of it, as gathered from the scanty information supplied in the paper, it was very desirable that the author be asked for more information, inasmuch as a process that extracted 99 per cent. of the gold contained in an ore was not met with every day, and should be indeed, worthy of the earnest consideration of the mining and metallurgical world.

Mr. R. R. TATLOCK (Glasgow) wrote that, having witnessed and conducted demonstrations of the capabilities of the MacArthur-Yates process on the full working scale, conjointly with Mr. M. Taylor Brown, he had formed the highest opinion of it, particularly in the case of ores containing both coarse and fine gold, and where water was scarce. The plant was part of an installation for Hannan's Brownhill Gold Mining Company, of Western Australia. The complete installation consisted of hoppers, liquor stock-tanks, 3 revolving-barrels, launders, percolation-tanks, and zinc precipitation-boxes, but the test run was made with only one of the barrels, as the barrel part of the operation was the differentiating feature of the apparatus from the ordinary cyanide or amalgamation process. The barrel was 4½ feet in internal diameter by 6 feet long, and was made of wooden staves and ends, carried on an iron shaft, and it was made to rotate by suitable gearing at about 16 revolutions per minute. A frame, free to rotate on the shaft, carried 2 corrugated copper amalgamated sheets; each sheet was 10 inches wide (after corrugation) by 3¾ feet long, presenting together a surface of about 12½ square feet, without taking into account the corrugations. The iron doors fitted into the barrel were large enough to admit of the plates being easily inserted and withdrawn, and they were easily taken off and replaced.

The details of the trial run were as follows:—The copper plates had previously been amalgamated, but were carefully scraped clean and weighed. The weight was 27 lbs. 2 ozs., quicksilver amalgam was then rubbed on, the amount used being about 1 lb. 8 ozs. (approximately), making the total weight of the plates about 28 lbs. 10 ozs.

The ore placed in the barrel weighed 2,997 lbs., and contained by assay 804·6 grains of fine gold. Coarse alluvial gold (weighing 4,603 grains and 884·2 fine) was also placed in the barrel, in order to enrich the ore and to represent, if possible, the position of matters when dealing with rich ore containing coarse gold. It was sprinkled in by hand, and care was taken that none of it fell directly upon the amalgamated plates, but that it was distributed as equally as possible throughout the whole mass of ore.

Water was then run into the barrel, and 25 lbs of crude cyanide of potassium (75 per cent.), which had been previously dissolved in water, was added, the total weight of water being 3,920 lbs.; this gave, approximately, a ½ per cent. solution of cyanide of potassium. The quantity of solution was more than would be required in ordinary circumstances, but it was necessary in order to fill up, as there was scarcely enough ore for the size of the barrel.

The doors were then closed, and the barrel revolved and stopped, after having run continuously with the exception of about four minutes, at half-time, when a stoppage was made to draw a sample of the ore. Immediately after stopping, the main discharge-doors were opened, the barrel given half a turn, and the contents discharged into the tank underneath.

Representative samples of the tailings were taken, carefully filtered off and washed, and a sample of the liquor was also taken, for assay, after filtration. The amalgamated plates were found to be in good condition, the surfaces looking very bright and free from flouring.

The plates weighed 29 lbs. 8 ozs. avoirdupois, showing a gain of 14 ozs. The plates were scraped, and yielded 12,088 grains, of which 400 grains were taken as samples for assaying. The remaining 11,688 grains were melted, yielding as bullion on first smelting, 4,860 grains, and on second smelting 88½ grains, and a total of 4,948½ grains from both smeltings. The total bullion, after an allowance for the gold (173 grains) in the 400 grains of sample amalgam, weighed 5,121½ grains.

The following assays indicate the fine gold in the tailings, the liquor, and the bullion:—Tailings, 19 grains per ton; liquor, 235 grains per ton of the liquor; liquor, 307 grains per ton of the ore; bullion, 750·4 fine.

The following statement shows the proportion of gold recovered, accounted for, and unaccounted for:—

	Grains.
Fine gold in ore, 2,997 lbs.	804·6
Gold in coarse alluvial gold, 884·2 fine, 4,603 grains introduced	4,070·0
Total gold in the working ore	4,874·6

Against this there was:—

	Grains.
Fine gold in bullion, weighing 5,121½ grains ...	3,843·2
Fine gold in liquor, weighing 3,920 lbs.	411·2
Total gold actually recovered ...	4,254·4
Fine gold in tailings, weighing 2,997 lbs.	25·4
Total fine gold accounted for ...	4,279·8
Fine gold unaccounted for, including gold-amalgam remaining on plate...	594·8
Total fine gold in working ore ...	4,874·6

The above statements showed an extraction of 87·27 per cent., which did not do full justice to the process, as new plates did not yield, when scraped, all the gold that they had taken, and therefore the figure of extraction (over 99 per cent.) obtained by deducting the gold contents of the tailings from the original gold contents of the ore was probably near the truth.

Mr. H. M. CADELL proposed a vote of thanks to the writer of the paper, and the resolution was cordially adopted.

The following paper by Mr. D. M. D. Stuart on "The Phenomena of Colliery Explosions" was taken as read:—

THE PHENOMENA OF COLLIERY EXPLOSIONS.

By DONALD M. D. STUART.

The subject of colliery explosions has engaged the attention of mining engineers for nearly a century, and experience and science have devised many precautions, with the result that the number of disasters have been greatly reduced during each succeeding decade. Explosions, however, still occur in the best arranged collieries, showing that there are some phenomena not yet fully recognized and understood; and, with this fact as a justification, the author ventures to offer this paper to the members.

The author had the advantage of investigating the first and second recorded explosions in mines that yield no fire-damp—viz., the disasters at the Camerton and Timsbury collieries, Somersetshire, in November, 1893, and February, 1895, respectively. These disasters provided opportunities for observing the phenomena of two explosions not complicated by the presence of fire-damp. They exhibited the effects produced by an explosive agent, and therefore pronounced its identity, as every agent is identified by the phenomena it produces. The records have this value: they demonstrate that explosions are produced in mines by gases derived from coal-dust, and that the processes are originated under ordinary working-conditions and operations; they also disclose the phenomena which identify explosions from this agent.

The effects of the disaster at the Camerton collieries were visible from the point of origin for 828 feet towards the coal-faces, and for 3,714 feet in the opposite direction towards the downcast shaft. The phenomena were equally clear at the Timsbury collieries, from the seat of origin to the upcast shaft, a distance of 2,900 feet, and into the several districts that branched off at intermediate points.

In the paths of the explosions, there were occasional exhibitions of destruction, where men had been exposed to violent forces; trams of coal hurled off the rails, crumpled up, and their contents scattered abroad; empty trams broken; the roof ripped down in large falls; timber structures reduced to matchwood; and wrought and cast-iron fittings and pipes torn or broken to pieces. These scenes of destruction were separated by intervals varying from 114 feet to 1,030 feet in length;[*] and in the intervening spaces the men had suffered no violence, the trams of coal were standing undisturbed, the empty trams were uninjured, the timber and fixtures were in their normal positions, and the iron fittings and pipes were not damaged or displaced. The phenomena of explosive violence at distinct points along the paths of the explosions, and the positive absence of such phenomena in the intervening spaces, demand for their explanation distinct modes of energy.

An examination of the local disturbances, in parallel passages, showed that the materials were displaced in opposite directions; and where the destruction occurred at junctions, the wreckage was distributed in the entrance of each road. The positions occupied by the displaced materials, indicated the exertion of explosive forces from a common centre, and exhibited the phenomena that must arise in a gaseous explosion, in which disruptive forces are necessarily exerted in radial lines, hurling movable objects in all directions around the gaseous body within a local area. The evidence in the disturbances and in the spaces between them left no room to question the occurrence of distinct local disruptions along the paths of the coal-dust.

Between the points of origin and the first disturbances, there were considerable lengths of road in which the men were found who fired the originating shots, also their cotton food-bags, loaded and empty trams, and timbering. The men had suffered no violence, not a bone was broken, nor their clothing disturbed, the food-bags were still hanging from the roof by cotton-tapes, the loaded and empty trams were alike undisturbed, and the timber standing in its ordinary position. Consequently there could not have been either explosive violence or a rapid gaseous movement between the shots and the first disturbances; the distances were 408 feet, 420 feet, and 578 feet respectively; and this undisturbed condition of road was repeated between every propagated explosion.

The author numbered the local explosions for facility of reference, and referring to the disaster at the Camerton collieries, he observed six loaded trams of coal in the road between No. 5 and No. 6 explosions, which threw some light upon the gaseous movement in the interval of 492 feet that separated these propagated explosions. The trams have an open end, in which lumps of coal are built up, and this wall of coal in the last

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[*] *Coal-dust an Explosive Agent*, page 30; *The Origin and Rationale of Colliery Explosions*, page 30.

tram faced the emergent gases of No. 5 explosion. About 60 lbs. of this exposed coal, in lumps of ½ lb. to 4 or 5 lbs. each, had disappeared. If the coal had been removed by mechanical force, the lumps or their fragments must have been present somewhere in the road, but the author could not discover any trace of them. He, however, observed heavy deposits of coked coal along the opposing faces of two rods or collars (6 feet long each) fixed next to the roof, almost immediately over the tram referred to. This coke and some fine carbon were the only visible remains of the missing coal, which had evidently been reduced to globules of coke by gases at an exalted temperature.* Had there been a great velocity in the horizontal movement of the gaseous body that attacked the coal, the particles of coke must have been swept along as they were produced ; but they ascended almost vertically to the faces of the overhanging timber, and were deposited there, indicating a comparatively slow onward movement of the gaseous body, and showing that the disruptive forces of No. 5 explosion were expended in the immediate vicinity of their production, about 120 feet from the tram of coal.

In a stall at the Timsbury collieries, about 210 feet from No. 6 explosion, a tram of coal was found undisturbed upon the rails; the blocks of coal standing from 15 to 18 inches above the woodwork, the top surface reaching a height of 4 feet above the floor. The hard faces of these blocks of coal all round the tram had been made to burst out into globules of bituminous matter, which underwent further destructive distillation, leaving residues of comminuted coke. Some globules remained attached to the faces of coal in different stages of production; and every ledge of coal, the edges of the woodwork of the tram, and the buffers, were loaded with accumulated particles of coke resembling small shot, or coarse sand.† These particles of coke did not ascend to the roof, but gravitated down to the resting-places where they were found ; showing an inadequate horizontal movement, in the gaseous body that attacked the coal, to carry the particles forward; and that the disruptive forces in No. 6 explosion, which were necessarily of an enormous velocity, were also expended in the immediate vicinity of their production.

Another observation upon the air-current at the Camerton collieries, adds to this part of the subject. Between the point of origin of the disaster and the downcast shaft, there were seven violent disturbances, in

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* *Coal-dust an Explosive Agent*, pages 68 and 69.

† *The Origin and Rationale of Colliery Explosions*, pages 20 and 55.

several of which, the falls were each estimated to measure from 600 to 800 tons of rock and shale. These falls were in the main intake-airway; the last one being 2,838 feet from the downcast shaft, and the road for this distance approximated to a straight line. During the occurrence of the explosions, the onsetter was standing at the bottom of the downcast shaft, and neither felt nor heard anything unusual. He observed that the flame of his open light was momentarily reversed towards the shaft, but insufficiently to arouse a suspicion that anything was wrong. Another man was standing in the intake at an intermediate point 1,848 feet from No. 10 explosion, and he did not feel or hear anything of the explosions beyond a puff of wind that put out his candle; he attached no importance to this as it often occurred, the air-current travelling at a high velocity.*

The absence of appreciable mechanical force in the movement of the atmosphere between the shot and the first disturbances, in the spaces between the successive disruptions, and at the end of the propagations, with the phenomena of intermittent exhibitions of explosive violence, amount to demonstration that a series of local explosions occurred at the *loci* of the disturbances, in which disruptive forces were exerted in all directions and expended in their immediate vicinity.

The foregoing phenomena in the atmospherical movement admit the element of time antecedent to each disruption, for the destructive distillation of the coal and the production of the explosive gaseous mixtures, to the ignition of which the local explosions were due. The author has, therefore, described the lengths of undisturbed road that are observed antecedent to each explosion, as gas-generating spaces.

Observations made at the *loci* of the disruptions disclosed the fact that they occurred at the junctions, sidings, where large cavities existed in the roof, at sharp angles in the road when the path of the explosion was against the air-current, and where a door formed a *cul de sac*. One condition common to these *loci* was a larger provision of atmospheric oxygen than could be obtained in the antecedent spaces.†

Another branch of evidence was the deposition of coked coal upon the timber, trams, and floor of the workings, which appeared to be deposited in these places under special conditions, and not in the general progress of distillation. In the immediate vicinity of the shot at Camerton collieries, the floor was covered with a crust of coke, and the

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* *Coal-dust an Explosive Agent*, pages 65 and 66.

† *Ibid.*, pages 72 to 73. *The Origin and Rationale of Colliery Explosions*, pages 14 and 28.

faces of the timber fronting the shot were thickly coated with coke to a height of 12 inches above the floor, above that point there was very little deposit.

At Timsbury collieries, a tram was standing between No. 4 and No. 5 explosions, from which the author took the following observations:—

> Tram loaded with shale, standing upon the rails, had not been disturbed. Coked coal-dust upon the end facing the course of the explosions. The buffer-ends, measuring 12 inches above the floor, covered with coked coal-dust, ⅜ inch thick. Many patches of coked coal upon the wooden end of the tram, thinning off to nothing at 21 inches above the floor, the upper 9 inches of the wood being clean. No trace of coke upon the angle-irons, draw-bar, link, wheel, or axles, nor upon any other part of the tram.

An obstruction in the path of the explosions will therefore retain a deposit of coke, if it present a surface at the necessary height, to which the intumescent coal-dust can adhere. The evidence at this tram, which is confirmed by many other observations, shows that the coal-dust upon the floor is subjected to distillation, the particles rising to a height in this case of 21 inches. The coal-dust on the sides and the upper parts of the timber is, no doubt, attacked by the hot educts; but in the intervals between the explosions, the author observed coked coal near the roof in one place only, and that was at a sheltered plank, which had flakes of coked coal lying upon it.*

In the vicinity of explosions, coked coal was observed upon the opposing faces of timber on opposite sides of the disruptions, and it is not difficult to conceive how the hot, pasty coal-dust would be projected against these opposing surfaces by the forces of the explosions which moved in radial lines.

Where propagations were arrested, with small coal left in suspension in a semi-distilled condition, it is also conceivable that with the atmosphere in front at normal or greater tension, and the atmosphere behind in an attenuated condition due to the chemical changes that had taken place, the suspended pasty coal would retreat and be deposited on the faces of timber contrary to the course of the explosions, and this deposition was observed at Timsbury collieries.†

The deposits of coked coal on the timber lying next to the roof, over the tram between No. 5 and No. 6 explosions at Camerton collieries, will present no difficulty when it is known that the distillation was

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* *The Origin and Rationale of Colliery Explosions*, page 32.

† *Ibid.*, pages 33 and 52.

going on in the face of the incoming air-current, and, consequently, the chemical action was energetic, and the globules of coke were carried upward with the educts.

The comminuted coke at the tram, beyond No. 6 explosion at Timsbury collieries, was in a receding air-current with the supply cut off; hence only a small quantity of coal was distilled; and the action was not sufficiently vigorous to carry the globules of coke in resistance to gravitation.

The positions in which the deposits of coked coal were found, are explained by the hypothesis of local explosions with antecedent gas-generating spaces, and the condition of the air-currents.

Observations were made upon the nature of the atmosphere that filled the workings after the disasters. The roads had collapsed locally at many of the disruptions, and the circulation of air was suspended. The products of the gaseous explosions with the residual gases, filled the roads in the fields of disaster, and were imprisoned between the falls; forming a series of still atmospheres, that could only be displaced by diffusion, until the final obstruction was reached and removed and the circulation of the air restored.

The exploring parties frequently advanced into the stagnant atmosphere more rapidly than diffusion was effected, to make apertures through the falls; and had favourable opportunities of observing the effects of this atmosphere. Their open lights burned brightly, and disclosed the absence of the small percentages of carbon dioxide and of the inflammable gases, that are appreciable by the ordinary tests; but they suffered physiological sensations that ended in unconsciousness. They observed the atmosphere laden with particles of soot, and compared it to the condition produced by "turning a bed-tick inside out and shaking it in the air." The author observed that this suspended matter had been universally deposited upon the walls and timber of the roads throughout the fields of disaster; and, upon examination, found it to be amorphous carbon, such as may be obtained by burning hydrocarbons in limited quantities of air. The carbon obtained by holding a glass rod in an illuminating gas flame, and the compact form of the deposit, are well known; the carbon at the Camerton and Timsbury collieries proved, upon investigation, to be the same in substance, but differed in the form of deposition. In numerous places in the mines, the carbon upon the timber and strata was in gossamer-like form, and gave the surfaces a veined appearance.* The author

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* *Coal-dust an Explosive Agent*, pages 54 and 55. *The Origin and Rationale of Colliery Explosions*, page 34.

collected these striated filaments upon paper; but, however carefully preserved, they broke down into powder under the slightest pressure. The general deposit was a loosely built up and dilated stratum, which, when touched with a flat surface, shrank to a fraction of its original thickness. It was obviously the accumulation of successive settlements of particles originally in atmospheric suspension; and that condition of the atmosphere in the mines immediately after the disasters is a fact of observation. These depositions of carbon were, therefore, distinct in structure from the deposition that arises from the impingement of a hydrocarbon flame upon a cold surface. The origin of this carbon is not far to seek; the residues of coked coal already referred to, are the evidence of distillation, showing that hydrogen and gaseous hydrocarbons flowed into the atmosphere of the workings; and these hydrocarbons provided the amorphous carbon, of which it formed the solid constituent.

The separation of this carbon of the educts involves questions in thermo-chemistry which cannot be dealt with in this paper, beyond saying that the processes that caused its separation were the sources of heat upon which the explosive phenomena depended.

The author suggests the following theory to explain the phenomena now recorded. The products of the ignition of the mining powder, with their unexpended heat, were projected through the planes of ruptured strata, in fan-like sheets, striking the coal-dust on the floor, and setting up destructive distillation. The educts flowed into the atmosphere of the mine, but could not undergo explosive combustion, although an ignition-temperature was at command, because the atmospheric oxygen was inadequate or not within reach to make an explosive mixture. In the loose dust and *débris* and in interstitial spaces, there was necessarily some oxygen, which would be seized by the free hydrogen and by the hydrogen constituent of gaseous hydrocarbons in the educts, its oxidation liberating the carbon of the latter in solid form to float in the atmosphere. The temperature reached by the oxidation of hydrogen being about 2,000 degs. Cent., and there being a large quantity of heat generated in that process, the remaining hydrocarbons that had not previously undergone change would, at that temperature and in the absence of atmospheric oxygen, undergo dissociation, placing free hydrogen at disposal for disruptive action where oxygen could be obtained, and leaving more of the fine carbon in atmospheric suspension.

A series of chemical actions of constant sequence was, therefore, established in the immediate vicinity of the shot, in which there was the partial oxidation of hydrogen referred to, generating heat, which instituted a series of chemical changes identical with those which the heat supplied by the products of the mining powder had originated; and these regenerative activities were of constant and similar reproduction along the path of the coal-dust, free hydrogen undergoing constant accumulation, until a place was reached in the workings where the available quantity of air was greatly increased, and there being an ignition-temperature at command in the partial combustion taking place, the accumulated hydrogen was oxidized with explosive violence, causing the disruptive effects observed at the *loci* of the initial local explosions.

The quantities of heat generated in the initial local explosions greatly exceeded the total quantity of heat in the products of the mining powder, and it will be readily understood that an advancing series of similar changes to those described was again established in the coal-dust beyond, producing secondary explosions at points farther away, where the conditions for the oxidation of the accumulated hydrogen were fulfilled; consequently, the explosions would be propagated along every path of the coal-dust, so long as atmospheric oxygen was available, and there were no wet spaces to bring down the temperature.

This theory satisfies the demand for chemical changes causing a constant regeneration of heat, and places an explosive gas at disposal for disruptive action, without the production of carbon monoxide or carbon dioxide, and which did not yield these gases as products. It accounts for the practical absence of carbon monoxide and carbon dioxide from the atmosphere in the fields of disaster, with the fact that the carbon constituent of the hydrocarbons was not oxidized, but disseminated in the atmosphere, where it was found in copious suspension by the exploring parties, and from which it had been deposited upon the vertical faces of the enclosing walls in dilated layers and in striæ, giving the faces of stone and timber the veined appearance already referred to.

It is not difficult to understand why there was an absence of mechanical effect upon the ventilating-power at the Camerton collieries, when it is remembered that the gaseous hydrocarbons that were being constantly added to the atmosphere of the mine, were almost immediately eliminated by the oxidation of the hydrogen constituent; and that the volume of the incoming air was being constantly diminished by the removal of its oxygen forming one-fifth of that volume, for the oxidation of the hydrogen in the explosions and antecedent actions in successive productions of steam, undergoing eventual liquefaction by surrender of heat; and that by means of this exhaustion, the mechanical equilibrium of the air-current was maintained.

The terminations of the explosive phenomena admit of explanation. Propagation of the explosions was observed to have been abruptly arrested in roads where dry coal-dust abounded, and at these places observations disclosed the presence either of coked coal-dust or amorphous carbon, indicating chemical activity that supplied heat and ignition-temperature. The absent factor in the explosive cycle was therefore atmospheric oxygen, and the condition of the air-currents confirmed the conclusion. Propagation failed, because the chemical actions languished to extinction, due to an inadequate supply of atmospheric oxygen for the oxidations which yielded heat to carry on the distillation and other chemical changes. The fundamental difference between the path of propagation and the path in which propagation failed was in the condition of the air-currents. In one very small split of the air-current, and in return air impoverished of its oxygen, the chemical processes were observed to have been arrested.

Propagation was also arrested in wet places, and is explained by the fact that the product of the oxidation of hydrogen would by its contact with wet surfaces undergo a change corresponding to what takes place in the condenser of a steam-engine. The external stratum of the product coming in contact with the cold wet surfaces would be instantly condensed, leaving a vacuous space into which another stratum would fall and be condensed, and the process would be repeated so rapidly during the slow gaseous movement as to make condensation practically instantaneous. The product being liquefied by surrender of heat, the temperature would fall below the distilling-point, and the chemical actions come to an end.

The disaster at the Timsbury collieries originated in the main intake-airway; and while the disastrous effects that are identified with a colliery explosion were produced from the shot to the upcast shaft on one side, there were no such effects from the shot in the opposite direction towards the downcast shaft. Observations, therefore, show that had the condition of the airway from the shot towards the downcast shaft also prevailed from the shot towards the upcast shaft, the disaster would not have happened. The difference between the two portions of the airway was as follows:—On the upcast side, it contained the full circulating current of air, which at the time of the disaster was about 18,000 cubic feet per minute, and the coal-dust was dry. On the downcast side, it contained the same circulating current for a distance of 150 feet; at that point the ventilation entered the intake from a side road; but 525 feet beyond, a door was fixed, and the air between the side road and the door was a still atmosphere. The coal-dust was more or less damp or wet at the side road and wet up to the door; the still atmosphere was laden with water vapour to saturation.*

At the Camerton collieries, the coal-dust was equally dry on both sides of the shot, and disastrous effects were produced in both directions. The propagation against the intake air-current after being active for 3,714 feet, causing great destruction, was abruptly arrested at 2,838 feet from the downcast shaft. The atmosphere at this point was the main intake air-current in which the 3,714 feet of propagation had occurred, and the author made the following observations of the condition of the road where the propagation was arrested, commencing in the vicinity of the last or No. 10 explosion†:—

	Feet.	Feet.
Archway and fall; floor and sides dry and dusty	—	90
Water and mud on floor; no dust	66	
Floor damp between the rails; damp dust outside of rails	24	
Last fall, floor and sides damp; no dust	21	
Water and mud on floor, sides wet; no dust	48	
		159
Floor damp between rails, intermittent wet spots; dust outside of rails damp to dry	234	
Floor and sides damp and muddy	24	
Floor and sides dry and dusty to horse-gug	261	
		519

The effectiveness of wet lengths of road in stopping the propagation of an explosion, is a fact of observation; and air saturated with water-vapour must, in the nature of the case, be a valuable contributory precaution.

The arrest of propagation is consequently brought about by atmospheric conditions in which heat cannot be generated for the reproduction of the distillatory and other chemical actions, because the supplies of atmospheric oxygen are inadequate; also by wet surfaces, which demand the surrender of the heat for the evaporation of their moisture.

Most of the principal phenomena of the disasters at the Camerton and Timsbury collieries have now been referred to, and the theory which the author has advanced upon his records and investigations, may be shortly stated as follows:—

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* *The Origin and Rationale of Colliery Explosions*, pages 45, 48, and 49.

† *Coal-dust an Explosive Agent*, page 28.

A colliery explosion, in which coal-dust is the principal agent, comprises numerous local explosions, separate in time and in space, at irregular intervals, where the available supplies of atmospheric oxygen are greatly increased, and caused by the explosive combustion of hydrogen derived from the coal-dust in the antecedent spaces, by a series of chemical actions, of constant sequence, which produce heat for regeneration without auxiliary intervention, and are constantly reproduced along the path of the coal-dust under the conditions named.

This theory accounts for the coked residues of coal, and the positions in which they were found; explains the presence of amorphous carbon in atmospheric suspension, and its characteristic deposition upon the enclosing walls throughout the fields of disaster; accounts for the practical absence of carbon monoxide and carbon dioxide in the gaseous products; supplies the heat for the distillatory action, for dissociation, for raising the air of the gaseous mixture to ignition-temperature, and for supplementing the losses due to the contact of the products of combustion with cold surfaces; allows time for the distillation of coal, and the chemical changes in the series of actions; provides the explosive gas for producing the disruptions; explains the occurrence of the disruptions at intervals, the absence of mechanical effects in the intervening spaces, the conditions under which propagation proceeds or is arrested, the maintenance of the mechanical equilibrium of the air-current at Camerton collieries, and excludes no coal—except that which yields no combustible gases when subjected to the temperature of destructive distillation.

Mr. G. E. J. McMurtrie (Cinderford) wrote that there were one or two points not explained by Mr. Stuart's theory of a coal-dust explosion, as exemplified at Camerton and Timsbury. According to Mr. Stuart, while the coal-dust on the floor was fused, that on the props, and on the crown-trees, or caps, appeared not to have been touched. Now, the latter was generally considered the most inflammable portion of the dust, and yet according to Mr. Stuart's statement was not touched, while the dust on the floor, which in thin-seam districts was very largely composed of under-earth and horse-dung, was fused. Surely, too, if the speed of these propagated explosions was not great, the gases whilst traversing such lengths as 1,030 feet must have greatly cooled down; if so, Mr. Stuart's theory did not explain the successive propagated explosions.

What, too, became of the oxygen in those lengths? Was it absorbed by the heated gases in their progress, or not? Mr. Stuart's statement that "propagation of the explosions was observed to have been abruptly stopped in roads where coal-dust abounded,"* was strange and contrary to what was generally received.

Prof. H. LOUIS (Newcastle-upon-Tyne) wrote that Mr. Stuart's theory, as far as he could follow it, seemed designed to account for the absence of carbonic acid and carbon monoxide in the after-damp. As it had been most conclusively proved that both of these gases did exist in after-damp, the application of this theory seemed to him to present some difficulties.

The theory appeared to be that "the products of the mining powder . . . projected through the planes of ruptured strata"† still retained sufficient heat to distil marsh gas from the coal-dust on the floor of the workings and to dissociate this gas into carbon and hydrogen. The temperature of such dissociation was not exactly known, but it was certainly higher than that of the interior of a gas-retort or above a bright red-heat. But Mr. Stuart's theory demanded that even after their heat had been absorbed in dissociating the gas, "the products of the mining powder" should still retain enough heat to ignite the hydrogen thus generated. It was not quite clear whence this additional quantity of heat was to come, nor why the gas should not ignite at this very elevated temperature, of which it need only be said that if the "products of the mining powder" were hot enough to perform these operations, they would be quite hot enough to dissociate water into its elements, or to fuse the strata through which they were projected.

He (Prof. Louis) saw no reason for any such complicated theory. It was well known that very finely divided particles of solid carbon suspended in air could be readily and instantaneously burnt, the difference between the mode of combustion of a gas and of a very finely divided solid being one of degree, rather than of kind.

Mr. JAMES ASHWORTH (Derby) wrote that Mr. Stuart's paper on "The Phenomena of Colliery Explosions" appeared to be devoted to a consideration of the phenomena of two explosions as diagnosed from the observations of the author, and not a consideration of the phenomena observed in connexion with other explosions. These phenomena appear to be capable of being summarized under the following heads, viz.:—(*a*) that an explosion when once initiated from any cause has not the

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* *Trans. Fed. Inst.*, vol. xii., page 379. † *Ibid.*, page 377.

character of a single or simple explosion, but has that of an uncertain number of explosions; (*b*) that the length of roadway traversed by these explosions is of uncertain length; (*c*) that the theory of the author is built up on the basis of dissociation of hydrogen gas from the products of distilled coal-dust, which first distillation is effected by the heat of the originating cause, and afterwards by the heat developed by each succeeding explosion; (*d*) that the product of each explosion is steam, and not carbon monoxide and carbon dioxide; (*e*) that the evidence of the point where an explosion has originated is to be found at the place where most damage is produced; (*f*) that the after-damp at Camerton and Timsbury collieries disclosed the absence of the small percentages of carbon dioxide and of the inflammable gases that are appreciable by the ordinary tests, but the open lights burned brightly and the explorers suffered physiological sensations that ended in unconsciousness; (*g*) that air saturated with water-vapour must be a valuable contributory precaution in stopping the progress of an explosion; and (*h*) that the effects, propagation, and after-damp of the explosions at the Camerton and Timsbury collieries were entirely different from those of any other recorded explosions.

The first consideration which suggests itself under the (*a*) paragraph of this summary is, that this conclusion of the author is not in accord with the observations of any other author who has dealt with the explosion of gases, or with the vibratory action of explosions in gases, or with the velocity of the flame developed by such explosions, nor with the effect of the condensation of the steam on the third and all succeeding explosions, excepting only the last one. With respect to this he says:— "The external stratum of the product coming in contact with the cold wet surfaces would be instantly condensed, leaving a vacuous space into which another stratum would fall and be condensed, and the process would be repeated so rapidly during the slow gaseous movement as to make condensation practically instantaneous. The product being liquefied by surrender of heat, the temperature would fall below the distilling-point, and the chemical actions come to an end."* Now, as the effect of condensation was continuously at work from the time that the originating explosion took place, and until the termination of the author's series of explosions, and as the "gaseous movement" is said to be "slow," it is clear that the theory set up cannot be complete in its argument without the effect of the successive condensations being also taken into account.

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* *Trans. Fed. Inst.*, vol. xii., page 379.

The author's theory depended at the outset on there being sufficient heat produced by the products of a blown-out or over-powdered shot, not only to distil gas from the coal-dust, but also to dissociate the hydrogen from the other products. This dissociation depended entirely on the heat of the evolved gases, and the author assumed this to have been 2,896 degs. Cent.; but as the powder had already expended a large proportion of its heat in breaking its way out of the shot-hole, it was not possible that this degree of heat could remain, and it must also be remembered that such a great heat could only exist so long as the products of the powder were confined, and, further, that if some of the powder-grains were driven out into the roadway, either unburnt or only partially burnt, the temperature could not approach that suggested by the theorist. Moreover, we had ample evidence that no heat of such exalted temperature was produced, because (taking the case of Camerton), the man and boy who were killed were able to escape out of the refuge-hole (105 feet from the shot) and run 57 feet after they had been burned in the refuge-hole. This latter circumstance, coupled with the fact that their bodies showed no signs of any secondary burns, would seem to be conclusive evidence that there was no such temperature then existing in the roadway as would dissociate hydrogen gas from the products of coal distillation. To further show that the author had immensely over-estimated the residual heat that was available for the working-out of his theory, it must be noted that at Camerton the initial points of his gaseous ignitions were placed at points 828 feet apart, and at Timsbury 573 feet apart, and that the men found in the incline at Camerton were within 258 feet of one point of ignition, and therefore exposed to its force as well as its heat, and yet neither of them showed any traces of these effects. The value of these facts in practically considering the author's theory is further shown by noting that the volume of hydrogen-gas estimated to have been exploded at this point was 1,000 cubic feet. This volume of hydrogen would represent not more than 5 per cent. of the cubic contents of the road, if evenly distributed, and as its ignition would be a detonating effect, and not a simple explosion, it was possible to assert, on the authority of Prof. Berthelot and Prof. H. B. Dixon, that the length of time occupied in traversing the whole length of the affected roadway at Camerton would occupy something less than one second of time. Until the facts of this first explosion were cleared up, it was not worth while to consider each succeeding explosion in detail; but there was one other fact in connexion with the author's theory, which also affected the basis on which it was built up, viz., the indications (*e*) which he had accepted as proof of the points where one or more of the ignitions took place. The first disproof of this acceptance lay in the fact that the men at Camerton were not blown to pieces, and that in every case where an explosion had been traced to its real point of origin, the men close to the point of ignition had been very little injured, and in many cases very little burnt. To instance a few cases:—Bardsley colliery, March 30th, 1873, two men were burnt, of whom one survived; East Ardsley colliery, August 4th, 1884, two men were burnt, of whom one survived; Higham colliery, Barnsley, October, 1857, gas fired at the furnace, the furnace-men got out alive, but all the horses in the pit were killed; Woodend pit, Leigh, August 13th, 1886, the gas fired at a lamp, but the man using it was scarcely singed, and a man close by got out alive, while 38 men further away were killed; Micklefield, and many more cases, might be quoted.

To prove that the product of explosion was steam (*d*), and not carbon monoxide and dioxide, the author said that at Camerton as well as at Timsbury collieries the ordinary tests disclosed the absence of small percentages of carbon dioxide and of inflammable gases; but it must be noted that he did not mention carbon monoxide, the presence of which was very strongly suggested by the fact that open lights burned brightly, and the explorers suffered physiological sensations which ended in unconsciousness. The doctor's report on the cause of death unfortunately did not state whether the characteristic pink coloration due to carbon monoxide poisoning was or was not present, but the position of the man's body at Camerton suggested that his death was not instantaneous.

With regard to the best means of arresting the propagation of an explosion, the author advocated the saturation of the ventilating-current with water-vapour (*g*). This point was not new, but as he (Mr. Ashworth) had often pointed out in communications on the subject of coal-dust, its value as a preventive measure to localize, or in any way prevent, an explosion was entirely illusory, because the safety-point of saturation could not be obtained. When considering this matter we have to bear in mind that the percentage of watery vapour which any current of air could carry was in direct proportion to its heat, that is, the greater its heat the more water it could carry, and the less its heat the less water it could carry; and as the effect of sprays was to lower the temperature, we cannot be surprised to find that the figures given by Mr. H. W. Martin, in his evidence before the Coal-dust Commissioners, proved that sprays gave a reduction of 2 degrees of heat, but no increase of aqueous vapour. Thus there were 7·3 grains of aqueous vapour in every cubic foot of air at the working-face when the sprays were at work, and exactly the same when the sprays were not at work, proving that the warmer air took this weight of vapour from the natural evaporation of the mine and from the men, animals, and lights. At the Maybach colliery, Saarbruck, the temperature was only lowered 1 deg. Cent. by spraying, and the humidity of the coal-dust at the working-faces varied between 2·05 and 3·65 per cent. Now, as this is under the percentage (5 per cent.) which Prof. Dixon, in his paper on the "Rate of Explosions in Gases,"* stated to give the highest explosive results when present in the air, it must be evident that spraying added directly to the risk of the propagation of a coal-dust explosion, and also indirectly by the possible production of water-gas, which would enhance the deadliness of the after-damp.

He (Mr. Ashworth) whilst thus showing the insufficiency of water-sprays, would, as he had always done, strongly advocate wet lengths of roadway, particularly the application of sprays placed at short distances apart, and so applied that the water would first wet the roof and timbering, and that the surplus would fall on the floor and keep it saturated to the extent of 50 per cent. over a distance of 200 feet as a minimum. A wet floor was not in itself a sufficient protective, neither was it a sufficient protective when assisted by water-sprays as ordinarily applied. His reasons for so strongly treating this part of the subject arose from observed phenonema not referred to by any other writer on the subject of coal-dust and other colliery explosions, viz., that the explosive flame when rushing through the galleries of a mine did not, as a rule, fill the area of the road but only a certain depth from the roof, and that the passage of the flame in this manner was frequently accompanied by an after-blast of air. As an example of these phenomena, he would quote a recent case which from the published data seemed to fulfil the conditions, viz., that of Nos. 15 and 16 bodies on the main west level of No. 8 pit and No. 56 in No. 1 district at Tylorstown colliery. Nos. 15 and 16 bodies were severely burned on the face and hands, to which caked dust adhered, and were superficially burned on the upper portions of the chest and forearms, and their clothes were ripped off. The burning effects he attributed to the explosive flame, which might fill about half the height of the level, the ripping off of the clothes to the after-blast, and the scorching to the residual heat of the explosion. In the case of No. 56 body, the evidence indicated these dual and consecutive effects even more clearly, because only the head and the front of the chest were burned, whilst the back was clean and unburned, although the clothes

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* *Trans. Fed. Inst.*, vol. iii., page 312.

were ripped off and the head, legs, and arms torn from the body. The tearing off of the clothes and the mutilation of the body, he (Mr. Ashworth) attributed to the after-blast. Perhaps it would be as well at this point to explain what he meant by the after-blast: it was the motion of air in mass caused by displacement. It might be seen when blank cartridge was fired from heavy ordnance by its effect on the grass in front of the muzzle. Its effect was also practically demonstrated when the s.s. "Cabo Machichaco" was accidentally blown up by dynamite in 1894, at the quayside, at Santander, when several persons in the town had their clothes torn off, and great damage was done both by concussion and displacement of the air.*

There were many more phenomena disclosed by colliery explosions, but time would not permit him (Mr. Ashworth) to do more than refer to some of them very briefly. First, then, as to the quantity of coal-dust which took part in an explosion, the writer had been and still was of opinion that only such coal-dust as was in suspension in the air at the time when an explosion was initiated took part in the actual explosion. And that coal-dust which was, as a matter of course, disturbed by the blast itself, or by the after-blast already referred to, was only affected by the residual heat of the explosion. Also that the coke which was oftentimes deposited on the opposite side of props, etc., to that exposed to the original blast, was so deposited by a "return current of air" caused by the condensation of the products of the original explosion, or by a "return flame," which was often in evidence after an explosion and was caused by the burning of the carbon monoxide gas in the presence of unconsumed oxygen or of oxygen supplied from the adjacent roads. To be brief, excellent examples of the effects of a return current caused by condensation were recorded in Messrs. J. B. and W. N. Atkinson's account of the Usworth explosion,† and of a return flame in Mr. William Galloway's account of the Pen-y-graig explosion.

In conclusion, and for the sole object of drawing attention to other phenomena, he would ask for an expression of opinion on the question, why a level or working-face ventilated by a current of air travelling from east to west should be more subject to disaster than one ventilated by a west to east current of air? Also why, when an explosive flame extended through the shaft to another mine or seam of coal, the west side was again preferred by the devastating flame? And lastly, whether a great deal of most valuable information might not be obtained by, firstly, a

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* *Engineering*, 1896, vol. lxii., pages 261, 299, 360, 448, and 515.

† *Explosions in Coal-mines*, page 69 *et seq.*

microscopical examination of coal-dust obtained from the ventilating-current or upper timbers, or ledges in the neighbourhood of the point of origin of all recent explosions, on lines similar to the microscopic examination of the Altofts dust made by Mr. W. E. Garforth; and secondly, by an exhaustive examination of each dust on lines similar to those pursued by Dr. P. P. Bedson when experimenting on the occluded gases of coal-dust, but without first drying the coal-dust.

Mr. W. N. ATKINSON (H.M. Inspector of Mines, Newcastle-under-Lyme) wrote that the essential part of Mr. Stuart's paper was the evolution of a theory concerning the manner in which coal-dust explosions were propagated. He had read Mr. Stuart's book on the Camerton explosion, where the evidence on which this theory was based was more fully set forth, but he was entirely unconvinced that any such mode of propagation as Mr. Stuart described actually took place, nor did he see the necessity of such a theory to account for all that was observed after a coal-dust explosion. He had investigated a great number of explosions both of fire-damp and coal-dust, some very minutely and others in a more cursory way, amongst the latter class being the explosions at Camerton and Timsbury. In no explosion had he seen indications which, in his opinion, lent any support to the idea that a coal-dust explosion "comprises numerous local explosions, separate in time and space, at irregular intervals."* It was easy to understand that differences in the quality of coal-dust, in chemical composition, fineness, purity, and dryness, would cause differences in the violence produced by its explosive combustion in air; and also that the propagation of a dust explosion might be almost arrested by local lack or impurity of dust, and be then resumed with full force under more favourable conditions.

Nothing was more difficult to gauge than the absolute or relative force developed in a mine explosion, and Mr. Stuart seemed to have gone on the principle of attributing every striking evidence of violence, such as a broken door or tub, or a big fall of stone, to a local explosion. Such striking evidences of force were at once observed, but to prove the absence of force in the intervening portions of road was a much more difficult matter, and on this essential feature of the theory the observations cited by Mr. Stuart in his account of the Camerton explosion were far from sufficient to maintain the theory. He (Mr. W. N. Atkinson) had heard it stated after an explosion that there had been no force on a certain section of road, and on examination found that this conclusion had been drawn because of the absence of evidence of force, the observer having

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* *Trans. Fed. Inst.*, vol. xii., page 381.

forgotten to consider that there was nothing there to leave traces of violence. The mere fact that timber remained in position was not always a criterion that great force had not traversed the road: much depended on how the timber was set. For instance, at Camerton, he observed, in the case of some of the timber which remained in position, that the posts were set in small recesses cut into the wall-sides, which would effectually preserve them from the force of a blast. When timber was once displaced, the amount of stone which fell bore no relation to the force of the explosion, as Mr. Stuart seemed to imagine, but depended on the nature of the roof. Uninjured full tubs, again, were not evidence of the absence of a force great enough to completely smash empty tubs. Neither Mr. Stuart's account of the Camerton explosion nor his own observations conveyed to his mind the conviction that there was any satisfactory evidence of the absence of force between the points described as the sites of local explosions, except at the point of origin of the explosion; and the absence of force for some distance on each side of the point of origin of several previous explosions, initiated in the same way as that at Camerton, had been observed and described in a number of cases.

No estimate was made by Mr. Stuart of the time required for the slow propagation of the flame through the spaces separating the numerous supposed local explosions, but surely, if such separate explosions were usual in coal-dust explosions, they could not fail to have been observed in the large number of cases where men had escaped and described what they saw and heard of the explosions. At Camerton, the onsetter observed but one reversal of the air. The progress of the flame was supposed to be "comparatively slow" between the various local explosions, and this was supported by a curious observation on a tram of coal, between Nos. 5 and 6 explosions, at Camerton, from which it was said that about 60 lbs. of coal had disappeared in lumps of ¼lb. to 4 or 5 lbs. each, and as the fragments could not be found, Mr. Stuart concluded that they had been transformed into coke and fine carbon, the coke being deposited on two bars almost immediately above the tram from which the coal had disappeared. To effect this phenomenon the explosion must surely have halted altogether at this point, because lumps of coal weighing 4 or 5 lbs. would require quite an appreciable time to be converted into coke and fine carbon. It is difficult to understand how coke so produced could be deposited on bars in the position described, but it may be noted that while this was going on Mr. Stuart supposed there was still an incoming air-current.*

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* *Trans. Fed. Inst.*, vol. xii., pages 375 and 376.

He would not now attempt to follow Mr. Stuart in the description of the chemical processes which were described as resulting in the intermittent explosions, but on this part of the subject it would be interesting to have the opinion of chemists. He was at a loss to understand, however, why it was thought necessary to place "an explosive gas at disposal for disruptive action, without the production of carbon monoxide or carbon dioxide, and which did not yield these gases as products."* It appeared to be Mr. Stuart's opinion that carbon monoxide and dioxide were not formed by coal-dust explosions; but according to Dr. Haldane's report on *The Causes of Death in Colliery Explosions and Underground Fires*, carbon monoxide was the most usual cause of death, and he had no doubt that this statement was correct.

He could not subscribe to Mr. Stuart's opinion that coal-dust explosions were arrested for want of oxygen, on roads containing sufficient oxygen for working purposes. Experiments made by Dr. Haldane and himself showed that, in the case of fire-damp, explosions easily occurred in atmospheres containing far less oxygen than was required to keep a lamp alight, and until the contrary was proved, it appeared probable that such would also be the case with coal-dust. No doubt, the arrest of explosions on dry roads was a difficult question, and one requiring further investigation. It was usually difficult to locate the exact place where the flame of the explosion ceased, and it was reasonable to suppose that a considerable amount of dust would be carried by the rush of air or gases beyond that point, both of which considerations were disturbing factors in determining the nature of the dust where the flame ceased. Mr. Stuart said, "propagation of the explosions was observed to have been abruptly arrested in roads where dry coal-dust abounded."† He (Mr. Atkinson) had paid considerable attention to this point, and believed that in those cases where such a conclusion at first sight appeared probable, that the real cause of the stoppage of the explosion lay in the impure nature of the dust at such places. A case in point occurred at Timsbury. He was told that in certain districts the explosion had stopped on roads where there was much coal-dust, and went to see one of these places. After locating the place where it appeared most probable that the flame had ceased, he examined the dust, which at that place was practically confined to the floor. It appeared black and dry, and by a cursory examination would pass as coal-dust and small pieces of coal; but a closer examina-

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* *Trans. Fed. Inst.*, vol. xii., page 378.

† *Ibid.*, vol. xii., page 379.

tion showed it to be largely mixed with shale. Examined in daylight, it was greyish-black in colour, and the majority of the particles large enough to show their composition were of a dark-coloured shale. It was possible that there were other conditions which might determine the arrest of a coal-dust explosion on a dusty road, but it appeared very improbable that lack of oxygen should be the cause in an ordinary mine roadway, whether an intake or a return air-way.

In treating of the Camerton explosion, Mr. Stuart took up the subject as if that explosion was the first in which coal-dust had been the only agent. He said "fire-damp was an acknowledged danger; but a large experience had failed to establish such a character for coal-dust, and the non-gaseous mines possessing a historical freedom from explosions, no opportunity had arisen to investigate the phenomena of an explosion in which coal-dust was the exclusive agent;" and a few lines below, coal-dust was referred to as a "hidden danger in coal-mining."* So far from being hidden, the danger of coal-dust had been widely acknowledged for some years previously, chiefly through the valuable researches of Mr. W. Galloway; and since 1880 it had been contended, and was still maintained by himself and others, that some of the most disastrous modern mine explosions were due solely to coal-dust. Then as now, there were dissentients from that opinion, and so recently as 1892, when the possibility of an explosion in some of the non-gaseous mines of Somersetshire† was suggested, it was said to be "putting theory against the facts."‡ It was true that the explosion at Camerton was the first to be recorded in this county, as occurring in a mine reputed to be absolutely free from fire-damp, but in the United States of America it had previously been reported that more than one severe explosion had occurred in mines where fire-damp had never been detected. Since the explosion at Timsbury, the absolute freedom from fire-damp of the Somersetshire mines had been questioned.

Mr. M. **Deacon** (Alfreton) thought that the members of the Institution were indebted to Mr. Stuart for the trouble that he had taken in preparing such a valuable paper; it raised several points which would be new to the minds of many of the members. The theory of separate explosions set up by Mr. Stuart was not clearly substantiated by the arguments, the principal of which were the intervals of disruption

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* *Coal-dust an Explosive Agent*, page viii.

† *First Report of the Royal Commission on Explosions from Coal-dust*, page 176.

‡ *Transactions of the National Association of Colliery Managers*, vol. iv., page 80.

and the absence of mechanical effect upon the intervening roadways of the mine. Doubtless, a variation in the constituents of the gases in the mine at different points would have the effect of varying the intensity of the explosion (or perhaps more correctly, in the case of coal-dust, "inflammation"), as it followed its course through the mine; but without a continuation of the flame it was difficult to understand how Mr. Stuart accounted for the separate ignition of the successive explosions.

Mr. Stuart said that the records of the Camerton and Timsbury explosions had this value, that they demonstrated that explosions were produced in some cases by coal-dust, and the processes were originated under ordinary conditions and operations. He (Mr. Deacon) did not quite agree with Mr. Stuart in these deductions, as he thought that coal-dust explosions were probably initiated by the firing of the resultant gases from the explosive. Certain qualities of blasting-powder had been proved to yield a very large percentage of carbon monoxide, amounting in some cases to nearly 20 per cent. of the total of the resultant gases. This gas, if collected in a vessel, could be easily ignited by a lighted match being dropped into it, and if a little coal-dust were sprinkled into the vessel at the same time, a long extension of flame might be obtained. He would like to know whether the blasting-powder used in the shots which were supposed to have created the Camerton and Timsbury explosions had been tested for resultant gases, and if so with what result?

With regard to the absence of evidence of mechanical force in certain portions of the mine, he (Mr. Deacon) thought that this, in many cases, might be due to the natural condition of the mine, and to the absence of timber or any other substance forming a resistance to the force of the explosion. At Blackwell colliery, this was found to be the case, but the evidence of heat, which was apparent more or less along the whole length of roadways covered by the explosion, satisfied him that in this case, at any rate, the flame was continuous throughout the whole extent of the roadways affected. There was no apparent evidence of separate explosions. Similar results were found at Blackwell to those at Camerton and Timsbury, in the small amount of damage done in the near proximity of the shot which was supposed to have caused the explosion. Three men and a horse, and some tubs of coal, were found about 90 feet distant from the point of the explosion on the out-bye side, none of which gave evidence of special mechanical disturbance; but there was no satisfactory evidence that the gaseous movement was not as rapid at that point as at any point of the explosion. The men and the horse were all slightly burned.

He (Mr. Deacon) only agreed with Mr. Stuart in his theory of separate explosions in so far as "separate explosions" might be taken to mean a greater development of force at one point in the travel of the flame than at another.

Mr. W. C. **Blackett** (Durham) said that one doubtless obtained from Mr. Stuart's paper a very closely-reasoned mind-picture of what that gentleman considered might occur in an explosion of coal-dust. But, except in some points of what were really sub-details of the main issue, the theory advanced differed in no important particular from others which had been promulgated by various persons over a considerable period of years. By the main issue, he (Mr. Blackett) meant the one broad fact that coal-dust could be fired in a mine, and the resulting phenomena attended by a consecution of explosive violence throughout those passages of the mine where the conditions lent themselves to the event. Mr. Stuart must, however, forgive those who cannot follow and acquiesce in all his views of these details.

For instance, it was impossible to agree with the statement that "the phenomena of explosive violence at distinct points along the paths of the explosions, and the positive absence of such phenomena in the intervening spaces, demand for their explanation distinct modes of energy."* From the observations which he (Mr. Blackett) had had the opportunity of making at several explosions in the County of Durham, he disagreed with the premises involved in this statement. It did not seem to him that there were any of these very distinct points of violence, or that there was any such positive absence of violence, in intervening spaces.

He (Mr. Blackett) had quite fresh in his mind the state of the Brancepeth mine after the recent disaster, and he thought that the thesis might be put more accurately by saying that the propagation of a coal-dust explosion through the galleries of a mine was distinguished by phases of increased violence occurring at successive stages in the path which had been prepared by what he had termed "pioneering phenomena."† The principal difference, therefore, between Mr. Stuart and himself, was that where Mr. Stuart maintained a succession of distinct explosions, he (Mr. Blackett) upheld one continuous action, having phases showing from stage to stage increments of greater violence.

At no point, in the paths of the explosion at Brancepeth, was there to be seen a positive absence of expansive violence. It was true that

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* *Trans. Fed. Inst.*, vol. xii., page 372.

† *Ibid.*, vol. vii., page 54.

there were points where, by comparison, there was very little violence; but in no case was this ever so small as to allow of the impunity of the stoppings, which in every instance were blown into the returns. A close examination of what Mr. Stuart called "local disturbances," but which he (Mr. Blackett) preferred to name "localities of increased disturbance," showed that of two moving forces which had been at work, there were always evidences of one being stronger than the other, and the former was always in a direction away from the initiatory point of explosion. Thus there were few, if any, points in Brancepeth where (without tracing it *ab initio*) one could not definitely say from which direction the blast had come; but, in order to do this, it was necessary to eliminate as guidances the position of most of the lighter articles which had got adrift or were loose. Very heavy articles, and those which were difficult to move and remained attached, were invariable in the certainty of their monition.

Now he (Mr. Blackett) thought that if Mr. Stuart were suddenly placed in the centre of one of his "local disturbances" situated between two "intervening spaces" of positive repose, he would be unable to say in which direction lay the initiating point of the originating explosion and if he was right he ought not to be so able, because each distinct explosion should show radiating force equal on all sides. But he (Mr. Blackett) ventured to say that there was not one single locality in Brancepeth where there was not some quite convincing sign which stood out pre-eminently over all its fellows. The "opposite directions" shown, to his (Mr. Blackett's) mind, simply conveyed an impression that the blast had originally loosened and carried away a number of articles which had returned with the back-draught of gases on their way to fill up the void caused by the condensation and cooling of the heated resultants, and they doubtless give a similitude to the "exertion of explosive force from a common centre" of "local disruptions."

In the length of road in which the men were found, who had been using the blasting-powder which originated the explosion at Brancepeth, all the stoppings had been almost dissipated, while within 100 feet of the shot, and within 60 feet of the powder-canister, which had also exploded, were displaced timbers and a heavy fall. Notwithstanding these indications, the road comparatively speaking was not greatly disturbed, although the water-tub which had been used by the men was smashed to pieces. Instead, therefore, of 400 or 500 feet mentioned by Mr. Stuart in this case, great violence had occurred well within 100 feet.

This central space should, according to Mr. Stuart, have been quiescent and devoted by the liberated heat solely to distillatory purposes, but within 60 feet of the fired blasting-powder, was a stopping of which barely two or three bricks remained together, and of which almost every brick had been blown away as far as possible and buried deep in dust and rubbish. Surely, an order of repose which could admit of the forcible ejectment of a solidly built brick-stopping was of a somewhat violent nature, and could scarcely be properly described as showing an "absence of appreciable mechanical force in the movement of the atmosphere."

It should also be remembered that this state of things prevailed throughout the Brancepeth pit wherever the explosion had travelled. He could not recall a single stopping which had remained. If Mr. Stuart's ideas on the subject were correct, one would certainly expect to find in those generating-spaces, which he said were so little influenced by any moving force, that even small particles of coke were enabled to ascend and settle on timbers under the roof, immediately over the point where the lumps of coal from which he supposed they were distilled, that the brick-stoppings, which at any rate cannot float in the air, would at least remain standing in their site, and those only be removed which happened to coincide with the centre of one of the "*loci* of disruptions."

But nothing of the kind was to be seen, and if it could so easily be shown that everywhere there was sufficient motive power to cause the disappearance of the stoppings, it must also follow that there was at least sufficient power to raise a heavy cloud of dust, which, becoming intimately mixed with the oxygen of the air, was in exactly the same favourable condition to suffer combustion as was the cloud of dust which an ordinary light ignited in the Brancepeth hopper some years ago.

It is quite natural to conceive that a rush of such phenomena through a mine would not maintain uniform characteristics. It would, indeed, be extraordinary if it maintained laboratory precision, and it was this continuous change in the conditions which had deceived Mr. Stuart. If a mine were suddenly overrun with fire-damp, and an explosion occurred before diffusion had been completed, similar phenomena would be experienced. Where the mixture with air was more favourable, there would be much violence, and where the proportions were excessive or otherwise, there would be less.

Mr. Stuart emphasized the violent injuries suffered by some men as compared with the immunity of others. But it was unnecessary to assume a detonation to account for such injuries. It was not difficult to assume that, where a phase of increased violence had severely developed itself, it was possible for the atmosphere to have reached a speed of 5 or

6 times that of one of the most rapid air-currents. Such a speed would be at least 100 miles per hour, and if imparted to a man's body would in its course account for all such injuries. An eastern typhoon would probably furnish among its hundreds of victims many such cases.

Reverting to the disappearance of 60 lbs. of coal, "in lumps of ¼lb. to 4 or 5 lbs. each," did Mr. Stuart really expect anyone to believe that any heat there ever was available during a mine explosion could distil such lumps so as to deposit the carbon immediately overhead, merely because Mr. Stuart was unable to find the lost coal? The disappearance of articles in a pit after an explosion, such as bricks from stoppings, and the like, was often very perplexing, but one did not generally jump to the conclusion that they had been volatilized. It is much more reasonable to conclude that one's power of discovery had failed. However great might be the absolute temperature reached by any of the products during a mine explosion, the time of contact was so brief as to preclude the idea that "lumps" of coal could be distilled. Why did particles of coke ascend to the roof from one tram, and descend to the floor from another, as mentioned by Mr. Stuart? It was impossible to establish any relation between coked dust, found after an explosion, and coal in the neighbourhood.

Probably one of the most striking features of Mr. Stuart's theory was that which allowed the specific heat of the gases to distribute a kindling temperature over such various lengths of road. Thus in one of his tables*:—No. 3 explosion, which only covered in its limits of destruction a distance of 18 feet, developed a temperature sufficient to distil gases and ignite No. 4 explosion at a distance of 390 feet; while No. 7 explosion, which covered 357 feet, had only a generating-space of 198 feet for No. 8 explosion. Suppose, therefore, the whole of the first 18 feet were filled with gases at a temperature of 2,000 degs. Cent. (which was not likely), this heat spread over a length of 390 feet would be reduced by admixture alone to about 145 degs. Cent. How then could No. 4 explosion be started unless combustion were continuous?

Mr. Stuart also utterly ignored the possible importance of the physical properties of dust. Everyone must remember the interesting experiments made by Sir Frederick Abel on dust at the time of the Seaham explosion, in which it was found that magnesia even helped to explode an otherwise non-explosive compound of fire-damp and air, owing to the peculiar catalytic action of such dust. It was more than possible that this peculiarity was exercised by dust in the violent combustion of its own products.

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* *Coal-dust an Explosive Agent*, page 30.

He (Mr. Blackett) would like Mr. Stuart to enlighten the members as to what really did take place in the Brancepeth hopper and in such similar instances. If it was not combustion, with more or less violence, of dust and air, what was it? And if it was combustion, why should not the same phenomena be produced in a mine as well as in a hopper? And if more confined, and the air more dense, why should such combustion not be increasingly violent?

To answer such questions, Mr. Stuart was obliged to deny the existence of the "pioneering phenomena," which alone could produce sufficient clouds of dust. He (Mr. Blackett) would like to remind Mr. Stuart that this term of "pioneering phenomena" did not occur in the Report of the Royal Commission.* There were very few mining engineers who would agree with Mr. Stuart in this statement, and there was definite evidence of the occurrence at Brancepeth. The rush of wind knocked down an elderly man, who was working near the shaft-bottom, and rendered him for a time unconscious. Upon recovery, one of the first things this man noticed was the sneezing of the horses in the stables (due to dust), and clouds of dust were seen to ascend out of the downcast shaft, were deposited on the surface, and penetrated into the winding-engine house. The engineman said that he heard a rushing noise, and knew that an explosion had taken place.

Violence also had been exerted within the south way, for some considerable distance, and the two boys working therein (who subsequently came out alive) felt a rush of air, which extinguished their lights, but they attributed it to a fall of stone. In such places, as the working-faces were approached, the propagation of the explosion ceased, because the air had no longer sufficient freedom, and therefore the "pioneering phenomena" ceased. Again, if there were such "an inadequate horizontal movement in the gaseous body which attacked the coal," as Mr. Stuart suggested, was it not difficult to account for the perfect ease with which one distinct explosion communicated itself against a very rapid air-current to another?

He (Mr. Blackett) found that his most searching observations failed to discover any dust completely coked. Quantities were intumesced, and much had a very soot-like appearance, but still, under the microscope, it seemed quite distinct from ordinary soot.

Mr. Stuart alleged the "practical absence of carbon monoxide" in the gaseous product of an explosion. He (Mr. Blackett) had closely examined scores of bodies killed by after-damp at Seaham, Tudhoe,

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* *Coal-dust an Explosive Agent*, page xiv.

Trimdon Grange, and Brancepeth. He had also felt the effects of breathing after-damp himself, and anyone who had seen the former and felt the deadly sickness and excruciating headache of the latter, was most unlikely to state that there was a "practical absence of carbon monoxide." Nothing could be more conclusive than the bright pink appearance of certain parts of bodies killed by this gas. The head and chest were so brightly coloured at times as to give a life-like appearance, such as was sometimes seen after violent and over-heating exercise, and, not unusually, effusion of blood had occurred from the ears and nostrils. He (Mr. Blackett) was also inclined to think that the bodies did not soon assume *rigor mortis*. In fact, the blood was no longer blood proper, but another chemical compound of the red corpuscle with carbon monoxide, and that only. Dr. Haldane's report to the Home Office, and his paper,[*] were the first clear medical evidence which had appeared on this subject, and they should be carefully read, when little further evidence would be needed to disprove Mr. Stuart's statement. It was not exaggeration to say that nearly all the bodies in a mine were killed by carbon monoxide, even many of those who would otherwise have died from terrible injuries.

He (Mr. Blackett) thought that the amount of labour and thought given to the matter by Mr. Stuart deserved considerate treatment, but, at the same time, he could not agree with Mr. Stuart's views, and he trusted that he had discussed the matter with all propriety.

Mr. STUART wrote, in reply to the discussion, thanking the members for the attention which they had given to his paper. It was difficult to condense the results of his investigations within the limits of a paper, and he thought that some of the misapprehensions in the discussion might have been due to this circumstance. He suggested that a further examination of the paper would remove many of the difficulties that had been felt; and observed that it contained the answers to several of the questions raised, *e.g.*, Mr. G. E. J. McMurtrie spoke of the coal-dust on the floor being coked, but, referring to the coal-dust on the timber, remarked—"According to Mr. Stuart's statement it was not touched;" whereas the paper stated—"The coal-dust on the sides and the upper parts of the timber is no doubt attacked by the hot educts."[†] Apart from this statement, the theory of chemical actions in the path of the coal-dust involved the distillation of the coal-dust on the timber. Mr. McMurtrie continued—"If the speed of these propagated explosions was not great, the gases while traversing such lengths as 1,030 feet must

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[*] *Trans. Fed. Inst.*, vol. xi., page 502.

[†] *Ibid.*, vol. xii., page 375.

have greatly cooled down; if so, Mr. Stuart's theory did not explain the successive propagated explosions," showing that he had overlooked the theory of the paper, particularly the hypothesis of a constant regeneration of heat along the path of the coal-dust—which was as essential for the production of explosive gas from coal-dust by distillation, as heat was necessary to distil gas from coal in a gas-retort; without this theory successive propagated explosions were impossible.

Prof. Louis remarked that "Mr. Stuart's theory, so far as he could follow it, seemed designed to account for the absence of carbonic acid and carbon monoxide in the after-damp;" but in the final paragraph of his paper, it would be found that the theory was designed to account for a variety of phenomena, of which the practical absence of carbon monoxide and carbon dioxide formed but one element; and that all the phenomena must necessarily find an explanation in the theory. Prof. Louis continued that "it had been most conclusively proved that both of these gases did exist in after-damp." Upon this question, Mr. W. N. Atkinson observed that "it appeared to be Mr. Stuart's opinion that carbon monoxide and dioxide were not formed by coal-dust explosions; but according to Dr. Haldane's report on *The Causes of Death in Colliery Explosions and Underground Fires*, carbon monoxide was the most usual cause of death, and he had no doubt that this statement was correct;" and Mr. W. C. Blackett remarked that "Dr. Haldane's report to the Home Office and his paper* were the first clear medical evidence which had appeared on this subject, and they should be carefully read, when little further evidence would be needed to disprove Mr. Stuart's statement." The statement made in his paper was respecting "the absence of the small percentages of carbon dioxide and of the inflammable gases, that are appreciable by the ordinary tests."† The facts recorded were, that the lights burned brightly in the after-damp, which was the ordinary test to prove the absence of more than 2 per cent. of carbon dioxide; and the exploring parties suffered faintness and unconsciousness only after long exposure to the after-damp; indicating that the carbon monoxide was considerably less than 1 per cent. of the gaseous mixture. If the hydrocarbons of the coal-dust had been burned in the explosions, large quantities of carbon dioxide, and appreciable quantities of carbon monoxide, would have been gaseous products forming a considerable portion of the after-damp. In such circumstances, the lights would have been extinguished, and all the exploring parties must have been rendered almost immediately unconscious. The contrary was the case; and the carbon constituent of the hydrocarbons was not

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entirely oxidized, but almost wholly separated out, and disseminated in the after-damp; consequently, the quantities of carbon dioxide and carbon monoxide that would be necessarily produced in the conditions set out in the paper were less than the small percentages named.

The appeal made by Mr. Atkinson and Mr. Blackett to Dr. Haldane's report upon *The Causes of Death in Colliery Explosions* called for notice. The fact that deaths have been largely due to carbon monoxide poisoning had been long known and accepted, and the supposition made by Mr. Atkinson and Mr. Blackett, that it was opposed in the paper, was imaginary. They would find it stated therein that members of the exploring parties "suffered physiological sensations that ended in unconsciousness," the well-known effects produced by carbon monoxide in the after-damp.

The properties of carbon monoxide were known to mining students more than thirty years ago, when Sir Lowthian Bell proved its explosive character; and Dr. Thomas Richardson, of Durham University, brought the researches of Dr. Le Blanc to the notice of mining engineers, which showed that the fatal effects of after-damp were due to the presence of carbon monoxide; this, when forming only 0·54 per cent. of the gaseous mixture, caused faintness, feelings of suffocation, stupefaction, and death. Mining engineers had not been so long ignorant as to the poisonous properties of after-damp, or the cause of death being due to the presence of carbon monoxide in that atmosphere, as some gentlemen have recently seemed to suppose.

Prof. Louis further observed:—

> The theory appeared to be that "the products of the mining powder . . . projected through the planes of ruptured strata," still retained sufficient heat to distil marsh gas from the coal-dust on the floor of the workings, and to dissociate this gas into carbon and hydrogen. . . . Mr. Stuart's theory demanded that, even after their heat had been absorbed in dissociating the gas, "the products of the mining powder" would still retain enough heat to ignite the hydrogen thus generated. It was not quite clear whence this additional quantity of heat was to come, nor why the gas should not ignite at this very elevated temperature. . . . He saw no reason for any such complicated theory.

By reference to the paper, the theory will be found stated in the following terms:—

> The products of the ignition of the mining powder, with their unexpended heat . . . striking the coal-dust . . . setting up destructive distillation. The educts flowed into the atmosphere of the mine, but could not undergo explosive combustion, although an ignition-temperature was at command, because the atmospheric oxygen was inadequate or not within reach. . . . In the loose dust and *débris*, and in interstitial spaces, there was necessarily some oxygen, which would be seized by the free hydrogen, and by the hydrogen constituent of gaseous hydrocarbons in the educts . . . its oxidation. . . . The temperature reached

> by the oxidation of hydrogen being about 2,000 degs. Cent., and there being a large quantity of heat generated in that process, the remaining hydrocarbons that had not previously undergone change would, at that temperature . . . undergo dissociation, placing free hydrogen at disposal for disruptive action where oxygen could be obtained. . . .

Prof. Louis was therefore under a misconception in supposing the theory demanded that the heat in the products of the powder should, after initiating distillation, effect dissociation in the educts, and subsequently provide an ignition-temperature; also in suggesting that the theory failed to indicate the source of the supplementary heat, or to explain why the educts were not burned. The theory had its illustration in the processes for the production of lamp and diamond black, which were not complicated.

Mr. James Ashworth referred to the phenomena recorded in the paper, and gave what he supposed to be a summary, under eight heads—for which there was very little justification. The statement marked (*h*) had not been suggested by the author of the paper, and it was contrary to his views. The statement (*e*) "that the evidence of the point where an explosion has originated is to be found at the place where most damage is produced," is also directly opposed to his (Mr. Stuart's) theory. The paper stated that between the points of origin and the first explosions, as well as in the intervals between succeeding explosions, the roads were undisturbed, and the evidence was given: "The men had suffered no violence, not a bone was broken, nor their clothing disturbed, the food-bags were still hanging by cotton-tapes, the loaded and empty trams were alike undisturbed, and the timber standing in its ordinary position."* Mr. Ashworth would find his criticisms upon "temperature, heat, distillation, and dissociation" answered in the paper; and in regard to his supposition that the explosion was instantaneous throughout the field of disaster, disallowing time for local explosions, and his appeal to the researches of Prof. Berthelot to sustain that idea, it would be found by reference to these researches that the conditions of propagation of explosions in gaseous mixtures confirmed his (Mr. Stuart's) theory of explosions at intervals along the path of the coal-dust.

There were other statements made in the discussion as representing his (Mr. Stuart's) theory, which were contrary to it; and with the replies already made to many misconceptions, he referred the members to his paper, feeling that its further perusal would remove the difficulties they had expressed; and he would now deal with only one of the remaining remarks upon this question.

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* *Trans. Fed. Inst.*, vol. xii., page 372.

Mr. W. N. Atkinson remarked that "in treating the Camerton explosion, Mr. Stuart took up the subject as if that explosion was the first in which coal-dust had been the only agent," and made him (Mr. Stuart) say that coal-dust was a "hidden danger in coal-mining." Mr. Atkinson complained that he (Mr. Stuart) had therefore done injustice to Mr. W. Galloway and others, whose investigations had shown the dangers of coal-dust some years previously. The words quoted will be found in the preface of *Coal-dust an Explosive Agent*, in the following connexion :—

> Fire-damp was an acknowledged danger; but a large experience had failed to establish such a character for coal-dust, and the non-gaseous mines possessing an historical freedom from explosions, no opportunity had arisen to investigate the phenomena of an explosion in which coal-dust was the exclusive agent. In November last, an explosion occurred at the Camerton collieries, Somersetshire, a non-gaseous mine, which afforded the occasion for studying the features of an explosion produced by an agent other than fire-damp, and of elucidating a hidden danger in coal-mining.*

It would be seen that the author's remarks were, that the Camerton explosion was the first occasion upon which coal-dust had been the only agent in a non-gaseous mine—which was a fact; and the task that he had set himself was to elucidate a hidden danger—hidden in the sense that a large number of mining engineers could not recognize it as an exclusive danger, though every one accepted fire-damp as such. Mr. Atkinson's separation of his (Mr. Stuart's) words from their qualification, and the prejudicial construction which he had offered upon the partial extract, appeared to be wanting in correctness.

He could have read earlier in the preface the remark that for some time previously coal-dust had been suggested as a danger; and observed that the researches of Prof. Galloway, Mr. Hall, himself, and others were referred to in the introduction to the volume, as antecedent to the author's investigations.

Mr. W. N. Atkinson has suggested a doubt as to the absolute freedom from fire-damp of the Camerton and Timsbury collieries, but offered no evidence for the statement. He referred to the Timsbury explosion, when some men stated that from forty to fifty years previously, when they were boys twelve years of age, they had lighted gas at a neighbouring mine. Mr. J. S. Martin, H.M. Inspector of Mines, heard the evidence, and disposed of the matter in his report as unworthy of serious attention. If Mr. Atkinson had known the facts as they were known to Mr. Martin and others, doubtless he would not have made the suggestion referred to.

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* Page viii.

In reply to the doubts suggested by Mr. Atkinson upon his cursory examination of the Camerton and Timsbury mines, and by Mr. Blackett as to the correctness of his (Mr. Stuart's) observations of the phenomena of the explosions, he had to state that he was engaged for five days in the Camerton and three days in the Timsbury collieries; and pursued the exact methods of observation and measurement acquired during several years' studies in physical and chemical laboratories. As the suggested doubts affected the value of fundamental observations, he felt it necessary to state that his records could not be questioned by any gentleman who had made equally exhaustive investigations with the advantage of the preceding experience in the methods of research referred to.

Referring to Mr. Maurice Deacon's remark, that "without a continuation of the flame it was difficult to understand how Mr. Stuart accounted for the separate ignition of the successive explosions," he (Mr. Stuart) replied that he relied upon the heat in the continuous oxidation of the hydrogen to ignite the explosive mixture at each *locus* of explosion; and in response to Mr. Deacon's desire to know the "resultant gases" of the mining powder used at Camerton and Timsbury collieries, he (Mr. Stuart) regretted that he had not the information to offer, as no experiment had been made.

Upon the important question of explosions at intervals along the path of the coal-dust, he (Mr. Stuart) observed that Mr. Deacon and Mr. Blackett appeared to accept the principle. Mr. Deacon said that "he only agreed with Mr. Stuart in his theory of separate explosions, in so far as 'separate explosions' might be taken to mean a greater development of force at one point in the travel of the flame than at another;" and Mr. Blackett observed that "the principal difference, therefore, between Mr. Stuart and himself, was that where Mr. Stuart maintained a succession of distinct explosions, he (Mr. Blackett) upheld one continuous action, having phases showing from stage to stage increments of greater violence."

The phenomenon to be explained was the exhibition of explosive violence in abnormally large sectional areas of road. The kinetic energy in Mr. Deacon's travelling "flame," and in Mr. Blackett's "continuous action," when emerging from normal sectional areas into large spaces, must suffer a diminution of power to exert disruptive action. The failure of this kinetic energy to effect disruption in the antecedent small area would, therefore, be more pronounced in the large space. The disruptive effects in the larger area consequently demanded for their explanation the exertion of potential energy disruptive in nature, and exhibited a mode of energy only known in the ignition of highly explosive bodies.

In estimating the value of the absence of disturbance of roof and timber in the intervals between the explosions, the natural strength of the roof formed a factor as suggested by Mr. Atkinson and Mr. Deacon, which was considered and recorded in his (Mr. Stuart's) investigations. The observations at the Camerton collieries upon this question were summed up in the following words :—" In the sections of violent energy, the roof was broken down, alike in friable strata requiring double timbering, and in firm strata needing only occasional props," which covered every description of roof between the explosions.

Mr. Atkinson carried the question further, saying :—" When timber was once displaced, the amount of stone which fell bore no relation to the force of the explosion, as Mr. Stuart seemed to imagine, but depended on the nature of the roof. Uninjured full tubs, again, were not evidence of the absence of a force great enough to smash empty tubs." Mr. Atkinson might equally say, that the effect of an explosion in military or submarine mines, bore no relation to the force of the explosion ! and his conflict upon this question was not with the writer (Mr. Stuart), but with an established principle in mechanics, viz., the relation of energy to work.

The absence of mechanical force between the explosions was a fact of observation. When considerable lengths of road with roof of the same nature, demanding timber uniform in strength and quantity, presented the phenomena of disruption at intervals in which the timber was displaced, sometimes fractured; and the roof, whether of shale, faulted stone, or strong bedded cliff, was broken down, while the timber and roof in the intervening spaces were not disturbed, there could be no question that disruptive energy had been exerted in the disruptions, and not in the intervals. When wooden structures, air-pipes, loaded and empty trams, were found at numerous points in the field of the explosions, undamaged and undisturbed; while in the spaces between them, corresponding structures were broken to pieces, air-pipes rent into parts, full and empty trams alike thrown off the rails, the woodwork broken up, the ironwork fractured and contorted, and the contents scattered abroad; the effects of mechanical violence at the *loci* of destruction, and of its absence in the intervals, had their demonstration. When the bodies of the men were found distributed over the field of the explosions, many at separate points, simply burnt, but not otherwise injured, while in the intervals between them other bodies were found blown to pieces; phenomena were exhibited that demanded for their explanation explosions at the *loci* of the mutilations, and their absence at the adjoining *loci* of unmutilated men.

Mr. Blackett ventured the remark that the mutilation of bodies would be produced by the air-current travelling at the velocity of "100 miles per hour," and referred to the Brancepeth explosion in which a case of mutilation was reported as follows:—"At first, an arm was found, and about 30 feet distant the remains of the body," which the manager described as follows:—"It was like a lump of flesh, we could not tell what it was." Mr. Blackett suggested that this mutilation was produced by a current of air at a speed of 100 miles an hour. He had to consider the force represented by a current of that velocity, to understand its impotence to effect such results. The human body sustains normally a pressure of 14·7 lbs. per square inch, and retained its structure and form under pressures of over 40 lbs. per square inch. The velocity of 100 miles per hour represented a pressure of 0·34 lb. per square inch; and this added to the normal pressure of 14·70 lbs., made Mr. Blackett's mutilating force 15·04 lbs. per square inch; or one-third of the resistance the body had successfully sustained in working operations. The teachings of mechanics would show Mr. Blackett, that when disruptive effects were to be produced by energy stored up in an elastic medium like a mass of air, the velocity of that mass to effect disruption by its impact, must be equal to the immense velocity reached in the ignition of highly explosive gaseous mixtures; and nothing less than a violent local explosion at the spot where the unfortunate man in the Brancepeth colliery stood, could have imparted to the air a velocity capable of exerting the disruptive energy exhibited in his mutilation.

A short distance from these mutilated remains, another man was found in the path of the explosions, who had suffered no mutilation, indicating the local character of the explosion, and illustrating the principle ennunciated by Prof. Berthelot, that the velocity of the explosive wave rapidly diminished in the conditions external to the exploded gaseous body.

The absence of disruptive energy in the intervals between the explosions was not only an observed fact, but must be so in the nature of the case from what was known of the behavionr of explosive gaseous mixtures upon ignition.

Mr. Atkinson declined to accept his (Mr. Stuart's) remark that the arrest of propagation in dry and dusty roads was due to the want of oxygen, but that question was governed by the teachings of chemistry. He continued to say that "he would not attempt to follow Mr. Stuart in the description of the chemical processes which were described as resulting in the intermittent explosions, but on this part of the subject it would be interesting to have the opinion of chemists." He (Mr. Stuart) would be pleased to hear that Mr. Atkinson had taken the opinion of chemists experienced in the treatment and explosion of gaseous mixtures and the destructive distillation of coal. Mr. Atkinson was probably not aware that his (Mr. Stuart's) investigations had been examined by a distinguished chemist, who had recorded the results in the *Chemical News** in the following words:—"On a careful perusal of Mr. Stuart's book, we are convinced that he interprets the phenomena in strict accord with the facts observed, and with well-known chemical and physical laws."

In conclusion, he (Mr. Stuart) observed that the importance of the subject of colliery explosions and the interest that must attach to new suggestions which propounded a rationale of the calamities fundamentally different from the prevailing opinion, appeared to call for the lengthy reply he had made to the discussion. He hoped that many of the objections to his theory had been removed by the further remarks now made, and that the Institution would continue to promote the elucidation of the subject.

DISCUSSION ON MR. G. E. COKE'S PAPER ON "THE SOUTHERN LIMIT OF THE NOTTINGHAMSHIRE COAL-FIELD."†

Mr. G. E. Coke (Nottingham) said the Ruddington boring, which had been continued, confirmed the idea that the limit of the Nottingham coal-field in that direction had been proved. The south-eastern extension into Lincolnshire was another question, and would never be known accurately until borings were made, but the probability was that the limit of the Coal-measures had not been reached, and that the coal extended further to the south-east.

Mr. James McMurtrie (Radstock) said that when exploring it was not desirable to arrive too suddenly at the conclusion that they had reached the margin of the coal-field. On the edge of the South Wales coal-field, towards the Forest of Dean and Somersetshire, ridges of the older rocks were found, and if it had happened that these rocks had been covered by newer formations, they might have come to the conclusion that the Coal-measures did not extend farther; but in the Forest of Dean and partly in Somersetshire the Coal-measures were exposed at the surface, and proved the existence of two separate basins. Although it

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* 1894, vol. lxx., page 84.

† *Trans. Fed. Inst.*, vol. xi., page 339; and vol. xii., page 100.

might appear that they had reached the edge of the Nottingham coal-field, a new coal-field might yet be found to the eastward.

Mr. J. A. **LONGDEN** (Nottingham) enquired whether Mr. Coke had any information as to the boring now being put down by the Wigan Coal and Iron Company in the neighbourhood of Tuxford ?

Mr. G. E. **COKE** said that the boring referred to by Mr. Longden was not yet completed. There was no doubt that the Nottinghamshire coal-field might extend some distance further southward, but if the strike of the Coal-measures continued in the direction shown in his paper, he thought he might safely say that no coal would be found to the west or south until the Leicestershire coal-field was reached. A bore-hole was made at Hathern, not many miles south-west of the Charnwood rocks at that point.

DISCUSSION ON MR. H. F. BROWN'S PAPER ON "MECHANICAL ROASTING OF ORES."*

Prof. H. **LOUIS** (Newcastle-upon-Tyne) wrote that while he fully recognized the excellent work that had been and is being done by Mr. Brown's furnaces, he ventured to think that his paper was scarcely fair to the inventors of other mechanical roasting-furnaces. Unless he was greatly mistaken, the forerunner of all roasting-furnaces of this type with mechanically-moved rabbles was the Spence furnace, and he thought that Mr. Spence was entitled to the credit of having in this sense led the way; at the same time the improved Spence furnace with its ingenious revolving rabble-blades, seemed by all accounts, to be working efficiently. The turret-furnace of Mr. Pearce, of Argo, U.S.A., was surely not a furnace to be omitted from a discussion of this nature, as many of these furnaces were in operation and working well. An examination of some figures given by Dr. Peters † from actual working results did not quite support Mr. Brown's contention that his furnaces "cost about one-half as much per ton capacity as other mechanical roasters." A Pearce turret-furnace was stated to have cost 5,460 dollars and roasted 16·1 tons per day, or, say, 339 dollars per ton per diem. The Brown parallel furnace, which would be used for a plant comparable as to output with the Pearce

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* *Trans. Fed. Inst.*, vol. xi., page 369.

† *The Mineral Industry*, 1894, vol. iii., pages 209 and 210.

furnace just mentioned, was stated* to calcine 10 to 12 tons per diem, and to cost 3,200 to 4,000 dollars; taking the mean of these figures as 11 tons and 3,600 dollars, the cost of the furnace per ton per 24 hours was 327 dollars, so that although there was a difference in favour of the Brown furnace, it was far from being as great as the author claimed. He (Prof. Louis) knew that this point was a difficult one, and must not be pressed too far, because so much depended on the nature of the ore to be calcined, its sulphur contents, the degree of desulphurization required and the fuel available, that no comparison was fair except it be on two furnaces working the same ores in the same district.

He (Prof. Louis) did not attach very much importance to the question of prime cost; that of working cost was, to his mind, a more serious one, and in that respect it was very difficult to say much when Mr. Brown had been compelled to "estimate" the very important item of repairs; it would be very interesting to have this figure from actual work, and that on furnaces which had been in operation for a year at least. It seemed as though Mr. Brown's ingenious devices for cooling and protecting the rabbles and rabbling-gear ought to keep down the item of repairs, but it would be more satisfactory to have figures derived from actual facts.

This, together with cost of power and lubricants, was the main element that determined the superiority or inferiority of machine as compared with hand-calcining. As far as he (Prof. Louis) had seen, a first-class experienced and careful furnaceman could do better work than most, if not all, automatic calciners (he had seen nothing of the results obtained by Mr. Brown's furnaces), but the automatic calciner would yield better results than careless or half-trained furnacemen, so from this point of view he did not know that there was much to be said either way in calcining ordinary simple ores (pyrites, etc.). The question would, then, be narrowed to that of whether the wages of the additional furnacemen would cost more or less than would repairs, power, and lubricants; these figures must depend largely on the relative prices of supplies and of various kinds of labour, and that is why he would especially like to have details as to costs of and items included in repairs, when Mr. Brown was in a position to give such from actual practice.

A point of considerable importance was that of the utilization of the fumes of sulphur dioxide for sulphuric acid manufacture; as far as he (Prof. Louis) could see, none of Mr. Brown's furnaces were constructed so as to admit of this, hence a substance of considerable commercial

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* *Trans. Fed. Inst.*, vol. xi., page 376.

value was necessarily wasted. He would be glad to learn whether this system had been found applicable to any form of muffle-furnace by which the sulphur might be utilized instead of being allowed to escape. Like Mr. Brown, he had purposely abstained from referring to revolving calciners of the Brückner, Oxland, etc., class.

Mr. J. A. **Longden**, seconded by Mr. **Gerrard**, moved that a cordial vote of thanks be awarded to the local committee who had made the arrangements for that meeting; to the South Wales Institute of Engineers for the use of their rooms; to the authorities of the exhibition; and to the owners of works and collieries opened to the inspection of members.

Mr. **Archibald Hood** (Cardiff), in acknowledging the vote of thanks on behalf of the South Wales Institute, said that The Federated Institution of Mining Engineers could not feel greater satisfaction than that body did in placing their rooms at the disposal of the members. They were highly honoured in having such an important Institution meeting in South Wales, including as it did almost the whole of the mining institutes of Great Britain.

The **Chairman** acknowledged the vote of thanks, and the meeting terminated.

The following notes record some of the features of interest seen by visitors to works and collieries, which were, by kind permission of the owners, open for inspection during the course of the meeting on September 15th, 16th, and 17th, 1896:—

NIXON'S NAVIGATION COMPANY, LIMITED, MERTHYR VALE COLLIERY.

There are two shafts at the Merthyr Vale colliery (upcast and downcast) both of which are in use as winding-shafts. The No. 1 pit (downcast) is 16 feet in diameter, and sunk to a depth of 1,485 feet to the Bute coal-seam. The No. 2 pit, also 16 feet in diameter, is sunk to the Bute coal-seam, which is reached at a depth of 1,467 feet. The landing in No. 1 pit is situated at a depth of 1,275 feet in the four feet coal-seam, and the seams worked comprise the four feet, six feet, nine feet, and five feet. The landing in No. 2 pit is placed at a depth of 1,410 feet in the nine feet coal-seam. The nine feet coal-seam is the only seam worked at this pit.

At No. 1 pit, the winding-engine is a marine engine, with two cylinders, each 84 inches in diameter, by 4 feet stroke, working at a steam pressure of 35 lbs. per square inch. At No. 2 pit, the winding-engine has two cylinders, 50 inches in diameter, and 6 feet stroke, with steam at a pressure of 60 lbs. per square inch. The drums on both winding-engines are conical, 24 feet on the large diameter and 11 feet on the small diameter.

The drainage is dealt with by means of a compound ram-pump placed in the four feet coal-seam, and forces the water to the surface (1,275 feet); and a Cameron pump placed in the lodge-room, 240 feet below the four feet coal-seam, pumps the water from this point to the main pump in the four feet coal-seam. The main pump is a tandem compound, the high-pressure cylinder being 32 inches in diameter and 7 feet stroke; the low-pressure cylinder is 64 inches in diameter, and 7 feet stroke; and the ram is 17 inches in diameter, and 7 feet stroke, and is capable of pumping 27,000 gallons per hour to the surface.

There are 17 hauling-engines underground, with cylinders varying in size from 26 to 7 inches. The main hauling-engines, at the shaft, are worked by steam, which is taken down the pit, and the smaller hauling-engines are worked by compressed air.

The air-compressor is situated on the surface to the south of No. 1 pit, and has two steam cylinders, each 36 inches in diameter, and two air-cylinders each 42 inches in diameter, all of 6 feet stroke, and working about 36 strokes per minute, at a steam pressure of 60 lbs. per square inch.

The ventilation is created by a Waddle fan, 40 feet in diameter, driven direct by an engine with a cylinder 32 inches in diameter, by 5 feet stroke; at 63 strokes per minute it produces 260,000 cubic feet per minute under a water-gauge of 2·5 inches.

A Nixon piston-ventilator is used when the rotary fan is not working; it exhausts, at 16 strokes per minute, about the same volume of air at a similar water-gauge. The motor engine has a single horizontal cylinder, 48 inches in diameter, and 6 feet stroke; it drives three rectangular air-pistons, each 50 feet by 22 feet, two of them being 7 feet stroke and one of 6 feet stroke.

There are 35 boilers of the Lancashire type, 30 feet long by 7 feet in diameter, working at a pressure of 60 lbs. to the square inch.

The workmen use Protector safety-lamps fitted with an electric lighter.

There are large fitters', smiths', and carpenters' shops, etc.; and most of the mechanical work connected with the colliery is made on the spot, the castings being supplied from the company's foundry at Mountain Ash.

The system in use for damping coal-dust is as follows:—

There is a large feeder of water in the top panel of tubbing, about 900 feet above the four feet coal-seam, and from this feeder a pipe is carried down the shaft, the pressure at the four feet landing being about 600 lbs. per square inch. From this point, pipes are laid along the main roads, in every case to the double parting on the haulage-planes, and in some instances further. In many cases a pipe is passed through the air-bridges on main roads, for the purpose of getting water into the return-airways. The size of the water-pipes varies from 2 inches near the shaft for the main-pipes to ½ inch in diameter for the branch-pipes. Wrought-iron pipes are used, capable of withstanding a pressure of 1,000 lbs. per square inch. On these pipes, at distances of about 60 feet, are fixed small gun-metal valves, one end of which is screwed to fit a cap; and four men are employed, each with a hose to carry out the watering.

The length of each watering-hose is 30 feet, sphincter grip, 1 inch in diameter, with a cap which fits upon the gun-metal valves on one end and a nozzle on the other. With this length, about 100 feet can be well sprayed.

In both pits there are 9·6 miles of pipes, and, of course, the same length of roads to water. The four men water the whole length once in two days, and also find time to do small repairs to the pipes.

This method has been proved to be efficient and cheap. Compressed air and water, and also various kinds of jets for high-pressure water have been used, and all have proved much more expensive; they required the same number of men to keep the sprays in order as are employed with the hose, and, in addition, the first cost of the sprays and the cost of maintenance was greater.

GREAT WESTERN COLLIERY COMPANY, LIMITED, GREAT WESTERN COLLIERIES.

Great Western Pits.

Two shafts are sunk to the steam coal-seams, and the pumping pit is sunk to the No. 3 Rhondda coal-seam.

The Hetty pit is 15 feet in diameter, and is 1,173 feet deep to the six feet coal-seam. The four feet and six feet steam coal-seams are being worked. The winding-engine has two cylinders, each 40 inches in diameter by 6 feet stroke, and is fitted with variable automatic expansion-gear.

The No. 2 pit, 14 feet by 10 feet, is sunk 1,425 feet to the five feet coal-seam. The winding-engine has two cylinders, each 30 inches in diameter by 4 feet stroke.

The Schiele ventilating-fan, 15½ feet in diameter, is driven by a compound tandem engine, with cylinders 20 inches and 36 inches in diameter, and 3 feet stroke, and belt-pulleys 20 feet and 6½ feet in diameter. At 160 revolutions per minute, the water-gauge is 3 inches and the volume of air 200,000 cubic feet per minute.

A compound air-compressor is being erected, with steam-cylinders 40 inches and 72 inches in diameter and 6 feet stroke; and air-cylinders 42 inches in diameter and 6 feet stroke. The fly-wheel weighs 30 tons.

The coal-washing machine, on the Coppée principle, has a capacity of 300 tons per day. There are 120 Coppée coke-ovens, which burn for 24 hours, producing 1,000 to 1,100 tons of coke per week, and the waste gases are utilized for raising steam in 7 boilers.

There are 18 Lancashire boilers, 10 of which are working, in addition to those at the coke-ovens. Some of the boilers work at a pressure of 80 lbs., but the majority work at 50 lbs. per square inch.

Tymawr Pit.

The Tymawr pit, 16 feet by 10 feet, is 1,440 feet deep to the five feet coal-seam.

The twin compound winding-engine has cylinders 32 inches and 48 inches in diameter by 5 feet stroke, and is fitted with variable automatic expansion-gear on the high-pressure cylinder.*

The Schiele ventilating-fan, 15½ feet in diameter, is driven by a compound tandem engine, with cylinders 19 inches and 32 inches in diameter and 3 feet stroke. The belt-pulleys are 20 feet and 6½ feet in diameter. At 160 revolutions per minute, a volume of 180,000 cubic feet per minute is produced at a water-gauge of 3 inches. An independent condensing-engine is used.

The air-compressors consist of two pairs of compound tandem steam cylinders, 22 and 40 inches in diameter by 5 feet stroke; and air cylinders 34 inches in diameter and 5 feet stroke. Separate independent condensers and engines are applied to each pair of air-compressors; together with apparatus, with a centrifugal pump, for cooling the condensing-water.

There are 10 Lancashire boilers each 30 feet long and 8 feet in diameter working at a pressure of 120 lbs. per square inch.

Special steam-pipes, of mild steel tubes, 8 inches and 10 inches in diameter, with wrought-iron flanges (solid welded) fitted with 12 and 14 bolts in each flange respectively, are used.

For underground watering of dust, water is taken down from the surface-reservoir. The pipes in use are given as follows:—In shafts, 1,500 feet of pipes, 2 inches in diameter; in the four feet coal-seam, 24,000 feet of pipes, 1¼ inches in diameter; in the six feet coal-seam, 4,500 feet of pipes, 1¼ inches in diameter; and in the five feet coal-seam, 9,000 feet of pipes, 1¼ inches in diameter: the total length of pipes in use being about 39,000 feet or 7·4 miles.

There are about 300 branch pipes, ½ inch in diameter, fitted with cocks for use with sprays or hose-pipes, and about thirty cocks, 1¼ inches in diameter, for watering horses, and for use in engine-houses as fire-hydrants.

Several forms of compressed-air-and-water sprays have been tried, but none are at present in use. A large number of different designs of ordinary water-sprays have been tried, and a number are regularly used. Hose-pipe watering is also largely practised.

The underground conditions of the company's collieries are such that dry cleaning of dust is totally inadequate.

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* *Trans. Fed. Inst.*, vol. xii., page 282.

OCEAN COAL COMPANY, LIMITED: DEEP NAVIGATION COLLIERY.

The Deep Navigation colliery comprises two winding-shafts, each 17 feet in diameter. The No. 1 shaft is used as a downcast, and is sunk to a depth of 2,280 feet to the 9 feet coal-seam; and the No. 2 shaft is used as an upcast. Each of the shafts is fitted with steel-rail slides.

At the No. 1 shaft is a Cornish pumping-engine, with a cylinder 100 inches in diameter, and 11 feet stroke. There are seven forcing-pumps on the pumping-engine, between the surface and the four feet landing, all of 10 feet stroke. The three top pumps are 26 inches in diameter; the two next pumps are 22 inches in diameter; and Nos. 6 and 7 pumps are 10 inches in diameter. A small special pump placed in the six feet landing delivers its water into the No. 7 lift. The lengths of each set of pumps respectively are 255, 270, 285, 300, 285, 300, and 270 feet. The pumping-engine is now only worked at the rate of two strokes in 70 seconds, but is capable of being worked at the rate of four strokes per minute. The total weight of spear-plates, pump-rods, and rams is 194 tons. There is a counter-balance beam in the shaft at a depth of 735 feet, one end being connected to the pump-rods and the other end carries a weight of 30 tons.

The winding-engine has two inverted vertical cylinders, each 54 inches in diameter, and 7 feet stroke. The winding-engine lifts 4 trams of coal on two flats at one lift (each tram when loaded weighs about 32 cwts.), and together with the cage, shackles, and rope raises a total weight at the start from the bottom of about 17 tons. The spiral drum varies between 18 and 30 feet in diameter.

The No. 2 shaft has a winding-engine with two cylinders 42 inches in diameter, and 6 feet stroke. Immediately adjacent is an air-compressing engine having two steam-cylinders, each 42 inches in diameter, and 6 feet stroke, and two air-cylinders, each 45 inches in diameter, and 6 feet stroke.

In addition, and close to the top of the shaft, is a Schiele ventilating fan, 14½ feet in diameter, driven by an engine with a cylinder 27 inches in diameter, by 3 feet stroke, with a spare cylinder. The colliery is ventilated by this fan, and the average quantity of air circulating throughout the colliery, as measured monthly, is 225,000 cubic feet per minute, at 62 revolutions of the engine and 167 of the fan per minute, and a water-gauge of 2·90 inches.

The coal worked is known as South Wales smokeless steam-coal, and is wholly produced from the four-feet and six-feet coal-seams. The four-feet has a section of about 5 feet of coal, and the six-feet yields about 6½ feet of coal. The yield of coal is at the rate of about 2,000 tons per day, the actual quantity for the year 1895 being 550,000 tons.

The underground main-and-tail haulage is worked by numerous compressed-air engines, each having two cylinders ranging from 20 inches in diameter downwards. The compressed air is conveyed from the air-compressor to the several engines by means of cast-iron pipes down to the bottom of the shafts, and by wrought-iron and steel pipes therefrom to the engines.

Steam is generated in 31 Lancashire boilers, each 7 feet in diameter, and 30 feet long, in three main ranges: 28 boilers being at all times under steam.

The usual workshops necessary for the establishment are erected or in course of erection.

The underground lighting is wholly by bonneted safety-lamps, except at the bottom of the shafts and the main-roads in immediate connexion therewith, which are lighted by electric lamps, as well as the whole of the houses and shops on the surface.

DOWLAIS CARDIFF COLLIERY, ABERDARE JUNCTION.

The Dowlais Cardiff colliery is situated at Aberdare Junction, about 9 miles south of Merthyr Tydfil, and 3 miles north of Pontypridd, at the junction of the Aberdare and Merthyr Tydfil valleys, and about 1,600 feet to the south rise of the coal-basin.

The pits have only recently been sunk to the steam coal-seams, and the colliery is not yet fully equipped for raising large quantities of coal.

Two pits, each 20 feet diameter in the clear, walled throughout with a minimum thickness of 12 inches of brickwork, are each sunk to a depth of 2,220 feet, and are 195 feet apart. In the south pit, 158 feet of cast-iron tubbing have been placed at a depth of 390 feet below the surface for tubbing back under a pressure of 100 lbs. to the square inch, 16,000 gallons of water per hour. At other parts of both pits, brick watertight walling has also been used with success for keeping back large feeders of water.

The winding-engine, for the north or downcast shaft, is a horizontal engine having two cylinders, each 42 inches in diameter, with a piston-stroke of 7 feet. The drum is of conical type, the small diameter being 17 feet and the large diameter 32 feet. The pressure of steam is 100 lbs. to the square inch.

The winding-engine for the south pit is of the same class, having cylinders 36 inches in diameter, with a piston-stroke of 6 feet, the drum in this case being of the plain cylindrical type, and 17 feet in diameter.

The pit-head framings are both of mild steel, 72 feet high from landing to centre of pulleys.

The pit-head pulleys are 18 feet in diameter, and from the centre of shafts to centre of drums the distance in each case is 150 feet.

The landing, or pit-top, is 27 feet above the level of railway-sidings.

Revolving-tipplers, screens, and picking-belts are now being erected for screening and cleaning the coal. The belts are each 45 feet long, by 5 feet wide, with balanced loading-ends for distributing the coal into the waggons.

For ventilation, a Schiele fan, 21 feet in diameter, capable of delivering 500,000 cubic feet of air per minute, with a water-gauge of 3 inches, has been erected near the top of the south, or upcast, shaft. It is driven through belt gearing by a compound condensing-engine, having cylinders 22 inches and 36 inches in diameter, with a stroke of 4 feet 6 inches. The fly-pulley on the crank-shaft is 20 feet in diameter, and the pulley on the fan-shaft is 8 feet 6 inches in diameter. The belt is of three-ply leather and is 3 feet 6 inches wide. An auxiliary engine has also been erected, having a single cylinder 36 inches in diameter and 4½ feet stroke.

Pumping in the shafts is mainly done by a horizontal compound condensing-engine, fitted with Davey differential gear. The cylinders are 45 inches and 78 inches in diameter, and have a piston-stroke of 10 feet. This engine pumps from a depth of 1,350 feet in three lifts. The top lift is 465 feet high, and consists of two plunger-pumps, each 16 inches in diameter, by 10 feet stroke, with a rising-main pipe 14 inches in diameter. The second lift is 540 feet high, and consists of two plunger-pumps, each 14 inches in diameter, by 10 feet stroke, with a rising-main pipe 12 inches in diameter. The third lift is 345 feet high, and has two plunger pumps, each 10 inches in diameter, and 10 feet stroke, and the rising-main pipe is 9 inches in diameter. The capacity of the top lift is 75,000 gallons of water per hour; that of the second, 60,000 gallons per hour; and the third, 45,000 gallons per hour. The valve-boxes and suction-pipes are fixed in rooms off the side of the pit. Auxiliary direct-acting steam pumping-engines are fixed at each of the pumping-stations, capable of dealing with the whole of the water met with in case of accident, or during repairs to the large pumping-engine.

At the level of the bottom of the shafts and in a heading between them, a compound horizontal condensing rotative pumping-engine is being erected, having two high-pressure cylinders, each 13 inches in diameter, and two low-pressure cylinders, each 23 inches in diameter, with a common stroke of 15 inches. There are four plungers, each 5 inches in diameter, with a stroke of 15 inches. This pump is capable of raising 5,000 gallons of water per hour to a height of 1,200 feet, and will raise all the water which finds its way to the bottom of the shafts, to the lodge-room, where the plunger-pumps (10 inches in diameter) of the main pump work, and is arranged to work with either compressed air or steam. A range of steam pipes, 10 inches in diameter, well covered with hair-felt, fossil-meal, and sheet-iron, is being carried down the south pit for working the steam-pumps and hauling-engines placed near the bottom of the shafts, and a range of pipes, 12 inches in diameter, has already been laid for conveying compressed air from the surface to these underground engines.

A twin compound condensing air-compressor has been erected for compressing air for hauling and other purposes in the mine. The steam-cylinders are 28 inches and 48 inches in diameter, by 5 feet stroke, and the air-cylinders are 27 inches and 42 inches in diameter, by 5 feet stroke. The pressure of steam is 100 lbs., and that of the air is 70 lbs. to the square inch.

At present, steam is supplied by 8 Lancashire boilers, but 2 more of the same description are being erected. They are each 8½ feet in diameter, by 30 feet long, having two furnace-flues, 3½ feet in diameter. The furnace-flues are fitted with conical water-circulating tubes. The working steam-pressure is 100 lbs. per square inch.

The lamp-room is 66 feet long, by 32 feet wide, and has stands and other appliances fixed for dealing with 2,000 safety-lamps.

Arrangements have been made for using the Martin and Turnbull system of damping dust. This system is extensively adopted in the Dowlais Iron Company's and neighbouring collieries, with very beneficial results. The annexed notes and table of hygrometrical readings are taken from a paper on damping dust in mines, read before the South Wales Institute of Engineers, in 1887, by Mr. H. W. Martin.*

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* Vol. xv., page 267.

COMPRESSED-AIR-AND-WATER SPRAY AT SOUTH TUNNEL PIT.

Little Vein Drift. Intake Airway.		Hygrometrical Readings taken with all Spray-producers.			
		Stopped.		Working.	
		Temperature. Fahrenheit.		Temperature. Fahrenheit.	
		Dry.	Wet.	Dry.	Wet.
		Degs.	Degs.	Degs.	Degs.
No. 1 spray-producer		64	62	...	...
300 feet	150 feet	64	62	62	62
No. 2 spray-producer					
300 feet	150 feet	64	62	62	62
No. 3 spray-producer					
300 feet	165 feet	64	62	62	62
No. 4 spray-producer					
300 feet	180 feet	64·5	62·5	62·5	62·5
No. 5 spray-producer					
300 feet	195 feet	64·5	62·5	62·5	62·5
No. 6 spray-producer					
300 feet	195 feet	65	63	63	63
No. 7 spray-producer					

The volume of air passing was 28,500 cubic feet per minute, at a mean velocity of 530 feet per minute. The water had a pressure of 90 pounds and the compressed air of 45 pounds per square inch.

Two methods of water-spraying are employed, one by water alone, under pressure issuing from a fine nozzle, or spray-producer; and the other, which is by far the more perfect, by water in conjunction with compressed air, issuing from a similar nozzle or spray-producer. By the latter system, the exceeding fineness of the spray is such that it is carried by the air-current for long distances and effectually cools the air and damps the dust lurking in crevices and behind the timber, as well as the roof, sides, and floor, without unnecessarily wetting the roads, which so often causes upheaval of the floor.

The compressed air and water are conveyed through the mine in two parallel ranges of pipes. Where it may be desired to fix a spray-producer, a pipe, ½ inch in diameter, is joined to the water-range, and one of the same dimensions to the air-range. The air-pipe is reduced to a fine cone-end, which is inserted into the water-pipe after the fashion of the nozzle of an ordinary steam-injector. The water-pipe terminates with a fine adjustable nozzle, or spray-producer.

BARRY DOCKS AND RAILWAYS.

These properties, belonging to the Barry Railway Company, consist of docks at Barry, a railway (main line) from Barry to Hafod in the Rhondda Valley, where it joins the Taff Vale Railway, Rhondda system; a branch from the main line joining the Taff Vale Company's main line at Treforest; a branch from Cadoxton to Cogan, where it joins the Taff Vale Railway (Penarth Branch); also branches from the main line, which join the Great Western, South Wales main line at Peterston and St. Fagans; an extension from Barry to Barry Island and a landing-pontoon at the dock-entrance; and the company have obtained power to construct railways from the main line near St. Fagans to join the Walnut Tree and Aber branches of the Rhymney Railway system near Caerphilly. The Vale of Glamorgan Railway, which is now in course of construction, joins this company's main line at Barry, and will have junctions with the Great Western railway at Bridgend and with that company's Ogmore Valley branch line, and will, when completed, be taken over and worked by this company.

No. 1 dock is situated on the northern coast of the Bristol Channel, about 9 miles south-west of Cardiff, and occupies the eastern site of the old channel between Barry Island and the mainland. The entrance to the docks is at the eastern end, and lies well under the shelter of the high land of Barry Island from all westerly and south-westerly winds, but it would be open to the southward with a sea-fetch of 14 miles, and to the south-east with a sea-fetch of 16 miles, were it not for the breakwaters, which completely cover these points of exposure, and the docks thus possess the great advantage of having their entrance in a well-sheltered position and close to deep water. A ship leaving the docks is in a few minutes in what sailors call "blue water," and is not exposed to the troublesome navigation which at Cardiff and Penarth is conducted for from 2 to 3 miles in an artificial channel (cut through the mud-flats), which is nearly dry at low-water. From Barry Island to Sully Island, which is about 3 miles to the eastward, there is good anchorage-ground.

The waterway between the breakwater-heads is 350 feet wide, and the channel is lighted by a flashing white light of the fifth order in a lighthouse 44 feet above high-water of ordinary spring-tides. The space inside the breakwaters affords shelter for pilot-boats, tugs, and small craft attendant upon the docks. From the breakwater-heads, a channel has been dredged for a distance of 1,350 feet to the entrances to the docks—two in number—one of which, to the basin, is available for two and a half hours before and after high-water, and the other, the Lady Windsor lock, can be used at any state of the tide, the entrance-channel having 16 feet of water at low-water of ordinary spring-tides. By this lock, the Barry docks become the only ones in the Bristol Channel that vessels can enter or leave at any time or state of the tide.

The basin-entrance is 80 feet wide, as is the opening, or passage, as it is generally called, between the basin and No. 1 dock. Both are closed by single pairs of wrought iron gates, which are actuated by direct-acting hydraulic rams, sufficiently strong to resist the shock of waves in rough weather and to hold the gates rigidly throughout their movement. The depths of water on the sills, which are curved, are as follows:—High-water of ordinary spring-tides, 37·7 feet; low-water of ordinary spring-tides, 1·6 feet; high-water of ordinary neap-tides, 29·3 feet; and low-water of ordinary neap-tides, 9·7 feet. The available depths are 3 feet more at the centre of the inverts, but as the bilges of vessels are now oftentimes very flat, the depths reckoned on are as stated, at which depths the bilge of flat-floored vessels will go free everywhere. The extra depth at the centre may, however, be of great utility in the case of vessels of exceptional draught, which could be kept in the centre of the entrance. Timber guiding-jetties, 200 feet in length, are erected seaward of the basin entrance, and one of masonry, with timber-fenders, 600 feet long, is placed to the west of, and for, the entrance to the Lady Windsor lock.

The Lady Windsor lock, which leads direct from the sea to No. 1 dock, has a length of 647 feet, a depth of 60 feet; it is 65 feet wide, and occupies the space immediately west of the basin. It can be divided into two locks, each sufficiently large to take an average-sized steamer, by means of gates, three pairs of which are provided, and which are similar in construction to those at the basin and entrance, and are worked in a similar manner. The depths of water on the sills of the Lady Windsor lock are as follows:—High-water of ordinary spring-tides, 49·8 feet; high-water of ordinary neap-tides, 41·4 feet; low-water of ordinary spring-tides, 18·7 feet; and low-water of ordinary neap-tides, 21·8 feet. The available depths are 3 feet more in the centre of the sills than these.

Road and railway traffic is carried across the passage and the Lady Windsor lock by means of two rolling bridges.

Vessels drawing 18 feet of water can enter and leave the docks through the Lady Windsor lock at low-water of ordinary spring-tides, and during fifteen days of each month vessels drawing 18 feet can enter and leave at low-water.

The basin, which is 600 feet long by 500 feet wide, with an area of 7 acres, has vertical walls, and the eastern side is used for a large timber import trade, the bulk of which goes to the Midland counties.

No. 1 dock is 3,100 feet long, with a maximum width of 1,100 feet, and is divided at the western end by a mole into two arms 1,500 feet long and 500 feet wide and 1,200 feet long and 300 feet wide respectively. The full width is left at the eastern end for a length of 1,600 feet to give ample space for the largest ship to swing, even when the dock is crowded with shipping. The water-area of this dock is 70 acres at high-water of neap-tides, with 26 feet of water; but at spring-tides the water-area is 73 acres.

No. 2 dock, in construction, lies to the eastward of No. 1 dock, from which it is approached by a passage closed by a caisson, and will have an area of 40 acres. The northern side of the dock will be sloped similar to that in No. 1 dock, and will be fitted with 10 high-level coal-tips. The southern side will be constructed with a perpendicular wall, and is intended for the import trade, for which ample sidings, sheds, and warehouses will be provided as occasion requires.

The shipping of coal takes place in No. 1 dock on the northern side, on the mole, at the western end of the dock, on the eastern side, and at the western end of the southern wall. On the northern side there are 11 fixed coal-tips, placed at distances apart varying from 174 to 300 feet, so as to suit the hatchways of different ships, and also 2 movable tips, while provision has been made for the erection of 2 more. There are 5 fixed tips on the mole, 300 feet apart, 1 at the western end and 2 on the southern wall, with 3 movable ones, and 2 fixed tips at the eastern end of the dock. The tips are distributed thus:—11 high-level, and 10 low-level (fixed); and 2 high-level, and 3 low-level (movable); a total of 26 tips. These tips have lifts of 37 and 42 feet and are each capable of lifting 20 tons. A steamer has been brought into dock, loaded with 1,900 tons of coal, and has left again on the same tide. The greatest quantity of coal shipped from one tip per hour has been 490 tons. By using two of the movable tips with a fixed tip, coal can be put on board a vessel through 3 hatchways at the same time, and by this means very quick despatch can be given.

All tips are provided with 2 weighbridges, one on the full and the other on the empty roads; thus the waggons can be re-tared at any time without difficulty and without additional charge. By the arrangement of the sidings, the full waggons are drawn down to the tips by means of a hydraulic capstan, while the empty ones clear themselves by gravity.

All the machinery on the dock is worked by hydraulic power, which is obtained at 2 engine-houses, one at the south-eastern end of the dock and the other at the north-western end, by 5 pairs of compound horizontal surface-condensing engines with steam-cylinders, 16 and 28 inches in diameter and 24 inches stroke, which are supplied with steam at a pressure of 80 lbs. per square inch, by 15 Lancashire boilers, 28 feet long by 7 feet in diameter. The pressure pumps are on the differential-ram principle, the diameters being 4⅞ inches and 6⅞ inches respectively; these maintain a working pressure in the accumulators of 750 lbs. per square inch. Another engine-house with further power is being provided for the No. 2 dock and the works in connexion therewith.

The entrances are provided with powerful capstans for warping ships in and out of dock. Waggon capstans are provided on all wharves and on all tips, while for the discharge of cargo, repairs, etc., there are available the following cranes:—20 hydraulic ballast and timber-cranes (movable); 4 hydraulic ballast and timber-cranes (fixed); 1 hydraulic fixed crane, 50 tons; 1 steam floating-crane; 2 travelling-cranes, 5 tons; 1 travelling-crane, 3 tons; 1 hand travelling-crane, 12 tons; and 1 hand travelling-crane, 1½ tons.

The docks are provided with two powerful tugs for moving vessels, both fitted with salvage and fire-pumps. There is also a steam fire-float and a steam-ferry.

There are 36 large buoys in No. 1 dock, for mooring vessels when waiting their turn, and for working to and from the coal-tips.

The whole of the docks, coal-tips, sidings, entrances, workshops, stations, and works are lighted by electricity. The electric-lighting plant is housed in an extensive building near the northern hydraulic engine-house, and comprises 7 vertical compound engines, driving 3 dynamos for incandescent lights and 7 for arc lights. The installation includes 100 arc-lamps of 2,500 candle-power each and 1,500 incandescent lamps of from 16 to 30 candle-power each.

There are two graving-docks connected with No. 1 dock, one situated at the north-eastern corner, belonging to the Barry Graving-Dock Company; and the other near the Lady Windsor lock, belonging to the Barry Railway Company. Persons using the latter are at liberty to select their own repairers. The pumping-machinery for this graving-dock consists of three centrifugal main-pumps capable together of pumping 54,000 gallons per minute, and two small drain-pumps capable together of pumping 12,000 gallons per minute, with condensers. They are supplied with steam at 100 lbs. pressure from 1 Cornish and 3 Lancashire boilers. The water can be either pumped into No. 1 dock, or into the sea. Both these docks can accommodate 4 large vessels at the same time.

The railways previously mentioned and already constructed give access to the coal-fields of the Rhondda, Aberdare, and Merthyr Valleys. The Vale of Glamorgan railway will give access to the Llynvi and Ogmore coal-district; and the new lines joining the Rhymney railway-system will give access to the Rhymney Valley and the Monmouthshire coal-fields, thus bringing the most important coal-districts of South Wales into direct communication with the docks. All the railways are so laid out as to be most economically and easily worked, and by the connexions with other railways access to the docks is available for imports and exports to and from all parts of the country. When the railways were opened in 1889, the passenger service was only between Barry and Cogan (near Penarth Dock); but by an agreement entered into with the Taff Vale and Great Western Railway Companies, a through passenger service is now established between Barry and Cardiff (riverside) and the Bute Docks (Clarence Road).

The rolling stock of the company consists of 89 locomotives, 72 passenger carriages, 16 passenger vans, and 693 goods and other waggons.

The company have extensive engine-sheds for housing their locomotives.

They also have, at the north-western end of No. 1 dock, very extensive fitting and repairing-shops, which are fitted with the latest improvements in machinery, and where all repairs to locomotives and other machinery are done.

The capital expended to 30th June, 1896, upon the various works amounted to about £3,400,000.

The following statistics will show the great increasing trade since the dock was opened in 1889 :—

EXPORTS AND IMPORTS FOR THE HALF-YEAR ENDING DECEMBER, 1889, TO HALF-YEAR ENDING DECEMBER, 1895.

Half-year ending	EXPORTS. Total Tons.	IMPORTS. Total Tons.
Dec. 31, 1889	1,091,666	14,745
June 30, 1890	1,571,087	29,517
Dec. 31, 1890	1,630,510	34,158
June 30, 1891	2,119,539	40,096
Dec. 31, 1891	1,848,502	47,437
June 30, 1892	2,166,414	42,703
Dec. 31, 1892	2,035,451	39,061
June 30, 1893	2,257,519	74,767
Dec. 31, 1893	1,959,651	70,638
June 30, 1894	2,493,376	75,575
Dec. 31, 1894	2,405,940	92,122
June 30, 1895	2,532,341	105,793
Dec. 31, 1895	2,527,334	101,079
TOTALS	26,639,330	767,691

NUMBER OF VESSELS ARRIVING AND TONNAGE.

DATE. Half-year ending	STEAMERS.		SAILING-VESSELS.		TOTAL.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
Dec. 31, 1889	461	440,679	137	127,279	598	567,958
June 30, 1890	648	639,124	193	189,300	841	828,424
Dec. 31, 1890	673	670,915	239	192,884	912	863,799
June 30, 1891	811	837,818	236	175,747	1,047	1,013,565
Dec. 31, 1891	802	807,390	247	186,316	1,049	993,706
June 30, 1892	840	904,070	308	257,769	1,148	1,161,839
Dec. 31, 1892	841	883,155	193	191,841	1,034	1,074,996
June 30, 1893	884	932,811	208	193,602	1,092	1,126,413
Dec. 31, 1893	875	886,417	195	187,076	1,070	1,073,493
June 30, 1894	900	1,045,924	178	210,799	1,078	1,256,723
Dec. 31, 1894	914	1,080,054	174	173,826	1,088	1,253,880
June 30, 1895	945	1,085,859	177	139,598	1,122	1,225,457
Dec. 31, 1895	976	1,117,946	180	172,719	1,156	1,290,665
TOTALS ...	10,570	11,332,162	2,665	2,398,756	13,235	13,730,918

It may be interesting to state that the population of the district, which in 1884 was about 100, is at the present time about 25,000.

THE BUTE DOCKS, CARDIFF.

In the year 1830, the late Marquess of Bute, seeing the great advantages likely to accrue from the provision of increased dock accommodation, particularly with regard to the development of the mineral wealth of the district, obtained an Act of Parliament for the construction of what is now known as the Bute west dock (but then termed the Bute ship-canal). Under this and an amending Act, passed in 1834, the Bute west dock and basin were constructed, with a cut or entrance from the Bristol Channel.

Following upon the construction of this dock and the Taff Vale railway, an enormous increase took place in the trade of Cardiff. For example, it may be stated that the export of coal rose from 4,562 tons in 1839 to 1,023,903 tons in 1854.

To meet the requirements of the port, the trustees under the will of the late Marquess of Bute (who had died in 1848) constructed, without parliamentary powers, the Bute east dock, upon land belonging to the Bute estate, a portion of which was opened on the 20th of July, 1855; and which was subsequently extended to its present dimensions.

In 1856, the trustees provided a tidal harbour for the accommodation of the coasting trade. The site of this harbour is now included in the Roath basin.

The trade of the port continuing to increase, Lord Bute's trustees in 1866 obtained an Act, authorizing the construction of the basin, known as the Roath basin, which was opened in the summer of 1874.

In the session of 1882, the Roath dock was authorized, which was afterwards duly constructed, and was opened in August, 1887.

The above is a short statement of the dates of the construction of the various Bute docks. These now consist of:—The Bute west dock, water area of 19½ acres; the Bute east dock, water area of 46¼ acres; the Roath basin, water area of 12 acres; and the Roath dock, water area of 33 acres.

The entrance channel, which is constructed through the East Mud, joining the river Taff at the Eastern Hollows, and continued through a shoal known as Cefn-y-wrach, is 400 feet in width at the narrowest part, and in other places is 600 feet in width.

The Bute docks are served principally by the following railways:—

The Taff Vale railway, with its various branches, affords communication with the important coal-fields of the Merthyr, Aberdare, and Rhondda districts.

The Great Western railway, the South Wales portion of which was opened in 1850. This railway brings traffic from the Monmouthshire coal-field on the east, and the coal district to the north of Bridgend on the west, of Cardiff.

The Rhymney railway had, for its original district, the valley of the river Rhymney, but now possesses a line in the Bargoed Rhymney valley, and (jointly with the Great Western Railway Company) lines in the Bargoed Taff valley, and the upper portion of the Taff valley.

These railways are the principal railways bringing coal traffic to the Bute docks; but the London and North Western, Brecon and Merthyr, and Midland railways, by means of running powers or otherwise, are also in communication therewith.

Until the year 1886, the Bute docks formed a portion of the Bute estate; but in that year a company was incorporated by Act of Parliament, under the style of the Bute Docks Company, to which company the docks were transferred.

The machinery and appliances of all kinds at the several docks are of the best construction and most improved designs. There may be noted, in particular, the Lewis-Hunter coaling-cranes; these cranes enable a vessel to load or discharge at three or more hatchways simultaneously, and are capable of loading a steamer of 7,000 tons burthen in 24 hours. By means of these cranes, the operation of shipping and unshipping can be carried on simultaneously; there being lines of railway under the cranes, parallel with the quay. Vessels carrying 9,414 tons of coal have been loaded by these cranes. Hydraulic power is extensively used for working the above and other cranes and machinery.

Large warehouses and transit sheds have been erected for the housing of grain, provisions, esparto grass, wines and spirits, and perishable or damageable articles of all sorts. The warehouses for grain are very large, and are calculated to contain about 600,000 quarters.

There is very extensive wharf accommodation for the storage of deals, timber, iron ore, and other goods not requiring to be under cover.

There are near to, and in communication with the docks, timber ponds or floats for the accommodation of the timber traffic, having a total extent of 28 acres, conveniently situated near the timber-yards, and in communication with the railways.

The following are some statistics showing the increase of the trade:—

Vessels cleared in 1870 were 6,892, of a nett register tonnage of 1,618,733 tons, and vessels cleared in 1894 were 9,907, of a nett register tonnage of 4,428,436 tons.

The imports and exports have been as follows:—

Year.	Imports. Tons.	Exports. Tons.	Total. Tons.
1840	451	45,591	46,042
1860	206,135	2,019,845	2,225,980
1880	1,041,313	5,249,824	6,291,137
1890	1,425,845	7,792,115	9,217,960
1894	1,676,977	8,130,243	9,807,220

THE DOWLAIS STEELWORKS, CARDIFF.*

The blast-furnaces, stoves, blast-engine house, bunkers, hoists and drops, and gantrys, etc., are all built on piles varying from 24 to 36 feet long, the total number of piles being 1,800, the quantity of timber used being about 80,000 cubic feet.

The 4 blast-furnaces are each 75 feet high from the hearth-level, and 85 feet high from the rail-level, they are 20 feet diameter in the boshes and 10 feet in the hearth, with eight tuyeres and an elaborate system of water-cooled boxes, built into the boshes, and surrounding the lower part of the hearth. The furnaces have closed tops, with cup-and-cone chargers; the gas passes through a main parallel to the line of furnaces with connexions for the stoves, then into a smaller main by which the gases are led to the boilers.

Inserted in the horse-shoe main of each blast-furnace is a Le Chatelier thermo-junction, which can be joined up with a self-recording apparatus, by means of which a record of the temperature of the hot-blast supplied to each furnace, and also the times at which the stoves have been changed, is obtained. An instrument also automatically records the time and interval at which the blast-furnaces are charged.

The blast for the furnaces is heated by eleven Cowper stoves, each 68 feet high and 24 feet diameter, with a heating surface of 47,500 square feet, giving an average temperature of 1,300 degs. Fahr.

At the back of the furnaces, and in a line with them, are 3 coke-bunkers, each having a capacity of 1,250 tons; 12 ore-bunkers, each

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* *Cardiff Illustrated*, page 175.

having a capacity of 867 tons; and 4 limestone-bunkers, each having a capacity of 850 tons. The ore and limestone-bunkers may be used at any time for calcining purposes.

The bunkers are filled from waggons running over a railway upon a gantry carried by iron columns, and the waggons are raised by a hoist. This hoist, as well as the furnace hoist, is water-balanced, the former having a lift of 58 feet, while the latter has a lift of 85 feet.

The engines for supplying air and water to the furnaces and lifts are contained in a large engine-house 146 feet long, 32 feet wide, and 60 feet high, with water-tanks on the top of 178,000 gallons capacity for the tuyeres, and 90,000 gallons for the hydraulic engines, and bottom tanks with a capacity of 120,000 gallons.

Three of the four blast-engines are of the compound surface-condensing type, direct-acting with the blast-cylinders below the steam-cylinders. The high-pressure cylinders are 36 inches in diameter, the low-pressure cylinders 62 inches in diameter, the blast-cylinders 88 inches in diameter, and all the cylinders are 60 inches stroke, fitted with piston valves. The fourth blast-engine is of the compound surface-condensing type, but with an independent condenser. The high-pressure cylinder is 36 inches in diameter, the low-pressure cylinder is 64 inches in diameter, the blast-pressure cylinder is 88 inches in diameter, and all the cylinders are 60 inches stroke. The high-pressure cylinder is fitted with Wheelock valve gear, and the low-pressure cylinder with ordinary piston valves. Each engine is capable of developing 1,200 horse-power, and delivering 25,000 cubic feet of air per minute, at a pressure of 4½ to 10 lbs. per square inch.

The pumping machinery includes 2 compound pumping-engines for the furnace and mineral hoists, each having a capacity of 1,500 gallons per minute; 6 compound pumping-engines for tuyere and cooler-water, each having a capacity of 400 gallons per minute; and 2 compound boiler feed-pumps, each capable of delivering 100 gallons per minute at the full boiler pressure. The 12 steel boilers are of the ordinary double-flued Lancashire pattern, 8½ feet diameter and 30 feet long, work at 100 lbs. pressure, and are gas-fired. The boiler chimney is 240 feet high, with an inside diameter of 13½ feet at the top.

The hydraulic and electric-light houses contain 1 double tandem compound hydraulic pumping-engine, delivering 160 gallons per minute; 2 compound hydraulic pumping-engines, each delivering 100 gallons per minute; and 1 compound hydraulic pumping-engine, delivering 90 gallons per minute. There are also 2 single tandem compound engines, with Proel valve-gear, each indicating 80 horse-power, and developing at the dynamo 230 ampères at 230 volts. All the hydraulic pumping-engines work at a pressure of 750 lbs. per square inch, and there is an independent surface condensing plant for the hydraulic and electric-light engines.

The weekly output per furnace is, with moderate driving, about 1,300 tons. The pig-iron is allowed to become cold on the beds, and its removal and breaking up is accomplished by mechanical means. The apparatus consists of quick-running overhead steam-travelling cranes, which sweep the whole surface of the pig-beds, and bring the iron to both of the 2 hydraulic-breakers, where it is broken and loaded direct into waggons.

The slag from the blast-furnaces is removed in ladles mounted on carriages, which tip it sideways while in a molten state wherever it is required. By means of a subway there is an independent railway connexion from the works to the wharf on the Roath dock, on which stand 6 hydraulic wharf cranes, each capable of lifting 35 to 40 cwts. These cranes are supplied with hydraulic power from the works, and are used for loading and unloading all the materials for the Cardiff and Dowlais works.

The plant for the production of mild steel consists of 6 thirty tons Siemens smelting-furnaces, each furnace having its own chimney. To assist in charging the materials into these furnaces a thirty tons electrically driven overhead crane is placed above the charging platform. In front of the smelting-furnaces are two sets of vertical heating furnaces for ingots, each having 10 holes and fitted with Siemens regenerators and valves. The furnaces are heated by gas supplied by 18 Ingham producers, charged by mechanical stokers.

The ingots when cast, weighing about 6 tons each, are removed from the casting-pit by a steam-crane and lowered into the vertical ingot-heating furnaces. Another steam-crane raises the ingot from the heating-furnaces and places it on a hydraulic-tilter, which lowers it on to the rollers of the slabbing-mill, where it is reduced to a slab of the desired thickness and width. The rolls of this mill are 36 inches apart, and can edge slabs 3½ feet wide. The slabbing-engine's cylinders are 48 inches in diameter, 60 inches stroke, and geared 2 to 1. The slab passes from the slabbing-mill to the slab-shear, where it is cut to the necessary sizes by a shear capable of cutting a slab 3½ feet wide and 10 inches thick; these are removed to the four re-heating furnaces by a circular charger which can draw and charge slabs up to 6 tons in weight, and is placed so as to take the slabs from the slabbing-mill and charge them into the re-heating furnaces, then to take them from these furnaces and place them on the rollers of the plate-mill, where they are rolled into a plate. The plate-mill rolls are 32 inches in diameter and 9 feet long, and the engines driving them have cylinders 54 inches and 60 inches stroke, and are geared 2 to 1.

The 10 Lancashire boilers in use for generating steam for the machinery in the steel-works are of the same dimensions and type as those described under the blast-furnace plant.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ODDFELLOWS' HALL, KILMARNOCK, DECEMBER 12TH, 1896

MR. ARCHD. BLYTH, COUNCILLOR, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed

The following gentlemen were elected:—

MEMBERS—

Mr. **THOMAS GOLDIE**, Drumpellier Colliery, Summerlee, Coatbridge.
Mr. **JOHN HENDERSON**, Cornsilloch Colliery, Larkhall.
Mr. **ARCHIBALD RUSSELL**, Indwe Colliery, Cape Colony, South Africa.
Mr **ALEXANDER SIMMONS**, Barblues House, Airdrie.
Mr. **GEORGE ROBERT THOMSON**, 204, George Street, Glasgow.

ASSOCIATE MEMBER—

Mr. **CLARENCE D. SMITH**, 11, Queen Street, Newcastle-upon-Tyne.

ASSOCIATE—

Mr. **WILLIAM S. THOMSON**, Bent View, Burnblea Park, Hamilton.

STUDENTS—

Mr. **CLAUD BANNATYNE**, 13, Fore Street, Camborne.
Mr. **ANDREW BURT**, Halbeath, Dunfermline.
Mr. **THOMAS TRAIN CHRISTIE**, Newcome, Uddingston.
Mr. **WILLIAM HOPE HENDERSON**, Anglo-American Club, Freiberg, Saxony
Mr. **ALEXANDER SMITH**, 238, West George Street, Glasgow.

DISCUSSION ON MR. BARROWMAN'S PAPER ON "THE HEALTH CONDITIONS OF COAL-MINING."*

Mr. J. **BARROWMAN** said that since his paper was printed, Dr. Snell had sent him a copy of a paper he had read a few years ago before the Sanitary Institute of Great Britain.† He was glad to say that the conclusions to which Dr. Snell had come from his experience and the experience of others, confirmed the conclusions that he (Mr. Barrowman) had indicated in his paper. Dr. Snell in one paragraph said:—

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* *Trans. Fed. Inst.*, vol. xi., page 240; and vol. xii., page 59.

† Vol. xvi., page 105.

> Statistics as to the general sickness-rate of miners are not so easy to obtain as rates of mortality. It appears that sick clubs recognize the fact that accidents to which miners are exposed render them a somewhat greater drain upon the funds than the ordinary members, and accordingly a small extra charge is made to them. Recently the Sheffield Equalized Druids examined this question. This society has among its members a large number of miners. From the report it appears that, according to Dr. Ratcliffe's miners' experience, the average sickness is 8 days and 20 hours, against 6 days and 10 hours for ordinary members each year. The committee of the Druids' Society found that their experience, at the same ages, was 7 days and 21 hours for ordinary members, and for miners alone 9 days 9 hours sick per member per year, showing that the miners have had 1 day 12 hours more than the ordinary experience of the society. Accidents may well be credited with this increased sickness run upon friendly societies. To obtain information for the purpose of this lecture, I issued to about 20 medical friends connected with collieries a series of questions. Those to whom they were addressed resided in all parts, from Scotland in the north to South Wales, and different coal-mining districts in England. From the replies with which they kindly favoured me, it is clear that in their opinion the general sickness-rate of a mining community compares not unfavourably with those of the population generally.

In another paragraph as to phthisis, Dr. Snell said :—

> The freedom of the miner from phthisis is a fact that hardly admits of dispute. Nor can this be got rid of by assuming as a reason that the miners are more or less picked men. The rarity of phthisis among miners is shown by the answers obtained by me from the medical men to whom inquiries had been addressed. Not one of these medical men admits to phthisis being anything but infrequent.

The **Chairman** moved a vote of thanks to Mr. Barrowman for his valuable paper, which was cordially approved.

DISCUSSION ON DR. HALDANE'S PAPER ON "THE CAUSES OF DEATH IN COLLIERY EXPLOSIONS."*

Mr. J. **Gilchrist** (New Cumnock) said that what struck him most in connexion with Dr. Haldane's paper and the discussions thereon was the fact, admitted by so many mining experts, but otherwise not so well known as it should be, that after an underground explosion explorers had two deadly gases to contend with, viz., carbonic dioxide or black-damp (specific gravity 1·529), and carbon monoxide or white-damp (specific gravity 0·969). In none of the Scotch explosions had any of the explorers been overcome by black-damp, but frequently they had been overpowered by a lighter gas, the composition of which was so clearly explained

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* *Trans. Fed. Inst.*, vol. xi., pages 502, 519, and 552 ; and vol. xii., pages 60 and 102.

by Dr. Haldane. He remembered an incident in connexion with the Udston explosion, where several men came and reported to Mr. Ralph Moore, late H.M. Inspector of Mines, that there was something wrong at a certain point inbye. Mr. Moore asked that some one should go and look at the place and ascertain what was the matter. Mr. Beith and himself volunteered, and, in going inbye, he remembered feeling the gas near the roof. They felt that there was a stream of hot gases near the roof coming down a heading. They at once saw that there was nothing to create any uneasiness; but he remembered that on returning he felt overcome, and thought he was going to faint. As an explorer, he had been surprised at the small proportion of victims who had been burned. At Udston colliery, if statistics had been kept, he thought it would have been found that more had been severely injured by the force of the explosion than otherwise. Two men were got out alive, proving that there was enough oxygen to support life. Again, after the Blantyre explosion, three men were saved about 18 hours after the explosion happened.

The **Chairman** said that the two men saved alive after the Udston explosion were found in one of the side roads, and had not experienced the force of the blast.

Mr. **Gilchrist** said that the first man was got in the cabin, which was wrecked, showing that the force of the explosion had passed through it.

The **Chairman** said a dead man was found outside the cabin.

Mr. M. **Ross** (Newton) said, with regard to the survivors of the Blantyre explosion, that he found them at a point immediately touching the roof of No. 3 pit-bottom, which showed distinctly that they were getting a certain amount of air at that point.

Mr. **Gilchrist** said that the survivors might get a little of the fresh air that was coming down the shaft.

The **Chairman** said that the survivors at Udston colliery were found near the pit-bottom.

Mr. **Ross** said that the survivors, viz., three men and a boy were found lying on the slope of the dirt that had fallen down the No. 3 shaft after the Blantyre explosion, and they could not get through. One man was within 1 foot of the door-heads.

The **Chairman** said that the difference between the circumstances attending the survivors at the bottom of No. 3 pit, Blantyre colliery, and those at Udston colliery was this: in the former case, they had travelled some distance to the shaft, while those at Udston were at the bottom at the time of the explosion.

Mr. **Ross** said that apparently the survivors at Blantyre colliery had travelled some distance, because immediately in front of them were men who had been knocked down before they reached the pit-bottom.

The **Chairman** said that everything in the way of the explosion at Blantyre colliery was forced towards the pit-bottom, and similar effects were observed at Udston colliery.

Mr. **Faulds** (Calderbank) said that Dr. Robertson in his remarks* attributed most of the deaths to shock, but he agreed with Mr. Gilchrist that the force of the explosion had caused deaths as well as shock.

The **Chairman** said that after the Udston explosion he had charge of the exploration of the dook, and also of one of the headings in the second shift, and every man there was burned, and when touched the skin was detached; the explosion had forced the dust into the skin. The explosion occurred on the Saturday morning, and the pit was cleared on the Monday morning, so that there was not time for decomposition of the bodies.

Mr. **Gilchrist** said that at Blantyre colliery, the exploration-work occupied three weeks. He was present when the last of the bodies was recovered, and he remembered it was said that it was due to the gases that the bodies had been so well preserved.

Mr. **James Prentice** read the following paper on "The Mineral Seams of New Monkland:"—

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* *Trans. Fed. Inst.*, vol. xii., page 61.

THE MINERAL SEAMS OF NEW MONKLAND.

By JAMES PRENTICE.

The parish of New Monkland occupies the extreme north-eastern corner of Lanarkshire. It is about 9½ miles long and 6½ in breadth, and extends to 20,117 acres. It is bounded on the north by the parishes of Kirkintilloch and Cumbernauld in Dumbartonshire (detached); on the east by Slamannan in Stirlingshire and Torphichen in Linlithgowshire; and on the south and west by Shotts, Bothwell, Old Monkland and Calder, all in Lanarkshire.

Although New Monkland, as a mining centre, does not figure so largely in the early annals of Scottish mining as Dunfermline, Newbattle, Tranent, or Culross, that fact has certainly not been due to any inferiority or want of mineral resources. On the contrary, it may be confidently asserted that there are few localities of equal area in Great Britain which have produced so much mineral wealth, or which have added so much to the commercial prosperity of this country during the last sixty years. It is probable that as far back as 150 years ago coal was wrought for smithy and milling purposes in the glens, and near the outcrops of some of the seams; but these workings could only be of a very simple nature, and not of great extent. Probably the beds of excellent peat, which extend so largely over the eastern and north-eastern parts of the parish, would provide amply for the domestic supply of fuel for the somewhat sparse population of the landward part of the parish.

Perhaps the earliest application of machinery to the working of mines took place in the Wester Moffat mineral field, about 1,500 feet to the south-east of the present mansion-house. In the glen there, near the Calder Water, a pit was sunk, about 36 feet deep, to the splint coal, at which a water-wheel was erected and used for pumping the water upwards of a century ago. On the same field, one of the earliest patterns of the Newcomen engine could be seen in 1846, standing in ruins at an old pit about 1,000 feet east of the present Clarkston railway-station. This old engine had for a working-beam a log of wood about 15 inches square, and the hand-gearing had been wrought by two pieces of rope attached to the pump-rod, which raised the water to the overhead tank for condensation purposes. The boiler was of the antiquated haystack pattern, and the whole arrangements belonged to the very earliest times of the application of steam to the purposes of mining. A similar engine, but of a more modern type, was working a pit on the same field, situated about 1,000 feet west of Clarkston church, about the year 1820. Engines of the Newcomen type were also in use at Stanrigg, Whiterigg, Airdriehill, Dykehead and Kipps in the early years of this century.

Except in the extreme north-western portion of the parish, through which the line of the Caledonian railway runs, the minerals near the surface belong to the Upper Carboniferous series, and at two points in the deepest part of the district the whole of the coal-seams in this series are represented. In common with the other mineral fields of Lanarkshire, New Monkland is very much intersected with faults, which have had the effect of cutting up the field into many isolated portions, in which separate pits have been sunk to work out the minerals. On this account there are perhaps a greater number of pits in this parish than are to be found in any similar area in Great Britain. As a rule, the principal faults run in a north-westerly and south-easterly direction, and vary in the amount of throw from 400 to a few feet. There are two principal east-and-west faults, one of which runs through the town of Airdrie, in a line parallel to Graham Street and Clark Street, and passes through Drumgelloch and the south of Clarkston village. This fault has a throw of at least 350 to 400 feet down to north in some portions of its course, and has had the effect of throwing down the seams, worked quite near the surface on the south side of Airdrie, to a depth of 500 or 600 feet under the northern part of the town, and it is on the downthrow side of this fault that all the known workable seams are found.

The other east-and-west fault, which is also a whin dyke, runs along a course nearly parallel with the northern boundary of the parish, and about 2,000 feet therefrom, and is an upthrow to north. The exact amount of displacement is not known, but as it brings up the Carboniferous Limestone series to a level with the lower members of the Upper Coal-measures, it cannot be less than from 1,000 to 1,200 feet. Subsequent to the occurrence of this fault, which had opened a crack about 60 feet wide in the strata, a flow of molten lava had been injected into the crack, and this now formed a wall of whin within the lines of the fault along its whole course. Another dyke of similar nature, with the same breadth of whin contained within its walls, runs in a parallel course about a mile to the south of the above dyke: this one, however, has neither upthrow nor downthrow. This has been proved in several places where mining operations have been carried up to it on each side, and, at one or two points, mines have been driven through it, the seams being found at the same level on both sides.

Referring to the north-east and south-west faults, of which there is a considerable number, the largest in respect of throw is that passing along a line parallel with the Bore Road, and running through Stanley House and the Airdrie cotton-works. This fault has a downthrow to north-east of 420 feet, and the strata embraced in the area to the east of this fault, including the racecourse, Drumbathie, and the northern portion of Springwells, are the deepest in the whole coal-field. Another fault, running nearly parallel with the above, passes through the western part of Rawyards, and has a throw of 120 feet up to the north-east. Still another fault, with an upthrow to east of 240 feet, passes through the curling-pond to the east of Rawyards; and immediately to the east of the pits now wrought at Stanrigg a series of three step-faults, each of about 100 feet rise to the north-east, throws up the strata about 300 feet. The result of this upthrow-fault has been to throw out most of the upper members of the Coal-measures on the eastern side of this fault, and consequently it is chiefly the lower coal-seams that are wrought in the eastern portion of the parish.

In the central part of the parish, and in the neighbourhood of Airdrie, the strata, as a rule, rise to the north, and the coal-seams crop out in that direction; but by the action of faults the same seams are often thrown down again, with the result that the outcrops are repeated in some cases as often as four times. In the eastern portion of the parish the rise is to the south-east and south, and in the northern portion the rise is to the north-west and north.

The Upper Coal-seam, which is the highest workable coal-seam in the Carboniferous system, is irregular in this locality and is on this account sometimes named the wandering coal. It has been wrought to only a small extent at two places in the parish. About the year 1850, a few hundred tons of this seam were wrought in the lands of Stanrigg. The seam was found near the surface and the coal was excavated with only the Boulder Clay for a roof. In this district, this coal-seam has never been found deeper than 20 or 30 feet; being so near the surface it is soft and friable, and cannot be worked profitably. The foundations of the large pumping-engine at Stanrigg pits were carried down to this coal-seam. Its thickness here is 2 feet 3 inches, and the quality is fair.

About the year 1874, a pit in the west end of the racecourse was sunk to this seam. It was worked for about two years, the coal being sold at the pithead for household purposes. This seam attains its greatest development at the collieries to the south-east of Glasgow, where it is found about 4½ to 5 feet in thickness and of excellent quality.

The Ell Coal-seam is the next workable seam in descending order, and is about 100 feet below the upper coal-seam. The strata overlying this coal-seam consist chiefly of sandstones, schists, and light-coloured argillaceous shales, the latter being specially characteristic of the ell coal. The area over which this seam extends in the parish is considerable, and it has been extensively wrought about Whiterigg and Clarkston. The following is a section of the seam at Whiterigg :—

	Ft.	In.
Coal	1	8
Sandy shale	0	11
Coal	1	7

The quality of the coal is fair. The coal is of a hard, splinty nature, and suitable for furnace and manufacturing purposes. The seam got its name from its thickness, and this name it retains in the Hamilton and Wishaw districts, although it there attains a thickness of from 7 to 8 feet. The nature of the seam alters as it gets thicker. To the south, it loses its hard, splinty nature, and becomes a free, soft coal, well adapted for household purposes.

The Pyotshaw and Main Coal-seam, or 9 feet coal, is found about 85 feet below the ell coal-seam, and is sometimes split up into two seams by a parting varying from a few inches up to 35 feet in thickness. The upper part of the seam, the Pyotshaw, is of a splinty nature, and suited for furnace and manufacturing purposes. The middle portion, sometimes called by the miners the "yolks," makes an excellent house coal, and the lower portion, or ground coal, is again of a splinty nature.

In some parts of the parish, especially in the neighbourhood of Airdrie and Rawyards, this seam has been subjected to the influence of the great intrusive sheet of whin, which extends over the whole of the central and eastern parts of the parish, and it has been rendered unworkable in some places on this account. At other parts, where its influence has not been so marked, the coal has been converted into semi-anthracite, and as such has been used as a steam coal. This seam has been very extensively worked about Rawyards, Colliertree, Wester Moffat, Whiterigg, Stanrigg, and Ballochney.

The Humph Coal-seam underlies the 9 feet coal at a distance of 48 feet, and although not now considered of very great importance, was one of the first coals wrought in the parish, being much sought after in the early days of mining as a smithy coal. When it is found in a suitable condition it is admirably adapted for this purpose, for which its quality is unsurpassed. The following is a representative section of this seam :—

	Ft.	In.
Coal, inferior	0	8
Parting	0	3
Coal, good	2	0

In excavating the seam, the inferior coal is usually left on to form the roof of the working. It has been wrought about Airdrie, Rawyards, Whiterigg, Stanrigg, Arbuckle, Arden, Wester Moffat, and Clarkston.

The Splint Coal-seam, which lies 30 feet under the humph seam, is the great furnace-coal of Scotland. It has been most extensively wrought over large areas of the parish, and except in the neighbourhood of Airdrie and Rawyards, where it is converted into a steam-coal by the action of the intrusive whin, has been almost exclusively used in the blast-furnaces around Coatbridge for smelting iron. The coal is of a strong, splinty nature, and about 5 feet in thickness. It has been worked extensively about Airdrie, Kipps, Rawyards, Whiterigg, Stanrigg, Darngavil, Arbuckle, Arden, and Wester Moffat.

The Virgin Coal-seam underlies the splint coal about 12 feet, and is about 1 foot 6 inches thick. It has never been wrought to any great extent in this parish, but in the Baillieston and Shettleston district it is a good house coal, about 2½ feet in thickness. The lower portion of the seam is of poor quality.

The Musselband Coal-seam lies 42 feet under the virgin coal-seam. This seam takes its name from a thin bed of musselband ironstone, of no economic value, lying about 4 feet above the coal, and which sometimes forms the roof of the working-roads. This coal-seam is very irregular in occurrence, and in many places is quite unworkable, being thin and not of good quality, and it everywhere has a very bad roof. At Drumshangie and Dykehead, the chief places in the parish where it has been worked, it attains its greatest development and best quality. A considerable area has been wrought also from the south-eastern portion of the lands of Rochsoles. It has been used to a considerable extent in gasworks, giving about 11,000 cubic feet of gas per ton, with an illuminating power of about 16 candles. The following is a section of the seam with the roof:—

	Ft.	In.	Ft.	In.
Musselband ironstone			0	4
Soft dark blaes			4	0
Coal, splinty	2	2		
Dark blaes	0	11		
Coal, free	1	0		
			4	1

The Blackband Ironstone lies 27 feet below the musselband coal-seam. Although the blackband ironstone was discovered by Mr. Mushet in the year 1805, and in a few years afterwards its great adaptability for use in the blast-furnace had been fully proved by experience, yet it did not come into very extensive use in the earlier years of the century. This may be easily accounted for by the comparatively small quantities of ore required to keep the furnaces then built in operation. But when Mr. Neilson's great invention of the hot-blast was introduced in 1828, taken along with the erection and starting of such important works as Gartsherrie, Summerlee, Langloan, and Carnbroe, a great and pressing demand at once set in for this splendid iron-ore, with the result that almost every available acre of ground in the parish was eagerly competed for and taken in lease by one or other of the great iron companies. Its geological position had by this time become perfectly well known, and the exact depth to which a pit would require to be sunk to reach it could be calculated to a certainty where any of the above-mentioned coal-seams were wrought or were known to crop out. Hence the marvellous rapidity with which the whole surface of the central, northern, and southern parts of the parish became dotted with pits for the working of the seam. Another important factor in this development was the making of the Ballochney railway in 1828, and of the Drumshangie branch some years later. These lines gave great facilities for the carriage of the iron-ore to the furnaces, and were the means of opening up new districts for the working of the ironstone as well as many of the other seams which, without these aids, might have long remained unwrought. It is, perhaps, not too much to say, that the prosperity of mining in the parish at the present day owes its origin to the impetus given to the industry by the operations in connexion with the searching for, and working of, this important seam in the past. Thus, in the eager search for ironstone in the shallower portions of the fields, bore-holes were often put down over the outcrop of this seam. These bore-holes, although they may have missed the ironstone, were carried on until one or other of the seams lying below it was found. In this way a knowledge of the lower seams, with their thickness and relative geological position, was gradually acquired, which is being amply utilized at the present day. Another important advantage has been gained by the utilization of the old ironstone pits for the working of the coal-seams. In many instances throughout the parish these advantages have enabled men of moderate means to start as coal-masters, who might otherwise have been unable to do so, and have added greatly to the more recent development of the coal-mining industry. The blackband ironstone may now be said to be wrought out. The most recent working in the seam was about eight years ago, at Darngavil.

Although this seam attains its greatest development, and is in its best condition, in the parish, yet it does not continue to be a workable seam over the whole area represented by its geological position. Thus, in the south-eastern portion of the parish it occurs as a foul coal about 12 inches thick, without any trace of ironstone, while in the eastern portion it dies out as a workable ironstone. Eastwards, from the western side of Arden, and the eastern march of Darngavil, it is represented by about 2 inches of inferior ironstone and 14 inches of foul coal. In its northern extension the seam retains its value as an ironstone until it finally crops out in the neighbourhood of Greengairs.

The thickness of the seam varied a little in the different parts of the field, but it averaged about 14 inches, and had a specific gravity of 2·88. The following is an analysis of the raw ironstone in its best state :—

	Per Cent.
Protoxide of iron	48·25
Carbonic acid	32·91
Carbon	12·90
Combined water	3·74
Phosphoric acid	0·94
Lime	0·56
Silica	0·40
Magnesia	0·30

According to this analysis, the metallic iron contained in the ironstone is equal to 37⅓ per cent., or about 1,500 tons of pig-iron per acre.

An accident of a peculiar kind arising from the calcining of a heap of this ironstone may be here referred to. It occurred at the north-eastern corner of Dykehead about the year 1840. A heap of blackband ironstone had been deposited on a hearth under which the splint coal-seam had been previously worked quite near the surface. After the ironstone had been kindled a sit took place letting down the burning ironstone into the old coal-workings. This at once set fire to the stoops of coal left to support the roof, and in a short time the old underground workings were in a blaze. The conflagration rapidly extended, and all efforts to put it out failed. A conference of the neighbouring proprietors and others was called at which it was decided to isolate the fire by cutting a deep channel round it, and carrying the cutting right down through the seam on fire. This was at once set about, and a large number of navvies from all parts were got to do the work. Large cuttings were made, at some points upwards of 40 feet deep, to intersect the seam. This plan was ultimately successful, although at the completion of the work the fire had extended almost to the very place where the men were at work. A lawsuit was raised to decide who was liable for the expense incurred, and was ultimately decided against the lessees of the minerals.

The Soft Ironstone is a peculiar seam of ironstone of poor quality, which lies about 5 feet below the blackband over a very limited area, and confined exclusively to a strip of the parish, extending from Rawyards in the south-west to Greengairs in the north-east. At no part of this strip does the width of the ironstone exceed 600 feet. It has been wrought at Rawyards, Airdriehill, Stanrigg and Whiterigg, but has never been a working of much value. As it was wrought in these places subsequent to the extraction of the blackband ironstone, great difficulty was experienced in keeping the roads in the seam in repair. So thin was the division between the seams, that falls often took place in the soft ironstone-workings, extending upwards into the old waste of the blackband ironstone-workings, and leading to considerable expense and danger in carrying on the works. The seam was about 20 inches in thickness in the centre of the strip, tapering down towards the edges of the area to an inch or two and finally disappearing altogether. The occurrence of this seam is remarkable as a geological curiosity, as it proves that before the blackband seam was formed a long narrow lake had extended over the area now containing the softband seam, which was entirely local in its nature.

The Virtuewell Coal-seam lies at a distance of 72 feet below the blackband ironstone. This coal is of excellent quality, and usually about 2½ feet thick. It has been most extensively mined over the parish at all parts where it is geologically represented, and has been, and is still, in much demand as a first-class household coal. Probably its name arose from the Virtue Well in the glen north-west of Airdrie, a mineral spring of some repute many years ago, near which the seam crops out, and where probably it was first worked. Many of the old blackband ironstone-pits have been utilized for the working of this seam, as it was only necessary to sink them 72 feet further to reach it. On this account the working of this seam became fairly general over the parish, with the result that it is nearly wrought out. In the eastern part of the parish it is known as the Johnstone coal-seam, where it has a seam of oil-shale immediately overlying it about 8 inches thick, which has been largely used at Stanrigg oil-works and elsewhere for making oil, and in some cases it has also been used in gas-works in the manufacture of gas.

The Ladygrange Coal-seam lies 42 feet under the Virtuewell seam. It has not been wrought to any appreciable extent in the western portion of the parish, where it is thin and of poor quality; but from Whiterigg eastwards the quality as well as the thickness improves, and towards the eastern boundary of the parish it becomes an important seam and is extensively mined. In this locality it may be said to be the uppermost of the now well-known steam coal-seams at present being so extensively worked. The thickness of the seam varies from 18 inches in the western part of the parish to 2½ feet in the eastern portion, and the quality of the seam improves in about the same ratio as the thickness increases.

The Musselband Ironstone and Shale is the next seam in descending order, and is found about 50 feet below the Ladygrange coal-seam. When the manufacture of mineral oil became a free industry, through the expiry of Mr. Young's patent rights, oil-works were established at various parts of the parish where this seam came near the surface, and considerable sums of money were expended in equipping these works and in sinking pits to this seam. Had the state of matters continued which existed about the year 1865 when these undertakings were commenced, this industry would by this time have attained large proportions; but, unfortunately for oil-makers, the prices obtainable for oil fell to a point at which they were unable to make it, and these works gradually dropped out of existence. Nor is it likely that oil can be made at a profit from this seam, which has only about 8 inches in thickness of shale, so long as the seams in the Uphall and Broxburn districts, which average 4½ feet in thickness, are available. The following is a section of the seam :—

Roof, black blaes.	Ft.	In.
Shale	0	5
Shale, with cannel coal	0	3
Musselband ironstone	0	7
Mussel bed	0	2
Clayband ironstone	0	3
Blaes	0	4
Coal	0	6
Soft fireclay	0	4
Floor, fireclay.		

The shale, along with the shale and cannel coal combined, produces about 30 gallons of crude oil per ton. The musselband ironstone and mussel bed are of little or no economic value, although various attempts have been made to select a part of the musselband ironstone and calcine it along with the clayband ironstone; but it is of very inferior quality and contains a large proportion of phosphorus, which is a most objectionable ingredient in any ironstone. This musselband gets its name from the enormous number of fossilized shells of which it is largely composed. These shells, which are very like the ordinary mussel in appearance, are those of *Anthracosia robusta* and *Anthracosia acuta*. The working of the seam has now totally ceased throughout the parish, except at Arden.

The Kiltongue Coal-seam lies 30 feet below the musselband ironstone and shale. It no doubt derived its name from the lands of Kiltongue in this parish, in which it probably was first wrought. This coal-seam varies greatly in its characteristics in different parts of the field. In the west, it is about 4 to 6 feet in thickness, and of rather inferior quality. In the central portion, comprising Rawyards, Drumbathie, Springwells, Bellsdyke, Thrashbush, Holehills, Airdriehill, Stanrigg, Whiterigg, Drumshangie, and Darngavil, it is in two divisions, with a parting of about 6 inches between them, the upper portion (which contains generally about 3 inches of cannel coal) being about 14 inches thick, and the lower portion 16 inches, the total thickness being about 30 inches. The chief attraction about the seam is the presence of the 3 inches of cannel coal in the upper division. This, however, is not found regularly over the whole area. It comes into the seam and dies out again in a most erratic manner, but when present it is a valuable constituent. When in its best state this cannel coal produces about 15,000 cubic feet of gas per ton, with an illuminating-power of about 40 candles, being, after the Torbanehill mineral, probably the best cannel coal in Britain. The seam in this district is now nearly wrought out. In the north-eastern part of the parish it is a seam of only about 20 inches in thickness, but of excellent quality. It is not present as a workable seam in the eastern or south-eastern parts of the parish.

The Lime Coal-seam lies about 20 feet below the Kiltongue seam ; but it is found in a workable state only over a small area at Glentore. In one of the pits on these lands it is about 20 inches thick, thinning down all round to about 14 inches. A seam of cannel coal at Drumbowie, in this parish, is found exactly on the same geological horizon. It is probably the same seam, but under different conditions. In both cases its occurrence is entirely local.

The Upper Drumgray Coal-seam lies about 40 feet below the Kiltongue coal-seam. No doubt it also derived its name from the lands of Drumgray, in this parish, in which it was first wrought. In the western and central parts of the field, it is a seam ranging from 20 to 30 inches in thickness, of a hard splinty nature and well adapted for furnace purposes. Over a considerable area, in the deeper parts of the field, it has not yet been sunk to. This has no doubt been due to the large expenditure required to reach the seam by sinking and equipping pits for the purpose, taken along with the thinness of the seam and the low price at which this coal had, till recently, to be sold. In the northerly portions of the parish, where it is comparatively shallow, it has been extensively mined, especially about Raebog, Stand, High Rigend, Nettlehole, and Rigg. In the eastern part of the parish, however, where it is sometimes called the Slamannan splint coal-seam, this forms the principal seam, and its product has achieved for this district the distinction of being one of the finest steam-coal districts in the kingdom. The conversion from a hard, splinty coal, which is its natural state, into a comparatively soft, free, steam-coal has been effected by the influence of the great sheet of intrusive basalt, or whin, which has been interjected into the strata after all the coal-seams were formed. This great whin sheet extends over all eastern Lanarkshire and southern Stirlingshire, and has modified and altered the quality of all the coal-seams within the sphere of its influence. This influence is in direct ratio to the thickness of the strata intervening between the seam and the whin, taken along with the thickness of the whin at the same point. Thus, at Arden, this seam is 200 feet above the whin, and the whin is 200 feet thick, and the influence of the whin exerted through the 200 feet of strata has been exactly sufficient to convert this coal into the best quality of steam coal. Nearer the whin the coal would probably have been "blind," more distant it would have retained its hard and smoky characteristics, and would not have been of the same value as a steam-coal. It will thus be seen how important have been the changes effected by this agency as regards the mining industry in this part of the parish. It may be interesting to notice here that the influence exerted by intrusive whin on a coal-seam lying under it bears a similar ratio to that above, with thickness and distance as factors, but the effect is not so intense by about a third. For example, in the case mentioned, had the Arden seam been lying 130 feet under the whin, it would probably have been affected to about the same extent as if it had been lying 200 feet above it. The following two analyses show the difference in the quality of this coal in the western and eastern districts :—

	Western. Per Cent.		Eastern. Per Cent.
Volatile combustible products	40·2	...	24·5
Water expelled at 212 degs. Fahr.	3·5	...	1·2
Fixed carbon	52·0	...	70·2
Ash	4·3	...	4·1

These analyses show that the coal in the eastern district is at least 20 per cent. better for steam-raising purposes than that from the western division, taking the fixed carbon as the important factor. Another noticeable fact is that the steam-coal has to a great extent lost the power of absorbing water, which is greatly in its favour. Commencing at Stanrigg, where this coal-seam is worked under the whin, and passing eastward over Arbuckle, in which the whin intersects the seam, finally dipping away under the coal-field to the east, this seam is in its highest state of perfection as a steam-coal in Arden, Easter Glentore, Greendykeside, Longriggend, Meadowfield, Roughrigg, Longrigg, Brownrigg, and Auchengray.

The Lower Drumgray Coal-seam lies about 80 feet below the upper Drumgray seam. About the centre of these 80 feet, there is a seam of coal varying from 9 to 20 inches in thickness which has been little worked, but is usually called the mid coal-seam. Unlike the upper Drumgray and the Kiltongue seams, which got their names from the places where they were first wrought, this seam can claim no connexion with the name of Drumgray. No trace of its existence is to be found at or near Drumgray. It extends only over the south-eastern part of the parish and along a very narrow strip on the south.

In the south-eastern district, this seam, in common with the others, has been affected by the proximity of the great whin sheet, and, being nearer it by 80 feet than the upper Drumgray seam, has been affected by it in a much greater degree, so much so that it might almost be classed as an anthracite. This, now-a-days, is no bar to its use as a steam-coal; in fact H.M. Navy will use no other kind, and consequently it is now being mined pretty extensively at Arden, Longrigg, and Roughrigg. It is as a household coal, however, that this seam shows to best advantage. It has been extensively wrought as such at Brownieside for the last twenty years, and is of first-class quality. A little to the north of Brownieside estate it dies away, and no trace of it is found in any part of the parish on the northern side of the Edinburgh and Glasgow road, from Clarkston church westwards. Recently this seam has been sunk to at Bellsdyke and Petersburn, and has been found at both places of good quality. The thickness of the seam in the steam-coal district is about 2 feet, although worked at some places as thin as 15 inches. In the house-coal district it is 2½ feet thick.

The Slatyband Ironstone.—Two hundred and forty feet of strata intervene between the lower Drumgray coal-seam and the slatyband ironstone. There are five or six thin seams of coal included in this 240 feet, but none of them is of any economic value, being only from 4 to 12 inches thick. The ironstone may be said to be at the very base of the Upper Coal-measures. It is extremely lenticular in occurrence, and varies in thickness, sometimes very rapidly, in a short distance. The quality of the ironstone is of the very best. It has been wrought at four places in the parish: Brownieside, Arden, Stanrigg, and Auldshields. At all these places, except Stanrigg, the working of this seam has been abandoned. The same characteristics, however, have been found in all the workings of this ironstone. Troughs or hollows occur in the floor of the seam in which the ironstone is found, sometimes 2 or 3 feet thick. A short distance beyond these troughs, ridges occur on which the ironstone may not exceed as many inches. These irregularities, along with the liability of the seam to extensive "wants," in which no ironstone is found at all, render the working a little uncertain. The quality of the ironstone is shown in the following analysis of a part of the seam from Brownieside:—

	Per Cent.
Protoxide of iron	54·03
Carbonic acid	33·22
Carbon	6·24
Combined water	2·36
Phosphoric acid	1·14
Sulphide of iron	0·57
Lime	0·86
Silica	1·05
Magnesia	0·53

This analysis shows 42 per cent. of metallic iron.

Glenboig Fireclay Seam.—This seam occurs about 720 feet beneath the slatyband ironstone. The whole of this 720 feet consists of the Millstone Grit, being beds of coarse gritty sandstone, from 60 to 120 feet in thickness, separated by beds of fireclay 4 or 5 feet thick, sometimes accompanied by 3 or 4 inches of coal. Towards the bottom of this series of rocks the partings of fireclay get thicker and form workable beds, and the Glenboig seam is one of them. It is about 6 feet thick, and lies near the bottom of the series. It is only a few fathoms beneath this seam to the topmost limestone of the Carboniferous Limestone series, and this working is, therefore, on the dividing-line between two of the great geological divisions of the Coal-measures. This seam of fireclay is of the very best quality, and the firebricks manufactured from it have a world-wide celebrity.

The preceding description exhausts the list of the seams which have been or are being wrought in the parish, and from them in recent years there have been raised upwards of 1½ million tons annually.

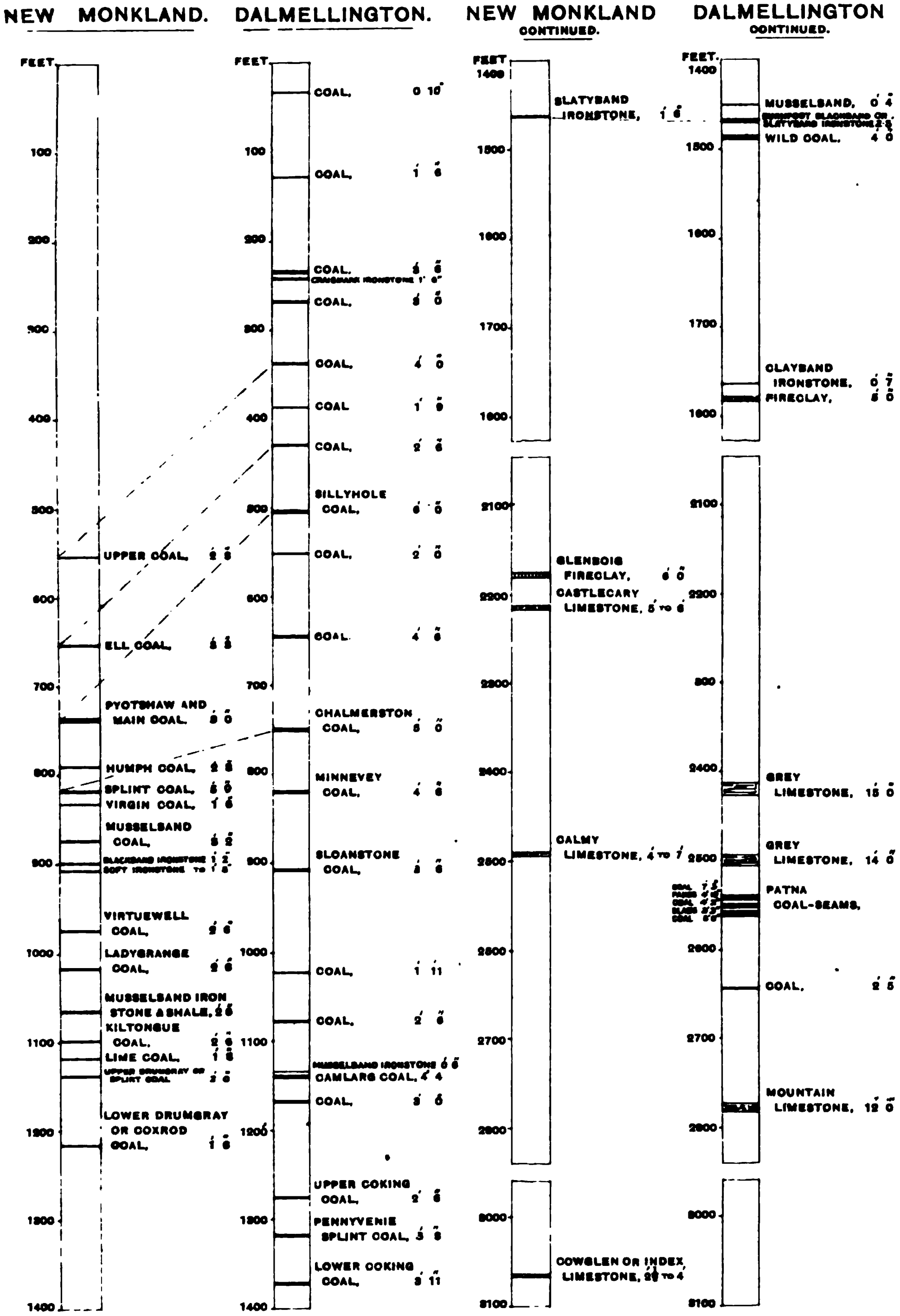
The following is an approximate section of the strata likely to be found underlying the Glenboig fireclay seam :—

	Feet.
Glenboig fireclay.	
Strata	30 to 60
Castlecary or Levenseat limestone	5 to 8
Strata, unproductive	300
Calmy limestone	4 to 7
Strata, containing two or three inferior coal-seams ...	540
Cowglen or index limestone	2½ to 4

The Lower Coal-measures begin immediately below the Cowglen limestone, and embrace about 1,200 feet of strata containing numerous coal-seams, some seams of blackband ironstone, and, towards the bottom of the measures, seams of clayband ironstone in great profusion.

In looking to the future of the mining industry in this parish, it is not likely that the present output will be exceeded. It may be kept up to about its present standard for a few years; but the early years of the twentieth century will witness a decadence, unless in the interim extensive operations are undertaken to sink to the Lower Coal-measures. This over a large area of the parish will prove to be a formidable undertaking; but there is a belt running east-and-west along the northern part of the parish, and about ½ mile wide, in which the upper beds of the Lower Coal-measures should be found within 900 feet of the surface. This area embraces Wellhills, Glenhove, Coathill, Easter Blairlinn, Mid Blairlinn, Limekilns, Garngibbock, Majiscroft, North Myvet, and Maryburgh.

To illustrate Mr. James Prentice's Paper on "The Mineral Seams of New Monkland"



On the western side of the parish also, a considerable area exists, where the depth would not very greatly exceed that mentioned above; for instance, the Glenboig fireclay-pits might be expected to reach the upper members of the Lower Coal-measures if they were sunk an additional 900 feet. In the deeper portions of the coal-field, about Airdrie, Clarkston, and Stanrigg, the depth to the top of the Lower Coal-measures will considerably exceed 2,400 feet. This is a depth far beyond anything we have yet contemplated sinking to in Scotland; but we may rest assured that when the time arrives that the industries of the country require it, the necessary capital and enterprise will be forthcoming, and New Monkland will in the future, as in the past, provide its share of that mineral wealth which is the foundation of the prosperity of our country.

Mr. PRENTICE suggested that some of the members might correlate the Ayrshire coal-seams with those of Lanarkshire. There was no doubt that the seams were all laid down practically during the same geological period.

Mr. GILCHRIST (New Cumnock) said that, in his opinion, the gas coal-seam in the New Cumnock district corresponded with the ell coal-seam in the Newmains district. A fine fireclay was found above the ell coal-seam, suitable for brick-making, and he found that at New Cumnock a corresponding clay occurred above the upper gas coal-seam.

Mr. BOWIE (Lugar) said that the slatyband ironstone of Lanarkshire and the blackband ironstone of southern Ayrshire were the same seam.

Mr. PRENTICE said that this would form a good basis from which the correlation could be worked upwards.

Mr. ROSS asked whether Mr. Prentice had overlooked the Palacecraig ironstone, which lies above the upper coal?

Mr. PRENTICE replied that this mineral had never been found, except in the Palacecraig coal-field, which was outside of New Monkland parish.

Mr. SMITH (Dalmellington) said that he had worked the Palacecraig ironstone at Dalmellington, and that the wandering coal-seam was the first workable seam found above the ell coal-seam, and the second workable seam below the Palacecraig ironstone.

The SECRETARY (Mr. Barrowman) submitted comparative sections of the New Monkland minerals as described in Mr. Prentice's paper, and of Dalmellington minerals as handed in by Mr. Smith, showing the correlation of the several seams, the slatyband ironstone of New Monkland, and the Burnfoot black band ironstone being placed on the same plane (Plate XXI.).

The further discussion was adjourned.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 12TH, 1896.

MR. G. B. FORSTER, PAST-PRESIDENT, IN THE CHAIR.

The **SECRETARY** read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on November 28th and that day.

The **CHAIRMAN** referred to the loss which the Institute had sustained in the death of the late Mr. William Armstrong, and proposed that a vote of condolence and sympathy should be sent to Mrs. Armstrong and family. Mr. Armstrong was one of the original members of the Institute, a Vice-President, and had been actively associated with the Institute from its commencement.

The motion was agreed to.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBERS—

Mr. **R. DONALD BAIN**, H.M. Inspector of Mines, 85, Pembroke Road, Clifton, Bristol.
Mr. **THOMAS BELL**, Mining Engineer, 15, Valley Road, Scarborough.
Mr. **STEPHEN CAMPBELL CRONE**, Mining Engineer, Oakhurst North, Longbenton, Newcastle-upon-Tyne.
Mr. **WILLIAM HENRY HEDLEY**, Mining Engineer, 34, Beverley Terrace, Cullercoats.
Mr. **WILLIAM LISHMAN**, Mining Engineer, Thornhill Park, Sunderland.
Mr. **HENRY LOUIS**, Professor of Mining, Durham College of Science, Newcastle-upon-Tyne.

MEMBERS—

Mr. CHARLES CHANDLEY, Mining Engineer, c/o Mr. E. Graham Price, P.O. Box 150, Coolgardie, Western Australia.

Mr. HENRY MOORE ANNESLEY COOKE, Under-manager, Pestarena United Gold Mining Company, Limited, Pestarena, Vall'Anzasca, Novara, Italy.

Mr. WILLIAM CHARLTON DAGLISH, Colliery Manager, Rodridge House, Hutton Henry Colliery, Wingate, R.S.O., Co. Durham.

Mr. TELFORD EDWARDS, Mining Engineer, Cowbridge, Glamorganshire, South Wales; and Tati, Matabeleland, South Africa.

Mr. JAMES FERGUSON, Visiting Director of Langlaagte Estate, etc., P.O. Box 253, Johannesburg, S.A.R.; and 31, Maxwell Drive, Pollokshields, Glasgow.

Mr. THOMAS FOWLER, Senior Inspector of Mines, Coolgardie, Western Australia.

Mr. ROBERT GORDON, Engineer and Mining Agent, Imperial Chambers, Coolgardie, Western Australia.

Mr. GEORGE WILLIAM HALL, Mine Manager, Coolgardie, Western Australia.

Mr. LESLIE HILL, Civil and Mining Engineer, Rossland, British Columbia, Canada.

Mr. WILLIAM HENRY TREWARTHA JAMES, Mining and Metallurgical Engineer, Cliveden, Shaw Street, Coolgardie, Western Australia.

Mr. EDWARD IVEAGH LORD, Civil Engineer, Mining Surveyor for the New Zealand Government, Greymouth, New Zealand.

Mr. HUGH FREDERICK MARRIOTT, Mining Engineer, c/o Messrs. H. Eckstein & Co., P.O. Box 149, Johannesburg, S.A.R.

Mr. WILLIAM FREDERICK DE MOLE, Civil and Mining Engineer, Coolgardie, Western Australia.

Mr. HENRY EDWARD NEAVE, General Manager of Lionsdale Estates, Ltd., Carolina, Transvaal, South Africa.

Mr. EDWARD PRITCHARD, Civil and Mechanical Engineer, 1, Victoria Street, Westminster; and 37, Waterloo Street, Birmingham.

Mr. JAMES SHAW, Mining Engineer and Contractor, and Mine Manager, Stanley House, Kent Town, Adelaide, South Australia.

Mr. JAMES STANLEY, Mining Engineer, Metallurgist, and Assayer, c/o Messrs. G. Graves Gifford & Co., Coolgardie, Western Australia.

Mr. FRANCIS EDWARD VINCENT, Mining Engineer, P.O. Box 179, Coolgardie, Western Australia.

Mr. JOHN WHIDBOURNE WATTS, Mining Engineer, General Manager United Ivy Gold Mining Co., Barberton, Transvaal, South Africa.

Mr. DAVID WILLIAM WELCH, Mining Manager, Union Bank, Coolgardie, Western Australia.

Mr. HENRY WILLIAM YOUNG, Civil Engineer and Authorized Surveyor, Greymouth, New Zealand.

ASSOCIATE MEMBERS—

Mr. ROBERT ALLEN, Metallurgist and Assayer, c/o Messrs. G. Graves Gifford & Co., Coolgardie, Western Australia.

Mr. THOMAS SALMON BACKHOUSE, Adelaide, South Australia.

Rev. JOSEPH CAMPBELL, Consulting Geologist, St. Nicolas College, Randwick, Sydney, New South Wales.

Mr. SEVERIN FLOWER, 29, Cornhill, London, E.C.

Mr. **Charles W. Langtree**, Melbourne, Victoria, Australia.
Mr. **Charles Lovell**, 29, Cornhill, London, E.C.
Mr. **John I. Lowles**, Mining Engineer, Leverington Chambers, Sylvester Street, Coolgardie, Western Australia.
Mr. **J. Gordon McLaren**, Mining Engineer, Leverington Chambers, Sylvester Street, Coolgardie, Western Australia.
Mr. **John Walton Robinson**, Merchant, 6, Gladstone Terrace, Gateshead-upon-Tyne.
Mr. **Henry Naunton Robson**, Representative of the International Gold Syndicate, 18, Club Chambers, Coolgardie, Western Australia.

Student—

Mr. **Nicholas Richardson**, Mining Student, Heworth Colliery, Felling, R.S.O.

ELECTION OF VICE-PRESIDENT.

The **Secretary** reported, in accordance with Bye-law 22, the nominations of the Council for the vacant office of Vice-President, and on a show of hands, Mr. R. Robinson was elected.

REPRESENTATIVE ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

It was unanimously agreed that Mr. J. Gerrard, H.M. Inspector of Mines, Manchester, be appointed as an additional representative.

DISCUSSION ON DR. HALDANE'S PAPER ON "THE CAUSES OF DEATH IN COLLIERY EXPLOSIONS."*

Dr. **Bedson** said that he was glad to have the opportunity of expressing his congratulations to Dr. Haldane on the successful and absolute proof that he had given of the fact that carbon monoxide was the harmful constituent of after-damp. Dr. Haldane's paper was the most important that they had had on this subject for many years. It established what previously was only surmised on the part of those who had considered what took place in explosions in coal-mines, and who felt that the deadly effects of after-damp

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* *Trans. Fed. Inst.*, vol. xi., pages 502, 519, and 559; and vol. xii., pages 60, 102, and 432.

could not be due merely to the reduction of available oxygen and the presence of a large quantity of carbon dioxide in the air. In Dr. Haldane's investigations the members had absolute proof of the fact that the injurious constituent in after-damp produced in coal-mines was the carbon monoxide which was formed by explosion. He (Dr. Bedson) took especial interest in that proof, because some eleven years ago he examined a sample of gas taken by Mr. J. B. Atkinson (H.M. Inspector of Mines) from the Usworth mine after the explosion in March, 1885; that examination showed the gas to contain 1·34 per cent. of carbon monoxide; the oxygen was (very much reduced) 5·38 per cent.; and carbon dioxide 4·79 per cent. Carbon monoxide acted more rapidly when the proportion of oxygen in the air was reduced, and replaced by such indifferent gases as carbon dioxide and nitrogen. That carbon monoxide would be formed in an explosion was shown by the experiments of Prof. H. B. Dixon in Lancashire, and by himself (Dr. Bedson) in the experiments made in the investigation upon fumes produced by roburite, gunpowder, and tonite for the Durham Coal Owners' and Miners' Associations. In both series of experiments it was proved that the explosion of such bodies as roburite and tonite, which by themselves, when out of contact with coal, produced no carbon monoxide, did produce carbon monoxide in the presence of coal.* The production of carbon monoxide in these cases could only be explained by the fact that the heated gases, containing a large proportion of carbon dioxide, reacting on the coal, produced carbon monoxide. From these experiments, therefore, they might expect to find in the after-damp in coal-mines a considerable quantity of carbon monoxide, a fact which Dr. Haldane had abundantly proved.

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LIVERPOOL, 1896.

The report of the proceedings of the Corresponding Societies Committee of the British Association for the advancement of Science was read, and also that of Mr. J. H. Merivale, the delegate representing the Institute, as follows:—

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* *Trans. Fed. Inst.*, vol. ii., page 384.

Togston Hall, Northumberland,
November 12th, 1896.

To the President and Council of the North of England Institute of Mining and Mechanical Engineers.

Gentlemen,

The delegates met on the afternoon of September 17th and 22nd, 1896.

Reports of various committees were presented, amongst others being one upon underground waters in the permeable formations of England and Wales. Though the final report of this committee was presented last year, Mr. C. E. De Rance, the secretary, will be glad to receive further information upon the subject.

The Seismological Committee reported that it had now been proved that any important earthquake was felt all over the world, and they considered that arrangements should be made for the record and study of those movements.

Dr. Haldane also read a paper on "The Detection and Estimation of Carbon Monoxide in the Air," and gave a demonstration of the method which he had devised. This method depends upon the fact that carbon monoxide is readily absorbed by blood when the two are shaken up together. The amount of carbon monoxide present in the air with which the blood has been shaken can be ascertained very readily by the extent to which the colour of the blood is changed. Deaths in coal-mines after explosions are usually due to this gas, which is extremely dangerous when breathed in small quantities for a considerable time. The author's method is capable of detecting 0·01 per cent. of the gas in air.

Prof. Clowes read a paper on "The Detection and Estimation of Carbonic Oxide in the Air by means of the Flame-cap Test." The standard hydrogen flame, 0·40 inch in height, gives a cap of 0·50 inch in air, containing 0·25 per cent. of carbonic oxide, and the height of the cap increases as the percentage of carbonic oxide becomes larger. The author, however, pointed out that as all combustible gases give flame-caps this method was only suitable when other gases were known to be absent.

Dr. P. Phillips Bedson read the report of the Committee on the Proximate Constituents of Coal. The paper dealt with the compounds produced by the long-continued action of dilute hydrochloric acid upon bituminous coals. By this re-agent almost the whole of the coal-substance was converted into chlorinated compounds, soluble in alcohol and similar solvents. Brown coal and other varieties of coal had been found to yield similar products, the complete investigation of which, it was hoped, would add materially to their at present meagre knowledge of the chemical constitution of coal.

In the geological section, Mr. Garwood presented the report of the Committee upon Life-zones in the British Carboniferous rocks. The report was as follows :— In a paper read before the British Association at Ipswich, in 1895, attention was called to the work of Dr. Waagen on the Upper Palæozoic rocks of the Salt Range, and reasons were given for supposing that the Carboniferous rocks of Britain might be divided into zones.* In that paper it was suggested "that a committee be appointed to enquire into the possibility of dividing the Carboniferous rocks

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* *Report of the British Association*, 1895, page 696.

into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists to whom these fossils may be submitted." This committee was appointed, and the members thereof beg leave to submit their report. The committee believes that the following districts would furnish good results, and recommends that those whose names are appended to the various districts be asked to take charge of those particular districts and to endeavour to carry out therein the objects of the Committee:—*England and Wales:* Northumberland and the Border, Prof. G. A. Lebour; northern part of Pennine chain and adjoining regions, Messrs. Garwood and Marr; southern part of ditto and adjoining regions, Mr. P. F. Kendall and Dr. Wheelton Hind; North Wales, Mr. G. H. Morton; South Wales, Mr. A. Strahan; Devon, etc., Mr. Howard Fox and Dr. G. J. Hinde. *Isle of Man:* Mr. G. W. Lamplugh. *Scotland:* Mr. B. N. Peach. *Ireland:* Mr. A. H. Foord.

The committee recommends that the following directions for working be communicated to the various workers:—

1. When possible, a typical measured section should be given of each locality examined, with notes of as many confirmatory sections as possible.

2. Any specimen not actually found *in situ* to be labelled to that effect, with a note of the exact conditions under which it was found.

3. All specimens should be labelled with the local name of the bed, giving as many additional details as possible, and in all cases the exact locality, which should further be noted on a large-scale map.

4. All specimens should be labelled when found.

5. So far as possible, workers are recommended to collect from one bed at a time, and to pack the specimens from each bed in a separate parcel before commencing to collect from another bed.

6. Attention should be paid to apparently identical forms separated by many feet or yards of deposit, as the forms may be mutations; large suites of such specimens should be collected; indeed—

7. As large a number of specimens as possible should be obtained of each species in every bed examined.

8. Absence of fossils in any bed should be noted whenever possible.

9. Attempts should be made to record the relative abundance of fossils, which may be roughly done by recording those which are very rare (*v. r.*), rare (*r.*), common (*c.*), and very common (*v. c.*).

10. In case of beds being obviously rich in micro-organisms, large pieces should be collected for future examination.

11. Considering the importance which cherts have assumed, it is very desirable to collect specimens of cherts.

Specimens may be kept by the discoverers or forwarded to the secretary of the committee (Mr. E. J. Garwood, Dryden Chambers, 119, Oxford Street, London, W.), on loan or for retention.

The committee recommends that the names of those whom they have mentioned as likely to undertake the charge of districts be added to the committee, and that the following palæontologists be asked to co-operate with the other members, and to identify such fossils as may be submitted to them, their names being also added (when not previously mentioned) to those of the committee:—Dr. G. J. Hinde (radiolaria and sponges), Prof. H. A. Nicholson (corals), Mr. J. W. Kirkby (entomostraca), Dr. H. Woodward (other crustacea), Mr. F. A. Bather (echinoderms and brachiopods), Dr. Wheelton Hind and Mr. E. J. Garwood (lamellibranchs and gastropods), Messrs. G. C. Crick and A. H. Foord (cephalopods), and Mr. R. Kidston (plants).

The members of the Institute might give very valuable assistance to the committee in this important work.

"The Geology of the Isle of Man," was the subject of a communication by Prof. W. Boyd Dawkins. His notes were based on a survey made during the last ten years, and on borings, carried out under his advice, through the thick covering of drift in the northern end of the island. The paper contains details of the Ordovician massif, the Carboniferous Limestone of the south, the Permian strata of the north of the island and the strata underneath the drift-covered northern plain, with general conclusions as to its solid geology. It might be concluded, from the identity of structure between the districts of Barrow and Black Combe in the Lake district, and the rocks of the north of Man, that there was little hope of the south-western extension of the Whitehaven coal-field sought by Messrs. Craine in their borings; but the discovery of a salt-field was a most valuable addition to the mineral wealth of the island.

Mr. G. H. Morton read a paper on "The Range of Species in the Carboniferous Limestone of North Wales," embodying the results of many years' collecting. The formation presents four well-defined subdivisions, each of them, with the exception of the highest, having distinct lithological characters—viz., Lower Brown Limestone, Middle White Limestone, Upper Grey Limestone, and Upper Black Limestone. Lists of fossils have been made, collected more or less continuously along the country from each subdivision, together with three separate lists of the species obtained, comprising the Llangollen, the Flintshire, and the Vale of Clwyd lists. Each list shows the relative scarcity and abundance, and the range of the species in the subdivisions. In the Llangollen list, there are 69 rare, 28 occasional, 16 common, and 27 very common species. In the Flintshire list, there are 92 rare, 35 occasional, 30 common, and 11 very common species. In the Vale of Clwyd list, which includes the Great Ormes Head, there are 16 rare, 22 occasional, 12 common, and 10 very common species. An examination of the first appearance and continuity of the species seems to indicate that they were introduced from some pre-existing area, and that the upper beds of the formation are more recent than in Derbyshire and Yorkshire, where the thickness of the limestone is very much greater.

The President of the Mechanical section, Sir Douglas Fox, in his address, sketched the progress that had been made during the quarter of a century since the association last met in Liverpool. His remarks on the construction and ventilation of tunnels and on the metric system will be of interest to our members:—

"*Construction and Ventilation of Tunnels.*—The rapid extension of tunnel-construction for railway purposes, both in towns and elsewhere, is one of the remarkable features of the period under review, and has been greatly assisted by the use of shields, with and without compressed air. This brings into considerable importance the question of mechanical ventilation. Amongst English tunnels, ventilation by fan has been applied to those under the Severn and the Mersey. The machinery for the latter is, probably, the most complete and most scientific application up to the present time. The intended extension of electrical underground railways will render it necessary for those still employing steam-traction either to ventilate by machinery or to substitute electromotive force. Great improvements have been lately made in the details of mechanical ventilators. The great improvements in subaqueous tunnelling can be clearly recognized from the fact that the Thames tunnel cost £383 per foot, whilst the Blackwell tunnel, consisting of iron lined with concrete, and 25 feet in internal diameter, has by means of the Greathead shield and grouting machine been driven from shaft to shaft a distance of 2,262 feet for £125 per foot. Tunnels have now been successfully constructed through the most difficult strata, such as water-bearing silt, sand, and gravel, and, by the use of grouting under pressure, subsidence can almost entirely be avoided, thus rendering the piercing of the substrata of towns underneath property without damaging it, a simple operation; and opening up to practical consideration many most important lines of communication hitherto considered out of the question."

"*The Metric System.*—The question of the early adoption in Great Britain of the metric system is of importance not only to the engineering profession, but also to the country at large. The recommendation of the recent Royal Commission, appointed for the consideration of the subject, was that it should be taught at once in all schools, and that in two years' time its adoption should be compulsory; but it is much to be regretted that, up to the present time, nothing has been done. The slight and temporary inconvenience of having to learn the system is of no moment compared to the great assistance which it would prove to the commercial and trading world; the simplification of calculations and of accounts would be hailed with delight by all, so soon as they realized its advantages. Great Britain is suffering greatly in her trade with the Continent for want of it."

Interesting papers were also read on the Liverpool overhead railway, and on horseless carriages.

Yours faithfully,

JOHN H. MERIVALE.

DISCUSSION ON MR. W. BLAKEMORE'S PAPER ON "COAL-CUTTING BY MACHINERY,"* AND ON MR. T. B. A. CLARKE'S PAPER ON "ELECTRIC COAL-CUTTING IN LONGWALL FACES."†

Mr. J. MORISON (Cramlington) said that Mr. Blakemore's paper came at an opportune time, when so many of the members were engaged in the introduction of coal-cutting machinery. One point which deserved attention was the apparently complete success of the machinery at the mines described in the paper and generally in America. Some cause must exist for that success, which did not exist in this country, for he was afraid coal-cutting experiments in this country had not been altogether successful. It was true that the machines did the mechanical work efficiently, and there was no difficulty in working the machines, but the subsequent labour of following the machine, getting out the coal and attending to the working-places and keeping the face in

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* *Trans. Fed. Inst.*, vol. xi., page 179. † *Ibid.*, vol. xi., page 492.

a fit condition, had generally been found a source of greater difficulty and cost than was expected when the machines were introduced. The causes to which this might possibly be attributed were, firstly, that in this country there was a more plentiful supply of a highly trained body of miners, who could get the coal to greater advantage than the unskilled labour available in newer countries; therefore coal could be produced by hand-labour under better conditions here than there. The second reason was that the coal-seams in this country selected for cutting by machinery were generally the most difficult, and where it was found almost a necessity to introduce some mechanical means, as they were practically unworkable by hand. In America, and other new countries, they could select seams for their special adaptability to the handling of machinery and the application of power. For instance, a seam from 8 to 8½ feet thick was referred to in the paper, and it had both a good roof and a good pavement. It was worked in pillars, and apparently the pillars were left, so that the machine did practically all the work that there was to do.

Another point that he noticed in Mr. Blakemore's paper was with reference to the air-compressing plant, which he would like to see described a little more fully.* He (Mr. Morison) understood that the air-cylinders were compounded and the air compressed in stages, and that the air was cooled during the intermediate stage of compression; so far as he could see it would do harm rather than good to cool the air after it was compressed finally. It would also be valuable if Mr. Blakemore would let the members know how much cooling-surface was required to reduce the temperature of the air so low as 50 degs. Fahr., and at what piston-speed the engine was working when this was effected.

The writer of the paper seemed to have used chiefly percussive machines, as the principal part of the paper was taken up by describing them. He (Mr. Morison) had seen these machines at work, notably the Harrison, and from his experience he could bear out Mr. Blakemore's description, namely, that when the men became accustomed to handling the machine it was perfectly easy to work. At first the workmen subjected themselves to unnecessary shocks by not being able to handle the machines properly, but after becoming skilled in their use, it was comparatively light work, much easier, he should judge, than actual pickwork.

Mr. R. Laverick (Rainton) said that the efficiency of the air-compressor was given at 77 per cent. He thought that this required some

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* *Trans. Fed. Inst.*, vol. xi., page 180.

explanation, as it was about 50 per cent. more than was usually obtained from an air-compressor. The writer also referred to the difficulty of driving, with a Stanley machine, a road wide enough for endless-rope haulage or sidings, but he had evidently overlooked the fact that there were double machines, which took out two cylinders of coal instead of one, and which would therefore make the road sufficiently wide.

He had had considerable experience in the use of disc-wheel coal-cutting machines, and also with a bar coal-cutting machine, the latter being driven by electricity, and he agreed with Mr. T. B. A. Clarke's remarks as to the respective merits of these classes of machines, except where he stated that "the wheel, owing to its large superficial area, has little or no tendency to climb, *i.e.*, to deviate from the plane of its cut." Mr. Clarke also stated that "the bar-cutter, however, had an almost insuperable preference for the path of least resistance."* In his experience, the disc-wheel had the same preference, both upwards and downwards, and owing to its large superficial area, soon locked itself in the cut, if not carefully attended to. The bar-cutter had the following advantages over the disc-wheel:—It was much lighter, and therefore easier to handle in the pit; if it came in contact with any very hard substance, it could cut over or under it and pass on, which could not be done with the disc-wheel; the bar could cut itself into the coal, whereas a place had to be made by hand-labour, into which the disc-wheel was placed before it could commence to cut.

Mr. T. E. **Forster** (Newcastle-upon-Tyne) said that Mr. Morison was probably right in saying that the absence of high-class skilled labour and the character of the coal-seams worked in America and Canada were, to a large extent, the cause of the more general introduction of machine coal-cutters there than in this country. When he was in Canada a few years ago, he (Mr. Forster) was in similar seams of coal to that described in Mr. Blakemore's paper, and he could say that they were very different to the seams of 2 feet or 2 feet 3 inches of this district. With the exception of the Mitchell longwall-cutter, American machines were not adapted for longwall working, and nearly all the seams there were worked on the bord-and-pillar system.

From Mr. Clarke's paper, it would be seen that a coal-cutter of somewhat similar design was tried in the Midlands, and the wear-and-tear was found so heavy that it had to be taken out and a disc-cutter substituted. Mr. Blakemore seemed to think that we were behind the times here, but he

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* *Trans, Fed. Inst.*, vol. xi., page 497.

(Mr. Forster) thought that the coal-cutters in use in England would compare favourably with the Mitchell coal-cutter. The Mitchell machine undercut about 1,000 square feet in eight hours, but a machine used in the Midlands undercut about 1,150 square feet, which was considerably better.

Mr. R. F. **Spence** (Backworth) said that a coal-cutter had been used for about eighteen months at Backworth colliery with fair success; it was a machine of the Gillott and Copley type that kirved 5 feet under, with a cutter-wheel 74 inches in diameter. The question as to whether the use of machines of this type was profitable or not depended upon how far it would cut underneath, as the costly part of machine coal-cutting was laying the way on which it ran. The thrust was so great that every sleeper had to be stayed, and the way most carefully laid. Consequently, the greater the depth of the kirving or cut made by the machine, and the fewer the removals and relayings of the way, the more economical would be the results.

The **Chairman** said that the members would agree with that part of the paper which said that coal-cutters were coming to the front. It was many years since he went to Yorkshire to see the first coal-cutter, which was simply a pick worked by machinery. They had been considerably improved since then, and would no doubt be extensively used in the future.

The Rev. **Joseph Campbell** read the following paper on "The Gold-fields of the Hauraki Peninsula, New Zealand," which he also illustrated with lantern-views:—

THE GOLD-FIELDS OF THE HAURAKI PENINSULA, NEW ZEALAND.

BY THE REV. JOSEPH CAMPBELL.

INTRODUCTION.

In one of a series of papers on New Zealand, written sixteen years ago, the author stated that "the mineral resources of New Zealand, which are contained amidst its extensive and varied geological deposits, have not yet by any means been fully developed. Sufficient, however, have been discovered to indicate the existence of mineral wealth, unsurpassed, if not unequalled, by any other region of the globe of equal extent."

The writer's recent investigations (made in June to October, 1896) have abundantly confirmed the truth of the above statement, and he is surprised that the mineral wealth with which the country literally teems should have been so long allowed to remain undeveloped.

For more than sixteen years the writer has lived amongst, and constantly studied, the geological formations of Australia and New Zealand; hence the opinions to which he gives expression are not the results of conclusions arrived at after a mere flying visit, but they are the expression of the firm conviction which has forced itself upon his mind as the result of much thought, numerous experiments, and many a weary journey across some of the roughest parts of those great countries.

The writer has read with interest the valuable paper on "Gold-mining in the Hauraki district, New Zealand,"* by Mr. Henry M. Cadell, and he thinks it will be found that in the main their opinions agree. The writer has, however, been careful to avoid going over exactly the same ground as that which Mr. Cadell has so well described, and this paper may almost be regarded as being complementary to his.

Situation, Area, etc.—New Zealand lies in the Pacific Ocean, between latitudes 34 degs. and 47 degs. south, 1,200 miles south-east of Sydney, the capital of New South Wales. It consists of three islands, viz., the

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* *Trans. Fed. Inst.*, vol. x., page 389.

North, South, and Stewart Islands. The total area of the islands is 100,000 square miles, and of this area 20,000 square miles are auriferous.

Compared with other countries, North America for example, how insignificant this sounds! But when the gold-yield of New Zealand is compared with that of the United States of America, its importance becomes more apparent. The annual yield of the United States is about 1,700,000 ounces; for New Zealand it is 300,000 ounces, or upwards of one-sixth of that of the States.

The gold-fields of New Zealand, with the returns for last year (1895-96), are the following:—

	Ounces.	Value. £
Auckland	117,029	450,829
Marlborough	3,173	12,681
Nelson...	3,813	14,007
West Coast	89,721	358,870
Otago	88,954	359,694
Totals	302,690	£1,196,081

It is only with that portion of the Auckland gold-fields, known as the Hauraki Peninsula, that the writer proposes to deal in this paper. The accompanying map (Plate XXII.) shows the various parts of this field.

GEOLOGICAL FORMATIONS.

In considering the geology of the Hauraki Peninsula, it will not be without interest to glance at a chart showing the relative positions of Australia and New Zealand. The shape of Australia will be noted, especially the curve of the east coast. Further away the trend of New Guinea in its south-eastern projection forms the beginning of an immense curve, having a clear relation to the eastern coast of Australia: of this curve New Caledonia, Norfolk Island, the northern peninsula of New Zealand, and the western coast of New Zealand are further developments.

Outside this curve again extends a second, commencing at the western extremity of New Ireland, following the trend of the Solomon Islands, the Santa Cruz group, the New Hebrides, and sweeping round the Kermadecs, strikes Cape Runaway in the North Island of New Zealand, the east coast of which completes this outer curve, as the west coast does the inner one.

Of these two curves, each producing an enlarged contour of the eastern coast of Australia, the outer one is volcanic throughout, but the inner one only where it approaches the former at North Cape, to culminate in a region of intense volcanic activity in the centre of the North Island.

If Australia were to subside 2,000 feet, nothing resembling a continent would be left. A narrow rocky barrier would be all that remained of eastern Australia; in the centre the Mount McDonnell ranges would emerge as a long mountainous island, and Western Australia would dwindle down to a chain of rocky islets. If, on the other hand, Australia were to be raised 8,000 feet, the vast continent would include New Zealand, the New Hebrides, the Solomon Islands, New Britain, and the greater part of the eastern Archipelago. Nor is this merely a fanciful supposition, for Australia undoubtedly had, by successive upheavals and subsidences, undergone many modifications in size and shape. At one time, probably at the close of the Palæozoic period, it stretched far to the north and also eastward, and included New Zealand. In Mesozoic times, it was almost entirely submerged in the Cretaceous sea, but was again resuscitated in the Tertiary period with the form that it now possessed. Hence the antiquity of Australia as a whole is only post-Cretaceous.

The following table shows the various sedimentary rock-formations of New Zealand and their relation to those of other countries:—

Sedimentary Strata.			New Zealand Representatives.
Post-Tertiary ...	Recent		Recent deposits.
	Pleistocene		Pleistocene. Newer glacial deposits.
Tertiary	Pliocene	Newer	Waganui formation.
		Older	Older glacial deposits.
	Miocene	Upper	Pareora formation.
		Middle	Ahuriri formation.
		Lower	Oamaru formation.
	Eocene	Upper	Oldest plutonic rocks of the Hauraki Peninsula.
Secondary ...	Cretaceous	Upper	Waipara formation.
		Lower	(wanting.)
	Jurassic	Upper	(wanting.)
		Lower	Putataka formation.
	Triassic		Maitai formation.
Primary	Permian		(wanting.)
	Carboniferous		Kaikoura formation.
	Devonian		(wanting.)
	Silurian	Upper	Kakanui formation.
		Lower	Wanaka formation.
	Cambrian		(wanting.)
	Laurentian		Manipori formation.

Metamorphic and igneous rocks are found amongst these various formations—the former from the Manipori to the Putataka, the latter intruding among all formations.

In the Manipori formation, gold has not yet been found in payable quantities. The Wanaka and Kakanui formations have hitherto proved most productive, comprising the greater part of the Otago gold-fields.

The Kaikoura formation contains no reefs of importance. The Maitai formation includes many gold-bearing reefs and alluvial deposits. The Putataka and the Waipara formations are rich in reefs, but the writer is inclined to think that the igneous rocks which abound among the Tertiary formations will produce more gold than all the others put together. These rocks contain the rich reefs of the Hauraki Peninsula. This most interesting region embraces the counties of Ohinemuri, Thames, and Coromandel, and extends from Te Aroha at the southern extremity to Cape Colville in the north, a distance of upwards of 100 miles.

The formation of the Hauraki Peninsula is due, in the writer's opinion, to successive plutonic upheavals which have taken place since Cretaceous times. There were land-surfaces in these parts, previous to Cretaceous times, which were connected with Australia. In the Tertiary period, these were disturbed and overlain by great masses of igneous rock (plutonic) upheaved from the bowels of the earth at successive periods. These plutonic rocks were in their day very much what volcanic rocks were in theirs. As is well known, the term "plutonic" is generally applied to rocks that have solidified at some depth below the surface, and "volcanic" to those which have solidified at the surface, having been poured out in great sheets or flows; but, after all, the terms are only relatively used, the plutonic rocks being the ancient equivalents of the volcanic. Some of the plutonic rocks which reached the surface, and thus were subjected to atmospheric influences, formed the breccias and indurated tuffs which were abundantly met with in the Hauraki Peninsula. These, at a later period, were again overlain by other igneous rocks, which, forced from below, elevated the region still further by upheavals as well as, in many cases, adding to the height of the existing hills by superficial deposits. These great elevations, attaining at Te Aroha a maximum of 3,175 feet above sea-level, occurred since Cretaceous times; hence they belonged exclusively to the Tertiary period. The oldest were of Upper Eocene age; and the others were more recent, being of Miocene or, perhaps, Pliocene age.

Extensive as these upheavals may appear, they are insignificant when compared with the mountain-building that took place in Asia during the same period: *e.g.*, the Himalayas, stretching for 1,500 miles from east to west, and rising to a height of from 20,000 to 30,000 feet above the sea, were formed in great part during Tertiary times.

In the absence of direct testimony, the writer cannot speak with certainty, but nevertheless is strongly inclined to the opinion that the glacial periods which succeeded some of the elevations of the rocks of the Hauraki Peninsula had not a little to do in bringing about the existing configuration. At any rate, some of the brecciated deposits remind one very strongly of moraine-deposits which, by the melting away of the ice by which they were being transported, were deposited where they are now found, and eventually indurated by the percolation of heated waters containing binding media in solution.

But passing from mere supposition and theory to facts, it is quite clear that great volcanic activity was manifested in the Hauraki Peninsula towards the close of the Eocene period and during the Miocene and Pliocene periods and deposited the basalt-rocks of varying texture that are plentifully met with, and the rhyolites that in some parts spread far and wide, notably around Waihi. It was also at this period that the thick beds of pumice and ashes were formed which cover so large an area of the province of Auckland, and have in some cases filled up the valleys between the ranges that are traversed by reefs.

It was, the writer believes, this outburst of volcanic activity which in a great measure caused the reefs and led to the deposition of their precious contents. It can easily be realized how immense masses of igneous rock forced from below and pressing against the existing superincumbent rocks would cause in them deep-seated parallel fissures. The general direction of these fissures would necessarily, in the case of the Hauraki Peninsula, be northerly and southerly. Now and then, the igneous rock would itself reach the surface by means of some of those fissures which it formed; at other times it would come forth in great flows from the rents which the constantly recurring earthquakes would cause.

Then we call chemistry to our aid to enable us to understand the formation of the reefs:—Steam, vapours, gases, and streams of heated waters from great depths would be forced along these fissures and cracks and through the rock-masses themselves under the influence of the expansive force of heat. These agents, under the varying conditions of temperature and pressure to which they were subjected, would act chemically on the rock ingredients, splitting them up, decomposing and re-arranging them according to well-known chemical laws.

Carbonic, sulphuric, hydrochloric, nitric, and sulphurous acids would break up the silicates, converting them into soluble carbonates, sulphates, chlorides, nitrates, and sulphides of the metals, while the silicic acid would be set free; and being to some extent soluble, it would be carried along by the circulating heated waters, and would be deposited in the fissures as hydrated silica, in which form it usually exists in the reefs of the Hauraki Peninsula. It may prove interesting to give an example of the kind of chemical reaction that takes place, thus:—$Fe_2SiO_4 + 2CO_2 + 2H_2O = 2FeCO_3 + H_4SiO_4$; and $Mn_2SiO_4 + 2CO_2 + 2H_2O = 2MnCO_3 + H_4SiO_4$. But further chemical changes occur, resulting in the addition of metallic substances to the silica thus deposited, *e.g.*, the carbonates coming into contact with the oxygen are reduced to oxides, thus:—$MnCO_3 + O = CO_2 + MnO_2$; $2MnCO_3 + O = 2CO_2 + Mn_2O_3$; $3MnCO_3 + O = 3CO_2 + Mn_3O_4$; $2FeCO_3 + O = 2CO_2 + Fe_2O_3$; and $3FeCO_3 + O = 3CO_2 + Fe_3O_4$. Then, proceeding a step further, we see how hydrochloric acid, which may be formed, *e.g.*, by the action of sulphuric acid on sodium chloride, thus:—$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$, acts on the higher oxides of manganese, and forms chlorine gas, thus:—$Mn_2O_3 + 6HCl = 2MnCl_2 + 3H_2O + 2Cl$; $Mn_3O_4 + 8HCl = 3MnCl_2 + 4H_2O + 2Cl$; and $MnO_2 + 4HCl = MnCl_2 + 2H_2O + 2Cl$. The chlorine, one of the natural solvents for gold, travels along till it meets with gold, which is scattered through rocks in fine grains to the extent, perhaps, of only a grain or two to the ton, and dissolves it, forming a soluble chloride of gold, thus:—$Au + 3Cl = AuCl_3$. The chloride of gold may be made to part with its gold by simple heat, thus:—$AuCl_3 = Au + 3Cl$; or, being soluble in water, it will probably be carried along until it meets with some chemical that precipitates it, *e.g.*, sulphate of iron, of the existence of which, on these gold-fields, we have abundant evidence. The action is as follows:—$2AuCl_3 + 6FeSO_4 = Fe_2Cl_6 + 2Fe_2(SO_4)_3 + 2Au$. Hence gold may have been deposited in the reefs in this way. From some specimens the writer has seen, he would judge that it was really so.

Now, leaving the carbonates, let us turn to the sulphates. These, coming into contact with decomposing organic matter, form sulphides thus:—$CaSO_4 + 4C = 4CO + CaS$; $CaSO_4 + CH_4 = CO_2 + 2H_2O + CaS$; $K_2SO_4 + 4C = 4CO + K_2S$; and $Na_2SO_4 + 4C = 4CO + Na_2S$. These alkaline sulphides also dissolve gold, and, hence, may have played an important part in the deposition of the gold in the reefs.

But in many of the reefs of the Hauraki Peninsula, we find intimately mixed with the gold such substances as iron pyrites, zinc blende, copper pyrites, galena, etc., forming very refractory ores. These substances probably came into the reefs as sulphates, which were reduced to sulphides by contact with organic matter thus:—$FeSO_4 + 4C = 4CO + FeS$; $ZnSO_4 + 4C = 4CO + ZnS$; and $CuSO_4 + 4C = 4CO + CuS$.

The existence of this carbonaceous matter has frequently been proved deep down in the country-rocks, where petrified portions of trees are occasionally found.

Galena probably came in as a bicarbonate which, in the presence of hydrogen sulphide, would become a sulphide, thus :—$PbCO_3\ H_2OCO_3 + H_2S = PbS + 2CO_2 + 2H_2O$. This same hydrogen sulphide, in the presence of oxygen, also acted on the sulphides of iron and copper, and converted them into iron pyrites and copper pyrites, thus :—$FeS + H_2S + O = H_2O + FeS_2$; and $2FeS + 2CuS = Cu_2S, Fe_2S_3$: hence we see how the ingredients of the reefs were supplied. It is interesting to note that the pyroxenes of the country-rocks sometimes contain both gold and silver.

This explanation of the infilling of reefs by gradual deposition seems hardly satisfactory in the case of some of the immense reefs that exist, *e.g.*, the so-called buck reef at Wairongomai Te Aroha, which rises above the country-rock to a height of upwards of 100 feet, with a width of 100 feet or more.

It appears to the writer, from the nature of the reef-forming material, that in these cases the mass of hydrated quartz, or, as it sometimes is, of hydrated quartz and felspar, has been forced into the fissures in a plastic condition, somewhat resembling thick porridge, the metallic ingredients segregating out as the mass cooled; and as in some instances they did not meet with the reagent necessary to precipitate the gold in metallic form, it exists in these reefs and in others also in a combined state as sulphide, telluride, and possibly as a silicate of gold.

In concluding these remarks concerning the formation of the reefs, the writer may say that the first few days' examination of this interesting field led him to the conclusion that the reefs were mainly of hydrothermal origin, and subsequent investigation has convinced him that this is the case.

THE GOLD-FIELDS.

The writer will now briefly describe a few characteristics of the gold-fields included in each of the counties embraced within the peninsula, viz.: Coromandel, Thames, and Ohinemuri; but a few words respecting the discovery of gold may not be without interest.

Following upon the discovery of gold in Australia in 1851, by Mr. Hargreaves, gold was first discovered in New Zealand by Messrs. Charles and Frederick King in the Kapanga Stream (Driving Creek) at Coromandel, in 1852. Governor Wynyard immediately proceeded thither and all tribes of the Hauraki assembled, and on November 30th, 1852, an agreement was drawn up and signed allowing Europeans to search for gold from Cape Colville to what is now known as the Thames township. The government agreed to pay £1 per annum for each miner. This agreement was for a term of three years; but before that time expired the Europeans had departed and the land reverted to the Maori owners.

In 1861, gold was again found at Coromandel and mining operations commenced anew. On November 9th, 1861, another agreement was made granting the right to search for gold from Cape Colville to a line drawn from Kerita to Mercury Bay. In 1863, the commencement of hostilities at Waikato so alarmed the Europeans that they abandoned Coromandel.

In 1867, gold was discovered at the Thames, and on July 27th of that year the land was thrown open for mining, thus including the two counties of Coromandel and Thames.

There was some difficulty in obtaining permission to mine in Ohinemuri county, owing to the obstacles which the Hauhaus or King Country natives (who refused to acknowledge the Queen's sovereignty) threw in the way. Permission was, however, granted on March 3rd, 1875.

OHINEMURI COUNTY.

Mr. Henry M. Cadell stated that:—

> This (Ohinemuri County) is at present by far the most important of the Hauraki gold-fields, its production last year (1894-5) being 110,000 ounces—more than twice that of all the others put together. The Ohinemuri mines have this further attraction, from an engineering and scientific point of view, that they exemplify the immense advantage to be derived from the adoption of the most modern system of gold-extraction.*

The production of gold during 1895-6 was 136,415 ounces.

The principal gold-fields in the Ohinemuri county are those of Waihi, Waitekauri, Komata, Owharoa, Karangahake, and Te Aroha, with which may be included Wairongomai, situated just outside the Ohinemuri county-boundary.

Te Aroha.—The township of Te Aroha lies prettily situated on the banks of the Waihou or Thames River, at the base of Te Aroha mountain, which towers grandly by successive peaks to a height of 3,126 feet above sea-level. The mountain sides, out of which the reefs crop, are clothed

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* *Trans. Fed. Inst.*, vol. x., page 407.

with forests. These forests consist of a variety of trees growing closely together, the surface of the ground being thickly overgrown with brushwood bound together by thorns and supple-jack (*Rhizogonum scandens*) forming an almost impenetrable jungle. In the undergrowth is manifested a rich variety of species of plants characterized by their peculiar habits and mode of growth. There are to be seen the large leaved *Alseuosmia* with its pendant fuchsia-like flowers varying from white to crimson; the white-flowered wharangi-piro (*Olearia Cunninghamii*) varying from a bush to a small tree; in rocky places the puka-puka (*Brachyglottis repanda*) with its hoary leaves, and perchance growing amongst it the *Rhabdothamnus* with its fairy-like bells of orange and scarlet—all these, and many more, intermingled in a most promiscuous manner, and bound together by the tough wiry stems of numerous creepers. Then, too, the manner in which nature has garnished the larger trees, among which are particularly to be noticed the totara, the kauri and the rata, is exquisite. Their trunks and branches are laden with epiphytic orchids, small shrubs, ferns, pendent lycopods and mosses, accompanied by large foliaceous lichens, to an extent which it is quite beyond the writer's powers to describe. One-twentieth of the varieties of ferns found in the world grow in New Zealand, and in the forests where there is no undergrowth of jungle or brushwood a delicate carpeting of various kinds of ferns is met with. The peculiar effect produced by areas of many square feet covered with the pellucid fronds of *Trichomanes reniforme*, or the finely cut *Hymenophyllum demissum*, in the cool open part of the forest, can scarcely be imagined by those who have not beheld them. One feels it is almost sacrilege to trample them underfoot; yet it must be done, for it is through these forests that the prospector has to force his way in order to discover the reefs which are completely hidden from view by the dense foliage.

Te Aroha (which has a population of about 500, exclusive of the numerous miners who live among the mountains) is already gaining a reputation as a sanatorium owing to the mineral waters and hot springs, which have proved highly beneficial in spinal, gouty, rheumatic affections and cutaneous diseases, chronic dyspepsia, neuralgia, sciatica, etc. These remedies of nature, so abundantly bestowed, are highly appreciated by the residents and only need to be made more public to secure the patronage of thousands of sufferers from various parts of the world.

The following is an analysis of the Te Aroha water:—

	Grains per Gallon.
Bi-carbonate of sodium	426·29
Chloride of sodium	60·45
Chloride of potassium	1·90
Sulphate of soda	32·67
Carbonate of lime	7·12
Carbonate of magnesia	4·21
Silica	7·12
Alumina and iron oxide	traces

Or a total of 539·76 grains of mineral matter in one gallon. The temperature is 112 degs. Fahr., and the water is used for bathing.

The following is an analysis of the water from the drinking-fountain:—

	Grains per Gallon.
Bi-carbonate of sodium	451·97
Chloride of sodium	66·14
Chloride of potassium	1·96
Sulphate of sodium	32·91
Carbonate of calcium	7·47
Carbonate of magnesium	4·21
Silica	8·60
Alumina and iron oxide	traces

Or a total of 573·26 grains of mineral matter in one gallon. The temperature is 109 degs. Fahr.

These hot springs are somewhat similar in nature to the mighty streams which in days long gone by were forced among the rocks of the district, and wrought the great changes which played so important a part in the formation of the reefs.

The Hot-lake District.—Some 50 miles to the south of Te Aroha lies the wonderful hot-lake district with which the Te Aroha hot-springs appear to be remotely connected. Much has already been written about this strikingly attractive country; but, inasmuch as the mighty forces which operated in the formation of the gold-fields are there to be studied in active operation, a few words upon it will not be out of place. It extends from Mount Tongariro to White Island in the Bay of Plenty—a distance of 125 miles.

A whole volume might be written upon the wonders of this hot-lake district, but it is no part of the writer's object to dwell at length upon the marvellous scenes presented—scenes of magic beauty, but awful when we contemplate the forces still in action amongst them. In many parts, notably in the vicinity of Taupo, Rotorua, and Roto Mahana, are to be seen volcanoes of boiling mud and pipe-clay some 3 or 4 feet high, steam-funnels or fumaroles puffing like steam-engines, solfataras, sulphur-deposits of great magnitude, chasms filled with boiling water or discharging steam, holes full of boiling mud of the consistency of porridge and the colour of lead, and last, though by no means least, geysers which at intervals throw up water to a height of 100 feet. It is not safe to walk about these places without a guide, for the treacherous crust sometimes gives way and the traveller's foot is plunged into scalding mud. Day after day the writer gazed upon these awful scenes, and, ever and anon, thought of the words of Horace, "Ignes suppositi cineri doloso," which phrase accurately describes this marvellous district.

One of the most interesting parts lies about the region of Roto Mahana, where the famous Te Tarata and Otukapaurangi, better known as the White and Pink Terraces, once stood. These were utterly destroyed by an earthquake and volcanic eruption on June 10th, 1886, probably one of the most striking instances of volcanic phenomena which have occurred during the nineteenth century and one which is certainly without parallel in the history of Australasia.

Having formerly inspected this marvellous district and feasted his eyes on its beauties, the writer was anxious during his recent visit to compare the present with the past. He therefore ascended Mount Tarawera, which rises 2,600 feet above the lake. This mountain was formerly a volcano but without a crater, somewhat similar to the trachytic cones of Central France. It stands not only in a direct line between Tongariro and White Island, which are the extreme points of this region of thermal activity, but it is nearly the central point of that line; hence it is not surprising that the effects of the eruption were very extensive. It is estimated that an area of country 1,850 square miles in extent was affected in a sensible degree, the springs and fumaroles becoming more active; and that the volcanic dust was deposited over an area of 3,700 square miles.

The eruption caused a great rent running in a south-westerly direction for about 2½ miles, varying in depth from 400 to 1,200 feet and having an average width of 660 feet. The writer noted six—but there are probably more—distinct points of eruption. In the lower parts, a portion of this great fissure is filled with water, forming lakes; but another part extends up the sides and through the very centre of the Three-Peaked mountain for a distance of about ¾ mile. The sides and bottom are composed of scoria from which issue steam and sulphurous acid gas. Here and there the ferro-chlorides have imparted beautiful orange, yellow, red, and brown tints. All around as far as the eye can reach extends a scene of utter desolation, which to one who had seen the district in all its former glory and beauty fills the soul with sadness.

But what has all this to do with the gold-fields of the Hauraki Peninsula? The writer believes that there is a close connexion between this district and these gold-fields, and this belief is much strengthened by a careful examination of these recent volcanic phenomena. It appears to him as if the great rent gives something more than a hint concerning the formation of the great parent reefs, which in several of the gold-fields extend in the same northerly and southerly direction, *e.g.*, the so-called buck reef at Wairongomai, but which the writer calls the parent reef, and which runs north-east by south-west; and that also at Coromandel, which runs north-west by south-east. From these parent reefs extend the auriferous reefs as lateral shoots, reminding one somewhat of the ribs of a whale. The country-rocks of these great reefs being of a harder nature than those which build up the Tarawera mountain, the rent has not been so extensive; and hence the reefs are not so wide as they would be if the great Tarawera rent were filled up with silica. Some of these great reefs, however, are 150 feet wide at the surface, and rise to a great height above the level of the country-rock which has fallen away and left the reef exposed. As to the filling in or formation of these reefs, the writer has already said that they are of hydrothermal origin, a conclusion to which he has been mainly led by a careful study of the deposits of hydrated silica left by the thermal waters of this wonderful district.

It was not until the latter part of 1880, that the Te Aroha portion of the Ohinemuri county was thrown open for mining operations. During the next two years, however, as many as fifty claims were granted, and Mr. S. Herbert Cox, who was sent by Sir James Hector (Government geologist of New Zealand) to report on the fields, said:—"As regards the future prospects of the field, they are, I think, of a very encouraging nature."

A serious bar, however, to progress lay in the way. A good deal of the ore was refractory, and at that time the appliances for the extraction of gold were of so crude a nature that much more gold was lost than was saved, not more than 40 per cent. being won. Very extensive reduction-works were erected at Wairongomai, 3 miles from Te Aroha. Through some error these works, costing between £20,000 and £30,000, were erected before it was proved whether the system which it was proposed to adopt for the treatment of the ore would be successful. After this great expenditure had been incurred, the treatment proved an utter failure, and it was concluded by many engineers that, though the field was undoubtedly a very rich one, the riches were locked up in such a way as to be unobtainable. This unfortunate and ill-advised experiment has been the means of keeping back for years one of the richest gold-fields in New Zealand, viz., Te Aroha.

In the report of the Department of Mines on the gold-fields of New Zealand for 1895-96, Mr. H. A. Gordon stated that Te Aroha:—

> Is a field where there are large auriferous, argentiferous, and cupriferous lodes, but the difficulty so far has been the extraction of the precious metals. The ores in many instances are rich in gold, but, being associated with sulphides of copper, zinc and galena, the cost of extracting a fair percentage of the gold has been too great to allow these lodes to be worked at a profit. There is no doubt the time will come when this will be a busy field. A process will be found out to treat the ores successfully and economically.*

The success which has attended the treatment of refractory ores by the cyanide of potassium process at Waihi and in other gold-fields, has given a great impetus to mining at Te Aroha and Wairongomai, and several companies have been formed to work some of the many claims. The mines, in connexion with which the disastrous failure, above referred to, at Wairongomai, occurred, are now included in the property held by the New Zealand Exploration Company. Some of the stone is exceedingly rich, and one sample assayed by the writer gave a return of £1,050 per ton. This ore contained telluride of gold, and not a speck of free gold was visible.

Karangahake.—Here is some of the finest scenery in the province of Auckland. In the Waitawheta gorge, the mountains rise to a height of 1,700 feet. Aerial tramways extend across, by means of which mines in apparently inaccessible places are being worked, and at different stages up the mountain-side workings are to be seen. The three principal mines are the Crown, Woodstock, and Talisman.

The Crown mine was the first to adopt the cyanide of potassium process in this part of the gold-field, and it is applied with such success that out of ore worth £3 17s. 6d. per ton the loss, as the manager, Mr. Daw, informed the writer, is only 8 to 9 per cent. Of the gold saved, about £2 worth is extracted by cyanide, and the remainder is won by passing the tailings over copper-plates, thus saving the coarse gold, which the cyanide process cannot touch. At present this treatment costs 20s. per ton, but it is estimated that by extending the plant the cost can be reduced to 14s. per ton. The reef in the Crown mine runs between diorite and felsitic rock. Here and there, it runs into the diorite, when it pinches and becomes poor. The water-supply is so good that 189 effective horse-power can easily be obtained.

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* Page 78.

Waihi.—Leaving Karangahake, after a ride of ten miles to the east through country overlain in a large measure by rhyolitic lava, Waihi is reached. At first sight the country is very disappointing from a gold-mining point of view, owing to the absence of those physical characteristics which usually distinguish a mining centre. There are no magnificent gorges as at Karangahake, no series of noble mountains with forest-clad sides as at Te Aroha, no wild rugged hills as at Coromandel. There is a low-lying mountain range it is true, but the mining operations of the well-known Waihi gold-field are not carried on there. The township of Waihi stands somewhat to one side of a swampy undulating plain, caused by the partial filling-in of the valleys or depressions between the hills (which no doubt once stood in bold relief) by volcanic matter, ash, breccia, etc., cast out about the end of the Pliocene period. When this was done, the rhyolitic lava poured forth and covered many of the lower hills, so that the reefs are in most cases quite covered up, and it will require a great deal of prospecting to trace them in some of the claims pegged out; and in many there will most likely be no reefs found, for, on the strength of the few that have been discovered, the whole country to the seashore has been pegged out without any other reason than that capital may be secured to reward the original prospectors and to engage in a fruitless search for reefs. The Martha and the welcome lodes are the best-known, and these are being very profitably worked by the Waihi Gold-mining Company, Limited, the premier gold-mining company in this district. Indeed, it was the successful application of the cyanide of potassium treatment to the Martha ore that gave such an impetus to mining in districts where the ore was refractory.

The Waihi company's present plant consists of 90 heads of stamps, the cyanidation being carried out in 24 vats, 24 feet in diameter; but a very large plant is being erected with 100 heads of stamps at Owharoa, about 6 miles distant, to which the ore will be conveyed by tramway. The annual average of the bullion from the ore treated is £1 6s 8d. per ounce, and the value extracted is £3 9s. 1d. per ton. Samples assayed by the writer yielded at the rate of £10 per ton. During the year 1895-96 the bullion extracted by this company realized £117,165.

The Grand Junction and Waihi Silverton are also well-known mines on this field. In the former mine the rhyolite overlies the auriferous formation to a depth of upwards of 200 feet. Perseverance has recently (October) been rewarded in the case of the Grand Junction mine by striking a reef supposed to be the Martha.

Waitekauri, about 5 miles distant from Waihi, is also a good reefing district, and it is thought that it will yield handsome returns. The writer, however, was neither able to visit this spot nor Komata.

THAMES COUNTY.

The Thames has for years been well known as the greatest gold-producing county of New Zealand, though latterly it has been outstripped in the race by the Ohinemuri county. The gold-fields in the Thames county were thrown open on July 27th, 1867. On August 12th of that year, the first reef was discovered by Messrs. Hunt, Cobley, Clarkson, and White, and up to the present time gold to the value of £6,000,000 has been produced, and this from an area not much over 1 square mile in extent. Latterly, there has been a great reduction of the output, but this is not because the field is worked out, but simply for want of capital for deep sinking and development, and for want of the proper method of treatment for the ores, some of which are of a refractory nature and of low grade.

The geological formation of the Thames is exceedingly interesting, but it has been so well described by other observers that it is unnecessary for the writer to dwell upon it beyond saying a few words for the purpose of confirming, as an independent witness, what has already been said about it. The rocks are of precisely the same class as those of the other gold-fields of the Hauraki Peninsula, consisting of such plutonic rocks as diabase, diorite, etc., and volcanic rocks as andesites, basalt, etc.

Perhaps the most interesting feature is the existence of three faults, viz., the Moanataiari fault, the collarbone fault, and the beach-slide fault. Mr. James Park, late Director of the Thames School of Mines, who resided in the district for several years, has written an excellent paper entitled: "The Mineral Resources of the Thames Gold-fields." In this paper he speaks of these faults as being "of the highest scientific and economic interest." Their scientific interest lies in the freshness and clearness of the evidence which characterizes their courses, both on the surface and in the mines; while their economic importance is to be found in the displacements of the gold-bearing reefs which they have caused, and in this respect they play an important part in the distribution of the gold. The Moanataiari fault runs almost at right angles across the trend of the reefs. It acts as a great underground watercourse or channel, dividing the gold-field into two distinct parts, a seaward portion and an upland portion. Mr. Park has taken careful measurements and estimates that the vertical downthrow is about 400 feet. The age of this fault is newer Pliocene or older Pleistocene. The collarbone fault joins the Moanataiari fault, and is of the same age.

Some engineers doubt the existence of the beach-slide fault, but the writer is decidedly of opinion, from the examination of the surface-features, that such a fault really does exist. It appears to follow the contours and windings of the present line of cliffs running behind the township of the Thames. It is proposed to sink shafts on the foreshore of the Thames, and this question will, of course, be speedily decided.

The prospects of success in picking up the lost leads seaward are, in the writer's opinion, good; and if they are picked up, they will prove as rich as those which proved so very productive in the early days of the Thames district.

The minerals associated with the gold at the Thames are: iron pyrites, copper pyrites, zinc blende, stibnite, and ruby silver, and sometimes galena. Magnificent specimens of these minerals are sometimes taken out of the mines. The gold occurs generally as fine irregular grains, threads, and thin plates or scales. Its average fineness is only about 680, owing to the admixture of silver.

Among what may just now, perhaps, be considered the minor gold-fields of Thames county must be mentioned the Ohui. Among the mines stands out very prominently the Maori Dream, and some stone from the main reef yielded by fire assay 237 ounces of gold, worth £2 16s. per ounce; but, owing to an admixture of sulphide of antimony, it will be necessary to apply some treatment in order to secure all the gold. From experience with such ores, the writer believes that no treatment is so well adapted to this class of ore as the thermo-hyperphoric treatment, or treatment by water-gas, by means of which 95 per cent. of the assay-value may be saved.

COROMANDEL COUNTY.

The Hauraki and the Kapanga gold-mines are probably the best known properties at Coromandel. The former because of the large returns which caused a revival of mining, the latter because the first discovery of gold in New Zealand was made on this property, and also because of its being the deepest mine in New Zealand, the main shaft being 1,007 feet deep. The reef runs north and south and has a dip 65 degs. west. At a depth of 940 feet, a band of complex ore, chiefly iron pyrites, 2 feet wide, cuts across the reef. The value of this ore is £3 per ton, but owing to the supposed difficulty of treatment nothing is being done with it at present though it is possible by the thermo-hyperphoric method to extract 95 per cent. of the assay value at the cost of a few shillings per ton.

On this field, the writer noticed three distinct formations and the deep shaft at the Kapanga gold-mine gave him an excellent opportunity of making a careful geological examination. Beneath the rhyolitic lavas which here abound, as at Waihi, lie a series of rocks which are basic in character; at first fine in texture, but becoming more coarsely brecciated as they descend in depth. At 900 feet, they are acidic, having become so by the elimination of the basic elements. (The water which permeates the lower rock is still acidulous, rapidly turning litmus paper red and attacking the nails of the miners' boots.) These rocks are clearly fragmental or clastic rocks which decomposed in angular fragments when exposed at the original surface, and were not, the writer thinks, laid down under water as tufaceous rocks, as is generally supposed. They are of a greenish colour, the coloration being caused by silicate of iron due to the decomposition of the hornblende. They appear to overlie Cretaceous rocks.

The value of the gold from the Kapanga mine is £2 18s. per ounce, and it is to so large an extent free that with the present appliances all but 3 dwts. per ton is recovered. This mine and the Scotty which joins it on the north, and the Hauraki, are certainly among the most promising properties in Coromandel county. Between the Kapanga and the Hauraki, lies the Blagrove Freehold mine, and 1 mile to the south of the township lies the Preece Point mine. These and others that might be mentioned are valuable mines, and the writer thinks that the district has a prosperous future before it.

Reference has before been made to one of the parent reefs on this field. A favourable spot for examining this reef occurs on the ground of the Triumph (Hauraki) gold-mine, in the Tokatea district, where it runs north-west by south-east. It assays traces of gold, and from it the payable reefs shoot laterally. These reefs do not run into the altered sedimentary rocks, but are confined to the igneous rocks. Here, as in most parts of the Hauraki gold-fields, the auriferous quartz is peculiar, as being hydrated, and containing numerous masses of beautiful minute crystals; and the bulk-stone is so similar that it is impossible to tell from which mine individual samples come. All the stone in Coromandel is regarded as being free-milling ore, excepting the Union Beach gold-mine, but some of the ore contains dark patches which, the writer finds, contains some combined gold, and which, of course, is not saved by ordinary battery methods.

In Coromandel county, the Success is the phenomenal mine as regards the occurrence of the gold, which is met with in plates from

$\frac{1}{32}$ inch in thickness to less, in a kind of pug-vein or siliceous belt of plastic hydrated quartz from which the gold may be panned out. For years this mine has been worked without a battery, the auriferous material being sent to a neighbouring mill. A battery is now being erected, though at a considerable cost, the carriage of the machinery from the landing-place to the mine costing £7 10s. per ton, owing to the steepness of the mountains on which the mine is situated and the extreme difficulty of making a good track for the teams to pass over.

Other important properties in the Coromandel county lie in the Cabbage Bay, Kennedy Bay, and Kuaotunu districts. In the last named district are situated the well-known Try Fluke and Kapai-Vermont gold-mines.

There is still a very large area of auriferous country in the Hauraki Peninsula which is absolutely unexplored. The writer has not the slightest hesitation in predicting that in it reefs as valuable as any that have been developed will be found, and he would very much like to see parties under competent engineers exploring these hitherto untrodden areas. It is an enterprise which in the near future would meet with an abundant reward, and as those who are first in the field will stand the best chance no time should be lost.

TREATMENT OF REFRACTORY ORES.

The writer has several times in the course of this paper referred to the abundance of refractory ores which exist in the gold-fields of the Hauraki Peninsula; and there is no doubt that the treatment of these is one of the greatest questions of modern mining enterprise. Speaking of these in his report to the department of mines on "The Gold-fields of New Zealand" for the year 1895-96, Mr. H. A. Gordon says:—

> There are also large lodes . . . known to contain rich auriferous and argentiferous ore, but of a highly refractory nature on account of having other base metals in the ore, which cannot at the present time be separated unless at a great cost. Some of these lodes contain gold, silver, copper, zinc, lead, antimony, and quicksilver ore. To separate these base metals by some simple and effective method has, up to the present, not been discovered.*

It is well known that by reason of the presence of these base metals the cyanide of potassium process which has been efficaciously applied in so many parts, not only of New Zealand, but of the world, absolutely fails in dealing with these ores to which Mr. Gordon refers. Many metal-

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* *Papers and Reports Relating to Minerals and Mining*, New Zealand, 1895-96, C.—3, page 27.

lurgists, however, claim to have solved the problem; and among the proposed methods of dealing with such ores must be mentioned those invented by Mr. A. Gordon French and Mr. James Park.

In Mr. French's system the ore is dried, crushed, and then roasted in a revolving reverberatory furnace—with a little salt to chloridize the metals. The salt is intimately mixed with the ore previous to its being put into the furnace. The roasted ore is then subjected to chlorination, and, after leaching, the gold in solution is precipitated by sulphate of iron, while the solution goes into a tank containing scrap-iron, where the copper is deposited. The silver in the ore, after leaching out the gold solution, is then leached out with hyposulphite of sodium on the same principle as the Russell process.

Mr. Park adopts the same method of roasting and chloridizing the ore, and then leaches it with water to extract the whole of the copper which, being in the form of a chloride, is soluble. It is then subjected to a cyanide solution to extract the gold and silver.

The Thermo-hyperphoric Process.—The writer has devoted some years of very careful study to the treatment of gold-ores, with the result that he also has invented a process which extracts 95 per cent. of the gold-assay value of any ore. To this treatment he has given the name "thermo-hyperphoric," a term derived from two Greek words which accurately describe the operation. The first word signifies that heat is employed, and the second that the result of the treatment is the elimination of all base elements that interfere with the amalgamation of the gold with mercury. As the writer proposes to communicate a paper on this invention at an early date, he will say but little about it in these pages. It is fitting, however, that in connexion with the subject of this paper he should give a brief outline of the thermo-hyperphoric process. Briefly, it consists in the application to refractory gold and silver, and other metal-bearing ores, of the well-known water-gas, which is made by passing steam over red-hot charcoal, or coke in closed retorts. One hundred lbs. of steam passing over 66½ lbs. of charcoal produce 11 lbs. of hydrogen (H) and 155½ lbs. of carbonic oxide (CO); but, owing to the lightness of the hydrogen, the volumes of the two gases are equal. These two gases are great reducers; and, when mixed, act more powerfully than in the single state; hence, when allowed to permeate the refractory ore, which is broken to the size of walnuts by means of a stone-breaker and heated to 1,200 degs. Fahr. in closed retorts or furnaces, all the sulphur, arsenic, tellurium, or other base elements are removed, and the ore becomes a free-milling ore. In order that the writer might show that the system could be applied on a large scale in a profitable way, he erected a complete plant on the Walter Scott gold-mine, Cangai, New South Wales, and from 150 tons of ore, containing an admixture of 16 per cent. of arsenic, sulphur, zinc, galena, and copper and iron pyrites, an ore from which only 12 dwts. per ton could be saved by ordinary methods, the writer, by his process, extracted 1¾ ounces, or 95 per cent. of the gold-assay value. And he met with the same success in dealing with large quantities of the refractory ores of the Haurkai gold-fields, which ores contained, among other substances, telluride of gold. To quote from the patent specification :—

> The positive results of the treatment of the ore or material by water-gas in closed chambers or retorts, are—(*a*) The ore or material becomes exceedingly friable, much more so than the best roasted quartz from open kilns, and may be easily broken by hand—thus the use of lighter stamps is permitted and easier grinding effected. (*b*) The auriferous particles are changed in form to a globular or approximately globular condition (the more minute the metallic particles the more perfect the spheroidal shape). The gold in this spheroidal form is less acted on by water in the amalgamating process, and hence the loss in the form of float-gold is reduced to a minimum. (*c*) The base materials with which the gold is chemically or mechanically combined or coated, namely, sulphur, arsenic, tellurium, antimony, bismuth, zinc, lead, iron and copper pyrites, iron oxide, etc., are eliminated, and leave the gold perfectly free for amalgamation. In addition to this, by means of flues and suitable chambers, bye-products may be saved and so reduce the cost of treatment.*

On small mines, the writer proposes to erect a bench of retorts built of fire-brick, but somewhat similar in form to those used in gas-manufactories, and having the water-gas-making retorts built in the bench. The capacity of this furnace would be 40 tons per week, and the cost of erection of the complete plant about £2,500. But on large mines, he would recommend a furnace of peculiar construction, with separate retorts and gasometers, for the manufacture and storage of the water-gas, and a new form of amalgamator. This furnace would be capable of treating 100 tons a day, and the cost of the complete plant would be about £6,000. The actual cost of treating the ore with the small plant, varies from 1s. to 5s. per ton, in addition to the ordinary battery treatment; but with the large plant the total cost of treating and amalgamating would not exceed 4s. per ton.

CONCLUSION.

In concluding a somewhat fragmentary paper on the gold-fields of the Hauraki Peninsula, the writer does not hesitate to say that if it

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* No. 26,297, 1896.

should fall into the hands of the New Zealand people it will not give universal satisfaction, because it will be considered that he has not given sufficient prominence to many mines. But in common justice, the writer feels that they will all acknowledge that, so far as he has gone, he has dealt fairly, even generously, with the gold-fields as a whole. It must also be borne in mind that the writer has dealt with the gold-fields in general terms from a scientific as well as a practical standpoint. He has only written what he knows and what he has seen, and he ventures to express the hope that his opinions may be acceptable to those to whom they are now communicated.

Mr. THOS. J. BEWICK (London) wrote that Mr. Campbell's paper was interesting, and in some respects abstruse. In the earlier parts of his paper the author propounded several purely speculative ideas. He called them "fanciful suppositions," and he would not attempt, if even he was able and had the time, to comment thereon, as in practice they were not of the slightest value. The value of the gold of the Kapanga mine was given at £2 18s. per ounce, and if this be correct, the gold must be very impure.

Mr. S. HERBERT COX (London) wrote that he had read Mr. Campbell's paper with a good deal of interest; but, as regards some of his statements, he held opinions which did not accord with those of Mr. Campbell.

Referring to the geological classification given in the table,[*] he would point out that a very perfect section of the Lower Secondary beds exists in the Hokanui mountains of Southland, and that, from his point of view, this section included rocks from Upper Jurassic age down to the base of the Trias, and also underlying beds, which may or may not be Permian. The whole of this group may be classed as the Putataka formation; and the Maitai formation was certainly not of Triassic age, for the rocks which constituted this series were overlain unconformably by beds in which *Monotis* and *Haliotis* occur, and were themselves represented by beds of slate, sandstone, and limestone, in the latter of which *Productus* was found. The Maitai formation was undoubtedly of Carboniferous age, and was a very large and important formation. He thought, moreover, that the Kaikoura formation should properly be classified with the Maitai

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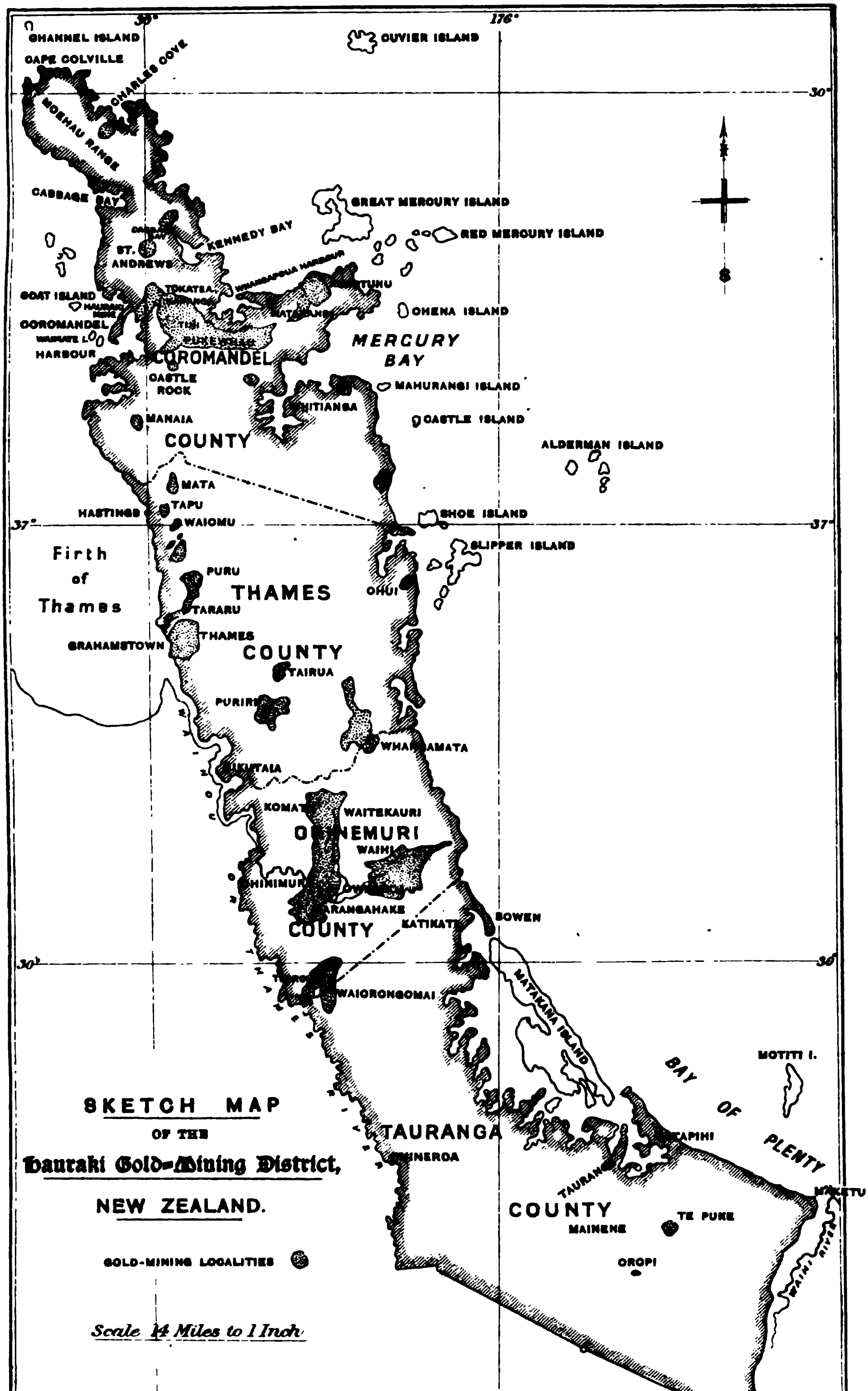
[*] *Trans. Fed. Inst.*, vol. xii., page 464.

To illustrate the Rev. Joseph Campbell's Paper on "The Gold-fields of the Hauraki Peninsula, New Zealand."



formation as the lower portion of it, and that probably these beds were of Upper Devonian age. To say that Devonian beds were wanting in New Zealand was manifestly wrong, for fossiliferous rocks of that age were found near Reefton.

It was only jumping to conclusions to classify the Kakanui, Wanaka, and Manipori formations as Silurian and Laurentian respectively, and to say that Cambrian beds were wanting. As a matter of fact, in Nelson, fossiliferous beds of both Upper and Lower Silurian age were known, but whether the Kakanui and Wanaka formations were their equivalents was purely a matter of surmise, as they were metamorphic rocks which had not hitherto yielded any fossils, and the same was the case with the Manipori formation.

Mr. Campbell said that he had only written what he knew and what he had seen, but surely he was wrong in stating that the Maitai formation contained alluvial deposits. His statement that the Putataka and Waipara formations were rich in reefs appeared to be a mistake, for they were neither of the class of rocks in which reefs occurred, and he (Mr. Cox) believed that he had seen every deposit in New Zealand belonging to these periods, and knew of no instance in which they were intersected by reefs.

Then, as regards Mr. Campbell's view that the gold-fields of the Hauraki Peninsula would supersede all the others, he (Mr. Cox) was again ready to question the correctness of his opinion. It must be borne in mind that by far the greater quantity of gold yet produced in New Zealand had been won from alluvial deposits, and that all of these had been found in the South Island, chiefly on the West Coast and in Otago. He had no doubt that many important discoveries of reefs would yet be made in the older rocks of the South Island, and seeing that these occupied a much greater area than the Tertiary auriferous rocks of the Hauraki Peninsula, it was only reasonable to suppose that the extent and value of the reefs in these formations would be quite as great or greater than those of Hauraki, especially when the extent and value of those already known at Reefton were taken into consideration.

Mr. Campbell's statement that all the quartz of the reefs in the Hauraki was hydrated was very interesting, but was it really the case? There were certainly innumerable instances in which hexagonal pyramids of quartz occurred crystallized in the reefs, and, of course, these were anhydrous, and much of the compact quartz did not give one the impression that it was an hydrated variety. However, presumably Mr. Campbell had tested this question, and any further information he could give about it would be of great interest. The theoretical questions which the author raised regarding the origin of reefs were much too large to allow of discussion with any hope of arriving at a definite conclusion. Moreover, the few remarks that he made upon his new process of treatment did not include sufficient details to allow of one's forming any opinion regarding its efficiency, and the members must wait for his promised paper on this subject before attempting to criticize it in any way.

Mr. H. M. CADELL (Bo'ness) wrote that he thought Mr. Campbell's paper contained a good deal of extraneous matter of no great importance in connexion with the subject, and that Mr. Campbell might well have given descriptions of several of the mines that he (Mr. Cadell) had omitted from his paper on gold-mining in the Hauraki district, instead of traversing the whole map of Australia and New Zealand, and going into elaborate chemical disquisitions on the origin of reefs in general, but of no special interest in connexion with those of the Hauraki gold-field. In his description of Te Aroha, Mr. Campbell devoted much space to the flora of the district, the diseases to be cured by the hot springs there, analyses of these healing waters, the hot lake district to the south, and the famous eruption of Mount Tarawera, but he devoted only a few lines to the description of the great reefs at Te Aroha, which, from a mining standpoint, were the most interesting features of the district. Since his (Mr. Cadell's) paper was written, a large amount of progress had been accomplished in the Hauraki district, and various new auriferous localities had been opened. It was a pity that Mr. Campbell had not recorded some of the latest information about these districts, which he could easily enough have obtained. The only part of the paper that appeared to have any really new matter in it was the last paragraph, in which Mr. Campbell referred to his own invention, which he called the thermo-hyperphoric process, for the treatment of gold ores. In this process, water-gas was to be the chief operative medium for recovering gold from refractory ores, but since Mr. Campbell said that he proposed to describe his new process in a subsequent paper, it was premature to discuss it now. He (Mr. Cadell) thought that in such a case Mr. Campbell need not now have broached this matter at all, as it apparently had no special relation to the Hauraki gold-field.

Mr. GEORGE J. BINNS (Netherseal) wrote that he was pleased to observe, not only in recent advices from the colony, but in Mr. Campbell's paper, confirmation of his opinion expressed some years ago as to the permanency of these gold-fields,* more especially as that opinion

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* *Trans. Fed. Inst.*, vol. iii., page 646.

was not, at the time, universally accepted by persons well acquainted with the district.* As regards the geological classification of the New Zealand rocks, it would perhaps have been better had the author given his authority for the scheme adopted, and stated that it was not the one usually accepted in the colony. For instance, in a recent "Report on Deep Quartz-mining in New Zealand," by Mr. Reginald A. F. Murray (Government Geologist for Victoria),† the classification followed was that of the New Zealand Geological Survey (Sir James Hector, Director), which differed from that given by Mr. Campbell in many important particulars, as for example, in the placing of the Maitai in the Carboniferous system, which, according to Mr. Campbell, was entirely wanting. As a matter of geological probability, it was not likely that a formation of such world-wide importance should be entirely absent. The Devonian also was usually considered to be fairly well represented at Reefton, even if the gold-reefing formation at the Lyell was not included.

Mr Murray places the Cape Colville rocks in the Upper Secondary or Lower Tertiary, whereas in the paper under discussion they are classed wholly as Tertiary. He (Mr. Binns) was unaware of alluvial deposits of Maitai age; perhaps Mr. Campbell would furnish details.

The author had not in his (Mr. Binns) opinion, placed sufficient emphasis on the large quantities of water which existed on the Auckland gold-fields; in the first place as surface-supplies, which were of inestimable value as a source of power, and, in the second place, as underground feeders, which had unfortunately done so much to retard the exploitation of the deep leads. As was pointed out in the Annual Report of the Hon. Mr. Cadman (Minister of Mines) for 1894, "Every year the payable stone in the upper levels is gradually getting less, and the time will come when, unless money is forthcoming to test the lodes at deeper levels the mines will have to be abandoned." Fortunately, the necessary capital had been forthcoming, and in his last report, the Minister of Mines stated that the company which had acquired the Queen of Beauty special claim, had decided to erect pumping and winding-machinery capable of proving and working the reefs to a depth of 2,000 feet. This would apparently be a first-rate plant, comprising a pump capable of raising 2,000 gallons per minute, together with air-compressors (compound steam and air), rock-drills, battery, electric light, etc. The New Zealand Government had wisely promised a subsidy of pound for pound, up to £25,000, towards this very desirable project.

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* *Trans. Fed. Inst.*, vol. iii., page 669.

† *Papers and Reports relating to Minerals and Mining, New Zealand*, 1894, C.—6.

If the deep levels were tested as proposed, and turned out anything like the yield of gold that had been produced in the past, the prosperity of this field would no doubt be very great; and if, in addition to this, the gold-extraction process introduced by Mr. Campbell should prove capable of extracting 95 per cent. for anything like 4s. per ton, success would be doubly assured.

Prof. H. Louis (Newcastle-upon-Tyne) said that he was much struck with the general similarity between the Hauraki district and the Comstock district (Colorado, United States of America), where heavy lodes, rich in gold and silver, occurred in somewhat the same way, and were in the same way intimately connected with hot springs in their immediate neighbourhood, and other similar hydrothermal phenomena. He did not entirely agree with Mr. Campbell's views respecting the formation of the lodes, as he did not see how it was possible for a fissure 600 feet to remain open at considerable depths below the earth's surface whilst it was slowly filling up with a deposit of silica that must have taken centuries to form, and he would prefer to ascribe its formation to metasomatic action.

Mr. Campbell had referred to two chlorination methods proposed by Mr. French and Mr. Park. As far as he (Prof. Louis) could follow the description, they seemed practically identical with methods in use long ago in California, except that in the processes as described by Mr. Campbell salt was mixed with the ores at the outset of the chloridizing roast—a practice that had been shown by Prof. S. B. Christy* to be attended by loss of gold, and which was therefore pretty generally discontinued.†

As regarded Mr. Campbell's own process, heating the ore by itself apart from using the current of water-gas before amalgamating was a very old process. Lazarus Encker, writing in 1672, stated that by the heating of gold ores—they heated over wood fires, but whether water-gas was thus formed and had any effect, he (Prof. Louis) could not say—"The fine, subtle gold shrank and ran together, and assumed a rounded corpus;"‡ and there seemed to be other reasons for believing that heating alone might accomplish a great deal that Mr. Campbell held was the result of his process.

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* *Transactions of the American Institute of Mining Engineers*, 1888-89, vol. xvii., page 3.

† Leaching with hyposulphite solution after chlorinating is an old process, *vide*, *The Metallurgy of Silver, Gold, and Mercury in the United States*, by Mr. T. Egleston, 1890, vol. ii., page 653.

‡ *A Handbook of Gold Milling*, by Prof. Henry Louis, 1894, page 17.

Mr. Campbell said he quite agreed with Prof. Louis that there were difficulties to be overcome in his or any other theory of reef-formation. He had not met with any theory that satisfied him: even his own was not altogether satisfactory. So far as the methods of ore-treatment proposed by Mr. French and Mr. Park were concerned, he quite agreed that they were in some respects old methods resuscitated and improved, and he wished these metallurgists, as he wished everybody working out this great question, success. He took a broad and general view of these things, and there was room for fifty processes if they could only bring them to perfection. Regarding the application of simple heat, they all knew that metallurgists could do a good deal with that, but he had so carefully considered and tried ore-treating in ordinary furnaces without the admission of any reducing-agents that he felt convinced good results could not be accomplished. He found that however careful they might be there was a coating of oxide of iron or something else on the ore, and that they could not save the gold. The question had been to find something that would remove the refractory elements or the infinitesimal quantity of coating that covered the gold, and he had found that water-gas took away the minutest quantity of any material that was inimical to the amalgamation of gold and quicksilver. He was a hard-working student, not in the least dogmatical, and he was only too glad to get any assistance from anybody, even from the very humblest miner with whom he came in contact.*

The Chairman proposed a vote of thanks to Mr. Campbell for his paper, in which the members had all been very much interested.

This motion was adopted, and Mr. Campbell acknowledged the compliment.

The following paper by Mr. Saville Shaw on "The Education of Metallurgists" was taken as read:—

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* Mr. Campbell will communicate a further reply to the discussion, at the ensuing meeting.

THE EDUCATION OF METALLURGISTS.

By SAVILLE SHAW.

It is with considerable diffidence that the writer ventures to address the members on the subject that forms the title of this paper, and he does so particularly in the hope that it may, perhaps, be the means of eliciting opinions from individuals with a wider experience than his own who might otherwise have remained silent.

The recent establishment of a department of metallurgy at the Durham College of Science, in charge of which department the writer has had the honour of being placed, makes him desirous of enunciating his own views as to the methods which should be adopted for the training of a student destined to devote himself to some branch of metallurgical industry.

After much discussion on the subject of the education of persons who are to engage in an industry based essentially on scientific principles, it may now be safely said that the most competent authorities have, practically, agreed to certain conclusions, which are briefly as follows :—

(1) That the individual who most needs thoroughly educating is the one upon whom the responsible management of the practical side of the industry will fall, and that the advantage to be gained by imparting any education beyond that of the most elementary character to the mere labourer is very doubtful.

(2) That details of a process or trade, if they are to be properly learnt, must be learnt by some sort of apprenticeship in the actual workshop, and not at any educational institution.

(3) That the work of the latter should consist chiefly in the training of the student in scientific method and scientific habits of thought, particular attention being paid to those branches of science upon which his industry is based.

Metallurgy is usually defined as "the art of extracting metals from their ores and adapting them for use," and an examination of metallurgical processes will show that they depend for their successful performance upon an observance of a certain order and method, which order and method are either the result of long practical experience, or have been deduced from theoretical study. The tools and appliances with which the metallurgist produces the desired result require, in many cases, a considerable degree of engineering skill in their manufacture and erection, and in order that the actual process of the various operations may be properly understood, a knowledge of the branches of natural science known as physics and chemistry is absolutely essential. Here are briefly indicated three of the main requirements for the outfit of the would-be metallurgist, viz., a knowledge of physics, of chemistry, and of engineering. In addition to these subjects there are several minor ones that he cannot afford to neglect: a knowledge of economic geology and mineralogy is often of great value to him, and acquaintance with two or three modern languages will not only tend to widen his views, but will enable him to learn more speedily what his neighbour is doing in his particular industry.

The course of study indicated by these various requirements does not appreciably differ from that which is offered by modern university colleges to regular students in science, studying for a science degree, except, perhaps, in the slight alteration in the curriculum which the advisability of acquiring some knowledge of engineering might entail. The pursuit of such a course of study would practically mean that for three years after leaving school, where it is assumed that he has received a good general education, the student should devote himself to pure science, and in the remaining one or two years he might then, while still devoting part of his time to purely scientific study, engage in work having some direct bearing on his future profession.

There are people of very considerable eminence in their respective professions, who, while never disputing for a moment the value and importance of purely scientific training, would yet introduce at a certain stage of the student's college career practical instruction in trade processes. Confining this idea to the question of the training of the future metallurgist, he would be set to work with experimental plant, with model gas-producers, model blast and reverberatory-furnaces, and generally to assist in the conduct on a fairly large scale of some modern metallurgical process. The system has already been introduced in America, and to a slight extent in this country, and the writer feels bound to join issue with its advocates for the following reasons:—

In the first place, the time at the disposal of the student is short, rarely five years, and in too many cases only three: four years may be taken indeed as distinctly more than the average. Bearing in mind that he will not improbably spend the whole of his remaining working life in the actual practice of one particular branch of our industry, it is surely inadvisable to curtail in any way the time devoted to the acquirement of systematized knowledge, or to attempt to curtail what is of more importance, his training in the habit of scientific thought and scientific method. Such a curtailment must be the inevitable result of any attempt to introduce instruction by means of experimental plant, and it is a point which merits the very serious attention of those who advocate this method of training. Abundant time and opportunity will be afforded to the student of acquiring a practical knowledge of manufacturing details during the rest of his working life, when it is almost impossible for him to continue his purely scientific studies.

It must also be borne in mind that training imparted in this way would of necessity be highly specialized, and the institution giving such training could only hope to instruct the student in some one branch of the industry, with the result that it would turn out not a budding metallurgist, but a copper-smelter, or a lead-smelter, or a steel-worker. Such a man might possibly have a better chance of securing an immediate return for his services than one trained on broader lines, but it could only be a question of a few years before the man with the better general scientific training would, other things being equal, assert his superiority. Surely the institutions in America and on the Continent which turn out their fourth or fifth year men with the title of "metallurgist," or "metallurgical engineer," can scarcely claim seriously for their product that he is what the title really implies? The idea that such a claim is made receives support from the fact that these institutions set their advanced students such exercises as the writing of "a thesis on the establishment and working of mines and smelting-works, under given conditions, with drawings, estimates, and written memoirs." Coming nearer home, no engineering department of one of the university colleges pretends to turn out a finished and perfect engineer, but what it does claim is that it has given its man that training which will enable him to become in time an incomparably better engineer than he could hope to become without such training.

So with metallurgical teaching. No university college or other educational institution can hope to turn out a metallurgist as a finished article. The finished article is essentially a product of years of experience, during which scientific knowledge has been applied to practical ends and aims.

The chief objection, then, to this method of teaching is the diverting of the very limited time of the student from the main object of his student life—the acquisition of scientific habits of thought; but there are other very weighty arguments against its adoption. There is, for instance, the question of the enormous expense of equipping an institution with plant of this character, and of maintaining it afterwards. Private munificence might overcome this difficulty, but yet to imagine one department of an educational institution thoroughly equipped with complete experimental plant representing the great and varied branches of metallurgical industry, is a task as hopeless as the establishment of such a department would, in the writer's opinion, be undesirable. To be consistent, the teaching of chemistry, and other branches of science upon which large industries are dependent, should be conducted on the same lines ; and the college student should forsake the test-tube and beaker for the vat or tank, and his flasks for sulphuric acid chambers, with a result that may well be left to the imagination.

The writer would not like it to be gathered from the preceding remarks that he entirely deprecates the introduction of experimental plant—very far from it. He merely states that it would be undesirable to burden the metallurgical department of a college with it, and he would like to take this opportunity of indicating one way in which such plant might be made to prove of the highest value.

Apart from the general question of the utility of plant as a teaching instrument, its introduction, duplicated as it would be at various institutions, would entail an enormous expense and give rise to a very great waste of teaching energy. By concentrating it at one central institution situated, perhaps preferably, in or near the metropolis, (where Prof. Roberts-Austen has already the basis of such an establishment), and conducting this institution on lines somewhat analogous to those on which the Physikalisch-Technische Reichsanstalt, at Charlottenburg, is carried, or akin to the Davy-Faraday research laboratory, recently founded by private munificence in our own country, much of this waste would be avoided. To such an institution, the more promising student might proceed from his college after his three or four years' training, his maintenance in certain cases being provided for by one of the scholarships founded by the Commissioners of the 1851 Exhibition, which might well be awarded for such a purpose.

An institution of this character would naturally require a large endowment, and the state might probably contribute to its support, as is done at Berlin. Under the direction of some eminent metallurgist working in co-operation with a committee representative of various branches of metallurgical industry, work of the greatest scientific and industrial value might be carried out, work which would be quite impossible if such plant were scattered all over the country, under the control of many individuals, and used solely for teaching purposes.

Having now indicated, he hopes quite clearly, the objections to this technical teaching, the writer would like to be allowed to suggest the part which the teacher of metallurgy should play in the training of the metallurgical student.

A student trained in pure science, and at the conclusion of his scientific training put directly into a smelting works, or asked to carry out a metallurgical operation on a large scale, would be confronted with a variety of problems and a set of conditions altogether new to him, and he would feel utterly at a loss as to how to apply his scientific knowledge. Carefully arranged in so many distinct pigeon-holes in his mind, and as carefully labelled "physics," "chemistry," and so on, as are these various branches of knowledge, the average student has comparatively little idea of correlating them, and still less of bringing them to bear collectively on any particular problem. The writer speaks from an experience of sixteen years of university colleges as student and teacher, and feels sure that others with much longer and wider experience will bear him out in this statement; indeed, the condition is almost an inevitable result of his training.

It is the business, then, of the metallurgical teacher at this period of the student's career to show him how the several branches of natural knowledge into which he has acquired some insight may be applied to the elucidation of some particular operation or process; to indicate to him, before he is confronted with the many problems, the manner of his attack—the fencing-master's instruction that will become useful in the battle. Though in the heat of the fight the exact designation of cut or thrust may escape him, it is none the less skilfully delivered. Habit will have become a second nature, and the results of his methodical and scientific training may be such as even to compel the admiration of the oft-quoted practical man who gained all his experience on the field.

Perhaps an actual example may make the point clearer, though there are objections to singling out one particular operation. For some years the process associated with the name of Sir Henry Bessemer has been applied to many other uses than the conversion of pig-iron into steel, notably to the concentration of the sulphides of metals, or to the conversion of the sulphides into the metals themselves, a current of air being blown through the molten matte in a converter, with the object of burning off a portion or the whole of the sulphur. The problem as to whether a matte of a certain composition can be successfully bessemerized is one which may be determined with some exactitude from purely theoretical considerations; the heats of combination of the various bodies taking part in the reaction are known, and the specific heats of the air used, of the nitrogen, slag, and metal produced are also known. It is true that certain assumptions have to be made, but these do not invalidate the result, and it is the elucidation of the method of attacking such a problem that is one of the duties of the metallurgical teacher, to show the student how to bring his thermo-chemistry and his physics to work together in harmony to help him to obtain the desired result.

In his general theoretical studies, attention would be paid to such points as the relations between carbon and oxygen, particularly with regard to the absorption and evolution of heat involved in the various changes considered. The many complicated reactions of the blast-furnace, and the light thrown upon them by the laborious researches of men like the distinguished Past-President of this Institute, Sir Lowthian Bell, would be dealt with in considerable detail. It would be easy to multiply such instances, but these should suffice to indicate the lines upon which, in the writer's opinion, the metallurgical student's theoretical training should run.

As regards the practical work of the student, many of the chief chemical reactions upon which the great metallurgical industries are based, reactions with which he has had no opportunity of becoming familiar, and which are known to him only as blackboard equations, may be studied practically in the metallurgical laboratory. The phenomena attending the oxidation of metals, the reduction of metallic oxides, the formation of metallic sulphides, and the various changes occurring when they are roasted or reduced may be given as examples of this class of work. The scale of his operations is very small, but, except in rare instances, there is not the slightest reason why he should not acquire a clear insight into the progress of the reactions as they would take place on the large scale.

The knowledge of the general methods of chemical analysis acquired in the chemical laboratory would be supplemented by the acquirement of a certain degree of skill in those special methods usually included in the term " assaying."

There is amongst otherwise well-informed persons a disposition to regard the terms "practical metallurgy" and "assaying" as synonymous, in much the same way that practical chemistry to some people means simply chemical analysis. This misconception is singularly unfortunate, and forms in some cases a real obstacle to the progress of a metallurgical department and of metallurgical teaching. Assaying and analysis are merely branches of the two subjects, and though a knowledge of each is essential for the equipment of the metallurgist or chemist, let it be borne in mind that they are but branches, each founded on that very knowledge of principles which it should be the teacher's first aim to impart to the student.

It may have been gathered from the foregoing remarks that the teaching of metallurgy proper seems to have been relegated to what may appear to be a subordinate position in the college curriculum. The writer is perfectly willing to accept that conclusion, believing as he does that the ultimate value to the student himself and to the industrial progress of the country of any strictly metallurgical knowledge that he may gain at college cannot rank for a moment with the value of his purely scientific training. It is difficult, even if the individual desires it, to secure a training in pure science later in life, whereas the greater part of that life may of necessity be spent in acquiring metallurgical knowledge and experience.

In conclusion, it may be well to be reminded of the fact that after all has been said on the subject of education, there still remains the chief factor in success to consider—the capacity or natural ability of the individual taught. Without this natural capacity, training and education can do comparatively little towards increasing the usefulness or the chances of success of the individual, whilst with it, even though the happy possessor may not have had the advantages of a college training, he is practically certain to play his part worthily in any industry in which he may engage.

Mr. **Thos. J. Bewick** (London) wrote that Mr. Shaw's paper contained a great deal of good advice which, however, it was next to impossible to carry into effect with many ordinary pupils. What languages other than English did the writer recommend should be learnt by the student? He concurred with the writer for reasons set forth in his condemnation in including several occupations not forming part of a metallurgist's education.

Mr. **Joseph Garland** (London) wrote that the author had apparently in his mind only the student of ample means, who could afford to devote a series of years to a mastery of the theory and the principles of metallurgy before entering upon the practical work of his profession; but he thought that the majority of young men were anxious, and found it necessary, to become qualified to take an appointment and to earn money as early as practicable, and this could only be done by the students acquiring as soon as possible a practical acquaintance with the work which lay before him.

Everyone knew how difficult it was for a young engineer, whether mining or metallurgical, to obtain an appointment while his qualifications were merely theoretical, and that the first question asked of an applicant was as to what experience he had had and what practical knowledge he had gained.

Bearing this in mind, he would reverse the order suggested by Mr. Shaw, and, instead of devoting a number of years to college or laboratory-work, the student should, after acquiring a fair knowledge of the theory and principles of metallurgy, begin to graduate in the practical school of metallurgical works, and so qualify for an appointment and the earning of a livelihood. Let him, by all means, if he wished to become proficient, still persistently and devotedly apply himself in his spare time to the acquirement of systematized knowledge.

Mr. W. M. **Hutchings** (Newcastle-upon-Tyne) wrote that he agreed with the general conclusions stated at the commencement of Mr. Shaw's paper. So far as metallurgy went, he felt sure that Mr. Shaw expressed right views, and indicated the lines on which education should proceed. He noted that Mr. Shaw expressed doubts as to there being any advantage in specially educating workmen. He believed that there were people who considered that some great good would result if the workmen, say in a smelting-works, were instructed in the science of the processes at which they were employed. For his own part, he did not hold this view, and speaking as an experienced manager, he would be very sorry to employ such workmen. He would as soon think, if he were a soldier, of wishing to command troops of which all the privates had received instruction in military tactics.

Mr. Shaw's objection to specializing too early, or even to attempting to specialize at all during the purely educational period, was also, he thought, quite right; and he had often had occasion to lay stress on a similar opinion when people had asked him for advice as to the education of their sons.

He (Mr. Hutchings) did not think that there was any use in trying to teach metallurgy in colleges as an art. It should be taught more broadly, as a branch of chemical and physical science, and should only be specialized at suitable stages and to a limited extent. In connexion with the question of not specializing during the education-period, came also the question of making use of experimental plant, and he was pleased to see that Mr. Shaw had dealt with this question in some detail. Here, again, he was quite in accord with Mr. Shaw's views. The nature of, and the reactions involved in, most of the processes concerned in metallurgical industries, could be well shown and studied in laboratory apparatus; and while the science was thus being taught, and made interesting and even fascinating to the student, he could receive sufficient instruction also, in general terms, as to the sort of apparatus in which these operations were conducted in actual practice. To go beyond this stage and erect a so-called "plant," which was something between laboratory apparatus and the full-sized plant, was a mistake. It was at the best an artificial business and a sham, working under conditions which did not bear any relationship to the actual manufacturing requirements. It would give students false ideas, cause them to imagine that they were much more advanced towards the status of practical men than they really could be, and would be very liable to create a set of metallurgical prigs. And whilst doing this, it would, as Mr. Shaw pointed out, waste time which ought to be used in studies for which in later life the man may never again have leisure or opportunity, whereas all that he can possibly learn from the experimental "plant" he would be able to obtain, and be obliged to obtain, a hundredfold better in the course of his regular employment. He could not imagine that any teacher of metallurgy, who had ever been connected with real and actual works-processes and conditions, would wish to use such a toy-plant for his students. He thought, however, that he himself would prefer to train them in broad, general knowledge, and tell them that practical experience and technical skill could only be obtained by long acquaintance with actual work. On the other hand, it was of enormous benefit, when it could be done, to allow the students, at suitable periods of their education, to visit works. Such visits, properly conducted, should not for a moment aim at going into details, or more than barely indicating the many considerations in actual work, which made all the difference between economic success or failure. Many such conditions of work would not even be shown to the instructor himself. But such visits could be made to show the students what sort of thing their science became when put into practice, and when it had to be made to pay; and they might get some glimpses of what they would have to learn when their purely scientific training ceased; the erection and the management and maintenance of large plant, the economical handling of large quantities of materials, and the training and management of men.

He well remembered how, in his own student days, such visits to works, with their actual life and stir, used to give a feeling of reality to his studies, and send him back with increased zest and interest to the laboratories, the lectures, and the books.

He hoped that Mr. Shaw would persevere in his determination to discourage the idea that a technical man could be produced at a college, and that narrow specialists could be, or ought to be, trained there. It was a huge mistake, even looked at simply in the personal interest of the man himself. He would have to be a specialist in later work, and that man would make the best specialist who had had the broadest basis of general scientific training given to him.

Mr. T. TURNER (Stafford) wrote that he had read Mr. Shaw's paper with considerable interest, and agreed in part with the writer, but regretted that in some important matters his views differed altogether from those recorded by Mr. Shaw. The writer of the paper wisely deprecated the provision of extensive plant on a manufacturing scale in connexion with metallurgical departments at university colleges, while he urged the necessity of a typical plant in the metropolis, and presumably at a few other representative centres throughout the country. There was a danger, where much plant suitable for the conduct of a particular series of operations was provided, that the instruction would degenerate into the mere teaching of a trade, the practice of which could be much better learned in the works. Mr. Shaw rightly insisted upon the necessity for instruction in pure science, particularly in physics, chemistry, and engineering; but when he said that "the course of study indicated by these various requirements does not appreciably differ from that which is offered by modern university colleges to regular students in science,"* and when he further added that "the teaching of metallurgy proper seems to have been relegated to what may appear to be a subordinate position in the college curriculum," and that he "is perfectly willing to accept that conclusion,"† Mr. Shaw took a position which would not be held by the majority of his colleagues, and which could not tend to increase the respect which was paid to his subject.

The study of medicine was in some respects very like that of metallurgy. The art of healing was based upon scientific principles, and

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* *Trans. Fed. Inst.*, vol. xii., page 489. † *Ibid.*, page 494.

the student commenced his training by following a strictly scientific course. As his scientific course progressed, however, opportunity was given to him to undertake practical work, to visit hospitals, etc., so as to learn, not merely abstract science, but the application of science to the healing art. A medical faculty was not required at every university college, but where it was needed no medical man would be content if the teaching of medicine proper were relegated to a subordinate position in the college curriculum. The object of the medical student's scientific training was not to turn out a finished and perfect medical man, but to give him that training which would enable him with further experience to become a trustworthy practitioner. Similarly, it was not every university college that required a metallurgical department, but where such a department was required it should be no makeshift, a miserably-equipped, half-starved appendage of a chemical department, nor should it be relegated to a subordinate position, with which its instructor (who does not enjoy the title of professor) was well content.

The ordinary course of study offered by a modern university college to students studying for a science degree was supposed to qualify for entry into works carrying on such diverse manufactures as dyeing and bleaching, soap-boiling and candle-making, acids and alkalies, leather-tanning, sewage-disposal, gold-extraction, or the production of iron and steel, to which it might be added that the man who had been trained to do all these things equally well, could not really do any one of them.

Referring once again to the illustration of the medical student, the man who intended to devote his life to metallurgical work should receive a grounding in pure science, and then by means of laboratory experiments, model plant, and by regular and systematic visits to works, should equip himself thoroughly for the special subject which was to form his life's work. The man who had merely received instruction in abstract science had been but half-trained. From the manufacturer's point of view, he often only had that little knowledge which was a dangerous thing, while from the point of view of the educationalist, pure science was little better as a mental training for practical work than the older system of grinding at classics, which, after all had been said or which might be said to the contrary, often led to the production of leaders in the industrial race.

If this country is to retain its supremacy in the metal trades—perhaps it would be more correct to say, to regain its supremacy—it must be prepared to expend considerable sums of money in the equipment of thoroughly efficient metallurgical laboratories, in at least several representative centres, and these departments must occupy no subordinate position, but must be equal in equipment and in status to the best of the chemical, physical, or engineering laboratories. Until this had been done Great Britain would still continue to be as much behind in research as heretofore, while our competitors would continue to make headway in the race.

Mr. **Jeremiah Head** (London) wrote that he had read Mr. Saville Shaw's paper with great interest. The three conclusions upon which he said the most competent authorities had practically agreed he was delighted to have the opportunity of endorsing, and he had never heard them so clearly stated before. On first looking over the pages of the paper, all Mr. Shaw's statements and arguments, put as he put them, received his ready assent; but, after reflection, he was not quite sure that Mr. Shaw had covered the whole ground—that he had said all which might be, and needs to be, said.

As far as he could gather from the eighth and ninth paragraphs of the paper, Mr. Shaw had in mind only, or mainly, "regular students in science studying for a science degree, except, perhaps, in the slight alteration in the curriculum which the advisability of acquiring some knowledge of engineering might entail."* These students, he assumed, had just left school, where they were understood to have received a good general education. He takes it for granted that the next three years would be devoted to pure science, and then for one or two more years purely scientific study would share their time and attention, with some work having a direct bearing on the profession chosen.

Having in his mind students of this kind, Mr. Shaw manfully battled against those who advocated their spending a portion of their four or five years in what might be called "playing at practical work." He contended that experimental laboratories on a semi-commercial scale, containing model gas-producers, and model blast and reverberatory furnaces, such as have been introduced into America, and to a slight extent in this country, as adjuncts to technical colleges, were a mistake. They were so, he thought, because they were exceedingly costly to establish and maintain; because they diverted the attention of professors and students from courses of study which were more important to the latter, and which would be likely to tell more certainly on their future careers; because they were, after all, not on a commercial scale, nor worked under commercial conditions; and because the students would probably, later on in their careers, learn anything they could teach much better and more easily. As Mr. Shaw put the case, he entirely agreed with him.

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* *Trans. Fed. Inst.*, vol. xii., page 489.

But there was another way in which it seemed to him possible to make a good metallurgist. Starting at the age of sixteen or seventeen with a good general education, we have four or five years at disposal before the boy becomes a man. Those four or five years were the best ones of his life for absorbing his professional intuitions. If he was destined to be an admiral of the fleet, he would be sent to sea during that period, and the more difficulties and dangers he went through then the better chance he would have of being a good admiral in the end. He would, no doubt, also be studying all the time the theoretical part of his profession, viz., navigation, meteorology, mechanical science, foreign languages, and so forth. But the point to be noted was, that all would be subordinated to the acquisition of the primary and essential intuitions of the sailor while still young. Carrying this idea into the field of practical metallurgy, he (Mr. Head) would suggest that one way of making a model metallurgist—say an iron or steel manufacturer—would be to commence by allowing him to serve a five years' pupilage in a good modern iron or steel works in the ordinary way, improving himself in his leisure time, so far as his energies and opportunities permitted, by acquiring a knowledge of the sciences upon which his profession rested. At or about the age of twenty-one, he should enter one of the technical colleges in this country or abroad, or the science department of one of our older universities, and should there cultivate as complete an acquaintance with the physical sciences, mathematics, and so forth, as his time and opportunities permitted.

The main advantages to the student of learning practical work under commercial conditions before seriously engaging in studies of a more abstract character were, he thought, two, viz.:—Firstly, the student would apply his mind to the practical side of his profession at the age when impressions are likely to be deepest and the intuitions most permanent; and, secondly, he would study the theoretical side containing the more difficult problems when his mind was more mature, and he could bring more knowledge to bear upon them.

He (Mr. Head) was aware that the plan suggested, which was applicable to the training not only of metallurgists but to technical experts of any kind, involved in all seven or eight years' training, and not four or five years as contemplated by Mr. Shaw. The time necessary to produce a "finished article," as he termed it, was one thing: the best disposal of that time was another thing. If the shorter period be chosen, he had no doubt that it could be well utilized in the way which haw suggested. He believed that it could be equally well utilized by apprenticeship as he himself suggested, supplemented by evening classes at a technical school and private tuition. But in neither case would a "finished article" be turned out able to cope *cæteris paribus* with competitors whose education had occupied the longer period. Mr. Shaw's ideal training might, of course, be supplemented by a three years' apprenticeship. But the average student would not take to working in the shops at the age of twenty-one, so kindly as he would have done at sixteen. And if he did, he would not so completely absorb the spirit of the practical mechanic or metallurgist. In the final result, Mr. Shaw's student might throughout his career be expected to aim at and satisfy himself with scientific achievements without too much regard for commercial results; whilst his (Mr. Head's) student would, he thought, be more likely to make financial success the end and object of all his operations.

But whilst it was well to discuss these matters to the utmost, he was well aware that dogmatism was dangerous and might be very misleading. And he agreed entirely with what Mr. Shaw said in his concluding paragraph, viz., that the chief factor in success was after all the natural capacity of the individual student.

Mr. R. A. HADFIELD (Sheffield) wrote that, there was very much in Mr. Shaw's paper with which the writer could heartily agree, and specially where he so strongly emphasized the impossibility of a merely college-trained student being capable of dealing with commercial routine and organization. But by the combination of practice and theory, which to an earnest worker were much more possible than was ordinarily believed, we had the result in an individual who in a comparatively short time would win his way to success. No country in the world presented such special opportunities as Great Britain with its multitudinous workshops of every kind, and if we let slip our supremacy it would be for want of that perseverance and energy of which our predecessors possessed so large a share. He did not, however, agree with Mr. Shaw in thinking that the metallurgical department of a college should not be burdened with experimental plant. If Mr. Shaw knew of all the good work done by the experimental plant of the Sheffield Technical School, he would form another opinion and see its great value. He thought too, that it would be the greatest mistake possible to concentrate experimental plant in any central institution, especially in the metropolis. There had been too much of this in the past, and it did not reflect credit upon mining education to find that all the leading engineers in the colonies were not British. There had been blundering somewhere, and the sooner we rectified it the better it would be for our commerce. It was impossible to estimate how much business had been lost to this country owing to our weakness in this direction. American engineers, for example, very commonly when abroad specified and encouraged American tools and plant. Apart from this proposed centralization, the writer thought that Mr. Shaw had offered a very valuable contribution to the cause of metallurgical education.

He would finally like to call the attention of those engaged in considering this important question to a letter by "General Manager" in *Engineering* of December 25th, 1896, where the weak points of the college or school side of technical training were ably described. There was not the slightest doubt that in all but very rare cases a student ought to be acquainted with general commercial knowledge, specially that relating to costing and estimating, otherwise the most sapient Whitworth scholar might find himself supplanted by the clever clerk described by "General Manager."

Mr. **Saville Shaw**, in reply, said that he was much gratified to find that his main object in writing the paper had been attained, and that it had been the means of eliciting opinions from men whose wide experience in various fields rendered their views of particular value. Especially was he grateful to Mr. Hutchings and to Mr. Jeremiah Head, well-known workers in entirely different departments of metallurgical industry for their valuable contributions to the discussion, and he was pleased to find that he had received their support.

He (Mr. Shaw) thanked Mr. Hutchings for his outspoken remarks concerning experimental plant, and heartily agreed with that writer as to the very real value of visits paid to works by the student during the intervals of his scientific studies. He only wished that manufacturers in this country could feel at liberty to extend, without injury to themselves, the privileges and opportunities which some of them already very generously granted to students.

Mr. Head's scheme of first letting the student serve his pupilage in the works, and letting him obtain his scientific education afterwards, was one which he thought all interested in the subject would consider admirable. There was, however, considerable difficulty in carrying it out in practice. The student who had spent five years in a works was only too often compelled, for want of means, to stay there and earn his living, whereas coming direct from school to a higher institution even the student in poor circumstances could often pay for his education, and partly for his maintenance during his educational period by obtaining one of the scholarships or exhibitions which existed in connexion with such institutions. There existed the danger also of the student forgetting much of his rudimentary science during these years spent at the works, and though the teaching of such students was often a delightful task owing to the ready way in which they applied the scientific knowledge that they were gaining, yet in other cases both teacher and student were heavily handicapped by the effects of the long interval. The plan of the student acquiring the requisite scientific knowledge in his leisure hours whilst attending works did not seem to answer in practice. The comparatively long hours and the physical exertion demanded by the work's daily routine seemed in all but exceptional cases to render the student unfit for any steady and serious work in the evening. On the whole he (Mr. Shaw) thought, as Mr. Head in one of his remarks suggested, that apprenticeship after the scientific training was the best plan under existing circumstances.

With regard to Mr. Joseph Garland's remarks, he (Mr. Shaw) thought that no doubt there would always be a certain number of young men who might find it necessary to do as Mr. Garland suggested, and entering directly into works, try to obtain their theoretical knowledge afterwards. The objections to this plan had been considered in the reply to Mr. Head. Want of means need not nowadays be a bar to an individual obtaining the highest scientific education that was to be had in this country, provided there existed no want of brains; the difficulty lay, as Mr. Garland pointed out, in securing an appointment after receiving this education. Manufacturers abroad were willing, indeed, as stated by Dr. Duisberg in his interesting address on "The Education of Chemists,"* to take the university student and pay him sufficient to keep him whilst he was learning the details of his trade, not expecting him to be of much use to them for a year or so, and one could only hope that in time the manufacturers in Great Britain might find that in the long run it would pay them to do the same thing.

Mr. T. Turner, in his comparison between the teaching of medicine and metallurgy, had perhaps overlooked the fact that the equivalent of hospital practice, viz., "regular and systematic visits to works," was an item which could hardly be inserted in the syllabus of the course of instruction at any educational institution in this country. These works were in the hands of private individuals or companies, and scarcely existed for educational purposes; the most that could be reasonably expected of their proprietors was that they might be willing to open their works for very occasional visits by the students. He (Mr. Shaw) was not

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* *Journal of the Society of Chemical Industry*, June, 1896, page 427.

aware of the existence of any metallurgical institution in this country where students might be taken to the bedside of a sick process, have the illness explained to them in detail, watch the progress of the disease, and see the effect of the remedies prescribed by the attendant physician. The establishment of such a metallurgical infirmary, which might then make Mr. Turner's analogy a reasonable one, would be hailed with delight by every teacher of metallurgy throughout the kingdom; but it was open to very great doubt whether the erection of model plant could answer this purpose satisfactorily. To quote Mr. Hutchings, model plant "was, at the best, an artificial business and a sham, working under conditions which did not bear any relationship to the actual manufacturing requirements;" and metallurgical science would be no more advanced by the treatment of a process that was shamming to be sick than would medicine by the doctoring of a patient who imagined himself to be ill.

Mr. Turner's remarks as to the scientific training given by university colleges being a qualification for entry into any one of a number of very diverse industries scarcely bore on the subject under discussion, but the obvious reply was that in many cases these industries were being successfully managed by men who had had this very training. It would also readily be conceded that, as th industries he named were all based on applications of various branches of science, the individual engaging in them would have a better chance of success if, as a preliminary, he had received some such training in those branches of science as a modern university college afforded.

With reference to other remarks made by Mr. Turner, he (Mr. Shaw) could simply say that he must decline to accept for a moment Mr. Turner's dictum that the position he had taken up was one "which would not be held by the majority of his colleagues," and he felt that he might await with confidence the verdict of those colleagues. Further, with reference to his remark regarding the position of a metallurgical department and the absence of titular distinction for the instructor, Mr. Turner should be aware that in nearly all cases where he might find cause for complaint it was chiefly a question of available, or rather of non-available, funds.

Mr. Turner seemed to think that their views on the actual subject under discussion differed widely, but after a careful reading of Mr. Turner's remarks, he (Mr. Shaw) failed to discern that they were not practically in agreement. Mr. Turner wrote that "the man who intended to devote his life to metallurgical work should receive a grounding in pure science, and then by laboratory experiments, model plant, and regular and systematic visits to works, should equip himself thoroughly for the special subject which was to form his life's work." Leave out the item "model plant," and in place of regular and systematic visits, substitute actual entry into or apprenticeship to works (as the visits could not be obtained in this country), and the course which he had endeavoured to map out in his paper was identical with that which Mr. Turner recommended. The advisability of using model plant was and must remain for some time largely a matter of opinion, and he (Mr. Shaw) was perfectly open to conviction on that point; but for the present, particularly after reading the remarks of Mr. Hutchings and Mr. Head, and until he had heard some valid reasons against the position which he had taken up, he felt that his opinion must be decidedly against it.

From Mr. Hadfield, Mr. Shaw was glad to hear that the experimental plant of the Sheffield Technical School was doing good work, and he hoped that under the careful direction of Prof. Arnold it would continue to do so. It was an educational experiment that perhaps required to be tried for a little longer time before a definite pronouncement could be made as to its real success. As Mr. Head remarked, it was dangerous to dogmatize on the entire question of metallurgical education, and the continued progress of such institutions as the Sheffield Technical School might in time afford reasons for modifying the opinions which at present he felt bound to uphold.

He (Mr. Shaw), in conclusion, desired to express his hearty thanks to the gentlemen who had contributed to the discussion, a discussion which he thought had proved both interesting and valuable.

Mr. A. H. Bromly's "Notes upon Gold-mining in Burma" were taken as read:—

NOTES UPON GOLD-MINING IN BURMA.

By A. H. BROMLY.

The author, having been engaged during the last two years in active work upon the first gold-mine to be opened up and operated by Europeans in Burma, presents these notes as being of possible general interest, and, perhaps of use to those who may have to carry out similar work in this, as yet, little explored and undeveloped country. They are to be regarded rather as the observations and notes of the pioneer than as an attempt at a polished scientific paper.

Gold is known to occur in more or less scattered localities throughout practically the whole of Burma; and as exploration progresses, its existence in fresh districts is reported, and conditions favourable to its occurrence are found to prevail. It is found in most of the stream-beds, being washed for by natives more or less intermittently, and in most cases doubtless with profitable results to the workers. A glance at the map shows the considerable number of streams and places whose names commence with Shwe (*i.e.*, gold or golden); but owing to the absence of restrictions as regards alluvial working and the very nature of the operations, returns of gold so won are non-existent.

With one or two exceptions, work by Europeans has been confined to the Wuntho division of Katha district, Upper Burma. Wuntho was annexed in 1891, and lies about 160 miles north-west of Mandalay, on the Mu Valley Railway, which provides a daily service to Mandalay (twelve hours), and Rangoon (thirty-six hours.) The distance to Wuntho from Rangoon is about 540 miles by rail. The district is hilly, and, generally speaking, the gold-bearing area may be termed a "trap" country. Igneous and schistose rocks have been much disturbed and metamorphosed by volcanic agency extending probably over two or more periods. Chloritic schists and clay-slates have been overlain by felspathic traps, the whole being broken and disturbed by syenite and greenstone-dykes. Most of these rocks yield reactions when tested for gold. The difficulty of a close study of the country's structure is accentuated by very heavy jungle and an overburden many feet deep, usually clay of varied colour. This latter has caused confusion, and by some been mistaken for alluvial drift. In reality, it is the product of decomposition *in situ* of the rocks due to a humid climate and dense vegetation. The overburden usually carries gold, and contains stringers and layers of quartz, occasionally very rich. Exploration shows that these quartz-leaders usually continue down and penetrate the solid rock beneath. The quartz thus found and pounded, together with the surrounding soil, has furnished material for native washers.

Some seventy years ago, an influx of Kachins and Shans took place from the north, who, by main force, held possession some two years, and practically washed out the country. Their workings were thoroughly and well laid out, and are extremely numerous in some districts. From the foregoing it will be understood that they are as likely to be found on the crest of a ridge as in the valley: the rains furnishing sufficient surface-water to wash the soil down artificial gutters, or sluices. So thoroughly and recently was their work done that the ordinary indications which guide a prospector have been removed to a great extent.

Although several areas have been taken up in Wuntho district, under Government licenses, the only property that has so far been developed and worked to any extent, is that held by the Choukpazat Gold-mining Company, Limited. This mine is located about 26 miles north of Wuntho, and 11 miles from Nankan railway station. The lode is a bedded lenticular body in clay-slate, varying from 8 feet in thickness downwards, the average being about 3 feet. Strike north-east by south-west, dip 20 degs. to 25 degs. south. The lode has been proved by shafts and winzes to a depth of 200 feet, becoming more compact, defined, and of better grade with depth.

The country rock of clay-slate is much impregnated with chlorite, and also in places the quartz itself. The quartz is often heavily mineralized, carrying iron and copper pyrites, arsenical pyrites, galena, blende, copper glance, and a tin-white mineral identified by Mr. Saville Shaw as tellurium or a telluride.* Wherever this latter occurs gold is associated, and the stone correspondingly enriched. Occasionally schistose filling replaces the quartz.

The mine has been opened by an adit driven (to date) about 450 feet into the hill; above the adit, by levels; and in depth, by shafts and winzes following the reef itself. The dip being slight, natives can sink and carry up stone in baskets holding about 60 lbs. each, without

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* Prof. Louis has promised to supply a note upon this mineral.

winding appliances. The ore is thrown into trucks standing in the adit and trammed out to dump. Water is hand-baled by buckets, but as a new level has just been started 60 feet below the adit, pumping will become necessary at the next rainy season.

A 2 feet gauge tram-line connects mine and mill, a distance of about 1 mile. Just before reaching the mill, a rise of 52 feet vertical has to be negotiated by means of a double incline 231 feet in length, with a hand-whim at top. Burmans run three trips a day, the trucks holding one ton; wind up incline, deliver to mill, and return to mine; at a cost of 0·75 rupee per ton, including maintenance of road.

The mill is a ten-stamp, 800 lbs., high mill, by Messrs. Bowes Scott and Western, with bins at the back, grizzly, spalling-floor, etc. Automatic feeders built on the spot have proved quite successful. The framing being of teak makes a substantial job; and power is furnished by a 40 horse-power portable Robey engine, thus providing for further additions. The drop is 7 inches; depth of discharge, 8 to 10 inches; number of drops, 90; mesh 30, or hole 0·021 inch square. Under these conditions, the output is about 2·2 tons per stamp per twenty-four hours—1 ton of 2,240 lbs.—and duty of stamps about 1·5 cwts. per effective horse-power per hour. These conditions of milling were arrived at after considerable trial and study, as giving the best results on a decidedly refractory ore.

From the plates, the pulp passes over two 6 feet corrugated-belt Frue vanners, by Messrs. Fraser and Chalmers. The concentrates are at present stored with a view to future treatment, but experiments show them to consist mainly of iron pyrites containing about 0·7 per cent. of copper, a little antimony, and about 2 to 2½ ounces each of gold and silver per ton. Milling returns give an average of 5 per cent. of sulphurets, value as above. Some of this, however, is not associated with the sulphurets, but is coated, non-amalgamable gold that escapes the battery. Returns over about 3,000 tons milled show the value of ore to be about 10 dwts. of fine gold per ton. As the bullion averages 0·850 fine, this value corresponds to rather over 11 dwts. of bullion.

The tailings vary considerably, from about 2 to 4½ dwts., and may be averaged at 3 dwts.: they prove to be amenable to cyanidation. This makes the average percentage recovered by amalgamation 51 per cent., locked up in concentrates 20 per cent., and in tailings 29 per cent.

At present the mill only runs twelve hours net daily. Night-work proved very trying to the native and Eurasian staff owing to chills inducing fever, and was temporarily abandoned. Hence the output is only 300 tons per month; but it is hoped to shortly add five more stamps, and run twenty-four hours daily, or an output of 900 tons per month.

Most of the gold occurs very finely disseminated, and often as thin plates and "paint." Many specimens, apparently rich, really contain but little, and as the author has noted this in other gold-ores from Burma, it may be useful to point out that panning is likely to be more than usually misleading, especially when conducted by a native in his batea, as his method of washing loses all fine gold.

At Choukpazat, some of the ore from outcrop was found to mill considerably under assay value, and investigation showed that gold escaped from the battery. Experiment proved at least 90 per cent. of this to be non-amalgamable by simple contact. Under the microscope some showed rough and blistery; some a dull, rusty colour; and others bright, but obviously coated. Under the knife a portion proved brittle. Short digestion in cold nitric acid, and also in cyanide of potassium, was found useless. Immediate amalgamation usually followed rubbing up in a wedgewood mortar; also after short heating in nitric acid, and after simple heating alone. Any would amalgamate with strong sodium amalgam, with pronounced action and the giving off of black greasy-looking scum (?sulphide of mercury). After a short interval and the formation of gold amalgam, the action upon fresh gold was found to be very slow and imperfect. Many of these characteristics have been noted by the author as being common to gold at Carndochan mine, North Wales.

Upon the workings deepening, this refractory gold was found to disappear, and the ore became better milling, in spite of the change from the oxidized to the pyritic zone, the decomposition-line being very shallow. When milling surface-ores, the plates could not be kept in decent order, whereas upon pyritic ore running up occasionally to nearly 10 per cent. of sulphurets, the trouble was much less. Some of the pyrites occurs as mispickel, and there is of necessity loss of mercury. With care this usually stands at about 0·75 ounce per ton. Often a strong smell of sulphuretted hydrogen is noticeable upon the plates and when opening out the mortar-boxes.

It is not easy to explain why in this particular case, oxidized surface-ore should be more refractory to mill than pyritic. It may be urged that, at first the plates being new, the difficulties were not due to the ore; but it is found, after months of running and with plates thoroughly set, a return to surface-ore still produces the old troubles. During the process of oxidizing, the bulk of the gold has become coated, and the ore also deleteriously affected from the milling point of view.

The amalgam usually requires much cleaning. That done, it will occasionally retort well, giving off clean mercury and easily smelted bullion. On the contrary, for no ostensible change in ore, the distilled mercury will come off fouled with sulphide, black and greasy looking. In such cases the mercury requires cleaning up with nitric acid and sodium, and the bullion repeatedly treated with nitre to get a good ingot and fluid slag. The skimmings from amalgam are frequently considerable, and often yield 10 per cent. of the bullion recovered. After cleaning off everything possible, the amalgam often contains a species of tin-like amalgam that will adhere slightly to the fingers on passing the hand through the bath. The skimmings are always especially troublesome, and it was found that repeated fusions with borax and nitre were better than scorifying; but it takes many such to get down the bullion and a clean free slag, the latter continuing for a long time very heavy, and exceedingly sticky. Bullion obtained from skimmings is usually brittle; fracture slightly greyish, distinctly mosaic, showing often greenish surface colouring; this may indicate the presence of bismuth. Generally, the author's practice was to finish by scorifying, using nitre, and then adding to the sponge gold, from retort, for final smelting. The ingots, when re-melted at Calcutta mint, lose but very little, and run about 0·850 fine, realizing 62 rupees per ounce, with exchange at 1s. 2d. per rupee.

Possibly some of these details may be considered elementary and unnecessary; but a record of facts is often useful, and in this case may serve as a guide to future workers in a new field. They serve also to illustrate the reasons for the method of milling adopted. The gold being fine, and not readily amalgamating, calls for a deep discharge with fine reduction. The pulp being retained an appreciable time in the mortar, facilitates amalgamation. The deep discharge, and the fact that the stamps are not lifted entirely out of the water, results in fine reduction with the use of a comparatively coarse screen. Under these circumstances the life of the screens is considerably increased.

From investigations recently made it is found that concentrating may probably be dispensed with, and direct cyaniding of tailings adopted.

In many cases in Burma, it will be found advisable, where water-power is absent, to use oil-engines. The jungles do not yield a useful kind of wood for fuel, and firewood means conflict with government forest officers, and a considerable duty. The author estimates that with oil, supplied by the Burma Oil Company at 7 annas per gallon at Sagaing, the cost of oil per horse-power at Choukpazat would be the same as for firewood, but with a considerable saving in favour of oil-engines in respect of drivers and firemen.

Labour and Working Costs.—Daily wages are: natives of India, 10 annas; local Burmans, 8 annas; Chinese smiths and carpenters, 2 and 3 rupees respectively.

Mining was at first done mostly by Indian labour, but the local Burman has been trained to the work, and gradually replaced the Indian, with considerable advantage all round. If the Burman can only be induced to come in to work, he is quicker and requires less supervision than the available native, and so far no steps have been taken to import miners from India, the local supply of labour having proved sufficient. The Burmans work on day wages, and drill double-handed. In driving an adit, 7 by 7 feet clear, six men work on the face at once, and drill six 2 feet holes per shift, clear away and load the stone. This makes the cost of drilling 0·25 rupee per foot.

The cost of driving the adit, taken over nine months, was as follows, per foot advance:—

	Rupees.
European miner	2·50
Smiths	0·93
Charcoal and baskets	0·29
Explosives	7·20
Candles	0·46
Native labour	6·22
Total, exclusive of management, etc....	17·60

Or, say, £1 0s. 6d. per foot.

The lowest monthly cost was 13·75 rupees, and the highest 24·75 rupees, according to whether the thickness of reef afforded a full, or partial, breast of quartz. Owing to turns and faults, the adit was frequently much larger than 7 by 7 feet.

The cost of all sinking and driving during the same period works out as follows, per foot of advance, and per ton of quartz won:—

	Per Foot. Rupees.		Per Ton. Rupees.
European miner	1·58	...	0·80
Smiths	0·82	...	0·41
Charcoal and baskets	0·28	...	0·14
Explosives	5·45	...	2·77
Candles	0·43	...	0·21
Native labour	5·53	...	2·82
Total, exclusive of management, etc.	14·09	...	7·15

Or, say, 16s. 4d. per foot, and 8s. 4d. per ton.

Each ton of quartz involved the getting of about ½ ton of mullock, partly owing to the adit cutting through the pinched portions of the reef between the lenses. All the quartz so far has been won by development works only, and it is reasonable to suppose that the cost of stoping will be considerably less.

Milling 300 tons per month costs about 4 rupees per ton, exclusive of management or re-treatment charges, as the following typical monthly sheet shows :—

COST OF MILLING.

Supplies :—	Annas per Ton.	Labour :—	Annas per Ton.
Oil, waste, etc.	2·4	Engine-driver	3·1
Screens	2·1	Firemen	2·8
Mercury	2·2	Mill coolies	4·2
Cyanide of potassium (plates)	0·5	Spallers and wood-carriers	4·7
Firewood	16·0	Carpenter	4·0
Shoes	2·6	Smith	1·0
Dies	2·5	Mechanic	3·0
		Millman	7·9
Total	28·3	Total	30·7

Or 59·0 annas or 3·7 rupees, or 4s. 3d. per ton.

The total working costs, therefore, are :—

	Rupees.
Mining	7·15
Transport	0·75
Milling	4·00
Total	11·90

Say 12 rupees, or 14s. per ton.

The value of 5 dwts. is 15 rupees, hence allowing 3 rupees for depreciation, general charges, clerical, bullion, royalty, etc., it is found that 5 dwts. just about covers expenses, working on the present scale. By increasing the output to 900 tons per month, it is estimated that the costs would be reduced by about 1½ rupees to 2 rupees per ton, including re-treatment charges.

These figures are very close, and leave but little margin for charges and expenses other than absolute working-charges, and management has to be added. Upon an output of 1,000 tons per month, it would probably be fairly safe to assume 15 rupees per ton as covering all local expenses; but before taking these figures as a basis for estimating, it would be advisable to compare the costs of working at the Burma Ruby Mines, given by Mr. Wynne in a paper read this year before the Institution of Mining and Metallurgy.*

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* 1895, vol. iv., page 292.

Mining in Burma is conducted subject to the rules and regulations of the Government of India. For gold, the maximum area held under a mining lease may not exceed ¼ square mile, with a distance of at least ¼ mile between grants to the same person or persons.

The royalty called for is 7½ per cent. of the value of bullion, which is excessive, and intending lessees should seek to arrange for better terms before signing.

The date of writing the above notes is November, 1896, and the present value of the rupee is about 1s. 2d.

NOTE ON THE TELLURIUM MINERAL OF CHOUKPAZAT.

BY HENRY LOUIS.

The tellurium-mineral occurs very finely disseminated in the Choukpazat quartz, but the writer had succeeded in collecting 0·375 grain for a rough quantitative analysis, that gave the following results :—

Tellurium	34·2	
Lead	57·4	
	——	91·6
Iron	0·2	
Calcium carbonate	3·8	
Silica	2·1	
	——	6·1
Silver present, but under 0·1.		——
		97·7

The above percentage-composition corresponds closely with the formula PbTe, which would require the elements to be present in the proportions of : tellurium 34·5 and lead 57·1.

The above composition and most of the physical characters, notably the cleavage, correspond closely with those of the rare mineral altaite, named by Prof. Dana from its occurrence in the Altai. In addition to this locality, altaite has only been hitherto found in one or two other places, chiefly in the United States of America.

Mr. THOS. J. BEWICK (London) wrote that the absence of a map was a great drawback to Mr. Bromly's paper. The operations described by the writer went to show that they were of a primitive description; and that the ores near the surface should be more difficult to treat than those of a refractory character found at some depth was remarkable, and contrary to what was found to prevail in gold-mining generally. He thought that it would be desirable in this paper, and in fact in all such papers, to convert local coinage, weights, and measures to British standards. Were the "available natives" referred to in the paper natives of Burma or India? The quantity of work done by the ten stamps mill, namely, 300 tons per month, or, say, ten tons per day, was far short of what ought to be accomplished.

PRESENTATION OF PRESIDENT'S (MR. T. DOUGLAS) STUDENTS' PRIZE.

At the conclusion of the General Meeting, a meeting of Associates and Students was held.

Mr. G. P. CHAPLIN was voted to the chair, and he presented (on behalf of Mr. Thomas Douglas, the late President) to Messrs. W. R. Bell and E. McGowan, the prize awarded to them for their paper on "Haulage at Wearmouth Colliery."*

Mr. W. R. BELL, on behalf of Mr. E. McGowan and himself, acknowledged Mr. Douglas' kindness in presenting the prize for their essay.

The meeting then closed.

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* *Trans. Fed. Inst.*, vol. xi., page 221

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT IDLESTOP AND AT DONCASTER, NOVEMBER 28TH, 1896.

MR. W. E. GARFORTH IN THE CHAIR.

Mr. GEORGE DUNSTON read the following paper on "The Eastern Extension of the Midland Coal-field, and the Exploration at Southcar:"—

THE EASTERN EXTENSION OF THE MIDLAND COAL-FIELD, AND THE EXPLORATION AT SOUTHCAR.

BY GEORGE DUNSTON.

The members will be interested in hearing what has led to this district being explored for coal. The writer's business necessitated his frequently crossing the North Sea *en route* to the Continent, and during bad weather soundings were taken at a point called Coal Pit, 30 fathoms deep, 5 miles long, and 1 mile broad, in latitude 53 degs. 29 mins. north, and longitude 1 deg. 45 mins. east, lying 37 miles from Cromer north-east quarter-north magnetic bearing, the Lincolnshire coast being 55 miles distant. Each sounding brought up particles of coal, and afterwards, from enquiries made from those engaged in the fishing industry, the writer came to the conclusion that this point was the easternmost outcrop of the Yorkshire and Derbyshire coal-field. The explanation given of the existence of this coal by the fishermen was, that ships laden with coal had been sunk at this point; but this theory was upset by the fact that Silver Pit and Sole Pit, between this point and the land, contained no coal, and that, had the existence of the coal been due to wreckage, it must have also been present in the other pits which are situated between Coal Pit and Donna Nook on the sea-coast, which is in about a direct line with Southcar and Barnsley, as shown on the North Sea chart.

Upon this information, Mr. Arthur Wilson consented to give his support to an exploration-scheme, and finally an agreement was made with the Vivian Diamond Boring Company, Limited, for a borehole to be carried down 3,000 feet at Southcar.

Afterwards adjoining landowners decided to contribute towards the expenditure, upon the joint report of the late Mr. Joseph Mitchell and Mr. Charles E. Rhodes, whose opinions have been justified by the results of the exploration. The opinion given by Mr. W. H. Chambers, both as to thicknesses of formation and the depth at which the well-known seams would be found (he gave it as his opinion that the Barnsley coal-seam would be found divided, as at Monckton Main), proved of great value to the syndicate.

The syndicate had also the advantage of Mr. H. B. Nash's professional services, who was most indefatigable in his efforts to make the exploration a success; and the fact that he strongly urged the necessity of maintaining the size of the borehole shows his foresight, for otherwise the borehole might not have been made to a sufficient depth to produce cores enabling the strata to be identified. The Barnsley coal-seam was reached within a few feet of the depth anticipated by Mr. W. H. Chambers and the late Mr. John R. Hewitt.

The borehole started in superficial deposits of sand, warp, and gravel, 32 feet in thickness; below this it passed through a part of the Trias and the whole of the Permian formations. It entered the Coal-measures at about the depth of 1,700 feet, and at a depth of a little over 3,000 feet reached the well-known Barnsley bed of the Yorkshire coal-field. The late Prof. Green recognized in these Carboniferous rocks the sections met with at the boreholes near Snaith and at Scarle, in the neighbourhood of Newark.

The first workable seam of coal (the Shafton) was found at a depth of about 1,920 feet, and is a little over 3 feet in thickness. Passing the Bagshaw and other thinner seams, the Swinton Pottery seam was found 3 feet 9 inches in thickness. The late Prof. Green, in reference to these two seams, wrote that :—"It seems to me that from these two seams we have a fair prospect, not only of obtaining the coal necessary to keep the works going during the sinking, but also of commencing a remunerative sale of coal before the Barnsley bed (which must be the mainstay of the undertaking) is reached, and it may be that it will be found worth while in the end to work all these seams simultaneously."

After passing through eight other coal-seams, the Kents thick coal-seam was found at a depth of about 3,000 feet, and about 4 feet 5 inches in thickness. Another 130 feet, and the Barnsley soft coal-seam was reached, with about 4 feet 9 inches thickness of coal. There is, then, a rock-parting of 39 feet before the Barnsley hard coal-seam was reached, with 4 feet 7 inches of clean coal without parting.

Two most important items in the present discovery are, that all the measures are perfectly flat, and that the strata overlying the seams of coal are of a strong rocky character. Out of a thickness of 9 feet 2 inches of shale above the Barnsley soft coal-seam, 9 feet of core was brought up, and the shale above the Barnsley hard coal-seam was equally solid. The cores were also identified and reported upon by Messrs. R. Russell, C. Tylden Wright, and F. J. Jones.

The following is an analysis, by Mr. Alfred H. Allen, of a sample of coal described as "hards," taken from the borehole :—

	Per Cent.
Moisture	2·72
Volatile matter	30·09
Fixed carbonaceous matter	66·15
Mineral matter (ash)	1·04
Coke	66·19
Sulphur	0·63

These results show the coal to have a very low ash, and to contain only a moderate proportion of sulphur. It is coal of excellent quality.

Notwithstanding the great thickness of the red sandstone passed through, and the great quantity of water necessarily pumped down the borehole during the process of boring, the water never reached the top of the borehole owing to the porous nature of the sandstone formation, until it reached a depth of 282 feet. Then a spring of brine was met with, which gave off saline matter in the water as tested with a hydrometer to the extent of 6 ounces to the gallon, or nearly 4 per cent.: at this point the water rose to the top of the borehole and overflowed very slowly.

At about 1,200 feet, a seam of anhydrous gypsum, 8 feet 10 inches in thickness, was passed through.

From what has been stated, it will be seen that the Barnsley coal-seams have been proved to extend over a very much wider area than had hitherto been supposed.

The geographical situation of Southcar, on the river Idle, about 3 miles from the Trent (near Stockwith), where turret type of boats can be loaded for the London, Hamburg, and other markets, is important in respect not only of securing cheap carriage of coal, but in saving the breakage of the coal.

By the Great Northern and Great Eastern Joint Railway, Southcar will be the colliery working South Yorkshire steam-coal nearest to Hull, Goole, Keadby, Boston, Grimsby, and London.

Before closing this paper, the writer is pleased to congratulate Mr.

Vivian upon the skill with which he carried to a successful termination the deepest coal-boring yet made in England, and he has pleasure in appending, for the information of the members, a section of the boring.

APPENDIXES.

I.—No. 1 Diamond-boring, by Vivian's Boring and Exploration Company, Limited, at Southcar.

No.	Description of Strata.	Thickness of Strata.		Depth from Surface.	
		Ft.	In.	Ft.	In.
1	Soil	1	6	1	6
2	Grey sand	3	0	4	6
3	Running sand	2	6	7	0
4	Loamy sand	1	0	8	0
5	Grey sand	1	6	9	6
6	Grey sand, mixed with clay	6	6	16	0
7	Red sandy clay	3	6	19	6
8	Red sand	2	6	22	0
9	Fine sand	6	6	28	6
10	Red sandy clay	0	6	29	0
11	Fine sand	2	6	31	6
12	Sand and gravel	0	6	32	0
13	Red and blue marl	3	0	35	0
14	Red and blue marl, with gypsum joints	10	6	45	6
15	Grey sandstone	1	0	46	6
16	Grey limestone	1	6	48	0
17	Red and blue sandy marl, with veins of gypsum	40	7	88	7
18	Red and blue marl, with veins of gypsum	4	0	92	7
19	Blue marl, with veins of gypsum	2	6	95	1
20	Blue marl, with beds of gypsum	12	6	107	7
21	Red and blue marl, with veins of gypsum and beds of sandstone	24	0	131	7
22	Red marl	6	0	137	7
23	Red and grey sandstone	5	11	143	6
24	Grey sandstone	93	9	237	3
25	Red sandstone	6	0	243	3
26	Red and grey sandstone, with beds of marl	30	11	274	2
27	Grey sandstone	14	9	288	11
28	Red and grey sandstone, with beds of marl	8	0	296	11
29	Red and grey sandstone	135	4	432	3
30	Red and grey sandstone, with small beds of blue shale	34	0	466	3
31	Red and grey sandstone	15	0	481	3
32	Red and grey sandstone, with small beds of blue shale	50	0	531	3
33	Red and grey sandstone, with small beds of marl	12	10	544	1
34	Red and grey sandstone, with beds of blue shale	13	6	557	7
35	Red and grey sandstone, with beds of red and blue shale	22	0	579	7
36	Red and grey sandstone	13	0	592	7
37	Red and grey sandstone, with beds of blue shale	16	0	608	7
38	Red and grey sandstone, with beds of blue marl	11	0	619	7
39	Red and grey sandstone, with beds of blue shale	51	1	670	8
40	Red sandstone	75	6	746	2
41	Red sandstone, with pebbles	206	10	953	0
42	Red sandstone, with pebbles and small beds of marl	10	0	963	0
43	Red sandstone, with pebbles	55	1	1,018	1
44	Red sandstone, with spots of marl	11	6	1,029	7
45	Red sandstone	35	5	1,065	0
46	Red sandstone, with beds of marl	115	6	1,180	6
47	Red and grey sandy marl, with veins of gypsum	3	0	1,183	6
48	Red marl, with veins of gypsum	4	0	1,187	6
49	**ANHYDRITE**	8	10	1,196	4
50	Very hard red sandy marl, with veins of gypsum	2	8	1,199	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
51	Very hard red and grey marly sandstone, with veins of gypsum	3	6	1,202	6
52	Red sandy marl, with veins of gypsum... ...	3	6	1,206	0
53	Red and grey sandy marl, with veins of gypsum	0	9	1,206	9
54	Red marl, with veins of gypsum	17	6	1,224	3
55	Red marl, with veins of gypsum and beds of limestone	9	0	1,233	3
56	Red and brown marl, with beds of gypsum and beds of limestone	5	4	1,238	7
57	Fine grey sandstone, with beds of blue shale and veins of gypsum	5	0	1,243	7
58	Fine grey sandstone, with veins of gypsum ...	8	4	1,251	11
59	Fine grey sandstone, with beds of pure gypsum	5	0	1,256	11
60	Fine grey sandstone, with beds of blue shale ...	12	6	1,269	5
61	Grey limestone ...	53	0	1,322	5
62	Blue marl, with veins of gypsum	7	2	1,329	7
63	Red marl, with veins of gypsum	44	8	1,374	3
64	Rotten red marl, with veins of gypsum... ...	14	0	1,388	3
65	Blue marl, with veins of gypsum	3	0	1,391	3
66	Rotten red marl, with veins of gypsum... ...	11	11	1,403	2
67	Brown and blue marl, with veins of gypsum ...	52	0	1,455	2
68	Brown marl, with beds of limestone	4	6	1,459	8
69	Limestone and red and blue marl, with veins of gypsum	11	6	1,471	2
70	Grey limestone ...	18	4	1,489	6
71	Grey limestone, with shale-joints	28	7	1,518	1
72	Light grey limestone	9	0	1,527	1
73.	Grey limestone, with shale-joints	185	8	1,712	9
74	Grey shale ...	12	0	1,724	9
75	Mottled shale ...	3	0	1,727	9
76	Red shaly limestone	0	6	1,728	3
77	Mottled sandy shale	5	0	1,733	3
78	Mottled shale ...	4	0	1,737	3
	Rotherham Red Rock—				
79	Red and grey sandstone ...	7	0	1,744	3
80	Mottled shale	3	0	1,747	3
81	Red and grey sandstone ...	1	10	1,749	1
82	Red and grey sandstone, with red joints	45	3	1,794	4
83	Coarse red sandstone... ...	2	6	1,796	10
84	Grey sandstone, with red joints	27	2	1,824	0
85	Grey sandstone, with red joints and shale ...	4	0	1,828	0
86	Blue shale ...	0	6	1,828	6
87	Grey sandstone, with small black veins ...	2	6	1,831	0
88	Blue shale ...	1	0	1,832	0
89	**COAL**	1	2	1,833	2
90	Soft fireclay ...	3	4	1,836	6
91	Hard fireclay, with balls of ironstone	0	5	1,836	11
92	Soft fireclay, with balls of ironstone	0	9	1,837	8
93	Black shale ...	1	6	1,839	2
94	Very rotten blue shale or fireclay	15	6	1,854	8
95	Grey sandstone ...	0	6	1,855	2
96	Blue shale or fireclay	1	0	1,856	2
97	**COAL**, mixed with black shale	0	5	1,856	7
98	Dark blue shale...	1	0	1,857	7
99	Dark blue shale, with balls of ironstone	21	3	1,878	10
100	**COAL**	0	10	1,879	8
101	Black shale ...	0	2	1,879	10
102	Soft grey fireclay	2	0	1,881	10
103	Blue sandy fireclay, with balls of ironstone ...	17	0	1,898	10
104	Blue sandy shale	13	0	1,911	10
105	Blue rock ...	7	6	1,919	4
106	Dark blue shale...	2	6	1,921	10
107	Grey fireclay ...	1	7	1,923	5
	Shafton Coal-seam—				
108	**COAL** ...	3	1	1,926	6
109	Grey fireclay ...	1	8	1,928	2
110	Grey sandstone and sandy shale	7	0	1,935	2

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
111	Dark blue laminated shale ...	6	10	1,942	0
112	Dark blue shale, with balls of ironstone	9	1	1,951	1
113	Grey sandy shale	22	8	1,973	9
114	Grey sandstone ...	1	9	1,975	6
115	**COAL**	0	8	1,976	2
116	Rotten grey fireclay, with balls of ironstone ...	13	5	1,989	7
117	Dark blue shale...	6	0	1,995	7
118	Grey sandstone...	0	7	1,996	2
119	Dark blue shale...	16	0	2,012	2
120	Grey fireclay, with balls of ironstone	7	7	2,019	9
121	Blue shale, with balls of ironstone	18	3	2,038	0
122	Blue sandy laminated shale ...	27	0	2,065	0
123	Grey fine-grained sandstone ...	7	6	2,072	6
124	Soft grey fine-grained sandstone	25	6	2,098	0
125	Dark sandy shale	1	0	2,099	0
126	Grey fine-grained sandstone ...	12	6	2,111	6
127	Grey sandstone mixed with shale	8	0	2,119	6
128	Dark shale, with balls of ironstone	7	6	2,127	0
129	Grey fireclay, with balls of ironstone	10	0	2,137	0
130	Ironstone ...	0	4	2,137	4
131	Soft grey fireclay	11	3	2,148	7
132	Grey fireclay, with balls of ironstone	12	10	2,161	5
133	Dark shale ...	4	5	2,165	10
134	Dark fireclay, with balls of ironstone	4	0	2,169	10
135	Light fireclay, with balls of ironstone ...	5	7	2,175	5
136	Grey fireclay ...	22	0	2,197	5
137	Black shale, containing gas ...	0	6	2,197	11
	Bagshaw Coal-seam—				
138	**COAL** ...	1	7	2,199	6
139	Grey fireclay ...	9	6	2,209	0
	Oaks Rock—				
140	Spongy grey sandstone: fine-grained at top, and coarse-grained at base ...	39	9	2,248	9
141	Blue sandy shale	1	6	2,250	3
142	Coarse grey sandstone ...	52	4	2,302	7
143	Blue sandy shale	16	10	2,319	5
144	Dark shale ...	4	0	2,323	5
145	Fireclay ...	3	0	2,326	5
146	Grey sandy shale, with beds of sandstone	8	0	2,334	5
147	Fireclay	6	0	2,340	5
148	Grey sandstone...	5	7	2,346	0
149	Dark shale, with ironstone ...	7	0	2,353	0
150	Black shale ...	1	6	2,354	6
151	Grey sandy shale	10	2	2,364	8
152	Grey sandstone...	7	10	2,372	5
153	Grey fireclay ..	20	0	2,392	6
154	Black and grey shale	0	10	2,393	4
	Swinton Pottery Coal-seam— Ft. In.				
155	**COAL** 2 9				
156	Fireclay band 0 3				
157	**COAL**, soft 0 9				
	——	3	9	2,397	1
158	Grey sandy fireclay	1	4	2,398	5
159	Grey fine-grained sandstone	17	8	2,416	1
160	Grey fine-grained sandstone, with black streaks ...	46	7	2,462	8
161	Grey sandstone...	6	6	2,469	2
162	Black shale ...	1	8	2,470	10
163	**COAL**	1	3	2,472	1
164	Soft fireclay ...	4	2	2,476	3
165	Sandy fireclay ...	7	5	2,483	8
166	Light grey shaly sandstone ...	7	0	2,490	8
167	Dark grey shaly sandstone ...	8	0	2,498	8
168	Fireclay, with balls of ironstone	4	9	2,503	5
169	Black shale, with balls of ironstone	17	11	2,521	4
170	Ironstone ...	0	4	2,521	8
171	Black shale ...	1	0	2,522	8
172	Ironstone ...	0	1	2,522	9
173	Black shale ...	1	0	2,523	9
174	Ironstone ...	0	2	2,523	11
175	Black shale ...	9	6	2,533	5
176	Ironstone ...	0	5	2,533	10
177	Fireclay	2	0	2,535	10
	Wooley Edge Rock—				
178	Grey sandstone, coarse and gritty ...	11	7	2,547	5
179	Blue sandy shale	2	0	2,549	5
180	Dark sandy shale	20	8	2,570	1
181	Blue sandy shale, with bands of sandstone containing ironstone	18	0	2,588	1

No.	Description of Strata.	Thickness of Strata. Ft.	Thickness of Strata. In.	Depth from Surface. Ft.	Depth from Surface. In.
182	Black shale	3	6	2,591	7
183	Blue shale, with ironstone balls	2	0	2,593	7
184	**COAL**	0	10	2,594	5
185	Fireclay	3	2	2,597	7
186	Blue sandy shale, with bands of ironstone	7	6	2,605	1
187	Black shale, with bands of ironstone	15	0	2,620	1
	Wathwood Coal-seam—				
188	**COAL**	0	11	2,621	0
189	Fireclay	1	0	2,622	0
190	Grey shaly sandstone	0	3	2,622	3
191	Fine-grained grey sandstone, containing lime	6	6	2,628	9
192	Dark sandy shale	4	8	2,633	5
193	Dark sandy shale, with balls of ironstone	3	3	2,636	8
194	Shaly sandstone	2	6	2,639	2
195	Sandy shale	5	6	2,644	8
196	Grey sandstone	2	6	2,647	2
197	Blue shale, with balls of ironstone	8	0	2,655	2
198	Dark blue shale, with balls of ironstone	3	0	2,658	2
199	Shaly sandstone	2	0	2,660	2
200	Blue shale	1	0	2,661	2
201	Blue shale, with bands of ironstone	6	4	2,667	6
202	Black shale	0	2	2,667	8
	Two Feet Coal-seam—				
203	**COAL**	0	10	2,668	6
204	Grey fireclay	1	0	2,669	6
205	Blue shale, with balls of ironstone	22	0	2,691	6
206	Light blue shale, with balls of ironstone	7	6	2,699	0
207	Blue shale, with balls of ironstone	5	0	2,704	0
208	Dark blue shale, with balls of ironstone	4	3	2,708	3
209	Black shale	0	8	2,708	11
	Abdy or Winter Coal-seam—				
210	**COAL**	1	0	2,709	11
211	Light blue shale, with balls of ironstone	19	4	2,729	3
212	Grey sandstone	67	2	2,796	5
213	Blue shale	1	0	2,797	5
214	Black shale, with spots of *coal*	1	6	2,798	11
215	Blue sandy shale	7	6	2,806	5
216	Grey shaly sandstone	6	11	2,813	4
217	Grey shaly sandstone, with balls of ironstone	16	6	2,829	10
218	Blue shale, with ironstone bands	15	6	2,845	4
219	Blue sandy shale	2	10	2,848	2
220	Fireclay	0	3	2,848	5
	Low Beamshaw Coal-seam—				
221	**COAL**	1	0	2,849	5
222	Black shale	0	2	2,849	7
223	Grey sandstone	5	0	2,854	7
224	Blue shaly sandstone	4	8	2,859	3
225	Blue shale, with bands of hard sandstone containing ironstone	28	9	2,888	0
	Kents Thin Coal-seam (?)—				
226	Black shale	1	0	2,889	0
227	Blue sandy shale, with bands of hard sandstone containing ironstone	24	0	2,913	0
228	Blue sandy shale and balls of ironstone	18	6	2,931	6
	Kents Thick Rock—				
229	Grey sandstone	45	0	2,976	6
230	Blue sandy shale, with bands of hard sandstone containing ironstone	5	0	2,981	6
231	Grey sandstone	3	6	2,985	0
232	Blue sandy shale, with bands of hard sandstone containing ironstone	1	6	2,986	6
233	Grey sandstone	2	0	2,988	6
234	Blue sandy shale, with bands of hard sandstone containing ironstone	3	6	2,992	0
235	Grey sandstone	1	0	2,993	0
236	Blue sandy shale, with small beds of grey sandstone	7	0	3,000	0
237	Grey shaly sandstone	3	9	3,003	9
238	Black shale	4	5	3,008	2
		Ft.	In.		
	Kents Thick Coal-seam—				
239	**COAL**	0	4		

No.	Description of Strata.	Ft.	In.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
240	Black shale mixed with *coal* ...	0	3				
241	Dark fire-clay ...	1	2				
242	**COAL**	0	7				
243	Fireclay	0	2				
244	**COAL**	1	11				
		——		4	5	3,012	7
245	Strong fireclay ...			1	0	3,013	7
246	Blue sandy shale			4	0	3,017	7
247	Grey shaly sandstone			10	10	3,028	5
248	Blue shale, with bands of hard sandstone containing ironstone			12	4	3,040	9
249	Blue shale ..			3	8	3,044	5
250	Blue sandy shale			6	0	3,050	5
251	Grey sandstone ...			6	0	3,056	5
252	Blue shale ...			7	0	3,063	5
253	Blue shale, with bands of hard sandstone containing ironstone			14	0	3,077	5
254	Blue sandy shale			1	6	3,078	11
255	Grey sandstone ...			2	6	3,081	5
256	Blue shale, with bands of hard sandstone containing ironstone			6	0	3,087	5
257	Grey sandstone...			19	8	3,107	1
258	Blue sandy shale			1	9	3,108	10
259	Blue shale, with bands of hard sandstone containing ironstone			12	0	3,120	10
260	Black shale ...			3	6	3,124	4
261	Blue shale, with bands of ironstone			8	2	3,132	6
262	Black shale ...			1	0	3,133	6
	Barnsley Soft Coal-seam—						
263	**COAL** ...			1	0	3,134	6
264	Dark fireclay...			3	6	3,138	0
265	**COAL**	4	1				
266	**COAL** and dirt	0	4				
267	**COAL**	0	4				
		——		4	9	3,142	9
268	Fireclay			2	0	3,144	9
269	Blue shale, with balls of ironstone			17	9	3,162	6
270	Blue shale, with bands of ironstone			17	10	3,180	4
271	Dark blue shale ..			0	8	3,181	0
	Barnsley Hard Coal-seam—						
272	**COAL** ...			4	7	3,185	7
273	Grey sandy fireclay			0	8	3,186	3
274	Grey fireclay, with balls of ironstone			3	6	3,189	9
275	Grey shaly sandstone			5	6	3,195	3

II.—SUMMARIZED SECTION OF STRATA AT No. 1 DIAMOND-BORING, SOUTHCAR.

Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
Alluvium, etc. ...	32	0	32	0
New Red Sandstone:—				
Upper Keuper ...	105	7	137	7
Lower Keuper ...	608	7	746	2
Bunter	434	4	1,180	6
Permian:—				
Upper Marls ...	88	11	1,269	5
Upper Magnesian Limestone ...	53	0	1,322	5
Middle Marls ...	132	9	1,455	2
Lower Magnesian Limestone ...	273	1	1,728	3
Coal-measures	1,467	0	3,195	3

Mr. EDWARD HULL (London) wrote that the syndicate which had carried out the important boring at Southcar were to be congratulated on the success of their undertaking. It was certainly one of the most important borings yet made in the eastward advance of coal-mining from the Yorkshire and Derbyshire coal-fields. There had never been any doubt but that all the coal-seams would be found under this part of the valley of the Trent and adjoining tracts; the only questions to be solved were the depths, thickness, and horizontality of the coal-seams themselves. These have been so far solved by this experiment.

Mr. G. **Dunston** said that the borehole was 13 inches in diameter at the surface, and was gradually reduced to a core of about 1½ inches at the bottom of the hole.

The **Chairman** (Mr. W. E. Garforth) remarked that in the boring at Snaith the core was about 14 inches at the top and ½ inch at the bottom, the depth being about 1,600 feet.

Mr. G. E. **Coke** (Nottingham) said that at Ruddington, the core was 4½ inches at a depth of 1,800 feet.

Mr. W. H. **Chambers** (Conisborough) said that the coal being softer than the overlying strata when the boring reached it, there would be a lengthening of the rods owing to the less resistance which would not be perceptible at the top, and as the thickness was measured by the length of the rods the probability was that the coals would be found to be thicker than shown in the section. As the borehole was at the lower portion so much reduced in diameter, a solid core of coal through the section was not obtainable, but the portions extracted were sufficient to enable the character of the seams to be identified.

Mr. **John Nevin** (Mirfield) moved a vote of thanks to Mr. Dunston and the other gentlemen who had invited the members to visit the site of the borehole. The members were deeply indebted to Mr. Dunston for affording them every information as to the boring.

Mr. G. E. **Coke** (Nottingham), in seconding the vote of thanks to Mr. Dunston, at the same time thanked the members of the Midland Institute of Mining, Civil and Mechanical Engineers for inviting the members of the Chesterfield and Midland Counties Institution of Engineers to join in that visit. The boring was exceedingly interesting to him personally, because he was superintending a borehole south of Nottingham. The Ruddington borehole, in conjunction with other boreholes put down, showed that the strike of the Coal-measures to the south of Nottingham was in a south-easterly direction, and, of course, that tended to confirm the supposition that coal extended a long distance eastward.

The motion was cordially approved.

Mr. **Dunston** said that from the commencement of this undertaking, the greatest assistance, courtesy and kindness that could be given were given by professional gentlemen connected with the mining industry. They appeared to be greatly interested in the undertaking, which had been commenced there, so far away from any working colliery. The contract was to bore to a depth of 3,000 feet, and when that distance was reached the contractors refused to accept further responsibility. There was a time of intense anxiety until the Barnsley coal-seam was reached, which certainly had been the cause of their meeting that day, and seeing what they had seen. He was greatly obliged to the members for their attendance that day, and for their hearty vote of thanks. When the boring was completed, the late Prof. Green and Mr. Russell took the roof and bottom of each section passed through, and samples of each change of strata, from top to bottom of the borehole, were now stored in three cabinets so that at some future time one of the cabinets might be presented to The Federated Institution of Mining Engineers if they had room for them. It would be a useful thing, probably, in future sinkings if such samples of the cores could be inspected. The borehole was blocked below the sandstone, and by pumping and analysis it was found that there was sufficient water of good quality to supply a colliery village.

The following is an analysis by Dr. A. Whitelegge, Dr. J. Mitchill Wilson, and Mr. A. H. Allen, of water from the Southcar borehole :—

Appearance	Clear.
Hardness	20·2 degrees.
Chlorine...	220·0 parts per million.
Nitrates	None.
Total solid residue	670·0 parts per million.
Loss on ignition...	150·0 ,,
Free ammonia	0·158 ,,
Albuminoid ammonia	0·010 ,,
Oxygen consumed in two hours at 100° Cent.	1·57 ,,

A meeting was also held at the Angel Hotel, Doncaster, Mr. John Nevin in the chair.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. JAMES BARRACLOUGH, Mechanical Engineer, 29, Raglan Street, Halifax.
Mr. FRANK F. FORSYTH, Mining Engineer, Kippax Colliery, Leeds.
Mr. HENRY ARTHUR PRINGLE, Mining Engineer, Norseman, Western Australia.
Mr. CHAS. WALKER, Mechanical Engineer, Grimethorpe, Barnsley.

ASSOCIATE—

Mr. JOHN ROBINSON RICHARDSON, Colliery Deputy, 18, The Crescent, Micklefield.

STUDENT—

Mr. THOS. PERCY NICHOLSON, Mining Student, Sharon, Rotherham.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD IN UNIVERSITY COLLEGE, NOTTINGHAM, OCTOBER 17TH, 1896.

MR. M. H. MILLS, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected:—

MEMBERS—

Mr. BENJAMIN PHERSON EKBERG, Mining Engineer, Doveton Street, Ballarat, Victoria.

Mr. DAVID LLEWELLYN EVANS, Mining Engineer, 5, Bute Crescent, Cardiff.

Mr. WILLIAM EATON WALKER, Colliery Manager, Manners Colliery, Ilkeston.

ASSOCIATES—

Mr. ARTHUR FISHER, Colliery Deputy, Fern Cottage, Staincross, Barnsley.

Mr. JAMES TRUMAN, Under Manager, Cadley Hill Colliery, Burton-upon-Trent.

STUDENTS—

Mr. CRICHTON WILLIAM MABEY FAWCUS, Student of Mining Engineering, Camborne Mining School, Cornwall.

Mr. WESTON APLIN SAUNDERS, Student of Mining Engineering, Camborne Mining School, Cornwall.

DISCUSSION UPON MR. GEORGE FOWLER'S PAPER, "HOW A MINE MAY BE DRY BUT NOT DUSTY."*

Mr. HENRY LEWIS (Annesley) said that Mr. Fowler had laid great stress upon the pit-waggons having fast ends; but he knew from experience, in the Leen valley, that such an alteration would be detrimental to the interests of the colliery owners. He would like to know the height of the pit-tubs from the rails to the top of the tub, and from the top of the tub to the roof in the stalls.

Mr. H. R. HEWITT (Derby) said that the title of Mr. Fowler's paper was somewhat misleading, as even after the elaborate plastering to which

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* *Trans. Fed. Inst.*, vol. xi., page 128; and vol. xii., page 98.

the length of road had been subjected, there must still be some dust in the atmosphere and on the floor. The mine itself was not exceedingly dusty, as there was only a thickness of 1 inch upon the roof-timber after the road had been driven and used for forty years, but the dust in this position must be an ever varying quantity, changing according to various circumstances. Closed trams were certainly preferable to open-ended ones, but they did not appear to be used at any mine, unless all coal and slack were loaded together, and the open-ended tub appeared to be a necessity where coal only was sent out. The high velocity of modern air-currents was responsible for the accumulation of some of the most dangerous dusts, but it would not be such a powerful factor if all coal were brought to the shaft by the slow-running endless-rope, instead of by the high speed of the main-and-tail rope. Mr. Fowler was fortunate in having no horses in his mine, and his method of putting a dry polish on the roof, sides, and floor of the main roadways was not one which could be generally applied. In fact, he thought it could not be successfully applied at more than half-a-dozen collieries in the Midland mines inspection district.

In the case of a permanent road like the one described by Mr Fowler, it did not matter how dusty it was, because no shot-firing was required to maintain the road in good condition. But where shot-firing was practised, even if all the precautions suggested by Mr. Fowler were adopted—except, of course, the permanent condition of roof and sides—then the use of blasting-powder should be strictly prohibited, and some high explosive should be used, and that only under proper supervision. By the introduction of high explosives, the number of shots fired had been greatly reduced, partly because the trouble attending shot-firing had been slightly increased, but principally because the use of blasting-powder had been abused, and therefore more manual labour was now exercised.

The watering of the roads was desirable for sanitary purposes, and he often noticed that workmen looked far healthier in a wet mine than those in a mine which was dry and dusty. He did not think that spray-jets, properly used, would give the workmen any disease; and, in opposition to Mr. Fowler, he thought that the health-conditions of mining in dry and dusty mines would be improved by their proper use.

Mr. T. A. **Southern** (Derby) observed that when he read Mr. Fowler's paper he did not understand him to suggest that what had been done in his colliery could be done so thoroughly in all collieries, for, of course, they all knew the great difference of conditions in different mines. At the same time, he thought that Mr. Fowler's paper was very useful, if only for the reason that it demonstrated clearly that in the first place, at any rate, everything that could be done ought to be done in driving the roads and timbering them to make the roof and sides as smooth as possible. By the Coal Mines Regulation Act, ever since 1887, they were required in certain cases, where a shot was fired on a main haulage-road, and the place was dry and dusty, to water the roof and sides within a radius of 60 feet of the shot-hole. He was curious to know whether any really effective or adequate measures had been taken for carrying out that enactment at any colliery where watering-appliances were not provided on main haulage-roads; that was, where they had not provided pipes and jets. He wondered whether it would be practicable where a colliery manager had a long length of main haulage-road to go through with a ripping, that instead of putting down pipes and jets he should utilize during the shot-firing operations some convenient form of portable fire-engine, because this seemed to him to be the only way, without a regular water-supply in pipes, to carry out this regulation of the Coal Mines Regulation Act in its entirety. So far as open-ended trams were concerned, the members would recognize that in a very low seam where they were in use, it would be a matter of some expense and difficulty to dispense with them, but there could be a medium between the two, because it was possible to use either an open-ended tram with a loose door to close the end when the tram was full; or a tram with the end half open, having only a bottom-deal half the height of the box, the upper half being open, and capable of being closed by a slide-deal. Both of these designs were in use at a few collieries.

Mr. A. S. Douglas (Hucknall Torkard) said that a short time ago, at one of his collieries, open-ended tubs had alone been used. All these had since been closed, and he had adopted the revolving-tippler recommended by Mr. Fowler. The practical result of this alteration was, that they had done away with several road-cleaners, and the dust upon the main roads was visibly decreased, while the percentage of round coal was by no means diminished. Where a seam would allow box-ended trams to be used, they were certainly preferable to open-ended ones. Where slack had to be loaded, as he presumed it had to be in most of the Leen valley collieries, it could not be loaded in open-ended trams.

Mr. H. Lewis said that he had been in the Leen valley twenty-eight years working the same coal-seam, and he said, without much fear of contradiction, that if they had box-ended trams they would make something like 20 per cent. more small coal than with open-ended ones. With very large lumps of coal, it would be impossible to lift them over the trams. When the loading was properly attended to, only a small quantity of dust was left on the roads. He was sure that it would be a very great mistake, indeed, for the collieries he represented to put in box-ended trams.

Mr. J. BAGNOLD SMITH (Newstead) remarked that he had a number of low stalls in a certain district of the pit, and for convenience he had reduced the height of his trams, leaving only 3 inches between the top of the tub and the roof, and it would not be possible to load anything but slack in this district into box-ended tubs. The roads were fairly clean. Some blasting had recently been made in a peculiar position, and he had used a portable fire-engine for watering the dust on the roof and sides. They brought the water to the place in tubs, but it was quickly absorbed by the bind.

Mr. T. A. SOUTHERN said that the members should bear in mind that Mr. Fowler's paper was not intended to apply only to flat collieries like those in the Leen valley. How could they use open-ended trams, if they had to pass over steep gradients, both uphill and downhill, on the way to the shaft.

Mr. GEORGE LEWIS (Derby) remarked that the discussion was rather drifting away from the subject of the paper, which was as to how a mine might be dry but not dusty. The loading of tubs was one of the points considered by Mr. Fowler as a means of decreasing the quantity of dust, but he thought that the discussion ought not to be confined to that subject. It could not be said that any particular kind of tub should be adopted at every colliery—at least he would not give Mr. Fowler the onus of making such a suggestion—or that all pit-tubs should be closed at the end, and he was sure they would like to hear what Mr. Fowler had to say before arriving at that conclusion. His experience was that both closed and open-ended tubs might be used with advantage, and the management should be more competent to say which was the most convenient for the situation. The dust on the roads, in his opinion, accumulated more rapidly where the tubs were drawn at a high rate of speed through the mine, rather than where they were drawn slowly. In these days, it was recognized that a tub of coal brought from the face to the pit's mouth should be, as far as possible, brought at a low rate of speed. The main haulage-roads were used as the intake airways, and when the current of air passing through the mine encountered the tubs its velocity was increased, and the current swept off the tubs every bit of dust during transit. He did not know what system of haulage Mr. Fowler adopted, but he supposed that it was a slow speed. He would himself prefer a close-ended tub, but where they had a tub 3 feet high and the seam very little, if any, higher, a difficulty presented itself as to the loading. He thought that Mr. Fowler's piece of road, which he had had specially prepared for this purpose, was a very good suggestion, but all these arrangements were, to a great extent, dependent upon the surrounding circumstances, and he was afraid that in many instances the system advocated could not be carried out. At the same time, it was obvious that, provided every crevice likely to contain an accumulation of dust could be previously filled, it was very desirable. How far this could be carried out in actual practice must be left for the future to determine. Their great object was to prevent, as far as possible, accumulations of dust on the roads; and, in his opinion, H.M. inspectors of mines had taken the right course in asking that certain arrangements should be carried out. It was the duty of the members to clear away the dust and to see that it did not exist, at least in such quantities as to become dangerous. Mr. Fowler had pointed out one way, but there were other ways that might possibly be equally serviceable, and for the present the alternatives could be left to the discretion of mining engineers.

Mr. Alfred Chambers (Eastwood) contended that on both sides of main roads all extra space from the rail to the sides of the roads should be built up with stone produced from the advanced road-making. Wide spaces were frequently the repositories of dust which the shovels of the road-cleaners but seldom touched, and such spaces at refuge-distances afforded no side protection to the refuge-recesses. A carefully-lined main road with hanging-walls inclined at a few degrees, the sides underpinned with a few courses of stone-work, and the interstices splashed with mortar, would, if executed as the road lengthened, prove in the end economical, as the constant use of the shovel in cleaning the road undermined unprotected sides, caused falls of side, and formed wide sections of road. The atmosphere of a dry mine, free from dust, was more healthy than that of a wet mine. He considered that originality and prevention were the leading features of Mr. Fowler's valuable paper.

Mr. George Fowler (Nottingham) said that he was extremely obliged to the members for the pains which they had taken in reading and discussing his paper. A short time before his paper was written, he read Mr. Haarmann's suggestions as to watering dust in German collieries.* He suggested a plan of watering, and produced figures in his paper to show what he had spent at a colliery in Germany in putting in water-pipes to prevent accumulation of dust, or rather to nullify and to free the roads of mines from this source of danger. His (Mr. Fowler's) paper was a response to that suggestion. His first thought on reading Mr. Haarmann's paper was that he did not like its suggestions; and he resolved to upset the water scheme, and to disprove the necessity for Mr. Haarmann's system. Whether the members approved of what he had proposed or not, he believed that in the future his suggestions would be adopted, and that in the mines of this country the main roads would be kept as clean as a factory, and that dust would be practically absent; certainly that it would not be tolerated to any dangerous extent. Mr. Haarmann stated that he had spent £10,000 to make arrangments for watering a mine, which, on the figures given, would be half the extent of Cinderhill colliery. The object of his (Mr. Fowler's) paper was to upset and abolish the watering-system, and he thought that he had substantially effected his intention; and if so, he was satisfied. He estimated that the carrying out of a watering scheme at Cinderhill colliery would cost £20,000 to £30,000; and to apply the system in all the collieries in which he was concerned it would have taken £100,000.

Mr. Henry Lewis had raised a point as to the effect of working collieries with close-ended tubs. Mr. Lewis and he were neighbours and old friends, and he did not think that their seams varied much. The conditions as to the height of the seam were very much alike; and when he first took charge of Cinderhill colliery, 25 years ago, open-ended tubs were in use at that colliery. He found that they had in consequence most dreadfully dirty roads, and he decided to effect amendment by closing the ends of the tubs. The tubs were 2½ or 2¾ feet in height. After he had introduced the closed tubs, a suggestion was made as to whether the close-ended waggons did not produce an increased proportion of slack. He experimentally had some tubs made with closed ends and others with open ends, and two stalls were worked with the close-ended tubs one week and the open-ended another. The coal was sorted by itself, and he found that the effect upon the production of slack was absolutely *nil*. The first thing a loader did with an open-ended waggon was to place big

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* "Description of the Arrangements at the Maybach Colliery (Germany) for Watering Coal-dust," by Mr. C. Haarmann, *Trans. Fed. Inst.*, vol. ix., page 90.

pieces of coal at the open end, so as to block it up, and then he threw the other coal over the side. If Mr. Lewis were to take off the top bar of the trams and place it at the end, he would get over the difficulty of the top of his trams being so near the roof. He was working the same seam of coal, which averaged 4 feet 6 inches in height, and there were stalls as low as 4 feet, or even lower.

Mr. H. LEWIS said that some were only 3 feet in the Leen valley.

Mr. FOWLER, continuing, said that he did not think there was any real difficulty about the use of closed tubs; and with low-sided waggons, or in a very low seam, by the use of a half instead of a whole end, much scattering of dust might be avoided. Recently, he was on a colliery bank where open-ended tubs were in use, and he noticed that bits of board had been used by the workmen to make temporary ends for the tubs. Therefore, he concluded, and he firmly believed, that the workmen preferred close-ended tubs; and if these were used in high seams, and half-ended tubs in low seams, it would stop the scattering of dust.

The Welsh skeleton-trams had bar sides and bar bottoms, and the whole arrangement seemed in the nature of travelling-screens, arranged to spread small coal on the roads from the face to the pit-bottom. He had recently heard a description given by a miner from this district who had been down a Welsh mine. He said that "he waded ankle-deep through dust, and he occasionally came across water squirts that wet him through." He (Mr. Fowler) thought that the scattering of coal from the trams was the cause of the roads being so dusty. He (Mr. Fowler) ventured to say that the adoption of close-ended trams at Cinderhill colliery was one reason why it was so free from dust, and Mr. Douglas had confirmed his statements as to the use of open-ended trams.

Mr. George Lewis very properly said that, after all, the details of tubs did not cover the whole question, which was really a financial one. If members would study his paper, they would see that finance was not forgotten in it, indeed it might be urged that it was too prominent. He would, however, like to say, in the first place, that the smoothing of the road at Cinderhill colliery cost exactly half the amount he had put down in his paper.

The intention of his paper was to show that dust was dangerous on main roads, and that if the members liked to make their main roads smooth and non-dust collecting it was not very expensive to do so. He would also remind the members that short belts of roadway dealt with in this manner would prevent an explosion from travelling beyond the belt.

He therefore suggested, although many persons were at present disposed to pin their faith on the safety of high explosives, believing there was no fear that these would ignite dust, that it might be wise to make certain belts or sections of roads smooth, and keep them free from dust, so as to prevent explosions from spreading. Mr. Chambers' remarks on this head seemed very much to the point.

At a previous meeting, Mr. Stokes had taken the line that the conditions at Cinderhill colliery were exceptionally favourable; but he ventured to disagree with those remarks. In the Midland mines inspection district, he believed that he was right in stating that nearly one-half, or let it be said one-third, of the coal was raised out of the top hard coal-seam. The conditions at Cinderhill colliery as to roof and floor, were in no respect different from those occurring in all top hard mines from Nottingham to Worksop. If he might express an opinion, he would rather work any top hard coal-seam than that which he worked at Cinderhill colliery. Considerable difficulties had occurred owing to faults, the main roads were much lengthened thereby, and it happened that they were working the coal from several royalties, which very much affected the simplicity of the laying-out of the mine; but for this and the former reason, the distance of 3 or 4 miles of road mentioned in the paper would have only been 2 or 3 miles. The conditions were about the same in the deep hard, deep soft, and low main seams as in the top hard coal-seam; and the only roads at all troublesome to maintain were in the blackshale coal-seam; but the difficulty was not very great, as the roof was good, and only the floor lifted.

If his paper impressed the members with the importance of keeping main roads free from dust, and the ease (as testified by Mr. Chambers and Mr. Douglas) with which it could be done, he thought that the propagation of explosions by dusty roads would cease to be a danger in mining operations.

The President said that Mr. Fowler's paper would prove of material value in all coal-mining districts. There were collieries where the suggestions could be made use of with advantage, and there were, perhaps, collieries where they could not be applied. He considered that the paper was a most valuable one, more especially owing to the discussion which it had provoked.

DISCUSSION UPON DR. J. HALDANE'S PAPER ON "THE CAUSES OF DEATH IN COLLIERY EXPLOSIONS."*

The PRESIDENT remarked that one of the many interesting points in Dr. Haldane's paper was that showing the proportion of bodies that were burned in an explosion to those who were neither burned nor injured. It appeared that in three colliery explosions investigated by Dr. Haldane, and immediately after which he had personally attended, the average percentage of bodies not injured was 77, showing that these unfortunate men might have escaped but for the after-damp. It appeared generally that the actual cause of death was the carbon monoxide in the after-damp, and Dr. Haldane explained that the inhalation of oxygen was the best treatment for a patient suffering from the effects of this gas. He thought that Dr. Haldane's recommendations should be taught at ambulance lectures, and that his paper should be in the hands of all lecturers who were conducting ambulance-classes.

Dr. JOSIAH COURT (Staveley) said that Dr. Haldane seemed to think that burns were slight even in cases of serious colliery-explosions. The statement was true in the case of bodies found at a distance from the origin of the explosion, but there was nothing that caused more severe burns to a man who was close to the place of ignition than an explosion of gas. Very often the burning was so severe that large areas of the skin and flesh were deeply charred, while at a greater distance from the explosion a man would not suffer so severely. The essential point, however, was that a man might receive a very deep burn which would not cause loss of life, while a superficial burn covering an extensive area would prove fatal by destroying the functions of the skin.

He thought that Dr. Haldane had shown conclusively that carbon monoxide in the after-damp was the source of the mischief, owing to its curious combination with the red colouring-matter of the blood. Carbon monoxide was an anæsthetic, like chloroform or ether, as well as a poison, and produced insensibility; one was a gas and the others were chemical compounds; but when they saw the results of their administration, all and each had some things in common. The application of chloroform would produce head symptoms, excitement, and sickness, apart from causing insensibility; and carbon monoxide would also cause headache, dizziness, and paralysis of the legs. If chloroform was taken in excess, death ensued from stoppage of respiration and heart-failure. Ether

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* *Trans. Fed. Inst.*, vol. xi., pages 502, 519, and 559; and vol. xii., pages 60, 102, 432, and 453.

frequently produced great nervous disturbance, vomiting, and extreme cold, the temperature of the body being greatly reduced. This fact might account for Dr. Haldane's statement as to why men—brought out of a pit suffering from a large dose of carbon monoxide—died on reaching the fresh air. Dr. Haldane pointed out that "when a man who has absorbed much carbon monoxide reaches cooler and fresher air again he very often gets much worse, and may lose consciousness."* It was naturally thought that when sufferers met with pure air they should at once recover. If exposed long to its influence, a man might die some time after carbon monoxide had left the blood, which showed that driving the carbon monoxide out of the lungs was not sufficient. The sufferer had to overcome the toxic action of the carbon monoxide, *per se*, upon the great nerve-centres. Possibly an explanation of men getting worse might be that the cold air diminished the vitality to such a degree that the poison meeting with less resistance became fatal to the man. After prolonged insensibility from ether, the body was very cold and the pulse feeble, and although sensibility might have returned, the mind was often not at all clear. The expulsion, as it were, of carbon monoxide by oxygen would not be enough, and although the giving to the patient of oxygen was the first and most important step, warmth to the body, with absolute quiet and nourishment carefully given by the stomach and bowels, should be persevered with. The patient must be treated very cautiously, and with perseverance, over a long period of time after the first effects of the gas had been overcome, and although Dr. Haldane's remedy, oxygen, should be used, the other means of restoring health must not be forgotten. It should always be remembered that beyond the blocking up of the lungs by this gas, the toxic action, the poisoning, had to be dealt with. Thus there were two causes, and one must not be lost sight of through the other.

Dr. Haldane suggested that cylinders of oxygen should be taken into the mine to the injured men, and—theoretically, of course—this was the proper thing to do. He bowed to the greater experience of members in these matters; but he thought that they would agree with him, if this oxygen was carried into the pit, it would have to be in a very much more portable form than in the way it was used, say, for an optical lantern. There would be great difficulty in carrying the cylinders, after an explosion, when the roof had fallen, and there were obstacles in many places. He agreed generally with Mr. Stokes' opinion, that the first endeavour of

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* *Trans. Fed. Inst.*, vol. xi., page 506.

explorers, as practical men, should be to get the injured men out of the foul and into the fresh air: it was desirable in the presence of carbon dioxide, but with carbon monoxide something else was wanted. The explorers who went in and bravely risked their lives to save their fellow-men required a purified atmosphere, and something to drive away the carbon monoxide, and if they were provided with some portable form of oxygen apparatus, so that while attending to the patients they themselves might breathe a better atmosphere, it would be an enormous advantage. The members should, however, remember that oxygen used in a careless way after an explosion might cause another one: the well-known properties of fire-damp and its great affinity for oxygen might result in an explosion should a blower of fire-damp issue somewhere through a fall of roof. The President (Mr. M. H. Mills) was of opinion that there were cases where life might be saved if artificial respiration could be at once applied; but, seeing that the majority of men died from carbon monoxide poisoning, that men could live much longer in carbon dioxide, and that there was always a certain amount of fresh air in the pit, it was obvious that the most urgent need was oxygen, and if this gas could be conveyed in portable cylinders by the explorers, it would benefit not only the sufferers, but also enable the rescuers to do their work and defy their enemy.

He suggested with great diffidence to the members, that in every large mining-centre life-saving stations should be formed, where bands of expert miners might be trained in the knowledge of ambulance-work, artificial respiration, etc., and especially in the use and administration of oxygen in portable tubes, so that they could start at a moment's warning to the scene of a mining disaster.

One thing had struck him as very curious, and that was that after an explosion, the majority of the miners rushed into the worst and most fatal places, the intake airways. It seemed also clear that, if the men travelled along the return airways, which, as a rule, were not at first filled with after-damp, many of them might escape. At Renishaw Park colliery, where 26 men lost their lives, one man smelt the gas and came out by the return airways to the upcast shaft, but the others ran into the main intake airways and lost their lives. He was persuaded that a very small percentage of men working in a colliery knew their way out of the mine by the return airways, and this want of knowledge in the event of an accident, would be fatal to them. Of course, proper regulations forbade men during work from leaving their own districts and wandering about the pit, and this would perhaps account for their ignorance. The Coal

Mines Regulation Act provided that each mine must have two shafts or outlets, but if the men could not find their way to both of them, that part of the Act became a dead letter. He would suggest therefore that in each district of a mine some of the workmen should be instructed how to find their way to the upcast shaft, and that boards or other means of direction should be placed so that the men could easily escape from danger. He was afraid that he could not advance the subject further than Dr. Haldane had done, because the question of carbon monoxide poisoning was in its infancy. The members, however, knew two guiding principles, and these were to get the men out of the pit as quickly as possible and to restore animation.

Mr. J. **BAGNOLD SMITH** (Newstead) said that if an oxygen-cylinder contained about 5 cubic feet of oxygen at a pressure of 500 to 1,000 lbs. per square inch, and the oxygen escaped, there was not much fear of anything happening unless the cylinder was dropped or otherwise injured. Since the explosions at Liverpool railway station and in London, the railway-companies now required that the cylinders should have mats placed round them. Large or small tubes were dangerous at any time if taken into a mine without such protection, as they would explode with a severe knock.

Mr. M. **DEACON** (Sheepbridge) remarked that most of the members knew, and he thought it only fair to tell Dr. Court, who had given them his experience from a scientific point of view, that it was the practice for the men to travel out of the mine by the return airways periodically, so that they would be able to find their way to the shaft in case of anything happening in the intake airways. This practice was generally adopted at the suggestion of the Home Secretary, and at the collieries under his charge the workmen were required to travel out by the return airways once a month, and he had had notices "This way to the return" placed at various points in the mine.

Mr. **JAMES ASHWORTH** (Chaddesden) said that Dr. Haldane had not only discussed the medical side of the question, but also the initiation, progress, mechanical effects, and the remedies to be applied. These different points were almost inseparable, and therefore it was not surprising that the opinions of medical men, mining engineers, and colliery officials did not accord in every detail. The members must recognize that Dr. Haldane had contributed most important information to the mining community. He had, however, without giving any proof, asserted that the pressure exerted by a colliery explosion was not excessive, and as a consequence had not materially influenced the death roll nor yet the mechanical damage done to the workings. It was, therefore, to that part of the subject—which, by the way, had not received much notice from students of coal-dust phenomena—that the following observations would be addressed. Dr. Haldane stated that :—

> The pressure during an explosion is probably not nearly so formidable as is sometimes assumed. So far as the writer is aware, there is nothing in a colliery explosion remotely resembling the detonation of, say, a mixture of hydrogen or fire-damp with pure oxygen, and the greater part of the energy liberated by the combustion must be rapidly taken up by the large excess of coal-dust, swept up by the blast.*

The effects produced by explosions in districts remote from the point of origin had at various times been attributed to one or other of the causes which Dr. Haldane did not accept, and with special reference to the question of pressure-effects, the explosion at the Udston colliery might be cited as having produced probably the best example. Messrs. Joseph Dickinson and C. C. Maconochie, in their *Report*, stated that "the pressure of air, both in the dook and Blantyre sections, had been so strong as to draw every shred of clothing off some of the bodies and to tear up tramroads there and elsewhere." Very few estimates of the pressure in pounds per square inch had been made, but Mr. A. L. Steavenson, on one occasion, estimated it at 200 lbs. per square inch, and Mr. W. E. Garforth and Mr. W. Galloway estimated it at Altofts colliery as being equal to moving the air at a speed of 100 miles per minute. Almost every explosion gave some distinct instances of force, which, if they were accurately recorded, might form the basis of a correct estimate of the force exerted. One of Dr Haldane's safety-recommendations, viz., that the doors on the main roads ought to be so strongly constructed that they would resist the force of an explosion, was based on the supposition that the pressure exerted by a colliery explosion was not formidable.

His (Mr. Ashworth's) previous observations had reference principally to the effects of pressure at points far distant from the place where such pressure originated. and it was now necessary to show what probably took place at the point of origin to create this pressure. If, therefore, it were assumed that the cause was a blown-out or overpowdered blasting-powder shot, its first effect was the projection of a very considerable volume of highly heated gas and dust into the roadway, and this, in its effort to expand and get rid of its heat, exerted the whole of its unused

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* *Trans. Fed. Inst.*, vol. xi., page 512.

force in violently pushing the ventilating-current both inbye and outbye. The first effect of this violence was to stir up the dust within the area of disturbance, and also to compress with great friction the dust which was already floating along and intimately mixed with the air-current. This compression and friction, coupled with the residual heat of the blasting-powder, occupied only a few seconds, during which period spontaneous combustion of the coal-dust occurred with the production of carbon monoxide, and this at once exploded or detonated before the pressure set up by the blown-out shot was exhausted. The length of roadway within which spontaneous combustion and the production of carbon monoxide gas took place was easily identified as being that in which little mechanical damage was done, and might measure as much as 200 feet on each side of the shot-hole. The time occupied in consummating this incubatory process might be roughly estimated by noticing what distance the men had run who were within the space named; thus, in some cases, the men have gone 15 feet outside the refuge-hole where they had been sheltering, but in no case had the distance exceeded, say, 50 feet. The stronger the air-current the shorter the distance run; thus, at Altofts and Albion collieries, the men had only just got clear out of the refuge-holes before being struck down. It was the explosion or detonation of this huge cartridge which devastated a mine, and its effects were so instantaneous that carbon monoxide gas was produced from the floating coal-dust by the pressure exerted, and carried the explosive flame over the intake airways with detonating speed. The pressure produced was most noticeably exerted on the narrow headings where there was the minimum length of air-cushion. Coking effects were largely caused by residual heat, and were found in maximum quantity where fire-damp was mixed with air, and in minimum quantity where the mine was free from fire-damp, but the quality of the coal also affected this result. It was, without doubt, the production of pressure, and the hindrance offered to its free expansion by the restricted size of the roadways, coupled with the velocities of modern air-currents, which was at the root of the universality of all modern colliery explosions. If an explosion originated on a main haulage roadway, the colliery with a ventilating air-current of high velocity was more susceptible to disaster than one having a low velocity, and the floating dust and that which settled on the top-timbers and the sides were the most dangerous.

Mr. H. R. HEWITT (Derby) observed that Dr. Haldane had made some remarkable statements regarding the various poisoning capabilities of certain gases in mines, to which he wished to draw attention.* When air contained only 5 or 6 per cent. of oxygen, death ensued after a period. With carbon dioxide, death ensued when the atmosphere contained 25 per cent. Carbon monoxide caused death in an atmosphere containing 1 per cent. only,† while one could breathe 50 per cent. of black-damp, containing 87 per cent. of nitrogen, 8·13 per cent. of carbonic acid, and also 30 or 40 per cent. of fire-damp.‡ It had been known for some time that carbon monoxide formed some portion of after-damp, but Dr. Haldane's researches had placed the members in full possession of the details, and he had shown that there was a larger percentage present than was anticipated. He thought, contrary to Dr. Haldane, that men in the track of the explosion must die from violence, not necessarily causing broken limbs and disfigurements, but causing shock to the system, due to air-compression. Death would not always be instantaneous, and then the victim would lie in the after-damp and show evident signs of having been asphixiated by carbon monoxide, The startling statement was made § that the removal of excess of dust and partial watering might increase rather than diminish the chances of a dust-explosion. Was this meant to imply that by doing this work, the finest and most dangerous dust was disturbed and allowed to mix with the air-current and become deposited elsewhere in the same roadway? It was also stated that the after-damp of Tylorstown colliery could have been produced by the explosion of only 0·10 per cent. of dust. These statements were of considerable moment and required to be carefully noted, as it was not necessary that the atmosphere should be heavily charged with dust before it was ripe for an explosion. They could not do much, he feared, to stop men who were not in the track of the explosion from rushing into the after-damp. It depended entirely upon the coolness and resource of the men themselves, and whether there was a capable leader amongst them. He thought that workmen in the Midland coal-field were fully acquainted with the return-airways, and he hoped that the custom would be always continued of bringing the men out of the mine by those airways at frequent intervals, so that they could always be acquainted with the second outlet. With regard to what Dr. Court said as to the men in the locality of Staveley not knowing the way out by the return-airways, he was surprised at that statement, because from his information men were

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* *The Causes of Death in Colliery Explosions and Underground Fires, with Special Reference to the Explosions at Tylorstown, Brancepeth, and Micklefield*, by Dr. John Haldane, pages 16 *et seq.*

† *Ibid.*, Table I., page 21. ‡ *Ibid.*, Table II., page 21. § *Ibid.*, page 25.

taken periodically through the returns, as stated by Mr. Deacon. He could not see the utility of placing light movable flaps in the fan-drift as a preventive against damage to the fan and drift. Timber was seldom used for supporting the fan-drift as Dr. Haldane seemed to imagine, and if the explosive force was sufficient to damage either the drift or the fan, light movable flaps would be blown to atoms; moreover, as many upcast-shafts were used for drawing coals, the suggestion as to a strong shaft-cover in such cases could not be carried out. He quite agreed that apparatus might be used for penetrating dangerous atmospheres, but the Fleuss was the only apparatus with which a lamp was supplied which burned without drawing in the outside air. In this apparatus, oxygen was supplied from a vessel carried on the back of the person wearing it, and the carbonic acid exhaled was absorbed by the use of sodium hydroxide or caustic soda. As colliery explosions were not of daily occurrence, they could not very well make their plans beforehand, and therefore what Dr. Haldane called "fatal delay" must ensue to a greater or less degree, but he should always acknowledge that Dr. Haldane had rendered mining engineers great assistance, from a scientific point of view, upon a difficult subject, by his clear elucidation of the matters brought to his notice.

Dr. W. B. Ransom (Nottingham) wrote that Dr. Haldane's proof that oxygen under pressure could drive carbon monoxide out of the blood, was a fact of very great importance. Cylinders of oxygen were now so widely used that he should have thought it possible to keep one ready for emergencies. Oxygen and artificial respiration persevered in for a long time were the best means of saving life in cases of poisoning by carbon monoxide. A small cylinder might also be useful, if carried with the mouse and men of a relief expedition.

Mr. W. N. Atkinson (Newcastle-under-Lyme) wrote that he had recently had an opportunity of making a practical test in a mine of the effects of carbon monoxide on a mouse. After an accident resulting in the death of the manager of the pit through a poisonous damp, given off from old goaves and abandoned workings in the No. 1 Rowhurst pit, Shelton colliery, a mouse was taken into the road on to which the damp issued, whilst he and others were engaged in taking samples of the atmosphere for analysis. The mouse was not watched during the whole of the time, but after about 10 minutes it was found to be lying on its side, panting, and evidently seriously affected by the poisonous gas. It was then taken into fresh air for a few minutes until it revived and appeared all right, after which it was again taken into the air containing the damp and left for 20 minutes, and when brought out it was dead. The observers were in the same atmosphere as that which killed the mouse, for about 20 minutes without feeling any serious effects, although it was obvious from a slight smell and the sensation produced, that the air contained some noxious ingredient. The burning of safety-lamps was not perceptibly altered. Analysis of the samples of air taken, made by Dr. Haldane, showed 0·17 per cent. of carbon monoxide at the place where the mouse was left for 10 minutes, and 0·16 per cent. at the place where it was left for 20 minutes. Dr. Haldane also found that the blood of the mouse was 72·50 per cent. saturated with carbon monoxide. Testing for carbon monoxide by a mouse was far from being an ideal method, but as it was the only known means (other than its effects on man) by which a dangerous percentage of this extremely poisonous gas could be detected in the mine, Dr. Haldane was to be congratulated on having brought it to the notice of members, who might avail themselves of it. In some cases, the test might afford valuable aid, because persons who saw a small animal overcome or killed, would be impressed by the fact, as indicating that there was really something very poisonous in the air, and would be more on their guard than if merely guided by their own sensations, and the absence of any warning from safety-lamps. He (Mr. Atkinson) thought that possibly the test might be more useful when gob-fires or other fires were being dealt with, than after explosions.

Dr. J. S. HALDANE wrote that he would like to take this opportunity of withdrawing a statement in his paper with regard to flames from burning oil having been seen near the pit-bottom after the Micklefield explosion by one of the survivors. The statement was based on what he understood the survivor in question, who was at the time still in bed suffering from burns, etc., to say. Probably, however, his memory was at the time somewhat affected, as Mr. Houfton (manager of the colliery) had written to say that he (the survivor) was now quite clear that there was no flame except that of the explosion itself.*

He thought that the custom mentioned by Messrs. Deacon and Hewitt of making all the men in a pit acquainted with the return airways might be the means of saving many lives in case of explosions or underground fires, particularly if the men were also informed that the after-damp of an explosion was formed on the haulage-roads, and that when it was met with the safest plan was usually to turn back.

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* *Trans. Fed. Inst.*, vol. xi., page 508.

According to Mr. Wardell's official report, the explosion at Micklefield did not reach the face at any point, and at two different points in the pit, horses were found quite uninjured near the face, although the men in the same districts were all found dead on the roads, where they had met the after-damp.

With regard to Mr. Ashworth's criticisms, he thought that they were in part due to a misconception of his (Dr. Haldane's) meaning. In pointing out in his paper that the injuries of the men and most of the damage to the pit in explosions were due, not directly to air-pressure, but to the momentum of the blast of air and dust, he did not wish to minimize the effects of an explosion. He thought it must be very evident that such effects as tearing off of the clothes, twisting of rails, etc., could not be produced by mere increase of air-pressure, however sudden. The pressure capable of being developed under the most favourable circumstances by an explosion of gas or dust and air was limited by the specific heat of the exploding mixture and by the heat capable of being developed by the union of the oxygen and combustible material present. Calculating from these data, he could not see how anything like the air-pressures quoted by Mr. Ashworth could actually occur. With regard to the mode of origin of an explosion from a blown-out shot, it appeared to him that the heat of combustion of any ordinary charge of explosive was quite inadequate to produce such effects over 200 feet of roadway as were postulated by Mr. Ashworth. He (Dr. Haldane) could see no reason for doubting the ordinary theory that in a dust-explosion the flame was simply propagated from particle to particle. With regard to the question of the possibility of propagation of an explosion by a wave of air-pressure, he would refer to Prof. Dixon's experiments quoted in the Report of the last Commission.

In conclusion, he hoped that this discussion and the differences of opinion expressed on various points of much practical importance might lead to experiments being conducted on a sufficiently large scale with a view to elucidating the phenomena of coal-dust explosions.

The further discussion was adjourned.

DISCUSSION UPON MR. WM. HOWE'S PAPER ON "LIFTING A VERTICAL RISING MAIN BY EXPANSION."*

Mr. H. R. HEWITT asked whether the method described by Mr. Howe had ever been tried by any one else, and with what result? It was a most serious matter to have a whole length of pipes suspended as Mr. Howe had described, and they were all pleased to hear that he had overcome a difficult matter successfully.

DISCUSSION UPON MR. A. GOBERT'S PAPER ON "THE GOBERT FREEZING PROCESS OF SHAFT-SINKING."†

The PRESIDENT said that some of the members had visited the North of France a few years ago to inspect the sinking of a shaft through water-bearing measures by the Poetsch freezing process. Mr. Gobert now brought before them an altogether new process of freezing the strata; and it appeared from his paper to be much more economical, and better suited to what would undoubtedly become a necessity in this district. There was no doubt that when pits were sunk further to the east of this coal-field they would have to pass through water-bearing measures, through which it would be very difficult to sink without making use of some such system as that which Mr. Gobert proposed.

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* *Trans. Fed. Inst.*, vol. xii., page 105.

† *Ibid.*, vol. xi., page 297.

DISCUSSION UPON MR. H. W. RAVENSHAW'S PAPER ON "PRECAUTIONS NECESSARY IN THE USE OF ELECTRICITY IN COAL-MINES." *

Mr. J. B. **Smith** drew attention to a danger existing in pits where electric signals were largely used. It was perfectly certain that an electric spark from these signal-wires would ignite gas, and he had given instructions if there was a sudden outburst of gas to switch all the batteries off.

Mr. H. R. **Hewitt** did not think that there was much fear of an occasional spark from bell-wires igniting gas, but it depended upon the pressure of the current.

Mr. J. B. **Smith** said that in chemical laboratories gas was regularly ignited in the eudiometer by the current from a couple of cells.

Mr. H. R. **Hewitt** thought that the danger of electricity in mines had been much exaggerated. Years ago, we were told that if electricity were introduced all sorts of accidents would happen, but they had not occurred. He believed that electricity would be much more commonly used underground than at present, and in particular that a system of portable electric lamps would shortly be introduced at most mines for the use of workmen.

Mr. J. B. **Smith** remarked that his experience of using electric lamps in collieries had not been satisfactory. The men at first said they would all like to use similar lamps, but when they felt the weight they said that "not for any money would they carry such a lamp." He, however, hoped that a lighter one would be introduced, as men could not be induced to use a lamp more than ½ pound heavier than the present oil-lamp. He did not think that the dangers of sparking had been overrated, and a current above 300 volts was in his opinion dangerous, on account of the shock that it gave to the system.

Mr. C. **Latham** (Nottingham) remarked that he had recently had placed in his hands a new portable miners' electric lamp of about two candle-power, weighing 3 lbs., and costing from 15s. to 20s., which would burn about 12 hours, and the cost of renewal was very small.

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* *Trans. Fed. Inst.*, vol. xi., page 306.

Mr. M. DEACON said that he had made comparative tests with ordinary Marsaut safety-lamps, and the Sussman electric-lamp, by means of a Letheby photometer. These tests showed that, with a clean wick, good oil, and a good reflector, the safety-lamp gave a light equivalent to the electric-lamp, viz., one candle-power, although the first impression was that the electric-lamp gave the more powerful light. In an electric-lamp, the radiation of the light was limited to the front and sides, whereas in the safety-lamp it was more or less diffused all round, which was advantageous to the miner from the point of safety. With regard to the safety of electricity in mines, the sparking of a motor, which was generally worked by high-voltage currents, was perhaps the greatest source of danger, as they sometimes got short-circuiting, causing violent flashing. This difficulty, which was one of the most serious mining engineers had to overcome, might be avoided by using the Stokes-Davis inverted motor; the chief difference between it and the ordinary motor being that the commutator-plates were placed on the inside of the motor, which was closed at the outer end by an ingeniously designed gas-tight joint, through which an explosive mixture could not pass. There was a point with regard to this motor upon which he required further experience, and that was as to whether the heat generated by a current of, say, 400 or 500 volts would cause short-circuiting by partial fusion of the commutator-plates. Whether that was so or not, its safety would not be affected, but the economical results would be seriously diminished. He had submitted such a motor to a severe test in a box containing an explosive mixture, the brushes being purposely set to cause violent flashing (which could be seen through a little talc window in the end of the motor) without igniting the gas, whilst a safety-lamp placed in the same box filled with flame and became extinguished.

Mr. ALFRED CHAMBERS thought that the ordinary safety-lamp had got a bad name through being left too long without cleaning. He believed that lamps should be cleaned at every half-shift. If a man used his lamp at the coal-face amongst dust and slack for a whole shift, he could not expect a good light to be produced.

The discussion was adjourned.

ALTERATION OF RULES.

The PRESIDENT moved, and Mr. H. LEWIS seconded, the following alteration of Article 1, Section VI., of the Rules, of which notice was given at the meeting held on April 4th, 1896, as recommended by the Council, to whom it was referred back at the Annual General Meeting, viz. :—

> There shall be three Ordinary General Meetings in each year, to be held in Chesterfield, unless elsewhere arranged for by the Council, in every April, August, and December, the meetings in April and December to be on the first Saturday in the month at 2·30 p.m., and the date of the meeting in August, which shall be the Annual General Meeting, to be fixed by the Council. Anything in the rules affected by the foregoing intended alteration to be adjusted accordingly.

The motion was carried.

The meeting was then closed.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE MASON COLLEGE, BIRMINGHAM, DECEMBER 3RD, 1896.

MR. R. S. WILLIAMSON, PRESIDENT, IN THE CHAIR.

The minutes of the last General and Council Meetings were read and confirmed.

The following gentleman was elected:—

STUDENT—
Mr. HERBERT EDWARD JACKSON, Camborne.

The SECRETARY read the following paper by Mr. Nicholas Trestrail on "The Duty of Cornish Pumping-engines, Past and Present, and as Compared with Others":—

THE DUTY OF CORNISH PUMPING-ENGINES, PAST AND PRESENT, AND AS COMPARED WITH OTHERS.

By NICHOLAS TRESTRAIL.

Since the Cornish pumping-engine had been somewhat perfected and its durability and economical working had been established, many engineers and engine-makers had tried to produce an engine of equal merit, and in trying to prove that this or that engine was superior to it all sorts of ingenious methods had been adopted. In some instances, the imagination had been considerably drawn upon, and purchasers of engines had been led away by a great deal of assumption. For instance, if a pumping-engine was erected and put under a scientific trial, a so-called duty was performed for a few hours only. This duty was then supposed to be established, and if after the engine had been working five years you were to ask the maker what duty it was doing, you would get for an answer "as performed at the trial;" whereas no such thing as duty had been considered since the trial had taken place. Those who had to pay the coal bill did not get any such results.

A great deal has been written lately as to the fallen duty of the Cornish pumping-engine, and voluntary engineering advice had been tendered to show what great improvements could be made. Some engineers suggested superheaters, others metallic packing, improved pistons, oils, fire-bars, blowers, fluids to take off scale inside the boilers, and a host of other things, each one in itself guaranteed to save a considerable quantity of fuel; most of these things had been tried, and the results were unsatisfactory.

The writer purposed dealing only in this paper with the pumping-engine, and in order to put the matter in a clear manner he would draw comparisons. By so doing, he would not for one moment disparage scientific research, his object being to invite engine-owners to adopt some standard system of independent reporting of the results, so that fair comparisons could be made between pumping-engines working under normal conditions from month to month, or year to year. Such comparisons would tend to save fuel and enlighten engine-owners and engineers as to what class of pumping-engine should be selected for any required purpose.

To fully consider this important question the writer thought that he ought to trace the duty of the Cornish pumping-engine from an early date to the present time. By so doing, we shall see where we are as compared with times past; and he hoped to show that the so-called low duty, as now reported, was more imaginary than real.

In the year 1811, engine-reporting began in the mines of Cornwall, and three engines were reported with an average duty of 20,000,000 foot-pounds per bushel (94 lbs.) of coal. The number of engines reported rapidly increased, and so marked a difference was shown in the reported duty that engineers strained every nerve to do something better than their neighbours, and engines gradually improved.

In the latter part of 1814, Mr. Woolf (a Cornishman, who had just returned from London, where he had made great improvements on the Hornblower two-cylinder engine) erected a compound engine on Wheal Abraham mine to work with what was called high-pressure steam in those days. This engine did a duty of 52,000,000 foot-pounds.

The high duty performed by the Woolf pumping-engine showed other engineers what advantage could be gained by working steam at a higher pressure and expansively. They then began to work steam at higher pressures also, and, with a slight alteration, got the best of their simple engines to supersede the Woolf compound engine, which after a while became troublesome and fell below the average duty of the best simple engines; in 1820 it was practically discarded.

The average duty reached 28,000,000 foot-pounds in 1820. From that time, nothing special occurred until 1825, when Mr. Grose made experiments on the generation and preservation of heat by covering all exposed steam-surfaces with a non-conducting material; and an engine with these improvements was erected at Wheal Towan mine in 1827, which reached the high duty of 62,000,000 foot-pounds, and in the following year 87,000,000 foot-pounds. This simple and inexpensive improvement put engineers again on their mettle, they quickly adopted Mr. Grose's ideas, and in 1828, the average duty reached 37,000,000 foot-pounds—a general increase, due to Mr. Grose, of 9,000,000 foot-pounds.

By the improvements now established, a desperate effort was put forth as to who could do the highest duty, and in 1834 the celebrated Austen 80 inches cylinder engine at Fowey Consols, erected by Mr. West, astonished the world, the first duty reported for the month of July being 90,000,000 foot-pounds, and for September 97,000,000 foot-pounds.

This extraordinary performance caused a doubt in the minds of other engineers, and a committee was appointed to conduct a trial of the engine on October 22nd. At the commencement of the trial, the coal was weighed, put in the coal-shed and the doors locked and sealed. There were two counters fixed on the engine, one belonging to the committee and the other to Mr. Lean, the reporter; the counters were carefully read, locked, and sealed. At the end of the trial, which lasted 24 hours 27 minutes, everything was carefully noted, and when the counters were unlocked the committee's registered 6,947 and Mr. Lean's 6,287 strokes respectively; showing a difference of 660 strokes. However, no special remark was recorded about the variation in the counters, and the engine was reported to have done 125,000,000 foot-pounds, reckoned on the basis of a bushel of coal supposed to be 94 lbs. That was equal to 149,000,000 foot-pounds on the basis of 112 lbs. of coal as reckoned at the present time, or 1·49 lbs. of coal per hour per pump horse-power, and allowing 15 per cent. as a fair average for efficiency, the consumption of coal per horse-power would be about 1·3 lbs. per hour.

The duty, strange to say, in November, 1834, only reached 88,000,000 foot-pounds, but for the whole of 1835, the average was 91,500,000 foot-pounds. The average for all the reported engines in the same year was 47,800,000 foot-pounds. The duty of this engine gradually diminished, and in 1839 the average duty was about 84,000,000 foot-pounds.

In 1839, a meeting of the Miners' Society was held at Redruth, and a wish was expressed that the duty might be calculated on a stroke measured by a plegometer instead of the method of ascertaining the number of strokes by a counter. Such an instrument was attached to the Loam pumping-engine at the United mines, and after a four months' trial the average duty as shown by the counter was 61,700,000 foot-pounds, and by the plegometer 60,200,000 foot-pounds, a difference of about 2½ per cent.

In 1840, the compound principle of pumping-engine was revived again by Mr. Sims erecting an engine with a 60 inches high-pressure, and a 90 inches low-pressure cylinder, on the Carn Brea mine. This year also the celebrated Taylor 85 inches cylinder pumping-engine of 11 feet stroke in the cylinder and 10 feet in the shaft was erected by Messrs. Hocking and Loam at the United mines, and began with a good duty, but in 1842 the average for all the year was 99,700,000 foot-pounds, one month reaching 107,480,000 foot-pounds. The load on the engine was 12 lbs. per square inch, 5¼ strokes per minute, and the boiler-pressure about

50 lbs. per square inch. The steam on the piston was cut off at 0·10 of the stroke. The shaft or pit was perpendicular, 1,170 feet deep, divided into 7 lifts, there were two balance-bobs underground and two at the surface, and owing to the number of balances at this depth no doubt great care was taken in balancing the rods. This pumping-engine did a better consecutive duty than any ever reported, and if the average duty be taken at 99,700,000 foot-pounds, and reckoned on the same basis as for Fowey Consols, the coal-consumption per pump horse-power per hour would be 1·87 lbs., or 1·62 lbs. per indicated horse-power per hour, and considering that this was for a 12 months' run, and not 24 hours only, it must be considered a very good performance.

Although Messrs. Hocking and Loam got a great duty out of the Taylor engine, two other 85 inches cylinder engines on the same mines only produced an average duty of about 65,000,000 foot-pounds, so that even in those days there was a marked difference in point of economy between engines of the same size and under control of the same engineers. This remark also applied to other engineers, as some engines under their control did a good duty while others only did a moderate duty.

The Sims compound pumping-engine during the year 1840, did an average duty of 90,000,000 foot-pounds, and although great rivalry existed between Messrs. Hocking and Loam with the Taylor engine, and Mr Sims with the Carn Brea compound (which engine showed the best duty of any compound pumping-engine reported) the Taylor always showed 10 per cent. better duty than the compound pumping-engine. The highest duty ever recorded for one month with the compound engine was 95,000,000 foot-pounds.

In 1843, the Taylor engine again did a very high duty, averaging 99,000,000 foot-pounds for the year, the highest month being 105,000,000 foot-pounds, whilst the Sims compound engine had fallen to 87,000,000 foot-pounds. This year was the highest average of any year recorded, showing 57,000,000 foot-pounds, and the highest monthly average ever recorded was 60,000,000 foot-pounds for December.

Although the Taylor engine did splendid performances for 1841, 1842, 1843, and 1844, averaging 97,500,000 foot-pounds, the best six engines during the same period averaged only 75,000,000 foot-pounds; so that for the four years the Taylor did 23½ per cent. better than six of the best engines. From this time, the duty of the best engines began to diminish, being worked almost to breaking strain, and the engines and pit-work not having been made heavy enough to stand the strain of such high expansive working, the duty naturally fell away; but although the better duties diminished, the lower ones gradually improved, so that the average duty kept about the same.

In 1847, the Taylor engine had fallen to 87,000,000 foot-pounds, and the best six engines averaged only 63,000,000 foot-pounds. For some reason or other for May, 1847, the duty was reported for the first time in two columns, one representing that done by the bushel and the other showing the equivalent when computed by the cwt. of coal.

The year 1847 was somewhat remarkable in engine-reporting, as the writer finds that in 1845 Mr. West's engines, including that at the Fowey Consols mine, had fallen below the best, and he withdrew all his engines from *Lean's Reporter*.

In January, 1847, the first *Monthly Cornish Engine Reporter* appeared in opposition to *Lean's Reporter*, and was published by Mr. Browne, of St. Austell. This reporter was almost monopolized by the West pumping-engines, and in carefully looking over one of the issues the writer is of opinion that the gentleman responsible for its production was very compliant, as members may judge from the following extract:—

> Where the steam-pipes and boilers are left uncovered for the purpose of drying the men's clothes, the following deductions are made from the actual consumption of coals:—

Engines working under 2 strokes per minute	1-7th.
,, ,, 2 and under 3 strokes per minute	1-8th.
,, ,, 3 and under 5 strokes per minute	1-9th.
,, ,, above 5 strokes per minute	1-10th.

Whatever allowances were made, the writer finds that Mr. West's engines rapidly increased in duty on the issue of this new reporter, and no doubt the calculations for allowances were made very minutely for the varying number of strokes, but no data was given as to the mode of arriving at these deductions. The *Monthly Cornish Engine Reporter* did not find much favour, and the publisher and the publication long ago ceased to exist.

The high duty of some of the best engines as reported by Mr. Lean gradually declined, so that in 1851 the celebrated Taylor engine fell to 62,000,000 foot-pounds and ceased to be reported.

In 1853, the Sims compound pumping-engine at Carn Brea mine fell to 42,000,000 foot-pounds. At this time, a new Sims compound pumping-engine was erected at the Perran St. George mine, with a high-pressure cylinder 60 inches in diameter and a low-pressure cylinder 100 inches in diameter, and a stroke of 9 feet in the cylinder and of 8 feet in the shaft; but this engine did very badly as compared with the Carn Brea engine, the highest duty recorded being 64,000,000 foot-pounds.

In 1854-5, the average duty of six of the best engines was 60,000,000 foot-pounds, and the average of the whole, 45,500,000 foot-pounds.

1856 was another important year, as in July the bushel of 94 pounds was discarded and the cwt. adopted as a standard. This great change did not affect the average duty, and from that time to the present the average duty of the best and the average duty of the whole has been just the same.

How much reliance can be placed on the weight of a bushel of coals that was measured, and supposed to weigh 94 lbs. the writer can hardly say. In 1838, he finds that Mr. Wicksteed was requested by the council of the Institution of Civil Engineers to obtain information as to the weight of coal adopted in this county, and Mr Nicholas Harvey, then a well-known engineer, said that "a bushel of Welsh coals varied from 80 lbs. to 112 lbs.," and a foot-note in Mr. Wicksteed's paper states:—"This statement shows how little reliance can be placed upon results of trials where coal is measured and not weighed. If the measure is large enough to hold 112 lbs. of coal, it should no longer be denominated a bushel." However, if the measured bushel contained 112 lbs. of coal previous to 1856, taking the number of engines reported and the conditions under which some of them worked, it must be considered even by the most prejudiced engineer that good work was done.

In scanning *Lean's Reporter*, the writer finds some rather curious statements respecting the performances of a few engines; for instance, a 70 inches cylinder engine in 1864, at the Crane mine, varied 21,000,000 foot-pounds throughout the year; the Tilley 70 inches cylinder engine, at Wheal Seton mine, 20,000,000 foot-pounds in 1865; Unity Wood 70 inches cylinder engine 24,000,000 foot-pounds in 1876; Tregurtha Downs 80 inches cylinder engine 23,000,000 foot-pounds in 1887; East Pool 70 inches cylinder engine 21,000,000 foot-pounds in 1891; the Goolds 80 inches cylinder engine at Wheal Grenville, 29,000,000 foot-pounds in 1893; but the most astonishing results were recorded for the Thomas 60 inches cylinder engine at West Basset, which varied during 1895 from 61,000,000 foot-pounds, the highest, to 28,000,000 foot-pounds, the lowest. This result, in the writer's opinion, went to show that the performances of engines could not be fairly compared, unless the quality of the fuel was tested at the same time, because there was no reasonable cause for such great fluctuations taking place. In fact, the Thomas engine at the West Basset mine being under the writer's control, he can confidently say that if ample allowance be made for the varying number of strokes per minute, this great fluctuation of duty could not be accounted for in the general condition of the machinery.

Considering the very bad conditions under which most pumping-engines have to work at Cornish mines with the shafts very deep, and extremely crooked, the duty taken as a whole will, the writer ventures to say, be better, all things considered, than in any other mining district having an equal number of engines.

Mr Dugald Baird, in a paper read before the Mining Institute of Scotland, said—

> The question of extracting water from a mine is a most important one, and is becoming more important as mines get deeper and more difficult to drain. It is, therefore, of consequence that we should be well informed as to the best practice in pumping. When it is said that there are, to the writer's certain knowledge, many pumping-engines giving as low as 10,000,000 foot-pounds duty for every hundredweight of Welsh best coal, or coal of equal quality, consumed, no apology is required for introducing the subject of this paper.*

In the same paper, Mr. Baird gives a table showing a test of four engines as follows :—

(1) Bull engine, cylinders 100 inches in diameter, pumping from a depth of 900 feet, boiler-pressure 53 lbs. per square inch, duty 50,265,312 foot-pounds, and age of engine 18 years.

(2) Davey differential underground engine, pumping from a depth of 900 feet, boiler-pressure 53 lbs. per square inch, duty 41,360,000 foot-pounds, and age of engine 2 years.

(3) Davey differential compound engine, cylinders 33 and 52 inches in diameter, pumping from a depth of 600 feet, boiler-pressure 80 lbs. per square inch, duty 69,705,890 foot-pounds, and age of engine 8 years.

(4) Compound bull engine, cylinders 28 and 48 inches in diameter, pumping from a depth of 504 feet, boiler-pressure 77 lbs. per square inch, duty 35,827,200 foot-pounds, and age of engine 6 years.

The average duty of the four engines is therefore 49,290,000 foot-pounds per cwt. of coal. All the engines were marked good, but the tests lasted from four to six hours only. The feed-water passed into the boilers at temperatures of 130, 125, 118, and 140 degs. Fahr. respectively, and the duty was reckoned on an evaporative power for fuel of 10 lbs. of water per lb. of coal. This quality of fuel would be considered very good in Cornwall. The duty, as described by Mr. Baird, cannot be said to be even moderate, looking at the fact that the pits are comparatively shallow and vertical, and the engines practically new, except one.

Many attempts had been made to compare the duty of Cornish engines with those of another type, and very careful trials instituted to show their superiority over the Cornish ; but trials got up by engine-

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* *Trans. Fed. Inst.*, vol. xi., page 94.

makers to show extraordinary results obtained by a new engine were hardly a correct way to form a basis as to what the same engine would do when working under normal conditions. Before trials commenced, everything was put into perfect order; they lasted only for a few hours; great care and attention was paid by the experts employed to conduct the experiments, and their one object was to show a result not previously recorded, and which could only be kept up for a short space of time. The manner of stoking in particular was as perfect as could be. Mr. T. I. Bramwell, in a lecture on the steam-engine to science teachers at South Kensington, said:—

> With respect to the stoking on these trial occasions, the stoking is done by men, some of whom are paid several hundreds a year. It is done by a hand fire-shovel, more like a banker's scoop than an ordinary shovel; the coal is broken into bits about the size of a walnut, the fire-door is opened about once in every two minutes (which you will find very wrong, according to Mr. Tredgold, and so it would be if the men were not trained to do it by sleight of hand so dexterous that it is hardly possible to see the operation performed); and in that way there is kept up an absolute uniformity of combustion, a uniformity so great that, during the five hours which the trial sometime lasts, I will undertake to say that the pressure-gauge does not vary one-sixth of a pound. So accurate is the firing that whereas the engine would blow off with 80 lbs., and thus waste steam which would spoil all the competitors' chance, at 77½ lbs. the engine would not run against the weight; therefore, the stoker's margin of possible working in these engines lies within 2½ lbs. Such accuracy you cannot hope to attain in daily work.

The above remarks referred to trials on portable engines, and there was no doubt in the writer's mind that the system of stoking was well considered and carried out in pumping-engine trials. Take, for instance, a trial conducted at the West Middlesex Water-works on a vertical triple-expansion high duty pumping-engine, by Prof. Unwin. Everything being in readiness, the work began, and the gross weight of coal was 11,299 lbs. (less the cinders found at the end of the trial and reckoned as unburned coal, 82½ lbs.), showing that the coal used was 11,216½ lbs. The duty was calculated on this latter quantity of fuel.

In another instance (a trial by Mr. O. Chadwick of a compound high duty engine at West Middlesex) the trial lasted twenty-four hours, the gross weight of fuel consumed was 10,989 lbs.; and, after deducting ashes (232 lbs.), clinker (412 lbs.), or together 644lbs., the net fuel burned was 10,343 lbs. The gross coal per pump horse-power per hour was 2·03 lbs., the net fuel burned per pump horse-power per hour was 1·91 lbs., and the duty was 116,000,000 foot-pounds. This duty was again reckoned on the fuel after all waste had been deducted. If the duty had been reckoned on the quantity of fuel put in the fire, and no deductions made for worthless rubbish, such as ashes and clinkers, the duty would have been 109,000,000, or 6 per cent. less.

It may suit manufacturers to reckon duty from this point of view, but an engine-owner knows that ashes and clinker are not of the same value as coal when it is raked out of the furnace.

The fuel used in such trials is of selected quality, the amount of waste got by Prof. Unwin was only 2·2 per cent., and that by Mr. Chadwick 5·8 per cent. Mr. Chadwick stated that the coal was wet, and considering the large amount of ash it could not be said to have been of very excellent quality.

Another case records the result of a competitive trial of a new triple-expansion Worthington engine and pump against four Cornish engines and boilers at the Grand Junction Water-works. The Worthington engine was supplied with steam from a Babcock and Wilcox boiler at a pressure of 120 lbs. per square inch. The feed-water was passed from the hot-well at 100 degs. Fahr., through an economizer to the boiler at a temperature of 140 degs. Fahr. Attached to the boiler also was a Meldrum blower, the fuel used being a mixture of coke and breeze. The Cornish engines were supplied with steam from Cornish boilers at a pressure of 38 lbs. per square inch. The feed-water passed direct from the hot-well to the boilers at a temperature of 90 degs. Fahr. No economizer nor Meldrum blower were attached to these boilers. In a table published as a result of this competition, which lasted seven days, the duty of the Worthington pumping-engine averaged 82,500,000 foot-pounds, and that of the Cornish engines 71,400,000 foot-pounds. Looking at these figures, a novice would suppose that the Worthington was 13½ per cent. superior to the Cornish engines; but from a commonsense point of view, it would be seen that by the aid of the economizer the feed-water was raised from 100 to 140 degs. Fahr., resulting in a saving of fuel of 4½ per cent., thus reducing the supposed economy to 9 per cent., to say nothing of what is gained by the use of the Meldrum furnace.

Let us try an imaginary experiment for a moment on these engines, and take away the economizer from the Worthington engine. The duty would be 4½ per cent. less, or 78,800,000 foot-pounds. We will now attach the economizer to the Cornish boilers; the duty of the Cornish engines would thereupon be increased to 74,600,000 foot-pounds, and the difference in the two now would be 5·4 per cent. in favour of the Worthington engine with the Meldrum blower attached to the boiler of this engine. One very important matter was omitted in the published account of this competitive trial, that was, the age of the Cornish engines, which ranged from 20 to 45 years, and when this Worthington was 45 years old, it will be interesting to those who live long enough to see what original part of it was left, and how the duty then compared with the result at these trials.

The writer was indebted to Mr. Rich, the manager of the Rio Tinto mines, Spain, for furnishing him with a detailed account of a trial of a Cornish pumping-engine, a facsimile of one which the writer designed and erected on the Tincroft mines. Of course, the pump-arrangement was of a suitable design for their respective requirements. In the calculations, the ashes and clinker, amounting to 3·4 per cent., are not deducted; but if they were, the duty becomes 115,300,000 foot-pounds. There was no feed-heater or economizer. The duty was reckoned on the total vertical height of the pump, and not by a height corresponding to that indicated by a gauge on the pump. The trial was conducted by the officials and engineers on the mine, with the following results :—

Dimensions.—Cylinder, 70 inches in diameter and 10 feet stroke; air-pump, 34 inches in diameter and 4¾ feet stroke ; feed-pump, 7 inches in diameter and 2 feet 5½ inches stroke ; plunger, 35 inches in diameter and 9 feet stroke (the full stroke between catches being 9 feet 1¾ inches). The four-beat valves had a clear diameter through the seat of 36 inches. Valve-box passages were 36 inches in diameter. The pipes to air-vessel were 35 inches in diameter. Rising-main pipe was 24 inches in diameter, length from top valve to top of column was 441 feet 6 inches, and the vertical height from water-level to top of column was 196 feet. The boilers were 6 feet in diameter, 30 feet long, with tubes 3¾ feet in diameter, fitted with eight Galloway tubes; the fire-bars were 5½ feet long, and the grate-area was 21·1 square feet.

The following are the results of a trial made from October 27th to November 3rd, 1894 :—

Time of trial	168 hours.
Time actually working	167 hours 52 minutes.
Number of strokes	102,279.
Coal consumed	78,484·5 lbs.
Feed-water pumped	830,561·2 lbs.
Specific gravity of water	1·0466.
Steam-pressure, mean of gauges on boiler ...	64 lbs. per square inch.
Vacuum gauge, mean	27·82 lbs. per square inch.
Temperature of injection water	67 degs. Fahr.
Temperature of hot-well	112 degs. Fahr.
Temperature of feed-water	109 degs. Fahr.

Ashes and clinker, not deducted	2,712 lbs.
Mean strokes per minute	10·154.
Volume of water pumped per hour	1,027·0515 cubic metres.
Total work per stroke	761,461·4275 foot-pounds.
Total work during trial	77,881,513,343 foot-pounds.
Full capacity of stroke	103,907·88 cubic inches.
Net capacity of stroke, after deducting 1 per cent. of slip	102,868·8012 cubic inches.
Volume of 1 lb. of water (standard) ...	27·7123 cubic inches.
Weight of water lifted per stroke	3,885·0073 lbs.
Volume of cubic metre	61,027·0515 cubic inches.
Total volume lifted during trial	172,404·17 cubic metres.
Effective horse-power	234·317 horse-power.
Duty per cwt. of coal	111,139,518 foot-pounds.
Work per stroke, mean of 8 cards	941,375·5097 foot-pounds.
Total work during trial	96,282,943,756·606 foot pounds.
Total work during trial	289·658 horse-power.
Mechanical efficiency	80·88 per cent.
Coal burnt per hour	467·559 lbs.
Coal burnt per hour, per indicated horse-power	1·6141 lbs.
Coal burnt per hour, per effective horse-power	1·9954 lbs.
Feed-water evaporated per hour	4,947·91 lbs.
Feed-water evaporated per hour, per indicated horse-power	17·082 lbs.
Feed-water evaporated per hour, per effective horse-power	21·112 lbs.
Feed-water evaporated per lb. of coal ...	10·582 lbs.

From a diagram taken during the trial, the writer finds that the steam was cut off at slightly over one-fifth from the commencement of stroke, and reviewing the results of this trial with those already referred to, it is plain that this engine did most efficient duty.

There are several good engines in Cornwall not reported by Mr. Lean, and the writer will give particulars of two engines working under difficult circumstances, although doing a fair duty.

The Tincroft engine, with a cylinder 70 inches in diameter, was erected and set to work in December, 1890. It was connected to the old pit-work, but since then the greater part of the old has been replaced by new pit-work, and the remainder overhauled. The shaft is rather crooked, but not so bad as others in the district. The duty performed is 74,000,000 foot-pounds at 4·21 strokes per minute, the steam-pressure in boilers being 40 lbs. per square inch. Owing to some of the rods being old, and a long run of flat rods underground (which was not included in the duty) a high rate of expansion could not be accomplished, and the steam was cut off at 0·372 from the commencement of stroke.

The Carn Brea engine, with a cylinder 90 inches in diameter, was erected with new pump-work complete for 2,214 feet deep, and set to work in July, 1893. This shaft was also crooked, the duty was 62,000,000 foot-pounds at 2·6 strokes per minute, and the steam-pressure in boilers was 44 lbs. per square inch. The stroke was 10 feet, and steam was cut off at 0·233 from the commencement of stroke. No economizers or feed-water heaters were attached to the boilers of these engines. The quality of the fuel was good for the price, viz., 12s. 11d. per ton delivered on the mine, but naturally not of the high standard of the selected coals used for other experiments. The ashes and clinker averaged for the two engines was 11 per cent. of the coal consumed.

Engines are generally compared by the duty, but unless the quality and price of the fuel was also considered it did not give a correct idea, and to an engine-owner or company it did not matter much whether their engines showed a high duty to them, for the question was as to cost of the duty performed. It was possible with ample boiler-power to burn an inferior coal which would show a lesser duty, but it would be cheaper than a superior coal costing more money and showing a higher duty. In this way it was possible for a good engine to be working cheaper while showing less duty, than a moderate engine showing good duty at a greater cost per 1,000,000 foot-pounds and burning superior coal.

A case was pointed out by Mr. A. Fraser, in a paper read before the Society of Engineers, as follows :—

> The most probable cause for the seeming reduction in the rate of duty is the use of inferior coal, which is found to be more economical in proportion than fuel of the best quality, of course where the boilers and grate-surface are adapted for the purpose of slow combustion. This fact has been proved by experiment at the waterworks at Kew Bridge, where a 90 inches cylinder Cornish engine was lately worked for several days from 5 boilers, burning the best coal that could be procured, costing about 25s. per ton, when the duty performed was ascertained to be 105,000,000 foot-pounds, the average duty with small coal costing 10s. 9d. per ton (which is the fuel in ordinary use) being 62,000,000 to 65,000,000 foot-pounds. By using the inferior coal a saving of about 27 per cent. is effected.*

The writer finds that the caloric duty of coal does not proceed in a direct ratio with its cost, and this is an important fact.

Having traced the performances of the Cornish pumping-engine as reported from the commencement to the present time, and also drawn

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* *Transactions*, 1864, page 78.

fair comparisons with others, the writer submits that the superiority claimed for other pumping-engines is not established. He is also not aware of any other printed monthly statement issued by an independent medium except *Lean's Reporter*, and for years past engineers throughout the country have thought fit to take the duty as presented in this publication as a fair basis to judge what the engines in Cornwall were doing, and these gentlemen have not been backward in expressing their views rather strongly, but at the same time they very forcibly claim something very good for their engines, without pointing out the conditions with which others have to contend A moment's reflection will convince one, on looking at sections of crooked shafts, that you cannot get the same pump-efficiency as from a vertical shaft. And, moreover, when a pumping-engine is erected on a mine the power is much in excess, or ought to be, of the load to be lifted, and the expansive working can be carried to a greater extent, and a good duty performed, provided a fair quality of coal be used. But as the load is increased by the increased depth of the mine, the engines with the boilers naturally become weaker by age and wear, and hence when economy is most desirable it is least attainable.

If members interested in pumping machinery in mining districts, whether coal or metalliferous, would adopt some standard system of independent reporting and put all pumping-engines practically on the same basis for calculating the duty and total cost for fuel per 1,000,000 foot-pounds, details could be easily settled, and it would be most interesting and useful not only to engineers but more particularly to owners of mines, to serve them as a guide in future in selecting the best engine for the particular purpose for which it is required.

If this paper served the purpose of the writer and influenced the institutes interested more or less in this important matter, inducing them to publish the results in a simple but scientific form, he was sure that the cost and labour attending it would be amply repaid in true economy being secured that might otherwise be lost. He would be delighted to render any little assistance in his power to help forward what he ventured to say was well worth the best efforts of all interested in economic mining.

APPENDIX.

AVERAGE DUTY PERFORMED BY THE CORNISH PUMPING-ENGINE IN THE MINES OF CORNWALL, AND REPORTED BY *LEAN'S REPORTER*, FROM 1840 TO 1895.

Year.	Average Duty of all of the Pumping-engines. Millions of Foot-pounds per 112 lbs. of Coal.		Year.	Average Duty of all of the Pumping-engines. Millions of Foot-pounds per 112 lbs. of Coal.
1840	 54	Per bushel of 94 lbs.	1868	 51
1841	 54		1869	 48
1842[a]	 54		1870	 52
1843[b]	 57		1871	 54
1844	 54		1872	 52
1845	 55		1873	 48
1846	 55		1874	 49
1847[c]	 53		1875	 48
1848	 53		1876	 51
1849	 54		1877	 50
1850	 52		1878	 50
1851	 55		1879	 50
1852	 50		1880	 50
1853	 48		1881	 50
1854[d]	 45		1882	 49
1855	 46		1883	 46
1856[e]	 46		1884	 48
1856[f]	 54		1885	 51
1857	 52		1886	 51
1858	 53		1887	 54
1859	 51		1888	 52
1860	 52		1889	 51
1861	 53		1890	 50
1862	 52		1891	 49
1863	 51		1892	 48
1864	 51		1893	 48
1865	 50		1894	 52
1866	 50		1895	 48
1867	 51			

[a] The highest duty ever recorded for one month was performed by the Taylor engine, 107½ millions of foot-pounds, for September.

[b] Highest average for one year ever recorded, and the highest monthly duty ever recorded, was in December—60 millions of foot-pounds.

[c] In May this year, the duty was reported in two columns: one by the bushel of 94 lbs., and the other as if computed by the cwt. of 112 lbs.

[d] Lowest average yearly duty ever recorded.

[e] First half-year.

[f] Second half-year. This year the bushel of 94 lbs. was dropped altogether, and the cwt. of 112 lbs. was adopted as the standard.

Mr. Chas. H. Treglown said that no one disputed the fact of the excellent economy which had been attained from the Cornish pumping-engine, where the general conditions of working had been favourable. The late Mr. Samuel Grose made several important improvements in the Cornish pumping-engine. At one of the mines in Cornwall there were three pumping-engines, two with cylinders 70 inches in diameter, and one with a cylinder 60 inches in diameter, made from the drawings of Mr. Grose. In 1867, these engines, working under the ordinary everyday conditions, had an average duty of 77 million foot-pounds per cwt. of coal. The shafts were vertical, and good average Welsh coal was used. The great variations and the falling-off in the duty of Cornish pumping-engines had been dealt with by Mr. Trestrail, but with regard to his allusions to crooked shafts, etc., it would be interesting to know, in some instances, the calculated amount of power absorbed in dealing with those disadvantages so prejudicial to the economical use of steam. He noticed in *Lean's Engine Reporter* for October, 1896, that the average duty from five engines was 44·68 million foot-pounds, and from three engines 49·82 million foot-pounds, consequently Mr. Trestrail's paper might prove of value from the discussion.

Mr. W. Beattie Scott (H.M. Inspector of Mines) asked Mr. Trestrail to give the average price of the coal used for the last ten years.

The discussion was then adjourned.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD IN THE MUNICIPAL SCIENCE COLLEGE, DERBY, DECEMBER 5TH, 1896.

MR. M. H. MILLS, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected :—

MEMBERS—

Mr. THOMAS HENRY HARWOOD, Mining Engineer, 56, Otter Street, Derby.
Mr. EDWIN MORGAN, Mining Engineer, 122, London Road, Derby.
Mr. JOSEPH DRURY MUDDIMAN, Mining Engineer, 14, Park Avenue, Albert Park, West Didsbury, Lancashire.
Mr. SAMUEL TURNER, Colliery Manager, St. John's Colliery, Staveley, Chesterfield.

ASSOCIATE MEMBER—

Mr. JOSIAH COURT, M.R.C.S., L.R.C.P. London, Physician and Surgeon, Staveley, Chesterfield.

ASSOCIATES—

Mr. JOHN BRIGGS, Under Manager, Church Street, Eckington, Sheffield.
Mr. WILLIAM MULLINS, Stallman, Holding Second Class Certificate, 8, Princes Street, Eastwood, Nottinghamshire.

STUDENT—

Mr. PERCY BOND HOUFTON, Mining Student, Bolsover Colliery, Chesterfield.

Mr. C. SEBASTIAN SMITH read the following paper on "Safety-Props for Supporting Cages in the Head-gear of Pits in Cases of Overwinding":—

SAFETY-PROPS FOR SUPPORTING CAGES IN THE HEAD-GEAR OF PITS IN CASES OF OVERWINDING.

By C. SEBASTIAN SMITH.

Accidents from overwinding have been responsible for so much loss of life and also damage to plant that no reasonable expense should be spared in providing means for preventing them.

Many years ago detaching-hooks were invented, to prevent the cage from being pulled over the wheel by letting go the winding-rope, and also to suspend the cage and to prevent it from falling down the pit. Detaching-hooks act with considerable certainty, but the speed at which the cage is run up to the wheel is at times so great that, after the rope is detached, the cage rises the full length of the suspending-chains, and then drops with so much force that the suspending tackle breaks away from the detaching-hook, and allows the cage to fall down the shaft. The only method of guarding against such accidents is to provide props in the head-gear to catch the cage.

At many pits it will be found that there is not sufficient height in the head-gear to fix ordinary props without obstructing the space necessary for swinging out the cages to change them.

Further, it is doubtful whether ordinary props without any appliance for holding them out firmly, when struck by the falling cage, could be relied on, and even if the cage be so caught, the jar of such a sudden stop would probably cause serious injury to any unfortunate men upon it.

To overcome these difficulties, the writer has designed the props represented by the drawings attached to this paper. Fig. 1 (Plate XXIII.) shows the parts in position before being brought into action. Fig. 2 shows the parts in position when brought into action. Fig. 3 is a plan. On the horizontal beams *A*, *A*, in the head-gear, are fixed four strong hollow frames *B*, *B*. Within these hollow frames are strong swinging-props *C*, *C*, supported by pivots at their upper ends on spring-bearings *D* on the frames, their lower ends being clear of the beams *A*, so that they are free to swing forward on their pins from the position shown in Fig. 1 into that shown in Fig. 2. When they are subjected to downward pressure, their spring-bearings yield and allow their lower ends to bear firmly on the beams *A*, so that no strain can come upon the frames or on the supporting-pins.

When the props *C* are in the forward position, shown in Fig. 2, the front faces project in an inclined direction beyond the faces of the frames, and terminate with projecting beaks, the inner face of the props being then vertical.

When the props *C* are in the backward position, shown in Fig. 1, the beaks are flush with the face of the frames, so that they do not interfere with the rising cage *E*. The props are held in this backward position by means of rods *F* sliding in guides on the frames, and engaging by their forked lower ends with pins *G*, on the props projecting through slots in the frames. The upper ends of the rods are pivoted to trigger-levers *H*, which in their turn are pivoted to brackets *I*, carried by the head-gear, so that when the rods are engaged with the pins *G* of the props, they hold the trigger-levers in the horizontally projecting position shown in Fig. 1. In this position, if the cage be raised higher than usual, it will come into contact with them, and in raising them upward will liberate the pins *G*, whereupon the props will swing forward by gravity, and will occupy the position shown at Fig. 2.

In the upper part of the frames *B* (Fig. 1) are placed wooden or iron blocks, *J*, with their lower ends resting upon the upper end of the sloping back-surface of the props. When the props are released, and swing forward, these blocks slide down and hold the props firmly in the forward position. The doors *K* are hinged to the frames, and are supported at the back by beams *L* tied across by strong tie-bolts *M*. Thus, whatever may be the wedging-strain put upon the props it is entirely taken by the tie-bolts.

From the above description it will be seen that, when the cage has been raised so as to disengage the props, and if the lifting-tackle should give way, the cage, in dropping, would be caught between the inclined faces of the props, as shown in Fig. 2, and would be effectually arrested by their wedging action. Should the cage yield to the wedging-force so as to descend to the bottom of the inclines, it will then be effectually stopped and supported by the beaks of the props.

After the cage has been again attached to the lifting-tackle, the nuts of the tie-bolts are unscrewed sufficiently to release the grip of the cage. The blocks are then drawn up, and the props are re-fixed as before, the tie-bolts are screwed up, and the apparatus is again ready for work.

Props thus constructed have been severely and repeatedly tested with heavily-loaded full-sized cages, and have acted perfectly on every trial.

The action is certain, it being impossible for the props to fly back, in consequence of the blocks falling behind them in the cases. The strain on the head-stocks in catching the falling cage is reduced to a minimum, nearly the whole force being absorbed by the tie-bolts, when the cage falls between the wedge-shaped faces of the props. In the case of a cage weighing with its load 8 tons, and falling 10 feet, this blow is equal to about 203 tons. This wedging-action also minimizes the shock of stopping, so that it is hoped that very little injury may be suffered by men standing upon the cage.

These props can be applied to any existing head-stocks, as not more than a few inches in height is required for their accommodation, and even if no space can be afforded, the beams carrying the prop-cases can, by unscrewing the tie-rods, be slid outwards whenever the cages have to be changed: no lateral connexion being necessary between these beams and the head-stocks.

The first set that were made of these props can be seen in action at Shipley collieries, and the writer feels confident that an inspection will satisfy everyone that by incurring an outlay no greater than the price of an ordinary set of props, perfect protection can be afforded against the chance of death from overwinding.

The PRESIDENT remarked that this safety-apparatus had been tried successfully at the Shipley collieries.

Mr. G. J. BINNS (Netherseal) observed that one great feature of this arrangement was that the cages were gradually arrested by the wedge-shaped position of the props. There was nothing very novel in the provision of auxiliary apparatus to stop cages from going down the shaft when overwound, and in some parts of the world their use had been made compulsory by legislation. A very simple kick-up lever was frequently used; but Mr. Sebastian Smith's arrangements saved the sudden jar of the cage stopping on a dead block.

Mr. A. H. STOKES (H.M. Inspector of Mines, Derby) said that he had seen the apparatus tested at Shipley collieries, and it experimentally performed all that Mr. Smith claimed for it in his paper. A number of accidents had occurred, which clearly pointed out the desirability of arresting the descent of the cage should the bridle-chains give way when an overwinding took place. The use of detaching-hooks

To illustrate Mr C. Sebastian Smith's Paper on "Safety-props for Supporting Cages in the Head-gear of Pits, in Cases of Overwinding."

Fig. 1.

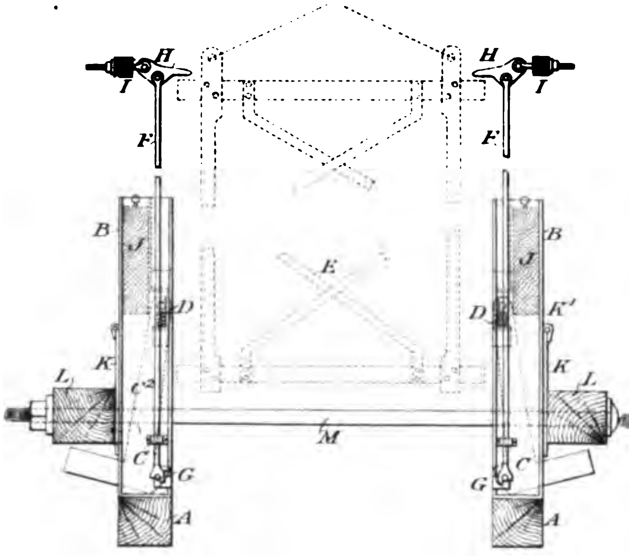


Fig. 2.

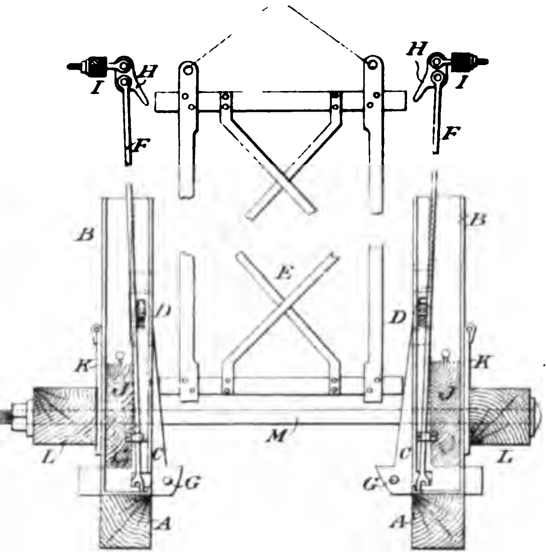
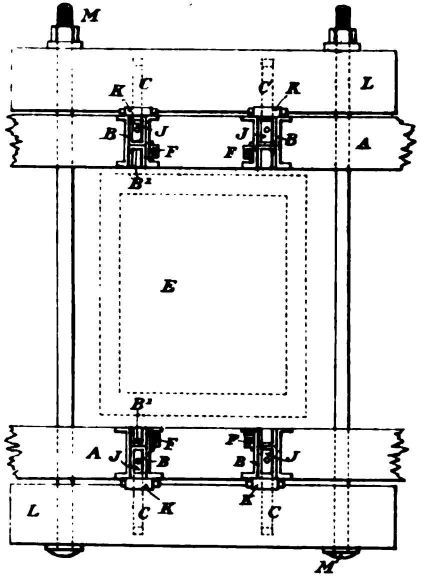


Fig. 8.



Andw Reid & Compy Ltd Newcastle on Tyne

was very necessary at fast-winding collieries, but, unfortunately, as they got rid of one danger in came another; and it was now found that occasionally when an overwinding occurred, the velocity at which the cage was travelling caused it to continue its upward course after the rope was detached, and then to drop back with its full weight upon the bridle-chains, which had, in some cases, proved unable to bear such a sudden and heavy shock. If such chains or couplings gave way, the cage then descended with a falling velocity, and if not caught and stopped by the props or keps, the cage must fall to the bottom of the shaft. Mr. Smith's arrangement was a good one, for it wedged the cage and helped to bring it to a stand before it arrived at a dead stop. Some such arrangement must be adopted in high head-gears with quick winding, if accidents due to falling cages after an overwind were to be prevented.

Mr. SEBASTIAN SMITH (Shipley) said that he had at the present time a full-sized double-decked cage fitted in a head-gear provided with these safety-props, and he would be very pleased to drop the cage again when it was convenient for members of the Institution to attend. He had been much obliged to Mr. Stokes for calling his attention to the question of preventing an accumulation of dust or snow in the cases, and he believed that Mr. Stokes at the same time suggested lids which he (Mr. Smith) had since provided. Wherever these props were adopted, he recommended that periodically the blocks be allowed to drop behind the props, to ensure their not getting choked with dust and rubbish. This operation could be effected in a few minutes without raising the cage into them.

Mr. WILLIAM SPENCER (Leicester) said that, simple though the arrangement might be, such matter required a considerable amount of thought and care, and those who gave the members a descriptive paper and detailed drawings, as in the present case, deserved their thanks, and the more so as Mr. Smith had kindly invited them to see his invention in operation at Shipley. He had pleasure in moving a vote of thanks to Mr. Smith for his paper.

Mr. G. E. COKE (Nottingham) seconded the vote, which was carried by acclamation.

DISCUSSION UPON MR. SIMEON WATSON'S PAPER ON "PIT-TOP SAFETY-FENCING."*

Mr. A. H. Stokes (Derby) said that the ingress and egress of large numbers of workmen through the shafts of a colliery was becoming a difficult question. It had generally been thought that 12 persons at one time were quite sufficient to put upon the cage, but as mines got deeper the winding became quicker, and also the number of workmen in each mine became larger. Consequently, when some hundreds of men had to enter and return from a mine, say 1,500 feet deep, the restriction of each cage-load to 12 persons was a serious matter, both with respect to the time occupied and the accelerated speed at which the men were now being passed through the shafts. In one case, he found that when the men were in the centre of the shaft they were travelling at the rate of 37 miles an hour. Mr. Watson had formerly restricted the winding to 12 persons on each deck, but he wished to use two decks of the cage, and that 10 men should ride on each of the decks, making a total of 20 men for each load. If this were done, it was necessary to make some arrangement for securing the safety of the men getting into and out of the cages, so that one banksman should have both decks under his complete control. The arrangement described by Mr. Watson was not in use when winding coal—this should be clearly understood—it was only used when men were going down or coming up. In winding men from two landings, the banksman, wherever he stood, could not see both the top and the bottom deck, and yet it was absolutely necessary that only one man should give signals and control the starting and stopping of the cage. In this arrangement, the responsible banksman, upon receiving his assistant's signal that the second deck was loaded, turned down the handle of the fencing apparatus, and no man could then either enter or leave the cage. The signal to the engineman was then given, and the cage proceeded on its journey. When men were ascending, the banksman did not lift the arms for the men to get off until the cage was on the props. If such an arrangement as this were applied at all collieries, he thought that there would be little objection to men riding on two decks; but without such an arrangement, there would be danger in

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* *Trans. Fed. Inst.*, vol. xii., page 122.

doing so. He called attention to the light and effective fencing used by Mr. Watson, as shown on the sketches and marked with the letter *C.*[*] The fence for each deck consisted of three loose bars, and all the bars went up with the cage. These bars or rods were very much better and quieter in action than a gate.

Mr. A. S. **Douglas** (Hucknall Torkard) thought that the system adopted at Hucknall Torkard colliery, by his predecessor in the management, was a simpler one, and it could be applied at a cost of 15s. to 20s.; it certainly answered the purpose for which it was intended as to fencing. It was simply a single bar with horizontal arms connected with the top and bottom decks, and was worked by the banksman on the lower deck. When the cage came up the banksman lifted his lever and liberated both decks.

Mr. A. H. **Stokes** said that Mr. Watson had copied the Hucknall Torkard colliery arrangement, but had very materially improved it in every respect.

Mr. T. A. **Southern** (Derby) said that in Scotland additional special rules, enacted since 1888, were in force relating to mid-insets in shafts, and they seemed very useful and admirable rules for ensuring safety.[†] These rules required that the gates of the mid-inset should be connected with an indicator in the winding-engine house, so that the engineman could see if the mid-inset was fenced, and he was prohibited from starting his engine while the mid-inset was unfenced. At the same time he thought it might be preferable to keep the engineman's duty as simple as possible, and therefore to avoid giving him another indicator to attend to.

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[*] *Trans. Fed. Inst.*, vol. xii., Plate V., Fig. 1.

[†] Additional Special Rules for East and West of Scotland Mines Inspection Districts.

2. Where a mid-working of a vertical shaft is not provided with an appliance which constantly acts as a fence, the gate fencing the shaft at every such mid-working, being a mid-working in use for the regular passage of workers, or the drawing of minerals from the mine, shall be connected with an indicator in the engine-house, which shall indicate to the winding-engineman whether the gate is open or shut, and the engineman is prohibited from moving the cage from the said mid-working until the indicator shows that the gate is closed. Should the indicator show at any time that the gate is open when the cage is not at the said mid-working, the engineman shall at once call the attention of the bottomer to the fact by signalling four.

3. The bottomer, at a mid-working in a vertical shaft, not provided with an appliance which constantly fences the shaft, being a mid-working in use for the regular passage of workers, or the drawing of minerals from the mine, shall not open the gate fencing the shaft until the cage is stopped at such mid-working, and he shall not signal the cage away until he has closed the gate, and shall not permit any other person to open the gate while he is on duty.

Mr. A. H. **Stokes** reminded Mr. Southern that there had been such an arrangement in use at Cinderhill colliery, Nottingham, for many years. At the mid-inset in the shaft, the props could not be put in without at the same time exposing a semaphore in the engine-house in front of the engineman.

Mr. **George Lewis** (Derby), having taken the chair vacated by the President, moved a vote of thanks to Mr. Watson for his paper. The vote was carried by acclamation.

DISCUSSION UPON MR. CYRIL E. PARSONS' PAPER ON "THE DEPOSIT AT THE MILL CLOSE LEAD-MINE, DARLEY DALE, MATLOCK."*

Mr. **Arnold Bemrose** (Derby) said that when they looked back and remembered the large number of lead-mines that had been worked in Derbyshire, and that a great amount of information which might have been gained was lost, they should welcome a paper giving them a description of the deposits in the Mill Close lead-mine. It would be interesting to know how far the wayboard or bed of clay was below the top of the limestone, and whether it could be correlated with other wayboards of clay in the district. In a clay in the upper limestone, between Matlock Bridge and Matlock Bath, coal was found about $\frac{1}{4}$ inch thick. This might possibly be correlated with the Mill Close clay-bed, as it occurred near the cherty beds in the limestone. The unevenness of the limestone below the wayboard was not peculiar to that mine. At Crich, below a shale- and clay-bed, there was a bed of limestone in which were furrows and potholes. A section of these seen in the quarry showed an undulating line separating the clay from the limestone-beds beneath it. Similar furrows could be seen in the limestone below the toadstone (lava) in Smalldale quarries. The Mill Close mine was worked down to the toadstone, and there the vein thinned out and ended in a leader of calcite. He was not aware whether the ore was worked below the toadstone in this mine. There was an allusion in the paper to evidence of volcanic action, but he did not see what that had to do with the subject of the paper, because the lava they met with in the Mill Close mine overflowed the sea-bottom whilst the limestone was being deposited, consequently the volcanic action took place previous to the formation of the ore. Volcanic action went on in Derbyshire as late as the time

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* *Trans. Fed. Inst.*, vol. xii., page 115.

when the Yoredale rocks were formed. After this, faults and cracks were made in the rocks by earth-movements, the water found its way down, and being charged with carbonic acid dissolved away some of the limestone and formed caverns in it. The mineral veins and lodes were then formed in the caverns and fissures.

Mr. G. E. COKE (Nottingham) considered that Mr. Parsons had given a very good description, not only of the deposits, but of the mine itself. He had seen the wayboard himself in one of the caverns, and it could not be far below the shale.

Mr. BINNS (Netherseal) said that he did not know what cromfordite was. It was mentioned in juxtaposition to carbonate of lead (cerusite) which seemed to indicate that it was a carbonate. Mr. Parsons further on said "some fine crystallized specimens of different minerals may be obtained in some of the side cavities, as nodular cauk, with a crystallized coating of iron pyrites (cromfordite ?)."* This seemed to lead to a different conclusion as to its composition. Mr. Parsons considered that the green colour in the decomposition-products of iron pyrites was due to traces of copper in the pyrites.† He did not know whether this necessarily followed, but thought it probably due to sulphate of iron as a decomposition-product. He had himself a specimen of stalactitic sulphate of iron from a somewhat similar mine—not a lead-mine, but a mine in which there was much carbonate of lime.‡

Mr. A. H. STOKES (Derby) said that Mr. Parsons mentioned pyromorphite as coating other minerals in a thin yellow layer. Pyromorphite was commonly a green ore. He also mentioned cromfordite as nodular cauk with a crystallized coating of iron pyrites (cromfordite ?). Cromfordite is carbonate and chloride of lead mixed in about equal parts. Cerusite is carbonate of lead by itself. Cromfordite and matlockite are similar minerals and very rare, and are indigenous to the district. There were good specimens in the Derby Museum, but beyond that they would probably have to go to Jermyn Street to see any. He had noticed one curious remark in this paper, and it would be interesting to many of them, that "in working [minerals], the miners consider the smell of gas indicative of ore."

Mr. H. R. HEWITT (Derby) noticed that silver was not found in payable quantities in the Mill Close ore. A most remarkable thing was

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* *Trans. Fed. Inst.*, vol. xii., pages 116 and 118. † *Ibid.*, page 119.

‡ *Ibid.*, vol. iii., page 649.

the presence of fire-damp, and he thought that this was the only lead-mine in the United Kingdom where safety-lamps were used in certain districts.

Mr. W. S. **Gresley** (Erie, Pennsylvania, U.S.A.) wrote asking whether the thin layer of bright coal mentioned as occurring near the Lees shaft in the wayboard, exhibited any peculiar features, either as a stratum or structurally? Had any fossils been detected in the laminæ of the coal or on top of it; or had *Stigmaria* been seen in the underlying clay? He supposed that this streak of coal represented about the most southern limit of coal in the Carboniferous Limestone that was so fully developed at about the same geological horizon in the east of Scotland. Was there anything about this layer of coal at Mill Close suggestive of its having grown or been formed on the spot, or contrariwise? Was the grain or lamination different from that of ordinary bright (presumably bituminous) coal? Could any reasons be advanced against the idea that this coal was formed from aquatic vegetation that grew under water and *in situ*, just as he (Mr. Gresley) supposed the clay upon which it lay had been accumulated? If the remains of *Lepidodendra*, *Sigillariæ*, and other land-plants were associated with this Mountain Limestone coal, might it not better be supposed that they were drifted vegetable-*débris* from off the land of the period, rather than that the trees grew where the coal was now found?

Did the lead-lode occur in the toadstone? The longitudinal section* showed that the Mill Close shaft was sunk through it, but did the lead-vein extend as far? Had any one demonstrated that the toadstone was of the same age as the limestone in which it was embedded? It was clear that the faulting, or some of it, occurred since the introduction of the toadstone. The occurrence of lead ore (formerly mined) in the Mountain Limestone at Caulke and Staunton Harold, near Ashby-de-la-Zouch, nearly due south of Mill Close was on record; and as the main lode there had an approximately north-and-south trend, it might be argued that the Mountain Limestone possibly contained payable quantities of lead-ore at points between those localities. Some day it might be desirable to put down boreholes in search of it, and the depth to the limestone might not be so great as was generally supposed. Near Ashby-de-la-Zouch the limestone lay within a few hundred feet of the base of the Coal-measures.

The **Chairman** proposed a vote of thanks to Mr. Parsons for his paper and drawings, and it was agreed to unanimously.

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* *Trans. Fed. Inst.*, vol. xii., Plate IV., Fig. 1.

DISCUSSION UPON MR. A. T. METCALFE'S PAPER ON "THE GYPSUM DEPOSITS OF NOTTINGHAMSHIRE AND DERBYSHIRE."*

Mr. **Arnold Bemrose** said that he had seen the workings at Aston, and they were correctly described by the author. There was an admirable set of specimens before the members that day, and he thought that the pseudomorphs of salt were very interesting. He had not himself seen any of these *in situ.* The subject of the paper was not only interesting geologically, but also from an economic point of view, as the rock was of great commercial value.

Mr. **G. E. Coke** asked what was the specific gravity of gypsum? He had found pseudomorphs of salt at Chellaston, and he supposed that they were not very uncommon.

The **Chairman** remarked that the paper dealt only with the deposits of Derbyshire and Nottinghamshire, but there was a very much wider field that might have been included. The members were probably all aware that gypsum was to be found deposited in large or small quantities all over the world, and that H.M.S. "Challenger" found beds of gypsum in process of formation at great depths of the ocean during the dredgings. All the rivers of this country were more or less charged with gypsum. The Trent was highly charged, and in its immediate neighbourhood many deposits were found. There was a difference of opinion as to whether the deposits were formed by percolation or precipitation. He had seen many of the gypsum-mines of this country, and there being a great difference in their appearance it struck one that in some cases it was almost impossible to accept the theory of precipitation. Mr. Metcalfe, in this paper, drew attention to peculiarly shaped pieces about the formation of which he would not hazard an opinion, but it seemed to him almost an impossibility to account for their existence by precipitation. Gypsum was found generally in the Upper Keuper, and in Derbyshire and Nottinghamshire there were traces of Magnesian Lmestone over it, which in all probability played an important part in its production. Some beds of gypsum in this country were 25 feet thick, but the quality and constituents varied in each district. In the county of Sussex, the deposit was very interesting geologically, and here also limestone was

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* *Trans. Fed. Inst.*, vol. xii., page 107.

found on the surface, wherever a deposit was found. There was one point about gypsum which they as mining engineers ought to take into consideration, and that was the method in which it was being worked. The system appeared primitive, although probably it might be best adapted for the purpose, but still there was considerable waste. Personally, he was an advocate for longwall working, and he had established such a system in a gypsum-mine with success, so that at the present time they were working the mine in very much the same way as mining engineers were working coal-mines. The gypsum could be sorted more readily and sent out in better form than before. He had pleasure in proposing a vote of thanks to Mr. Metcalfe for his paper.

The motion was carried by acclamation.

DISCUSSION UPON MR. ALFRED SIERSCH'S PAPER ON "PHOTOGRAPHY IN THE TECHNOLOGY OF EXPLOSIVES."*

Mr. A. H. STOKES said that this was one of the most valuable papers that had appeared in the *Transactions*. The advantage taken of photography for registering the flame when making experiments with explosives proved that all the explosives tested gave flame when fired. If reference were made to Figs. 24 and 25 (Plate IV.), where two cartridges were simultaneously fired, it would be seen that between the two records of firing there was a light. It was a curious disclosure, because it might indicate that one shot had been fired a little in advance of the other, and that the residuum or gases from the first shot had been ignited by the flame of the second shot. This was an important matter, as the fumes given off from the firing of some explosives were themselves explosive, and the firing of a number of shots nearly simultaneously and in close proximity to each other, might lead to remarkable results. There were other sketches deserving notice, such as Figs. 27 and 28 (Plate V.), which indicated that a water-cartridge was not absolutely safe. Perhaps it was the safest means of firing a high explosive; but it had its faults, and the figures showed a small flame, although fired in a water-cartridge and under water in a glass beaker. The value of the water-cartridge was, perhaps, best seen by comparing Figs. 27 and 28 (Plate V.) with Figs. 6 and 8 (Plate II.), in

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* *Trans. Fed. Inst.*, vol. xi., page 2.

the latter two of which the same explosive was fired without a water-covering. There was another point worthy of notice which would be seen by referring to Figs. 30 and 31 (Plate IV.), namely, that the degree of security of an explosive decreased as the diameter of a cartridge was increased. That was a curious record, and one that required further investigation. The photographs were splendidly done, and he hoped that some member of the Institution would endeavour to follow Mr. Siersch's example and publish similar results. Mr. Siersch had described very plainly the *modus operandi*, showing that the photographs could be taken with some degree of safety to the apparatus and probably satisfactory records obtained. The paper deserved the greatest consideration from the members.

Mr. H. R. Hewitt thought that congratulations were due to the author for his successful manipulation of the camera upon so delicate a subject and for the sharp outlines of the photographs accompanying his paper in the *Transactions*. The explosives used in the tests were of a somewhat different character from those employed in this country, and it appeared that progressit, Fig. 16 (Plate II.), gave the least amount of flame, and blasting-gelatine, Fig. 5 (Plate II.), the largest, when 3·53 ounces of each were used freely suspended. He had ignored gun-cotton, Fig. 2 (Plate I.), as being an explosive not used in the mines of this country. In the second series of experiments, where wet-paper stemming was used, progressit, Fig. 22 (Plate III.), again came out most favourably. It would be well if the author would state the chemical composition of these explosives or their English equivalents, so that the matter could be treated as coming nearer to themselves. In looking through the *Report* of H.M. Inspectors of Explosives for 1894, he found that progressit was under examination at the Home Office during that year. In the report for the year 1895, the following remarks appeared with reference to the same explosive :—

> The preliminary examination to which all new explosives are submitted showed that chemical changes occurred in the powder during keeping, and that a more special examination would be necessary before the explosive could be licensed. Up to the end of the year, however, no sample of the powder has been submitted for the purpose, and the explosive has apparently been abandoned.

In view of these experiments, this action or inaction of the patentees was to be regretted. The luminous zone on each of the flash-pictures, Figs. 24 and 25 (Plate IV.) was a very interesting feature of these double charges fired simultaneously. He would like to ask the author what explanation he could give with regard to this peculiar phenomenon. The danger from this luminous zone of glowing gases in an underground atmosphere when simultaneous shots were fired could not be overestimated. The conclusion (*d*) deduced by the author* that under otherwise identical conditions the degree of security of an explosive decreased as the diameter of the cartridge was increased was open to some doubt, as the difference in the size of the two holes experimented upon (Figs 30 and 31, Plate IV.) was only 0·59 inch. It would have been more satisfactory if a wider field had been experimented upon, say 1 inch and 3 inches holes, so that a greater change could be noticed in the relative pictures. It would be interesting to know what admixture the author recommended for increasing the security of an explosive, as this seemed to be a step in the direction of obtaining an explosive which would give a minimum amount of flame. The experiments (Fig. 34, Plate V., and Fig. 9, Plate I.) showed that the admixture which he used greatly reduced the amount of flame, and the same remark applied to the reduction of the carbon constituents of the explosives as shown by Figs. 41, 42, 43, and 44 (Plate VI.). Many of the explosives experimented with appeared to be nitro-compounds. This class of explosive was too shattering for general use in coal-mines in this country, besides which it was impossible to make a nitro-explosive which was nearly flameless. For the solution of this problem he thought that the nitrate-of-ammonium class must be looked to as being preferable.

Mr. L. W. DE GRAVE (Derby) suggested that the luminous appearance between the two shots in Figs. 24 and 25 (Plate IV.) respectively might have been caused by a bright spot on the metal inside the camera. In Fig. 6 (Plate II.) and Fig. 7 (Plate I.) bright patches were also shown which had every appearance of being caused by reflected light.

Mr. J. B. SMITH (Newstead) observed that he had always been interested in this subject, and had taken photographs of explosives some years ago. The double photographs which had been referred to were of very great interest, and in them perhaps would be found an elucidation of an entirely new theory of coal-mine explosions. The intermediate light in them he regarded, not as a defect in the camera or lens, but as a proof that that these shots propelled matter at very high velocities. When particles collided at a high velocity, light was to be expected, and it was found in these pictures. These illustrations threw much light on the subject, and were suggestive of new ideas as to explosion phenomena. The rapid motion of small particles and their collision

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* *Trans. Fed. Inst.*, vol. xi., page 4.

producing a light showed that the physics of molecular motion entered into the question, and from such phenomena one might deduce the true theory of explosions of dust and gases.

Mr. Alfred A. Siersch, replying to the discussion, said that the following table exhibited the composition and the relative strengths of the blasting explosives used in his experiments. The relative strengths of the explosives were determined according to the Trauzl method in leaden blocks 7·87 inches in diameter and 7·87 inches long, 20 grammes being used of each explosive:—

Table showing the Composition and Strength of the undermentioned Explosives.

Vol. XI.		Explosives.			Volume of Cavity in the Leaden Block.
No. of Plate.	No. of Figure.	Name.	Composition.		
			Per Cent.		Cubic Centimetres.
I.	7	Gelatine-dynamit II.	45	Blasting-gelatine (Nitro-glycerine and nitro-cotton)	800 to 900*
			55	Other ingredients	
I.	9	Roburit	88	Nitrate of ammonium ...	1,200
			12	Dinitro-benzole	
I.	10	Carbonit	25	Nitro-glycerine	560
			34	Nitrate of potassium	
			38½	Rye-meal	
			1	Wood-meal	
			1	Nitrate of barium	
			½	Bicarbonate of sodium ...	
I.	11	Wetter-dynamit ...	66	Guhr-dynamit	560
			34	Bicarbonate of sodium ...	
II.	4	Hellhofit	40	Dinitro-benzole	Over 1,600
			60	Nitric acid, 48 degs. Baumé	
II.	5	Blasting-gelatine ...	94	Nitro-glycerine	1,500
			6	Gun-cotton	
II.	6	Gelatine-dynamit I.	65	Blasting-gelatine (Nitro-glycerine and nitro-cotton)	1,050 to 1,200*
			35	Other ingredients	
II.	8	Guhr-dynamit ...	75	Nitro-glycerine	1,000
			25	Kieselguhr	
II.	12	Westfalit	95	Nitrate of ammonium ...	710
			5	Resin	
II.	13	Dahmenit	7½	Naphthalene	400
			67	Nitrate of ammonium ...	
			19½	Nitrate of potassium ...	
			6	Bichromate of potassium ...	

* Volume varies according to temperature.

TABLE SHOWING THE COMPOSITION AND STRENGTH OF THE UNDERMENTIONED EXPLOSIVES.—*Continued.*

Vol. XI.		Explosives.			Volume of Cavity in the Leaden Block.
No. of Plate.	No. of Figure.	Name.	Composition.		
			Per Cent.		Cubic Centimetres.
II.	14	Grisoutine	12 88	Blasting-gelatine (Nitro-glycerine and nitro-cotton) Nitrate of ammonium ...	620
II.	15	Grisoutit	44 10 46	Nitro-glycerine ... ... Wood-meal ... ... Sulphate of magnesium (crys.)	515
II.	16	Progressit	95 5	Nitrate of ammonium ... Hydrochloride of aniline ...	610
III.	20	Antigrisou	79·2 10·8 10·0	Nitrate of ammonium ... Dinitro-naphthalene... ... Chlorate of ammonium ...	700
V.	34	Roburit, with 5 per cent. admixture	12 83 5	Dinitro-benzole ... ... Nitrate of ammonium ... Other ingredients	1,290
V.	35	Grisoutine, with admixture	84 12 4	Nitrate of ammonium ... Nitro-glycerine ... ... Mononitro-benzole	940
VI.	41	Nitrate of ammonium and carbon compound	94 6	Nitrate of ammonium ... Dinitro-benzole	600
VI.	42	Do.	92 8	Nitrate of ammonium ... Dinitro-benzole	750
VI.	43	Do.	88 12	Nitrate of ammonium ... Dinitro-benzole	1,200
VI.	44	Do.	82 18	Nitrate of ammonium ... Dinitro-benzole	1,600 to 1,800*

* Volume varies according to temperature.

The discussion was adjourned.

DISCUSSION UPON MR. W. BLAKEMORE'S PAPER ON "COAL-CUTTING BY MACHINERY."*

Mr. **Henry Davis** (Derby) wrote that it would be interesting to be informed by Mr. Blakemore whether he had had experience with the Jeffrey coal-cutting machine, as this machine overcame the difficulties which he had discovered in employing the Stanley header. Whilst the weight of the Stanley machine for, say 5½ feet diameter cut, was 7,166 lbs., that of the Jeffrey machine, constructed to hole 6 feet deep by 3 feet 3 inches wide, was 2,350 lbs., and by the use of a special truck this machine, after holing the width of one heading, might be removed to another heading with very little loss of time. This, instead of taking a large gang, was effected by two men. Further, the Jeffrey machine will cut through materials, other than stone, stronger than coal, and should it meet with hard material, the reversing-gear will draw back the machine a few inches, when the cutters will again attack and cut through the harder material, if not the first time, by repeating the operation. In case of unevenness in the floor, the Jeffrey machine may be raised to cut at any height by using skid-boards of greater thickness, or it will cut in fire-clay under the seam of coal should it be considered desirable. The Jeffrey machine was essentially a heading-machine, and cut at the bottom of the seam; it was equally effective in thin or thick seams, and it made slack of a suitable granulation for boilers mechanically fed. With regard to heading for a double haulage-road, there was nothing to compete with the Jeffrey type of machine, as it accommodated itself to any desired width of road. With a machine cutting 3 feet wide, it was only necessary to slide it sideways on its skid-rails in order to cut 3, 6, or 9 feet or any desired width. Moreover, the Jeffrey machine squared up the work as it proceeded and would turn away roads at any desired angle. Mr. Blakemore did not appear to have employed the Jeffrey coal-cutter in the mines of the Dominion Coal Company, and this would account for the absence of any reference to this machine, which was extensively used in the United States of America, and also was being adopted with very considerable success in British and colonial mines where the conditions were suitable.

Mr. W. **Blakemore** (Cape Breton) wrote that he had used the latest Jeffrey machine, which he understood was a considerable improvement upon any previous machine, and he had used the machine which was sold two or three years ago both as a bar and chain-cutter in the mines of the

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* *Trans. Fed. Inst.*, vol. xi., page 179.

Dominion Coal Company, and he had been obliged to lay both aside for the reasons stated in his paper. He was fully aware of the advantages of the Jeffrey machine, and was averse to continuing a discussion upon the lines initiated by Mr. Davis, simply showing the comparative merits of two competing machines; and nothing that Mr. Davis had stated was new to those who have had experience with machines of this type in seams of coal peculiarly liable to intrusions of hard material.

He quite agreed that the Jeffrey machine, as well as the Stanley header, would get through stronger material than coal "other than stone," but if the material be harder than "stone," as hard in fact as the iron pyrites which was found near the base of some of our seams, no machine would cut it. Mr. Davis then fell back on his reverse gear to withdraw the machine, but it was too late to do this when the teeth or cutters on the chain were broken, as invariably occurred instantly they came in contact with such hard material as he had described. His experience, based upon the constant use of almost every type of coal-cutting machine in the market, confirmed the statement which he made in his paper, to the effect that a solid percussive machine was the only type which could be used successfully in such seams as he was describing, because it was the only machine which was not purely mechanical in its action, and which allowed the workmen to use his intelligence and skill in directing every blow which it struck.

Of course these remarks were governed entirely by prevailing conditions in any given mine, and were intended to apply only to such a condition as he had laid down in his paper. At the same time, he was willing to admit that in a seam of coal entirely, or practically, free from instrusions of hard material the Jeffrey was a good machine, but he would not for a moment compare it with the Stanley header, because they were of distinctly different types, and were used for essentially different purposes. The Jeffrey machine could only be compared with the Mitchell longwall machine described in his paper. This machine, as stated, he had used with the most satisfactory results. It possessed every feature of value claimed for the Jeffrey machine, it was simpler in construction, cheaper, and, in his judgment, as efficient in every respect.

It would be interesting for Mr. Davis to state whether he had been able to cut coal with the Jeffrey machine at lower than the standard rate for the Mitchell longwall machine, which was 1d. per ton to the operators, or having regard to the thickness of the seam, was equivalent to ¼d. per square foot.

THE DETERMINATION OF, AND USE OF, THE MAGNETIC MERIDIAN IN MINE-SURVEYING.

BY R. F. PERCY.

There are many reasons why the use of the magnetic needle in mine-surveying is unsatisfactory. While the errors due to change in declination may be reduced to a minimum by making allowances, it is not practicable to make similar provision against magnetic storms, or for diurnal variations. The extent of the needle's daily movement may be inappreciable, or may exceed $\frac{1}{3}$ deg., and its irregularity permits no exact forecast. The mean arc is not less than $\frac{1}{6}$ deg., so that if, during the night, a survey be made by the approved fast-needle method (in which orientation is obtained by needle-bearings of convenient lines in the traverse), and if, so as to be literally up to date, a plotting-meridian be taken in the course of the next day, the probability is that the mine and the surface-meridians will sensibly diverge, causing a deflection of more than 13 feet per mile.

It is evident that the magnetic meridian is too shifty to be relied on as an exact base of reference; nevertheless other modes of transferring reference-lines from surface to mine are tedious or delicate, requiring so much care that they are seldom practised. Experience, too, shows that, in spite of drawbacks, the magnetic meridian is a valuable traverse reference-line. Approaching-drifts, set out by the dial, have over and over again justified its use by thirling correctly. The dial or miner's compass, is so convenient and handy that it is not a matter for surprise that many surveyors employ it exclusively in the mine, and refuse to attempt other methods.

Seeing that the dial is unlikely to be displaced from the position which it holds, its weak points ought to be thoroughly known, and every effort made to avoid mistakes. The most frequent errors are probably due to local magnetic disturbances, which remain undetected because no test is applied.

Mr. James Henderson* insisted that it was highly important that land and mine-surveys should be conducted with the same instrument; but it

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* *Trans. Fed. Inst.*, vol. ix., pages 30 and 222.

appears unnecessary to employ on the surface a dial specially designed for subterranean work when, as is usually the case at collieries, the superior and more suitable instrument, the theodolite, is available. It is, however, essential that the surface-meridian shall be determined with the same instrument as that used underground. At collieries where more than one dial is in use a plotting-meridian must be taken with each, as it is possible that meridians which are not parallel will be required.

To obtain a meridian, it is usual in this district to select a few points on the plan which can be unmistakably identified in the field, and at those stations (or in alignment) bearings are taken to the pit-shaft with the dial.

There are two great objections to this system :—First, if the work is to be well done, the stations should be in the neighbourhood of the workings, and where these are at a long distance it is impossible for the surveyor to feel sure that he has observed the exact centre of the shaft. This is owing to the incapacity of the eye to distinguish the object without a telescope, to the thickness of the hair which prohibits exact bisection, as well as to parallax, since the slightest movement of the eye causes a swing in the line of sight. The other objection is that at each station there is no proof that the needle rests in the normal position. Prof. H. Stroud* said that no definite conclusion could be drawn unless the needle remains parallel to itself as tested at several positions, and the writer thinks that in determining a meridian upon which the entire survey of a mine is based, this test ought never to be neglected. The method which he adopts supplies these tests, and obviates the difficulties mentioned, by combining the use of theodolite and dial.

The theodolite having been erected at one of the selected field-points and adjusted to zero, is directed to the shaft and clamped. The dial is next set up at any suitable point, a convenient distance (300 feet or so) away, and the telescope is directed to it, so that the shaft-theodolite-dial angle is measured. The bearing of the theodolite-dial line is next obtained, the observation being more precisely made by reading the vernier of the dial and by sighting a strip of white paper pasted upon the object-glass shield of the telescope. The dial is subsequently moved to other suitable points around the theodolite, the telescope being from time to time directed to it, so as to measure the deflection of the dial-lines from the theodolite-shaft base-line, while the needle gives magnetic readings.

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* *Trans. Fed. Inst.*, vol. ix., page 29.

Fig. 1 and an example will perhaps make the preceding statement more clear. The various observations being noted, as shown in Fig. 1, the magnetic bearing of the base-line as ascertained at each point where the dial was fixed may now be calculated. If the bearings agree, it may be concluded that the needle was parallel to itself at several points in the vicinity of the selected station.

Stations.		A.	B.	C.	D.
Magnetic bearings	...	+152° 30′	+224° 0′	+348° 48′	+ 62° 30′*
Theodolite-angles at T	...	− 84° 31′	−156° 3′	−280° 50′	−354° 36′
Differences	...	67° 59′	67° 57′	67° 58′	67° 54′

The mean bearing of the shaft from station T is therefore 67° 57′.

By applying this method at each selected station, magnetic bearings can be obtained which arithmetically satisfy the test of parallelism.

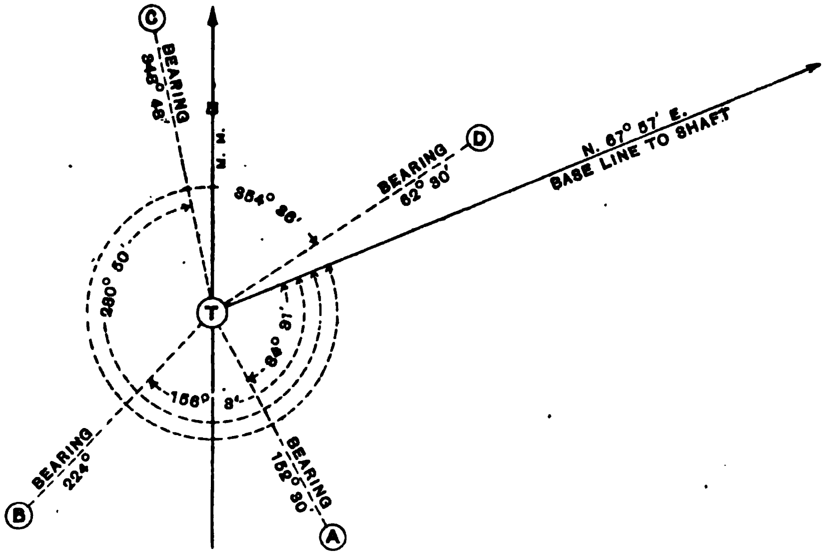

Fig. 1.

It now remains to lay down the meridian on the plan and to apply the test to the set of mean bearings from the various stations.. If the lines, which have been observed, be drawn on the plan, meridians can be plotted from each, and if these coincide or are parallel, it is a graphic proof of the harmony of the bearings. A better way is to use tracing-paper, and save wear-and-tear of the plan: the meridian being assumed, and the bearings drawn from a point in it. The protractor is inadequate for this purpose, but plotting by tangents and checking by chords will secure

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* 360° should be added to this bearing to obtain the difference.

any degree of accuracy. The tracing-paper should be laid on the plan with the radiant point on the shaft and the bearings passing through their respective stations, and the meridian transferred, inked-in and dated. Should the lines on the tracing-paper fail to fit, the obvious conclusion is that the surface-plan is not correct.

The employment of this method has shown that stations in the field, reasonably assumed to be free from disturbance, have not always been so, and that it has prevented an unfortunate reliance which otherwise would have been placed on a single magnetic reading.

If a still closer approach to the mean declination be required, the observations may be repeated at a different hour, a few days later, and taking the mean of the two results will probably further eliminate error.

In conclusion, the writer thinks that a meridian so determined may be safely trusted for four or five years if the proper abatement of declination be regularly made.

AN IMPROVED PROTRACTOR.

BY R. F. PERCY.

The cardboard protractor has now nearly ousted the brass one from the colliery survey-office. The latter may be more accurately divided than the former, but since it is necessary to apply the parallel rule to bearings which are pricked on to the plan by hand, the results of plotting directly from a card protractor are probably more reliable. Apart from the waste of time in pricking off the bearings from the brass circle, they soon make unsightly rings on the plan, and in a few months become useless, as the change of magnetic declination renders all the bearings, previously pencilled on the plan, misleading. The surveyor who wishes to keep his plan clean, and the indolent surveyor alike, are tempted to make such bearings serve as long as possible, from a natural repugnance to rubbing them out and spoiling the surface of the paper in order to substitute figures differing by so small an arc. The allowances for declination, which should be regularly made, are delayed, and avoidable errors thus creep in.

To avoid frequent shifting of the plan-meridians, allowances may be made, as suggested by Mr. H. Jepson,* by numerically altering the bearings before plotting, but this is quite unnecessary if a simple card protractor, such as the writer uses, be employed.

The writer's protractor is made of strong pasteboard, thin, so that the rule is not raised sensibly above the plan (the thick ones usually sold allow the pencil, by a trick of the wrist and elbow, to deviate from the edge of the rule). It is made as wide as convenient from west to east, and narrow, where length has no advantage, from north to south. As many parallel, north-and-south, lines as can be, are, with the greatest care and accuracy, drawn at intervals of 2 or 3 inches, and at the ends of all these parallels, on the left at the north edge, and on the right at the south edge, divergences of 1 degree and fractions of 1 degree are indicated (Fig. 1). The part within the divided circle is, as usual, cut away, and the plotting is executed within that space.

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* *Trans. Fed. Inst.*, vol. vii., page 274.

The parallel meridians allow the protractor to be placed exactly where it is needed, very few meridians being required on the plan. A circle 10 or 12 inches in diameter on a card 24 inches wide will permit plotting anywhere within 15 inches of a meridian, and no meridian need be indicated on a plan within 30 inches of another. The divergences marked at the ends of the parallel lines will allow the protractor to be twisted for declination so as to bring the meridian to the date of the survey. An allowance for six months change can thus easily be made. If the change be assumed at ⅛ degree per year, there will be no serious error in a period of four years; if a new meridian be then determined, it will be found to distinctly diverge from the old one, and by inking in the new line with a distinguishing colour no mistake is ever likely to occur from applying the protractor to a wrong base-line.

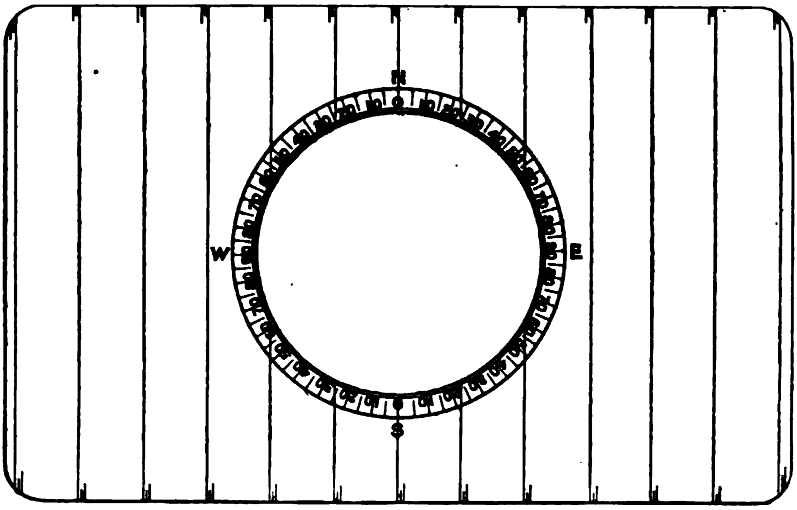

Fig. 1.

The writer has found that a small card-protractor of this kind is very convenient. It allows the plan to be kept clean, in the absence of pencilled bearings; it reduces the number of lines of reference on the plan to a small number; it saves the trouble of drawing new meridians every year, which are liable to be twisted too much or too little; it enables old surveys to be as easily plotted as new ones; and it completely removes all excuse for the existence of plans crowded with short pencilled meridians, recent and ancient, dated and otherwise, which create great confusion.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

SPECIAL GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
DECEMBER 14TH, 1896.

MR. JOEL SETTLE, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected :—

MEMBER—

Mr. **GEORGE EAGLE**, c/o Messrs. Cross & Eagle, King Street, Manchester.

ASSOCIATE MEMBER—

Mr. **PETER TURNER**, Shelton Collieries, Stoke-upon-Trent.

ALTERATION OF RULE.

The **PRESIDENT** said that the Council had decided to recommend an alteration of Rule 4, which provided that a payment of £10 would entitle a person to life membership. Having regard to the fact that some gentlemen had been life members for a number of years, it was found that £10 was too low a sum to fix life membership in the future, and it was thought that the amount should be increased to £25.

Mr. E. B. **WAIN** moved the adoption of the recommendation of the Council, which was seconded by Col. **STRICK** and carried.

Mr. **GREGORY** read the following paper on an "Improved Safety-lamp":—

IMPROVED SAFETY-LAMP.

By JNO. GREGORY.

The improved Heath and Frost safety-lamp is designed so that under no possible circumstances can it be put together and sent out of the lamp-room, without the protective gauze.

The growing adoption of the use of shields or bonnets in safety-lamps of Mueseler and Marsaut types, whilst undoubtedly increasing their safety in currents of high velocity, has also opened the door to the possibility of safety-lamps being taken into the workings of a fiery mine without the gauze, and becoming, in fact, neither more nor less than naked lights. It is no easy matter in many forms of safety-lamps to ascertain whether the gauze is inserted or not, especially when the shield is locked or permanently fastened to the body of the lamp; and even when removable for inspection, the labour and loss of time unavoidable in thoroughly examining a large number of safety-lamps is such as to offer an inducement to the examiner to shirk a complete scrutiny in every case.

This is no imaginary danger, and the following extract from the presidential address on "Safety in Mining," delivered at a general meeting of the Federated Institution of Mining Engineers in 1895, by Mr. W. N. Atkinson, showed that it had not escaped notice:—

> With respect to the lamps in use, two points strike me as especially requiring attention. The first is the abolition of the old screw-lock and the adoption of a lock incapable of being opened surreptitiously without detection, and this is an improvement of easy attainment at small cost, applicable to most of the lamps now in use. The other point is the risk attending the use of lamps with close shields, that lamps may be taken into the mine without the gauze. That this is a real risk is proved by its occurrence in the experience of a number of persons. The remedy is not so obvious as the improved lock, and it involves some alteration in the construction of the lamps, but it is a danger deserving of serious attention.*

From the following short description of the Heath and Frost safety-lamp it will be seen that the safety of the lamp, instead of depending solely on an ocular examination, is assured by mechanical means.

Referring to Fig. 1, it will be noticed that the lamp illustrated resembles outwardly a bonneted Mueseler of ordinary pattern with petroleum

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* *Trans. Fed. Inst.*, vol. ix., page 303.

burner. The gauze *A* is riveted, or otherwise securely fastened to the metal ring *B*, which has its upper edge milled for convenience in screwing, and has two male threads of different diameters cut thereon. The oil-vessel and the poles surrounding the glass up to and including the middle ring are made in one piece, and a female thread is cut in the middle ring. The bottom of the shield has also a female thread of smaller diameter, and it will be readily seen that the only means of connecting the top and bottom of the lamp is by the use of the ring *B*, which is inseparable from the gauze. A small catch, *C*, falling into a slot in the milled ring secures the latter from being turned after screwing the parts together, and also ensures the separation of the shield and gauze when unscrewing.

The Mueseler safety-lamp described is only a typical case, and the principle embodied can be applied at small cost to almost every form of safety-lamp in use. By securing the oil-vessel to the middle portion of the lamp, it is a simple matter to convert lamps of the ordinary type into the new system.

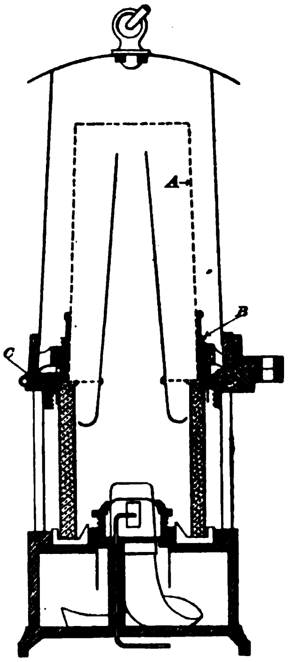


Fig. 1.

It is found in practice that the additions to the oil-vessel do not cause the slightest inconvenience to cleaning and filling, and it is claimed that no more time is occupied in trimming and screwing together than in the old form of lamp.

Mr. A. M. Henshaw suggested that a few more slots should be cut in the rim, so that the catch would lock at each of them.

Mr. E. B. Wain said there was no doubt that the danger referred to in the paper was a real one. There was not a colliery manager who had not met with bonneted safety-lamps with some defect in the gauze, and occasionally with the gauze missing. Such a thing ought not to happen; but safety-lamp cleaners were not infallible. An appliance such as had been described by Mr. Gregory would prevent any danger arising from such a cause, and they were indebted to him for having brought the matter before them.

Col. **Strick** proposed a vote of thanks to Mr. Heath.

Mr. H. R. **Makepeace** seconded the proposition. He thought that the arrangement provided by Messrs. Heath and Frost overcame the difficulty in the best possible way. It depended upon the gauze being riveted securely to the rim, and so long as they were joined together, forming one whole, the lamp-top could not be put on without the gauze being there.

The vote of thanks was carried unanimously.

Mr. E. B. **Wain** read the following paper on an "Improved Apparatus for Drawing Timber in Mines" :—

IMPROVED APPARATUS FOR DRAWING TIMBER IN MINES.

By EDWARD B. WAIN, M. Inst. C.E.

The timber needed daily for a colliery, as a rule, exceeds in cost any other material, and any apparatus for reducing this heavy expenditure should be readily welcomed. Although props in many coal and ironstone-mines are often broken during the first time of being used, they still prove valuable for cutting into pit-sleepers, or lids, or for building chock-packs, etc. Many props, which are in good condition for further use, are buried in the wastes.

Timber left undrawn in goaves often loses more than its own value, as it prevents the roof from falling, and thus increases the amount of time in building the packs, through having to bring the material from a greater distance. When the roof in the goaves cannot fall at regular intervals, an additional weight or pull is thrown upon the props standing next to the coal-face; this pressure breaks them more quickly or causes them to reel out, and that portion of the roof, which should be in good condition, is liable to sink or "cut-by" next to the coal, thus forming an obstacle in breaking down of the web of coal.

In those seams where roof in the goaves breaks down in considerable quantities, the removal of the timber is seriously impeded through its being surrounded by falling dirt, causing the expense of its recovery to be almost as much as the props are worth, although probably they are loose at the head. Under these circumstances, timber-drawing is often a dangerous operation through the state of the roof above, which frequently is broken up to such a height that temporary timber cannot practically be set. The operations are simplified by the use of the new appliance known as the Sylvester pulling-jack. The machine is of very simple construction, being founded on the principle of the ordinary "dog" or "ringer-and-chain" in general use throughout the country. It consists (Figs. 1, 2, 3, and 4, Plate XXIV.) of a notched bar about 3 feet long, 1½ inches deep, and ⅝ inch in thickness, having notches formed along one edge 1 inch apart and $\frac{7}{16}$ inch deep; one side of each notch is square, the bottom round, and the other side curved outwards. To one end of this bar is fitted, by means of a swivel-joint, about 3 feet of chain, and a hook for attaching it to a firm post. The notches of this bar form the fulcrum for a 3 feet lever, which is made with a forked end, through which pass two $\frac{7}{16}$ inch bolts, the bolts being placed a little more than 1 inch apart. The bolt, which turns in the notches, allows the lever to describe an arc sufficient to bring the sliding-block to the next notch. The other bolt connects the lever, by means of a link, to the block which slides along the notched bar. This sliding-block serves two important purposes: firstly, it is fitted with a catch-bolt, which falls at right angles into the notches of the bar, holding the block while the lever reaches forward into the next notch; and, secondly, the hinder part of the block being formed into a jaw-shaped recess, it allows any link of the chain, used for attaching to the prop to be withdrawn, to be connected and securely held. This prevents, to a considerable extent, the loss of distance along the notched bar when taking hold of a fresh portion of chain, as the length of chain may be easily regulated.

The lever of the machine being short, it allows the appliance to be used where the ordinary "ringer" or "dog," which is 3½ or 4 feet in length, would be found very inconvenient by the closeness of the surrounding timber. With this short lever, however, one man has several times been known to break new $\frac{5}{16}$ inch chain, its leverage being in a proportion of 30 to 1, and the ordinary "dog" or "ringer-and-chain" on an average only 6½ or 6¾ to 1.

When looking at the machine, it may at the first glance be considered slow in action by its only moving 1 inch per stroke of the lever; yet when we calculate that probably one-third or more of the distance advanced by an ordinary "dog-and-chain," is lost again through the springing back of the prop in consequence of the necessity of having to take hold of a fresh length of chain after each motion, the "pulling-jack" has really the advantage in regard to speed as well as power.

Another advantage of the machine is that when a post to be withdrawn is several feet distant from any standing props, it is not necessary to set a temporary one to serve as a fulcrum to remove the buried prop, which is often very difficult to do, as the brink of roof may have been damaged by the breaking down of the goaf. The appliance in these cases is attached to a firm post, which may be several feet away, and the long chain passed over a short post or sleeper which is loosely reared up at an angle against the prop to be withdrawn, as shown in Fig. 5 (Plate XXIV.); on the chain being drawn forward the inclined short post reels back, thus lifting the prop upwards and out of the surrounding dirt. The "dog-and-chain" is at a disadvantage for this purpose by its having to take hold of a fresh portion of chain at each operation of the lever.

The process described does not necessitate the removal of a large amount of the fallen roof, and allows the person using the machine to stand in a place of safety. When withdrawing a number of props it is often found dangerous to remove the last of the number, but the miner may keep himself safe by first slightly loosening the prop and attaching the machine to a firm post some distance away, instead of having to stay under the unsupported roof to knock out the prop with a hammer. The same may be said when removing the sprag at the buttock end of a web of coal, or when removing the legs supporting wooden bars or steel girders in the roadways.

Many props are lost in places which apparently are cleared, for when they are three-parts buried and require a little extra trouble to remove, it is well known that some miners will take an axe, cut off the top of the post and cover it over; but as the "pulling-jack" can usually remove them faster than they would be cut through with the axe, this waste of timber will be often prevented.

Various other purposes to which the machine may be applied are its likelihood of promoting the use of steel props, as, for a considerable time back, many attempts have been made to substitute iron or steel for wooden ones; but where the roof breaks down heavily, the expense of recovering steel props has prevented them from coming into general use up to the present time.

In recovering waggons, rails, plates, etc., which may be accidentally buried in the stalls through the sudden occurrence of heavy falls, it is rarely necessary to remove the dirt—except for the purpose of regaining the materials, and the work is greatly facilitated by using a strong power, such as may be applied by this machine, to withdraw them.

Sometimes labour and loss of time is caused when waggons are locked together through their breaking away in jigs or endless-rope work; the "pulling-jack" in these cases may be hitched to the rails, rope, or chain, and has been found to be of great service.

The appliance is also found useful for drawing the ends of elevator-chains together to make a connexion after repairs, lifting the chains on to the pulleys, and in straining wire-ropes for fencing, signal-wires, etc.

The writer has 24 of these machines in use, and they have given every satisfaction, the first cost, which is not heavy, being repaid in a few weeks. It has been found that when a machine is provided for each stall, the best results are obtained, as it is always ready at hand; where one is kept at a certain station to serve for a number of stalls, much trouble is experienced in getting each set of men to return it promptly to the station, and then the other places delay withdrawing some of their props until it is impracticable to recover them.

The only difficulty which is found in using the "pulling-jack" for the first time, is that when the sliding-block has arrived at the top of the bar, and it is required to take hold of a fresh length of chain, the miner when first using the "pulling-jack" is at a loss how to release the block; this is easily done by keeping the lever in the last notch and pressing it forward, thus relieving the catch-bolt of the weight resting upon it; the bolt is then raised and the little handle turned crossways upon the shoulders provided, which prevents the catch-bolt from engaging in the notches as it is slid down the bar.

The weight of the machine being only 28 lbs., including the 3 feet piece of chain and hook attached to the notched bar, it is found very convenient for the use of one man.

The sliding-block is cast in steel, and the notched bar made of rolled steel, the notches being machine-cut and hardened to prevent wear. The wearing parts are the three pins and the catch-bolt, which may be renewed at a very small cost.

The writer hopes that the new appliance, through its high leverage and general handiness, will commend itself to other colliery managers, enable valuable timber to be recovered, and that it will afford means of accomplishing what is necessarily dangerous work with much greater safety. He has had the machine in work for the past two years, and is more than satisfied with its working. The inventor is one of his workmen, who has taken great interest in the question of economy in the use of timber; and the machine, as it is now shown to the members, is a result of much careful study of the nature and requirements of the special work.

After having carefully tested and proved the advantages of the apparatus, he has great pleasure in introducing it to the members of the Institute, and believes that so useful an accessory for mining work will meet with the success which the care and thought devoted to it by the inventor deserved.

To illustrate Mr. E. B. Wain's Paper on "An Improved Apparatus for drawing Timber in Mines".

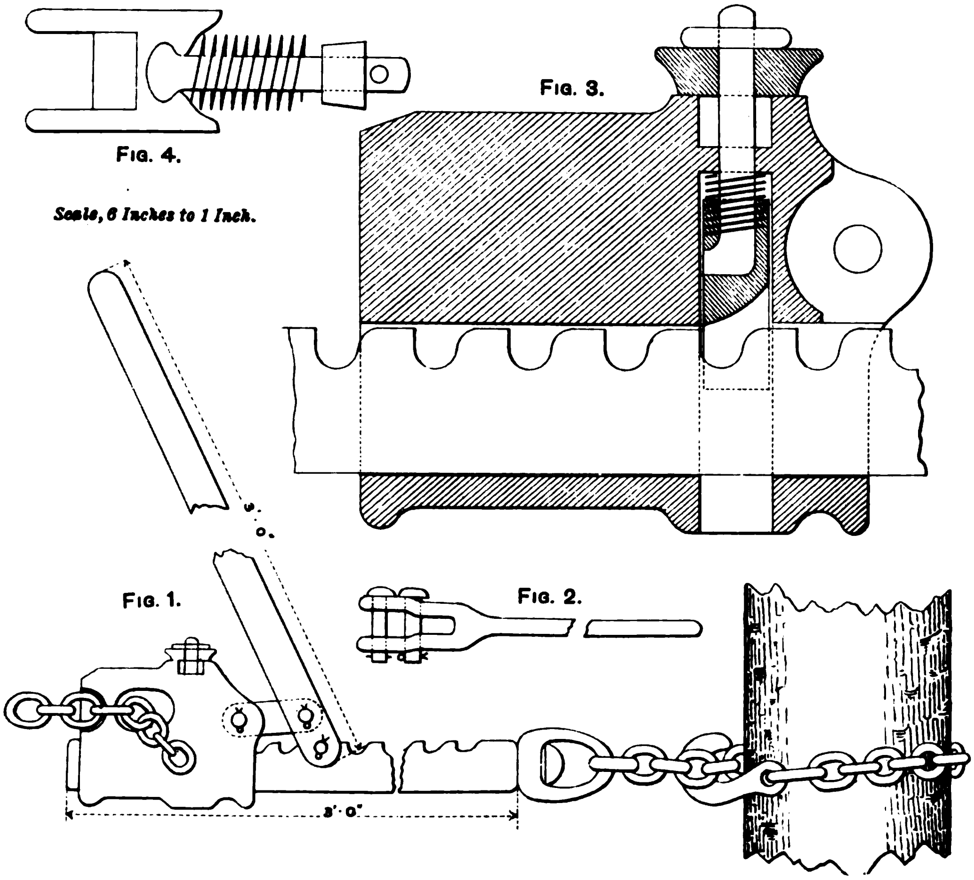


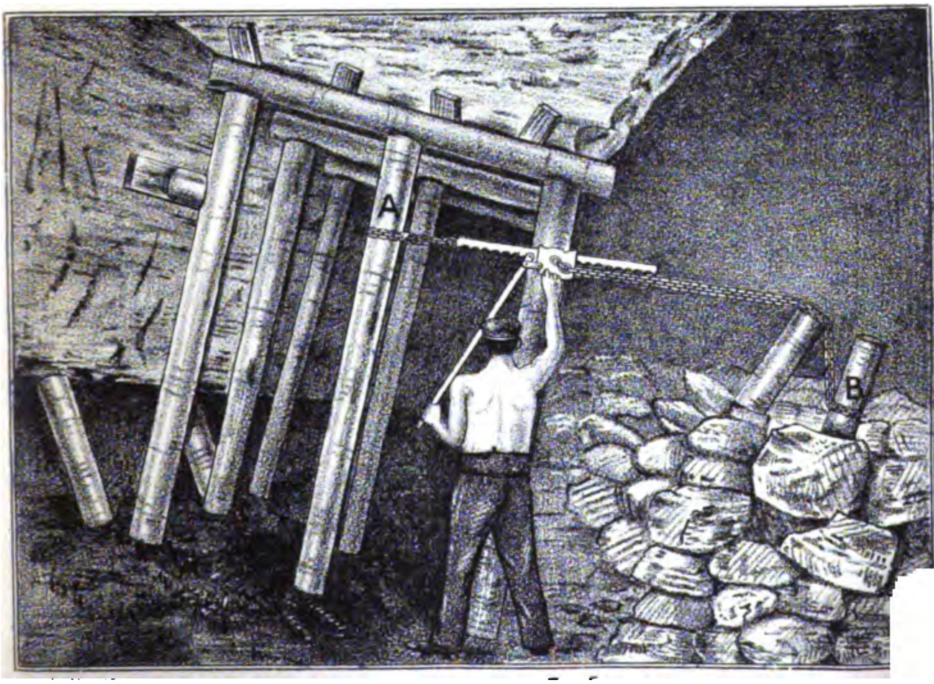
FIG. 4.

Scale, 6 Inches to 1 Inch.

FIG. 3.

FIG. 1.

FIG. 2.



Mr. H. R. **Makepeace** said that the members had been interested in having this handy little appliance for drawing timber brought before their notice. They all knew that a number of accidents did occur in drawing posts out of wastes, even a few feet from the roadways. The roof settled on the packs, and was cracking without showing any sign of weakness. A man drew the posts out in the ordinary way. He discarded the old "dog-and-chain" as unwieldy, took a big hammer, and hit at the prop till he could bring it out with his hands. Accidents happened in that way in places which appeared to be safe. The roof fell and men were injured; sometimes, unfortunately, life was lost. This machine appeared to be exceedingly handy, easily applied, and exerted very great power. He thought that it was a very useful machine, and hoped that it would be generally applied.

Mr. J. **Heath** considered the machine a very good one, and thought that it would draw many posts which the "dog-and-chain" would not move. He thought, however, that the "dog-and-chain" was not used so much as it ought to be.

Mr. **Makepeace** said that he had seen the "dog-and-chain" lying about a place where men were drawing timber by hand. Serious injuries sometimes resulted from the practice.

Mr. E. B. **Wain** remarked that with the "dog-and-chain" there must be a certain amount of loosening before it could be applied, but with this machine they might venture upon whatever the machine would stand.

A vote of thanks was accorded to Mr. Wain for his paper.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
JANUARY 18TH, 1897.

MR. JOEL SETTLE, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated :—

ASSOCIATE—

Mr. HENRY WHITEHURST, Under-Manager, Grange Colliery, Burslem.

STUDENT—

Mr. JOHN CADMAN, Mining Student, Durham College of Science, Newcastle-upon-Tyne.

DISCUSSION UPON MR. C. SEBASTIAN SMITH'S PAPER ON "SAFETY-PROPS FOR SUPPORTING CAGES IN THE HEAD-GEAR OF PITS IN CASES OF OVERWINDING."*

Mr. E. B. **WAIN** remarked that the apparatus, which seemed to be efficient, was simple, and Mr. Smith was to be congratulated upon having introduced something which was very valuable. One great drawback to detaching-hooks hitherto had been the shearing away of the chains, which set the cage at liberty. This apparatus appeared to guard against the possibility of the cage falling. They would remember the circumstances attending an accident at a colliery near Manchester, when a cage was overwound with the old detaching-hook with safety-props in

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* *Trans. Fed. Inst.*, vol. xii., page 564.

the head-gear. The connexion between the detaching-hook and the cage had been lengthened, and the props in the head-gear were not sufficiently low to catch the cage; the rope was detached and the cage fell down the pit, and care must be taken with such apparatus to prevent similar mishaps. In this apparatus, there seemed to be a heavy blow on the props, but that was more due to the heavy weight of the model cage, and the paper showed that the weight was taken up by the wedges and tie-rods. He should like to know whether that really was so?

Mr. W. N. **Atkinson** observed that this apparatus for preventing the fall of the cage after overwinding appeared to be a very ingenious contrivance, especially with reference to the way in which the shock of the descending cage was taken up by the props acting as wedges. The great question with all these contrivances was whether they would stand the ordinary wear-and-tear of work, and not get out of order and fail when they ought to come into action. That could only be tested by experience. As far as he could judge, this apparatus appeared to be efficient, although the drop of 10 feet which had been spoken of was a considerable amount to allow. If men were in the cage and had a drop of 10 feet they might be thrown out.

The **President** thought there was no doubt that the contrivance for arresting the fall of the cage was a good one, but the distance to fall appeared great.

A vote of thanks to the writer of the paper was agreed to, and Mr. **Taylor** briefly acknowledged the same on behalf of Mr. Smith.

Mr. C. E. **de Rance** read the following "Notes on Water-Supply":—

NOTES ON WATER-SUPPLY.

BY C. E. DE RANCE, ASSOC. INST. C.E., F.G.S., H.M. GEOLOGICAL SURVEY.

All fresh water, whether visible in streams and rivers or concealed beneath the earth's surface, is derived from rainfall, which alike affords the water issuing as springs, stored in reservoirs, reached in borings, present in the bodies of men and animals, absorbed by agricultural crops, utilized in various manufacturing processes, the preservation of fisheries, the purposes of inland navigation, the production of steam, and often that of electric energy.

The first rainfall observations of a systematic character were made two centuries ago by a Lancashire squire, one of the Towneleys of Towneley, near Burnley, on the borders of Yorkshire and Lancashire. In 1766, Dr. Heberden, F.R.S., placed a rain-gauge on the top of the central tower of Westminster Abbey, and two others on lower elevations, but little was done until Mr. G. J. Symons, F.R.S., in 1859, commenced to collect rain records. In 1861 he wrote to all observers known to him for their records, of whom 168 replied; in 1863, he wrote to the *Times* newspaper that he had 700 stations, and in the following year he announced that the development of the enquiry had proved so rapid, and its bearing on engineering, agricultural, and sanitary questions so far-reaching that, sacrificing pecuniary prospects, he determined not to "abandon an investigation, the ramification and importance of which we cannot see." In the current volume for 1895,* the modest four-paged pamphlet of 1861 has developed into a volume of nearly 240 pages, containing no less than 3,084 complete records of rainfall in the British Isles.

The annual volume of Mr. Symons may be regarded as the only basis on which the "water capital" of the British Isles can be even approximately estimated, and looking to the national importance of these observations, as to their correctness and continuity, and their bearing on the well-being of the nation, it will be realized that the conditions are anomalous, that such a magnificent organization should be carried out by a voluntary staff controlled by a volunteer chief, and

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* *Symons' British Rainfall*, 1895.

by means of funds dependent on voluntary subscriptions, which funds are not sufficient to send out inspectors of rain-gauges, which are much needed, or to compute and print the local averages of rainfall, for which ample material has been collected in numerous districts.

Mr. Symons, after a long series of years' observations,* arrived at the following conclusions as regards the British Isles :—

1. The wettest year will have a rainfall of nearly half as much again as the mean.

2. The driest year will have one-third less than the mean.

3. The driest two consecutive years will each have one-quarter less than the mean.

4. The driest three consecutive years will each have one-fifth less than the mean.

A rainfall, or hyetographical, map was prepared by Mr. Symons for the Royal Commission on London Water-supply, presided over by the Duke of Richmond (1866). From this map it will be seen that England and Wales may be divided into three areas, the rainfall being less than 25 inches per annum east of a line ranging from Shields to Reading, while west of a line, ranging from Shields to Start Point, the Lower Palæozoic areas of the Lake District, Wales, and Dartmoor receive a rainfall of more than 75 inches, rising to over 150 inches in Seathwaite.

The available rainfall in any district is dependent upon the hydro-geological conditions, which are governed by the direction of the strike of the hills and valleys in regard to the prevalent wet wind, the height of the hills, and that of intervening gaps in their crest, the comparative porosity of the rocks of which the hills and valleys are composed, and the steepness, or flatness of the gradient, of the descent from the crest of the hills to the sea, or that of tidal rivers. The amount of loss due to evaporation is also largely influenced by the hydro-geological conditions. After a long drought, the first rain never passes a foot underground, through the dry condition of the surface even in porous soils, and, in subsequent rains, the water-capital is in direct relation to the relative porosity of the material—impermeable rocks passing off nearly the whole of the rainfall, and in those of the older geological ages, where the declivity is great, little is evaporated, and none absorbed.

It is often possible, without any knowledge of the geology of an area, to form a correct estimate of its degree of porosity by inspecting an Ordnance map of the scale of 1 mile to 1 inch. Let squares of 1 inch be

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* *British Rainfall*, 1883, page 32.

traced on tracing-cloth, each of which when placed over the map covers an area of 1 square mile, it may safely be assumed, if the area so covered contains no engraved stream-lines, that the area is wholly composed of porous rock, receiving the whole of the rainfall, except that portion which is evaporated, the balance finding its way into the underground stores of water below. When the linear extent of the stream-lines is above 1 inch, one-third of the rainfall will be evaporated, one-third absorbed, and one-third run off in floods. If numerous stream-lines intersect there will be no absorption, and the water must be either caught in large catchment-reservoirs capable of holding many months' supply, on the flat lands suitable for crops or cattle, or lost altogether in floods, which bring discomfort, loss of property, and often disease to the regions below. Again, without a geological map, with a knowledge of the area of the district drained by a stream, an inspection of the size of the sectional area of the arches of the bridge over a stream will give a key to the porosity, or impermeability of the strata forming the drainage-area. The sectional area of the arches entirely differ in identical areas, composed in the one case of porous, and in the other of impermeable rocks. The author is indebted to the late Mr. Henry E. Martin, M. Inst. C.E., for the first observation, and to the late Mr. Collet Homersham, M. Inst. C.E., for the last.

Percolation of Rainfall into the Ground.—Between 1796 and 1798 simultaneous experiments were made at Manchester by Dr. Dalton, and by Mr. Maurice at Genoa. Dr. Dalton's gauge was a cylinder 10 inches in diameter and 3 feet in depth, open at the top and closed at the bottom, filled with earth, and sunk into the ground until the top was level with the surface. He found that 25 per cent. of the rain was absorbed. These observations were probably taken with the soil resulting from the decomposition of vegetable matter mixed with the stiff Lancashire Boulder Clay. Mr. Maurice's observation gave the larger figure of 39 per cent.; while the very careful observations taken by Mr. Dickinson between 1836 and 1843 at Nash Mills, near Hemel Hempstead, Hertfordshire, gave 42 per cent.; this was with a chalky porous soil. The Nash Mills observations have been continued to the present time by Mr. Dickinson's partner, Sir John Evans, Bart., F.R.S.

The gauge and two cast-iron cylinders, 18 inches in diameter, and 3 feet in length, turned to a knife-edge on the top, are sunk to a depth of 3 feet below the level of the ground in which they are placed, so that the edge just projects. One of the cylinders is filled with the ordinary surface-soil of the neighbourhood, and the other with fragmentary chalk. Grass is placed on and around the cylinders. The rainfall is observed in the immediate neighbourhood of the gauges, and the register is made up at 9 a.m. The year is divided into two parts, the winter half commencing on October 1st, and the summer half on April 1st.

The following figures give the average rainfall for thirty years :—

Winter.				Summer.		
Rain. Inch.	Soil. Inch.	Chalk. Inch.		Rain. Inch.	Soil. Inch.	Chalk. Inch.
13·75	5·70	8·53	...	14·09	0·81	2·11
	Annual average ...		...	27·84	6·51	10·65

The varying capacity of soils for the downward transmission of water is well shown in the above table, but Sir John Evans points out that it is doubtful whether a 3 feet tube is a fair test of the water that would really make its way down to feed the chalk water, as it is possible that atmospheric influence may reach even 10 feet, and water may be drawn up by capillarity within the limit of superficial evaporation.

Mr. Greave's observations at Lea Bridge from 1852 to 1873, with an average rainfall of 26·80 inches, gives an average percolation of 26·60 per cent. He finds the abundance of water, in a river, to be more closely dependent on percolation than on mere rainfall; for many consecutive months there was no percolation whatever; five times there was no percolation for six months; and only in one year (1860) was there percolation every month. The greatest percolation is after snow thaws, especially after frequent thaws of small falls. A wet winter gives abundant springs in the following autumn, but if that be followed by a dry winter it will obliterate the effects of the previous wet winter. Mr. Greaves is of opinion that a flat soil will never produce a flood if it be effectually under-drained, as it then resembles the percolation-gauge; such under-draining would diminish floods, and the water would be run off gradually and improve the dry-weather discharge. Mr. Greaves considers a percolation-gauge should be 36 inches deep, and that at that depth water is safe from the surface-loss. He suggests that in the different degrees of capillarity of different soils lies the cause of their variations in healthiness, the high capillary power of a clay soil producing a constant summer exhalation.

On this subject, a very important paper, read by Mr. R. H. Middleton, M. Inst. C.E., on "The Relative Value of Percolation-Gauges," before the Society of Engineers in 1895,* throws a considerable

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* *Trans.*, page 153.

amount of doubt upon the practical value of the results obtained in these gauges, and tends to show that the conditions are too artificial to give natural and reliable results. One inch of rainfall, falling in one year, gives a daily average of 40,000 gallons per square mile. In most porous rocks it may safely be assumed that one-third of the rainfall percolates; 30 inches of rainfall giving 400,000 gallons per day.

Gravitation Supplies.—The Palæozoic rocks in the Lake District, as at Thirlmere, and in Wales, as at the sources of the Severn and the Wye, occur in districts receiving the heaviest rainfall of the United Kingdom, over an area having no chemical or artificial pollution disadvantages, the land is of small value, the population is scanty, and no one can doubt that the acquisition by Manchester of the Lake District soft water, and by Liverpool and Birmingham of Welsh soft water is a national advantage.

(1) *Disadvantages.*—The legal and parliamentary expenses, buying up land, and riparian owners' rights, or, as regards the latter, compensation in bulk, of which the conditions imposed by Parliament, are not only often onerous but most unjust; but this hardly affects the works described above, though it has a very considerable onerous effect on the great chain of gravitation-waterworks in Lancashire and Cheshire derived from reservoirs in the Lower Carboniferous rocks.

(2) *Economic Drawback.*—Preventing for good the area of the reservoir-site from producing food-stuff for cattle, such areas being generally the most suited for that purpose in the region.

(3) *Danger.*—The possibility of the failure of the reservoir-embankments, and the loss of life and property by sudden floods. This danger is also present in all our manufacturing districts where lodges or small reservoirs are constructed with earthen banks for the storage of water for trade purposes, without the trained supervision usually of necessity provided in a reservoir for waterworks purposes. The possibility of pollution from manured lands.

Saturation-plane.—In flat tracts composed of perfectly porous deposits, resting on impermeable material, the ground water-line, or saturation-plane, may be only a few feet or few inches from the surface, and this position has governed the first choice of sites of the older towns and villages in England, which invariably occur on tracts of permeable material. Indeed, it was not until waterworks induced artificial conditions that impermeable areas became inhabited: this is well seen by comparing maps of London of the time of Queen Elizabeth and subsequent periods, when it will be seen that London was first restricted to the lowland river-gravels, then extended to the terrace-gravels, and thus remained until its waterworks enabled the London Clays of the north of London to be built on and inhabited. Now its extension is governed by a new factor, facility of locomotion, and its progress follows the lines of railway and tramways. Probably in the near future, the spaces between will be filled up through the influence of the motor-car, and where the population goes the waterpipes of the engineer will follow. Before leaving this portion of the subject, it may be well to point out that shallow wells and ordinary pumps, under natural conditions, are not altogether unwholesome, but main-drainage in porous districts introduces two dangers: (1) the junctions of the sewer-pipes are constantly defective, and dangerous percolation takes place; (2) this is accentuated by the fact of a trench being dug, and extensive temporary pumping taking place, which causes the outside of the line of sewer-pipes to form a free underground water-way, carrying deleterious matter from one point to another. Local wells under such conditions must be always discarded, even if no injurious element can be discovered by chemical analysis, as pathological germs cannot be detected by its processes.

In sandstone and limestone rocks, intersected by valleys, the saturation-plane descends from the junction of the porous rocks with the impermeable material below, at their outcrop to the level of the deepest valley on the dip, intersecting the junction of the porous and the watertight deposits. Any valley occurring between will be either waterless, or only temporarily supplied with a ready-made stream at certain periods of the year, varying as to the exact date, according to the previous rainfall (Fig. 4, Plate XXV.). Such temporary streams, in the Chalk and in the Carboniferous Limestone, are called "bournes," "nailseas," and "gypseys" in different districts; they only occur when the ground-water or saturation-level of the water, stored in the ground, rises above the level of the bottom of the intersecting valleys. This rise in the ground-water is almost invariably connected with outbreaks of typhoid-fever, the water, in populated districts, in its rise absorbing deleterious elements, taken up from the surface of porous rocks, especially those of a calcareous nature.

In the case of sandstone and grits, the filtrating power is so strong that these bad results do not often occur. In the case of both this class, and of that of the calcareous rocks, the saturation-plane will invariably be found, under undulating ground, to be slightly curved, and roughly parallel to the absolute surface, the additional surface of the hills giving locally a larger percolation.

Cones of Exhaustion.—These cones are inverted, the base being the surface-area drained, and the apex the point of suction. When the well is first pumped the water is always harder than after it has been pumped for some time, the area of absorption having its soluble salt removed. If the pumps be lowered to obtain a larger supply, a fresh concentric zone is brought under contribution, and the water again hardens, after a time softening to the point previously experienced with the central circle (Fig. 5, Plate XXV.).

It by no means follows that the base of the cone is a circle, or even a conic section of any kind, as one side may be abruptly terminated by a fault cutting off the porous material, for the porous stratum may unconformably thin off or overlap an older unconformable strata. In wells of this class the radius of the base of the cone of exhaustion may be 2¾ miles; if two wells are placed within that distance, their action will be reciprocal, the deepest and strongest pumps getting the larger supply, the cessation of pumping at one point, at once raises the saturation water-level, as shown for instance in the floor of adjacent quarries, and increasing the supply obtainable at the nearest pumping-station.

Pumping-level.—When pumping in an ordinary well has produced a cone of exhaustion, and a constant quantity is daily abstracted, the water is said to stand at the pumping-level. If no pumping takes place on Sundays, the water rises somewhat higher and forms the rest-level, which seldom in 24 hours rises to the original saturation or ground-level of the water. The water-supplies of Nottingham, Mansfield, Birkenhead, Wallasey, Southport, Ormskirk, Coventry, Wolverhampton, Lichfield, Liverpool (in part), and Birmingham are derived from wells belonging to this group.

Springs occur under Several Conditions.—The first method is restricted to calcareous rocks, where streams flowing at the surface over a naturally puddled river-bed, suddenly disappear down a swallow-hole, following the line of a natural fissure or joint; the water makes its way vertically to the first impermeable layer, over which it travels down the dip until the measures are intersected by a valley, when the water issues in a cavern-like outlet as a ready-made stream, often a distance of many miles from the point at which the water was taken in. Numerous examples might be quoted, as the chalk springs at Carshalton, forming the River Wandle in Surrey; the Chadwell springs near Amwell, Hertfordshire, intercepted by the New River on their way to the River Lea; and the tributary streams of the

River Swale, in the Carboniferous Limestone of north-western Yorkshire. In this case it will be noted that the direct flow occurs in what is practically a defined channel, and has therefore two important disadvantages—(*a*) it is not filtered, nor has it even the advantage of oxidation, afforded to water flowing under the influence of air and sunlight; (*b*) it has not the protection of the law, which considers underground water "free, like game," to all who have the right to take it; even if in the process every drop is consumed, and the original person using it is thus entirely deprived of it. The law assumes, perhaps correctly, that, except under the conditions just named, all underground water occurs in sheets and not in defined channels, and it gives "no right of support of water," so that if pumping operations in plot A, deplete plot B, on which buildings had previously stood, which were destroyed by the pumping, B has no remedy for such destruction. But, on the other hand, the law gives B the right, if he has a well, to have it kept pure; and though A cannot be prevented from sinking a well to take B's water, B can get an injunction against A if he allows objectionable matter to pass into his well, so as to pollute it.

Other classes of springs are as follows:—"Surface-springs," small in volume, uncertain in quantity, possibly dangerous, and always suspicious in quality, thrown out where streams or shallow valleys traverse alluvial deposits of varying porosity. If the supporting impermeable material be more or less trough-shaped, the axis of the trough will carry the larger volume of water, and when intersected by a valley will form a spring, or give to a shallow well a fair supply for strictly local purposes, while wells on either side will not. This is the class of condition usually dealt with by the so-called "professors" of the art of the divining rod, or "dowsers." No instance is known to the author of any first-class supply of water being met with, by the process named, during the thirty years in which he has investigated supplies of underground water.

The third class are "valley intersection springs," occurring where the depth of the valley is sufficient to intersect the saturation-level of the water in the rock; the yield is largest when the bottom of the valley happens to coincide with the junction of the porous and impermeable material (Fig. 6, Plate XXV.).

The fourth class are "springs of outcrop" where the porous rocks reach the surface and the dip-planes are fully charged. Any additional rainfall so raises the ground-level of the water or saturation-level, that springs issue, strange as it may appear, on the outcrop junction of the porous and impermeable strata at its highest level (Fig. 4, Plate XXV.).

Faults.—The hydro-geological effect of a fault is entirely governed by the nature of the material with which the fissure of the fault is filled. This is invariably derived from above, either from the immediate surface, or from the upward prolongation of the fault, from ground since removed by denudation. No better example of this can be found than at Liverpool. The district is traversed by several important faults, some of which intervene between the four public wells, which together yield 6,000,000 gallons of water daily. The faults being in the present and in the past wholly surrounded by porous New Red Sandstone, are themselves porous, water passing freely through them in either direction to the point of lowest suction (Fig. 3, Plate XXV.). On the contrary, the Bootle fault, which traverses the western side of Liverpool, divides an eastern area of good water—which has not altered since 1851, when Dr. Phillips analysed it for Mr. George Stephenson—from a western area of polluted saline water, in which all public wells have been long given up, and private wells are following their example. This fault is naturally puddled by the former occurrence (upwards) of the Keuper Marl, and the draught exceeding the percolation, the tidal river is directly drawn on (Fig. 1, Plate XXV.).

Faults may be wholly porous even with a downthrow of 1,000 feet, or wholly impermeable, and naturally puddled, with a downthrow of less than 100 feet. To predict what is the nature or degree of permeability, or otherwise, of the fissure of a fault, it is necessary to be acquainted not only with its existing upcast and downcast sides, or as the miner would say, its "hanging-wall" and its "foot-wall," but their former upward prolongations. Where beds of marl, clay, or shale were originally present on the ground, since removed by denudation, the fault-fissure is invariably filled with impermeable material, although the existing upcast and downcast sides of the fault consist of porous material.

Where porous strata, charged with water, dip towards and terminate against a fault, which brings up impermeable material, or is itself naturally puddled, water at pressure will constantly rise on the face of the fault and form a chain of springs (Fig. 2, Plate XXV.). The water which thus rises being of a warm and uniform temperature throughout summer and winter, it is not uncommon to see lines of fault in winter marked out by a green grass belt when hoar frost covers the ground. The late Mr. Taunton, M. Inst. C.E., in his evidence before the Royal Rivers Commission, on behalf of the Thames and Severn Canal, showed that the bed of the Thames absorbed large volumes of water in passing over porous strata, and that these were returned to the area lower down its stream by the action of the faults intervening. Where faults do not occur, there is no doubt whatever that large volumes of good water are lost by passing down under the overlying strata to the sea. Water thus travelling can often be intercepted, as at Gainsborough, where the rainfall of an area lying 7 miles to the west is reached, by boring through nearly 1,000 feet of marls, on its way to the German Ocean.

Artesian Planes.—Where bands of permeable and impermeable rocks alternate, each layer contains a separate sheet of water, often of different quality, which flows down the dip-plane of the strata confined by the impermeable layer above and below (Fig. 6, Plate XXV.). Such water flows with the head due to the difference of vertical level of the area of outcrop from that of the area of discharge, less the frictional resistance caused by the fragments of rock through which it passes; when the facilities of discharge are less than the quantity capable of being received, the porous rock will be full up to the roof formed by the impermeable layer above. This is also always the case when all outlet is stopped by faults throwing in an impermeable barrier, on the principle that a quart-pot can only hold a quart and no more (Fig. 2, Plate XXV.).

Marine and Tidal Leakage.—A fertile source of loss is the passage of water below sea-level, which may be called marine and tidal leakage. Good examples of this occur in the well-known Hessle Whelps, at the mouth of the Humber, near Hull, where the water with imprisoned air issues at pressure in the bed of the Humber. Other examples occur in the bed of the Thames, in North Kent, and Essex, and in the fresh water-springs met with in open seas, as in the Mediterranean, and the Spithead wells in the Solent, the first of which was recommended by the late Mr. R. W. Mylne, C.E., F.R.S. (then consulting hydraulic engineer to the War Office), as the result of an enquiry, held by the writer under his direction, which resulted in the rainfall of Osborne, in the Isle of Wight, being rendered available for the supply of the forts in the Solent.

The enormous loss of effective rainfall that takes place through the percolated water being carried under the sea is hardly recognized in this country. But in Queensland, Australia, the writer's former colleague, Mr. R. L. Jack, government geologist to that colony, in the *Annual Progress Report of the Survey* for 1894, published in Brisbane by authority in 1895, has shown that:—

> The amount of water contributed to the water-bearing strata of the Lower Cretaceous formation every wet season, by such rivers as the Darling, is so great, and consequently the amount of leakage into the sea is so great that the quantity abstracted by the artesian wells, large as it is, and even if it were ten times greater, is insignificant by comparison. Finally, as the leakage into the sea is so vast, and is entirely beyond human control, the draught on our underground supply made by artesian wells is not worth controlling.

It is of interest to note that Mr. Jack gives the details of no less than 372 artesian borings, giving a united daily yield of 395,000,000 gallons of water, and these have penetrated about 80 miles of strata. Most of these borings intercepted more than one sheet of water, some of them as many as eleven. Of these borings, 40 were over 2,000 feet in depth, and 16 were over 3,000 feet.

The writer has tabulated from Mr. Jack's report the following details of the deeper borings, to which special reference is given:—

The pressures are given in maximum lbs. per square inch observed, and the temperatures in Fahr. degs.

Borings Over	1 Million Gallons and Over.			2 Million Gallons and Over.			3 Million Gallons and Over.			4 Million Gallons and Over.		
	No.	Temperature.	Pressure.	No.	Temperature.	Pressure.	No.	Temperature.	Pressure.	No.	Temperature.	Pressure.
		Degs.	Lbs.		Degs.	Lbs.		Degs.	Lbs.		Degs.	Lbs.
1,000 feet	10	112	180?	3	120	—	5	124	200	2	108	—
2,000 ,,	6	180	60	2	81	25	—	—	—	1	126	—
3,000 ,,	2	196	8	—	—	—	—	—	—	—	—	—

In the deepest boring of 3,948 feet the water rose 3,890 feet; out of ten borings over 3,000 feet, two gave 1,250,000 gallons and 1,400,000 gallons respectively; five less than 250,000 gallons, and one only 20,000 gallons with a temperature of 161 degs. Mr. Jack gives much additional information in a paper on "The Submarine Leakage of Artesian Water."* He quoted Mr. H. C. Russel, who showed that the Darling river only carried away 1½ per cent. of the rainfall, while the Murray river carried away 25 per cent. of the rainfall, the conditions of climate, wind, rain, and evaporation being the same, the disparity being due to the porous character of the one basin and the impermeability of the other. The rainfall in the Darling area in 1891 was 27·27 inches, the balance of the overflow being absorbed and passed on by the strata under the sea. In this connexion Mr. Jack stated in his official report that some artesian borings had shown marked fluctuations in the flow of the water that they afforded, which could alone be ascribed to variations in the amount of rainfall absorbed, after making due allowance for the possible caving-in of some holes, or bad jointing of the tubes, or the precipitation of mineral matter in them. That submarine leakage extensively takes place had been proved by a boring at Normanton, on the edge of the Gulf of Carpentaria; this, commencing at a level of 30 feet above the gulf, penetrated at 1,950 feet below it, the plane of artesian water, and it appeared that there was

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* *Proceedings of the Royal Society of Queensland*, 1896, vol. xii.

reliable information that fresh water bubbled to the surface at pressure far out in the Gulf of Carpentaria.

Similar facts are established by Mr. A. Gibb Maitland in a paper on "Extra-Australian Artesian basins,"[*] in which he showed that the great water-basins of both the coastal and greater interior regions of the United States of America are not the ideal synclinal trough which figures in text-books, the two rims differing in level by many thousands of feet. The Cretaceous Dakota sandstones discharge heavily by artesian springs into the valleys of the Missouri, the Big Sioux, the James, and the Vermillion rivers, and though the actual discharge into the sea-bed is not capable of being seen or visited, the reduction of hydraulic head in the coastal artesian-wells shows that water is not confined in a sealed basin. Reference to any geological map of South Britain will show that the Triassic, Oolitic, and Cretaceous porous rocks similarly dip eastward under the German Ocean.

Artesian Wells.—The distance from the area of absorption is less important than the relative level between that area and the point where the artesian water will be intercepted by boring. For, though the mechanical friction of the grains, between which the water percolates and passes, is probably equal in all directions, the level to which water will rise after overcoming the friction is governed, as in pipes, by the hydraulic head. It is important to consider where the area of depletion of water will take place in the area of absorption of rainfall, so as not to clash with any existing cone of exhaustion. Thus, at Gainsborough, two borings yield a so far unlimited supply from an area 6 or 7 miles distant.

Most artesian wells at first deliver water at the surface, and often many feet above it, but whether they continue to do so depends on whether there be a free waterway underground, and if so, the relation of its sectional area of disposal to the absorption area of percolation. When pumping takes place, the artesian head is diminished, and an artesian pumping-level is brought into existence, and an artesian rest-level at its cessation.

Where faults intercept the dip, and water is pounded up, a rock may contain water (as the late Mr. Hawksley called it) of cistern-age, water absorbed and accumulated from year to year, that cannot get away, and not derived from rainfall of the current year. Such wells at first draw not only on annual revenue, but on their capital, and soon diminish in their yield.

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[*] *Proceedings of the Royal Society of Queensland*, 1896, vol. xii.

Appended hereto are some details of various classes of rocks. It must be ever realized that the harder the rock, and the closer its grain, the more any water yielded must pass unfiltered through fissures and joints. The more open the grain, the larger are the interspaces, and the greater the volume capable of being stored. Thus a chemical analysis of any set of rocks will form a fair guide as to the general character of the water likely to be met with.

The writer trusts that these general remarks may be helpful to those members who, on their own resources, may have to solve important requirements for water-supply without the advantage of the various data, at once obtainable by an engineer in this country.

	Specific Gravity.	Weight of a Cubic Foot.	No. of Cubic Feet in a Ton.	Holds Gallons per Cubic Foot.	Gallons per Cubic Yard.	Gallons per Acre 1 Yard Thick.	Gallons per Square Mile 1 Yard Thick.
		Lbs.	Cubic Feet.	Gallons.	Gallons.	Gallons.	Gallons.
Water—Rain ...	1·000	62·5	35·8	6·23	168	—	—
„ —Sea ...	1·026	64·1	35·0	6·23	—	—	—
Ice	0·940	58·7	—	—	—	—	—
Sand	1·886	118·0	19·2	2·00	54	261,360	167,270,400
Chalk	2·315	145·0	15·4	2·00	54	261,360	167,270,400
Bath Oolite ...	1·837	115·0	19·5	1·25	33	—	—
Magnesian Limestone	2·316	145·0	15·4	1·75	47	—	—
Good building sandstone ...	2·266	142·0	15·8	0·625	17	—	—
Pebble-beds ...	2·506	151·0	14·4	0·733	20	96,800	61,952,000
Granite... ...	2·662	166·0	13·5	0·185	5	24,200	15,488,000

Mr. R. H. COLE moved a vote of thanks to Mr. de Rance for his valuable paper.

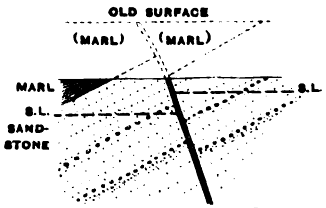
Mr. T. M. FAVELL, in seconding the proposition, said that there was a well belonging to the Sunderland and Shields Water Company that had been 40 years in existence. It had been supplying fresh water, though hard, and the water had recently turned salt. Twenty years ago, when two shafts were sunk at Whitburn colliery, a great quantity of water was met with, so that the Kind-Chaudron system of sinking had to be adopted. Part of this water was fresh and part of it was salt. Possibly the sinking of the shafts caused communication of the salt water from the sea with the fresh water of the land; and that might be the cause of the damage of the water at the well.

Mr. DE RANCE said that would most likely be one of the causes.

The proposition was adopted.

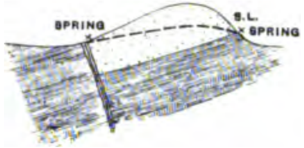
To illustrate Mr C. E. De Rance's "Notes on Water-Supply."

Fig. 1.



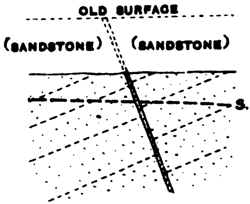
Water-tight Fault, no Springs.
Two Saturation Levels (S.L.)

Fig. 2.



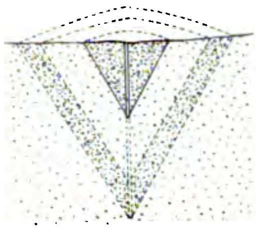
Water-tight Fault, Springs,
Saturation-Level (S.L.)

Fig 3.



Porous-Fault, no Springs,
Common Saturation Level. (S.L.)

Fig. 5.

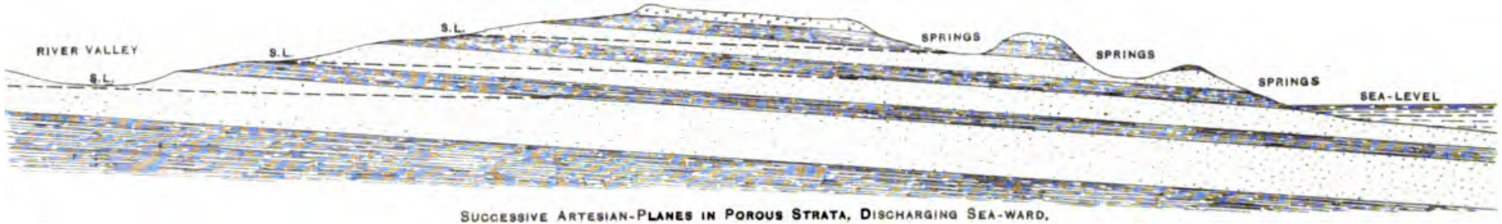


Cones of Exhaustion.

Fig 4.

Seasonal Variation of Saturation-Level (S.L.), resulting in
Temporary Bournes, after winter rains, and Permanent
Springs at Lower Levels.

Fig. 6.



Successive Artesian-Planes in Porous Strata, Discharging Sea-ward,
Saturation Levels (S.L.)

Andw Reid & Compy Ltd Newcastle on Tyne

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE MASON COLLEGE, BIRMINGHAM, FEBRUARY 2ND, 1897.

MR. R. S. WILLIAMSON, PRESIDENT, IN THE CHAIR.

The minutes of the last General and Council Meetings were read and confirmed.

The following gentleman was elected :—

MEMBER—

Mr. SAMUEL RENDELL, Mechanical Engineer, Klerksdorp, Transvaal.

It was agreed that a letter of condolence be addressed to the relatives of the late Mr. William Farnworth, who was a member of the Institute from its formation, and was President in 1882.

Mr. F. G. MEACHEM read the following paper on "Bumps and Outbursts of Coal" :—

BUMPS AND OUTBURSTS OF COAL.

By F. G. MEACHEM.

In 1893, the writer gave a description* of an irruption or an earth explosion—locally called a bump—at Hamstead colliery. Since then, there have been some very rough experiences of a like nature, and it may be useful to place on record the writer's notes of his observations made during the course of the last 20 years.

These bumps occur without the slightest warning, and are often accompanied with most disastrous results. The depth of the mine is 1,950 to 2,100 feet where these bumps take place. Most occur in the driving of the gate-roads, and those in the workings are not so heavy.

(1) A considerable amount of trouble was experienced from bumps in the western workings in the thick coal-seam. Thinking that the work could be effected with greater safety while driving the roads on the top of the sawyer layer of coal. Adopting an old South Staffordshire method, wooden cogs were placed on each side of the road, and this system proved a most efficient protection by keeping up the roof. The cogs were, however, totally inadequate to prevent the occurrence of bumps.

In 1882, a very severe bump occurred, killing William Wall and injuring several other workmen. Fig. 1 (Plate XXVI.) shows the effect of this bump, an unfortunate workman having been thrown against the roof and killed, while the road was filled with coal. When the road was cleared, it was found that the coal and dirt had been thrown up from the bottom without breaking the trees or timber couplings.

(2) A road was being driven 1,200 feet distant from any workings in solid coal in the middle of the thick coal-seam, as being probably the strongest place and least likely to suffer should a bump occur. Fig. 2 (Plate XXVI.) shows the effects of a bump which occurred, three of the workmen were seriously injured by being thrown against the top, and a

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* *Trans. Fed. Inst.*, vol. v., page 381.

tub was driven 2 inches into a bar, against which it was thrown. None of the timber was broken, but the road was filled with *débris* for a distance of 60 feet from the working-face.

(3) This place was then being driven by three shifts of workmen in 24 hours. But after consultation with deputies and workmen, it was decided to stop the third shift and to drive the road near the bottom of the seam, leaving only the benches coal below, the workmen thinking that the soft fire-clay, which underlies the thick coal-seam would not blow up as the coal had done. Within a week, the road was cleared and worked down to the benches coal, placing the road in the position shown in Fig. 3 (Plate XXVI.). About 24 feet of road had been driven, and especial precautions taken and instructions given as to the timbering. The writer inspected the road and considered that the timbering was efficient and capable of withstanding the most severe bumps. Larch trees, placed 18 inches apart, and from 6 to 8 inches, were used, and similar sized bars. The road in the position shown in Fig. 3 was continued, as the workmen still held the opinion that it was the safest position. Similar timbering was continued, the trees being laced together on the top with lugging-poles (4 inches in diameter), and completely covered over the top with oak slabs, 1 and 2 inches in thickness. Many feet further had not been driven before a terrible earth-shock occurred, at 10 p.m. on July 27th, 1896, entirely destroying the timber, as shown in Figs. 3 and 4 (Plate XXVI.).

The coal at the face of the road was burst out from the solid for a distance of 6 feet, and converted into fine slack. Thomas Richards was completely buried, and two other workmen were fastened under the timber a short distance down the road. Two of the workmen were quickly liberated, and strenuous efforts were made to reach Richards, who was in the back, and his early release was anticipated. A careful examination, however, showed that it would be impossible to do so except by passing over the setting shown in Fig. 3, and then digging down to him. At 11 p.m., a second bump occurred, completely filling the place with *débris*, small coal and slack, and shifting some of the broken timber. As soon as the place was still, digging was resumed, until at 1·30 a.m. a third bump shook the place, the under-manager, one of the workmen, and the writer received slight injuries, and it was decided to withdraw for ½ hour, and allow the place to settle. All persons were withdrawn, and it was not until 4 a.m. that we reached the body of Richards, who had been suffocated by the fine slack.

(4) After this road had been standing for a week, it was decided to get against the top of the seam and to drive one turn only in 24 hours, and the writer's experience of this plan is shown on Fig. 5 (Plate XXVI.). The marks *A* show fire, where the coal ignited from spontaneous combustion.

(5) It was therefore decided to drive the roads as shown in Fig. 6 (Plate XXVI.). The holing is made on the top of the brazils, the greater part of the work being done with a pricker 12 feet in length. After the holing is made to the depth of about 2 or 2½ feet, a slight bump usually occurs, throwing out the broken coal shown in the drawing, and the workmen have to exercise great care, or they would be buried or injured. One workman has been injured since this method of working has been adopted in driving the four gate-roads which had previously given so much trouble. Prior to the adoption of this plan the following experiments had been made :—

(1) Driving continuously, that is three shifts per day.

(2) Bore-holes driven in front proved completely useless.

(3) Holes were sunk into the bottom, within 6 feet of the back, and Fig. 2 (Plate XXVI.) shows the utter uselessness of this method.

(4) Careful watching shows that bumps occur when the workmen are cutting through what is locally known as a " hard spang." That is, the coal is of such a quick nature that it cuts very freely, but every now and then a hard piece is met with, and it is while cutting this hard piece that a bump occurs. This fact has led to the adoption of blasting whenever a " hard spang " is met with.

The writer personally attended several of these experiments, and found that the shot brought the bump with it, and this did not give the required safety. One of these shots was fired only a few hours before Richards was killed.

(6) Fig. 7 (Plate XXVI.) illustrates an accident which occurred on November 3rd, 1896, and Fig. 8 is a plan. In this case, the men were at work repairing, and all timber was apparently safe. Without the slightest warning the place crushed in, as shown in Fig. 7. It is open to question whether this was an actual bump, as only two men happened to be in the place at the time. One workman was killed, and the most careful questioning of the other failed to establish whether there had been a bump or not. While the work of rescuing the injured man and recovering the body was proceeding, two small bumps occurred, and the workmen were withdrawn for a short time, until the place settled, before

The Federat *utbursts of Coal."* VOL. XII. PLATE XXVI

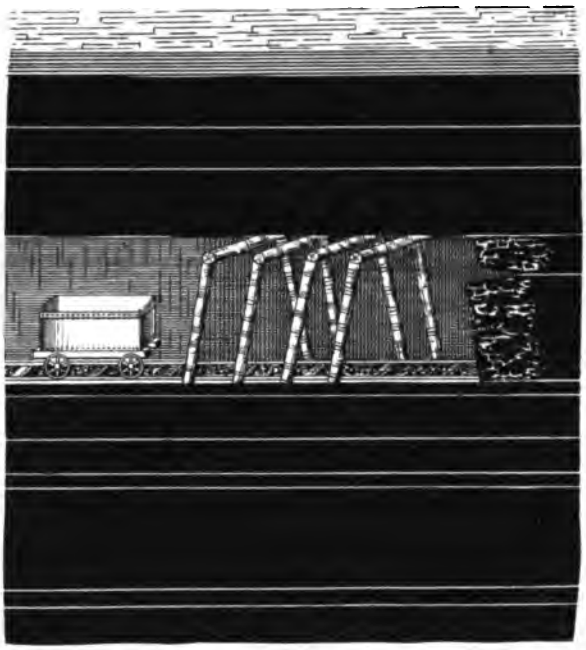


FIG. 6.

, 8 Feet to 1 Inch.

FIG. 8.

recovering the body of Hodgkins. The writer believes that a bump occurred, but there was no conclusive evidence.

APPENDIX.

Section of Thick Coal-seam at Hamstead Colliery.

	Ft.	In.
Roofs	2	0
Top Slipper	1	8
Tow Coal and White Coal ...	4	5
Parting...	0	1
Foot Coal and Brazils ...	4	4
Batt	0	6
Slips	1	9
Parting...	0	0
Stone Coal	2	6
Batt	0	6
Slipper and Sawyer	4	4
Bench Batt	0	8
Benches	1	3
Total	24	0

Mr. Arthur Sopwith said that an enquiry into the nature of the bumps occurring in the thick coal-seam at Hamstead or elsewhere was of scientific interest rather than likely to lead to any practical advantage. At the same time, if there be any possible avoidance of these extremely unpleasant occurrences, the means of doing so can only be arrived at by forming some definite conclusion as to the cause. He had been much struck with the fact—at least he believed it to be so—that while bumps are frequent in working the whole or solid coal, there is not any enormous pressure subsequently felt on the pillars or, at any rate, not what might be expected, if bumps when a heading is being driven are due to pressure as ordinarily understood. Again it is generally recognized that pressure is not due to increased depth, but depends upon the conditions of the immediately superincumbent strata; and while bumps may be, and indeed we may take it that they are, more frequent and on a larger scale than in other collieries, and it is probably only a coincidence that they are associated with workings lying so far below the surface as at Hamstead colliery.

About twenty-seven years ago, he had a good deal of experience in sinking and driving in the clays of the Tertiary formation in Bohemia. It was easy, and apparently, secure work, but subject to sudden and sharp movements, followed by twisting of the timbers and sometimes loss of the heading or shaft. Such an effect was not caused by the ground being heavy with water or on account of slips, and it clearly was not due to direct pressure, as the action was common to any depth. He arrived at the conclusion that the clay existed rather in a state of tension than compression, and when liberated by a length of cutting, such as a heading or shaft, a sudden relief took place, and although this might mean only a fractional part of an inch of severance it affected a very large weight, which for some appreciable time was by its release kept in vibration, with the result of upsetting the equilibrium of the surrounding ground.

Allowing that his conclusion was correct in the cases alluded to, it could be reasoned *à fortiori* that a similar action would take place when a severance was effected by the driving of a heading in a massive and comparatively-speaking crystalline bed like the thick coal-seam. This explanation would account, he thought, for the booming noise—the result of reverberations due to an enormous mass in a state of vibration. He noticed that the diagrams which Mr. Meachem used to illustrate his paper appeared to show a conical opening above the heading, such as might be expected if there was a tensional relief. It is difficult to describe one's impression of the tension existing, more especially as with bodies such as clay or coal, one cannot imagine much of that property of matter. His view, however, was that the effects coincided with what might be expected from a relief from tension rather than any other cause. As an absurdly exaggerated illustration, imagine the surrounding of a shaft or heading to be a very thick ring of india-rubber in an extreme state of tension, and that severance took place—part of the timbering would be bared, while the rest would be subject to intense pressure. In the case of coal, however, it is enough to imagine that a severance of merely a few inches takes place, but this may mean the setting into vibration of thousands of tons of coal and overlying strata.

Now, any noise connected with ordinary pressure in a mine, and by ordinary pressure he meant the tendency of overlying beds to weigh upon coal, is quite distinct from the thunder-like reverberations attending a big bump. There appears in the latter, a very close resemblance to the noise attending the vibrations of an earthquake. Curiously enough the little damage caused by the recent earthquake was probably not due to the slight amount of actual vibration but on account of the free play of buildings and their comparatively soft foundations. Indeed, in the case of a large water-tank, placed on a solid brick-pillar, in this neighbourhood, a crack was discovered in one of the plates on the morning following the earthquake.

It is not therefore unreasonable to suppose that bumps correspond in a miniature degree to an earthquake, inasmuch as they mean the vibration of an enormous mass of coal and rock—the setting up of this vibration may be accounted for as he had described—the effects of such vibration in a confined and rigid mass can be understood. Not merely would there be the vibrating shocks but timber being displaced, and a continuing tendency of coal to release itself, there would be effect given to any impending action of ordinary pressure.

Mr. **William Wardle** observed that, in his experience, bumps arose from gases being held under pressure in coal-seams and surrounding strata, rather than from the depth of the pit, and he had had great trouble from bumps recently in working a coal-seam, only 3½ feet thick, in driving straight headings 9 feet in width. Bumps occurred in several instances, and tore the roof of the headings from end to end, and as a preventative he carried breasting-stalls (instead of headings), 60 feet wide, between the roads, and worked the coal, 15 feet on opposite sides of the roads, and put in here and there a wooden chock, ripped down the roof of the roads, and built up the whole space, with the exception of the roads, solid with dirt. Since then, no bumps had occurred, and the roads stood much better than when they were driven in the narrow width. He accounted for the bumps ceasing to occur in the wider places by the larger area of exposed face, liberating the gas retained under pressure over this larger area.

Mr. H. W. **Hughes** believed that the tension in the overlying strata was relieved suddenly, a slight movement took place, and a bump resulted.

Mr. **George Turner** stated that, in his opinion, bumps were due more to a combination of causes than to any one particular cause, and the sudden liberation of pent-up gas could not altogether be lost sight of. He had had considerable experience with the working of very thick seams in this country and in India, and he had found, as a rule, that bumps were much more frequent and intense at a time when the greatest quantity of pent-up gas was being given off from the seam. At Sandwell Park colliery, some years ago, at one part of the workings gas was being given off somewhat freely, and frequent and severe bumps occurred; but after the pent-up gas had been drained, very little trouble from bumps was experienced.

Mr. W. F. **Clark** did not believe that gas had much to do with the occurrence of bumps at the Hamstead colliery.

Mr. W. **Beattie Scott** said that he saw no reason to alter his opinion formed 21 years ago, when he wrote an article to the *Colliery Guardian* on the subject of bumps, when he urged, and still adhered to the same opinion, that these bumps were due to superincumbent pressure. In such outbursts, the pressure became too great for the resistance of the coal and the floor. He held the opinion that gas had nothing whatever to do with the matter, and that bumps occurred most frequently in the neighbourhood of faults.

Mr. **Meachem**, in replying to the discussion, said after considerable observation and experiments, extending over a number of years, he was fully of opinion that all bumps which had occurred at Hamstead colliery, and he thought, he might add, in the majority of coal-mines, were due to one cause, viz., weight thrown upon the rocks until their tension or power of resistance was overcome, just as the bending of a stick will frequently result in its being broken. He was therefore somewhat in agreement with Mr. Sopwith. In a district where great lines of faulting exist, the downward pressure of the earth's crust would certainly be most strongly marked. It might be safely assumed that the earth's crust-movement, which resulted in breaks and faults, would also produce in coal many lines of division and imperfect cohesion, which would reduce its power of resisting weight or pressure. Hamstead colliery was situated in a district cut by two great faults, and disturbed by many minor lines of faulting springing from the main ones. To this cause was due, no doubt, the friable nature of some portions of the thick coal-seam. The coal withstood the pressure until its breaking strain was passed, and then a wreckage took place, accompanied, in many instances, with loss of life. When working, by holing with the pricker on the top of the seam, explosive violence had thrown masses of coal, indicating the force behind, which had been held back until the point of resistance had been overcome. Nevertheless the only safe way of working is by bringing about, as it were, a number of small bumps, and allowing the force to gradually expend itself, rather than incur its whole violence by driving in any other parts of the seam.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,
FEBRUARY 10TH, 1897.

MR. GEORGE A. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. PETER INGLIS, Hallside Colliery, Newton.
Mr. J. B. KILPATRICK, Connelbank, New Cumnock.
Mr. JAMES RUSSELL, Clyde Ironworks Collieries, Tollcross.
Mr. DAVID WILSON, Newton Colliery, Newton.

ASSOCIATE MEMBER—

Mr. THOS. H. BARR, 10, Bothwell Street, Glasgow.

STUDENTS—

Mr. WM. ROBERT SCOTT, 56, Braid Road, Edinburgh.
Mr. KENNETH P. MACKINTOSH, Lamancha, Peebles-shire.

DISCUSSION OF MR. PRENTICE'S PAPER ON "THE MINERAL SEAMS OF NEW MONKLAND."*

The SECRETARY (Mr. J. Barrowman) drew attention to an entry in the *Reg. Priv. Coun. Scot.*, vol. x., dated 1616, illustrating the ancient date of coal-working in New Monkland parish. John Muirhead of Braidenhill had a going coal-pit on these lands near the march with the lands of Kipps, which had one draught and passage for the course of the water which was drawn from the said pit. He had been in possession of

* *Trans. Fed. Inst.*, vol. xii., page 435.

the pit and passage for many years, but Matthew Newlands of Kipps, out of private grudge, had caused the water to be dammed, whereby the pit was drowned and made unprofitable.

In a report dated 1794 by Messrs. John Grieve and James Taylor upon the minerals in the track of the then projected Edinburgh and Glasgow canal, reference was made to a considerable number of collieries in operation in the parish at that date. At Faskine, on its south-western border, a pit 234 feet deep employed 70 colliers, the whole output being sent by the Monkland canal to Glasgow. At Airdrie, a stair pit, levelled from Airdrie burn, worked a seam of coal 4 feet thick, the top portion of which was sold for smithy purposes and was sent as far as Greenock, Kilbride, Cumbernauld, and Whitburn. Whinhall colliery at Airdrie had a gin-pit 120 feet deep employing 8 colliers. The main and Pyotshaw coal-seam was worked at Colliertree by 18 colliers by a pit 84 feet deep. Reference was made to coal working, probably in the Kiltongue coal-seam at Kipps, and also at Nettlehole and Glen. At Darngavil, the splint coal-seam was worked from a mine by 5 colliers, and coal had been worked thirty years before at Mochriesinch. Mr. Prentice referred to the cannel coal in the Kiltongue seam as being, after the Torbanehill mineral, probably the best in Britain. There was a thin seam of cannel coal at Glenbuck, in Ayrshire, called the cokeyard gas coal-seam, which was worked some years ago and compared favourably with the Kiltongue cannel. According to an analysis made by the late Dr. Wm. Wallace, the Glenbuck coal yielded 14,080 cubic feet of gas per ton, of an illuminating power of 41·28 candles and 730 lbs. of dry coke per ton, containing only 16½ per cent. of ash. Dr. Wallace considered this coal of about equal value with Torbanehill mineral.

The PRESIDENT said that Mr. Prentice's paper raised rather an interesting point, viz., the thickness of strata through which whin would burn coal, and it might not be unprofitable if some of the members gave their experience on the point. He would like to ask if the distances named in the paper were derived from his experience, and would he put it as a general rule that 180 feet under the coal would have the same effect as 200 feet over it, or was it simply a probability?

Mr. PRENTICE thought that it could scarcely be accepted that his statements were capable of general application. The only instances that he had quoted referred to one colliery, where there was a coal-seam 120 feet above the whin, and another 84 feet under, it being at two points practically vertical, and the under seam was less burned than the upper one. He supposed that when the whin was interjected all the strata lying above must have been lifted upwards, cracks and fissures would be formed, and the radiation of heat would be very much greater above than below.

At Stanrigg, there was a coal-seam lying 66 feet above the musselband ironstone containing gas coal and shale. When the pit was sunk to a coal-seam lying 80 feet below, the fissures were found to be filled with oil which had been liberated by the heat of the whin, and driven downwards into the cracks. Thick oil could be collected from every crack. In one place there was a hollow in which the oil had accumulated, and the drawers for two years burned this natural oil. This occurrence suggested that the heat had been greater below than above. Of course the heat would escape through the cracks, and would perhaps do less damage to the coal lying above the whin.

The **President** asked Mr. Prentice whether he had been able to form any theory regarding the formation of the ironstones.

Mr. **Prentice** said that he would not like to commit himself to any theory on the subject. At the outer edge of the basin, in which the ironstone was found, there was an immense deposit of animal remains and shells, but whether they had anything to do with the formation of the ironstone he would not like to say.

The further discussion of the paper was adjourned.

Mr. **James Hastie** read the following paper on "Sinking, Surface-fittings, and Coal-cleaning Plant at Whistleberry Colliery, Hamilton":—

SINKING, SURFACE-FITTINGS, AND COAL-CLEANING PLANT AT WHISTLEBERRY COLLIERY, HAMILTON.

By JAMES HASTIE.

Whistleberry colliery belongs to Mr. Archibald Russell, and is situated on his estate of Auchinraith, to the west of Hamilton, and adjacent to his Greenfield and Whitehill collieries.

The shafts at Whistleberry are the deepest in the Hamilton district, this being caused by a large fault throwing down to the north. The distance between the two shafts is 58 feet, and they are of rectangular shape.

No. 1, *the Downcast Shaft*, is 1,080 feet in depth, and 21 feet by 6½ feet inside the woodwork. It is divided into four compartments: one division of 5 feet for pumping-machinery, another of 1 foot for haulage-ropes, etc., and between these there are two divisions of 7 feet each for the winding cages (Figs. 1 and 2, Plate XXVII.).

The downcast shaft is lined with wood from top to bottom, pitchpine, 5 inches thick, being used from the surface to the rock-head. Whitepine, 3 inches thick, is used in hard, and pitchpine, 4 inches thick, for soft strata. The corner rackings *C* (Figs. 1 and 2, Plate XXVII.) are of pitchpine and whitepine 3 inches by 3 inches, the wall-plates *W* are of pitchpine 9 inches by 3 inches, with pitchpine needles *N* 6 feet long by 9 inches by 4 inches placed 4 feet apart, having whitepine filling-in pieces *F* 4 feet long by 4 inches by 2 inches placed between, and rackings *R* 2½ inches by 2 inches placed on each side. The side-bars *S* are notched ½ inch at each end to receive the end-bars *E*, which are 1 inch longer than the breadth of the pit.

During sinking, the end of one of the 7 feet spaces was closely lined with ⅝ inch lining, thus dividing the pit into two divisions for ventilation; the other end of the space had sliding-deals 1 inch thick, and between these the sinking-kettle was run.

The slides *T* for the winding-cages are of pitchpine, 5 inches by 4 inches, in 30 feet lengths, having square ends butted together and fastened by fish-plates; the slides are fixed to the needles *N* with bolts and wood screws.

No. 2, the Upcast Shaft, is 1,041 feet deep, and is of the same dimensions as, and fitted up for winding coals in a similar manner to, No. 1 pit.

Before sinking-operations were begun, both shafts were fitted with safety-doors on the pit-head to prevent anything from falling down the pits while the kettles were being emptied. The size of the kettles for raising the material was 3 feet 2 inches broad at the top, tapering to 2 feet 4 inches at the bottom, by 3 feet deep. The safety-doors are shown in elevation in Figs. 3 and 4 (Plate XXVII.).

On May 15th, 1894, the ground was cut and both shafts were sunk to the rock-head and left standing till the permanent machinery was erected. Sinking-operations were commenced in No. 1 shaft on October 8th, and in No. 2 shaft on November 12th, 1894, and both shafts were completed in November, 1895, thus taking an average of twelve months and ten days to finish the sinking. In course of sinking, six workable coal-seams were passed through, and mining operations were commenced in four of these seams in January, 1896.

The coal-seams passed through were :—

At	906	feet deep, the	Ell coal-seam ...	3	feet	1	inch thick.
,,	950	,,	Pyotshaw coal-seam...	3	,,	10	,,
,,	978	,,	Main (Jewel) ,, ...	4	,,	4	,,
,,	1,028	,,	Humph ,, ...	3	,,	0	,,
,,	1,066	,,	Splint ,, ...	3	,,	9	,,
,,	1,070	,,	Virgin ,, ...	2	,,	9	,,

During sinking operations, water was met with in both shafts to the extent of about eight barrels per hour, but this was cut off by lodgments made in both shafts at a depth of 348 feet, which allowed the sinkers to work dry in the bottom of the shafts. Whilst the shot-holes were being drilled, these lodgments were emptied by a water-barrel, the water being wound to the surface. The sinking was carried on continuously in 8 hours shifts, with from six to eight workmen in each shift. The explosives used were powder, dynamite, and gelignite, fired by means of strum (fuze) and detonators.

This sinking was finished without any serious accident, as were other four shafts sunk for the same firm, there being not one fatal accident; the total sinking in these shafts amounted to 5,250 feet, and some of the pits were heavily watered.

Surface-Fittings.—The winding-cages are made of iron, with oaken bottoms bolted together: each weighs 20 cwts. and holds two hutches abreast. The hutches are 4 feet 1 inch in length, 2 feet 4 inches in width, and 1 foot 8 inches deep; they have cast-steel edged wheels, 14 inches in diameter. The trams are of larch, slots and starts of oak, the ends of wood, and the sides and bottoms of steel. An angle-iron is placed on the outside of the hutches to catch the coal-tippers. The hutches weigh 4½ cwts. each, and carry a load of 10 cwts. of coal. The winding-ropes, made of best patent steel wire, are 3½ inches in circumference and weigh 24 cwts. The total working-load is 73 cwts.

The pit-head frames of both pits, of pitchpine, 14 inches square, are made on the trestle pattern. The perpendicular height to the top of the uprights is 54 feet, the crown-beams which rest on these are of oak, 16 inches by 14 inches. The plummer-blocks of the winding-pulleys rest on pitchpine beams placed across the crown-beams. The winding-pulleys are 12 feet in diameter, with malleable-iron arms and cast-iron rims.

The winding-engines of both pits are of the same dimensions, each consisting of two horizontal coupled cylinders, 26 inches in diameter and 5 feet stroke, with balanced valve-gear, suitable for a working steam-pressure of 80 lbs. per square inch. Each engine is fitted with parallel winding-drums, 14 feet in diameter and 8 feet wide, covered with oak 5 inches thick, and fitted with brake-gear and lever-power.

The Guibal exhausting ventilating-fan *F* is 26 feet in diameter, 8 feet broad, with eight arms. It is driven by an engine with a horizontal cylinder, 14 inches in diameter and 3 feet stroke, fitted with expansion-gear. At present the fan is going at about 40 strokes per minute, giving abundant ventilation for the opening out of four seams of coal.

Both of the winding-engine houses, *A* and *B* (Fig. 5, Plate XXVII.), 48 feet long by 34 feet broad, are built with bricks and covered with slated roofs. The fan-engine house, *G*, 29 feet long by 10 feet broad, is built of the same materials. These houses are finished off inside with wooden lining, ⅝ inch thick, to a height of 5 feet, the rest of the walls being plastered and painted.

There are six Lancashire boilers, *C* (Fig. 5, Plate XXVII.), for supplying steam to the engines. The boilers are 30 feet long by 8 feet in diameter, fitted with ten Galloway tubes in each. The steam-pressure is 80 lbs. per square inch. The flues all lead to a chimney 160 feet high, 14 feet in diameter at the base, and tapering to 7 feet at the top; and the draught from the flues into the chimney is regulated by means of an Auld damper. The boilers are covered with brickwork, and the steam-pipes and connexions are covered with pearl fossil-meal. The boilers are fed by a horizontal Tangye pump, *D*, which receives its water from a pond, *K*, built of brick and cement. Before the water enters the boilers it is heated at *H* by the exhaust steam from the engines.

Workshops.—The joiners' shop, *T*, is 38 feet by 25½ feet; the smithy, *S*, 31 feet by 25½ feet; the engineers' shop, *R*, 22 feet by 25½ feet; the store-room, *P*, 24 feet by 25½ feet; and the ambulance-rooms, *N*, 16 feet by 25½ feet. These shops are all placed in line, and built of brick with slate-roofing. The lamp-room, *L*, is built in the same line as the workshops, with an interval of 9 feet. It also is built of brick with slate-roofing, the dimensions being 26 feet by 16 feet. An oil-store, *M*, is erected at the back. The office and electric-light house are not yet built, but their approximate position is shown at *V* and *W*.

The railway-sidings are laid off for dry-cleaning plant. There are 13 roads in all, 11 of which are used for coals, 1 for the locomotive-engine shoving in the empty waggons, and 1 spare road. These roads are laid with steel rails, weighing 80 lbs. per yard, with sleepers 10 feet by 10 inches by 4 inches, cast-iron chairs, fish-plates and spikes all joined together. At the outlet from these sidings, there is a waggon weigh-bridge, *X*, over which all material crosses, and on which it is weighed.

Coal-cleaning Plant.—The foundations for the coal-and-nut jiggers are upright and cross-pieces of pitchpine 10 inches square, set in cast metal sockets, bedded in cement, the whole being bolted together with malleable-iron bolts 1½ inches in diameter. The foundations for the coal-cleaning tables are also of pitchpine, 8 inches square, set on brick foundations, and the whole joined together by cross-beams, iron-glands, and bolts (Figs. 6, 7, and 8, Plates XXVII. and XXVIII.).

At both pit-heads, the hutches are landed 25 feet above the level of the railway. The area of flooring of the pit-head scaffold is 4,410 square feet. The sides of this building are lined with wood, the roof is formed of curved, corrugated, galvanized iron sheets with malleable iron couples. The tipper-scaffold, where the hutches are emptied into the coal tippers, has an area of 4,030 square feet, the sides and roof are fitted up similarly to the pit-head scaffold. The scaffold for the coal and nut-tables has an area of 5,100 square feet, the sides are lined with wood, and the roof is made of corrugated galvanized iron sheets on wooden couples. Windows are placed on the roof on each side of the ridges, over the picking-bands (Fig. 6, Plate XXVIII.).

The hutches from the two pits on leaving the cages run on to the hutch weighing-machines, *W*, and after being weighed proceed to the hutch-tippers, *T*. Before the tippers are reached, the two lines of rails from the hutch weighing-machines converge so that all the hutch-tippers are common to both pits, the hutches being guided into the desired tipper by an arrangement of points, under the control of the workman in charge. The hutch-tippers, *T*, are self-acting, after being started, and when the hutch has been tipped, it is left standing in the tipper till it is bumped out by a loaded one, it then runs to the dish at the foot of the elevating-haulage passing over the self-acting greaser, *L*, on the way.

The haulage, *H*, consists of two pitch-chains joined together by long pins carrying rollers for supporting the chains. The chains are provided with catches for engaging with the axles of the hutches, and propelling them up the incline, which has a rising gradient of 1 in 7, to the points diverging to the two pits at the back of which the hutches are marshalled.

The gradients for running the hutches are as follows :—

Loaded hutches	—on straight rails	1 in 48.
,,	on curved rails...	1 in 36.
Empty hutches	—on straight rails	1 in 40.
,,	on curved rails...	1 in 30.

The coal is discharged from the hutch on to the distributing-jigger, *D J*, which takes the place of the distributing-band. From the distributing-jigger the coal passes on to the screening-jigger, *S J*, where the large and small coal are separated, the large coal passes on to the picking-bands, *C*, which are of the bar-grating type so as to allow of any small coal, that may be caused by the trimming of the coal, passing through on to the close bottom-plate, along which it is scraped by the return-band into the dross-conveyor, *D*. The picking-bands are fitted with an improved form of radial-end, *R*, for lowering the coal into the waggon without breakage. The radial-end possesses the further advantage of making it very easy to load and trim the waggon, one workman only being required for this purpose. The band is under the easy control of the trimmer, being provided with a friction-clutch for starting and stopping, and one for working the raising-and-lowering gear of the radial-end; both of the clutch-levers are within his reach, it being only necessary to move the levers to give the desired effect.

There are four sets of tipper-jiggers and picking-bands provided for treating the large coal, three of them being now at work.

The dross coal is delivered by the jigger-screens into a conveyor, *D*, of the flight or scraper type, in which there is an entire absence of leakage. This conveyor is running at right angles to the screens, and being common to them all, it receives the whole of the dross from them, besides what is scraped back from the picking-bands.

After clearing the screens, the conveyor is inclined at an easy gradient over the top of the nut jigger-screens, where the dross is delivered for screening.

There are two nut screens, *N J*, both driven from the same point, and arranged to absorb each other's vibration, which is consequently not communicated to the staging, and the same arrangement is applied to the distributing and large-coal screens.

The dross in landing on the screens, which are extra wide, quickly spreads on the plates, and the result in screening is most satisfactory.

On the first screen-plate, the dross is separated into two sizes, and each of these is again separated into two other sizes by the remaining screen-plates. The four sizes obtained may be classified as "gum," "singles," "doubles," and "trebles." The singles, doubles, and trebles are each delivered by the screens on the nut picking-bands, *N*; those for the doubles and trebles being of the bar type, and for the singles of the plate type.

In order to reduce the breakage of coal as much as possible in loading the nuts, shoots have been dispensed with altogether, and the picking-bands have been inclined downward at the ends as near the waggons as possible.

For the continuous removal of the stones and refuse, which are picked from the coal, a conveyor *S* is run across below the seven picking-bands, and openings are made in the floor between each two bands through which the refuse is shovelled on to the conveyor, from which it is delivered into a waggon, and taken to the dirt-heap.

The whole of the screening-plant is driven by a high-pressure steam engine *E*, the power being transmitted to the machinery by a hair belt.

The gum coal is delivered by the jigger-screen into conveyors *G* leading to the fire-holes at the boilers. The conveyors are not yet erected, but when completed they will form an important part of the labour-saving appliances at the colliery.

By an extension, the gum-coal conveyor is made to receive the gum from the doubles and trebles picking-bands, and the gum coal can be delivered into waggons or to the fire-holes as desired. These conveyors are driven by a small engine.

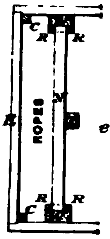
The appliances at this colliery are capable of raising and handling an output of 1,200 tons per day in one shift, with the coals and nuts thoroughly cleaned, and in first-class condition for the market.

APPENDIX.

STRATA SUNK THROUGH IN SINKING THE No. 1 SHAFT, WHISTLEBERRY COLLIERY.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Surface	4	2	4	2
2	Soil and yellow clay	6	6	10	8
3	Fine muddy clay	18	4	29	0
4	Red sandy clay and stones	6	0	35	0
5	Red sandstone	18	0	53	0
6	Fireclay	3	0	56	0
7	Rock	58	0	114	0
8	Fireclay and fakes	8	4	122	4
9	Sandy fakes	12	0	134	4
10	Rock	32	9	167	1
11	Fireclay and blue fakes	23	0	190	1
12	COAL	0	5	190	6
13	Fireclay	15	0	205	6
14	Hard sandstone	2	0	207	6
15	Fireclay	10	7	218	1
16	Kingle rib	1	7	219	8
17	Grey fakes and ribs	11	6	231	2
18	Blaes	11	0	242	2
19	COAL	1	4	243	6
20	Fireclay	4	6	248	0
21	Sandstone	4	0	252	0
22	Fireclay	3	6	255	6
23	Fakes	4	0	259	6
24	Fireclay	28	6	288	0
25	Blue fakes	24	0	312	0
26	Hard sandstone	2	10	314	10
27	Blue fakes	0	9	315	7
28	Sandstone	34	0	349	7
29	Fireclay	10	6	360	1
30	Hard sandstone	10	0	370	1
31	Blue fakes	3	6	373	7
32	COAL	0	8	374	3
33	Fireclay and balls	8	0	382	3
34	Dark sandy fakes	5	9	388	0
35	Hard rock	8	3	396	3
36	Dark fakes	4	0	400	3
37	COAL	0	6	400	9
38	Fireclay	2	4	403	1
39	COAL	0	9	403	10
40	Fireclay	5	10	409	8
41	COAL	0	7	410	3
42	Fireclay	5	6	415	9
43	Blue fakes	11	9	427	6
44	Hard silvery fakes	4	8	432	2
45	COAL	1	0	433	2
46	Fireclay	6	9	439	11
47	COAL	0	9	440	8
48	Fireclay	5	9	446	5
49	COAL	0	9	447	2
50	Blue fakes	2	6	449	8
51	Rocky plies	5	6	455	2
52	Coaly blaes	0	10	456	0
53	Fireclay	10	2	466	2
54	COAL	0	9	466	11
55	Fireclay	2	9	469	8
56	Fakes	2	0	471	8
57	Rock	42	3	513	11
58	Coaly blaes	8	4	522	3
59	Fireclay	27	2	549	5
60	Hard rock	8	1	557	6
61	Kingle ribs	4	3	561	9
62	COAL	0	8	562	5
63	Hard fakes	5	0	567	5
64	Kingle ribs	4	0	571	5
65	Hard silvery fakes	15	0	586	5
66	COAL	0	9	587	2
67	Fireclay and balls	4	3	591	5
68	Hard sandy fakes	9	0	600	5
69	COAL	0	4	600	9
70	Fireclay	2	3	603	0
71	Rocky plies	9	0	612	0
72	Blue fakes	8	0	620	0
73	COAL	0	7	620	7
74	Hard rock	17	0	637	7
75	Fireclay	4	0	641	7
76	Blue fakes	7	0	648	7
77	Hard rock	37	5	686	0
78	COAL	0	10	686	10
79	Blaes	20	6	707	4
80	COAL	0	8	708	0
81	Fakes and fireclay	43	5	751	5
	Upper Coal-seam—				
82	COAL	1	0	752	5
83	Fakes with ribs	30	11	783	4
84	COAL	0	4	783	8
85	Rock	3	6	787	2
86	Black blaes	12	10	800	0
87	COAL	0	4	800	4
88	Stone	0	2	800	6
89	COAL	1	0	801	6
90	Fireclay	0	6	802	0
91	White fakes	19	11	821	11
92	COAL	1	1	823	0
93	White caulms	13	0	836	0
94	Hard grey fakes	3	10	839	10
95	White caulms	17	10	857	8
96	Black blaes	4	11	862	7
97	White caulms	31	4	893	11
98	Rock	4	0	897	11
	Ell Coal-seam—				
99	COAL	8	1	906	0
100	Fireclay	2	5	908	5
101	Rock	6	8	915	1
102	Black blaes and ribs	3	9	918	10
103	Kingle rib	4	3	923	1
104	Hard fakes	2	10	925	11
105	Blue fakes and ribs	20	7	946	6
	Pyotshaw Coal-seam—				
106	COAL	3	10	950	4

The Federat...nt at Whistleberry Collieries, Hamilton." Vol. XII. Plate XXVII



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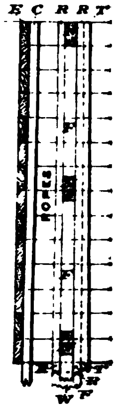
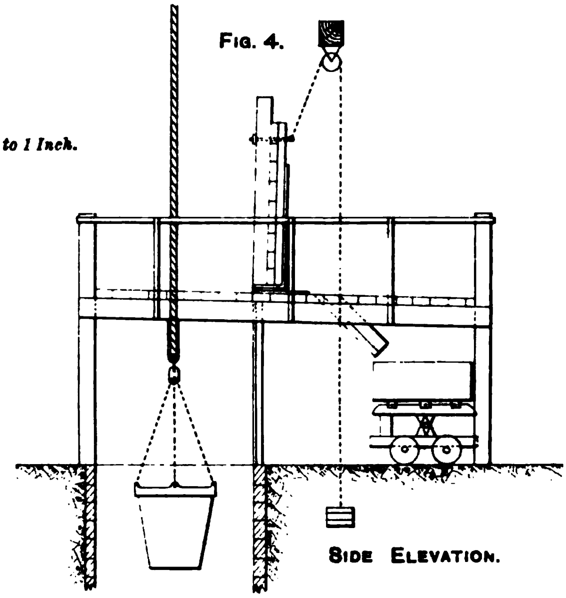


Fig. 4.



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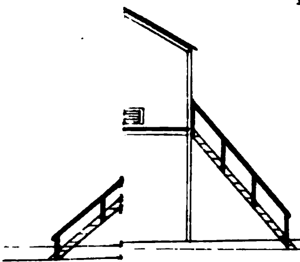

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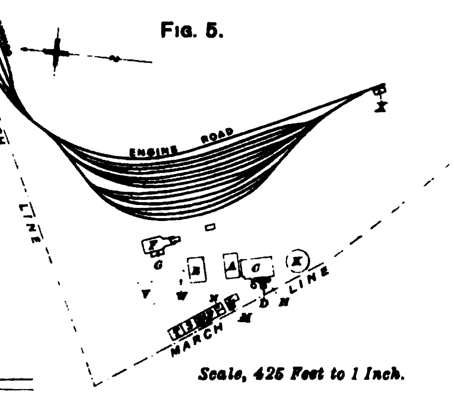
Fig. 5.



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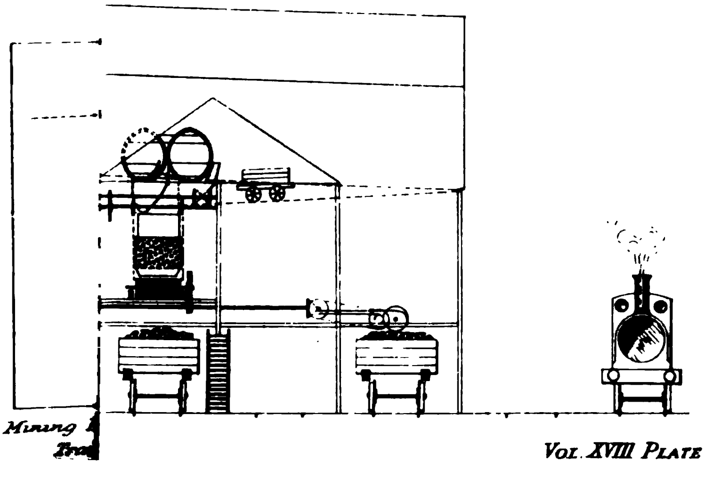

Mining I
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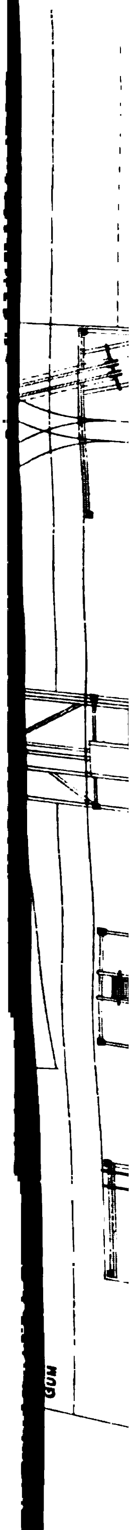
Vol. XVIII Plate III

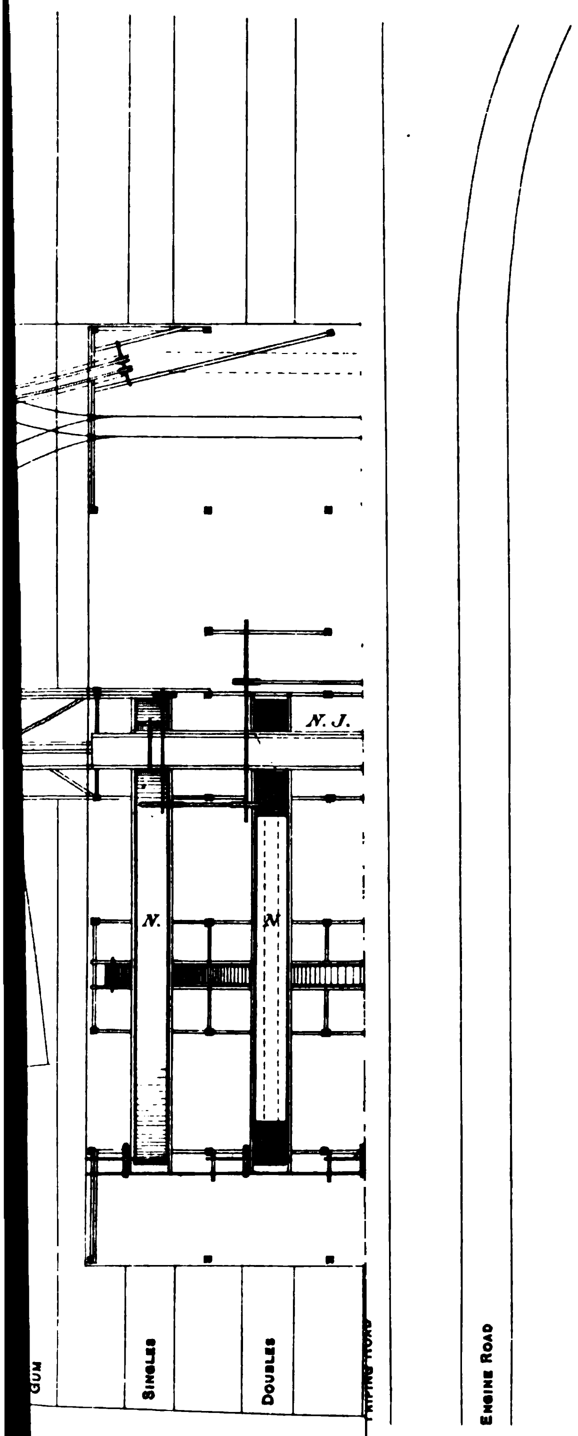
fittings, c



Reid & Co

fittings, and Coal-cleani

Vol. XII Plate XXVIII



Reid & Comp^y L^td Newcastle on Tyne

Vol. XVIII. Plate IV.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
107	Fireclay... ...	4	8	955	0
108	Fakes	5	11	960	11
109	Rock	12	11	973	10
110	Dark fakes ...	0	4	974	2
	Main Coal-seam—				
111	COAL ...	4	4	978	6
112	Rock	2	2	980	8
113	Fakes	5	4	986	0
114	Rock	16	3	1,002	3
115	Fakes	13	4	1,015	7
116	Hard fakes ...	2	7	1,018	2
117	Soft fakes ...	1	6	1,019	8
118	Daugh	0	6	1,020	2
119	Fakes	5	1	1,025	3
	Humph Coal-seam—				
120	COAL ...	3	0	1,028	3
121	Fakey plies ...	20	8	1,048	11
122	Blue fakes ...	1	0	1,049	11
123	Ribbed fakes ...	5	1	1,055	0
124	Black blaes ...	7	0	1,062	0
	Splint Coal-seam—				
125	COAL ...	3	9	1,065	9
126	Blaes	1	0	1,066	9
	Virgin Coal-seam—				
127	COAL ...	2	9	1,069	6
128	Dark fakes ...	0	9	1,070	3
129	Kingle rib ...	0	8	1,070	11
130	Fakes	9	1	1,080	0

The PRESIDENT asked for information as to the gradients on the surface for loaded waggons and empty waggons.

Mr. HASTIE said that the gradients were generally from 1 in 65 to 1 in 70. After they got the waggons placed in the empty sidings they worked down through the colliery by gravity without horse or engine-power.

Mr. J. T. FORGIE (Bothwell) said in connexion with sidings at collieries that the Glasgow and South Western Railway Company would not allow a locomotive engine to pass into a siding with a radius of less than 660 feet. The curves on the other part of the sidings, of course, were not so important, though it was of importance that curves should be of large radii unless there was a sufficiently heavy gradient. He had tried 1 in 60 and 1 in 90, but where there were quick curves 1 in 70 made one of the best gradients, and covered all sorts of weather. He noticed that Mr. Hastie adopted a simple covering for the pit-mouth. Recently he had used a projecting beam, so that the kettle and the stuff were tipped 14 feet from the pit-mouth. This system was independent of the quick action of the engineman acting on the signal of the pit-head man, and there was no risk of some of the stuff going down the shaft. He thought that the projecting beam was the safest means to adopt in tipping the kettle at a sinking-pit. There was a little liability attached to the fastening of the catches. He thought that this was the safest way of sinking, because at the pit-head they got the kettle swinging clear, leaving the workmen absolutely safe from any stuff in the tipping falling down the shaft.

He (Mr. Forgie) thought that the cost of sinking depended, of course, on the depth of the shafts, the amount of water to be pumped, the size of the shaft, etc. In the case of a modern Hamilton colliery, and another in another district with small shafts 16 feet by 6 feet and 14 feet by 6 feet, and 1340 feet deep, in the latter the estimated cost of the sinking (including 120 feet of whin), machinery, and fitting up of the whole erections complete for an output of 600 or 700 tons a day, pumping 600 or 700 gallons of water per minute, fitting up all the pit-heads and screens, was £9 per foot. The Hamilton colliery, on the other hand, would cost for sinking and fitting with the requisite machinery, including washing or dry-picking plant, from £16 to £20 per foot.

The President asked if the arrangements on the surface were under the control of one man. If so, where did he stand, and did he direct into which tipper each hutch should go?

Mr. Hastie replied that three tippers were at work: the pit-head man, by holding up his fingers, pointed to one, two, or three, touched the lever, and the hutch ran in itself. If it went a little hard, they had to stop it, or use a "snibble." If they had a larger output than at present, another workman would be required for each tipper, and the costs would be even cheaper than at present. The tipper emptied a hutch and righted itself in less than 30 seconds. One workman drew the hutch to the weighing-machine and from the weighing-machine to the tippers, and the hutch came back of itself. At present five workmen were employed at the pit-head, two at each pit and one at the tippers. These workmen could perform double the work that was done at present, viz., 200 tons a day.

Mr. R. McLaren (Uddingston) asked how the tubs were taken from the weighing-machine.

Mr. Hastie replied that hand labour was used.

Mr. McLaren then mentioned that, at Preston Grange colliery, a large weighing-machine was used, over which a trailer passed, and the tub was weighed while moving over the weighing-machine: its speed was controlled by the trailer, and hand labour was dispensed with.

Mr. Thorneycroft asked the percentage of dirt that was taken out from the nuts, peas, etc.

Mr. Hastie, replying, said that it was impossible to tell what dirt was taken out of each kind of coal, because it was all taken away together.

The **PRESIDENT** asked if they had any special reason at Whistleberry for adopting dry cleaning instead of washing, as the cost of the former seemed heavy compared with the latter.

Mr. **HASTIE** considered that dry cleaning was suitable for Hamilton dross. In other districts where the dross was dirty, he considered that washing would be most suitable. Another matter that weighed with them was the water question, and the colliery being situated on his own estate, Mr. Russell chose dry cleaning, which was really sufficient for the coal.

Mr. **FORGIE** thought that the plan of dry cleaning was defective, because with coal-seams which contain much dirt, it would be in his opinion, almost impossible to pick the smaller sizes by means of hand-picking. Then there was the difficulty of keeping the hands at work. While any official was there the workmen were picking industriously, but when his back was turned much dirt was left with the coal.

The discussion was adjourned.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

Held in the Rooms of the Literary and Philosophical Society, Sheffield, January 23rd, 1897.

Mr. G. BLAKE WALKER, President, in the Chair.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated :—

Members—

Mr. Edward S. Benn, Mechanical Engineer, 36, Peel Street, Morley, Leeds.
Mr. Hugo George Henry Green, Mining Engineer, 82, Westgate, Wakefield.

Associate—

Mr. Richard Cremer, 25, Cookridge Street, Leeds.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS

AND

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

JOINT MEETING,
HELD IN THE ROOMS OF THE LITERARY AND PHILOSOPHICAL SOCIETY,
SHEFFIELD, JANUARY 23RD, 1897.

MR. M. H. MILLS, IN THE CHAIR.

Mr. JONATHAN PIGGFORD read the following paper on "Electric Haulage at Pleasley Colliery":—

ELECTRIC HAULAGE AT PLEASLEY COLLIERY.

BY JNO. PIGGFORD.

In 1891, Mr. Hendy wrote a paper describing the collieries belonging to the Stanton Ironworks Company, Limited, in which he referred to an electric plant then recently erected for the purpose of working the underground haulage at Pleasley colliery.* The installation at that time having only been at work for a short period, did not afford sufficient data to enable Mr. Hendy to give a reliable opinion as to its economic efficiency, and it is for the purpose of supplying in some degree this want that the writer describes what has been done since that paper was printed. At that time, the plant consisted of a horizontal steam-engine with a single cylinder 20 inches in diameter and 36 inches stroke, having a piston speed of 170 feet per minute. This engine, by means of belts and counter-shafting, drove a compound-wound Crompton dynamo capable of yielding, at a speed of 790 revolutions per minute, 130 ampères, at a pressure of 520 volts. Two cables, insulated with bitumen (each consisting of nineteen copper wires of 15 Birmingham wire-gauge, and having an insulating resistance of 300 megohms per mile, and an outside

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* *Trans. Fed. Inst.* vol. ii., page 537.

diameter of 1 inch), after passing through the usual switch-board, carrying current-indicator, voltmeter, main switches, and fuses, were taken down the upcast pit in solid pitchpine casing, having double grooves, the whole being enclosed by means of a cover fixed in front of the casing. These cables conveyed current to thirty-three incandescent lamps of 16 candle-power, and also to a motor placed underground developing 60 horse-power at a speed of 570 revolutions per minute (Figs. 6 and 7, Plate XXIX.). This motor drives the rope on the road marked *A B C*, in Fig. 1 (Plate XXIX.), which is a plan of the working-roads of the mine at the time of its erection. The plan shows the distance traversed by the rope, the gradients of this and other roads in the mine, and the average tonnage per day conveyed over the same.

Previous to the introduction of electricity, the average output of the district *A B C*, was about 300 tons per day. Eleven horses were employed to convey this quantity, and as soon as the motor commenced work these horses were all withdrawn.

The beneficial results to be derived from the application of the electric-power system were soon apparent, and the experience gained of the wear-and-tear, taken over a reasonable period of time, was so favourable as to induce the managing-director to extend it into other districts of the colliery. At the present time, forty-eight horses have been withdrawn from these districts, the output has been increased from 300 to 1,500 tons per day, and the total output of the pit has been increased from 1,000 to 1,700 tons per day.

If the average purchase cost of a horse be £22, and the average life be eight years, the annual charge under this head is £2 15s., which, on a year of 260 working days, gives a cost of 2½d. per horse per day. To which must be added 2s. for drivers' wages and 1s. 10½d. for horse-keep, harness, etc., making a total of 4s. 1d. per horse per day, and this multiplied by 48, the number of horses withdrawn, gives a sum of £9 16s. as the daily cost of working these roads by horses, supposing (which is quite impossible in the restricted space) that the number of horses withdrawn could have dealt with the extra tonnage. The actual present cost of working these roads by electricity is as follows:—

	£	s.	d.
Interest on capital expended on plant at 10 per cent. per annum, over 260 days per year	1	3	1
Cost of haulage-ropes	0	13	0
Cost of coal and stores for engines	0	4	1
Wages	5	10	0
Total cost per day	£7	10	2

These statements show a saving of £2 5s. 10d. per day, or £595 16s. 8d. per annum, to which sum may fairly be added interest on the value of horses saved, viz., £1,056, which at 10 per cent. per annum would equal £105 12s., making in all a saving of £701 8s. 8d. per year.

These various extensions have been carried rather outside the limits of reliable working, and in consequence the plant is being rearranged and duplicated, and when finished it will consist of two horizontal steam-engines, built by Messrs. Plowright Brothers, of Brampton, Chesterfield, each with two cylinders 14 inches in diameter and 30 inches stroke, running at a speed of 100 revolutions per minute, and driving, by means of belting and counter-shafting, two Crompton compound-wound dynamos (Figs. 8 and 9, Plate XXX.), each of which is capable of generating current for driving a motor of 60 horse-power. The generators are wound to run at a speed of 790 revolutions per minute and to yield an output of 120 to 130 ampères at a pressure of 520 volts. The old cables, as originally fixed, are still in use, and have been supplemented by a concentric cable of the same dimensions, lead-covered, double-armoured, and braided and compounded, which hangs open in the shaft, being held in position by cast-iron clips secured to the sides of the shaft by wrought-iron spikes, driven into wooden plugs, for which holes were bored in the brickwork. A section of this cable (Fig. 2), showing the insulation and armour, and a plan and section of the clip for carrying the same in the shaft, are shown in Figs. 3 and 4 (Plate XXIX.).

At the present time, the old cable only is in use, and conveys electric energy to four motors in various parts of the pit, the location of each being shown by the letters *A*, *B*, *E*, *G* in Fig. 5 (Plate XXIX.), Fig 5 being a plan of the underground roads at the present moment. This cable also supplies current to 138 sixteen candle-power incandescent lamps, which are distributed as follows:—Dynamo-house, 10; engine and boiler-houses on surface, 16; top of pits, 16; screens and sorting-belts, 20; workshops, 24; offices, 12; pit-bottom and main roads, 32; motor-houses, 7; and office, 1; a total of 138 lamps.

At the terminals of the cables in the motor-house *A*, the necessary controlling-switches, a current-indicator and voltmeter are fixed. The switches are arranged so that the field-magnet circuit of this motor (which is shunt-wound) is never disconnected from the circuit, and is, therefore, always excited whenever the dynamo at the top is connected and running. There are two switches, one of which controls a large resistance-frame, so that the speed can be varied at will whilst starting, and the other is used for switching-off the main current. The separate switches are provided with but one handle, which cannot be removed from the main-switch in order to work the regulating-switch, unless the former is on, whilst *vice versa* it cannot be taken from the regulating-switch in order to work the main one until the regulating-switch has been put into the position which corresponds to the lowest speed.

The resistance-switch is not provided for the purpose of running the motor continuously at low speeds, but simply for convenience in starting, and to allow of running at a very low speed occasionally, if required, in case of accident to rope or tubs.

The motor *A* is arranged to work with about 120 to 130 ampères, at a pressure of 460 volts, at a speed of 570 revolutions per minute, and develops 60 horse-power. It is connected to the pulley which drives the endless-rope by means of two counter-shafts: the first transmission being by cotton belting, and the other by spur-gearing (Figs. 6 and 7, Plate XXIX.).

Three motors are also working endless-ropes on inclines, mostly in favour of the load: two of these are easily capable of developing 5 horse-power, and the other 10 horse-power. These types of motors, with their haulage-gear, are shown respectively in Figs. 10, 11 (Plate XXIX.), 12, and 13 (Plate XXX.). They are compound-wound, compound winding being found most convenient, as in case of accident or overload it prevents the motors from losing their fields, and consequently their power of hauling.

The switching arrangements for these motors are not quite the same as those for the larger motor, the shunt-winding not being always connected to the mains. They are provided with a combined starting and controlling-switch, which always connects and fully excites the field-magnets before any large current is put through the armature. This arrangement ensures easy starting under full load without an excessive rush of current, and consequent flashing of the brushes.

The incandescent lamps are supplied from the cable which affords current to the motors, and are worked four in series; the lighting, of course, is not absolutely steady, but it is sufficient for all practical purposes.

The compound winding of the dynamos is arranged, as far as possible, so that the potential at the pit-bottom shall be sustained approximately constant, no matter whether the motors are on or off.

In carrying out the present extensions it is proposed to run both sets of plant in the engine-room, one supplying the large motor direct, and the other one the lights and the three small motors, as well as another 10 horse-power motor intended to be placed at the point *F* (Fig. 5, Plate XXIX.), and to be used for hauling coal up the dip road *F H*. Arrangements are also being made to work another rope off the large motor to serve the road *K*.

In connexion with this distribution of power, a system of switches is being arranged (Figs. 14 and 15, Plate XXIX.) by which any of the motors can be switched into either pair of cables, and also either pair of cables can be put on to either dynamo, but under no circumstance can both dynamos be put on to one cable.

It should be mentioned that the large motor and the two dynamos are of the same dimensions, so that their armatures are interchangeable. Both the types of small motors are also built on the same lines, so that all parts are duplicates, and, of course, interchangeable.

The whole of the dynamos and motors have been fitted from the first with carbon brushes, which have given the greatest satisfaction, the first generator and large motor never having been re-turned since they were started in January, 1891.

The losses and horse-power of the system, as now worked, are shown in Table II., the distribution of power in Table I., the dates of the various installations and outputs of coal in Table III., and the costs of working in Table IV.

APPENDICES.

TABLE I.—DISTRIBUTION OF THE ELECTRIC POWER.

	Revolutions of Engines per Minute.	Revolutions of Dynamo per Minute.	Dynamo.		Indicated Horse-power of the Engines.	Electric Horse-power produced by Dynamo.	Electric Horse-power at the Motors.	Ratio between Horse-power supplied to Motors and Horse-power produced by the Dynamo.	Ratio between Horse-power supplied to Motors, and Indicated Horse-power of the Engines.	Ratio between Horse-power produced by Dynamo and Indicated Horse-power of the Engines.
			Volts	Amp.	H.-P.	H.-P.	H.-P.	P. Cent.	P. Cent.	P. Cent.
Plant, running with full load	100	700	500	94	84·00	63·00	56·70	90·00	67·50	75·00
Engines, dynamo, motors, and empty ropes	93	650	500	75	67·86	50·26	45·24	90·00	66·66	74·06
Engine, dynamo, motors, and lights	92	640	500	32	44·54	21·44	19·30	90·01	43·33	48·13
Engines, dynamo, and lights... ...	92	640	500	—	38·52	—	—	—	—	—
Engine, and driving pulleys	100	—	—	—	13·10	—	—	—	—	—

TABLE II.—THE PERCENTAGES OF LOSSES AND HORSE-POWER OF EACH PART OF THE SYSTEM.

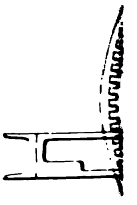
	Horse-power.	Per Cent.
Engine and large pulley	13·10 ...	15·60
Dynamo, cable, and 138 lights	25·42 ...	30·26
Motors	6·02 ...	7·17
Gearing and empty ropes	23·32 ...	27·76
Load	16·14 ...	19·21
Totals	84·00 ...	100·00

TABLE III.—DATES OF ERECTION AND OUTPUTS OF COAL.

Dates on which the Various Ropes were put on.	Total Output of the Colliery.	Number of Horses Employ'd	Lengths of Rope in Use.					Number of Horses With-drawn.
			Engine-plane *A B C.*	Engine-plane *E F.*	Engine-plane *B D.*	Engine-plane *G H I.*	Total Lengths.	
	Tons.		Feet.	Feet.	Feet.	Feet.	Feet.	
1891, Jan. ...	1,000	59	3,450	—	—	—	3,450	11
,, Sept. ...	—	—	1,578	—	—	—	5,028	6
1892, Sept. ...	—	—	—	2,514	—	—	7,542	7
1893, Oct. ...	—	—	—	—	5,076	—	12,618	6
1894, Jan. 18	—	—	1,500	—	—	—	14,118	5
,, Jan. 27	—	—	—	1,500	—	—	15,618	3
1896, April 11	—	—	1,500	—	—	—	17,118	4
,, July 16	1,700	59	—	—	—	7,614	24,732	6
Totals ...	—	—	8,028	4,014	5,076	7,614	24,732	48

TABLE IV.—COSTS OF WORKING, ETC.

Name of District.	Length of Rope in Use.	Number of Horses in Use.	Number of Horses With-drawn.	Output of Coal.	Total Cost, Including Wages, Engine-coal, Ropes, and Interest on Capital.	Cost per Ton.	Cost per Ton per Mile.
	Feet.			Tons.	£ s. d.	d.	d.
Engine-plane *A B C*	8,028	50	26	500	3 2 2	1·49	1·96
,, *E F*...	4,014		10	540	1 7 10	0·60	1·58
,, *B D*	5,076		6	235	1 6 5	1·35	2·81
,, *G H I*	7,614		6	230	1 13 9	1·76	2·44
Totals	24,732	50	48	1,505	7 10 2	1·19	—
Horse-road, No. 51...	1,980	7	—	145	1 8 7	2·36	6·30
,, *K* ...	1,299	2	—	50	0 8 2	1·96	7·96
Totals	—	59	48	1,700	9 6 11	—	—



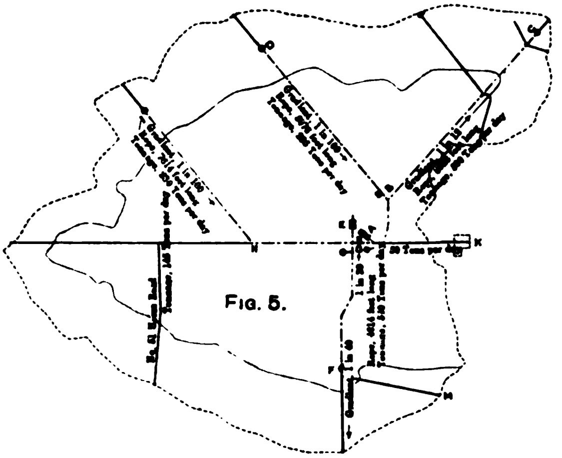
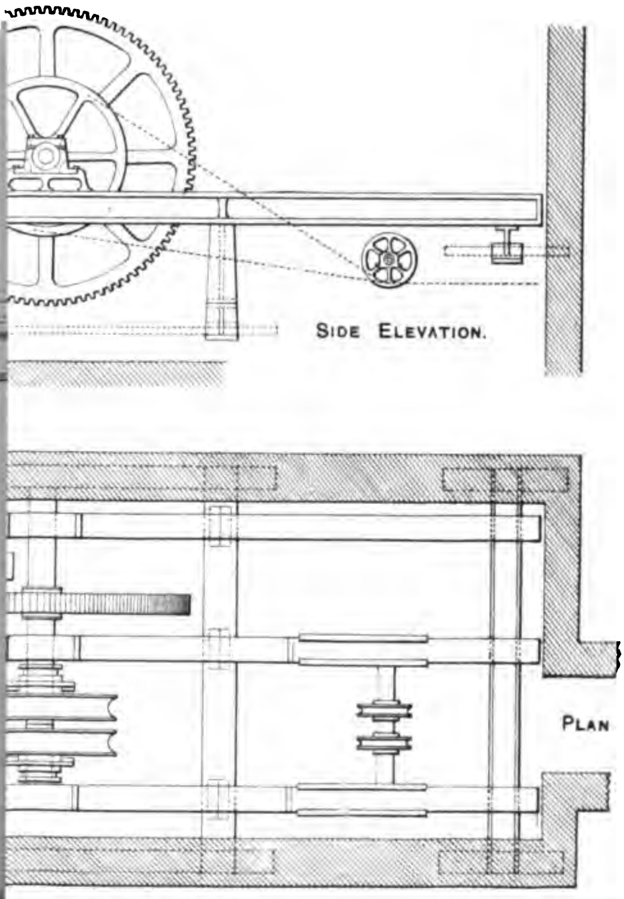


Fig. 5.

Scale, 1 Mile to 2 Inches.

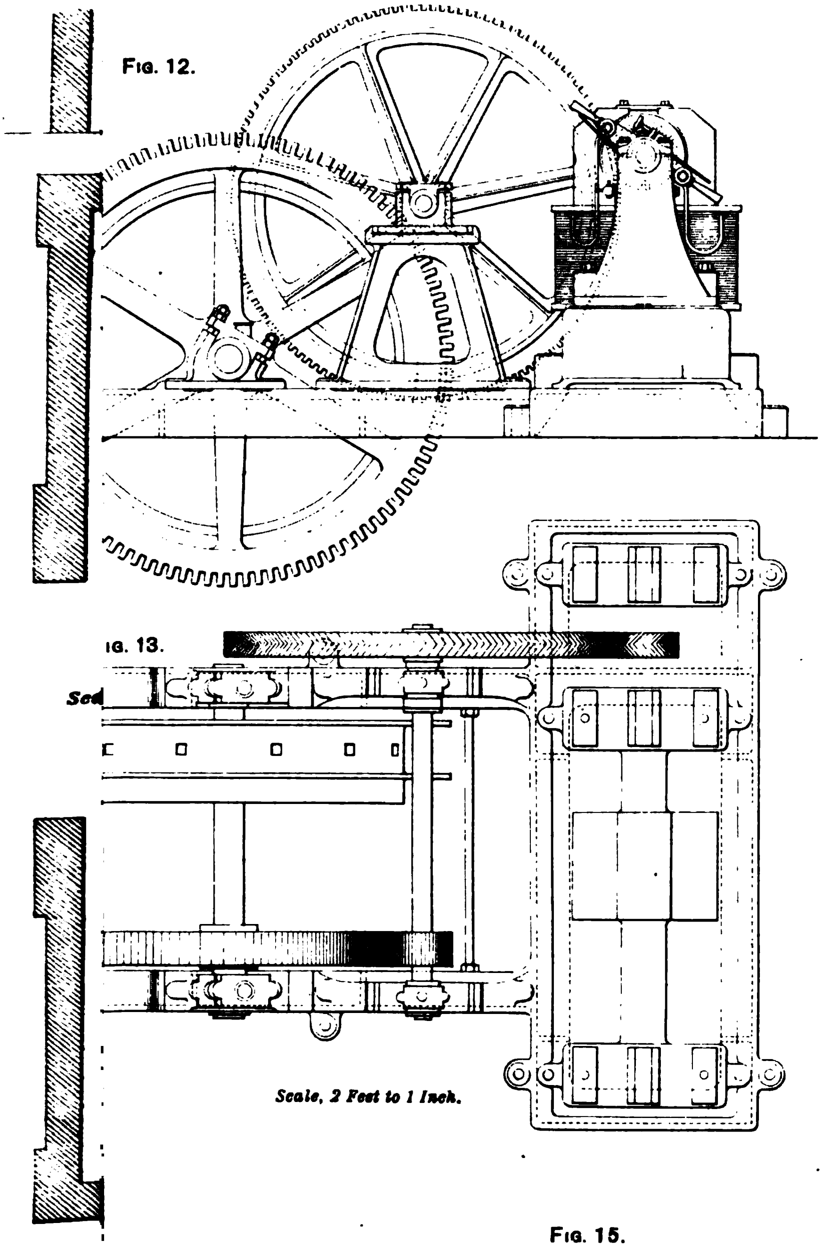


Chesterf

Scale, 8 Feet to 1 Inch.

Fig. 12.

IG. 13.



Scale, 2 Feet to 1 Inch.

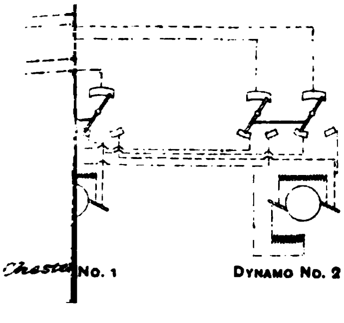
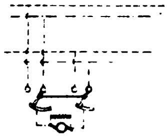


Fig. 15.



Lighting Circuit

Mr. J. A. **Longden** (Stanton) said it seemed to him that Mr. Piggford had not obtained the economy that he ought to have done. Mr. Piggford took the horse-keep at 1s. 10½d. per day, or reckoning on 5 days' of work per week, it amounted to 9s. 6d. per week, which seemed excessive. The total weight of wire-rope in use was 13 tons, at 30s. a cwt., and the life of the ropes being reckoned 3 years, which was rather low, he obtained a cost of 10s. a day when divided by 260 working days. So far as those items were concerned he thought that the saving should be considerably more than £700 per annum. It was an unusual thing for economies to be under-estimated. He hoped that Mr. Piggford would obtain much greater economy than was shown in his paper.

Mr. St. John **Durnford** (Acton Hall colliery) said that the over-estimation of the horse-keep would go against the argument that the economy had been under-estimated. Electric haulage had been installed at Acton Hall colliery, and with an output of 1,200 tons a day from one pit, they had reduced the horses from 40 to 32 in the first six months that the electric haulage had been in operation. There seemed to be no doubt that electric haulage was the cheapest haulage that could be used underground. The cables were hung in the shaft (1,200 feet deep) at Acton Hall colliery from top to bottom without any intervening supports. This arrangement was adopted because the cable was strong enough to hang alone, and if anything fell down the pit it did not catch or damage the cables.

Mr. **Snow** (Hickleton Main colliery) stated that the electric haulage at Hickleton Main colliery was subject to breakdowns, possibly owing to the machinery being built, without a sufficient reserve of power for the work required. The loss on the cables and motors was about 20 per cent.

Mr. A. A. **Atkinson** (Barrow collieries) enquired whether the 75 per cent. of efficiency shown in Table I was the amount of useful work got out of the steam engine. If so, electricity was a more economical source of power than compressed air, which usually had an efficiency varying from 25 to 40 per cent.

Mr. **Churton** (Leeds) enquired as to the amount of the loss of power between the motor and the rope-drums, what was the diameter of the rope-drums, and what was the speed of the ropes ?

Mr. R. **Holliday** (Acton Hall colliery) remarked that Mr. Piggford stated that the magnet circuit of the large motor coupled direct to the cables was not separated when they switched off. Had they had any accident when turning off the current at the engine-room? There would be a very powerful induced current, and at Acton Hall colliery a workman had been very severely injured by this current.

The CHAIRMAN (Mr. M. H. Mills) was of opinion that there was much more loss between the engine and the electric motor than was generally supposed. Mr. Piggford stated that "the resistance-switch is not provided for the purpose of running the motor continuously at low speeds, but simply for convenience in starting, and to allow of running at a very low speed occasionally, if required, in case of accident to rope or tubs." This resistance-switch must of necessity waste some power. What with tubs going off the road, and starting and stopping, there must be a greater loss than was shown by Mr. Piggford. He should like Mr. Piggford to make a comparison between the use of compressed air and electricity.

Mr. G. J. BINNS (Netherseal) enquired whether the small motors were continuous-running, and whether the author of the paper thought the adoption of a number of small motors, which would be frequently stopped and started, and might be all standing, or all running at once, would be favourably circumstanced for electric haulage.

Mr. PIGGFORD, replying to the discussion, stated that the horse-keep was reckoned at 8s. a week ordinarily, and that for 5 days was 1s. 7·20d. per day; harness and repairs averaged 1·15d. per day; horse-keep, which included horse-keeper's attendance, was 2·15d.; making in all 1s. 10·50d. per day. The cost of ropes was no doubt slightly underestimated, but he did not want to make the resulting economy appear more favourable than it was in reality. There were 24,732 feet of rope in use, weighing 13 tons. He had allowed 10 per cent. on the cost of the installation, including the ropes. He had taken the whole cost, and taken the life of the rope at 3 years, which was a low period, but one of the ropes was working under extreme conditions. The life of that rope was not a long one, but 3 years was well within the mark—that worked out to 13s. per day. Mr. Durnford said that the number of horses at Ackton Hall colliery had been reduced from 40 to 32, a small saving. It was probable that the breakdowns at Hickleton Main collieries arose from taxing the machinery too heavily. Electrical machines must not be worked to the full extent, otherwise breakdowns would ensue. The electric plant at the Pleasley collieries was not worked to anything like what the motors were wound to yield, and hence the safety and freedom from breakdowns. Mr. Mills had got an erroneous idea with respect to the resistance, which was only used when starting the machine, and was switched out when speed was attained. The loss in the cable, according to Table I. of experiments, was about 6·30 horse-power, or about 7½ per cent. The loss by friction in the gearing, etc., had not been separately determined by experiment. Table II. showed how the power was utilized. There had been no accident such as that described by Mr. Holliday. The 75 per cent. referred to by Mr. Atkinson was the ratio between the horse-power produced by the dynamo and the indicated horse-power of the engine.

Mr. **CHURTON** remarked that it was possible to have a high efficiency from motor and dynamo, and still experience considerable loss in reducing from a high to a lower speed.

Mr. **PIGGFORD** said that all the endless ropes were run at about the same speed. The 10 horse-power motor ran at 1·78 miles per hour; the two small motors, of 5 horse-power, ran at 1·82 miles per hour; and the big motor at 1·89 miles per hour.

The **CHAIRMAN** (Mr. **M. H. MILLS**) moved a vote of thanks to Mr. Piggford for bringing the subject of electric haulage before them. It was a matter of increasing interest—all of the members were thinking whether it would not be advisable to use electricity instead of compressed air or steam, or any other source of power.

The resolution was agreed to.

Mr. **HENRY E. MALTBY** read the following paper on "The Enlargement of a Shaft at Lidgett Colliery, without Interruption of Coal-winding":—

THE ENLARGEMENT OF A SHAFT AT LIDGETT COLLIERY, WITHOUT INTERRUPTION OF COAL-WINDING.

By HENRY E. MALTBY.

There are some engineering operations which are interesting, and perhaps worth recording, not so much from the magnitude and importance of the work as from their unusual character, and from the special difficulties encountered in carrying them out under conditions which are somewhat novel.

The coal at Lidgett colliery was until recently drawn up two circular shafts, each 7 feet in diameter, situated 510 feet apart, with the winding-engine placed midway between them. Both shafts were worked from the same drum, and in each of them a single-decked cage holding two tubs was placed. This arrangement was originally laid out for the winding of ironstone, and for such purpose was no doubt suitable, but for the winding and screening of coal it could not be considered either convenient or economical.

As the output of the colliery increased, it became a matter of the greatest importance that the whole of the coal should be drawn and dealt with at one point. This change necessitated either the sinking of a new shaft, or the enlarging of the small one near the screens, and the latter arrangement was decided upon owing to the difficulty of sinking a shaft suitable for the levels underground from a point sufficiently near the screens to be convenient for banking.

The widening of a shaft without interfering with the daily drawing of coal would under any circumstances have been an undertaking of somewhat difficult character, but it was rendered more onerous in this case owing to the presence in the shaft of a column of air-pipes (7 inches in diameter), which it was of the utmost importance should not be broken, together with a rising water-main (5 inches in diameter), and electric cables (Fig. 1, Plate XXXI.).

The shaft is 225 feet deep to the Lidgett coal-seam, and with the exception of 27 feet at the top, which was made ground, was put down through strata sufficiently hard to require blasting.

It was thought that by making the enlarged shaft of a rectangular shape, and lining it with timber, the sides could be more promptly secured, the pipes and conductors more easily kept in position, and the operation as a whole conducted with greater safety, than if made circular in shape and lined with brickwork. The shaft was laid off for widening each night from 6 p.m. until 4 a.m. of the following morning, and on Saturday afternoon from 4 p.m. until 4 a.m. on Monday morning. The work was commenced on May 5th, 1896. It will be seen on reference to the drawings (Fig. 2, Plate XXI.) that the enlargement was not made equally all round the old shaft, but that the greater part was excavated from the side farthest away from the pipes, this arrangement affording a threefold advantage :—The pipes were to some extent clear of the shots, the workmen had a deep ledge to stand upon when dressing the corners, and as much ground was left for the explosive to work in as possible.

The shaft was enlarged to a sufficient size to allow of oaken frames, made of timber, 6 inches square—the side pieces being 11 feet 1 inch long and the end pieces 9 feet long—being put in ; the first frame was bolted immediately to and under strong baulks fixed across the pit-mouth, the other frames being hung by bolts from the frame above. The frames were spaced 3 feet apart in bad ground, 4½ feet apart in moderately strong ground, and 6 feet apart in hard ground, and were lined at the back with backing-deals, 1 inch in thickness (Figs. 3 and 4, Plate XXXI.).

The pipes were secured in position by a piece of timber (6 inches by 5 inches) bolted to the side-pieces of the frame, collars being fastened across from this timber to the end-piece, bevelled to fit the pipes, these supports being placed when necessary.

It was essential that the two ranges of wooden conductors which had to be used every day for guiding the cage should not be damaged, but securely fastened in their proper position, and this was done by bolting one of them on to the side piece of the frame, the other being bolted to a piece of timber (6 inches by 4 inches) fixed from the end piece to the piece supporting the pipes. On the completion of the widening of the shaft this piece was moved on the same timbers to the middle of the shaft, and there fastened as a strengthening piece (Figs. 1 and 2, Plate XXXI.).

A wooden cover of the same size as the old shaft was made to fit the top of the cage, and, when lowered to the place where the widening was being done, acted as a platform on which the men could work (Fig. 4, Plate XXXI.).

Before any shots were fired, the cage was lowered to form a scaffold on which the material blasted could fall, and to prevent any of it from falling down the pit. The stone was drawn by a sinking-engine and kibble, the engine being fixed at right-angles to the winding-rope and clear of the pit-bank, the rope running over a small pulley fixed in the headgear.

The pit-mouth was covered by a bridge, running on rails, which were hinged at a point clear of the shaft, so that when the cage came to bank the rails could be pulled over clear of the shaft; when the kibble came to bank the rails were placed over the pit, and the bridge run over them. The rails were mounted on a strong wooden frame so as to be easily placed in position at night and removed at the end of the shift in the morning.

The rope was run down, kibble attached, cover fixed on cage, bridge fixed in position, and the shaft changed from a winding to a sinking one in about 10 minutes.

Gunpowder was used for blasting, and was fired by electricity, either from a battery or the lighting-cables, and the sinkers had the advantage of the electric light when at their work.

The work occupied four months, and was completed without accident of any kind and without the pit losing an hour of its ordinary drawing time. The depth sunk during each week averaged 13½ feet. The labour cost was £2 6s. 8d. per foot, which is of course high for the amount of material excavated when compared with an ordinary sinking-pit; but when the time necessary to prepare for commencing work every afternoon, and putting conductors in for the pit to draw coal at the end of each shift is considered, it may be deemed moderate. The securing of the pipes also required time and care.

The fact that the work was completed without injury to life or limb, and without even breaking a pipe, reflects great credit on the contractor, Mr. Henry Joyner, of Barnsley.

REFERENCES TO PLATE XXXI.

Fig. 1 is a plan of the old shaft;
Fig. 2 is a plan of the widening of the shaft;
Fig. 3 is an end view, during the widening of the shaft;
Fig. 4 is a side view, during the widening of the shaft; and
Fig. 5 is a plan of the finished shaft.

The CHAIRMAN (Mr. M. H. MILLS) said that Mr. Maltby's paper contained a record of work which had been ingeniously carried out. The shaft was not deep, so that there was no danger in using a square shaft, otherwise for greater depths, a square shaft would not have been advisable.

A vote of thanks was accorded to Mr. Maltby for his paper

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To illustrate Mr. Henry E. Maltby's Paper on "The Enlargement of a Shaft at Lidgett Colliery" etc.

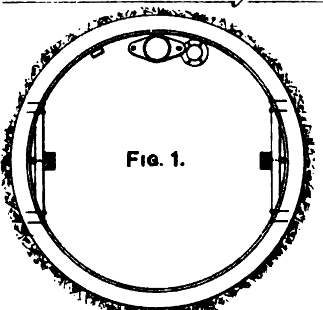

Fig. 1.

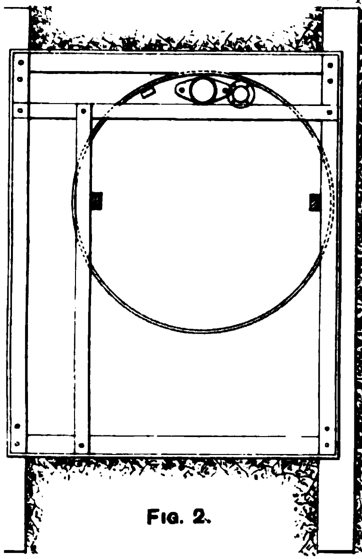

Fig. 2.

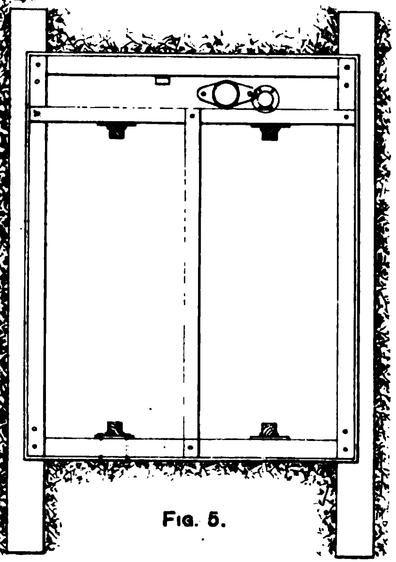

Fig. 5.

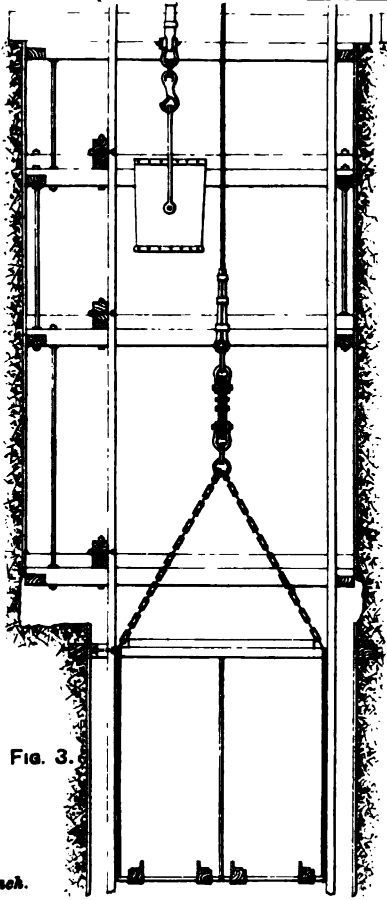

Fig. 3.

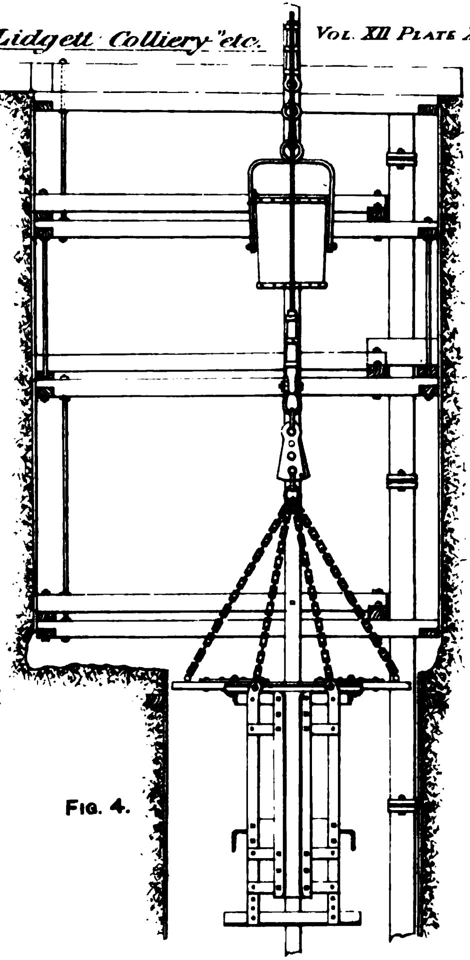

Fig. 4.

ld and Midland Counties Institution of Engineers.
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Scale, 5 Feet 4 Inches to 1 Inch.

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APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

COKING CAPACITY OF COALS.

Détermination expérimentale du pouvoir agglutinant des houilles. By Louis Campredon. *Comptes Rendus de l'Académie des Sciences,* 1895, *vol. cxxi., page* 820.

Existing classifications of coals give no indication of their coking capacity, and chemical analysis, as generally practised, does not afford any precise information on this point. The author was led to undertake a series of experimental trials for determining the coking capacity of coals by a method similar to that employed for ascertaining the binding power of cements, viz., mixing the coal with an inert substance and carbonizing the mixture in a closed vessel, when the product retained, in the form of a solid button, a quantity of inert matter in direct proportion to its coking capacity.

A weight-unit of coal finely pulverized was mixed with variable weight-units of fine siliceous sand, the grains of which were practically uniform; and the mixture was raised to a bright red heat in small porcelain crucibles, so as to carbonize the coal. After cooling, the product varied from a powder without consistence to a more or less compact button; and it was easy to determine, by a few trials, the maximum weight of sand which a coal could agglomerate into a solid mass by carbonization. If the weight of the coal be represented by unity, the weight of agglomerated sand will give its coking capacity, which was found to be *nil* for all coals that yielded a pulverulent coke, while it attained 17 for the most coking coal hitherto tried in this manner.

The following are a few of the results obtained with coals dried at 100° Cent. by this method, which has been employed for three years in the laboratory of the Trignac works:—

	Volatile Matter.	Ash.	Fixed Carbon.	Coking Capacity.
Unscreened Aberdare coal	10·90	6·20	82·90	0
,, Newcastle coal	34·25	10·80	54·95	2
,, Scotch coal	34·72	8·35	56·93	4
Cardiff coking slack...	19·80	7·70	72·50	6
Unscreened Lens coal	27·20	8·70	64·10	13
,, ,, oxidized by heating to 100° Cent. for a year	28·12	8·55	63·33	0
Newcastle coking slack	27·83	8·75	63·42	14
,, ,, ...	29·50	8·50	62·00	17
Pitch from Beckton gasworks	44·82	0·60	54·58	20

As shown by this table, there is no correlation between a coal's composition and its coking power.

J. W. P.

REMOVAL OF SILVER AND GOLD FROM SEA-WATER BY MUNTZ-METAL SHEATHING.

By A. Liversidge. *Journal and Proceedings of the Royal Society of New South Wales*, 1895, *vol. xxix., pages* 350-366.

A distinct loss of silver and gold has been observed in old Muntz-metal plates which have been exposed for a considerable time to the action of sea-water, about one-half of the silver and one-third of the gold originally supposed to have been present being absent when compared with new specimens. The scale upon the surface of these old plates, however, while showing about the same loss of silver, indicated a gain of 7 dwts. of gold, or about 700 per cent. This increase in the amount of the latter metal may be accounted for either by precipitation from the sea-water or by concentration, due to the solution of the other constituents of the sheathing, leaving the gold unattacked. Experiments with samples of new sheathing which had been exposed to the influence of salt-water showed a slight decrease in the amount of silver and an increase in that of gold; but these results were not considered satisfactory, as the gold contained platinum from the sulphuric acid used to dissolve the metal for analysis. M. W. B.

THE AMOUNT OF GOLD AND SILVER IN SEA-WATER.

By A. Liversidge. *Journal and Proceedings of the Royal Society of New South Wales*, 1895, *vol. xxix., pages* 335-349.

Evidence is given in favour of gold being present in sea-water off the New South Wales coast in the proportion of about 0·5 to 1 grain per ton, or in round numbers from 130 to 260 tons of gold per cubic mile. This, of course, means an enormous amount for the whole of the ocean, the cubic contents of which used to be reckoned at 400,000,000 cubic miles, and if the gold be uniformly present at the rate of only 1 grain per ton, the total amount would represent over 100,000,000,000 tons of gold. A later estimate is 308,710,679 cubic miles: this even would contain over 75,000,000,000 tons of gold. But at the present day, it would probably not pay to extract the gold by itself, although it might as a bye-product in the manufacture of salt, bromine, etc. The enormous amount of gold in the sea is, however, probably very small in comparison with the amount scattered throughout sedimentary and crystallized rocks, *i.e.*, apart from gold in veins and other deposits.

All sea-waters contain some silver, usually from 1 to 2 grains per ton, but the author considers the scorification and cupellation process lacking in the necessary precision for the exact determination of silver in such minute quantities as occur in sea-water. M. W. B.

KOLAR GOLD-FIELD, MYSORE, INDIA.

Notes from the Geological Survey of India. By R. D. Oldham. *Records of the Geological Survey of India*, 1896, *vol. xxix., page* 82.

Certain pecularities of the so-called champion reef in the Kolar gold-field show that it is not a reef or vein, but a true bed of metamorphic quartzite. The lie of the quartz is strictly conformable to that of the schists on either side, and in more than one place it has been bent sharply up and then down again into a synclinal and anticlinal fold, whose axes dip steeply to the northwards. Where the quartz is bent, the bedding of the hornblende-schists follows it, and can be seen curving over the vacant spaces where the quartz has been worked out. There can be little doubt that this interpretation is the true one, and that the gold of Mysore, as of the Transvaal, occurs in a bed, and not in a true vein. This discovery is of interest as adding yet another to the many analogies between the geology of India and Africa, and is not without its bearing on the economic question of the life of the Kolar gold-field. M. W. B.

PROSPECTING FOR MAGNETIC MINERALS BY MEANS OF MAGNETIC MEASUREMENTS.

Sobre la Busca de Minerales atractivos por medio de Medidas Magnéticas. By JUAN PIE Y ALLUÉ. *Revista Minera, Metalurgica y de Ingenieria*, 1896, *vol. xlvii., page* 357, *and illustrations.*

The hanging compass is used for the purpose of exploring for a deposit of magnetic mineral; by its means nearly all the deposits of magnetite, and a great number of those of copper, zinc, cobalt, and nickel, which exercise some magnetic attraction, have been discovered in Sweden. This instrument consists of a freely-suspended magnetic needle contained in a round metallic box, the needle being so balanced as to lie horizontal when exposed only to the action of the earth's magnetism. By noting the angle of inclination or dip of the needle, the existence and approximate dimensions of the deposit can be determined, although it may be overlain by barren strata.

More detailed examinations are made next by means of the Thalen magnetometer, or the Tilberg magnetic balance or inclinometer. These two instruments are now often combined into one. The Thalen magnetometer consists of a magnetic compass graduated into four quadrants, the zero-points being at the north and south. The compass-box is prolonged in the east-west line by an arm made of brass, to which a vertical bar of soft iron can be secured, whilst a magnetic needle can also be attached to it. The instrument can be used in two ways, by the method of tangents and of sines.

In the former, the compass-box is levelled and is turned round till the needle lies on the north-south line. The magnetic needle is then attached to the arm and the angle of deviation noted; the needle is then removed, the soft iron bar secured in its place, and the angle again read. The former angle represents the horizontal component of terrestrial magnetism and of the attraction of the mineral deposits, the latter the vertical component.

In the method of sines, the magnetic needle is attached and the compass-needle is then brought to zero; the first needle is removed and the angle is read, and the same operations as before are then gone through with the bar of soft iron.

Before a series of observations is commenced the instrument must be adjusted in a perfectly non-magnetic locality, the needle on the arm being so placed as to cause a deviation of about 30 degrees. This angle will be constant for all non-magnetic spots and is equal to that obtained along the neutral line of the deposit, a line which divides the curves of maximum and minimum intensity.

The ground, in which the dipping compass has shown the existence of mineral, is marked out by ranging rods, into squares of from 10 to 30 feet length of side; at each intersection, the angle a of deviation is determined by either of the above methods, the method of tangents being usually sufficiently accurate; these angles are noted on a plan, and all points of equal magnetic intensity are joined; isodynamic curves are thus produced, forming two groups of closed curves, one of maximum, the other of minimum intensity. The neutral line passes between these two groups. The centre of the maximum curves or the point of maximum intensity is always to the north of the deposit and that of the minimum curves to the south, provided that the deposit does not come to the surface and is not far from vertical. If the mineral crops out at the surface the main mass of it lies immediately below the centre of the curves of minimum intensity. Let v be the angle of deviation due to the vertical component; then values of G are determined by the formula $G = \frac{\tan v}{\tan \alpha} - 1$; the values of G thus obtained are written down on a plan and all points of equal value are joined. A series of closed curves will thus be obtained surrounding more or less regularly a central point, which is the plan of the apex of the deposit.

The calculations of Prof. Thalen have led him to the following conclusion:— The distance from the surface to the centre-point of the deposit is twice the distance between the points of minimum intensity and the intersection of the neutral line with the magnetic meridian. This conclusion is only applicable when the method of sines is used, when the deposit is approximately vertical, and the sine of the neutral angle is less than three times the sine of the smallest angle of deviation.

The magnetic balance of Prof. Tiberg is used to determine the vertical components of the magnetic force. It consists of a compass-box containing a magnetic needle capable of moving only in one plane, and suspended like the beam of a balance with its centre of gravity below the point of suspension when the compass-box is vertical. By means of a little wax, the needle is made to hang horizontal in a neutral locality. It is then taken on to the ground and set up over each point of intersection, and the compass-box, lying horizontal, is turned until the needle coincides with the east-west line of the box. The box is then turned on its axis, which coincides with that line, until it is vertical. The inclination of the needle is then noted, it being determined solely by the vertical components of the terrestrial magnetism, and that due to the deposit. From the angles so obtained, isoclinic curves may be plotted, the centre of the deposit being at the point that has shown the maximum angle of inclination. H. L.

WETHERILL SYSTEM OF MAGNETIC CONCENTRATION.

ANON. *The Engineering and Mining Journal* (*New York*), 1896, *vol. lxi., pages 564-565, with 5 drawings.*

In the system of magnetic concentration invented by Mr. J. Price Wetherill, of Bethlehem, Pennsylvania, extremely low currents, obtained by the use of magnets of great power, are effective in separating minerals which have hitherto been considered non-magnetic. This process was developed in separating the several minerals associated with zinc oxide in the franklinite of New Jersey.

A large number of minerals have, until lately, been considered incapable of magnetic concentration without a previous roasting to render them sufficiently magnetic to be acted upon by any practicable electro-magnetic separator. Such are red and brown hæmatite, siderite, chromite, menaccanite, rutile, franklinite, pyrolusite, psilomelane, tephroite, rhodonite, garnet, and most of the minerals containing iron or manganese, or both, as well as most of the chemically pure salts of these metals.

A full description of the working of the Wetherill magnetic separator is given, illustrated by drawings in section, side elevation, and plan. The process is in use at the works of the Lehigh Zinc and Iron Company, at South Bethlehem, Pennsylvania, where 1,000 tons of ore per month are treated by it—garnet, franklinite, tephroite, and fowlerite being removed from willemite, zincite, and limestone, and the latter subsequently separated by jigging. J. W.

FURNACE-RESIDUE FROM IDRIA CINNABAR ORE.

Die Brennrückstände von der Verhüttung der Idrianer Zinnobererze mit Kalkdolomitische Gangart. By F. Janda. *Oesterreichische Zeitschrift für Berg-und-Hüttenwesen*, 1896, *vol. xliv.*, *pages* 549-552.

The residue from Idria cinnabar ore, roasted with dolomitic limestone in (*a*) a movable bar-furnace and (*b*) a shaft-furnace, averaged:—

	Per Cent.			Per Cent.	
	a.	*b.*		*a.*	*b.*
$CaSO_4$	3·94	2·09	MgO	5·42	10·27
$MgSO_4$	0·67	0·99	CO_2	7·26	18·11
CaS	0·80	0·10	P_2O_5	0·08	0·13
FeS	2·04	0·85	SiO_2	40·30	25·82
FeO	1·42	1·14	Carbonaceous matter	10·10	3·84
Fe_2O_3	5·44	6·54	Hg	0·005	0·003
Al_2O_3	4·11	7·40	MnO, alkaline chlorides, etc.	0·225	0·497
CaO	18·19	22·22			

In the former case, the ferric sulphide is oxidized on recalcination or on exposing the hot residue to the air and evolves sulphur dioxide. Being brittle and porous, the residues absorb moisture from the air and gradually crumble down, the calcium sulphide, which is particularly hygroscopic, being decomposed by the atmospheric moisture and carbon dioxide into sulphuretted hydrogen, and into carbonate and hyposulphite of lime, the latter oxidizing by degrees to sulphate with separation of sulphur.

The changes occurring in roasting the ore with dolomitic gangue are: volatilization and decomposition of the cinnabar; oxidation of more than half of the pyrites to ferric oxide, leaving a lower form of sulphide behind; oxidation of the ferrous carbonate, this effect being well manifested in shaft-furnace residues by a thick, deep red incrustation on the surface of the heap, the red dust from which yielded on analysis 15·5 per cent. of Fe_2O_3, and 9·8 per cent. of Al_2O_3. The carbonates of lime and magnesia are decomposed and part with their carbon dioxide, this being particularly the case with the latter base, which loses its carbon dioxide at 300° to 400° Cent. Calcium sulphide is formed by various reactions favoured by the presence of carbon dioxide and sulphuretted hydrogen and by the absence of oxygen. A small amount of magnesium sulphide is produced by the reducing action of carbon on the sulphate. The carbonaceous matter results from the incomplete combustion of organic substances in the mass, and partly, in shaft-furnaces, from the wood charcoal; when treated with concentrated sulphuric acid the *a* residues gave off sulphuretted hydrogen, followed by sulphur dioxide, from the reduction of the acid by the carbonaceous matter.

On extraction with water, the residues *a* and *b* both yield a liquor containing sulphuretted hydrogen and calcium sulphide in proportion to the amount of lime present, except in cases where the original ore was low in sulphide of iron. The *a* residue extracts also contain calcium di-sulphide, as is proved by the evolution of sulphuretted hydrogen when manganous chloride is added; on the other hand the extracts from *b* residues contain much calcium carbonate.

Some of the ore treated in the shaft-furnaces contain sandstone rich in pyrites and gypsum. This stone, after roasting, splits readily along the gypseous layers and becomes encrusted with a yellow coating of basic ferric sulphate on exposure to air. A fine-grained tough sandstone is also occasionally present, containing much ferrous sulphate, magnesium sulphate, and organic matter, all of which are decomposed by roasting. C. S.

SOLUBILITY OF LEAD AND BISMUTH IN ZINC.

Ueber die Löslichkeit von Blei und Wismuth in Zink. Nachweis einer kritischen Temperatur. By W. SPRING *and* L. ROMANOFF. *Zeitschrift für Anorganische Chemie, vol. xiii.* [1], *pages* 29-35.

In these experiments the heating of the crucible was effected by a gas-furnace, the temperature being regulated by controlling the supply of gas in accordance with preliminary observations, and recorded (up to 500° Cent.) by a mercury thermometer containing compressed nitrogen, the platinum cone and calorimeter being used for the higher temperatures. To facilitate the drawing of samples, the crucible was perforated at one side and the aperture closed by a plug of graphitic clay. A sufficient quantity of the denser metal to cover the hole being inserted in the crucible, the zinc was laid on the top, covered by potassium iodide, sodium chloride, or powdered carbon to prevent oxidation, and heat was applied for two hours to bring the mixture to the temperature desired, the contents being stirred for a few minutes every half-hour. After ¼ hour's rest, to allow the metals to separate into two layers, the superficial stratum of metal was removed by a spoon, the central portion run off through the plug-hole, and the lower layer ladled out, the entire removal being effected in less than 1 minute, to minimize the reduction of temperature.

The results of the analysis of the top and bottom layers, expressed in percentages of the saturated solution (Etard method) show that in the former, the solubility of zinc in bismuth ranges from 14 at 266° Cent. to 30 at 750° Cent., and in lead from 1·2 at 334° Cent. to 41 at 900° Cent., the solubility of bismuth in zinc in the lower layer being 3 at 419° and 27 at 750°, and that of lead in zinc respectively 1·5 and 25·5 at these temperatures.

The curves drawn from these figures indicate that, with rising temperature, the two solubilities tend to equalize the points at which they would be identical, *i.e.*, the critical temperatures, being about 850° Cent. for bismuth-zinc, and above 900° for lead-zinc. These curves show a perfect analogy with those drawn by Prof. Alexeiev for unmixable liquids, and demonstrate the similarity between the mixture of fused metals and ordinary liquids. C. S.

TREATMENT OF ORES BY THE COMBINED SALT AND HYPOSULPHITE PROCESS AT KAPNIK IN HUNGARY.

Combinirte Kochsalz- und Hyposulfit-Laugerei auf der Königl. Extractions-Hütte zu Kapnik in Ungarn. ANON. *Berg-und Hüettenmännische Zeitung*, 1896, *vol. lv., page* 373.

The ores treated at Kapnik amount to about 2,000 tons annually, and contain copper, zinc, lead, and about 0·057 per cent. of silver and gold. These ores used to be treated by smelting, but the increase in the cost of fuel and the diminution in the value of the metals produced, especially silver, rendered it imperative to abandon this method. In 1872, the cost of smelting was 4·28 florins (about 8s. 6d.) per ton, resulting in an annual loss of about £2,500; in 1894, the cost of leaching (giving better technical results) was only 2·50 florins (about 5s.), giving a profit on the year's work of about £1,700.

The ores are first submitted to a chloridizing roast in a Bóde furnace, followed by a finishing roast in a reverberatory furnace. The roasted ore is leached first with hot salt solution of 20° to 22° Baumé for four days, by which about three-fourths of the gold and silver are extracted, and the residue is leached with a solution of the hyposulphites of sodium and calcium for two days, at the end of which time the tailings contain only 0·001 to 0·003 per cent. of the precious metals.

The gold, silver, copper, and lead are thrown down in the metallic state by means of iron from the salt solution, and as sulphides by means of the sulphides of calcium and sodium from the hyposulphite solution.

The entire plant consists of ore-sheds, 18 Bóde and 2 reverberatory furnaces, 20 cooling-vaults, 20 leaching-vats, 462 stoneware tubs for iron precipitation, 65 oaken leaching-tanks, depositing and settling-tanks, etc., the total capital outlay for a plant capable of treating 2,000 tons a year being £8,200; the ore-shed cost £500, the furnaces £1,480, the cooling-vaults £220, and the leaching-plant £6,000.

H. L.

ORE-CONCENTRATION IN THE BUTTE DISTRICT, MONTANA, U.S.A.

By CHARLES W. GOODALE. *The Engineering and Mining Journal* (*New York*), 1896, *vol. lxii., pages* 269-270.

The ores of the Butte mining district present a variety of combinations, and may be classified as follows:—

1. Copper-silver ores, which are produced by the mines of the Anaconda group, and by the Mountain View, Colusa, Silver Bow, and Parrot. These high-grade ores are roasted and then smelted; but a large proportion of the output is low-grade and siliceous, and hence requires concentration. The copper-bearing minerals occur in a gangue of quartz and felspar.

2. Silver-copper ores, of which the Gagron vein is the largest producer. The grade of the ores from this mine is such that nine-tenths of the output requires concentration. The silver and copper-bearing minerals of this vein are found in a quartz-gangue associated with felspar and smaller quantities of barite and fluorite.

3. Silver ores containing a small amount of gold, such as those of the Alice and other mines on the Rainbow lode, the Lexington, the Blue Bird, and others. The gangue is quartz, carrying pyrite, galena, and argentite, with manganese. Good

results on ores of this class cannot be obtained by concentration, as a large part of the silver-bearing minerals are disseminated through the gangue in such minute grains that even the finest practicable crushing does not liberate them from the quartz. Moreover, a great loss is sustained from the floating-away of the rich silver-glance in the form of a greasy scum upon the surface of the water. Nearly all of these ores are therefore treated by chloridizing-roasting and amalgamation at a cost of 22s. to 30s. per ton, and with a saving of about 85 to 90 per cent. of the silver and 40 per cent. of the gold; the fineness of the resulting bullion being from 0·400 to 0·700.

In the Butte district, two general systems are in use. At Anaconda and at the Butte reduction-works, steam-stamps, hydraulic separators or classifiers, Collom jigs, and revolving slime-tables are employed; while at the Butte and Boston, the Boston and Montana, the Parrot and the Colorado concentrating-works, Blake rock-breakers, Cornish rolls, revolving-screens, Harz jigs, and frue-vanners are in use. Hydraulic sizing is also in use in the last-named mills for the separation from the slimes of material which 10 and 12 meshes jigs can treat. At the Butte reduction-works, frue-vanners are used for the overflow-slimes from the tanks which supply the round tables. J. W.

QUINET ROTATING CARRIER-TUBE.

Tube transporteur rotatif. By A. Godeaux. *Revue Universelle des Mines*, 1896, *vol.* xxxvi., *page* 284, *with drawings.*

In screening and loading-plants, cases frequently occur in which the difference of level is insufficient to afford such a slope of shoot as will permit the coal to slide by itself into the hoppers. In the Quinet carrier-tube, the usual Archimedean screw was suppressed, the case only being retained, and a slight slope given to the tube sufficed to ensure the transport of nut-coal in a direction parallel with its axis. Two of these carrier-tubes have been erected at the Bascoup central screening-station, where they give complete satisfaction. The tube is erected almost parallel with the picking and carrying-belt, from which it receives the cleaned nuts, through a hopper that delivers at will either into the tube or into shoots leading directly to a railway-waggon, according as it may be desired to send away the nuts mixed with dust or not so mixed. Inasmuch as, in the former case, the nuts fall upon the dust at the bottom of the waggon, breakage is reduced to a minimum while the mixing is sufficient.

The carrier-tube, sufficiently strong to be self-supporting, is supported on a pair of rollers at each end, and is kept in position by a pair of smaller rollers at each end and above the tube. In this case, motion is given by ropes to one of two pulley-rims of different diameters, embracing the lower end of the tube and permitting of 38 or 47 revolutions per minute, the delivery in the former case being 6·8 tons per hour. The tube is 16 inches (40 centimetres) in diameter and 20 feet (6·14 metres) long, the inclination being nearly 8 degrees. The power required to rotate the tube running light or empty is only about 0·2 horse-power, and this power is not greatly exceeded when the tube is loaded. By suppressing the central shaft and cross-stays that were adopted in the first installation, the breakage is reduced from 8½ to 5 per cent. J. W. P.

KREISS ORE-CARRIER.

Ueber die Kreiss'sche Förderrinne. *By* C. Blömeke. *Berg-und Hüttenmännische Zeitung,* 1896, *vol. lv., page* 397.

The Kreiss ore-carrier is a simple metallic channel of semicircular cross-section, attached to or suspended from inclined springs, and moved backward and forward at a rapid rate by cranks, the ore being carried forward by inertia ; sometimes the inner surface of the channel is roughened, to increase the grip of wet ore, by the insertion of perforated or dentated plates.

Experiments were made at the Diepenlinchen mine, near Stolberg, with one of these carriers about 10½ feet long, 11 inches wide, and 4 inches deep, the first 25 inches or so being horizontal and perforated for the escape of water. A speed of 470 revolutions of the crank per minute was maintained, but the slope of the carrier (12 degrees) was too steep to convey the ore (in pieces of about ⅛ inch in diameter), except as a very thin layer. When in a horizontal position, however, the machine acted efficiently, and at an angle of 6 degrees conveyed pieces $\frac{1}{12}$ inch in diameter at the rate of 80 inches (2 metres) in 1 minute, the time of transport increasing with the size of the lumps up to 8½ minutes for those ⅗ inch in size. The coarser lumps did not move forward satisfactorily, owing to the wet condition of the ore, but when a perforated plate-lining was introduced, all sizes, up to 1½ inches, were conveyed by the carrier with ease. Owing to the favourable result of the tests, a carrier divided into two parts, one horizontal 28 feet (8·5 metres) long, and 9 inches wide, and the second 23 feet (7 metres) long, and 15 inches wide, is now installed at the mine, and conveys 75 tons of ore *per diem* up a vertical height of 33 inches. The power required is said to be no greater than in other systems, and the expenditure for repairs is low, the wooden springs being very durable, and the perforated lining being replaced from worn-out sieves. C. S.

SIMPLON TUNNEL.

Le percement du Simplon. *By* G. Colombo. *Revue Universelle des Mines,* 1896, *vol. xxxiii., page* 1.

The proposed tunnel, nearly 12½ miles (20 kilometres) long, which will constitute the most important passage of the Alps, and is estimated to cost nearly £6,000,000 (150.000,000 francs), will traverse from north to south, first, the micaceous shales and a bed of gypsum for 12,140 feet (3,700 metres), then alternating strata of limestone, mica-schists, limestone, and gneiss for 31,800 feet (9,700 metres), and lastly, a thickness of 20,800 feet (6,330 metres) of mica-schist and gneiss, the strata being almost perpendicular to the centre line of the tunnel. Neither the shales nor the gneiss, although very hard, are expected to cause any great difficulty; but such is anticipated in the case of the gypsum, although only occurring over slight lengths of the tunnel.

The method proposed by the contractors consists in driving two single-line tunnels, 56 feet (17 metres) from centre to centre, and connected by cross-drifts every 656 feet (200 metres), one tunnel only being driven, first, with the heading of the other tunnel, which will be completed only when the traffic requires it. Each tunnel will have a height of 18 feet (5½ metres) above the rails, and a width at the rail-level of 14¾ feet (4½ metres), which the commission of experts appointed by the Italian Government proposes to increase to 15½ feet (4·7 metres), while the headings will be 12¼ feet (3·85 metres) high by 12 feet (3·7 metres) wide. During the work, the heading of the second tunnel will serve to take off the water, for the entrance of the air for ventilating and cooling the working-places, and also for the entrance of the trains, which will make their exit, as will also the air, by the first tunnel. In this manner, a ventilation, perfectly under control, dry working-places, and convenient and regular transport will be obtained, and this far better than by a single tunnel with double line of way, which would cost at least as much. The rock-drills to be used are of the improved Brandt type, working with water under pressure, with which a hole of 2¾ inches (7 centimetres) diameter and 4 feet (1·25 metres) long has been bored in Antigorio gneiss in less than 15 minutes, and by means of which the contractors reckon upon a daily advance of 19 feet (5·85 metres), except during the first few months, so that the first tunnel, and the heading of the second, may be completed in 5½ years from the commencement of the works, while they also hope to accelerate the work by a method of taking off the spoil by means of water.

For rock-drilling and ventilation, it is intended to utilize a force of 800 horse-power—taken from the river Rhône at the northern end of the tunnel, and one of 1,700 horse-power from the rivers Diveria and Cherasca at the southern end—for sending about 18 gallons (from 80 to 100 litres) of water per second, at a pressure of 1,500 lbs. per square inch (100 atmospheres), into each end of the tunnel; but far more water-power will be available if required.

It has long been acknowledged that the difficulty of driving a long tunnel can only be got over by having plenty of motive power at command, which permits of not only pushing forward the works with rapidity, but also of overcoming the difficulty caused by the vitiated air of the working-places and of the heat due to the depth of the tunnel from the surface, which in the present case is 7,000 feet (2,135 metres). The question of cooling and ventilation constitutes the greatest difficulty in the Simplon tunnel; but the disadvantageous influence of the great heat in long drivings has been much exaggerated, because facts show that workmen can stand very high temperatures when the ventilation is sufficient. It is calculated from the experience obtained with the Saint-Gothard tunnel that the temperature in that of the Simplon will increase a Fahr. degree for every 113 feet (1° Cent. per 62 metres), so that the highest temperature will not exceed 102° Fahr. (39° Cent.); but the contractors are bound to take means for ensuring that the temperature in the working-places shall never exceed 77° Fahr. (25° Cent.).

These means consist in the forcing in of air by means of a water jet, after the manner of the injector, with, if necessary, the use of water in the form of spray; and calculations based upon experiment show that 11 gallons (50 litres) of water per second will be sufficient to lower the temperature on each side of the tunnel to 68° Fahr. (20° Cent.). Inasmuch as a circulation of 1,765 cubic feet (50 cubic metres) of air per second with 18 gallons (84 litres) of cold water at the northern end and 16 gallons (75 litres) at the south is provided for, the contractors feel sure of satisfying this condition. The ventilation will be ensured, both during the execution of the works and in the course of actual working, by fans erected at both ends of the tunnel, and capable of supplying at least 1,765 cubic feet (50 cubic metres) of air per second.

The contractors undertake to make the first tunnel and the heading of the second for the sum of £2,180,000, not including the purchase of land and permanent-way materials, and to complete the second tunnel, not including the permanent-way and ballasting, for an additional £600,000, if decided upon within four years.

J. W. P.

WORKING A THICK COAL-SEAM AT ARNAO, SPAIN.

Abbau mit Bergversatz auf der Steinkohlengrube von Arnao in Asturien (Spanien). By — DACH. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen,* **1896,** *vol. xliv., page* **395.**

The Compagnie Royale Asturienne des Mines of Liége is working a seam of coal up to 40 feet thick, at Arnao, on the northern coast of the Spanish province of Asturias. The outcrop of the seam forms an arc open towards the north, distant on an average 660 feet from the sea and 100 to 130 feet above sea-level. The seam dips to the north and extends far under the sea, the furthest points reached so far being some 660 feet beneath the sea and 1,650 feet from the coast. The dip of the seam averages over 20 degrees, while the sea-bottom slopes very gently, so that the thickness of rock between the coal-seam and the sea-bottom which is only 130 feet at the coast-line, increases further north to 590 feet; these rocks consist of Coal-measures, alternately shales and sandstones.

The submarine portion of the seam has been opened up by a vertical shaft 250 feet deep, the surface being 65 feet above the sea, while the pit-bottom is 185 feet below it; thence an engine-plane is driven in the seam at a downgrade of 23½ degrees. The panels on either side of the engine-plane are opened by a series of horizontal drifts, about 33 feet apart vertically; only every third one of these is used as a tramway, the other two above it being connected with it by self-acting inclines; as soon as these levels have reached the boundary coal-getting commences, working backwards, by taking off slices 10 feet wide rising from each level to the one above it. When such a slice is complete, the place is carefully stowed by building a dry-stone wall 3 to 5 feet thick of good stone close against the pillar of coal left standing, the space behind this wall being carefully packed. The dry-stone wall is built of blocks of Devonian limestone quarried close to the pit, the filling behind the wall consisting of the stone got in the mine and of metal made in the quarry. When the thickness of the seam does not exceed 11½ feet, the whole thickness of the seam is taken in one lift; when it is thicker, it is better to divide it into several lifts not exceeding 10 feet, or at the outside 11½ feet, the footwall lift being got first, care being taken that each successive lift shall be at least a division behind the one previously worked out; the workings thus assume a step-like profile in longitudinal section. The horizontal levels are driven in the seam close to the roof.

Timbering is effected by means of caps 11½ feet long, which rest at one end in the wall of the stowed slice, at the other end in holes cut in the coal, supported by props in case of need. The props set against the coal can be drawn when the next slice is being got; in the lower lifts, the caps, together with any lagging-boards, can be recovered when the next upper lift is worked, but the roof of the seam is so bad that it requires very close timbering, and but a small portion of this timber can be drawn when its neighbouring slice is being stowed.

Where the seam is very thick and three or four lifts have to be worked, the levels are liable to creep and their maintenance becomes expensive; in these cases it is preferred to drive the level on the floor side of the seam, to stow it at the same time as the workings, and to drive fresh levels in the coal as required.

In order to ventilate the workings, the main shaft is made the downcast, the air passing down the engine-plane to the lowest level, and thence ascending through the workings up to the level of the shaft-bottom, whence it passes to the upcast shaft, where it is heated by the steam-pipes of the underground hauling-engine and is connected with a chimney 130 feet high, also heated by steam; a Guibal fan is kept in reserve.

The coal is worked up to a depth of 100 feet beneath the sea, the rib thus formed being left standing to prevent surface-water from making its way into the deep workings.

It has been found that the most careful packing is compressed 30 to 40 per cent., so that a settlement of several feet occurs in the thicker parts of the seam, producing at times fractures that continue up to the sea-bottom; water has thus made its way into the workings, but never in serious quantities, and the fissures appear gradually to close again, becoming silted up by the sand of the sea-bottom.

The workings above sea-level, where the same attention to the maintenance of the roof is not required, are worked in a very different manner. Here self-acting inclines are driven in the strata above the roof; from these horizontal levels are driven across the seam about 10 feet high, from these again a pair of levels are driven 150 to 200 feet right and left in the seam, one near the roof and one near the floor. The coal is then worked in slices across the seam 11 feet wide by 11 feet high, which are then closely stowed. A vertical shaft is sunk near each incline in order to serve for the introduction of the requisite stone, and also as an upcast shaft. The stowed stone of the worked-out levels thus forms the roof of the next lower working, and has to be carefully timbered by caps set lengthways of the seam and supported by props, the space between the caps being close planked. Much of this timber can be recovered when the next slice is being worked. As all the surface belongs to the company, any damage to it can be neglected, the great object of the stowage being to furnish a good roof for the next lower lift.

The amount of coal got per hewer, the hewer being paid by the tub, is 2½ to 3 tons *per diem*.

H. L. AND C. S.

KÖFLACH METHOD OF WORKING COAL-SEAMS.

Vorschlag eines Abbauverfahrens für mächtige, flachliegende Braunkohlenflötze. By HANS GUTMANN. *Oesterreichische Zeitschrift für Berg-und-Hüttenwesen,* 1895, *vol. xliii., page* 497, *and illustrations.*

Among the various methods of working mines known to the author, the Köflach appears the best suited for thick horizontal coal-seams, where there are no quicksands, as in the lignite-district of Northern Bohemia. The principal advantages of this system are that little wood is required for timbering the mine.

The method of working is as follows:—A bord is driven against the goaf, and at right angles to it, a level or stall about 12 feet wide, and 6½ feet high, undercutting 20 or more feet of the roof. Neither the main roadways nor the bords must undercut more than this thickness. The level when completed has on one face the goaf-pack, and at the head a packing chiefly of refuse from the working above. The roof is next broken up from the top, the wastes from the upper working being utilized, the packing is sloped away, the top coal got down, and the workmen stand on it as it falls to get at the remainder. This is broken up by blasting, the coal being then worked at an angle of about 45 degrees. Taking down and getting out the coal, and bringing down the roof, are operations naturally carried out at different times. With care it seldom happens that the roof suddenly breaks up, or the goaf begins to thrust. The work can be carried out in such a way that the packing is always left at a suitable height for the miners to reach the roof easily.

The angle at which the coal is got down does not vary, but the face of the coal advances steadily, the goaf being always carefully packed. Sometimes a narrow shoot has to be made, to get rid of the coal, before the next bord is reached, but this is not always necessary. As soon as all the coal in the roof has been got down up to the main roadway, a large goaf-pack is made to protect the workings, and the coal carried off. In this way a thickness of 30 feet of coal can be reached, and brought down at one time. Even twice this thickness may be dealt with, if two levels are driven; in the lower the roof will be much looser than in the upper, where it falls in partly from the superincumbent strata.

In the Wöllan and Köflach mines, a miner can fill four tubs per shift when driving roadways, and six tubs when bringing down the roof; the pay is about 9d. per tub for the first kind of work, and about 5d. for the second. Odd work, such as making good the packing, propping the face, and opening the shoot, is not paid for. One difficulty of this system is that most of the small coal as it falls is wasted, and may cause spontaneous fires, but if the levels are systematically and rapidly driven the heaps of coal are kept within moderate limits, and do not become dangerous. If care were taken the coal could be got out in large pieces, and there would be little dust or small coal. It is impossible wholly to avoid dirtying the coal by falls from the roof, or breaking it when it is thrown from the rubbish into the tub.

The author proposes to apply the method to lignite coal-seams in the following way:—In a seam 30 feet thick, where all the coal has to be taken out at once, gateways must first be driven from home, to be afterwards widened as required, and pillars left 45 feet by 42 feet. In each of these pillars, three parallel stalls 15 feet wide should be cut, and a long working-face thus obtained, running diagonally to the cleat of the coal, from the edge of the workings towards home. The coal-face in the different workings must always be in a vertical straight line, the lower levels being worked till they run into the end packings of the upper. Ventilation is easily obtained by sending a strong current of air through the main gateways, and as the face is not carried quite up to the roof, a passage is left between. The end packings of each level must be made very solid, since they are utilized afterwards.

There is said to be no loss of coal in working with this system; thick seams with two or more levels can be economically worked; there is less danger to the workmen from sudden falls of the roof; large open spaces are avoided, and danger of fires and explosions minimized. The author gives data for calculating the working cost, which depends partly on the ease with which the coal is got down, and the firmness of the roof. B. D.

WORKING THIN COAL-SEAMS.

Note sur l'Exploitation des Veines Minces du Bassin Franco-Belge. By F. Cambessédès. *Bulletin de la Société de l'Industrie Minérale,* 1895, *vol. ix., page* 529.

The mean useful thickness of the coal-seams worked in France and Belgium is generally less than 3 feet, and most of them contain various stone-bands, so that the driving of headings and pushing forward of the stalls generally furnishes too much rubbish to permit of working by preparatory headways and packing, for the disposal of the rubbish would require headways of too great width, and too large pillars would necessarily be left so as to prevent crushing in, while taking up the rock to the surface would involve too great expense. It is generally more economical to take out the coal as contiguous headings are pushed forward, while gobbing the spaces both with the sterile portions of the seams and with the rock excavated in driving the headings; and yet, when the thickness of the seams approaches 3 feet, and they do not contain too many sterile beds, some companies, both in France and Belgium, adopt methods which involve the falling in of the roof after forward headings have been previously driven, or at any rate combined methods with previous driving of the main rolley-ways.

Seams are now won in Belgium and the North of France, which are only just thick enough for the miner to work in a recumbent position; this thickness corresponding with a clear height of about 13 inches; and, when the working of seams of about 10 inches is mentioned, it must be understood that the intercalated rock bands give the total height required for hewing. Moreover, these thin seams are only worked when they yield clean and tolerably large coal, and when their dip is sufficient to avoid any great expense in bringing the coal up to the loading place. Very thin seams are also worked a few feet above headings driven for proving or working other seams. When the net thickness exceeds about 14 inches and the dip is considerable, a seam is often worked, especially with the aid of shoots, made of sheet iron, which were first used in Belgium. After a visit by several French engineers to the Couchant de Mons or Borinage district of Belgium, these shoots were adopted by the Aniche Company, and they are now generally employed both in the Nord and in the Pas-de-Calais coal-fields.

The shoots are made of plates $\frac{1}{16}$ inch thick, 3¼ feet long, and 4 feet wide, with a width of 1 foot turned up to a right-angle on each side, the lengths being connected by iron wire passed through small holes at each angle. The passes in which these shoots are placed have the same width as inclines, with a sufficient height for all the rubbish they yield being contained in the stall. The shoots are placed in one half of the pass or bing-hole, the other being left for the passage of workmen. The author enumerates the advantages afforded by the use of shoots in comparison with inclines, and gives several examples, with illustrations, of thin seams worked by shoots.

In working ordinary thin coal-seams, gobbing must generally be adopted; and a choice has always to be made between rising and forward stalls, this choice depending upon the nature of the deposit, which exerts a preponderating influence, and the advantages and disadvantages inherent in each method. As regards the nature of the deposit, the author mentions the influence of gravity, of thickness and composition, of dip, cleavage, fractures, the underlying and overlying rocks, and fire-damp, all of which are discussed in turn. The advantages and disadvantages inherent in the methods themselves are considered separately under the following heads:—(1) Interference with one another, or the reverse, of the workmen at the face, thus influencing the rapidity of taking out the coal; (2) bringing up of the coal and rock to the loading-place; (3) support of stalls and headings; (4) stock and conditions of haulage; (5) preparatory workings; and (6) variations in strike and dip.

The method of working a large number of thin seams in the Franco-Belgian coal-field is described in detail, frequently with the aid of illustration, showing the methods employed in each; and, in addition to this, all the seams mentioned are included in tables, giving their name, with vertical sections showing the angle of dip and cleavage, with observations. J. W. P.

WORKING COAL-SEAMS WITHOUT INCLINED PLANES.

Ueber die Vorrichtung des Flötzes ohne Bremsberge. *By* J. Jicinsky. *Oesterreichische Zeitschrift für Berg-und Hüttenwesen*, 1895, *vol. xliii.*, *page* 77.

In thin seams, where little useful material is thrown away, it is especially desirable to open up the workings and bring the coal to bank as speedily as possible. The latter process is usually effected by means of inclined planes, with or without trams and rolleys. These at first answer well, but as soon as the workings are extended the inclined planes are subject to a great pressure, the ridge and sides fall in, the track is shifted, and when most wanted is least available. For these reasons, a system of winning the coal without inclined planes, by utilizing the winzes and drainage cross-cuts, with rope-gear, has been adopted in a mine in Westphalia, which the author had lately the opportunity of inspecting.

The seams of the Consolidation colliery have a northerly inclination of 40 degrees, and are from 2½ to nearly 10 feet thick. The vertical distance between the levels varies from 30 to 90 feet, the total space between the highest and lowest being from 260 to 330 feet. The principle of the new sytem is as follows:—As soon as a group of coal-seams has been reached, a horizontal winning gallery is cut along the whole length, with cross galleries intersecting all the principal seams. The different levels follow the same direction, connexion being made by making winze-pits upwards through the unproductive part of the rock. From these, according to the height required, corresponding drainage cross-cuts are made, whence the different levels are ventilated and worked. Each cross-cut and winze form a division of the winning gallery with a working length of 650 to 1,300 feet, and each section can be drained, ventilated, and the coal removed separately. As the latter operation is carried out by rope-gear, the main cross-cut is made as straight as possible, with few sharp corners. Iron, wood, or brickwork is used to support it; pinewood being preferred to oak, because of its greater elasticity under pressure. This cross-cut is ventilated by compressed air, brickwork partitions, or by a fan; the best and safest method is by means of brickwork partitions, as neither fans nor blowers get rid of all the foul air. The main galleries are chiefly driven through an unproductive part of the seam, surrounded by solid rock. This is certainly a costly process, but, as no coals can be extracted from the sterile rock, no repairs are necessary, and it serves as a main gangway. Cross-cuts run from the main galleries at given intervals, and from these the winzes are worked, and are provided with two sets of trucks, one to balance the other when hauling. They are lined with wood or masonry, unless the rock is very solid, and always worked upwards from below, for greater convenience in getting rid of the coal. The drainage cross-cuts are opened out from the winzes, and it is seldom necessary to clear them out, as ventilation and drainage naturally follow the excavations.

The advantages of this method of bringing the coal to bank by utilizing the winzes and levels, instead of conveying it to the surface up inclined planes, depend on the nature of the rock and other circumstances. The author gives tables showing the cost of working a mine with the two systems, and proves an economy of 39 per cent. with the new method. In another mine, with less pressure, the coal from three seams took four years to bring to bank with the old system, and three years with the new; the economy was about 30 per cent. In both cases stone cross-cuts were required; the difference lay only in the cost of maintenance of the inclined planes and of the winzes. The advantages claimed are: better working conditions and ventilation, greater facility in sending the coal to bank, smaller cost of repairs, and shorter ventilating-galleries. B. D.

EFFECTS OF WORKING A DEEP SEAM OF COAL UNDER A RAILWAY.

Effets produits par une Exploitation houillère à grande Profondeur sous un Chemin de fer: Moyens de protection employés. By — BRIÈRE. *Revue générale des Chemins de fer*, 1896, *vol. xix., pages* 20-27.

The railway from Capdenac to Rodez crosses the Aveyron coal-field for a distance of about 4½ miles and had previously (in 1876-1886) suffered from the subsidence of the surface, resulting from the removal of coal from an underlying seam belonging to the Campagnac colliery. In the present instance, the latter company began in 1890 to work a deposit of coal exceeding 200 feet in thickness, and 525 feet below the surface, mainly lying under the valley of Offet, a little nearer Rodez than the Fraysse tunnel, the thinner part of the seam extending under the latter for some distance. The plan adopted for working the coal was to drive a heading about 65 feet below the roof of the seam, take out all the coal to a height of 8 feet, and after packing the goaf, repeating the operation at successively higher levels until the upper part of the seam had been cleared, whereupon work was resumed on the same lines at a lower level.

To avoid the inconveniences attendant on the expected subsidence of the tunnel and embankment across the Offet valley, the railway company at first proposed to reconstruct this portion of the line at some distance away, but finding that it would still be within the area affected by the subsidence and would also be a very expensive plan to adopt, it was decided to repair any injuries to the existing line as they occurred.

Soon after the working of the coal-seam was begun, the surface commenced to subside gradually, so that the Fraysse tunnel moved as on a hinge, the Rodez end sinking about 14 inches in the first six months and necessitating the erection of shoring-frames and an extra stone lining in the parts most affected. Meanwhile it was decided to open the tunnel from above, an operation which took eighteen months (January, 1892 to July, 1893) to complete.

The embankment across the Offet valley was also affected by the gradual fall of the ground and had to be heightened by means of the *débris* from the new cutting in order to maintain the line at its normal level. This embankment was pierced by two openings, the one a triple aqueduct to carry off the waters of the valley, and the second bridging the Offet road. The former has been replaced by a triple drain in rough stone, and the latter, after successive reductions in diameter by repeated shorings, has had to be bricked up and the roadway carried up the embankment on either side to a level-crossing at the top. As the surface still continues to subside, and consequently the height of the embankment above the valley has to be still further raised, it is expected that ere long the approaches to the crossing will become too steep for vehicles and another means of maintaining the communication by road will have to be devised.

At present some 1,000 feet of the railway-line are affected by the depression, which has already attained 21½ feet, and is expected to ultimately amount to 65 to 80 feet, so that the cutting in place of the Fraysse tunnel will have by that time almost disappeared, whilst the embankment will be about 160 feet high, or more than double its original altitude. This, however, will take some thirty years to effect.

The total outlay incurred by the Orleans Railway Company on the alterations amounts to £26,000, apart from the expenses of maintaining the line at its normal gradient, which average £60 a month, and the cost of repairing the approaches to the level-crossing, some £24 monthly. C. S.

BROWN COAL-MINING OF NORTH-WESTERN BOHEMIA.

Technische Einrichtungen bei dem Braunkohlenbergbau des Nordwestlichen Böhmens und dem Steinkohlen-bergbau des Pilsener Rivieres. By M. REMY ZU ZABRZE. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen,* 1896, *vol. xliv, pages* 55-61.

The brown coal is worked from the outcrop, or quarried where it will pay to remove the cover. Shafts are sunk where the bearing is thick, care being taken to prove the ground by bore-holes, as there are awkward beds of running sand to be passed through.

In open workings, the first operation is to take off the cover. This is piled in heaps at intervals along the strip to be taken off, and the pillars of coal left between are shot down with dynamite. This gives an enormous quantity of coal at once, and it takes some time to get it filled away.

The piled up cover is filled into the excavations, and the remaining pillars shot down. At the Richard Hartmann mine, a steam-dredger, having buckets provided with strong iron teeth, is used for removing the rubbish. An inferior part of the seam containing pyrites is left behind in the goaf; this in most cases takes fire, and the goaf is a smouldering mass until all the remaining coal is burnt up. Shafts are sunk to the dip, and they generally have to be walled or tubbed.

Sometimes the Pœtsch method of sinking is used to get through the running sand when it is very bad. At the Venus mine at Brux, after other systems had failed, the running sand was passed through successfully with the Pœtsch method.

The chief mine tramway is always driven forward to the new shaft-bottom, and the coals inclined down to it. The coal reaches a thickness of 30 feet, and is worked on a modification of the bord-and-pillar system. Places are turned away in the bottom of the seam about 60 feet apart, leaving 9 to 12 feet of coal near the goaf, a square block is cut out of the pillar of about 45 feet on the side, 3 feet of top coal or so being left on. The large block is simultaneously undercut, and cut up vertically. The vertical cuts are 2 feet wide, and the underholing about 5 feet high. Strong butts and scaffolding are placed in the vertical slits for the workmen. After the block has been cut up on three sides and underholed, the props nearest the rolleyway are knocked out and the coal allowed to fall. Any coal that remains hanging, after knocking the timber out, is brought down with shots. The top coal is always kept on for safety, a good parting between it and the bottom coal preventing it from coming away during firing.

The output of such a pillar, 30 feet by 45 feet by 45 feet, is about 2,700 tons of coal. In working, the roof has to be closely watched, the magnesium light being used for that purpose.

The mine-waggons are of large dimensions, holding 15 to 16 cwts. of coal. The practicability of using such large waggons is only attained by keeping all the ways wide, straight, and as level as possible. The waggons have wooden bodies, with an iron top to prevent breakage on unloading. A. N.

MONAZITE FOR INCANDESCENT GAS-BURNERS.

Brazilian preferred to Carolina Monazite. ANON. *The Engineering and Mining Journal (New York),* 1896, *vol. lxii., page* 78.

Carolina monazite occurs in irregular crystals, some being as large as a grain of wheat, and requiring crushing. For these reasons the Auer-Welsbach Company, of Berlin and Vienna, prefers the Brazilian monazite, which comes in the form of a fine sea-washed sand.

A ton of Brazilian-monazite sand, costing at present in Hamburg about £24, yields, with good working, from 45 to 55 lbs. (20 to 25 kilogrammes) of pure thoria, which is worth from £480 to £600, according to its degree of purity.

Thorium oxide is now worth, in Germany, from £10 to £15 per pound according to purity. Mr. Mason, U.S.A. consul at Frankfort, suggests the establishment in the monazite region of North America, of a laboratory "where, by employing the most improved and economical methods, the monazite, including the poorer sands which have been concentrated by a process recently perfected, may be worked up, the thoria extracted and made available as a finished product in all countries where incandescent gas-burners are manufactured." J. W.

NAPHTHA DEPOSITS IN THE ISLAND OF TSCHELEKEN, RUSSIA.

Der Naphta-Reichthüm der Insel Tscheleken. By K. CHARITSCHKOW. *Chemische Revue über die Fett-ünd Harz-Indüstrie*, 1896, *vol. iii., page* 86.

Tscheleken, in the south-eastern division of the Caspian Sea, has long been noted for its springs of naphtha and deposits of ozokerit, which were worked in a primitive manner, the oil being mainly shipped to Astrabad in Persia and the ozokerit to Baku, but has been neglected for some years, the attention of prospectors having been concentrated on the Apscheron district. Recently the officials of the Trans-Caspian territory, in looking for a source capable of supplying liquid fuel for the railway at a low price, have made several essays in Tscheleken with satisfactory results, and the island is again looking up as a petroleum-field.

The oil itself is very thick, of the consistency of ointment at 37° Fahr., and solid at 32°; the contained water is difficult of removal and causes inconvenience in distillation. The specific gravity is 0·868, and the flashing-point 51⅓° (Abel-Pensky). When distilled, 2·8 per cent. of light distillate (up to 400° Fahr.); 11·9 of fractions boiling at 400° to 480° Fahr.; 7·6 per cent. of fractions at 480° to 520° Fahr., and 6·6 per cent. distillate at 520° to 590° Fahr. come over, leaving a semi-solid residue well adapted for the direct preparation of vaseline. About 5 per cent. of paraffin—yielding 3 per cent. when refined—is present in the oil and begins to deposit at a not very low temperature.

Two of the distillates form burning oils; the one—of specific gravity of 0·795—flashing at 84° Fahr. and very similar to American petroleum, and the other—of specific gravity of 0·8216—flashing at 167° Fahr. The first-named burns brightly at first, but the illuminating-power falls off greatly, and the second is of inferior quality, but when combined they form a useful burning oil—of a specific gravity of 0·800, flashing-point at 95° Fahr.—like American but with a higher flashing-point, suitable for use as a safety oil for special purposes.

It is expected that the vaseline and paraffin industries will, at Tscheleken, manifest a more favourable development than has hitherto been the case in the Caucasus. C. S.

PETROLEUM OF SALT CREEK, WYOMING, U.S.A.

By Messrs. W. C. KNIGHT *and* E. E. SLOSSON. *Bulletin of the School of Mines, University of Wyoming, Petroleum Series, No.* 1, *June*, 1896.

Only a small area of the Salt Creek oil-field, which lies around the river of that name, has hitherto been tested, its limits not yet having been ascertained. Wells have been sunk by three companies, about 50 miles north of Caper, and a small oil-refinery has been erected containing one 50 barrels cheese-box still. The average daily production is 10 barrels. In 1895, 7,019 barrels were obtained, the yield for the present year (1896) being estimated at 20,000 barrels.

The crude oil is bright red by transmitted, and dark green by reflected, light. It has a specific gravity, at 59° Fahr., of 0·9095, and at 158° Fahr. of 0·8755. Its flashing-point (open cup) is 410° Fahr.; burning-point, 500° Fahr.; viscosity, at 68° Fahr., 15·74, at 212° Fahr., 1·49. The oil remains liquid at 1·4° Fahr. No paraffin is deposited on cooling.

The chemical composition of the oil has not yet been studied; but it is considered, owing to the violent action of concentrated acids, that it contains a large proportion of unsaturated hydrocarbons.

As the oil is naturally suited for the production of lubricating-oil, the authors consider that the best results will be obtained by adopting the Russian process of continuous distillation, cracking being prevented by the use of superheated steam. This method has been found to increase the yield of the distillate, with a specific gravity of 0·900 to 0·925, from 22·94 to 29·98 per cent., or a gain of 7 per cent., and that of a higher specific gravity from 4·96 to 12·53 per cent., or a gain of about 7·5 per cent.

The following tables contain particulars of the two chief grades of lubricating-oils at present manufactured :—

	Specific Gravity.	Viscosity at 68° Fahr.	Flashing-Point.
Car oil	0·9065	15·05	Above 213° Fahr.
Engine oil	0·9125	25·17	,, 273° ,,

	Burning Point.	Cold Test.
Car oil	Above 263° Fahr.	Below 1·4° Fahr.
Engine oil	,, 328° ,,	,, 5° ,,

The oil is considered to occur in two oil-sands, one of which crops out about 2 miles from the existing wells, and dips about 555 feet to the mile; the other, about 2 miles further away, is indicated by the presence of oil-springs.

The existing wells vary in depth from 809 to 1,200 feet. The water associated with the oil contains a large percentage of sodium sulphate. Only small quantities of gas are given off from the wells.

The charges in connexion with drilling are very high, the cost of plant and labour for a first well amounting to £1,200. Coal and wood are also dear, but it is anticipated that workable coal will be discovered within 8 or 10 miles of the wells.

As regards the geological age of the oil-field, it is younger than those of the Eastern States, and more nearly approximates to the Hungarian, Galician, and Bukowina oil-fields. M. W. B.

PETROLEUM IN ORAN, ALGERIA.

Les Récherches de Pétrole dans le Département d'Oran (Algérie). By Alfred Evrard. *Le Génie Civil, 1896, vol. xxix., pages 235-237.*

The surface-manifestations of bitumen in Oran occur in a fairly regular line between Port aux Poules and Mazouna, a distance of some 74½ miles, coinciding with the axis of an anticlinal fold, and indicating the existence of a system of important subterranean fissures in the same plane. On account of the loose nature of the surface-beds of marls, subsidences have occurred, covering the outcrops of these fissures and masking their presence, except at the places where bituminous springs are encountered.

The best-known petroleum centre in this region is at Aïn-Zeft, where four wells have been sunk, in addition to three galleries, but only one – No 4 well – yields any considerable quantity of oil. This well is 1,365 feet deep, and struck oil in a bed of sand on June 26th, 1895, the daily output being 4,400 gallons at first, which, however, declined to a regular flow of 1,540 gallons *per diem* by November, 1895. It is noteworthy that this, the first well exceeding 1,300 feet in depth, produces a larger quantity of oil than the average of those at Baku (1,320 gallons). None of the other wells had struck the oil-sand, but were confined to the marl and gypsum surface-formation, the occasional layers of bitumen and oil met with being no doubt due to infiltration through interposed calcareous or schistose beds. The failure of the previous borings may be therefore ascribed to ignorance of the geology of the locality.

In addition to the Aïn Zeft explorations, permits have also been granted to bore at Tarria in a concession of quadrilateral form, traversed from north-west to south-east by the line of fracture referred to, and in a diagonally opposite direction by the Wady Tarria, where a number of bituminous exudations and deposits of sulphur have been discovered. So far, only a few unimportant excavations have been made, but the situation is favourable for striking the oil-sand, although the depth at which the latter occurs can only be determined beforehand by preparing a sectional plan of the strata.

The Sidi Brahim concession, which is also situated on the same line, lies to the west of Aïn Zeft and about 28 miles east of Mostaganem on the right bank of the river Chéliff. Here a gallery has been driven about 16 feet into the marl and gypsum exposing a spring of tar and oil yielding 6⅝ gallons per day. Two borings have also been sunk; one, after meeting indications of oil at 55, 429, and 550 feet respectively from the surface, had to be abandoned as the result of an accident, but the other was driven to a depth of 748 feet, and passed through five layers exhibiting oil, and one yielding a copious supply of gas. This well is being deepened and the oil-sand is expected to be struck at a less depth than at Aïn Zeft. There is a suitable site for an oil-refinery near by, with an unfailing supply of water, or a pipe-line of 3 miles would meet the railway at Relizane.

The sulphuretted oil from the gallery at Sidi Brahim, like the surface oil at Aïn Zeft, is dark brown, and very viscous, with a specific gravity of 0·980. That from the No. 4 well at Aïn Zeft can hardly be considered as yet exhibiting the true constitution of the bulk in the oil-sand, but from the examinations made it is anticipated that the oil from the whole district will yield some 15 per cent. of burning oil, 28 per cent. of intermediate oil, 31 per cent. of good lubricating-oil, and 23 per cent. of paraffin, vaseline, etc., on account of which latter constituents, pipe-line transport will be unsuitable for the crude oil, except for short distances, and it will, therefore, be advisable to erect oil-refineries near the wells. C. S.

ACTION OF ALUMINIUM CHLORIDE ON PETROLEUM DISTILLATES: THEORY OF ORIGIN OF PETROLEUM.

Ueber die Einwirkung von Aluminiumchlorid auf Theer-und Erdöldistillate; und über die Theorie der Erdölbildung. By Fr. Heusler. *Zeitschrift für angewandte Chemie, 1896, vol. xi., pages 288 to 292, and 318 to 321.*

Having found aluminium chloride to possess, in the perfectly dry state, the power of decomposing thiophene in brown-coal tar-oil, with the evolution of sulphuretted hydrogen and the formation of sulphurous resin together with sulphide or sulphochloride of aluminium, the author essayed the effect of this reagent on petroleum distillate in view of the known inefficiency of sulphuric acid in the removal of sulphur. The results were particularly satisfactory, the sulphur being completely removed without the waste occasioned by the acid process, 95 per cent. of the total oil (benzene) being left after refining. In the case of the sulphur oils from Ohio, although they contain no thiophene, the sulphur was removed, no resin being formed, and as no high molecular oils (lubricating-oils) are found after the process, it is evident that the lower fractions of the Ohio oils do not contain any unsaturated hydrocarbons. The method of refining is performed by gradually adding to the oil at boiling-temperature sufficient dry aluminium chloride (about 0·8 per cent. suffices when working on a small scale) to effect desulphurization—the boiling being continued for some little time after the reaction has ceased—and treating the cooled oil with soda to drive off the sulphuretted hydrogen, separating from the resinous deposit, if any, and redistilling. By this means the sulphur content of Ohio oil was reduced to 0·02 per cent.

The same reagent is also found to act in a satisfactory manner on crude cumol from coal-tar, as well as on crude xylol, but less efficiently on benzol, owing to the low temperature at which the reaction in the latter case has to be performed.

The "artificial petroleum" produced by Prof. Engler's method of distilling train-oil at a low temperature was also treated with aluminium chloride in the above manner, and was found to yield a fraction, boiling at 376° to 536° Fahr., of almost identical constitution with the light fractions from brown coal-tar, and agreeing with the composition found by Profs. Engler and Jezioranski for the distillate boiling above 392° Fahr.*

From this circumstance, coupled with the fact that Prof. Engler's distillate corresponds with brown-coal tar-oil or shale-oil rather than with natural petroleum, the author considers that the said product represents merely an intermediate stage in the formation of petroleum in the earth, and that the subsequent elaboration of the oil was effected in a manner probably similar to the above recorded action of aluminium chloride. The actual agent effecting the conversion is still undetermined, but in view of the fact that no other metallic chloride has been found to exert the same action as the aluminium salt, it would appear that Prof. Ochsenius' "brine theory" is untenable.

With regard to the formation of naphthalenes in petroleum, the author, in conjunction with Dr. Gärtner, has obtained these bodies from the distillation of brown-coal tar, and Prof. Nefgen has lately discovered them amongst the distillation-products of Scotch shale. C. S.

SULPHUR IN PETROLEUM.

Der Schwefelgehalt des Petroleums. By C. Engler. *Chemiker Zeitung*, 1896, *vol. xx., page* 197.

The export of Lima (Ohio) petroleum to Europe has greatly increased of late, but its use for illuminating purposes has been deprecated on account of its alleged high percentage of sulphur. The author's experiments, however, show that this complaint is based on insufficient grounds, since, in respect of sulphur-content, Lima oil, though a little inferior to the best Pennsylvanian and Russian oils, is better than those of Alsatian and Galician origin, the average percentages of sulphur found being 0·02 to 0·03 for standard white Pennsylvania oil, 0·027 for Russian oil, 0·043 for Lima oil, 0·043 to 0·0615 for Galician oil, and 0·067 for oil from Alsace, while the very finest refined Astral oil only contained 0·0195 per cent.

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* *Trans. Fed. Inst.*, vol. x., page 574.

As compared with coal-gas, these figures exhibit petroleum in a very favourable light; for a 14 lines burner consuming 50 grammes (1¾ ozs.) of oil per hour only liberates into the air 0·01 to 0·02 gramme (0·154 to 0·308 grains) of sulphur, equivalent to 0·1225 gramme (1·891 grains) per 100 candles per hour, whereas standard English gas, for the same degree of illumination, discharges into the air 0·513 gramme (7·817 grains) per hour, or about four times as much as petroleum. Even gas of a high degree of purity, such as that of Carlsruhe, contaminates the atmosphere with sulphur to a greater extent than oil.* C. S.

OCCURRENCE OF PLATINUM WITH GOLD AND SILVER.

Ueber den Einfluss einiger Platinmetalle auf die Richtigkeit der bei den Gold-Inquartations-proben erzielbaren Resultate. By DR. E. PRIWOZNIK. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii.*, *page* 272.

Platinum is a frequent associate of gold, and is often found pure, not only in alluvial gold but also in the ore. Its presence therefore in refined gold bars and even in coins is not surprising. Silver also contains platinum, but the proportion in both the precious metals is not more than a few thousandths per cent. In one analysis, only 0·0053 per cent. of platinum was found in 75½ grains of mint gold, and about the same in pure silver. This metal is now so much in demand that more attention should be paid to it at the mints. As platinum diminishes the ductibility of gold only when mixed with it in large quantities, the small proportion in mint gold cannot affect the process of coining, but it may cause difficulties in mixing and testing the alloy. To determine this point, the author mixed small quantities of platinum with mint gold, and tested the compound not only by inquartation with silver, but also with concentrated sulphuric acid.

The usual method of assaying alloys of gold in mints is to mix the gold and copper with a certain quantity of silver and lead, and to melt the whole in a crucible in a distilling muffle. The lead is then driven off by admitting air, and the silver and gold remaining are rolled and boiled with concentrated nitric acid. The silver is dissolved out and the gold washed in hot distilled water, annealed, and weighed in an assay balance to the ten thousandth part of a gramme. The art of the assayer consists in so managing the process that the unavoidable silver residuum left in the gold, usually from ¾ to 1 thousandth part, counterbalances the loss of gold due to the muffle and volatilization. This result is obtained in most of the European mints.

An official account of the processes employed in assaying gold has been published by order of the Austrian mint authorities. In the middle of this century, sulphuric acid was used in Vienna instead of nitric acid to separate the silver and gold, the result being that, especially in poor alloys, the residuum of gold was more compact. Concentrated sulphuric acid was also successfully used for this purpose in Saxony, although many experts were opposed to it. No inconvenience was experienced from the fumes, or from the high boiling-point attained. After boiling with nitric acid the gold has a smooth and brownish appearance, with sulphuric acid the surface is yellow and lumpy. If the alloy consists only of gold, copper, and silver, sulphuric acid gives results as satisfactory as nitric acid, but not if the gold contains platinum, because platinum will not dissolve in sulphuric

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* Dr. R. Kissling, in the same volume of the *Chemiker Zeitung* (page 199), publishes independently results agreeing practically with those of Prof. Engler.

acid. This is seen in laboratories, where sulphuric acid is evaporated in platinum vessels, and retorts of this metal are used in chemical works for concentrating the acid. It is not even soluble when largely alloyed with silver.

To prove that sulphuric acid should not be used when quartating gold with silver, if it contains any platinum, the author made various tests. An alloy containing 900 parts gold, 100 parts copper, and 2 parts platinum yielded after quartation 901·2 thousandth parts when boiled with sulphuric acid, and 900 thousandth parts when treated with nitric acid. The same results were obtained with 5 parts of platinum. When the quantity was doubled and quadrupled, it was all dissolved when boiled in nitric acid. But these alloys contained too little platinum to reveal its presence by a coarse dull surface or its peculiar grey hue. An alloy was next used containing 900 parts gold, 100 parts copper, and 100 parts platinum, and yielded, after boiling with nitric acid, 907·6 parts of gold, in other words, 92·4 per cent. of the platinum was dissolved, and 7·6 per cent. was left. Thus, if a sample of gold contains 2 per cent. of platinum, the gold is perfectly refined when treated with nitric acid, but if the percentage of platinum be higher some part remains unaffected by the acid. The experiments prove that when a certain quantity of platinum is associated with other easily soluble metals, as silver and copper, nitric acid will dissolve it, and only leave the gold. Sulphuric acid, on the contrary, though a much stronger chemical, does not touch the platinum, all of which remains in the gold; and the weight of the latter, after refining, will be the greater the higher the proportion of platinum in it. The presence of the platinum is easily perceived by the coarse and crystalline character of the grains of gold. To assay gold containing more than 2 per cent. of platinum, Prof. Chaudet recommends that it should be quartated with silver, the grains drawn out, rolled, and boiled with nitric acid. If the gold thus obtained shows an undue diminution in weight, it must be subjected to the same test until the weight remains constant, care being taken that the loss by waste is less than the silver residuum, otherwise the results will not be accurate.

Alloys of silver and platinum, if dissolved in nitric acid, yield a perfectly clear solution. If, after boiling, the acid has a yellow or brown tint, this is due to the presence of palladium, which frequently accompanies platinum and gold. To ascertain whether palladium also was soluble in nitric acid, the author melted 1,250 thousandth parts of silver in a cupel with 102 thousandths of palladium and the due proportion of lead. After separating the latter, the silver showed on cooling a somewhat dull surface. Heated with nitric acid, it dissolved entirely and yielded a brownish solution. Even traces of palladium are sufficient to colour nitric acid, but as the metal is wholly soluble in the acid, it will not affect the results.

The influence of iridium, rhodium, and ruthenium, all metals belonging to the platinum group, affect the assaying of gold more than palladium or platinum. Mint gold, mixed with a small quantity of osmium-iridium, showed after quartation with silver and lead a coarse grain full of bubbles, with grey and black specks. The metal iridium was visible in the bubbles on the surface, for at the temperature of assay it will not form an alloy with gold. Mixed with platinum it yields a homogeneous alloy, harder and firmer than pure platinum, and is used for making strong vessels for chemical purposes, and for standard weights, because it undergoes no change in bulk or weight. Iridium is said to be often found in American coins. To separate it, the gold in the United States mint is melted with 2 to 3 parts of silver, and left from half to three-quarters of an hour in the furnaces to cool, when the iridium is deposited. The silver and gold alloy is then refined with nitric acid. Rhodium oxidizes with difficulty, and when compact is not soluble in any acid. Like iridium, therefore, its presence in gold would, after quartation, make the proportion of refined gold higher than it ought to be. Ruthenium in gold alloy produces similar results, but it has a great affinity for oxygen, and a strong tendency to form oxide of ruthenium. Osmium does not affect the quartation of gold, as when heated it gives off osmic acid. B. D.

KASELOUSKY SYSTEM OF PUMPING.*

Note sur la Machine d'épuisement a Transmission hydraulique Système Kaselousky. By Messrs. Griot *and* Rodde. *Bulletin de la Société de l'Industrie Minérale,* 1896, *vol. x., page* 117, *and drawings.*

The great depth to which winding-shafts are now carried complicates the pumping-arrangements; and the expenses of sinking and maintaining the shafts increase in a higher ratio than the depth, so that attempts are everywhere made to reduce the number of shafts, while erecting upon them powerful engines for winding and pumping. Pumping-engines that leave the shafts perfectly free for the work of winding are welcomed as a great boon; and in Germany a type of pumping-engine with transmission of power by water under pressure, which appears to afford a happy solution of this question, is now coming into use.

The principle is to use water under great pressure for working underground pumps that force the mine water to the surface in a single lift. The water under pressure, which is forced by pumps on the surface into the underground pumps, again returns to the surface-pumps through steel pipes of very small diameter; and a pipe of less than ¼ inch inside diameter leads compressed air, when required, into small regulators mounted on the water-pipes near the pumps, for preventing ram-strokes; and the water of the mine, which is only subject to the pressure due to the depth of the shaft, is raised to the surface in cast-iron pipes. This method of pumping, therefore, only occupies in the shaft the space required by the two small pipes, forward and return, for the water under pressure, that for raising the mine water and the small pipe for compressed air, leaving the shaft practically free for the work of winding.

The surface-plant consists of a steam-engine driving hydraulic pumps for subjecting the water to great pressure—for instance, about 300 lbs. per square inch. On leaving the hydraulic pump, the water passes into a very sensitive pressure-regulator, for preventing ram-strokes in the pipe leading the water under pressure to the pumps underground. The latter consist of four single-acting pumps, coupled two and two, so as to give the effect of double-acting pumps, drawing the water from the mine and forcing it to the surface. They are worked by motor-plungers with water under pressure from the surface which, after doing its work, is forced to the surface to be used over and over again, being received under pressure by the hydraulic pumps. To make good any leakage at the packings of the motor-cylinders underground, there is a reservoir on the surface, having a capacity far in excess of any possible leakage, in which terminates the return pipe from the underground pumps, and from which the hydraulic pumps draw their supply.

Water under great pressure, which can now be employed owing to the improved construction of pumps and pipes, plays a part similar to that of high-tension electricity in transmitting power to a distance. In the case of liquids, friction, independent of pressure, is in direct ratio to the square of the speed, so that,

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* "Joseph Moore Hydraulic Pumping Arrangement," *Trans. Fed. Inst.*, vol. iv., page 331.

doubling the pressure of the motive water reduces to one-fourth the loss of load in the pipes; and the formula expressing this loss of load shows that it is practically in inverse ratio to the cubes of the diameters, so that, by suitably determining the pressure of the motive water and the diameters of the pipes, the loss incurred by transmitting power to underground pumps may be reduced to a few units. The return of the water under pressure to the pumps on the surface, thus permitting the same water to be used over and over again, and therefore pure and properly lubricated, greatly reduces the friction in the pipes and pumps; but without such a return of the water under pressure this system of pumping would be impracticable in most mines, the acid and muddy water of which causes scale and corrosion in the pipes.

The Kaselousky system has been applied to several mines in Westphalia, including the Pluto and Gottessegen collieries. J. W. P.

PUMP-PACKING AND LUBRICATION IN MINES.

By Eckley B. Coxe. *Transactions of the American Society of Mechanical Engineers*, 1894, *vol. xv., page* 599, *and drawings.*

The author describes a novel system of overcoming the difficulties usually found in packing pumps in mines, especially where the plungers are attacked and eaten away by the sulphuric acid in the water. Instead of surrounding the plunger with stuffing-boxes, it is made to slide through a cylinder cast with a large central and several smaller grooves. The central groove is larger at the bottom, narrowing towards the top, and has a hole at either end. A pipe connects the cylinder through the lower hole with a smaller cylinder containing the grease, and having above it a piston driven by water. By means of two cocks, the water can be introduced either above or below the piston of the grease-cylinder. The packing consists of beef-fat taken from the kidneys, where it is especially fibrous.

To pack the pump-plunger, water is sent below the piston of the grease-cylinder, and raises it. The cylinder is then filled with fat, thoroughly rolled in graphite, the action of the water reversed, and, the piston being forced down, the grease is sent through the pipe to the cylinder surrounding the plunger. This action is continued until the lubricant is forced through the grooves in the cylinder and leaks out at the top hole, when the packing is complete. Two piston rings, turned in the two outside grooves, prevent any leakage of grease past the plunger. To renew the supply it is only necessary to reverse the flow of water, and fill up the grease cylinder. The author states that this is done every morning, and no renewal of the packing is required during the day.

The plunger becomes in this way thoroughly coated with grease and graphite, and the action of the acid water upon the iron is prevented, except at the ends of the plunger. These ends are made heavy to resist corrosion, and it is found that in practice they also become covered with grease and are thus protected. Tallow was at first tried, but it oozed out of the pipe to the plunger; with the fat now used there is no leakage, on account of the fibre it contains. Another advantage of this method of packing is, that a supply of grease can be sent to the plunger at any time while it is running, and irrespective of the speed. A pump of this description was supplied to a mine where the water was very bad, and the plungers previously used had only lasted six months; it has now been worked for five years without repairs. Some of these pumps run under a pressure of 200 to 400 feet of water. One lb. of grease is required per day for a plunger 16 inches diameter with 6 feet stroke, and making 10 to 20 strokes per minute. B. D.

STONE QUARRYING NEAR BERLIN.

Die Kalksteinbrüche der fiscalischen-stadtischen Societat zu Kalkberge-Rüdersdorf im preuss. Reg. Bez. Potsdam. By CARL STEGL. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii.*, *page* 125.

The quarries at Rüdersdorf are among the largest in Europe, and are worked on the latest and most scientific principles. They employ from 1,000 to 1,200 workmen. Rüdersdorf is about 15 miles from Berlin, and the limestone-quarries lie between the station and the town. The state has ¾ shares, and the city of Berlin ¼ share, in them. They communicate with the river Spree, through a stream which has been rendered navigable, and thus cheap water-carriage is available to transport the stone. Tram-lines are also used for hauling it from the quarry up to the railway-station. In the regular system here adopted for working the quarry, the fault is carefully avoided of breaking it up into a number of small detached workings. To enlarge a quarry is often difficult, because it becomes choked with accumulations of rubbish and chippings left on the ground to save the immediate cost of removal—an error which sometimes ultimately necessitates the abandonment of the quarry.

The limestone or chalk-marl of the Rüdersdorf quarries forms part of the Triassic formation surrounding the Harz district.. The strata generally lie below the depression running across North Germany, and their isolated appearance at the surface at Rüdersdorf is caused by a local upheaval. The lie is from south-west to north-east, and the formation is from 330 to 660 feet thick. The boundary-walls of the quarry are about 100 feet high. There are really two quarries: in the shallower the workings have reached water, which is drained off through canals and a tunnel into a lake. In the course of years a new valley, now covered with plantations and workmen's cottages, has been formed by the excavations and rubbish heaps. The quarries furnish immense quantities of building-stone, most of which goes to Berlin, lime, which is burnt in large furnaces, stone for cement, and freestone. All the broken pieces are utilized, and no waste is allowed. The clay limestone is worked up in a neighbouring factory into Portland cement. The heaps of refuse collected in the course of a century are sorted, and the better stones among them also sent to the cement-furnaces. In fact, the prosperity of the quarry chiefly depends upon this careful utilization of all kinds of stone, both quarried and cut, which are immediately carried off the ground and worked up. The two quarries, workmen's quarters, canals, water-tunnels, tram-lines, and lime-pits, are shown on a map attached to the original paper. In both quarries there is water; it is pumped from the one by an engine of 150 horse-power, and drained off from the other by canals, which also serve for transport.

The stone is quarried by undermining the boundary-walls. Horizontal galleries are cut through the rock, about 10 feet apart, and about 30 to 100 feet in depth, according to the quantity of stone required. These are intersected at right angles by vertical shafts running parallel to the wall. As the latter are excavated, the whole wall is gradually supported upon pillars, which are cut away till the limit of safety is reached. Holes, filled with dynamite, are then bored in the pillars, and fired by quick matches and fuzes. As the front holes are fired more quickly than those behind because the fuze is shorter, the wall of stone begins to break up after the first few shots, and in less than a minute the whole falls into the quarry. Sometimes the explosions do not follow in the right order, and the stone wall sinks, but does not break up; various means are then employed to bring down the wall, but it is a delicate and dangerous process. The quantity of stone obtained at each blasting is from 200 to 300 truck-loads. It is sorted in the quarry and carried off on small tram-lines, and brought to the surface by an inclined mountain-railway or by steam-power. The stone is separated into large building-stone, lime for burning, small stone and rubbish, freestone (the most valuable), and stone for concrete. There are two engines of 180 horse-power for hauling it up, one at work, the other in reserve. The main tram-line ascends at an angle of about 30 degrees to the railway-station. There are four head-wheels at different levels, all converging to the railway.

The arrangements for bringing up the trucks, and passing them from the incline on to the railway, are ingenious. The loaded trucks, big or little, follow each other in any order along the line, and are not coupled. The apparatus for connecting them consists of a series of cages on wheels fitting over each truck, and driven by an endless-rope from the engine at the top of the incline. As soon as the loaded trucks have been brought up by means of the cage, or the empty ones sent down to the quarry, and reach the level, the cage loosens its hold upon the foremost truck, which runs along the level by itself to the loading or unloading-station, while the cage passes along a wooden scaffolding overhead. As each truck reaches the level, the connexion between it and the cage is severed, and the latter remains suspended in the scaffolding. One machinist is required to adjust the different cages to the trucks, which are all of the ordinary gauge; the journey occupies about 2 minutes, and each load is about 50 tons. Immense quantities of stone are thus brought up daily. Drawings and a full description of the apparatus are given in the paper.

The broken ground in the neighbourhood of the quarry is also utilized to transport the stone. The narrow-gauge tram-lines are so laid with reference to the incline that both the full and empty trucks run many feet by their own weight, without external traction. Where the slope is too great a hand-brake is applied. The empty trucks, running down at great speed, pass certain spots where the descent is steepest, and are here checked by raising a plank placed centrally between the rails. A lever tilts up the plank against the bottom of the first truck, and the latter is raised and carried with it. All the other trucks follow, and their speed is thus effectually checked before they drop on to the rails again. One slope about 200 feet long, with an incline of 20 degrees, has been made to convey empty carriages to the bottom by means of an endless flexible chain. The chain is tightened at the top and bottom of the incline by stretching it over drums; it runs above and below the raised sleepers, and the trucks catch on to the upper part. As soon as they approach the bottom of the quarry they run loose from the chain and complete the journey to the loading-station alone. By these means the stone is brought up and the empty trucks are sent down with the least possible expenditure of manual labour. The smaller tram-lines have a gauge of 19 inches, and are mounted on U-shaped iron sleepers, in lengths of 10 feet, which are easily laid and transported. Their weight is about 5 lbs. per foot, and the heavier rails weigh 10 lbs. per foot.

The limestone which does not come into the market in the raw or hewn state is burnt in large kilns, into which it is delivered at the top and passes out as burnt lime into the railway-trucks below. One furnace delivers 12 tons in twenty-four hours; the total daily output is 216 tons. The total annual quantity of stone wrought is 1,000,000 tons, of which more than half is fit for building, and the net profit is £38,400 per year. The cost of working 1 cubic foot of stone is 1⅜d. The number of workmen employed is 987, at an average wage per man of £44 per year. Tools and blasting-materials are provided, and all work is piece-work. The working day consists of ten hours—from 6 a.m. to 6 p.m.—with two hours' interval for meals.

B.D.

CEDAR VALLEY QUARRY, IOWA, U.S.A.

By Samuel Calvin. *The Engineering and Mining Journal (New York)*, 1896, *vol. lxi., pages* 544-5, *with* 2 *illustrations.*

The Cedar Valley stone-quarry, in Cedar County, Iowa, is one of the most notable and interesting in the state. In front of the quarry flows the Cedar river, while behind it, and flanking it at either end, stand the low bluffs bounding the valley of this stream.

The quarrying has been carried downward over an area of 300 feet length and 125 feet width, until the bottom of the quarry is at present about 60 feet below the water-level of the adjacent Cedar river. The whole thickness of the quarry stone is more than 116 feet. The beds worked belong to the Upper Silurian system, the Niagara Series, and to, what has been called in Iowa, the Anamosa stage. The stone is a light-coloured, warm grey or buff, laminated dolomite, the light grey tints predominating. The best stone, as usual, occurs in the lower portion of the deposit. The absence of bedding-planes, and the firm cohesion between adjacent laminæ, make it possible to take out a much larger amount of heavy-dimension stone than can generally be obtained at quarries worked in this formation. Hydraulic stripping is one of the effective means employed for reducing working expenses.

There are 3 double and 1 single channelling machine, each equipped with boiler and engine to supply its own power; there are also 3 steam drills; 5 direct and 2 indirect steam hoists, capable of lifting from 4 to 6 tons each, and 1 direct connected hoisting apparatus; 11 large derricks; and 1 steam crusher which, by use of a recently installed electric light plant, it is expected to run night and day. One of the channelling-machines holds the championship record in its line of work. It has been made to cut 400 feet in 5 hours, and for 10 hours its record is 750 feet. The channels cut by the machines are 6 to 12 feet deep, and 6 feet 6 inches apart. Two systems are cut at right angles to each other, so that when the machines have completed their work a number of combined or prismatic blocks are ready for removal.

To guard against overflow during any unusual rise in the river, a levée has been constructed along the water-front, at an expense of about £4,000. J. W.

SEPARATION OF SILICATES BY ELECTROLYSIS.

Recherche des Silicates par Électrolyse. By — Mayençon. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1896, *page* 13.

Inasmuch as the silicates are generally insoluble in water and the acids, it has hitherto been necessary, for separating the silica, to employ a tolerably long process. The new method is founded on the fact that a silicate subjected to electrolysis yields soluble silica at the positive, and the other elements at the negative electrode. It has hitherto been supposed that substances decomposable by the electric current must be either melted or dissolved; but the author's researches show that solid substances, even the most insoluble, may be decomposed by the current, it being sufficient to reduce them to powder, and form with that and pure water a mud through which the current is made to pass.

A small quantity of silicate, in the form of mud, is laid on a metal plate connected with the negative pole of a battery, and covered with a piece of filter-paper, on the top of which is laid a plate connected with the positive pole, when bubbles of oxygen will form round the positive plate. If the plate be of platinum, when it is disconnected blue test-paper placed over it is reddened by the dissolved silica; and, if the plate be dried, there will remain a more or less abundant deposit of silica. For obtaining a larger quantity of separated silica, a porous charcoal is employed which condenses in its pores the silica and the oxygen. When a plate of silver, or even of zinc or copper, is connected with the positive pole, and afterwards treated by an acid, if an excess of ammonia be poured into the liquor white flocculent particles of silica are formed.

If the plate charged with silica be dried and sufficiently heated, a drop of hydrofluoric acid allowed to fall upon it will immediately produce an intense white vapour consisting of silicon fluoride. The most characteristic reaction, however, is the following:—A small transparent bead of phosphorous salt is formed at the end of a fine platinum wire, dipped several times into the water covering the porous charcoal, and then placed in the flame of a blow-pipe, when it will become opalescent, showing flakes of silica. J. W. P.

SILVER EXTRACTION AT CERRO GORDO, IQUIQUE, CHILI.

Das Silberlaugereiwerk Cerro Gordo, Iquique, Provincia de Tarapaca, Chile. By HERMANN SCHAEFER. *Berg-und-Hüttenmännische Zeitung,* 1897, *vol. lvi., page* 1.

The ores treated at Cerro Gordo are mined in the district of Challacollo, about 15 miles to the east of it. The elevations of the two points are respectively 4,124 feet and 5,079 feet above sea-level. The chief mining areas are Lolon and Buena Esperanza, both of which are being actively worked. They are traversed by four veins striking north 15 degrees to 20 degrees east and south 15 degrees to 20 degrees west, and dipping 25 degrees to the westward. The veinstuff consists of quartz, with but little calcspar or barytes; the silver occurs mostly as horn-silver, rarely as argentiferous galena, though carbonate of lead occurs at times; rich pockets sometimes occur, carrying native silver and embolite, the percentage of silver rising in such places to 12 per cent. The average silver contents, in depth, amount to 0·09 per cent. The veins join, forming a mass 40 feet wide, with a richness of 0·10 to 0·12 per cent. of silver. The average width of the veins is 26 feet. The country-rock is quartz-trachyte. The main shaft is the Pique Lolon, with a vertical depth of 440 feet, where it is traversed by the No. 11 level. Two new levels, 66 feet apart vertically, are being driven below the last named.

The ores, as they come from the mine, are screened and divided into three grades: *colpa* (lumps), *gouzas* (smalls), and *mampas* (fines). They are carried to Cerro Gordo in carts drawn by mules; there are 30 carts in use, which carry some 2,500 tons per month. At the works all the ore is crushed in ball-mills to a No. 8 screen, mixed thoroughly with 8 to 14 per cent. of salt, also finely ground, and roasted in two White-Howell furnaces, each of which puts through 50 tons in 24 hours. The roasted ore is discharged into vaults, where it is allowed to lie for the sake of a complete after-chloridizing, when the ore should be dark-brown and smell strongly of chlorine. The ore is run in iron cars to the leaching-vats, each of which takes 12 car-loads, or 8 tons, of roasted ore. The vats are rectangular, 14½ feet long, 12 feet wide, and 3 feet deep, and are fitted with a false bottom consisting of a wooden grating covered with sacking, upon which is a layer of canes. When the vat has been charged, the first wash-water is run on, the heat in the ore being sufficient to raise it to the boiling-point. The ore is leached three times with water, whereby 20 per cent. of the silver in the ore is dissolved. It is precipitated by sulphide of sodium.

The ore is then leached six times with hyposulphite solution, of a strength of 0·4 to 0·5 per cent., each solution remaining on the ore for an hour. It has been found that no better results, but actually somewhat worse ones at times, were obtained by using the Russell extra-solution. The hyposulphite solutions are also precipitated by sodic sulphide. The sulphide of silver thus obtained contains 24 to 32 per cent. of silver, whilst that precipitated from the wash-water only contains 7 to 11 per cent. After the ores have been washed, they still retain about 0·01 per cent. of silver, and are dumped on to the waste-heap. It takes about 12 hours to extract 90 per cent. of the silver contents from an 8 tons lot of ore by the above process.

The sulphide of silver is filtered in a filter-press, and pressed into cakes ½ inch thick; these are dried, barrelled, and shipped to Europe for further treatment. In the first half of 1896, products containing 10,000 lbs. of fine silver were shipped to Europe; the residues contained 1,500 lbs., thus corresponding to an extraction of 85 per cent. The gold contents of the sulphide vary between 0·07 and 0·002 per cent.

H. L.

IMPROVEMENTS IN SHAFT-SINKING IN RUNNING STRATA.

Die neuesten Fortschritte beim Schachtabteufen im Schwimmenden Gebirge mittels Senkschächte. By — RIEMER. *Zeitschrift des Vereines deutscher Ingenieure,* 1896, *vol. xl., page* 1461.

One of the most important improvements was introduced by Mr. Simon at the Neue Hoffnung mine, near Pömmelte. He sank a circular shaft-wall furnished with an iron cutting-ring, which also formed an anchor-ring for a number of bolts, to a depth of 135 feet. To the top of this wall a cast-iron pressure-ring was secured by means of these bolts, the ring projecting on the inside and acting as a thrust-ring against which numerous hydraulic presses were placed exerting together a pressure of 1,500 tons, by means of which the iron tubbing was forced down, a revolving cutter being used to clean out the interior of the shaft. By this means the shaft was sunk into the Coal-measures to a depth of 338 feet in nine months, with a finished diameter of 15 feet.

Mr. Pattberg now suggests a modification of this method by providing the iron-tubbing with pipes, sixteen to twenty-four in number or even more, the object being to avoid hoisting up the *débris* formed by the action of the cutter; it is to be pumped up in the form of mud through these tubes, the power applied being sufficient to draw up any pebbles or pieces of stone that will enter the pipes. This method is to be tried very soon for a new colliery-shaft.

H. L.

SHAFT-SINKING THROUGH QUICKSANDS AT LOEDERBURG.

Abteufen eines Schachtes auf der Königl. Braunkohlengrube bei Löderburg. By — HUHN. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen,* 1896, *vol. xliv., page* 393.

A shaft was recently sunk in the lignite-mines at Löderburg, in which considerable difficulties had to be overcome. It was known that, at a depth of 65 feet, a bed of very fine-grained quicksand, 33 feet thick, would have to be traversed, the quicksand resting upon clay, the upper 2½ feet of which was clay alone; the remainder of the bed contained irregular masses of sandy conglomerate, at times of considerable size. It was to be presumed that no tubbing could be carried down in this, unless it were possible for men to work in the shaft-bottom. Below this sandy bed comes again pure clay, in which a watertight bed for the tubbing could be obtained.

The shaft was sunk 20 feet in diameter in the clear to within 7 feet of the quicksand, and was provisionally secured with channel-iron curbs and planks; this portion was then walled, and at a point 40 feet above the shaft-bottom cast-iron blocks were built in and secured to the bottom of the wall by means of twenty anchor-bolts. These castings were for the purpose of taking the thrust of six hydraulic presses by means of which the tubbing was forced down. Cast-iron tubbing was used in ten segments, each ring being 5 feet deep; the metal was 1½ inches thick, with the exception of the lowest ring which was made 2¼ inches thick. The shoe also consisted of ten segments 2½ feet deep, 2¼ inches thick, with one horizontal and two vertical ribs on each segment; the cutting-edge was made of sheet steel of medium hardness 0·6 inch thick and 16 inches deep, let in flush with the outside of the shoe and secured by countersunk bolts. The flanges of the tubbing-plates were machined, and leaden strips 0·1 inch thick were used for making the joints.

The bottom of the shaft was accurately levelled, the shoe put together on it, and upon the shoe seven rings of tubbing were built up; pressure was put on by means of the hydraulic presses, and the loosened earth in the inside lifted out by means of elevators. In spite of considerable difficulties, due mainly to the settling of the lower part of the shaft-walling that carried the cast-iron pressure-blocks, the tubbing was finally forced successfully 5 feet deep into the pure clay, by which means watertight joints were secured, the final pressure being 250 atmospheres (3,750 lbs. per square inch) with eight presses at work. The shaft was then sunk in the usual way with temporary wooden cribbing down to the coal-seam and walled up from below, the wall being taken up to meet the tubbing and being protected against the cutter of the tubbing-shoe by a double bed of boiler-plates. The entire shaft was completed in 644 working days at a cost of £6,820. [The depth of the shaft is not stated in the paper]. H. L. and C. S.

SINKING AND LINING A SHAFT BY THE BADIOU METHOD.

Note sur le Fonçage et le Muraillement du Puits Conte-Grandchamps des Mines de la Chapelle-sous-Dun, Saône-et-Loire. By A. Gardon. *Bulletin de la Société de l'Industrie Minérale,* 1896, *vol. x., page* 83.

This shaft was sunk to a depth of 984 feet (300 metres) and lined by aid of the movable centreing or template devised by Mr. Badiou.

The sinking was effected with large unguided kibbles; and the mouth of the shaft was closed by balanced shutters that could be easily opened and closed. The first 20 feet were sunk and lined without an engine; and working was then continued as long as possible with a single rope, and afterwards with two ropes, for balancing the load on the winding-engine. The 1¼ inches ropes were guided on to the drums by an apparatus, sliding in a frame and worked by heart-shaped cams, advancing by a rope's diameter at each revolution of the drum.

The first 20 feet section of the lining consists of quarrystones behind which a tower of porphyry stones was built, backed by an inverted hollow truncated cone of concrete, laid on a wide timber foundation for giving a large bearing-surface, because of the slight resistance of the supra-Liassic marl on which it rested.

THE SINKING OF THE VICQ PITS, ANZIN COLLIERIES, BY THE POETSCH FREEZING SYSTEM.

Fonçage des Puits de Vicq par le Procédé Poetsch. By — SACLIER *and* — WAYMEL. *Bulletin de la Société de l'Industrie Minérale*, 1895, *vol. ix., pages* 27-148, *and* 9 *plates.*

The results of borings and other exploratory works in the valley of the Scheldt showed that difficulties would be met with in connexion with sinking through the Tertiary and Cretaceous strata overlying the Coal-measures, owing to the presence of large volumes of water.

The Thiers pits, sunk in the ordinary way, were lined with 257 feet (78½ metres) of tubbing. The sinking involved the pumping of 9,000 gallons of water per minute, at a cost of £75 per foot, and occupied a period of twenty-six months. After careful consideration of the various methods of sinking, it was resolved that two pits should be simultaneously sunk at Vicq by the Pœtsch system, one 12 feet (3·65 metres) in diameter and the other 16·4 feet (5 metres) in diameter, to be fitted with cages carrying eight tubs, capable of raising 300,000 tons of coal per annum. A section of the strata, as determined by a boring made in 1892, was as follows:—

	Metres.	Feet.
Soil	1·00	3·28
Sand	2·10	6·88
Gravel	3·65	12·00
Argillaceous sandstone	3·50	11·48
Sandy clay...	0·50	1·64
Chalk, broken	17·25	56·60
White marl	32·00	105·00
Grey marl	13·00	42·65
Grey marl, with pyrites	4·00	13·12
Strong stone	1·50	4·92
Marl, with flints	12·50	41·00
Blue marl	25·00	82·00
Blue clay, impervious to water	58·00	190·29
Green sand	13·65	44·78
Depth to Coal-measures ...	187·65	615·64

The water contained in these measures is very abundant down to a depth of 300 feet, but a secure foundation for tubbing is found in the blue marl.

The feed and condensing-water required for the freezing-plant amounted to 3,500 gallons per hour, and a well was sunk to the chalk, a distance of 800 feet from the site of the pits, whence the water was drawn by means of a centrifugal pump. This well, 6½ feet in diameter and 49 feet deep, cost £400. The two pits were sunk 120 feet apart, and the borings intended to receive the circulating-pipes for the freezing-process were 36 in number, each 300 feet in length, and of a total length of 10,860 feet (3,312 metres); 16 of them being arranged in a circle 16·73 feet (5·10 metres) in diameter for the small pit, and 20 of them in a circle 21·33 feet (6½ metres) around the larger pit. The mains for the conveyance of the freezing-fluid consisted of a series of steel pipes of various diameters, the smaller ones, 1·18 inches (30 millimetres) in diameter and 0·16 inch (4 millimetres) thick, being placed concentrically within the larger ones, which were 4·57 inches (116 millimetres) in diameter and 0·28 inch (7 millimetres) thick, each series being connected to an appropriate ring of pipes. The chilled liquid from the freezing-machine passed through one of the rings of pipes down the inner tubes and returned through the outer one to the surface and then back to the refrigerator. The ring-pipes were 7·87 inches (200 millimetres) in diameter, and the freezing-liquid moved at a speed of 4 inches (10 centimetres) in the smaller and 53 inches (1·35 metres) per second in the larger pipes. Elaborate calculations are given, the final result being that the work represented the abstraction of 110,272,900 calories from the ground about the large and 87,008,100 from the smaller pit; and, after allowing 25 per cent. for loss, the total of 250,000,000 calories of heat had to be removed. The amount of fluid in circulation amounted to 9,400 lbs. (4,250 kilogrammes) per hour, and its temperature being raised by 2·5° Cent., the amount of heat abstracted corresponding to 250,000 calories per hour, hence the time required to freeze the ground would be about 1,000 hours, or forty days.

The liquid-freezing machinery consisted of four double-acting cylinder compressors, each 14·17 inches (360 millimetres) in diameter and 21·26 inches (540 millimetres) stroke, grouped in pairs and coupled at right-angles to a shaft carrying a pulley 18 feet (5½ metres) in diameter, which was driven by a belt from the fly-wheel, 21 feet (6·4 metres) in diameter, of a horizontal condensing-engine with two steam cylinders each 22·83 inches (580 millimetres) in diameter and 43·31 inches (1,100 millimetres) stroke. The cylinders are fitted with cooling jackets, the heat developed in compression being absorbed by allowing a small quantity of liquid ammonia to enter with the gas on the intake stroke. The ammonia is forced by the compressors through an arrangement of tubes 3·15 inches (80 millimetres) in diameter, placed in two tubs 88 inches (2¼ metres) in diameter and 9·84 feet (3 metres) high, each containing seven coils of steel tubes and a total length of 3,200 feet (980 metres), with an inside cooling-surface of 990 square feet (92 square metres) and outside surface of 1,260 square feet (117 square metres).

The condensing-water was supplied by two plungers 6·69 inches (170 millimetres) in diameter and 10 inches (254 millimetres) stroke. The cold water entered at the bottom and overflowed to the top of the tubs, and was afterwards used as injection-water for the condensing engines.

The two refrigerators, in which the liquefied ammonia was reconverted into gas by heat abstracted from the solution of calcium chloride at its higher temperature, was similar in construction to the condensers. The tubs, 7·87 feet (2·4 metres) in diameter and 9·84 feet (3 metres) high, were fitted with eight coils of pipes of a total length in each of 3,628 feet (1,106 metres), with an inside surface of 1,120 square feet (104 metres) and outside surface of 1,420 square feet (132 square metres). Contact between the fluid and the tubs was promoted by a series of rotating paddles. The saline solution was drawn from the base of the refrigerating-vats by two Burton duplex steam pumps, with plungers 10·24 inches (260 millimetres) in diameter and 10 inches (254 millimetres) stroke. The suction-pipe was used by both pumps; but each had a separate delivery, being connected to the surface-tubes to No. 1 pit and the other to No. 2 pit. The solution, heated by passing through the pipes, entered the refrigerating-tubes at the top; the ammonial vapour returned, by pipes 3·15 inches (80 millimetres) in diameter, to the compressors. A special series of separators was placed between the compressors and the condensers in order to separate the mineral oil carried over by the gas, and to prevent it from being deposited in the cooling pipes. The compressors were arranged so that they could be worked singly or in groups of 2, 3, or 4.

The total quantity of ammonia in use in the apparatus was 1,614 lbs. (732 kilogrammes). The solution of calcium chloride measured 2,180 cubic feet (62 cubic metres), and contained 25 tons of dry salt. The density of the solution was 1·25, corresponding to a specific heat of 0·68 per kilogramme or 0·85 per litre.

A freezing-machine was started with one compressor on May 28th, 1894, the temperature of the surface being then 11·65° Cent., and cold was developed at the rate of 285,000 calories per hour. On the following day, the temperature of the solution had fallen to − 4·7° Cent. at the refrigerator, and to − 1° Cent. in the return pipe. A second compressor was then started, producing from 250,000 to 275,000 calories, which reduced the temperature of the solution to − 7° and − 4° Cent. respectively. On June 2nd, the third compressor was started, producing from 260,000 to 300,000 calories, and reducing the temperature of the saline solution to − 10·60° and 8·35° Cent. respectively. On June 12th, the fourth compressor was started, and continued working until July 1st.

The freezing of the No. 2 pit was completed on July 1st, and afterwards only two or three compressors were used until July 15th, when the initial freezing operations may be considered to have been completed. The thermal equivalents of the work done during these periods are shown in the following table:—

Heat Absorbed.	No. 2 Pit. Calories.	No. 1 Pit. Calories.
Formation of ice	43,040,000	70,075,200
Cooling ground outside circuits	16,825,615	28,285,845
,, ,, inside circuits	14,473,982	22,917,860
Total utilized	74,339,597	121,278,905
Loss	25,574,640	32,793,936
Totals	99,914,237	154,072,841
Work of engines	100,379,694	161,354,901

Sinking in the smaller pit was begun on July 2nd, and in the larger pit on July 16th, the ground being then frozen in a ring 47·24 inches (1·20 metres) thick, extending 17·72 inches (45 centimetres) outward from the freezing-pipes, and 29·53 inches (75 centimetres) towards the centre in the smaller, and 21·65 and 39·37 inches (55 and 100 centimetres) respectively in the large pit. As the source of cold was placed entirely outside the ground to be excavated, a large proportion was left loose, and could be excavated by shovelling, and it was only necessary to break down a small portion of ground by shearing with picks and taper-pointed wedges without the use of explosives. The most favourable results as regards rapidity of sinking were obtained in the upper part of the chalk, which was like thin mud, the thickness of the ice-ring being about 6 inches in the small pit and 8 inches in the large pit. The compact chalk, was also rapidly sunk through, owing to the existence of a number of vertical fissures, which allowed it to be readily broken by hammers and wedges. In these beds, the maximum rate of sinking of 8 and 6½ feet (2¼ and 2 metres) per day was obtained. The speed diminished in the more flinty strata below, until it became as little as 1, 1¼, and 1½ feet (30, 40, and 50 centimetres) per day. During this period, the temperature of the pit fell to − 12° Cent. The diameter of the unfrozen portion of these strata varied from 3¼ to 5½ feet (1 to 1·65 metres) in the large pit, but in the small pit the strata were entirely frozen, and had to be broken by hammers and wedges, with great difficulty.

The first section of tubbing consisted of 20 rings of metal 1 inch (25 millimetres) thick, extending from two wedged curbs at a depth of 100 feet (30·70 metres) from the surface. The second length of tubbing of 205 feet (62·60 metres) in depth, formed of 44 rings varying from 1·77 to 1·18 inches (45 to 30 millimetres) in thickness, stands upon rings placed on the marl at a depth of 306 feet (93 30 metres). The third length of tubbing of 15 rings, 1·97 inches (50 millimetres) in thickness, was placed in the plastic clay, and completed the total height of tubbing of 386 feet (117·65 metres). The rings were backed with concrete about 8 inches thick, made of two parts of hydraulic lime to three parts of burnt shale. In the two lower rings of each length of tubbing a stronger mixture of equal parts of ordinary cement and burnt shale was used. About 10 per cent. of chloride of calcium was mixed with the water to prevent it from freezing.

The total cost of the sinking was as follows:—

	Per Cent.	Total. Francs.	Per Metre (3·28 Feet). Francs.
Patentee's royalty	4·6	32,760·00	139·20
Temporary plant and buildings ...	2·7	19,582·40	83·25
Borings for freezing-tubes	10·4	73,673·03	313·10
Freezing-plant	35·0	248,765·56	1,057·20
Measuring-apparatus	0·3	1,899·68	8·10
Freezing cost	4·7	33,030·95	140·40
Sinking and tubbing	40·5	287,454·77	1,221·65
Carriage	0·6	4,562·00	19·40
Tools	0 7	5,257·00	22·35
Sundries	0·4	2,865·00	12·15
Totals	99·9	709,850·39	3,016·80

If the cost of the plant be charged to this single sinking, its employment in future work would relieve them to the extent of £40 (1,000 francs) per metre, and the work could then be done for about £80 (2,000 francs) per metre. The items especially chargeable to the freezing-plant are as follows:—

	Francs.
Patent rights	32,760·00
Boring	73,673·03
Erecting	14,084·72
Measuring-instruments	1,899·68
Freezing cost	33,030·95
Total	155,448·38

This sum, corresponding to about £26 (660 francs) per metre, represents all that would have been available for paying the cost of pumping, temporary lining, and the numerous other charges incidental to a difficult sinking in heavily watered ground. The expenses of the sinking at Vicq may consequently be summarized as follows: —

	Francs.	Cost per Metre (3·28 Feet). Francs.
Material	234,680·84	1,000·00
Freezing	155,448·38	660·00
Sinking	319,721·17	1,360·00

M. W. B.

WIDENING AND RE-TUBBING AN AIR SHAFT.

Note sur l'Élargissement et le Remplacement du Cuvelage du puits Saint-Marc No. 1, des Mines d'Anzin. By — PRUD'HOMME. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale,* 1896, *page* 48.

The Saint-Marc pit constitutes one of the most important seats of working owned by the Anzin Company, in respect to both the deposit and the output, comprising two shafts, one, No. 2, of large diameter, used exclusively for winding, and the other, No. 1, serving for ventilation, only 8 feet 6 inches (2·6 metres) in diameter. The latter, besides not having a sectional area sufficient to pass the quantity of air required for working, gave great trouble through the bad state of the tubbing, which sometimes allowed so much water to burst in as to completely disarrange the ventilation. For widening the shaft and providing it with new tubbing, a direct method was sought that should not interrupt the ventilation, and therefore winding in the other shaft. It was ultimately decided to adopt the following method, which had the advantage of being simple, inexpensive, and easily executed, while leaving shaft No. 1 quite clear of all pipes, and this work was carried out with complete success.

An annular tank, placed at the base of the old tubbing, collected the water which flowed into a lodge constituted by an old stone-drift connecting the two shafts at the depth of 246 feet, pumps, erected in a level near No. 2 shaft, forcing the water to the surface. The author describes, with the aid of drawings, the various works under the three heads: – (1) Erection of circular tanks and pumps; (2) fitting up of shaft No. 1 for the work; and (3) widening thereof, with putting in of new tubbing.

The use of pipes and portable pumps, owned by the company, permitted of executing the work in five weeks at the comparatively small cost of £10 per linear foot; and its immediate consequences were a great improvement in the ventilation and the keeping back of a feeder giving more than 730 gallons of water per minute.

J. W. P.

PREVENTION OF SPONTANEOUS COMBUSTION OF COAL, ETC.

V. Balzberg's Apparat zur Verhinderung der Selbstentzündung von Kohlenvorräthen. By V. WENHART. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1895, *vol. xliii., page* 319.

The object of the Balzberg apparatus is to prevent spontaneous ignition and explosion in stores of coal and other combustible substances, explosives, cotton, grain, etc. Spontaneous combustion, which always takes place in the lowest and innermost layers, may be prevented if the temperature be considerably lowered, and if incombustible gases be allowed to permeate the smouldering mass. This object the inventor proposes to attain by introducing liquid carbonic acid, which absorbs much heat in its evaporation or vaporization, while the carbonic acid gas which it gives off, being of great density, drives out the oxygen of the air from the lower layers of the combustible substance. Liquid ammonia, sulphuric acid, and even steam may be substituted for carbonic acid, but the latter best answers the purpose and is not so expensive as it was formerly. It should be kept in wrought-iron holders, and connected by copper tubes to the apparatus. Several of these injectors may be introduced into the stores of combustible material.

The invention is based on the principle that carbonic acid expands at certain well-known temperatures, and thereby produces a lowering of the temperature in its vicinity below that necessary for combustion. The valves discharging the fluid are automatically opened by the expansion of some substance easily susceptible to changes of temperature. The apparatus consists of a cast-iron cylinder, closed at the top with a spring disk, and filled with olive oil or other sensitive liquid. Above it is a hollow rod in two parts; the lower is held against the disk by a spring, while the upper communicates with a valve. As long as the normal temperature prevails in the mass, the two parts are disconnected. As the oil becomes heated it expands, and the disk and spring are pushed up, the lower part of the rod lifted, and at the moment the critical temperature is reached the two parts join, the valve is raised, and communicates with a double-seated valve above it. The latter is connected to the pipe containing the carbonic acid, and the pressure in it is higher than in the lower valve and hollow rod. A little of the fluid is forced out, the pressure falls, the double-seated valve descends, and allows the remainder of the carbonic acid, at high pressure, to pass upwards through openings, and exhale into the mass of smouldering material. As soon as this action has produced the necessary cooling effect, the rod and valve return to their original position, and an equilibrium of pressure is re-established.

To adjust the apparatus to the temperature at which the carbonic acid will exhale, that is, slightly above the maximum normal temperature in the mass, it is plunged in a bath of water and regulated by means of a micrometer-screw. When the hollow rod is lifted, it carries with it a disk which strikes against an electric wire connected to a bell, and thus conveys warning that the temperature is rising. Electricity is also used to give automatic notice that there is no more carbonic acid in the lateral pipe. A return valve, usually held closed by the pressure of the carbonic acid in this pipe, is pushed up by a spring as soon as this pressure is removed by the exhaustion of the carbonic acid, and brings another electric wire in contact with a bell. The size and number of the carbonic acid holders depend on the quantity of coal stored. The apparatus can also be used to give warning of fire, or by inverting the double-seated valve to signal an undesirable fall in temperature, and for other purposes. It is very easily worked, and when once adjusted nothing is required but to replenish the holders, care being previously taken to shut off the pipe connecting to the apparatus. The electric battery and bells and the carbonic acid-holders should be located in a space contiguous to the store of material.

Drawings of the apparatus are given in the original paper, and a plan of the method of arrangement, as applied to coals in the hold of a ship. B. D.

PRECAUTIONS AGAINST SPONTANEOUS IGNITION OF COAL AT SEA.

Sicherung gegen Feuersgefahr auf See. ANON. *Dinglers Polytechnisches Journal,* 1896, *vol. ccc., page* 130.

For the prevention of spontaneous combustion of coal in the holds, etc., of ships, Mr. Emanuel Stauber has invented a system of ventilation which consists in the formation of an air-space in the bottom and centre of the coal-stowage, by perforating the floor and erecting two longitudinal perforated bulk-heads. At various heights, a series of perforated horizontal pipes, communicating with the air-space at the centre, are hinged on to the bulk-heads so as to fold out of the way while the hold is being filled or emptied. A double cowl on deck, fitted with a vane, permits the escape of the gases given off by the coal and allows fresh air to circulate in their place. This system is said to prevent the coal from shifting as the vessel rolls, the friction from which cause is considered as one of the chief factors in the production of spontaneous combustion. C. S.

SULPHUR-MINING AT POPOCATEPETL, MEXICO.

ANON. *The Engineering and Mining Journal* (*New York*), 1896, *vol. lxi.*, *page* 493.

The survey of the volcano Popocatepetl, Mexico, for the purpose of determining the best location for an aerial cable-railway to the summit has just been completed. It has been determined to start the line from the ranch of Tlamacus, and it will be connected with the Interoceanic Railroad at the base, so that the business of shipping sulphur can be cheaply accomplished. The process of extracting sulphur is being carried out in the crater. J. W.

TEXAN AND OTHER AMERICAN SULPHUR-DEPOSITS.

ANON. *The Engineering and Mining Journal* (*New York*), 1896, *vol. lxii.*, *page* 26.

The advance in the price of sulphur has directed attention to sulphur-deposits in many parts of the United States, as well as to some in the West Indies.

Deposits of sulphur occur in Texas, about which reliable information is given in a report by Dr. Eugene A. Smith, State Geologist of Alabama. The sulphur is closely connected with a loose, exceedingly fine-grained material which has been looked upon by some geologists as the sediment from lakes of moderately recent date. The ore contains about 50 per cent. of sulphur, and there are some 30,000 tons actually in sight. These deposits have also been examined by Mr. John E. Rothwell, of Denver, Colorado, who tested the property by boring and shafts, and proved an even larger quantity of sulphur.

There are numerous large deposits of sulphur in Utah; but they are situated at a great distance from any market, with high railway-freights. The same objection applies to the deposits of Lower California. The Louisiana deposit has recently produced a few thousand tons of good sulphur, and bore-holes show that the quantity there is enormous.

In the West Indies, in Saba and Santa Lucia, and in some islands near the South American coast are deposits of sulphur which have been examined but not yet worked, though near the ocean. J. W.

CYCLOTOMIC TRANSIT-THEODOLITE.

ANON. *The Engineering and Mining Journal* (*New York*), 1896, *vol. lxi.*, *pages* 445, 446.

This form of theodolite was designed by Mr. Adolph Lietz from ideas suggested by Mr. Luther Wagner, of San Francisco. The object of the inventor has not been to replace the old form of transit-theodolite by a less expensive and not so reliable an instrument, but to avoid unnecessary mechanism by the introduction of the cyclotome by which a transit may be performed with an instrument having but one axis or central cone upon which to revolve. In the so-called compound centered theodolite, the main graduated plate or azimuth-circle and the horizontal limb to which is fixed the telescope and vernier have each an independent motion on their respective axes, which enables the operator to place the zero of the vernier in coincidence with that of the plate in whatever direction the telescope may be pointed. In the cyclotomic transit, the main plate or azimuth-circle is made a part of the rigid substructure, so that when the instrument is set in position for work this plate remains stationary.

The azimuth-circle is graduated to half degrees, but the figures from 0 to 360 degrees are engraved upon a separate band termed the cyclotome, which revolves independently round the outer edge of the azimuth-circle, so that any of the graduation-lines may be made the zero by bringing the 360 degrees mark of the cyclotome opposite to it. As this independently revolving circle or band appears to have been sliced from the main plate it is termed the cyclotome, and hence the name cyclotomic transit.

The cyclotomic transit-theodolite is handled in the following manner when employed for determining horizontal angles. Having set the instrument above the station-point upon the tripod, and levelled it by means of the parallel plates and screws in the ordinary manner, the horizontal limb or telescope, with vernier, is unclamped and revolved around the figured circle which remains clamped until a tick is heard which indicates that the zero of the vernier is in line with that of the cyclotomic ring. This ring is thereupon also unclamped and the telescope is revolved until the object or back-station point is sighted, when it is clamped and the slow-motion or tangent-screw is brought into use for the purpose of bisecting the object. The vernier and the cyclotomic ring are then brought into direct line with one of the graduation-lines of the main-plate or azimuth-circle by means of a separate screw provided for the purpose, so that the plates are now set to read off the angle formed by any other station-point by unclamping the telescope and revolving it round to the required object. It will be seen that the cyclotome answers the purpose of the revolving main-plate of the compound centered transit theodolite, and by its introduction the main clamp and tangent-screw may be dispensed with, which affords opportunity to bring the plates close to the levelling head, thereby lowering the centre of gravity and increasing the rigidity of the instrument. F. C. S.

THE PREPARATION OF TELLURIUM AT SCHEMNITZ.

Tellurerzeugung auf der K. ung. Blei-und Silberhütte zu Schemnitz in Ungarn. By J. Farbaky. *Zeitschrift für angewandte Chemie*, 1897, *pages* 11-18.

The Schemnitz tellurium-works were established in 1891, and at first the metalloid was extracted from the ore by precipitation with zinc; but since 1895 the process of precipitation by means of sulphur dioxide, proposed by Dr. A. Mály, has been exclusively employed.

The first stage is to attack the ore by strong sulphuric acid, to which end 770 lbs. (350 kilos) of concentrated acid are raised to boiling-point in a cast-iron pot, into which 330 lbs. (150 kilos) of Transylvanian ore are ladled with continued stirring. This results in the decomposition of the metallic carbonates, and the solution of lead, copper, and zinc, along with the tellurium and a part of the silver, leaving gold and silica in the residue. The action of the acid is assisted by gradual and progressive heat until the mass is of a syrupy consistency, a stage attained usually in about six hours.

The mass is next lixiviated with 55 to 66 gallons (250 to 300 litres) of boiling water containing 10 to 15 per cent. of hydrochloric acid, to extract the soluble compounds formed, the acid acting as a precipitant of the dissolved silver and re-dissolving the tellurium hydroxide thrown down during the dilution of the mass. This operation, with continued stirring, lasts for six hours, and on the following day the liquid and solid materials are separated by filtration under pressure, the gold and silver in the residual cake being recovered in the ordinary manner.

The filtrate is run into lead-lined wooden precipitating-tanks about 40 inches long by 20 inches wide, into which a current of gaseous sulphur dioxide (purchased in a liquid form in strong cylinders) is passed. At the end of twelve hours, the green solution turns brown, and black flakes of tellurium begin to separate out; and when a sample of the liquor ceases to give a precipitate with a little hydrochloric acid and sodium sulphite, the operation is at an end. The mother-liquor is absorbed by slaked lime and ashes, and roasted, etc., for recovering the other metals present. The six days required for precipitation in the tanks may be abbreviated to one-fourth or even less by increasing the contact between the sulphurous acid and the liquor—by using carboys instead of precipitating-tanks.

The product is usually between 72 and 85 per cent. pure, the chief impurity being copper, of which about 6 per cent. is present, along with about 8 per cent. of tellurium oxide. So far it is not apparent how the copper is precipitated and experiments on this point are in progress; the process, however, compares favourably in this respect with the zinc process, since the crude tellurium obtained by the latter was only about 29 per cent. pure and contained some 13 per cent. of lead, 15 per cent. of copper, and 12 per cent. of antimony. It was hoped by repeated solution, re-precipitation, and washing to obtain a product 94 to 97 per cent. pure, but the process, though efficient on a small scale, is unsatisfactory in practice, besides being expensive, so the product is dried carefully at a low temperature to prevent oxidation, and the mass is fused in luted earthenware crucibles and either cast in sticks of 1 to 2 inches in diameter or granulated.

C. S.

INCREASE OF TEMPERATURE WITH DEPTH IN THE EARTH'S CRUST: CHARMOY AND MACHOLLES BOREHOLES, FRANCE.

Sur les Sondages profonds de Charmoy (Creusot) et de Macholles près Riom (Limagne.) By A. MICHEL LÉVY. *Comptes Rendus de l'Académie des Sciences*, 1896, *vol. cxxii.*, *page* 1503.

On account of the great depth of these boreholes, which exceed 3,280 feet (1,000 metres), and the interesting nature of the rocks in which they stopped, the author considered the opportunity favourable for ascertaining their geothermic degree.

The Charmoy borehole was started at an altitude of about 1,023 feet (312 metres) in the lower Permian shales, marked γ 11 on the French geological map, to the scale of 1 : 80,000. The hole passed through 3,620 feet (1,104 metres) of lower Permian, consisting of shales, sandstones, and conglomerates, and then penetrated about 213 feet (65 metres) into the eruptive granulite, being stopped at a total depth of 3,832 feet (1,167·87 metres) a few days before the experiments were made. The albitic granulite at the bottom of the borehole is coarse-grained, and traversed by small blackish veins sometimes charged with iron pyrites. For taking the temperature at the bottom of the borehole, inclined thermometers like that of Dr. Walferdin, modified like those which served for Mr. Dunker's experiments in the Sperenberg and Schladebach borings, were used, care being taken to keep them as far as possible from the influence of water-circulation. The temperature found by the geothermometers let down in light tools, well open both below and at the side, was 128·75° Fahr. (53·7° Cent.). A very cold spring gushing out a few feet from the borehole gave, on June 2nd, 1896—when the outer temperature in the shade was 70° Fahr. (21·1° Cent.)—that of 49° Fahr. (9½° Cent.). Supposing this spring to represent the mean temperature of the spot, and that it issues from a depth of 65 feet (20 metres), the temperature of the Charmoy boring increases 1° Fahr. per 47 feet (1° Cent per 26 metres).

The Macholles boring, near Riom, the site of which is a few feet from a point on the contour-line of 328 metres on the map of the French survey, near the hamlet of Macholles, passed through 13 feet (4 metres) of surface and alluvium, about

2,296 feet (700 metres) of Lacustrine limestone (stratum m_{1-b} on the French geological map) alternating with shaley marls, and then about 984 feet (300 metres) of siliceous sandstone and very fine arkoses. At a depth of 3,287 feet (1,002 metres) the hole entered a series of calciferous shales, exudations of heavy petroleum mingled with bitumen having been noticed at the depth of 3,231 feet (985 metres). On June 12th, at a depth of 3,299 feet (1,005·66 metres), the temperature of 171° Fahr. (77·2° Cent.), and on the following day that of 172·4° Fahr. (78° Cent.) were recorded; but the author regards them only as minimum. To obtain a more correct reading, he enclosed a Walferdin thermometer in a steel tube hermetically sealed, which, after remaining at this depth for one hour, was drawn up intact, showing a temperature of 174·4° Fahr. (79·1° Cent.). Supposing the mean temperature of the spot to be the same as at Charmoy, the temperature increases 1° Fahr. per 25·7 feet (1° Cent. per 14·16 metres).

It is evident that this geothermic degree—less than half the mean—is due to the volcanic manifestations, thermal springs, etc., of which the Limagne is still the arena. Neither the proximity of the Châteaugay basaltic eruptions, nor the neighbourhood of the Quaternary puys (that of La Nugère being 7 miles to the west) appear to be the cause of this; but the eruptions special to the Limagne, basalts, and peperites, would appear to be the dominant factors of this elevation in the geothermic curves. J. W. P.

METHOD FOR DETERMINING HIGH TEMPERATURES.

Termofon, ny metod för bestämning af höga temperaturer. By Prof. J. Wiborgh. *Jernkontorets Annaler*, 1896, *page* .

It is very important in metallurgy to possess the means of determining, as exactly as possible, the temperature at which the work is carried on. The reactions change with the temperature; and, especially in the case of steel, the product varies greatly according to the heat at which it leaves the furnace. As regards the manner of determining the temperature, although many attempts have been made, the results have not hitherto proved very satisfactory, inasmuch as no temperatures above 1,400° Cent. can be determined, because most instruments, such as the pyrometer, must come into direct contact with the heated substance, and therefore be destroyed. Only a few pyrometers, those for instance which depend on optical manifestations, can be regarded as really efficient; and, although several such instruments have been devised, they have generally turned out unpractical. Now, if an instrument be contrived which, although destroyed in high temperatures, shall indicate the temperature sought, while being comparatively cheap so that its loss is of no great consequence, the object is attained.

In the middle of a fire-resisting body, having as high a degree of cohesion as possible, and which does not deteriorate the substance to which it is applied, is inserted an explosive which detonates at a determined temperature, with the addition of a firing substance, like that employed in percussion-caps, and enclosed in an hermetically sealed case. Such a body, that may be called *thermophone*, is to be thrown into the furnace or bath of molten steel, the temperature of which it is required to ascertain; and the time is noted which elapses before explosion ensues, the temperature being a function of the time, and all the thermophones being of identical composition and conductivity. If a thermophone is arranged to explode at a given temperature, say 500° Cent., the time that elapses before explosion can be calculated from it for all required temperatures, and a trustworthy table of temperatures may be compiled. J. W. P.

MINING IN TURKEY.

Die bergbaulichen Verhältnisse in der Türkei. *By* DR. W. MAY. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1896, *vol. xliv.*, *page* 223.

Mining matters generally are regulated by the law of August 25th, 1887, o.s., and are now administered by a department of the "Ministry for Forestry, Mining and Agriculture" that was formed some three years ago. To obtain a mining concession, a written request for permission to prospect must be forwarded to the governor of the province; the nature of the mineral to be sought for, and the limits within which it is proposed to carry on prospecting operations, must be specified, but these limits may include areas of a good many square miles. The applicant has to find security for the repayment of any surface-damage that may ensue from his work. There are no specified fees, and the expenses connected with these first steps are said to be trifling. The permit gives the right to prospect for a year, and may be extended to a second. Before its expiration, a report on the results, together with a plan on a scale of $\frac{1}{5000}$, and samples of the useful minerals found, have to be sent to the department of mines in Constantinople, together with a petition for the granting of the concession; this is published, and if no objections are filed within two months, the concession will be granted in the course of another two months or more, if all is in order, by means of a firman from the Sultan. The cost of the latter depends on the importance of the concession, averaging about £200 Turkish (about £185 sterling). The grant is for ninety-nine years, except in the case of chrome ore, emery, boracite and meerschaum, when it is for sixty years only. The tax that is payable is 10 piastres gold (about 1s. 8d.) per hectare of area, and from 1 to 5 per cent., generally the latter, of the gross values of the ores, except in the case of the four above-named substances, when it is raised to 10 per cent.

During the last four years there have been granted 5 concessions for silver-lead, 1 for silver, lead, and antimony, 1 for antimony, 4 for chrome ore, 1 for emery, 4 for manganese, 1 for lignite, 1 or 2 for boracite.

The copper-mines at Anjhana, on the upper waters of the Tigris, are worked by the state, but probably without any profit at the recent low prices. At present, Anjhana produces about 120 metric tons, Batman about 720, and Old Okku 923 tons of black copper, containing about 75 per cent. of metal. The state also works the silver-lead mines at Bulgandagh, which produces annually about 1,500 kilogrammes of silver. The litharge got as a bye-product is sold by public auction.

The only true coals of the empire are worked in the basin of Heraklea on the Black Sea, producing about 150,000 tons yearly, chiefly consumed by the Imperial Turkish fleet. Great Britain is almost the only country that sends coal into Turkey, the amount thus sent having been 461,132 tons in 1893; Constantinople consumes about 95,000 tons annually.

The meerschaum mines near the Eskischehir station on the Angora railway also belong to the state. The crude mineral is cleaned, dried, polished, classified, and carefully packed in cases weighing 30 kilogrammes gross, or 15 kilogrammes nett. This is supposed to be the finest quality produced. Till within the last six or seven years the annual output was about 8,000 boxes, but so many of the best pits are under water that scarcely 4,000 boxes are now got.

The asphalt-mining industry is of very small importance.

Of the silver and lead-mines, the most important are those of Hodscha-Gürnisch (Balia) near Edremid, worked by a French company, the Société des Mines de Balia-Karaaïdin, and producing some 4,000 tons of ore per annum. An English company, the Asia Minor Mining Company, produces some 3,000 tons yearly of silver ores from the mines of Lidschesi.

Important deposits of manganese have been found in the peninsula of Keosendere. The number of known deposits and veins of antimony is rapidly increasing, and Turkey will certainly play an important part in the world's markets for this metal.

Turkey possesses sufficient deposits of chromite to be able to supply by itself the present needs of the world. About 20,000 tons, averaging about 48 to 56 per cent., are exported annually, about half of the production belonging to a Smyrna firm.

Another Smyrna firm controls the greater part of the emery output, and exports about 7,000 tons annually. This product is now exposed to keen competition with that got in the island of Naxos, which is of better quality and is sold at lower prices—at £3 8s. the ton it is said—by the Greek Government, who own the monopoly.

The boracite (strictly speaking calcic borate, with 40 to 60 per cent. boric acid) concessions near Panderma, now produce 5,000 to 6,000 tons per annum, and a neighbouring French company, the Société Lyonnaise des Mines et Usines de Boran, now produce about the same amount.

The production of salt, which is also a state monopoly, is about 200,000 tons per annum ; in 1894 it was 203,128·235 tons. In this year the consumption of the country is given as 215,747 tons, and 15,515 tons were exported, none being imported into Turkey.

Of late years there have been some borings for petroleum, and new finds of silver-lead, and other ores are reported. Building-stone and fuller's earth are also among the mineral products of Turkey, especially the latter in the province of Angora. H. L.

THEORY OF TURBINES, FANS, AND CENTRIFUGAL PUMPS.

Sur la théorie des turbines, pompes et ventilateurs. By A. RATEAU. *Comptes Rendus de l'Académie des Sciences,* 1896, *vol. cxxii., page* 1268.

The theory of turbines, centrifugal pumps, and fans is generally established from the theorem of the *vis viva*, but it is preferable to substitute that of the moments of the quantities of motion, by which a general formula is more quickly obtained. This method has the additional advantage of being applicable to the various machines as they exist with all their imperfections, while the other does not take sufficient account of loss of head by friction, or the disturbances and shocks affecting the fluid inside the revolving portion.

If the theorem of the moments of the quantities of motion be applied to a turbine-wheel, constantly receiving a total mass, I, of fluid per second, taking the turbine-shaft for the axis of the moments, inasmuch as the internal forces of the system do not enter into the expression of this theorem, the formula deduced from it will hold good, whatever be the shocks and friction inside the revolving portion. The only forces external to the system, producing a moment that is not *nil*, are (1) the useful motor couple given by the apparatus, which may be designated by M and (2) the friction of the shaft, and also of the wheel sides on the fluid not circulating in the revolving portion, always very slight, producing a moment that may be designated m. Gravity will cause no moment if the shaft be vertical, or if the admission be symmetrically disposed round the shaft when horizontal ; and the same will be the case as regards the forces of pressure at the entrance and exit of the revolving portion.

If i be the mass delivered by a small element of the wheel ; r_0, the radius at entrance to the turbine ; $u_0 = \omega_0 \ r_0$, the speed of rotation at that point ; a_0, the projection, at this speed, of r_0 the absolute speed of the fluid at this entrance ; and r_1, u_1, a_1, v_1, the corresponding elements at the point of exit, then, in accordance with the theorem of the moments of the quantities of motion,

$$M + m = \Sigma \ i \ (r_0 \ a_0 - r_1 \ a_1). \quad \ldots\ldots \quad (1)$$

This fundamental formula of the motor moment is also applicable to any part of the wheel, supposing a_1 to be considered as answering to the exit-point of this portion. If the parenthesis be the same for all the elements, i of the volume delivered, as is the case in a centrifugal turbine, the sum will only bear upon i, giving

$$M + m = I \ (r_0 \ a_0 - r_1 \ a_1) \quad \ldots\ldots \quad (2)$$

If we multiply the two members by the angular speed ω, we shall obtain in the first member M ω and $m \ \omega$, representing the useful power P, and the power p, lost by external friction,

$$P + p = I \ (u_0 \ a_0 - u_1 \ a_1) \quad \ldots\ldots \quad (3)$$

The useful power P, may be written g I K, K being the part of the fall or head H really utilized ; and in the same way may be stated $p = g \ I \ k$, when

$$g \ (K + k) = u_0 \ a_0 - u_1 \ a_1 \quad \ldots\ldots \quad (4)$$

The yield, or useful effect, ρ of the apparatus is equal to K ÷ H, so that

$$\rho = \frac{u_0 \ a_0 - u_1 \ a_1}{g \ H} - \epsilon \quad \ldots\ldots \quad (5)$$

$\epsilon = k + H$ being a very small quantity, in which it will be convenient to include leakage at the joints.

The preceding formulæ also apply to centrifugal pumps and centrifugal and helicoidal fans, it being sufficient to change the signs of M and P, and to reverse the ratio of formula (5), in which case H will be the height generated by the apparatus. Be it remarked that loss at the distributor diminishes a_0, while loss in the wheel increases a_1 ; and, if a_0 and a_1 can be calculated, the useful effect may be deduced from them. Important conclusions may be drawn from these formulæ, which are useful for many purposes. J. W. P.

SEPARATE VENTILATION IN FIERY PITS.

Ueber Separat-Ventilation bei Aus-und Vorrichtungsarbeiten in Schlagwettergruben. By J. Mayer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1896, *vol. xliv., pages* 53-57.

As a subsidiary means of ventilation in the case of restricted workings and distant places which cannot be efficiently supplied with air from the main current, the separate system is useful and saves the expense of parallel airways, but the latter method is the safer for workings of over 300 feet in length, as it enables the current to be controlled in the vicinity of the working in case of accident, and also affords better chance of escape for the men than the single headings. Besides, there is the danger, unless the brattices or pipes are very strongly put together, of their breaking and stopping the ventilation altogether.

Unless due provision be made for the supply of fresh air to the fans working the separate system, the roadways, headings, etc., supplied in this way will only be filled with air that has already done duty as part of the main current and is therefore not competent to effect thorough ventilation. Besides, there is a great waste of air, even when iron pipes are used, ranging from some 25 per cent. in a distance of 360 feet to 75 or 77 per cent. at 1,600 feet from the fan.

In ventilating a cross-driving, in the Heinrich shaft of the K. K. Kaiser Ferdinand's Nordbahn pit, of a total length of 1,800 feet (555 metres), a Capell fan, driven at 600 revolutions per minute, gave a discharge of 210 cubic feet (6·012 cubic metres) and produced ½ inch (12·75 millimetres) compression of the water column; at 1,000 revolutions the results were 330 cubic feet (9·342 cubic metres) and 1·06 inches (27 millimetres) respectively. This quantity was sufficient to ventilate the face thoroughly, but quickly damaged the working parts of the machinery. During the execution of the necessary repairs, a compressed-air exhauster with ⅛ inch (3 millimetres) jet was employed, but fell behind the fan in point of efficiency by about 20 per cent., although using up more air. Nevertheless, for ventilating fiery mines, the safety of the workers being the first consideration, the exhauster is preferable to the fan.

Another advantage of the use of parallel headings is that, in pillar work particularly, they allow the gas to "bleed" from the coal better, and so help to clear the seam.

The author controverts the statement made by Mr. Uthemann that the current of air only increases in proportion to the square root of the compression (*i.e.*, of the revolutions of the fan), and maintains that the ratio is a direct one, except, perhaps, in the case of small fans, where the influence of waste is greater in proportion than in larger machines. Still, as increased speed is the reverse of economical, it is better to make the airways larger than to force the ventilator.

C. S.

ELECTRICALLY-DRIVEN FAN AT THE RAMMELTER AIR-SHAFT OF THE GERHARD COLLIERY, LOUISENTHAL.

Die Ventilationanlage mit elektrischem Antrieb auf dem Rammelter Wetterschacht des Steinkohlenbergwerks Gerhard zu Louisenthal. By — ALTHANS. *Zeitschrift für das Berg-Hütten-und Salinen-Wesen im Preussischen Staate,* 1896, *vol. xliv., page* 453, *and* 1 *plate.*

In November, 1895, the last ventilating-furnace of the Gerhard colliery was replaced by an electrically-driven fan. This was applied to a shaft 190 feet (58 metres) deep, and of 69 square feet (6·4 square metres) sectional area. This shaft lies 2,600 feet (800 metres) from the nearest winding-shaft, and it was found difficult to arrange for boilers and engine at it, so much so that a large Guibal fan which had been built there in 1866 had been removed. In making the calculations for the new fan, the Pelzer system was selected. The quantity of air was taken as 49,400 cubic feet (1,400 cubic metres) per minute as a maximum; the equivalent orifice of the mine, which has long and very narrow airways, was assumed to be 10·76 square feet (1 square metre) and the necessary maximum water-gauge was calculated from the formula $h = \left(\frac{0{\cdot}38\ \mathrm{V}}{a}\right)^2$ to be 3·11 inches (79 millimetres). Allowing a manometric efficiency of 50 per cent, the peripheral velocity was calculated from the formula $u = \sqrt{g\frac{\mathrm{H}}{2}}$ (where H = water-gauge, V = average weight of 1 cubic metre of air) and was found to be 117 feet (35·6 metres) per second. The fan was to be coupled direct to the shaft of the motor, hence a high speed and small diameter were considered desirable; a fan of 7·38 feet (2·25 metres) diameter, with an intake on the one side of 29 square feet (2·69 square metres) area, was selected, and this fan would accordingly have to make 303 revolutions per minute. The effective work of the fan would, from the above figures, be 24·6 horse-power. As the manufacturer guaranteed an efficiency of 62·5 per cent., the power to be developed by the shaft of the dynamo amounted to 40 horse-power.

The generating-station consists of a horizontal engine, with one cylinder 14·17 inches (360 millimetres) in diameter and 25·59 inches (650 millimetres) stroke, with variable expansion-gear. It works under a steam pressure of 75 to 90 lbs. per square inch (5 to 6 atmospheres), making at most 93 revolutions per minute.

The dynamo is a polyphase machine developing 500 volts and 35,500 watts. The rotating field-magnets are arranged radially round the shaft, and the machine is to work at 64 alternations per second; as there are 8 poles, it has accordingly to make 480 revolutions per minute; the diameter of the driving wheel is 11·48 feet (3·5 metres), and of the pulley of the dynamo 25·98 inches (660 millimetres), or a ratio of 5·3 to 1. The magnets of the polyphase dynamo are excited by a small continuous-current dynamo coupled direct to the former.

The leads consist of three bare copper wires of 0·08 square inch (52 square millimetres) section and 2,600 feet (800 metres) long, carried on iron poles by means of insulators.

The motor is an asynchronous polyphase motor of a maximum of 40 horse-power. It is similar to the dynamo, but possesses 12 poles instead of 8, hence should only make 320 revolutions per minute, but makes somewhat less when running under load on account of slip. The fan is coupled direct to the shaft of the motor.

Since the plant was started in November, 1895, it has given entire satisfaction. It needs no special attendance, but is examined once every four hours.

The annexed table shows the results of a series of trials of this fan :—

	Number of Experiments.					
	1	2	3	4	5*	6*
Number of revolutions per minute—Engine	81	81	86	86	93	93
Dynamo	418	418	443	443	485	486
Motor	272	272	285	285	306	303
Slip of belt—per cent. ...	2·6	2·6	2·8	2·8	1·6	1·6
Electric slip—per cent. ...	2·51	2·51	3·39	3·39	5·26	6·48
Exciting dynamo—Volts ...	47·0	46·0	49·0	49·0	52·5	52·4
Ampères	19·4	19·5	18·3	18·5	17·8	17·8
High-tension dynamo—						
Volts	495	500	500	500	500	500
Ampères	42·0	44·5	44·5	46·5	53·0	54·0
Water-gauge—Millimetres ...	58	56	63	61	71	68
Inches ...	2·28	2·20	2·48	2·40	2·80	2·68
Volume of air per minute—						
Cubic metres ...	1,265·6	1,460·1	1,324·1	1,538·5	1,490·0	1,618·0
Cubic feet ...	44,695	51,564	46,762	54,333	52,620	57,149
Useful effect of the fan—						
$\left(\frac{V\cdot h}{60\cdot75}\right)$ horse-power ...	16·30	18·17	18·44	20·85	23·51	24·45
Indicated power of the steam-engine—Horse-power ...	45·1	46·6	53·5	53·1	63·6	65·6
Mechanical efficiency of the installation—Per cent. ...	36·1	38·9	34·5	39·3	36·9	37·3
Equivalent orifice of the mine—Square metres ...	1·05	1·23	1·06	1·24	1·12	1·24
Square feet ...	11·302	13·240	11·410	13·348	12·056	13·348

* The last two trials were not made on the same day as the first four.

The working costs could not be calculated direct, as the dynamo and air-compressor are run together, but it is calculated that the additional expense due to this installation amounts to 2·2 marks for wages and 27·4 marks for stores per diem, or per annum 10,804 marks (about £540) for about 16 horse-power, or 675·25 marks (£33 15s.) per horse-power per annum; a great direct saving over the furnace has thus been attained, whilst the volume of air extracted is about doubled. H. L.

APPLIANCES FOR BREATHING IN AFTER-DAMP AND THE WALCHER-GÄRTNER PNEUMATOPHORE.

Ueber Athmungs-und Rettungs-Apparate beim Bergbau im allgemeinen und über den Walcher-Gärtner'schen Pneumatophor im besonderen. By DR. AUGUST FILLUNGER. *Oesterreichische Zeitschrift für Berg-und Hüttenwesen,* 1896, *vol. xliv., pages* 581 *and* 591, *and illustrations.*

Numerous forms of apparatus to enable men to breathe in workings filled with irrespirable or poisonous gases have been devised. They may be classified as follows:—

(1) *Respirators,* in which the inspired air traverses sponges or similar media saturated with chemical reagents, such as the Roberts respirator, consisting of a sponge soaked in milk of lime.

(2) *Hosepipe apparatus,* in which the air for respiration is conveyed through pipes; to this class belong the apparatus of Messrs. Pilâtre de Rozier, Prasse, and Loeb, in which the air is under normal pressure, and which do not admit of use beyond a distance of 100 feet. Other forms, in which air is used under pressure as in diving dresses, are those of Messrs. Denayrouze-Rouquarre, L. v. Bremen, and Mayer. These are all too cumbersome for ordinary use.

(3) *Reservoirs,* in which the air for respiration is carried by the miner on his back. To this class belong the arrangements of Messrs. Combes, Kraft, and Fayol, in which air is expired into the open, and the well-known Galimbert bag, in which it is returned to the reservoir. Some of these arrangements include devices for purifying the expired air, such as those of Messrs. Bartan and Schulz. The Galimbert apparatus alone seems to have been used for mining purposes.

(4) *Oxygen apparatus.*—To this class belong the methods of Messrs. Schwann, Fleuss, and the very recent pneumatophor of Walcher-Gärtner. These all act by providing a supply of oxygen and using the same volume of air over and over again by absorbing the carbonic acid gas produced and introducing fresh oxygen as required.

The Schwann apparatus, known as the aerophor, consists of a flat reservoir carried on the breast, whilst expiration takes place into a knapsack-like receiver in which slaked lime is contained to absorb the carbonic acid. Oxygen under a pressure of 4 to 6 atmospheres carried in metal cylinders can be forced into this receiver, whence the air is expelled into the bag in front.

The Fleuss apparatus is somewhat similar, but has been improved in its details; it weighs about 30 lbs. and costs about £60.

The pneumatophor is the most recent contrivance of the kind (German patent No. 88,703 of 1895). It consists of a bag, carried on the chest of the user, about 23½ inches by 19¾ inches, and 2 inches deep when moderately expanded, having thus a capacity of about ½ cubic foot. The bag is made of any material impervious to air. There is a small tube in the centre that terminates in a plain mouthpiece of vulcanite, the wearer's nose being closed by a clamp. Inside the bag is a cylinder of perforated sheet-iron 8 inches long and 3 inches in diameter, inside which is a stoppered bottle containing a 25 per cent. solution of caustic soda, so disposed that it can be broken by a few turns of a screw, the handle of which projects outside the bag. Just below this cylinder, a small steel flask of compressed oxygen is secured. This flask is made of seamless steel tested to a pressure of 250 atmospheres. It is 12 inches long, and its capacity is 3·66 cubic inches, so that under a pressure of 100 atmospheres it will contain 2 cubic feet of oxygen. There is a valve in the neck of the flask actuated from outside the bag, whilst the flask opens into the interior of the bag. The weight of the entire apparatus complete is 10 lbs. Its present cost is about 40 florins complete (say about £4). Any ordinary exercise can be performed by men wearing it, and it affords an ample supply of oxygen for 1 to 1¼ hours, even when violent exercise is being taken by the wearer.

Numerous mining engineers and others have worn the apparatus and gone into experimental drifts, etc., filled with smoke or irrespirable gases, and they consider its action to be quite satisfactory. H. L.

MORTIER FAN.

Der Mortier-Ventilator. By A. v. Ihering. *Glückauf,* 1896, *vol. xxxii., pages* 217 *to* 223.*

The Mortier fan consists of a median disc of iron keyed to a horizontal shaft. On either side of the disc are riveted sheet-iron blades, held in position by an outer ring of iron on either side. There are thirty-six such blades, placed radially at their inner circumference but at an angle of 40 degrees with the radius at their outer, the curvature being in the direction of revolution of the fan. The fan is of the same width as the return airway, and is surrounded by a closely-fitting casing of iron plates that leads into a rectangular evased stack. The entire lower portion of the casing is movable by means of two hinges, so that it can be set almost in contact with the fan or at some distance from it, the motion being controlled by a pair of long screws with hand-wheels; this portion of the arrangement is spoken of as the multiplying shutter. Its use will be explained further on. On the upper part of the casing and projecting inwards from it, just below the ring of blades, and so as almost to touch the median disc, are a couple of fixed hollow sheet-iron blocks, shaped like the segment of a circle. It should be added that the ratio of the inner to the outer diameter of the fan-blades is 0·7 : 1, and that these are bent to an arc whose radius is about one-half that of the inner circle.

When the multiplying shutter is close up to the fan and the latter is set in motion, the air that reaches the exterior circumference of the fan with a feeble velocity in the upcast is caught up by the blades; it is not, however, carried round by them, but, as a resultant of its original and its acquired velocity, it is driven through between the fan-blades into the lower half of the inner fan-space across which it passes in a straight line to be caught up again by the blades on the opposite side of the fan and projected into the chimney. The function of the fixed segments is to prevent any of this air from rising up vertically, also to prevent the formation of eddies or of the return of the air into the interior of the fan. When the multiplying shutter is, however, drawn back so as to allow a free passage between it and the fan, the normal air-current produces an induced air-current in this free space, which causes a certain amount of air to be exhausted without ever passing through the fan, and this increases the efficiency of the

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* *Trans. Fed. Inst.*, vol. x., page 591.

machine, a larger amount of air being set in motion with, of course, a corresponding diminution of the depression produced by the fan. It is found that in the extreme position of the shutter the total amount of air exhausted is 1⅓ of the normal, and in a half position the amount is 1¼ of the normal volume.

The first fan of this type in Germany has been erected at the Monopol pit, near Camen, and a series of experiments have been tried with it by the author of the paper. The fan is 81·7 inches in diameter and 63 inches wide. The following table shows the results obtained:—

No. of Experiment.	Volume of Air per Minute. Cubic Feet.	Velocity of Periphery per Second. Feet.	Effective Depression. Inches.	Theoretical* Maximum Depression. Inches.	Coefficient of Manometric Efficiency.
1	70,620	68	1·98	2·01	0·984
2	86,880	96	3·78	4·02	0·930
3	96,050	120	5·70	6·31	0·906
4	103,100	124	6·15	6·76	0·909

The next table shows the effect of varying the position of the multiplying shutter, that is to say of working with varying widths of interspace between the shutter and the periphery of the fan:—

No. of Experiment.	Number of Revolutions of Fan.	Width of Space between Shutter and Fan. Inches.	Quantity of Air per Minute per Indicated Horse-power. Cubic Feet.	Increase. Per Cent.
1	25	2	1006·5	—
2	25	7	1282·0	—
3	25	13	1412·6	39·8
4	36	2	706·3 (?)	—
5	36	7	706·3	—
6	36	13	900·6	27·5
7	46	2	445·0	—
8	46	7	540·3	—
9	46	13	688·7	54·0

The increase in the quantity of air for the same horse-power is seen to be from ⅓ to ½, with a fully-opened multiplying shutter, more than when the latter is nearly closed.

H. L.

CALCULATING THE DIMENSIONS OF A SINGLE-INLET GUIBAL FAN.

Calcul des Dimensions d'un Ventilateur Guibal à une Ouïe. By ÉMILE GOSSERIES. *Publications de la Société des Ingénieurs du Hainaut,* 1896, *vol. v., page* 129.

For determining the dimensions of a fan a knowledge of the mine-temperament alone is not sufficient, as it is also necessary to take into consideration the depression and the volume of air to be delivered. From the depression will be deduced the speed of the fan according to its diameter. A knowledge of the volume of air will permit of determining the diameter of the inlet, and consequently that of the fan. Taking 49 feet (15 metres) per second as a suitable speed of the air in the central inlet, the diameter of the latter will be determined by the volume; and, adopting Prof. Guibal's expression of D ÷ d = 3 for the ratio

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* Calculated by the formula $H = \frac{u^2}{g} \frac{d_a}{d_w} 12$.

between the outside diameter and that of the inlet, gives the outside diameter. Under these conditions, if Q be the volume of air to be delivered, we shall obtain

$$0{\cdot}785\, d^2 \times 15 = \mathrm{Q},$$

whence

$$d = 0{\cdot}3 \sqrt{\mathrm{Q}} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

$$\mathrm{D} = 3d = 0{\cdot}9 \sqrt{\mathrm{Q}} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

and

$$\mathrm{Q} = 1{\cdot}25\mathrm{D}^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (3)$$

If v represent the tip speed of the vanes, and s the theoretical sectional area of the air-outlet under the sliding shutter, the expression $\mathrm{Q} = v\, s$ may be stated; but in practice, according to Prof. Guibal, this sectional area should be doubled, so that $s = \mathrm{S} + 2$, whence

$$\mathrm{Q} = 2 + v\,\mathrm{S} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4)$$

If h be the actual water-gauge, K the manometrical coefficient, 0·65, and δ the density of the air, 1·2, according to Mr. Murgue,

$$h = \mathrm{K}\, \delta\, v^2 \div g = 0{\cdot}08\, v^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (5)$$

whence

$$v = \sqrt{\frac{g\, h}{\mathrm{K}\, \delta}} = \sqrt{12{\cdot}57 \times h} = 3{\cdot}55 \sqrt{h} \quad . \; . \; . \; . \; . \; . \quad (6)$$

On the other hand, in order that the contraction-coefficient of the passage of the air expelled under the sliding-shutter be maximum, the section of the outlet must approach a square form; *i.e.*, the width, L, of the fan must be equal to the height of the section of the passage under the sliding shutter, *i.e.*, $\mathrm{S} = \mathrm{L}^2$. Substituting for v and S their values in equation (4) gives $\mathrm{Q} = \sqrt{12{\cdot}57 h} \times \mathrm{L}^2 \div 2$, whence $\mathrm{L} = 0{\cdot}752 \sqrt{\mathrm{Q}} + \sqrt{h}$. As, however, the air is not always uniformly distributed between the vanes, it is advisable to adopt a rather larger coefficient, giving

$$\mathrm{L} = 0{\cdot}8 \sqrt{\frac{\mathrm{Q}}{\sqrt{h}}} = 0{\cdot}8 \sqrt{\theta}. \quad . \; . \; . \; . \; . \; . \; . \; . \quad (7)$$

To ascertain the number of revolutions for a water-gauge h, it may be deduced from formula (5), N being the number of revolutions per minute, that $v = (\pi\, \mathrm{DN}) + 60$ and $v^2 = (\pi^2\, \mathrm{D}^2\mathrm{N}^2) \div 60^2$, which by substitution becomes

$$h = \frac{\mathrm{K}\delta}{g} \times \frac{(\pi^2\mathrm{D}^2\mathrm{N}^2)}{60^2} = 0{\cdot}000218\, \mathrm{D}^2\mathrm{N}^2,$$

and

$$\mathrm{ND} = 68 \sqrt{h}. \quad . \; . \; . \; . \; . \; . \; . \; . \quad (8)$$

For avoiding shock, the vanes should be bent backwards as regards the direction of rotation, so as to make with the radius an angle a given by the formula $\tan a\, \mathrm{V} = u\, r$, whence $\tan a = (u\, r) \div \mathrm{V}$, if u be the angular speed, r the inlet-radius, and V the speed of the air coming upon the vanes. From $v = u\,\mathrm{R} = u\, 3r$ may be obtained $u\, r = v \div 3$; but $v = 3{\cdot}55 \sqrt{h}$ (6), whence $u\, r = 3{\cdot}55 \sqrt{h} \div 3 = 1{\cdot}183 \sqrt{h}$, and $\mathrm{V} = \mathrm{Q} \div (\pi d \times \mathrm{L})$. Substituting in this formula for d and L their values in equations (1) and (7) we get

$$\mathrm{V} = \mathrm{Q} \div \left(\pi \times 0{\cdot}30 \sqrt{\mathrm{Q}} \times 0{\cdot}80 \sqrt{\frac{\mathrm{Q}}{\sqrt{h}}}\right) = 0{\cdot}75 \sqrt[4]{h}. \quad . \; . \quad (9)$$

Introducing into the expression $\tan a = (u\, r) + \mathrm{V}$ the values (A) and (g) we get

$$\tan a = (1{\cdot}183 \sqrt{h}) + 0{\cdot}75 \sqrt[4]{h} = 1{\cdot}577 \sqrt[4]{h}. \quad . \; . \; . \quad (10)$$

Thus, for a water-gauge of 4¾ inches (120 millimetres) the root of the vane will make an angle of 79 degrees 10 minutes with the radius, and then rise to join the outer circumference in a radial direction.

J. W. P.

WATER INUNDATION AT THE WURM COAL-FIELD, AND UNDERGROUND PUMPING ENGINES.

Le Coup d'eau du 14 *Avril*, 1896, *dans le Bassin de la Wurm.* *By* FRANZ BÜTTGENBACH. *Revue Universelle des Mines*, 1896, *vol. xxxiv., page* 96.

It appears from the archives of the Rolduc abbey, near Aix-la-Chapelle, that coal was worked in the district so early as 1113, and working has continued without interruption from that time to the present, nearly 3,000 men being now engaged in the Wurm coal-field. The first workings were situated about 200 feet (60 metres) above the level of the valley, the water flowing off by outfall-adits. About 1634, shafts were sunk below the level of the valley, the water being raised by pumps driven by water-wheels; and old documents show that, about 1724, a depth of 820 feet (250 metres)—620 feet (190 metres) below the valley—was reached. It was not until 1816 that the first steam-engines were erected, and now the depth from the surface of 1,410 feet (430 metres) is attained. In a district where working has been continued for so long a period it is to be expected that large bodies of water will be encountered, which, on being tapped unexpectedly, may flood the workings; and such accidents have occurred at various periods, more than sixty miners having thus lost their lives in 1834. This gave rise to a regulation enjoining that, when nearing old workings, advance bore-holes should be drilled, into which, after the water was reached, iron pipes fitted with cocks and pressure-gauges should be inserted for drawing off the water gradually.

During the night of April 13-14, 1896, in a rise 150 feet (45 metres) long put up from the main rolleyway at the level of 886 feet (270 metres), in the Langenberg colliery, the rock surrounding a pipe (the pressure-gauge of which showed 210 lbs. per square inch or 14 atmospheres) for drawing off the water from old workings at the level of 656 feet (200 metres) gave way, and the water burst into the mine, filling the rolleyway with *débris* of all kinds. As, however, this road was in communication with the Gouley shaft, sunk to the depth of 1,410 feet (430 metres), the water found an outlet in the workings connected therewith, 525 feet (160 metres) below those of Langenberg. The twelve men engaged in repairs at the Gouley colliery were able to escape before the complete submersion took place; and in the Langenberg mine, where the inburst occurred, there were only four men engaged in a blind drift put off from the main rolleyway. As this drift had a slight rise, the water did not reach the face where the men were at work, only attaining a height of 5 feet (1·5 metres) in the main road, which, however, was so much filled up by *débris* at the entrance of the drift that the men were shut in, being afterwards rescued.

A week after the inburst, the Langenberg mine and also those of Ath and Laurweg, at the same level, were completely freed from water, while Gouley, one of the principal collieries of the district, remained flooded over the whole height of the main rolleyway. Inasmuch as its two underground pumping-engines were drowned, and there was no pumping-engine on the surface in reserve, it became necessary to draw in buckets the water, estimated at more than 33,000,000 gallons (150,000 cubic metres). The underground pumping-engines at Langenberg were also submerged to half the height of the cylinders, but continued to work, thanks to the enginemen, who stuck to them though the water came up to their waists, and also owing to the fact of the water flowing into the Gouley pit. If it were not for this circumstance, the Langenberg mine would certainly have been flooded in half an hour, and the men drowned, had the inburst happened during the day; and this accident, which might have proved so fatal and certainly involved great expense, suggests the reflexion that it is not well to rely entirely on underground pumping-engines, but also to have others in reserve on the surface. J. W. P.

UMBALLA CITY WATER-WORKS.

By C. E. GOUMENT. *Indian Engineering*, 1896, *vol. xix., page* 76, *and* 1 *plate.*

The water-supply is taken from twenty wells, 7 feet in internal diameter and 40 feet deep, pitched 60 feet apart from centre to centre. This spacing was arrived at by experiments previously made to determine the cone of exhaustion around the wells for the maximum head to which they are worked, viz., 7 feet. The wells are situated in a tract of sandy waste land, about 8 miles from Umballa, and between the Tangri river and one of its main branches. There are no ponds or other sources of pollution within a considerable distance of the site, and the nearest village is more than half a mile away. As an additional precaution against contamination, an area of 2,000 feet by 1,000 feet has been fenced around the wells.

The water-level is 6 feet below ground at the wells, and falls considerably towards Umballa, where it is about 30 feet below ground. The ground also falls from the wells to the city. Advantage has been taken of this slope, in the dual system designed by the writer, to obtain a part of the supply by gravitation. The full supply could have been procured in this way, but the velocity in the main being low, owing to the flatness of the hydraulic gradient, the pipes would in time have become choked with sediment. It was therefore necessary to resort to pumping to obtain the necessary scour for keeping the pipes clear. The velocity required for this purpose is 3 feet per second, and the engine is designed to pump the water through the main at this velocity. It may be noted that the provision of pumps at the well allows of a reduction in the size of the supply-main, and the saving effected in this way is considerable.

The wells are connected by cast-iron pipes (9 inches in diameter) laid 4 feet below spring-level in a line parallel to the wells and about 10 feet from their centres. A T-branch (4 inches in diameter) makes the connexion between this line of pipes and each well. A sluice-valve is fixed on each branch, enabling any one well to be cut off for examination or repairs without interrupting the supply from the others.

The pumps are placed exactly opposite the centre of the line of wells, and the suction-pipe of the pumps joins the connecting-pipe at this point. A valve placed on each side of this connexion allows of half the wells and connecting-pipes being cut off for repairs while the other half remain in use.

The gravitation-main, 8 inches in diameter, takes off from the connecting-pipe near the pumping-station, and is laid below spring-level for a distance of 3,400 feet from the wells, where it emerges above water-level and joins the pumping-main. From this point onwards to Umballa there is a single line of pipes (8 inches in diameter) which acts as a force-main when the pumps are working, and as a gravitation-main when they are at rest.

The daily supply is about 240,000 gallons; of this about 96,000 gallons per day are obtained by gravitation and the balance is pumped.

The pumping-engines at the well are each of 30 horse-power; two have been provided, each capable of doing the whole work, so that one may always be available while the other is under repair.

The water is delivered at Umballa into an elevated reservoir which holds 220,000 gallons, or one day's supply. The tank was designed by the author on the lines of the Norton tower on the Vyrnwy aqueduct, Liverpool waterworks, and may be described as a huge steel bowl with a deep cylindrical rim resting on a circular tower of brickwork at a height of 26 feet from the ground. The bottom is spherical, of mild steel plates (½ inch in thickness). The tank is 58 feet in diameter, and the depth of water in the middle is 19 feet; it is covered by a corrugated iron roof on double boarding, and enclosed all round by folding shutters to keep the water cool in summer. The advantages of the design are: (a) the accessibility of all its parts for periodical painting or repairs; (b) its elasticity, which gives it perfect freedom for expansion and contraction for variations of temperature; and (c) it also compares very favourably in point of cost with other designs for elevated tanks. M. W. B.

COMPOUND WINDING-ENGINES IN IDRIA.

Ueber die bisherige Anwendung von Compound-Förderdampfmaschinen im Allgemeinen und über die mit diesem Maschinen-system in Idria erzielten Betriebsresultate. By C. Habermann. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1896, *vol. xliv., pages* 261 *and* 279, *and plate.*

The reason why compound winding-engines have not met with a more extended employment in mining industry is chiefly to be sought in the circumstance that at collieries the economizing of fuel is not a matter of consideration, there being always a plentiful supply of unsalable fuel. Furthermore, simplicity of construction is preferred, as entailing less outlay for repairs and less trouble to the engineman. In the case, however, of metalliferous mines situated at a distance from available supplies of coal, and also in the case of collieries where improved methods of manipulation leave but little waste coal, the advantages presented by compound engines become more decidedly apparent, and it was for the former reason that a compound winding-engine was installed at the Inzagi shaft in Idria in 1890, and a second similar engine at the Josefi shaft at the end of 1892. At the former shaft, the engine is not set up at the pit-mouth, but lower down the hill side, the floor of the engine-house being 150 feet below the level of the shaft-bank; and the distance from the centre of the pit-mouth to the axle of the winding-drum is 306 feet. The winding-rope is passed over an intermediate wheel to clear the roadway passing along the upper side of the engine-house.

The engine itself is a horizontal non-condensing compound engine, differing little from the ordinary type. The cranks are set at an angle of 90 degrees, and the receiver lies under and parallel to the slide-valve of the large cylinder below the level of the floor. Both the receiver and the cylinders (jacketed) are heated by direct steam, the retention of heat being secured by wood lagging. Gooch link-motion and Rider expansion-gear, with hand lever, are provided, and steam may be admitted direct into the low-pressure cylinder by a special valve. The large cylinder is fitted with Mather and Platt soft cast-iron rings and steel springs, and the expansion-eccentrics are situated next the crank-bearings so that the slides approach closely to the cylinder. The flywheel is 98 inches in diameter and serves as a brake, the cheeks of the brake being made to engage on the wheel by means of hand-and-foot levers, and another brake is fixed on the driving-wheel, which is 118 inches in diameter. Motion is imparted from the engine to the winding drum by bevel gearing. Amongst the safety-appliances are an indicator to show the position of the cage in the shaft, an automatic signal to announce the arrival of the cage at a certain height, and also electrical signalling-apparatus and speaking-tube communication with the loading-stage.

The mean efficiency of the engine is 40 horse-power, and the indicated horse-power 50, at 7 atmospheres pressure. The total load is some 53 cwts., and each cylinder is capable of lifting that weight, independently of the other.

It having been found from the indicator-diagrams that the relative dimensions of the cylinders were not economical, the net load having been reduced from 1 ton down to 12 cwt., the diameter of the high-pressure cylinder was reduced from 14¼ inches (360 millimetres) to 11¾ inches (300 millimetres), bringing the relative diameter of the high and low-pressure cylinders down to 1 : 2·82 instead of 1 : 1·93 as previously. Thus altered, the winding-engine works satisfactorily and is easy to manage.

A double range of boilers, only one set being in use at a time, is employed for the generation of steam. Each battery consists of two upper-boilers 23 feet long and 3¼ feet in diameter, and four under-boilers 16½ feet long by 2¼ feet in diameter; the feed-water is run into the lower set and the upper set receiving the first heat from the fires. The boilers have a total heating-surface of 753 square feet.

Beechwood fuel is used, owing to the scarcity of coal. From comparative experiments of the amount of fuel and steam required to produce 1 horse-power per hour with the compound-engine and the ordinary engines already in use on the same property, it appeared that before the alteration of the compound engines the consumption of steam averaged 73·87 lbs. (33·58 kilogrammes), and afterwards 64·15 lbs. (29·16 kilogrammes), the one simple engine using 78·25 lbs. (35·57 kilogrammes), and the other, of older construction, 113·14 lbs. (51·43 kilogrammes) per horse-power per hour. The last named was worked at 4·4 atmospheres pressure, and the other one at 5·5 atmospheres, the result showing the advantage obtained by using the higher working-pressure.

These isolated experiments do not, however, afford so reliable a practical guide as the average results obtained from the continuous working of the engines for a year. These show that the one compound engine consumed in 1893 123·15 lbs. (56·16 kilogrammes) of steam per horse-power per hour, the quantity sinking in 1894, after the reconstruction, to 110 lbs. (50·02 kilogrammes). The second compound engine consumed in the same periods 128·2 and 110·8 lbs. (58 27 and 50·37 kilogrammes) respectively, whereas the average consumption of the two older non-compound engines was 122 lbs. (55·45 kilogrammes) and 151 lbs (68·62 kilogrammes). The differences noticeable between these results and those of the first series of tests are attributable to the cooling of the cylinders, etc., during the time when the engines were not working.

The author's conclusions, derived from further comparative data of the consumption of steam in ordinary winding-engines, are to the effect that compound engines offer an economical advantage only when the load has to be raised from moderate depths and the work is fairly continuous, as is the case in coal-mines. On the other hand, when the depth of the shaft is considerable, the variation in the moment of the load when the weight of the rope is not compensated, and the interruptions due to making up the load in small quantities at various levels, militate against the employment of the compound engine, the ordinary type being better able to cope with these conditions. C. S.

NEW WINDING ARRANGEMENT.

Nouveau dispositif d'Extraction pour les Puits de Mines. *By* A. Desprès.
Le Génie Civil, 1896, *vol. xxix., pages* 9-10.

The proposed system consists of a chain counter-balance suspended in a vacant part of the winding-shaft, or in a neighbouring ventilating-shaft, and fastened on to an endless-rope which passes over the same pulley as the two winding-ropes. It is claimed that a strictly constant moment is thereby ensured with regular strain, and that the load can be raised from a depth four times as great as the length of the chain. The counter-balance acts directly on the periphery of the winding-drum, the chain-rope weighs less than either of the cage-ropes, and less power is required with the cylindrical drum than with conical drums of the same minimum diameter.

The arrangement of the ropes on the drum is such that one cage-rope and one part of the endless-rope unwind side by side, giving place to the other cage-rope and the other part of the endless-rope which are simultaneously being wound on the drum. The endless-rope is of a total length equal to half the depth of the pit and the working-length is one-fourth of that depth. One end of the chain is attached to the rope and the other hangs down in the pit so as to leave about 25 or 30 feet loose when the first-named end has reached its normal limit of level, thus allowing a play of twice the above distance.

When the depth of the pit is increased, it is sufficient to lengthen the chain and alter its point of suspension in the shaft. To provide for this contingency the winding-drum should be large enough to allow of an extra number of turns of rope being taken up. C. S.

WINDING-GEAR AT WESTPHALIAN COLLIERIES.

Notes d'un Voyage dans le Bassin Houiller de Westphalie. By — ROBIAUD. *Bulletin de la Société de l'Industrie Minérale*, 1896, *vol. x.*, *page* 241.

At pit No. 1 of the Monopol colliery, the flat balance-rope, weighing 17 lbs. per yard (8·5 kilogrammes per metre) is worked by two supplementary steel-wire ropes, winding on the drum, 13 feet (4 metres) wide and 26 feet (8 metres) in diameter in the coils of the winding-ropes, without which arrangement the drum must have had an excessive width. At No. 2 pit, however, the small round ropes do not pass round the drums; but each is connected at one end with the cage and at the other with the balance-rope, this system of compensation permitting the use of lighter winding-ropes, since the cage is partially supported by the balance-rope, though the saving thus effected is set off by the cost of the two supplementary ropes.

Compound engines, which effect great saving in coal, are coming more and more into use, those at the Consolidation and Monopol collieries working with great regularity. The compound system has the advantages of (1) permitting the utilization of steam at considerable pressure with a high degree of expansion, without complicated mechanism; (2) diminishing the loss by radiation, as the lowering of temperature in each cylinder is less; and (3) diminishing the variation of strain to which the piston-rods, connecting-rods, and crank-pins are subjected.

Round ropes, with cylindrical and spiraloid drums or Koepe pulleys are used almost exclusively. The Koepe system, with simple working parts, is economical for moderate depths of winding; but the slightest irregularity in the shaft may cause breakage of the balance-rope and consequent stoppage, while it is necessary that the rope be always drawn taut by the cages. At Consolidation No. 2 pit, each cage holds six tubs, of which four are drawn off simultaneously at the two floors of the landing; and for drawing off the two other tubs the cage must be raised a little, which is only possible when the other cage acts as a counter-weight. Moreover, the winding rope can be lubricated but imperfectly, so as not to diminish its adhesion on the wooden-rim of the Koepe pulley.

Cylindrical drums, with balance-rope underneath the cages, require too powerful winding-engines, if the necessity has to be provided of winding without the balance-rope. They are far from giving equality of moments, and in most cases the so-called balance-rope only serves to prevent the occurrence of negative moments. As in the Koepe system, the distance apart of the pulley-spindles in the head-gear should be sufficiently great to permit of the balance-rope folding easily under the cages or not fouling the winding-rope.

The cost of a winding-engine, with spiraloid drums, is rather high, owing to their enormous weight; and its distance from the shaft should be considerable so as to give a better lead to the rope. The ropes should always be perfectly regulated for the avoidance of sagging, which might throw them out of the grooves, and this regulation is effected by taking out the six or eight bolts which attach the drums to their bosses keyed on the shaft. After this tedious operation, it is often necessary to complete the regulation by clamps or stretchers between the rope-splice and the cage, thus introducing complications unfavourable to safety.

The method of compensation used at Monopol No. 2 pit (cylindrical drums with balance-rope) affords an interesting solution of the problem. The balancing is sufficiently accurate for the depth of 1,640 feet (500 metres) but less satisfactory at 2,624 feet (800 metres), if the necessity should arise for working the cages without balance-rope. This method entails extra expense for guiding in the shaft, and the five ropes moving therein greatly increase the chance of accident or stoppage, while rendering inspection of the winding-gear more difficult. The maintenance of the balance-rope and supplementary ropes requires a dry sump.

The conclusion arrived at is that each of these methods has its advantages and disadvantages. The use of round ropes is economical on account of the excellent quality and low price at which steel wire may be purchased; but, so long as Manila fibre is cheaper than steel wire, the use of winding-pulleys with flat Manila ropes is to be recommended for moderate depths. J. W. P.

COUNTER FOR WINDING-ENGINES.

Der Aufhubzähler für Fördermaschinen. By V. Mayer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii., page* 651, *and plate.*

The methods used in many mines for counting how many times the cages are brought to bank are very primitive, and being mostly manipulated by workmen aboveground, it may be doubted whether the counting is always correct. There are various apparatus for registering the number of windings automatically, but none are satisfactory, all requiring too much personal attention. The author describes an instrument invented by him which, in his opinion, combines simplicity and ease in working, registers automatically and accurately the number of times the cages are wound up in a double shaft, and requires no adjustment by hand. To procure this result, the action of the winding-engine is indicated in such a way that one cage has reached the pit's mouth, and the other is nearly at the top, before their positions are registered. Once fixed on the engine, this apparatus always indicates, from whatever level in the pit the cages are wound. It has been working successfully for three years at the mines at Přibram, in Bohemia.

The instrument consists of a small prolongation, fixed centrally on the shaft of the winding-engine, rotating at the same speed as the shaft working the cages. A projection attached to it terminates in a helical wheel, which drives in opposite directions two vertical screws by means of worm-wheels set at right angles to the motor-shaft. Two nuts, resting against a central scale, work up and down two screws, and represent in miniature the two cages in the shaft. Each nut carries a projection, and every time they pass a pawl in the middle of the scale connected to a counter the pawl pushes the counter round a quarter of a revolution; the pawl is so adjusted that not until both cages have reached the bank is a complete number marked on the dial-face. As the two cages must have reached the pit-mouth before the counter moves on, the engineman cannot make the counter work by winding the empty cages up and down the shaft. Of course, the windings are thus counted in sets of two, and the number entered in the book must be doubled.

To make the apparatus work automatically, it must be easily and quickly thrown in or out of gear, and allowance made for winding up the coal from different levels. The instrument is coupled by turning a screw which adjusts the lower projection to the helical wheel in any given position. Sometimes the position of one cage in the shaft is altered, while the other is stationary at the pit's mouth. To avoid altering by hand the position of the corresponding nut, it is adjusted on the screw to a height agreeing with the highest level in the mine from which coal is wound. When it reaches the pawl it indicates this height, when it exceeds it, it marks the position of a cage wound from the lowest level. It is adjusted by bringing the nuts into positions on the screws corresponding to the cages in the shaft, the left-hand nut representing the left-hand cage, and so on. The screws and pawl are protected by glass, and the apparatus, once fixed, is permanently adjusted, and needs no further attention. It is made in one size, and indicates for drums from 6½ to 26 feet in diameter, and shafts from 1,370 feet to 5,200 feet in depth. However high the cage may be lifted in the pulley-frame, the indicator is not thrown out of gear. It is said to work well and easily, and to require little lubrication. Drawings of the apparatus are given in the original paper. B. D.

WILMOTTE CAGE-KEEPS OR PROPS.

Note sur les Taquets Wilmotte. By Louis Eloy. *Revue Universelle des Mines*, 1896, *vol. xxxiii.*, *page* 70, *and illustrations.*

Cage-keeps may be divided into two classes, lifting and lowering. The former are so named because the cage has to be lifted to allow of the keeps being withdrawn and the cage being lowered. Lowering keeps are so constructed as to be capable of being withdrawn from under the load. The second system is preferable, inasmuch as it implies an economy of time and of steam, and is less heavy on the engine because it avoids the necessity of lifting the cage and the consequent rapid reversal of the engine. With equal conditions of safety these keeps are therefore to be preferred; the ropes must, however, be always kept under strain. It is, moreover, difficult to design an arrangement sufficiently substantial to admit of keeps being withdrawn under a 10 tons load. For example, the Stauss keeps, which are worked by a combination of jointed rods, are liable to rapid wear of the joints.

The Wilmotte keeps appear to unite the following conditions necessary to successful work, as laid down by the inventor:—(1) Keeps should be simple, capable of being easily and accurately worked without tiring the workman, and readily taken out and replaced for repairs when necessary without interfering with continuous winding; (2) In normal working, keeps at intermediate stations must always be placed clear of the cages; (3) When a cage is landed at any stage, the workman should merely have to bring the keeps under the cage; when the latter starts away the keeps should drop back into their places automatically and without counterpoises; (4) The keeps must be strongly made, able to resist shocks and not readily worn away, with few joints or parts liable to be bent out of shape.

These conditions have been realized by the keeps designed by Mr. Wilmotte of Seraing. The best form applied at the Artistes Ichorré pit consists of two pairs of obtuse-triangular shaped steel castings; the lower part of these is curved, and works on a curved seat in the frame that carries them: the two other angles of the triangle end in horizontal surfaces, upon one of which the cage bears when it is on the keeps, whilst the other bears against a portion of the seat-frame when the other face is horizontal. The respective pairs of keeps are keyed on shafts connected by rods, which can be turned by cranks and levers; there is no strain on these shafts. When the lever-handle is thrown over the keeps are brought under the cage and kept there by the weight of the cage; as soon as the latter leaves them, they drop backwards by their own weight into their recesses and clear the cage; a tooth on the lower part of the curved surface works in a corresponding socket and prevents the keeps from having too much play or from getting out of their place.

Mr. Wilmotte has also modified his system so as to enable the keeps to work by lowering. The bearing-surface between the cage and the keep then becomes an inclined cycloidal curve, instead of a horizontal surface of contact. In order to resist the couple formed by the weight of the cage, the inventor, in the arrangement that is about to be introduced at the Espérance et Bonne Fortune pit at Montegnée, lets his keeps run level on their shafts; on these latter are keyed four cams, corresponding to each keep, of such a shape that when the cage is on the keep these cams receive the thrust of the keep and transmit it to the seat-castings; when the cams are turned this bearing-surface is gradually diminished, and at the same time the shaft carrying the keeps is proportionately lowered backwards; the keeps gradually drop below the cage, and when the bearing-surface of the cam has cleared the seat, the weight of the keep pulls it down clear of the cage.

H. L. AND J. W. P.

BREAKAGE OF WINDING-ROPES.

Der Seilbruch auf der Zeche Hansa bei Huckarde. By K. HABERMANN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1896, *vol. xliv., pages* 635-637, *and Gluckaüf*, 1896, *vol. xxxii., page* 693.

One of the winding-ropes in the Hansa pit, 2,172 feet deep, near Huckarde, parted suddenly above the surface, while the loaded cage was ascending, on June 30th, 1893, and, flying back towards the engine-house, damaged some crane T-brackets. It killed the engineman, who had reversed the steam, but was unable to stop the engine, owing to the speed attained by the second cage in its descent after the loss of the counterpoise, so that the second winding rope was broken off the drum when run out, and fell with the cage to the bottom of the shaft.

An examination into the cause of the accident showed that the rim of the winding-pulley, 16 feet in diameter, was broken on the inside, having become worn from an initial thickness of over 1 inch down to between ⅛ and ⅜ inch, probably by side-friction of the rope, owing to the imperfect relative arrangement of the drum and pulley. In consequence of the breakage, the rope must have fallen on to the axle of the pulley, and the great increase of tension due, on the one hand, to the high rate of winding speed (about 33 feet per second), and, on the other, to the descent of the cage, proved too much for the strength of the wire, though the rope was 2 inches in diameter, constructed of hard crucible cast-steel, capable of bearing a strain of 100 tons per square inch, and had not been in use quite twelve months.

Safety-catches were in use, and appeared to have come into action several times during the fall of the cages, as shown by marks on the wooden guides, but they failed to hold either of the cages.

The circumstances of this case confirm the opinion that steel wire of this class is very susceptible to shocks. With a view to the prevention of similar accidents it is advisable to occasionally test the thickness of the walls of the pulley-groove.

J. W. P. AND C. S.

ZINC-ORE DEPOSITS OF ISERLOHN, WESTPHALIA.

Das Zinkerzvorkommen von Iserlohn. By L. HOFFMANN. *Zeitschrift für Praktische Geologie*, 1896, *pages* 45-53, *and five figures.*

In the neighbourhood of Iserlohn, in Westphalia, there are a number of deposits of zinc ores. The formation, of Middle Devonian age, consists of beds of slate and schists (Lenne Slates) overlaid by limestone, in places passing into dolomite, with occasionally belts of loam (Elberfeld Limestone). The ore-deposits, which are known over a length of some 7½ miles, occur in this limestone either near the plane of junction with the slates or directly in contact with them. They are massive deposits, usually of a semicircular or triangular cross-section, the diameter of the semicircle or the base of the triangle being formed either by slates or by the bedding-planes of the limestone, so that this side (the foot-wall side) is generally defined very sharply. On the hanging-wall side and in the direction of their strike, approximately east-and-west, their boundaries are mostly irregular, and at times indistinct. All these deposits extend to only moderate depths, the deepest having been worked down to 670 feet (205 metres). The ores are chiefly calamine, silicate of zinc, zinc blende, and iron pyrites ; there are also smaller proportions of galena and brown hæmatite, and very rarely cerusite and pyromorphite. The accompanying minerals are calcspar and quartz.

There are only four of these deposits being worked at present, their characteristics being very similar. As regards the formation of these ores, the author considers the oxidized ores to be secondary minerals, as these occur in the upper portions of the deposits and on the hanging-wall, whilst the sulphuretted ores are found in depth and on the foot-wall side, and only occur on the hanging-wall when this is formed by a protecting layer of loam. Hence it may be assumed that the oxidized ores were formed from the sulphides by the action of atmospheric agencies. The zinc blende was oxidized to sulphate of zinc, which formed calamine by the action of carbonic acid, or by double decomposition with the carbonate of lime of the limestone. Silicate of zinc was produced by the action of soluble silica or alkaline silicates, although it is possible that the smithsonite was a primary mineral constituent. The brown hæmatite was formed by the oxidation of pyrites. The sulphide ores were evidently deposited from aqueous solution, as shown by their structure, but they were not deposited in pre-existing cavities, but in consequence of replacement of the limestone by the ores. It is probable that these ores were formed by the action of hydrogen sulphide upon solutions of bi-carbonates of the metals.

It would seem that these mines are within a brief period of complete exhaustion, and that there is but little hope of finding fresh deposits, as the whole zone of contact between the slate and the limestone has been carefully explored. They are all worked by the Märkisch-Westfälischer Bergwerksverein, and the ores smelted at Letmathe, where 6,302 tons of zinc and zinc dust were produced in 1894 in which year the mines employed 350 men underground and on the dressing-floors, and produced 7,240 tons of calamine, 4,482 tons of zinc blende, and 64 tons of pyrites.

It is noteworthy that serious settlement of the ground has occurred over some of these mines, which has led to a series of disputes between the mining company and the town of Iserlohn H. L.

THE REACTIONS OCCURRING IN THE METALLURGICAL TREATMENT OF BLENDE.

By E. Prost. *Bulletin de l'Association Belge des Chimistes*, 1896, *vol. x.*, *pages* 212 *and* 246.

In roasting blende, the amount of sulphur left unoxidized is influenced by the quantity of calcic and magnesic carbonates in relation to lead sulphide, silica also affecting the results by facilitating the decomposition of the latter compound. In the course of the operation the sulphides of zinc and iron become converted into the corresponding oxides; lead sulphide into sulphate or silicate.

From the examination of the cold-water extract of a number of samples of roasted blende, the author found that of the 57·8 per cent. of zinc in the original blende only 0·2 per cent. remained as sulphate; on the other hand, 5·02 out of a total of 5·60 per cent. of lead was in combination with sulphuric acid.

The amount of iron oxide present influenced the proportion of zinc extractible by means of ammonium tartrate, owing to the formation of a double oxide of zinc and iron ($ZnFe_2O_4$) in roasting. For example, with a blende containing 15·2 per cent. of iron and 45·29 per cent. of zinc, only 63·64 per cent. of the total zinc was extracted by ammonium tartrate, whilst when the iron only attained 1½ per cent. to 62·86 per cent. of zinc, 95·42 per cent. of the latter was recovered by this reagent.

The state of combination of the 2½ to 3 per cent. of zinc usually found in the residue after distillation on a practical scale was also examined, with the result that fully one-half consisted of unaltered sulphide. In some instances, zinc oxide preponderated, but this was most likely due to variations in the constitution of the crude mineral, the condition of the mixture, the furnace heat employed, and other like considerations.

Three sets of experiments were conducted for examining the reductive influence of carbon on the zinc in the roasted blende.

A. *On Zinc in the Condition of a Simple or Compound Oxide.*—Here it was found that the zinc present as simple oxide volatilized completely at a temperature approaching 1,075° Cent., and even when combined with oxides of iron, alumina, or lead, volatilization occurred at 1,075°, 1,250°, and between 1,200° and 1,250° Cent. respectively, the inference being that these oxides did not retard the reduction of the zinc.

B. *On Zinc Oxide in Presence of Compounds of Sulphur.*—Chemically pure specular blende was used in this series of experiments; the temperature employed —1,200° to 1,250° Cent.—was previously ascertained to be the most convenient for permitting the detection of any zinc sulphide formed during the reaction.

It appeared that the action of iron in disengaging zinc from its sulphur compounds was regulated by the zinc-iron ratio in the mixture and by the temperature of the operation. To ensure success a larger amount of iron than is theoretically necessary to combine with the sulphur should be present. The influence of temperature was shown by the fact that with an excess of 190 per cent. of iron the zinc was all driven off at between 1,200° and 1,250° Cent., whilst at 1,075° Cent. a considerable proportion remained unliberated. Lime acted more powerfully in the same direction, since all the zinc was volatilized at 1,250° Cent., when the excess of lime amounted to only 75 per cent. more than the theoretical weight required. By increasing the amount of lime, the zinc may all be disengaged at about the fusing-point of gold. Sulphate of lime did not seem to prevent the reduction of the zinc oxide, even when iron and lead—either of which might be supposed to favour the decomposition of the reduced gypsum by the silica in the mixture and the combination of the liberated sulphur with zinc—were present, and although such a reaction would presumably be facilitated by the higher working-temperature of the zinc-furnace, it appeared from experiments made at 1,450° Cent. that the increased activity of the carbon neutralized this tendency. Sulphate of magnesia, however, was decomposed into magnesia and sulphurous acid (SO_2) by the action of carbon at high temperatures, and thereby assisted in the formation of zinc sulphide; but this mattered little because the percentage of this magnesium compound was very small in blende. On the other hand, the presence of lead sulphate—which was decomposed by red-hot carbon—favoured the production of zinc sulphide to a considerable extent.

The iron in the coal employed in the reducing-furnaces was chiefly in the state of pyrites, and had no influence on the zinc, but the lime assisted reduction as stated above.

C. *On Compounds of Zinc with Silica.*—The results obtained by roasting zinc oxide, lead oxide, and silica, at 1,000° Cent., and then reducing the mass with carbon at 1,200° to 1,250° Cent., pointed to the formation of a double silicate of zinc, which could not be reduced. However, at practical working-heat all the zinc was volatilized. The temperature at which the zinc silicate was formed influenced the reducibility at a given temperature; for instance, with a roasting heat of 1,450° to 1,500° Cent., the whole of the zinc was reduced in the working-furnace, and to within about 1 per cent. at between 1,200° and 1,250° Cent., whereas when the roasting heat was 1,550° Cent. a larger proportion was left unreduced at 1,200° to 1,250° Cent., although the whole was volatile at 1,500° Cent.

From the researches, the author concluded that in practical work no compounds were formed in the course of the reduction that were not broken up again at the temperatures (1,450°. to 1,500° Cent.) employed. He also considered that it would be feasible to minimize the present loss of 4 to 5 per cent. of zinc in the lead-residues by mixing lime with the mass before reduction, and, to some extent, by exercising a greater amount of care in mixing the materials with the reducing agent. C. S.

CINNABAR AT TRIPUHY, BRAZIL.

Das Zinnober-Vorkommen von Tripuhy in Minas Geraës, Brazilien. By E. HUSSAK. *Zeitschrift fur praktische Geologie,* 1897, *page* 65.

It has long been known that cinnabar occurs on the Tres Cruces property, close to the station of Tripuhy, situated not far from Ouro Preto, the capital of the province of Minas Geraës. The author has examined this district, and finds that the cinnabar is known only in the form of fragments and pebbles in a thin layer of *cascalho* (alluvium), resting upon steeply-inclined strata of highly decomposed metamorphic slates, often micaceous. This formation occurs in all parts of

Ouro Preto, often alternating with true itabirite, and showing at times total or partial passage into that rock. Neither in the stratified rocks nor in a dyke of black augite-porphyry that traverses them, nor in the narrow strings and small lenticules of quartz that occur in them, is there any trace of cinnabar to be found; so that this ore is only known in the alluvial deposit. The latter is in too small quantity to be worth working. Besides the cinnabar, the gravels consist exclusively of the *débris* of the above-named slates and itabirites, together with various iron ores and a series of curious titano-antimoniates, characteristic of this district. The author holds that the original matrix of the cinnabar was itabirite, which rock was accompanied by micaceous slates carrying titano-antimoniates. The cinnabar has not yet been found *in situ*. H. L.

POWERFUL EXPLOSIVE.

Explosif de grande puissance à l'acétylène. By M. Matignon. *Bulletin de la Société Industrielle du Nord de la France*, 1896, *page* 98.

Acetylene is destined to play an important part among explosives of the future. An explosive mixture, only made at the moment of detonation, may be formed by combining acetylene and nitrogen protoxide in proportions represented by

$$C_2H_2 + 5\,N_2O = 2\omega_2 + H_2O,$$

each element constituting of itself a stable explosive requiring a very powerful detonator. This mixture, whose speed of explosion is comparable with that of panclastite or nitro-glycerine, shows a theoretical pressure which, for the same density of charge, is as three to two compared with panclastite, and four to three as compared with nitro-glycerine, these ratios practically representing the relative power of these explosives. J. W. P.

II.—REPORT OF THE CORRESPONDING SOCIETIES COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LIVERPOOL, 1896.*

The Corresponding Societies Committee of the British Association beg leave to submit the following Report of the Conference held at Liverpool.

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The meetings of the Conference were held in St. George's Hall, in the small Concert Room, on Thursday, September 17th, and in the Crown Court on Tuesday, September 22nd, at 3·30 p.m.

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At the first Conference (September 17th, 1896) Mr. George Abbott, General Secretary of the South Eastern Union of Scientific Societies, read a short paper entitled "District Unions of Natural History Societies." Mr. Abbott remarked that while local Natural History Societies had done much good work, yet that in many cases their efforts had been weak, irregular, and desultory. He thought the chief cause of failure had been want of organisation. A step in the right direction had been taken by the Unions of Scientific Societies already existing, such as those of Yorkshire and the East of Scotland, but he considered that the British Association did not sufficiently foster such unions. He therefore felt that a plan was necessary which would organise the local societies under the guidance of the British Association, which should help to bring these unions into being through the agency of an organising secretary.

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Mr. J. H. Merivale thought that federation did not imply the slightest loss of independence on the part of any local society joining a union. The great advantage was that the transactions of all the local societies were to be found in one publication. He was certain that if the natural history societies throughout the kingdom would unite as the societies composing The Federated Institution of Mining Engineers had done, the result would be excellent.

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Mr. Eli Sowerbutts thought that while in some respects federation must commend itself to all, there were some questions of great delicacy involved in it which made him hesitate to come to any decision at that meeting. He felt sure that a society would not submit to be controlled by another society as regards the publication of its papers. There were also many other matters needing careful discussion before any decision could be safely arrived at.

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SECTION C.

At the second Conference (September 22nd, 1896) Mr. W. W. Watts said that, though the labours of some of the Committees nominated by Section C had come to an end, the Geological Photographs Committee was still in existence. Though much assistance had been received from Leicestershire and some other places, a very large area was still unphotographed. The eastern counties had sent very few photographs. The Erratic Blocks Committee still existed, and their work was being largely done by the committees of local societies. Some societies in Yorkshire were doing most admirable work. Those were the two chief committees of Section C which needed the co-operation of the local societies.

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COMMITTEES APPOINTED BY THE GENERAL COMMITTEE AT THE LIVERPOOL MEETING IN SEPTEMBER, 1896.

1.—RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.	Grants.		
		£	s.	d.
Seismological observations	*Chairman.*—Mr. G. J. Symons. *Secretaries.*—Mr. C. Davison and Prof. J. Milne. Lord Kelvin, Prof. W. G. Adams, Dr. J. T. Bottomley, Sir F. J. Bramwell, Prof. G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Mr. G. F. Deacon, Prof. J. A. Ewing, Prof. C. G. Knott, Prof. G. A. Lebour, Prof. R. Meldola, Prof. J. Perry, Prof. J. H. Poynting, and Dr. Isaac Roberts.	100	0	0
To enquire into the proximate chemical constituents of the various kinds of coal.	*Chairman.*—Sir I. Lowthian Bell. *Secretary.*—Prof. P. Phillips Bedson. Prof. F. Clowes, Dr. Ludwig Mond, Profs. Vivian B. Lewes and E. Hull, and Messrs. J. W. Thomas and H. Bauerman.	10	0	0
The collection, preservation, and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Mr. W. W. Watts. Prof. T. G. Bonney, Dr. T. Anderson, and Messrs. A. S. Reid, E J. Garwood, W. Gray, H. B. Woodward, J. E. Bedford, R. Kidston, R. H Tiddeman, J. J. H. Teall, J. G. Goodchild, and O. W. Jeffs.	15	0	0
To study life zones in the British Carboniferous rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Mr. E. J. Garwood. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Dr. Wheelton Hind, Dr. G. J. Hinde, Mr. P. F. Kendall, Mr. J. W. Kirkley, Mr. R. Kidston, Mr. G. W. Lamplugh, Prof. G. A. Lebour, Mr. G. H. Morton, Prof. H. A. Nicholson, Mr. B. N. Peach, Mr. A. Strahan, and Dr. H. Woodward.	15	0	0
State monoplies in other countries	*Chairman.*— *Secretary.*—Mr. H. Higgs. Mr. W. M. Acworth, the Rt. Hon. L. H. Courtney, Prof. H. S. Foxwell, and Prof. H. Sidgwick. [The Chairman to be appointed by the Council.]	15	0	0
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Prof. R. Meldola. *Secretary.*—Mr. T. V. Holmes. Mr. Francis Galton, Sir Douglas Galton, Sir Rawson Rawson, Mr. G. J. Symons, Dr. J. G. Garson, Sir John Evans, Mr. J. Hopkinson, Prof. T. G. Bonney, Mr. W. Whitaker, Prof. E. B. Poulton, Mr. Cuthbert Peek, and Rev. Canon H. B. Tristram.	25	0	0
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2.—NOT RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.
To confer with British and foreign societies publishing mathematical and physical papers as to the desirability of securing uniformity in the size of the pages of their Transactions and Proceedings.	*Chairman.*—Prof. S. P. Thompson. *Secretary.*—Mr. J. Swinburne. Mr. G. H. Bryan, Mr. C. V. Burton, Mr. R. T. Glazebrook, Prof. A. W. Rücker, and Dr. G. Johnstone Stoney.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman.*—Prof. J. D. Everett. *Secretary.*—Prof. J. D. Everett. Prof. Lord Kelvin, Mr. G. J. Symons, Sir A. Geikie, Mr. J. Glaisher, Prof. Edward Hull, Dr. C. Le Neve Foster, Prof. A. S. Herschel, Prof. G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, and Prof. Michie Smith.
To consider the best methods for the registration of all type specimens of fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, Prof. H. G. Seeley, and Mr. H. Woods.
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THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1896-97.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. ..	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath	100	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, B.A.	267	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863..	Belfast Nat. F. C. ..	Museum, College Square. F. J. Bigger, M.R.I.A.	500	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831..	Berwicksh. Nat. Club ..	Dr. J. Hardy, Old Cambus, Cockburnspath, N.B.	400	10s. 6d.	7s. 6d.	History of the Berwickshire Naturalists' Club, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Mason College, Birmingham, W. P. Marshall and W. Boulton	273	None	£1 1s.	Journal, bi-monthly; Proceedings, annually.
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	C. K. Rudge, Literary and Philosophic Club, 20, Berkeley Square, Bristol	156	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, 5, Chapel Street, Peterhead	147	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc..	Thomas Gibbs, 30, High Street, Burton-on-Trent	200	None	5s.	Annual Report. Transactions, occasionally.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C...	H. E. Forrest, 37, Castle Street, Shrewsbury	189	5s.	5s.	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	Walter Cook, 98, St. Mary Street, Cardiff	450	None	10s. 6d.	Transactions, half-yearly.
Chester Society of Natural Science and Literature, 1871	Chester Soc. Nat. Sci...	Grosvenor Museum, Chester. G. R. Griffith and G. P. Miln	600	None	5s.	Annual Report. Proceedings, occasionally.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. W. F. Howard, 15, Cavendish Street, Chesterfield	360	£1 1s. None	Members, 31s. 6d.; Associates and Students, 20s.	"Transactions of The Federated Institution of Mining Engineers," about every two months.
Cornwall, Mining Association and Institute of, 1859	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Penelvan, Camborne	275	10s. 6d.	Minimum, 10s. 6d.	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. ..	G. B. Millett, Penzance..	90 Membs. 13 Associates	None	£1 1s.	Report and Transactions, annually.
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C. ..	Public Hall, Croydon. R. F. Grundy	226	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C. ..	N. M. Richardson, Montevideo, Chickerel, Weymouth	340	None	10s.	Proceedings, annually.
Dublin Naturalists' Field Club, 1885..	Dublin N. F. C.	R. Lloyd Praeger, National Library of Ireland, Dublin	210	5s.	5s.	"Irish Naturalist," monthly; Report, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gal. N. H. A. Soc.	Dr. E. J. Chinnock, Grey Friars', Dumfries	210	2s. 6d.	5s.	Transactions and Journal of Proceedings, annually.
East Kent Natural History Society, 1857	E. Kent N. H. Soc. ..	19, Watling Street, Canterbury. Stephen Horsley	89	None	10s. 6d.	"South Eastern Naturalist," occasionally.
East of Scotland Union of Naturalists' Societies, 1884	E. Scot. Union	William D. Sang, 28, Whyte's Causeway, Kirkcaldy, N.B.	10 Societies 900 Membs.	None	Assessment of 4d. per member	Proceedings, occasionally.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	H. M. Cadell, B.Sc., 5, St. Andrew Square, Edinburgh	150	10s. 6d.	12s. 6d.	Transactions, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1896-97.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Essex Field Club, 1880	Essex F. C.	William Cole, 7, Knighton Villas, Buckhurst Hill, Essex	359	10s. 6d.	15s.	"Essex Naturalist," monthly.
Federated Institution of Mining Engineers, 1889	Fed. Inst. Min. Eng. ..	M. Walton Brown, Neville Hall, Newcastle-upon Tyne	2,400	None	None	Transactions, about every two months.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	J. B. Murdoch, Capelrig, Mearns, Glasgow	250	None	10s.	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc. ..	S. M. Wellwood, 207, Bath Street, Glasgow	238 Members 25 Associates	7s. 6d. None	Members 7s. 6d. Associates 2s. 6d.	Proceedings and Transactions, annually.
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc. ..	John Mayer, 207, Bath Street, Glasgow	640	£1 1s.	£1 1s.	Proceedings, annually; occasional papers.
Hampshire Field Club, 1885	Hants. F. C.	Hartley Institution, Southampton. W. Dale, F.G.S.	250	None	7s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc. ..	John Hopkinson, F.L.S., The Grange, St. Albans	250	10s.	10s.	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	A. J. Crosfield, Carr End, Reigate	89	10s.	10s.	Proceedings, every two or three years.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. ..	F. A. Black, 16, Union Street, Inverness	164	None	5s. and 2s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	W. Lawson, 35, Molesworth Street, Dublin	100	None	£1.	Journal, annually.
Leeds Geological Association, 1874 ..	Leeds Geol. Assoc. ..	Dr. D. Forsyth, Higher Grade School, Leeds	75	None	5s.	Transactions, annually.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	H. B Wilson, Westfield, Armley, Leeds	203	None	6s	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	J. M. Gimson, 100, New Walk, Leicester	327 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875..	Liv'pool E. Soc.	R. C. F. Annett, Royal Institution, Liverpool	322	None	Resident, £1 1s.; Non-res., and Students, 10s. 6d.	Transactions, annually.
Liverpool Geographical Society, 1891	Liv'pool Geog. Soc. ..	Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Chapel Street, Liverpool	500	None	£1 1s.	Report, annually; papers occasionally.
Liverpool Geological Society, 1858 ..	Liv'pool Geol. Soc. ..	Royal Institution. H. C. Beasley	50	None	21s. and 10s. 6d.	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit Phil. Soc...	Royal Institution. J. M. McMaster	272 Members 11 Associates	None	£1 1s. Ladies, 10s. 6d.	Proceedings, annually.
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc...	Museum, Yorkersgate, Malton, Yorkshire. Rev. S. Jenkinson	100	None	5s. and 2s. 6d.	Science Notes, monthly.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Hillside, Ramsey, Isle of Man	133	2s. 6d.	Gentlemen, 6s.; Ladies, 3s.	Yn Lioar Manninagh, quarterly.
Manchester Geographical Society, 1884	Manch. Geog. Soc. ..	Eli Sowerbutts, F.R.G.S., 16, St. Mary's Parsonage, Manchester	800	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly; "Geography," monthly
Manchester Geological Society, 1838..	Manch. Geol. Soc. ..	5, John Dalton Street, Manchester. Jas. Tonge and Jos. Crankshaw	230	None	£1.	Transactions, eight or nine parts per annum.
Manchester Microscopical Society, 1880	Manch. Mic. Soc. ..	E. C. Stump, 16, Herbert Street, Moss Side, Manchester	214	5s.	6s.	Transactions and Report annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1896-97.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Manchester Statistical Society, 1833 ..	Manch. Stat. Soc. ..	63, Brown Street, Manchester. Francis E. M. Beardsall and T. Gregory	227	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	339	1s. 6d.	3s. and 5s.	Report, annually.
Midland Institute of Mining, Civil, and Mechanical Engineers, 1869	Mid. Inst Eng.	T. W. H. Mitchell, Regent Street, Barnsley	252	None	£1 10	"Transactions of The Federated Institution of Mining Engineers," about every two months.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, 3, Oxford Street, Norwich	264	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,100	None	21s. and 42s.	"Transactions of The Federated Institution of Mining Engineers," about every two months.
North Staffordshire Naturalists' Field Club and Archæological Society, 1865	N. Staff. N. F. C. A. Soc.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	424	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton N. H. Soc. ..	H. N. Dixon, M A., East Park Parade, Northampton	150	None	10s.	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Henry Wilkins, 3 2, Alfreton Road, Nottingham	173	2s. 6d.	5s.	Transactions and Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley	350	5s.	7s. 6d.	Report, annually; Meteorological Observations, occasionally.
Penzance Natural History and Antiquarian Society, 1839	Penz. N. H. A. Soc. ..	Museum, Public Buildings, Penzance. Dr. H. Montgomerie	80	None	10s. 6d.	Report, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	320	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, B.Sc., 105, Freehold Street, Rochdale	243	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Linden House, Rochester	140	None	5s.	"Rochester Naturalist," quarterly.
Scotland, Mining Institute of	Mining Inst, Scot. ..	James Barrowman, Staneacre, Hamilton, N.B.	490	None	31s. 6d. and 21s.	"Transactions of The Federated Institution of Mining Engineers," about every two months.
Somersetshire Archæological and Natural History Club, 1848	Som'setsh. A.N.H. Soc.	The Castle, Taunton. F. T. Elworthy	557	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	L. Péringuey, South African Museum, Cape Town	88	None	£2.	Transactions, annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng. ..	Alexander Smith, 3, Newhall Street, Birmingham	145	£1 1s.	31s. 6d.	"Transactions of The Federated Institution of Mining Engineers," about every two months.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1896–97.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Tyneside Geographical Society, 1887 ..	Tyneside Geog. Soc. ..	Geographical Institute, Barras Bridge, Newcastle-upon-Tyne. G. E. T. Smithson	1,054	None	10s. and 5s.	Journal, half-yearly.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	Museum, Warwick. W. G. Fretton, F.S.A., and S. S. Stanlay	88	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	215	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, F.G.S., Hopton, Mirfield	156	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, F.L.S., Sunny Bank, Leeds	449 and 2,567 Associates	None	Members 10s. 6d.; Associates 1d.	Transactions, annually; "The Naturalist," monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. T. S. Noble, F.G.S.	400	None	£2	Report, annually.

INDEX OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY THE ABOVE-NAMED SOCIETIES DURING THE YEAR ENDING JUNE 1, 1896.*

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Brown, John	Electrolytic Crystallisation of Metals	Belfast N. H. Phil. Soc.	*Report and Proc.*	1894–95.	28–33	1895
Elwen, T. L.	The Resistance of Air Currents in Mines	N. Eng. Inst.	*Trans. Fed. Inst.*	X.	62–66	"
Rücker, Prof. A. W. ..	The Magnetic Survey of Great Britain	Fed. Inst. Min. Eng. ..	*Trans.*	IX.	417–420	"
Steavenson, A. L. ..	The Mode of Obtaining a True North Line	N. Eng. Inst.	*Trans. Fed. Inst.*	X.	53–57	"
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* The Titles of Papers on other than Mining and Mechanical Engineering, etc., have not been reprinted.

Section B.—CHEMISTRY.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Charleton, A. G.	The Gold-milling Process at Pestarena, Italy	Fed. Inst. Min. Eng.	*Trans.*	IX.	344-352	1895
Clarkson, T.	Sampling	,, ,,	,,	,,	312-314	,,
Clowes, Prof. F.	The Limiting Explosive Mixtures of Various Combustible Gases with Air	,, ,,	,,	,,	373-375	,,
,, ,,	The Change of Composition Produced in Air by Flames and by Respiration	,, ,,	,,	,,	376-378	,,
Ferguson, Prof. J.	Presidential Address: Recent Contributions to the Literature of Gold-making	Glasgow Phil. Soc.	*Proc.*	XXVI.	1-13	,,
Jameson, John	The Recovery of Bye-products in the Manufacture of Hard Coke	N. Eng. Inst.	*Trans. Fed. Inst.*	X.	330-334	,,
Lewes, Prof. V. B.	Mining Explosives	Fed. Inst. Min. Eng.	*Trans.*	IX.	320-332	,,
Lohmann, B. H.	Shot-firing in Fiery and Dusty Mines	N. Eng. Inst.	*Trans. Fed. Inst.*	X.	351-353	,,
McConnell, J.	The MacArthur-Forrest Process	Fed. Inst. Min. Eng.	*Trans.*	IX.	410-416	,,
Marloth, Dr. R.	The Origin of the Nitrates in Griqualand West	S. African Phil. Soc.	,,	VIII.	113-118	1896
Martin, Robert	The Treatment of Timber for Use in Mines	Mining Inst. Scot.	*Trans. Fed. Inst.*	X.	531-533	,,
Meachem, F. G.	Poisoning of Horses by *Lathyrus sativus*	S. Staff. Inst. Eng.	,, ,,	,,	183-186	1895
Murton, C. J., and Saville Shaw	A Deposit found at Delaval Colliery, Benwell, Northumberland	N. Eng. Inst.	,, ,,	,,	67-71	,,
Sexton, Prof. A. H.	Aluminium: Is it to be the Metal of the Future?	Glasgow Phil. Soc.	*Proc.*	XXVI.	88-96	,,
Siersch, Alfred	Photography in the Technology of Explosives	Fed. Inst. Min. Eng.	*Trans.*	XI.	2-6	1896
Stokes, A. H.	Photometric Value of, and Notes upon, Various Illuminants used in Mines	Ches. Mid. Count. Inst.	*Trans. Fed. Inst.*	X.	135-159	1895
Winkhaus, Bergassessor	Experiments with Explosives	N. Eng. Inst.	,, ,,	IX.	250-274	,,
,, ,,	Safety Explosives	,, ,,	,, ,,	X.	337-350	,,
,, ,,	The Blasting Efficiency of Explosives	Fed. Inst. Min. Eng.	*Trans.*	,,	264-271	,,
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Section C.—GEOLOGY.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Andrews, Miss M. K.	Notes on Moel Tryfaen	Belfast N. F. C.	*Report and Proc.*	IV.	205-210	1895
Andrews, Wm.	New Water Supply at Kenilworth	Warw. N. A. F. C.	*Proc.*	40	54	,,
Barke, F.	Sectional Report—Geology	N. Staff. N. F. C. A. Soc.	*Report and Trans.*	XXIX.	100-104	,,
Bell, Dugald	On the Orientation of Boulders	Edinb. Geol. Soc.	*Trans.*	VII.	108-110	,,
,, ,,	On the Origin of Certain Granite Boulders in the Clyde Valley	Glasgow Geol. Soc.	,,	X.	16-22	,,
,, ,,	On the Alleged Proofs of Submergence in Scotland during the Glacial Epoch: II. Clava and other Northern Localities	,, ,,	,,	,,	105-120	,,
Bennie, James	On the Occurrence of Peat with Arctic Plants in Boulder Clay at Faskine, near Airdie, Lanarkshire	,, ,,	,,	,,	148-152	,,
Bolton, Herbert	On the Geology of North East Lancashire in its Relation to the Physical Geography	Manch. Geol. Soc.	,,	XXIV.	56-67	,,
Brodie, Rev. P. B.	The Reign of Dinosaurs	Warw. N. A. F. C.	*Proc.*	40	20	,,
,, ,,	Sections of Upper Keuper, near Rowington and Henley, Warwickshire	,, ,,	,,	,,	58	,,
Brown, Nicol	The Profit and Loss of Gold-mining: Ancient and Modern	Glasgow Phil. Soc.	,,	XXVI.	14-35	,,

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Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Burton, F. M.	The Story of the Lincoln Gap	Yorks. Nat. Union	*The Naturalist*	For 1895	273-280	1895
Cadell, H. M.	Notes on the Section in the New Haymarket Tunnel	Edinb. Geol. Soc.	*Trans.*	VII.	119-120	"
" "	Gold Mining in the Hauraki District, New Zealand	Mining Inst. Scot.	*Trans. Fed. Inst.*	X.	389-416	"
Callaway, Dr. C.	Lecture on the Igneous Rocks of Shropshire	Car. and Sev. Vall. F. C.	*Trans.*	I.	135-137	1896
Cantrill, T. C.	On a New Keuper Outlier near Kidderminster	Birm. N. H. Phil. Soc.	*Journal*	I	162-166	1895
Coke, G. E.	Boring below the Blackshale Coal-seam at Apperknowle, near Sheffield	Ches. Mid. Count. Inst.	*Trans. Fed. Inst.*	X.	483-488	"
Cole, Prof. G. A. J.	Hullite	Belfast N. F. C.	*Report and Proc.*	IV.	221-225	"
Colenutt, G. W.	Plateau and Valley Gravels of the Isle of Wight	Hants. F. C.	*Proc.*	III.	143-153	1896
Collins, J. H.	Notes on Cornish Fossils	Cornw. R. Geol. Soc.	*Trans.*	XII.	73-86	"
Currie, Jas., jun.	On an Iona Erratic containing Withamite	Edinb. Geol. Soc.	"	VII.	116-118	1895
Davies, Rev. J. S.	Dolomites	E. Kent N. H. Soc.	*S. E. Naturalist*	V.	153-158	1896
Davies, T. W., and T. Mellard Reade	Description of the Strata Exposed during the Construction of the Seacombe Branch of the Wirral Railway	Liv'pool Geol. Soc.	*Proc.*	VII.	327 348	1895
Dawkins, Prof. W. Boyd	Recent Additions to the Museum of Owens College	Manch. Geol. Soc.	*Trans.*	XXIV.	01-106	1896
De Rance, C. E.	The Depth to Productive Coal-measures between the Warwickshire and Lancashire Coal-fields	Fed. Inst. Min. Eng.	"	X.	244-256	1895
" "	Glacial Theories, Past and Present, and the Application to Staffordshire	N. Staff. N. F. C. A. Soc.	*Report and Trans.*	XXIX.	107-128	"
Dickinson, Jos.	On River Valleys	Manch. Geol. Soc.	*Trans.*	XXIV.	137-163	1896
Dickson, E.	Chemistry as an Aid to Geology	Liv'pool Geol. Soc.	*Proc.*	VII.	243-270	1895
"	The Geology of the Country between Preston and Blackburn	" "	"	"	276-288	"
"	Further Notes on the Section at Skillaw Clough, near Parbold	" "	"	"	314-320	"
Dron, Robert W.	The Southern Ayrshire Coal-fields	Mining Inst. Scot.	*Trans. Fed. Inst.*	X.	378-388	"
Durham, James	The Post-Glacial Geology of the Dundee District	E. Scot. Union	*Proc.*	1891-5.	66-74	"
Fisher, Robert	Notes on Mining in Portugal	Mining Inst. Scot.	*Trans. Fed. Inst.*	X.	121-126	"
Forster-Heddle, Prof. M	On the Occurrence of Tachylyte at Loch Screden, Mull	Glasgow Geol. Soc.	*Trans.*	"	80-85	"
Fox, Howard	The Radiolarian Cherts of Cornwall	Cornw. R. Geol. Soc.	"	XII.	39-70	1896
" "	Supplementary Notes on the Cherts and Associated Rocks of Roundhole Point, Cataclews Point, and Dinas Head	" "	"	"	71-72	"
Fox-Strangways, C.	Glacial Phenomena near York	Yorks. Geol. Poly. Soc.	*Proc.*	XIII.	15-20	"
Gardner, J. Starkie	The Bournemouth Leaf-beds	Dorset N. H. A. F. C.	"	XVI.	178-184	1895
Greenly, Edward	Notes on the Sutherland Gold-field	Edinb. Geol. Soc.	*Trans.*	VII.	100-107	"
Halse, Edward	The Quicksilver Mines and Reduction Works at Huitzuco, Guerrero, Mexico	N. Eng. Inst.	*Trans. Fed. Inst.*	X.	72-354	"
Harrison, Rev. S. N.	Geological Report	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	III.	21	"
" "	The Glacial Geology of the Isle of Man (Retiring Address)	" "	" "	"	27-32	"
Harrison, W. J.	A Bibliography of Midland Glaciology	Birm. N. H. Phil. Soc.	*Proc.*	IX.	116-199	"
Hick, Thomas	On some Recent Advances in Palæobotany	Yorks. Geol. Poly. Soc.	"	XIII.	43-57	1896
Hicks, Dr. H.	On the Pre-Cambrian and Cambrian Rocks of South Wales	Cardiff Nat. Soc.	*Trans.*	XXVII.	90-95	1895
Hind, Dr. W.	The Romance of a Flint (Presidential Address)	N. Staff. N. F. C. A. Soc.	*Report and Trans.*	XXIX.	17-39	"
Hobson, Bernard	Notes on a Specimen of Permian Limestone from Skillaw Clough	Liv'pool Geol. Soc.	*Proc*	VII.	320-322	"
Holmes, T. V.	The Geology of the Lea Valley	Essex F. C.	*Essex Naturalist*	VIII.	198-201	"
" "	Notes on the Geological Section at Chelmsford, in which Mammoth and other Remains were Discovered, November, 1894	"	" "	IX.	10-16	"
" "	Notes on a Map, including the greater part of S. E. England, recently issued by the Geological Survey	"	" "	"	112-115	1896
Holmes, T. V., and J. C. Gould	Geological Notes on a Supposed Earthwork near the Railway Station at Harlow	"	" "	"	59-70	"

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Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Holmes, T. V., and E. T. Newton	Discovery of Mammalian Remains at Great Yeldham, Essex	Essex F. C.	*Essex Naturalist*	IX.	115-118	1896
Holroyd, W. F., and J. Barnes	On the Rocks and Fossils of the Yoredale Series of the Marsden and Saddleworth Valleys	Manch. Geol. Soc.	*Trans.*	XXIV.	70-99	„
„ „	On the Stratified Clay of Strathearn, and on the Imatra or "Fairy Stones" found therein	„ „	„	„	110-112	„
Horne, John	Note on the Occurrence of *Alethopteris lonchitica* in the Carboniferous Beds of Loch Ryan	Edinb. Geol. Soc.	„	VII.	111-112	1895
„ „	Note on a Band of Fossiliferous Ironstone in the Cambrian Rocks of West Ross-shire	„ „	„	„	113-114	„
Howard, F. T.	The Geology of Barry Island	Cardiff Nat. Soc.	„	XXVII.	42-55	„
Hull, Prof. E.	The Eastern Limits of the Midland Coal-field	Fed. Inst. Min. Eng.	„	XI.	9-17	1896
Hutton Alex.	Arbroath: its History, Geology, Botany, and Zoology	E. Scot. Union	*Proc.*	1891-95	1-7	1895
Jenkinson, Rev. S.	Along the Cliffs from Hayburn Wyke to Robin Hood's Bay	Malton F. N. Sci. Soc.	*Science Notes*	2	37-38	„
Jukes-Browne, A. J.	The Origin of the Valleys in the Chalk Downs of North Dorset	Dorset N. H. A. F. C.	*Proc.*	XVI.	5-13	„
Jukes-Browne, A. J., and Rev. E. A. Woodruffe-Peacock	Coloured Map of the Surface Soils and Natural History Divisions of Lincolnshire	Yorks. Nat. Union	*The Naturalist*	For 1895	288	„
Kendall, J. D.	The Whitehaven Sandstone Series	N. Eng. Inst.	*Trans. Fed. Inst.*	X.	202-224	„
Kinahan, J. H.	On Possible Land Connections, in Recent Geological Times, between Ireland and Great Britain	Manch. Geol. Soc.	*Trans.*	XXIV.	113-130	1895
La Touche, Rev. J. D.	The Parallel Roads of Glen Roy	Car. and Sev. Vall. F. C.	„	I.	85-89	„
Lamplugh, G. W.	Notes on the White Chalk of Yorkshire. Parts I. and II.	Yorks. Geol. Poly. Soc.	*Proc.*	XIII.	65-87	„
Lapworth, Prof. C.	Discovery of the Lower Cambrian Fauna in the Midlands	Birm. N. H. Phil. Soc.	*Journal*	II.	1-2	„
Local Sub-Committee	Report on Coast Erosion	E. Kent N. H. Soc.	*S. E. Naturalist*	V.	147-148	„
Lomas, Joseph	Notes on some Fossil Plants from Doulton's Delph, St. Helen's	Liv'pool Geol. Soc.	*Proc.*	VII.	288-292	1895
„ „	The Geology of the Faroe Islands	„ „	„	„	292-314	„
„ „	A Theory to Account for the Hexagonal Form of Basalt Columns and other Structures	„ „	„	„	323-325	„
McDakin, Capt. J. G.	The Dover Coal-field	E. Kent N. H. Soc.	*S. E. Naturalist*	V.	149-151	1896
McLennan, Jas. S.	A Ramble up the Maich Water	Glasgow Geol. Soc.	*Trans.*	X.	121-128	1895
Maidwell, F. T.	Drift Deposits at Coventry	Warw. N. A. F. C.	*Proc.*	40	47	„
Mansell-Pleydell, J. C.	Plateau and Valley Gravels, Sarsen Stones at Little Bredy and elsewhere in the County	Dorset N. H. A. F. C.	„	XVI.	75-80	„
Mason, F. H.	Gold-mining in Nova Scotia	Fed. Inst. Min. Eng.	*Trans.*	X.	281-287	„
Merritt, W. H.	Economic Minerals of the Province of Ontario, Canada	„ „	„	„	288-316	„
Monckton, H. W.	On the Geological Nature of the Land that has fallen out of cultivation in Essex	Essex F. C.	*Essex Naturalist*	IX.	70-71	1896
Neilson, James	On the Calderwood Limestone and Cementstone, with their Associated Shales	Glasgow Geol. Soc.	*Trans.*	X.	61-79	1895
Newton, E. T.	Notes on the Remains of Pleistocene Mammals Found in the Neighbourhood of Chelmsford	Essex F. C.	*Essex Naturalist*	IX.	16-19	„
Oates, Robert	The Copper and Tin Deposits of Chotà-Nagpore, Bengal, India	Fed. Inst. Min. Eng.	*Trans.*	IX.	427-451	„
Oldfield, G.	Record of Borings	Malton F. N. Sci. Soc.	*Science Notes*	2	50,64,72	1895, 1896
Paul, J. D.	Cutting at the Swithland Reservoir	Leicester Lit. Phil. Soc.	*Trans.*	IV.	10-13	1895
Platt, S. Sydney	Large Fossil Trees Found at Sparth Bottoms, Rochdale	Rochdale Lit. Sci. Soc.	„	„	90-92	„

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Polwhele, T. R.	Anniversary Address: The Relation of other Sciences to Geology	Cornw. R. Geol. Soc.	*Trans.*	XII.	9-17	1896
Reade, T. Mellard	The Moraine of Llyn Cwm Llwch on the Beacons of Brecon	L'pool Geol. Soc.	*Proc.*	VII.	270-276	1895
" "	Note of Further Glacial Striæ at the Quarry, Little Crosby	" "	"	"	326	"
Reid, Clement	On Charred Pine-wood from Dorset Peat Mosses	Dorset N. H. A. F. C.	"	XVI.	14-16	"
Reid, James	On the Landslip at Sandgate	E. Kent N. H. Soc.	*S. E. Naturalist*	V.	158-163	1896
" "	The Vegetable Origin of *Parka decipiens*	Perths. Soc. N. Sci.	*Trans. and Proc.*	II.	123-127	1895
Renwick, John	Notes on an Excursion to Glen Fruin, with a Description of the Moraine on its South Side	Glasgow Geol. Soc.	*Trans.*	X.	96-104	"
Richardson, Ralph	Old Edinburgh Geologists	Edinb. Geol. Soc.	"	VII.	81-99	"
" "	Geological Sketch of the Excursion on the Berwickshire and East Lothian Coast, June 27th, 1894	Berwicksh. Nat. Club	*History*	XV.	183-184	1896
Sawyer, A. R.	Remarks on the Banket Formation at Johannesburg, Transvaal	Fed. Inst. Min. Eng.	*Trans.*	IX.	360-369	1895
Seeley, Prof. H. G.	On a Pyritous Concretion from the Lias of Whitby	Yorks. Phil. Soc.	*Report*	For 1895	20-29	1896
Shaw, F. G.	The Gold-fields of Matabeleland	Fed. Inst. Min. Eng.	*Trans.*	XI.	29-37	"
Sheppard, Thos.	On another Section in the so-called Interglacial Gravels of Holderness	Yorks. Geol. Poly. Soc.	*Proc.*	XIII.	1-14	"
Smallman, R.	The Geology of Warwickshire	Ches. Mid. Count. Inst.	*Trans. Fed. Inst.*	X.	160-161	1895
Smith, John	From the Doon to the Girvan Water, along the Carrick Shore	Glasgow Geol. Soc.	*Trans.*	"	1-12	"
" "	On a Section of Carboniferous Strata near Giffen Station, Ayrshire	" "	"	"	25-28	"
" "	The Geological Position of the Irvine Whale Bed	" "	"	"	29-50	"
" "	On an Alleged Bed of Shells at High Melmont, near Galston, between 400 and 500 feet above sea-level	" "	"	"	58-60	"
" "	On a Bed of Fossil Plants, and one of Limestone with Magnesia, in the Calciferous Sandstone Series at Meikle Busbie, near Ardrossan	" "	" "	"	129-132	"
" "	On a Bed of Ironstone Occurring in Trap Tuff, in the Parishes of Stevenston, Dalry, and Kilwinning	" "	" "	"	133-136	"
" "	On a Mineral in a Fumerole, at Auchenharvie Castle	" "	"	"	137-138	"
Sollas, Prof. W. J., and R. Ll. Praeger	Notes on Glacial Deposits in Ireland: II. Kill o' the Grange	Dublin N. F. C.	*Irish Naturalist*	IV.	321-329	"
Stainier, Dr. X.	On the Pebbles Found in the Belgian Coal-seams	Manch. Geol. Soc.	*Trans.*	XXIV.	163-184	1896
Steel, Thomas	On Australian Coals	Glasgow Geol. Soc.	"	X.	51-57	1895
Stephens, F. J.	Some Geological Notes (on Radiolarian Chert Graptolites) for 1895	Cornw. R. Geol. Soc.	"	XII.	87-88	1896
Stirrup, Mark	On the Work of Subterranean Waters: Recent Explorations of Swallow Holes, Caverns, and Watercourses of the Limestone Districts of France	Manch. Geol. Soc.	"	XXIV.	53	1895
Sutcliffe, R.	Notes on the Leinster Coal-field	" "	"	XXIII.	238-251	"
Sykes, E. R.	List of a Small Collection of Mollusca from a Raised Beach on Portland	Dorset N. H. A. F. C.	*Proc.*	XVI.	171-174	"
Tate, Thomas	The Malham Dry River Bed	Yorks. Geol. Poly. Soc.	"	XIII.	58-63	1896
" "	The Yorkshire Boulder Committee and its Ninth Year's Work	Yorks. Nat. Union	*The Naturalist*	For 1895	339-345	1896
Thompson, Beeby	Geological Notes	N'ton N. H. Soc.	*Journal*	VIII.	139-144 214-218	"
Thompson, Miss S. M.	A Bit of Foreshore	Belfast N. F. C.	*Report and Proc.*	IV.	210-214	"
" "	The Galway Conference, 1895: Geology	Dublin N. F. C.	*Irish Naturalist*	"	235-237	"
Todd, John	On the Borings for Coal, and the Experimental Salt Works in the North of the Isle of Man	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	III.	65-72	"
Ward, John	Summary of Literature relating to the Geology, Mineralogy, and Palæontology of North Staffordshire	N. Staff. N. F. C. A. Soc.	*Report and Trans.*	XXIX.	105-106	"

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Ward, John	On the Occurrence of Marine Fossils in the Coal-measures of North Staffordshire	N. Staff. N. F. C. A. Soc	*Report and Trans.*	XXIX.	129-138	1895
Watts, W. W.	The Geology of the Shropshire Rocks (Microscopic Structure of the Rocks)..	Car. and Sev. Vall. F. C.	*Rec. of Bare Facts*	No. 5	16-19	1896
Webb, W. M.	Notes on the Shells from the Brick-earth at Chelmsford	Essex F. C.	*Essex Naturalist* ..	IX.	19-20	1895
Werveke, Dr. L. van ..	The Occurrence, Mode of Working, and Origin of Petroleum in Lower Alsace	Fed. Inst. Min. Eng. ..	*Trans.*	,,	390-401	,,
Whitaker, W.	Some Surrey Wells	Croydon M. N. H. C. ..	,, ...	1894-95.	132-150	,,
Winstanley, R.	Presidential Address: A Few Thoughts on Geology	Manch. Geol. Soc. ..	,, ...	XXIV.	38-52	,,
Woodward, A. S... ..	Presidendial Address	Malton F. N. Sci. Soc...	*Science Notes* ..	2	54-56	,,
,, ,, ...	Notes on the Collection of Fossil Fishes from the Upper Lias of Ilminster in the Bath Museum	Bath N. H. A. F. C. ..	*Proc.*	VIII.	233-242	1896
,, ,, ...	On the Fossil Fishes of the Upper Lias of Whitby. Part I.	Yorks. Geol. Poly. Soc.	,, ...	XIII.	25-42	,,
Wright, Joseph	The Occurrence of Boulder Clay on Divis	Belfast N. F. C.	*Report and Proc.*	IV.	216	1895
Young, Dr. John.. ..	On the Occurrence of Pyroxene or Augite, in Large Crystals, in Two Localities in Western Scotland	Glasgow Geol. Soc. ..	*Trans.*	X.	13-15	,,
,, ,, .. .	On the Protoconch of *Orthoceras*, and on the Evidence of its Remains in certain Scottish Carboniferous Species, with Illustrative Specimens	,, ,, ..	,, ...	,,	139-141	,,
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Section D.—ZOOLOGY.

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Bolton, Herbert	Animal Life of the Lancashire Coal-measures	Manch. Mic. Soc. ..	*Trans.*	For 1895.	123-135	1896
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Section E.—GEOGRAPHY.

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Section F.—ECONOMIC SCIENCE AND STATISTICS.

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Atkinson, W. N.	Presidential Address	Fed. Inst. Min. Eng. ..	*Trans.*	IX.	299-309	1896
Kirkup, Austin	The Prevention of Accidents in Mines	,, ,, ..	,, ...	X.	2-18	,,
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Section G.—MECHANICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Atherton, J.	New Method of Re-lighting Miners' Safety-lamps	Manch. Geol. Soc.	*Trans.*	XXIII.	234-238	1895
Bainbridge, E.	Presidential Address	Chest. Mid. Count. Inst.	*Trans. Fed. Inst.*	X.	419 430	1896
Baird, Dugald	The Duty of Pumping Engines	Mining Inst. Soc.	" "	XI.	94-102	"
Bennett, A. W.	Telephonic Communication in and about Coal-mines	Midland Inst. Eng.	" "	X.	372-375	"
Cooksey, J. H.	Presidential Address	S. Staff. Inst. Eng.	" "	"	172-176	1895
Durnford, H. St. J.	Notes on the Sinking of the No. 1 Pit at the Ackton Hall Colliery, with special reference to the Thinning Out of the Silkstone and Beeston Coal-seam	Midland Inst. Eng.	" "	"	444-451	1896
Hall, Henry	Self-igniting Safety-lamps	Manch. Geol. Soc.	*Trans.*	XXIV.	131-137	"
Hay, William	Fencing-gates for Winding Shafts	Chest. Mid. Count. Inst.	*Trans. Fed. Inst.*	X.	480	"
Kell, G. J.	Obituary of Joseph Mitchell	Midland Inst. Eng.	" "	"	107-108	1895
Kennedy, R.	Electrical Machinery for Mines	" "	" "	"	98-105	"
Meachem, J., jun.	Electric-power Plant at Haden Hill Colliery	S. Staff. Inst. Eng.	" "	"	178-182	"
Platt, James	Coal-washing Plant at the Wirral Colliery, Neston, Cheshire	Fed. Inst. Min. Eng.	" "	XI.	55-59	1896
Reid, A.	Methods of Closing the Tops of Upcast Winding Shafts	Mid. Inst. Eng.	" "	X.	367-370	"
Saint, William	Improvements in Water-spraying Apparatus for Coal-mines	Manch. Geol. Soc.	*Trans.*	XXIII.	252-256	"
Scott-Anderson, T.	Electric Welding	Fed. Inst. Min. Eng.	"	XI.	40-52	"
Thompson, E.	The Use of Steel Girders in Mines	" "	"	X.	272-276	"
Thomson, G. Carruthers	Smoke Abatement with Reference to Steam Boiler Furnaces	Glasgow Phil. Soc.	*Proc.*	XXVI.	148-173	1895
Turner, George	Coal-mining in Assam, India	S. Staff. Inst. Eng.	*Trans. Fed. Inst.*	X.	356-364	1896
Walker, G. B.	The Roth Method of Firing Shots	Midland Inst. Eng.	" "	"	95-96	"
Walters, H.	Lead and Lap of Winding and other Engines	Fed. Inst. Min. Eng.	" "	XI.	64-68	1895
Winstanley, R.	On West's Safety Detaching Hook	Manch. Geol. Soc.	*Trans.*	XXIV.	108-110	"

Section H.—ANTHROPOLOGY.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Laver, Henry	Potash-making in Essex: A Lost Rural Industry	Essex F. C.	*Essex Naturalist*	IX.	119-133	1896

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Section K.—BOTANY.

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EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and Surname.

Discussions are printed in *italics*.

The following contractions are used:—

C.—Chesterfield and Midland Counties Institution of Engineers.
M.—Midland Institute of Mining, Civil, and Mechanical Engineers.
S.—Mining Institute of Scotland.
N.E.—North of England Institute of Mining and Mechanical Engineers.
N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.
S.S.—South Staffordshire and East Worcestershire Institute of Mining Engineers.