A paper read at the General Meeting of the American Institute of Electrical Engineers, New York, May 21st, 1891. Vice-President Crocker in the Chair.

NOTES ON ELECTRICITY IN MINING WORK.

BY SYDNEY F. WALKER, OF CARDIFF, ENGLAND.

When the writer was asked to contribute a paper to the TRANSACTIONS of the Institute, his feeling was that he had far more to learn from his confreres on the other side of the Atlantic than they could learn from him, and it is with considerable diffidence that he now ventures to forward the following notes upon a branch of electrical work in which he has had some experience.

Electricity has been used in mines in this country:

For signalling on engine planes and in shafts.

For speaking from point to point of the mine.

For shot firing.

For lighting; and for transmitting power to distant parts of the mine, to work pumps, coal cutters, etc.

It should be mentioned that electrical work in mines, so far as the writer's experience goes, is different from every other kind of work that the electrical engineer has to deal with. The apparatus is placed in the hands of men who are often altogether ignorant of electricity and the conditions under which it has to work are often many times more severe than any that would be met with elsewhere.

Damp is in a great many mines a constant feature, and so also are falls of roof, damage to roadways and many constantly recurring accidents, such as ropes breaking, horses taking charge, etc. Further, it has happened in this country that those who have designed apparatus for mines have never even seen one, and would therefore consider what experience has proved to be the ordinary requirements of successful working, simply ridiculous.

The signals that have been used are for ringing the cage up and down the shaft, and for ringing to the engine house and to various points on the road, where mechanical haulage is used.

The ability to stop a train of wagons instantly from any part of the engine plane has proved of such immense service that the engine plane signal has been adopted almost universally in the coal mines of the United Kingdom.

In this signal, as will be doubtless well known, connection is made between two naked parallel iron wires, which represent opposite ends of the circuit. As many as eight bells have been rung together on this plan, from any part of a haulage system extending over several miles.

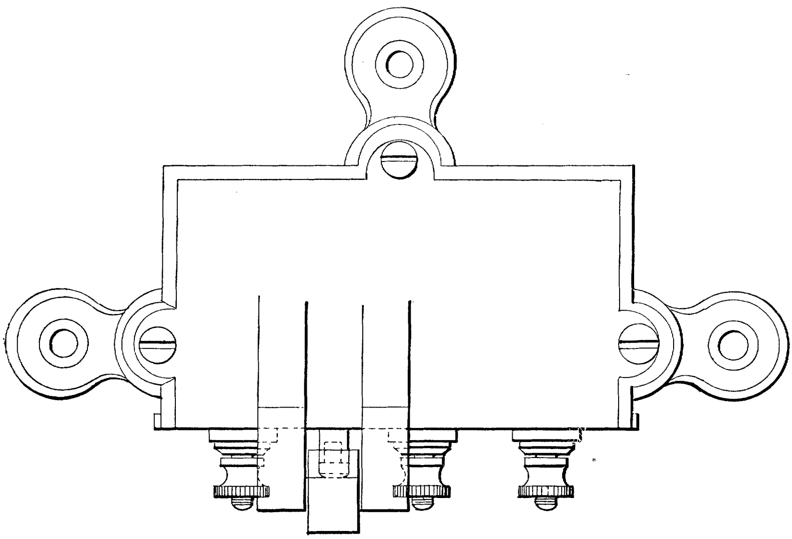


FIG. 1.

The great difficulties that have been met with in maintaining the engine plane signal are:—

The practical impossibility of keeping up the insulation, and the therefore constant drain upon the battery from the leakage current, etc.

The numerous joints that are made in the wires, owing to the constant breakage; each joint introducing considerable resistance into the circuit from its being not only unsoldered, but not even tightly twisted, or the ends of the wires clean.

The secret of success with this signal and with the shaft signal has been, making everything very strong, having a large reserve of power everywhere, and making the battery of large cells.

The electro-magnets, for instance, of the author's mining bells, are turned out of 2″ and $2\frac{1}{2}$″ iron and with the battery power used with them would work through 50 miles of the wire employed—No. 8 S. G. Batteries of the largest sized Leclanche cells, if plenty of them be allowed, will stand well with these bells—the signal often going on working for twelve months without any attention beyond repairing the wires when they are broken.

The principal difficulties with shaft signals are:

The wet which is always present at the bottom of the shaft where the ringing key is placed, and the liability to damage of the insulated wire that is used for line and battery wires, more

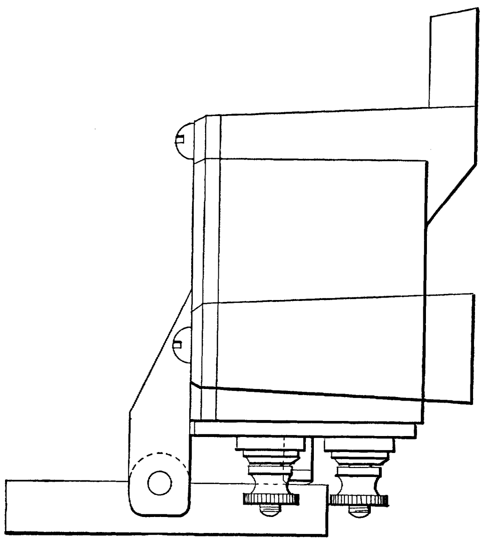


FIG. 1*a*.

particularly the latter. Falling coal damages the covering of the wire, admits moisture and the wire is soon parted.

Wet also plays great havoc with the connections to the ringing keys and with the contacts.

These difficulties have been overcome in the writer's practice, by fixing strong and well-covered wires in the shaft, protecting them with boarding, having no battery wire in the shaft, and by the design of the key shown in Figs. 1, 1*a* and 1*b*.

The key case is made of cast-iron and brass fitted together with flanges to exclude moisture as far as possible, so that the contact lever is unaffected by the ever-present damp.

An external lever of iron operates the internal contact lever by means of the sliding pin shown. The terminals of the key are outside the case, so that the wires can be cleaned off from time to time, and the signal kept going with little trouble. Where the terminals are hidden, no matter how carefully they are protected, damp always finds its way to the connection and destroys it, while the presence of the fault may be unsuspected.

The same remark as to batteries, that was made with reference to engine plane signals, applies here. The cells should be of the largest size and plenty of them, so that they may stand the drain

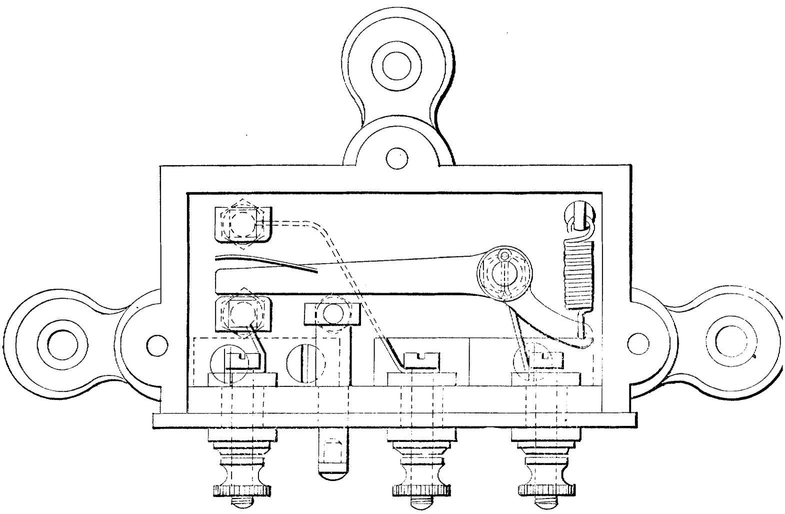


FIG. 1*b*.

of the leakage current often unavoidable, and of the incessant ringing, without requiring too frequent attention.

Signals are also used on the surface, for locomotive or haulage roads, but these can be dealt with in the same manner as ordinary railway signals.

Tin and lead mines have hardly adopted electricity at all in any form, partly on account of the conservative tendency of the owners, and partly on account of the enormous quantities of water present, and of the peculiar nature of the working of the mines themselves. The water present is usually strongly impregnated with metallic salts.

One tin mine in Cornwall tried a telephone between a level some 200 fathoms down and the surface, but the whole of the working parts were dissolved away in no long time. One telephone, however, has survived in a Cornish mine, between a level 600 fathoms deep and the surface, at Dolcoath, near Camborne; and a great boon it has been. Probably this fact has kept it alive. Any one who has been down a few hundred fathoms, either by ladder or man engine, in a tin mine, will thoroughly appreciate this.

Telephones have been very little used in coal mines, owing to the monopoly which has prevailed. In fact, they have only been used for surface work, such as from colliery to shipping port and therefore need no remarks here. The monopoly being about to expire, we are hoping for big developments shortly.

For firing shots by electricity small hand magneto machines giving from 20 to 40 volts are used, and they provide current for firing fuses formed generally of two pieces of copper and bedded in gutta percha, their ends being covered with a detonating composition of high electrical resistance which is fired by the passage of the current through it.

The principal difficulties in connection with shot firing have been:

The loss of power of the magnets, due to loss of magnetism and the uncertainty as to the voltage required by individual fuses.

It would appear as if the fuses that are used in this country are made without any gauge so that it is no uncommon thing to find one or two of a batch of fuses fire with as low a voltage as two or three volts, while others require 30 and 40 volts and even more. This uncertainty in the voltage has led to considerable trouble at the mines which use this system of firing shots. A batch of fuses will be taken into a mine and perhaps none of them, or only one or two, will fire. The exploder is brought out and tested, perhaps on a low voltage fuse, which it fires. It is taken into the mine again, when it may fire some and not others, and so on.

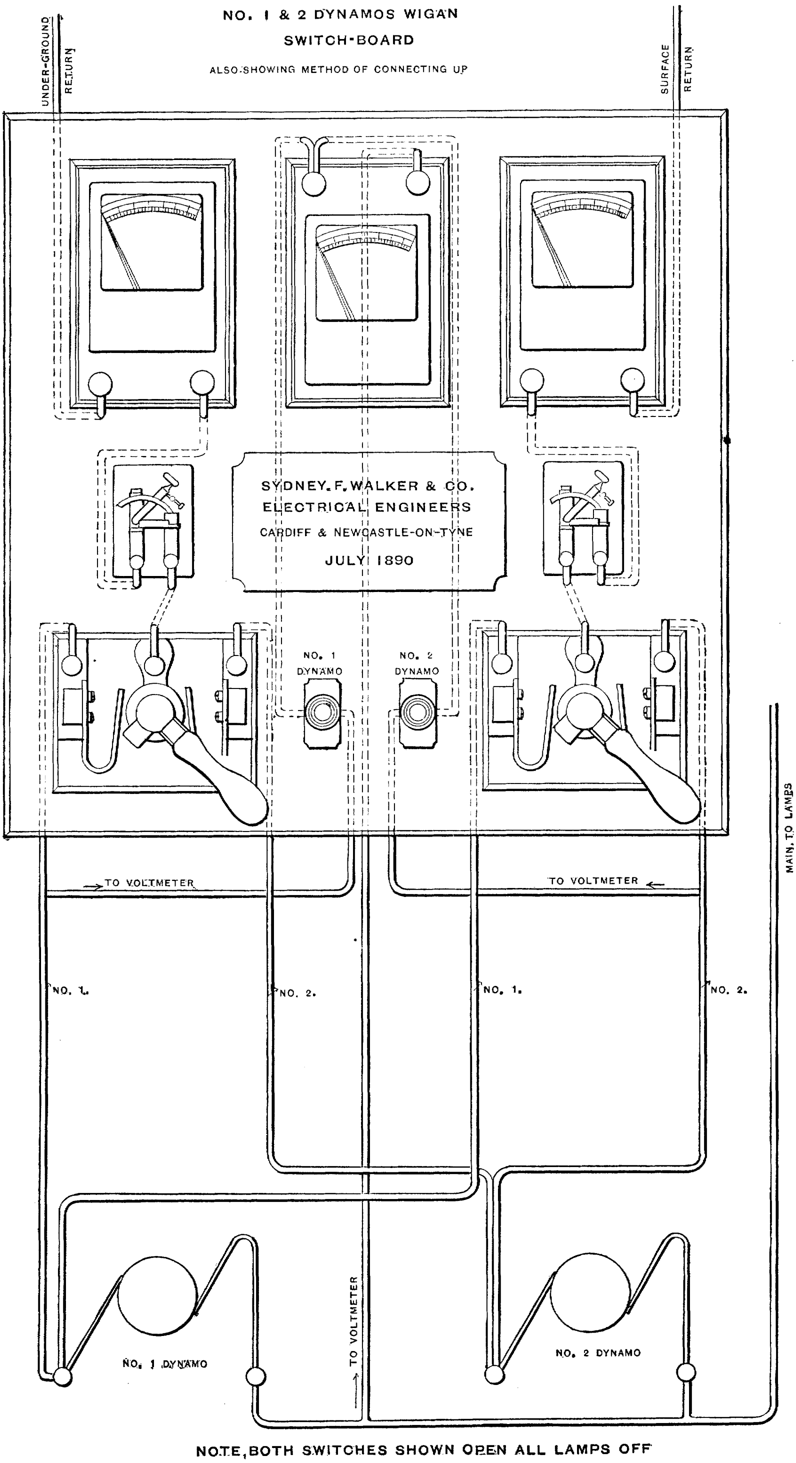
In a few mines where the electric light is installed, fuses have been fired by branch currents taken from the lighting service. As the voltage used for lighting is now always 100 or 110 volts, this plan gets over both difficulties, but in the writer's opinion, and, he imagines, in that of most members of the Institute, the practice is a very dangerous one. In some collieries in South Wales, batteries have been entirely displaced for working both the shaft and haulage signals, branches from the lighting service supplying the necessary current. An incandescent lamp is generally included in the circuit, so as to reduce the strength of the current passing through the bell coils. The lamp, which is arranged to light only when a signal is given, gives visual notice as well as the audible notice given by the bell. In one colliery, the current for firing shots is taken from the end of one of the iron signal wires. It has been found that only one connection is necessary, the other fuse wire being merely pushed into the hole that has been drilled in the coal for the charge, making contact, of course, with the body of the coal. This arrangement necessitates there being sufficient leakage on the lighting system to allow of the mass of the coal itself, with the rails, pulleys, ropes, etc., in connection with it, being used as a return.

In the instance mentioned, however, the arrangement has led to the somewhat startling result, that the polarity of the dynamo, placed on the surface, and at some distance from the pit's mouth, was twice reversed, apparently by electric currents induced in the bed of the coal itself. In another mine in Staffordshire, where old wire ropes are used for electric lighting mains, the leakage current is used to work the electric signal bells. In some of the South Wales collieries, where a branch of the electric light service is used to work the signals, it is no uncommon thing to see one of the iron signal wires sparking violently on the tops of a train of passing iron coal trams.

For lighting, the almost universal practice in mines is to have at least one compound wound dynamo, driven by a separate engine, laid down specially for the purpose.

In a few cases, the surplus power of the fan engine has been used, but the plan is not to be recommended, as it ties the electric light system too much to the requirements of the ventilating system. Added to this, it leaves no margin for the variations that occur even in the best made dynamos, between full load and light loads.

The plan adopted by the writer for a large colliery in Lancashire last summer seems the one to be preferred Two dynamos were provided, each having its own engine. The dynamos were constructed to give 200 lamps of 16 c. p. each, and the engines to work up to about 23 H. P. each. One dynamo was arranged to supply the surface lights and the other the underground lights, or motors if they were used; but a simple set of switches was provided, so that all the work, and each part of the work



NO. 1 & 2 DYNAMOS WIGAN
SWITCH-BOARD
ALSO SHOWING METHOD OF CONNECTING UP
UNDER-GROUND
RETURN
SURFACE
RETURN
SYDNEY F. WALKER & CO.
ELECTRICAL ENGINEERS
CARDIFF & NEWCASTLE-ON-TYNE
JULY 1890
NO. 1
DYNAMO
NO. 2
DYNAMO
TO VOLTMETER
TO VOLTMETER
MAIN TO LAMPS
NO. 1.
NO. 2.
NO. 1.
NO. 2.
TO VOLTMETER
NO. 1 DYNAMO
NO. 2 DYNAMO
NOTE, BOTH SWITCHES SHOWN OPEN ALL LAMPS OFF

FIG. 2.

could be thrown on to either dynamo instantly, provided of course that the latter was running and furnishing its proper voltage. Fig. 2 shows the arrangement of the switch-board that was used in this case and Fig. 3, 3*a*. the two way switch. It will be noticed that the latter has good rubbing surfaces, and that the switch is completely locked on either side.

The engines in this case had only one cylinder each. They were fitted with very heavy fly wheels, and with Acme governors. The latter were arranged with adjustable springs allowing for a variation of 10 per cent. in the speed if required. This, however, was not found necessary, but as an instance of the variation heretofore referred to. The two dynamos were made from the

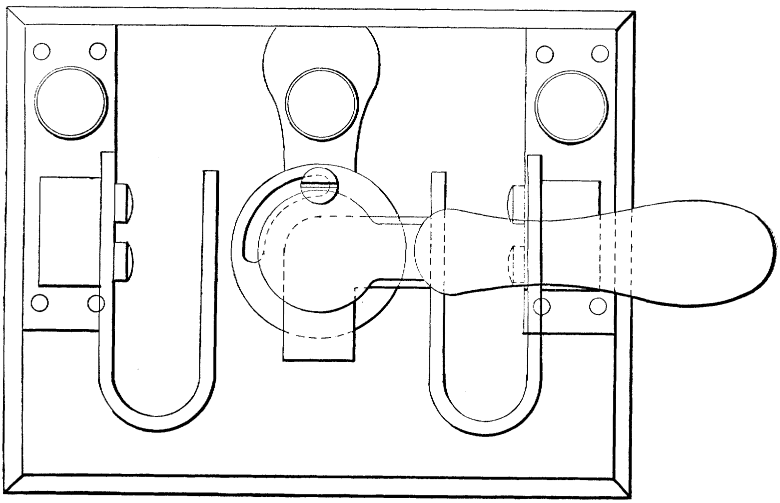


FIG. 3.

same iron, the same copper and by the same hands, yet one gave the specified voltage, 110 volts, at 785 revolutions, the other at 810 revolutions. The writer prefers two cylinder engines for electric lighting work, for the double reason that they work more steadily—badly spliced belts are less noticeable with them—and that the higher speed obtained with the smaller engine, and shorter stroke, enables countershafting to be dispensed with. It will be understood that the two dynamos were not connected electrically at all. Each did its own work, whatever it might be. In practice this resolved itself into one dynamo and engine running for 40 hours, and then the other, and so on. The colliery not being fully developed did not require all the power provided. The reason the dynamos were not connected electrically was, the writer's experience has been that when this course is adopted, one machine takes more than its share of the work, so that its armature becomes strained if it is supposed to be working near its normal output. Though the two dynamos are supposed to be furnishing the same E. M. F. between their terminals, in practice they never do; and if one be only one-half volt ahead of the other, the latter not only cannot furnish any current, but its coils furnish a path for the current furnished by its more powerful partner.

Arc lighting has been almost entirely abandoned for colliery work, very largely, the writer believes, owing to his persistent

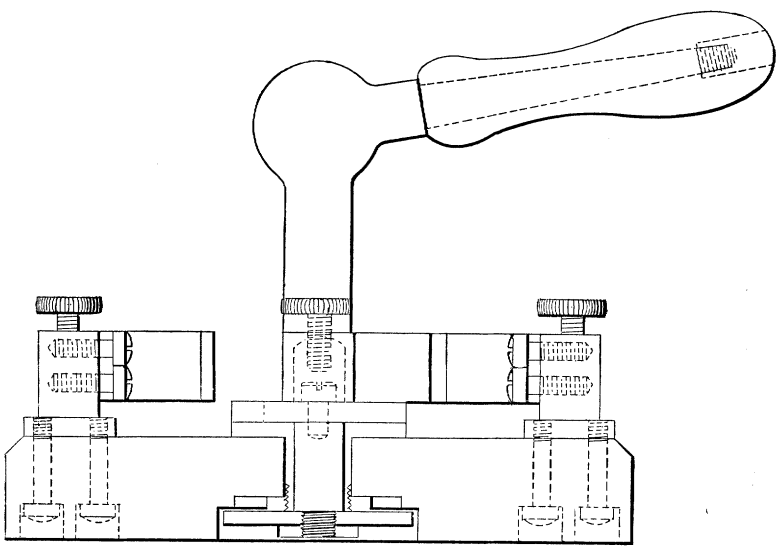


FIG. 3*a*.

effort in pointing out the solid advantages of large incandescent lamps. The improvement in the manufacture of 32 candle power, 50 candle power and 100 candle power lamps, and the advent of those of 200 candle power and upwards, has rendered electric lighting very simple; 100 candle power, 200 candle power or 300 candle power lamps are now placed over coaling screens and on pit banks, where arc lamps were formerly used, while in the yards and among sidings from 300 candle power to 600 candle power lamps are generally employed.

At the coal washing machine of the Dowlais Iron Company, where a powerful light is required for shunting trucks at night and on top of the coke ovens, 600 candle power and 1000 candle power lamps are used.

Some difficulty has been experienced with the 1000 candle power lamps in the open, owing, in the writer's opinion, to the manufacture of glass not having kept pace with the requirements of the lamp.

For underground engine-houses, offices, etc., the standard 16 candle power lamps are used, with an occasional 50 candle power or 100 candle power where a specially good light is required.

Callender's cables, with bitumen insulation, have been generally used for some years past for colliery work. Medium insulation being used for about the pit top and on the main roads underground where it is dry—heavy insulation where it is wet.

In the writer's opinion, this form of insulation is quite equal to the more expensive forms of rubber and gutta percha, if the wet be kept from it. For this purpose, for cables that have to be plâced in the shaft, where it is invariably wet, the writer has the cable with heavy insulation overlaid with two thick layers of jute, put on the reverse way, and then with two coatings of tape soaked in waterproof material. This covering appears to stand all the water that is found in a pit shaft for a good many years. In the writer's experience, india rubber will not stand for long if the wet gets to it, nor will gutta percha unless it be very pure and very thick. Since cable makers have taken to adding other material to the G. P. they appear to have taken three parts out of the life of the material, where damp is present. Of the few installations of arc lamps still working at collieries, one may be mentioned which was fitted up by the writer's firm in December 1882. It consists of five of the mechanical commutating Brockie lamps, worked from an old type Gramme dynamo, furnishing 200 volts and 10 amperes at 1400 revolutions.

The lamp, as will doubtless be remembered, has no regulating system, except an electro-magnet actuating a grip clutch. The electro-magnet is energized by a shunt current, brought direct from the dynamo, and this current is broken for an instant every 15 seconds, by a revolving commutator, placed near the dynamo.

There are three shunt or feed wires for the five lamps, the revolving commutator breaking each in succession.

The dynamo in this case is driven by a double-cylinder vertical engine, made by Tangyes of Birmingham, and the whole apparatus has not cost £10 for repairs in the eight years it has been running.

Old wire ropes, as already indicated, have been used rather extensively in two or three mines. In some cases the old rope has been used as a return, in others as both lead and return. Mr. Sopwith, the manager of Cannock Chase Colllery has led the way in this matter, and others have followed him. It appears that when he determined to light his colliery by electric light, he decided to do all the work himself, and proceeded to study the matter very carefully. A paper given by the writer to the North of England Mining Institute had the honor of being well thumbed amongst others. In the early days of his apparatus, however, Mr. Sopwith had trouble with some of his cables. Wet got to them and parted them. He therefore decided to try old wire ropes. These he has placed in wooden troughs in the shaft, and filled in the space round the rope with a mixture of coal dust and pitch. For distribution on the surface he has had brick troughs built, in which flat wire ropes are laid, bedded in the coal dust and pitch mixture. Underground, the writer believes, the old ropes are just laid in the coal dust. Mr. Sopwith states that since he adopted the above plan his troubles have ceased. Others who have followed him have not always been so fortunate. In one case where the writer was asked his views on the matter, he pointed out that there would be great danger of sparks, and that it would not be necessary that the two ropes should be in contact with each other, or both with some other conductor, for sparks to pass. One rope might be in contact with a conductor, which, though not touching the other rope, touched another conductor, and the final contact or break of contact, causing sparks to pass, might be in such a position that it would be difficult to trace the connection.

He also pointed out, amongst other things, that wherever the ropes or their supports encountered moisture, troublesome electro-chemical actions tending to destroy the rope would probably ensue.

Both of these predictions were verified almost to the letter. Sparks were generated at the bottom of the pit from just such a series of connections as he had foreshadowed. One rope touched a sheet of galvanized iron at the landing stage at the pit bottom; that is to say, sometimes it touched and sometimes it did not. The iron sheet was bearing against an iron pipe which went a little way into the workings and this or some other conductor in connection with it was bearing against one of the insulated conductors leading to the lamps and had rubbed its insulation through. The result was that sometimes the series of connections were complete and then broken, giving rise to sparks. In the same pit, one of the ropes before mentioned was eaten right in two at one of the landing stages; and in another pit in which the precaution was taken to fix one rope in the down cast and the other in the up cast, the iron supports of one rope, where they were driven into the pit props, were eaten into just as if they had formed part of a galvanic battery, or had been used as anodes in a plating bath. In another case where a naked iron rope was used as a return, the writer heard of a man receiving a very severe shock, while only 160 volts were in use on the system. It was an electric pumping plant.

The writer's feeling is therefore, that no naked conductors for electric lighting or power should on any account be used in any part of the mine and that the insulation should at all times be maintained as high as it possibly can be. Even for cables used to distribute current about the surface, the writer's invariable practice is to use insulated wire, for fear that the wires may be brought accidentally into contact and the attendant troubles ensue. The writer understands that in one mine in America, power was transmitted at a voltage of 280 or 300 volts, the rails being used as a return and lamps being worked from the same system, arranged two in series. If such an arrangement were used in this country, he would expect trouble to follow before long.

Not a great deal has yet been done in transmitting power by electricity for use in mines. There are several isolated pumping plants at work, one or two haulage plants, and one or two coal cutters.

The voltage used for pumping has been 300 and 500 volts, in one case as much as 700 being used. The plan that has been almost universally adopted for electric pumping plants has been to use a series wound motor, a shunt wound generator; both of sufficient power for the largest amount of work they may be called upon to do; and a separate engine whose speed can be varied in accordance with the requirements of the work. The most frequent application of electrical pumping plants has been for raising the water out of dip workings, which are often a long distance from the shaft, either to the sump at the pit bottom whence it would be raised by the main pumping engine, or to the surface. In dry seasons this water may not be much, so that the pump is lightly loaded. In wet seasons the reverse would be the case. Up to the present these requirements have been met by an increase or decrease of speed at the engine, giving rise to higher or lower voltage at the terminals of the generator and motor, with greater or smaller driving power. The writer's view is that as the use of electricity for transmitting power becomes more general, this system will give way to the simpler one, having only two or three dynamos as generators, all running at the voltage of the lamps; the motors for the pumps, hauling engines, etc., being connected in parallel, just as so many lamps, and the variation of the loads on the motors being dealt with as so many lamps turned in or out would be. The regulation of the increased or decreased load on the pump with varying seasons, can easily be dealt with mechanically and without any waste of electrical power.

The largest return obtained from an electrical pumping plant in this country has been 40 per cent. in actual work done in raising water, of the brake horse power delivered to the generator. It is obvious, however, that the efficiency of the pump and the size of the delivery pipes must have a material effect upon this figure.

In the majority of the pumping plants that have been laid down in this country, the pump has been geared up with one or two wheels and then driven by a belt from the shaft of the motor. Quite recently, however, Messrs. Golden & Co., of London, have worked out self-contained pumping, hauling and coal cutting plants; the motor, gearing and machine being all on one bed-plate. This, it will be seen, places electrical mining plants more on a footing with steam and hydraulic plants, as it is only necessary to place the combined machine on rails, run it into its place and connect the branch cables. In working this out, however, a somewhat unexpected difficulty arose. It is one, the writer believes, American engineers dealt with some time since in their tram-car work, and it is one which it would have been thought that skilled mechanical engineers would have foreseen. When a belt was no longer interposed between the motor shaft and the pump, so that the former had to start against a dead load without any flexible coupling between that would give—few armatures could be got to stand the strain; they broke up.

The reason of this was, of course, the flimsy nature of the mechanical joint between the armature spindle and its core, which for electrical reasons is usually provided. A sound mechanical joint, properly distributed, got over the difficulty at at once.

Messrs. Golden have also provided a spark protector in the shape of a cover over the commutator, so that if gas is present where the motor is working it cannot get to the spark at the commutator.

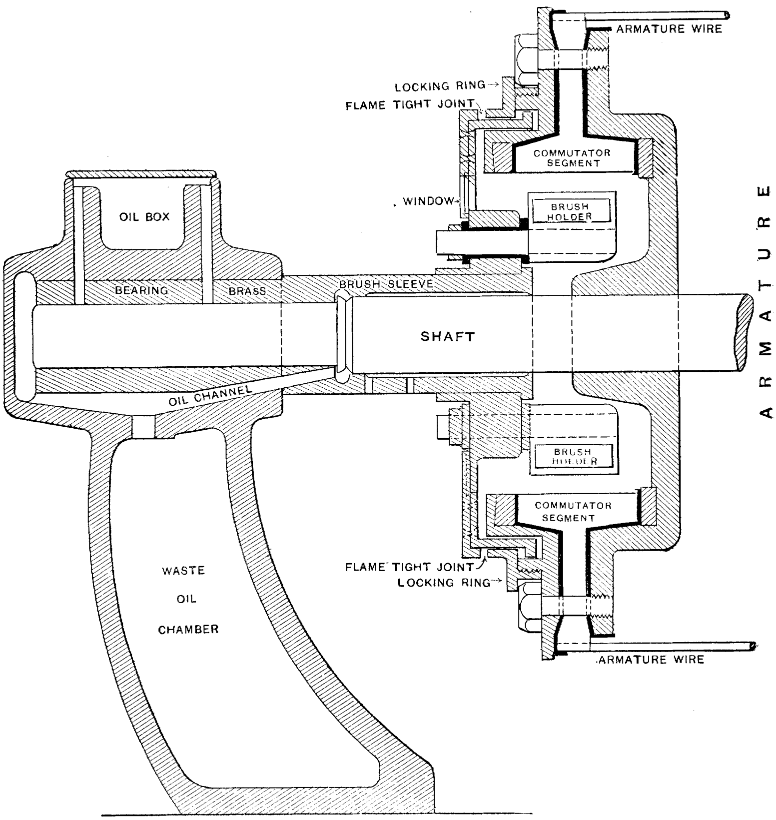


Fig. 4. Stokes's Safety Commutator.

Though this is, perhaps, a necessary concession to the feelings of mine owners; in the writer's opinion, it is both useless and unnecessary. His view is, as he expressed it at a recent meeting of the Institution of Civil Engineers, that you cannot bottle up the sparks, but you should reduce their tension below firing point.

Mr. A. H. Stokes, H. M. Inspector of Mines for Derbyshire, has attacked the problem in another way. He makes the commutator hollow and places the brushes inside. Experience will prove, of course, if this is successful, but the writer's view is that it will be found to give rise to more trouble with the brushes than it gives protection from explosions. It will never be possible to see if the brushes are properly set, and any sparking which takes place within the very confined space available will cause very serious trouble from the heat developed (see Fig. 4).

In electrical haulage, the principal work has been done in Yorkshire: 40 per cent. in weight of coal and trains drawn up an incline has been obtained in one case, of the brake horse power delivered to the generator.

The principal difficulties in connection with haulage appear to be the matters of variation of speed and reversal of direction. Where the system consists of an endless rope always travelling in one direction, the matter is, of course, much simplified; but for variations of speed the use of resistances in mines is a matter that requires great care, simple though it seems to trained electrical engineers.

For reversals the writer's view is that the motor should always travel in one direction and the operation of reversing be performed mechanically. If the variation of speed can also be conveniently accomplished by mechanical means, it will be easier and safer. In the matter of gearing for reducing the speed between motor and driving drum or pump, practice has settled down after many trials in other fields, to what American experience has proved to be the best, viz.—spur gearing. A short time since, when the writer was studying this question, he sent to every institute in the United Kingdom for papers on the subject, but none could help him out. The universal practice with other appliances where reduction of speed was necessary was to use spur gearing. Why was this? Why not worm gearing? At last he wrote to the Secretary of the American Society of Mechanical Engineers, who kindly sent him a copy of a paper which had been read before his society, which gave the solution of the whole problem. From a careful series of experiments made by Messrs. Sellers, it appears that while you can get 98 per cent. return of your power with spur gearing, and rarely less than 90 per cent. without much wear; with worm gearing 75 per cent. was the utmost you could get by any means, 60 per cent. and less was more nearly the rule, and the wear was very heavy. A namesake of the writer's, Mr. J. Blake Walker, the manager of one of the Yorkshire collieries has introduced a system of electric haulage, in which the old wire rope is used as a conductor, the motor travelling over it, and taking its current from it. The object of this plan is stated to be the saving of the power expended in driving the rope; but it appears to be forgotten that power is also expended in driving an electric current *through* a rope, just as in driving the rope round a pulley. The writer has not heard how far the plan has been successful, or if there be any margin between the above two figures.

The only other matter the writer proposes to deal with is that of the voltage that should be used in mines. His view is that while those engaged in a mine are becoming accustomed to the use of electricity, the voltage should be kept as low as possible; and he believes that though low voltage means a larger expenditure for copper, the interest on the difference between the cost of cables under say 100 volts and 500 volts, will be more than balanced by the saving in the cost of maintenance, owing to the great difficulty of maintaining the insulation with the higher voltage. Added to which, it will be a great convenience to work all the electrical apparatus from one source of supply. As already indicated however his views on this point, though accepted by mining engineers have not been by electrical engineers. The writer regrets that he will not be able to attend the reading of his paper in person; but will be pleased to reply to any criticisms or to answer any questions that may be asked; and may perhaps at some future day hope to have the opportunity of meeting his American fellow members.

Discussion.

[communicated by hollon c. spaulding.]

I have read Mr. Walker's paper with great interest, and I must add a little surprise, as showing a transition state which I had imagined the British electric mining engineers to have suffered from less than their American cousins. Certainly some of the make-shift methods described by Mr. Walker are not of the ultra-conservative ways which have been held up to us on this side of the water as types of English practice in some lines of scientific work.

While agreeing in general with the statements contained in the article, I may call attention at random to some points of difference in opinion and practice. In regard to the reversal of motors for instance, the writer's experience would certainly warrant the reversal of the armature itself by electrical means instead of more cumbersome mechanical methods. From the smallest size up to electric hoisting machines of 60 horse power brake capacity, for example, no trouble has been experienced with this method, and we certainly see no reason for turning to earlier devices for accomplishing the same results.

While the question of spur vs. worm gearing is still an open one, the advantages of compactness and silence go a good ways in recommending worm gearing in some lines of work, and it is certainly a debatable point, whether the difference in efficiency amounts to more than a negligible quantity when a well lubricated worm and gear takes the place of the two pairs of spur gears. One example in particular occurs to the writer as an illustration. A 10 horse power motor having been in use for several months in a travelling crane, the worm having a maximum speed of 1600 revolutions per minute and being placed *over* the gear, both being entirely encased in an oil tight jacket and the teeth of the gear acting as paddles, delivering a constant supply of oil to the contact point.

I cannot quite understand Mr. Walker's difficulty in operating two or more generators in multiple, both machines supplying current to the same system of feeders, from which may be operated lights or motors for various kinds of work. What is known to our engineers as an "equalized bar," supplying a close connection between the armatures of various machines working together, seems to answer every requirement in the writer's experience.

The switch-board shown, while certainly ingenious in its arrangement, would apparently not answer our American requirements as the switches are all single pole instead of double.

As to the voltage to be used in mining operations, the American practice of nothing higher than 220 volts below the surface seems to correspond most satisfactorily with Mr. Walker's ideas.

The development of a line of air and gas-tight motors and accessory apparatus is certainly most interesting as increasing the field of usefulness and safety in fiery mines, but, without going into the subject in detail, is not the true solution of the problem of electric installations in fiery mines, the provision of such a thorough ventilating system as is offered to better advantage than in any other way by the flexibility and ease of manipulation of a low voltage constant potential power and lighting system?

[COMMUNICATED BY H. WARD LEONARD.]

Almost every English electrical engineer, who has visited in the United States, has been reported as being very much surprised at the inferior quality of our construction work here, as compared with that done in England. It is, therefore, with no small amount of surprise that I observe the methods which Mr. Walker describes as being in use in the mines in England The character of the work which he describes as having been done in connection with signalling system in mines in England is such that it is not at all surprising that he states that only "one telephone has survived" which has been installed for mining use, and that this one has survived is surprising, in view of the character of the work which he mentions.

The following is a quotation from his paper:

"The great difficulties that have been met with in maintaining the engine plane signal are: the practical impossibilities of keeping up the insulation, and the therefore constant drain upon the battery from the leakage current, etc. The numerous joints that are made in the wires, owing to the constant breakage; each joint introducing considerable resistance into the circuit from its being not only unsoldered, but not even tightly twisted or the ends of the wires clean."

This statement indicates a lack of knowledge as to the necessary conditions in order to secure success and a lack of proper materials for the work undertaken which it is difficult to conceive. The quality of the mine fuses used in the mines in England appears to be inexcusably bad, judging by his statement that these fuses vary so greatly in the quality as to require sometimes two or three volts, while others require 30 or 40 volts at the generator in order to supply sufficient current to fire them. It is not surprising that this uncertainty has, as he states, led to considerable trouble at the mine which uses this system of firing shots.

Another quotation is as follows:

"In one colliery the current for firing shots is taken from the end of one of the iron signal wires. It has been found that only one connection is necessary, the other fuse wire being merely pushed into the hole that has been drilled in the coa for the charge, making contact, of course, with the body of the coal. This arrangement necessitates there being sufficient leakage on the lighting system to allow of the mass of the coal itself, with the rails, pulleys, ropes, etc., in connection with it, being used as a return."

It is difficult to believe that such an instance as this can be cited for any other purpose than to show how extremely unsatisfactory the use of electricity will prove when installations are made in total disregard of proper requirements and methods. That any one having any knowledge of the subject should voluntarily use a leakage current from a lighting system for the purpose of operating such important work as shafts and haulage signals and the explosion of mine fuses seems incredible to any one who has had any connection with the use of electricity for important operations.

Mr. Walker mentions what he very properly calls "a startling result," namely that "the polarity of the dynamo placed on the surface was twice reversed, apparently by the electric currents induced in the bed of the coal itself." It is probable that the dynamos for incandescent lighting are shunt-wound, as is common practice in this country; and how any possible current produced by the dynamo, of the nature which he described, could reverse its field it is difficult to understand; in fact, appears ridiculous, especially in view of his statement that it was apparently by electric currents which were "induced" in the bed of the coal by a continuous current.

It is rather surprising that one of the reasons advanced by Mr. Walker why two-cylinder engines are preferable for electric tric lighting work is that "badly spliced belts are less noticeable with them." Belts which are so badly spliced as to occasion flicker in the lights are a feature of electric lighting work which I have not seen in the past eight years in this country where the plant has been installed by any one who has ever had any previous experience with the subject.

Mr. Walker states that he found it impossible, in his experience, to properly operate two dynamos in multiple arc with each other. He states that, "while the dynamos are supposed to furnish the same E. M. F. between their terminals, in practice they never do." Apparently Mr. Walker is totally unfamiliar with the methods which are in use throughout the world for equalizing the E. M. F. and consequent current of dynamos in multiple arc. It would probably surprise Mr. Walker greatly to see what is common practice with the Edison company in this country, viz: the operation of as many as twenty different dynamos, frequently of different sizes, all operating in multiple arc and dividing the current exactly in proportion to their sizes.

If we can judge from Mr. Walker's paper, it is common practice in the mines in England to use the old wire rope for electric conductors. That any such conductors should be used in a mine is only less surprising than that a party, whom he states studied the matter very carefully, proceeded to insulate the old wire rope by "a mixture of coal dust and pitch." Mr. Walker states that the gentleman who originated this novel insulation met with entire success; but I am not surprised at the further statement that "others who have followed him have not always been so fortunate."

In view of the character of the work which Mr. Walker describes, it is very amusing to notice his statement, that he understands that "in one mine in America the power was transmitted in a voltage of 280 or 300 volts, the rails being used as a return, and lamps being worked from the same system, arranged two in series;" and that "if such an arrangement were used in England he would expect trouble to follow before long."

Mr. Walker states that a short time ago, while he was studying the proper kind of gearing for haulage he "sent to every institute in the United Kingdom for information on the subject, but none could help him out." He seemed surprised to learn that, in other appliances, where reduction of speed was necessary "spur gearing was generally preferred," and he asks, "Why was this? Why not worm gearing?" And it is rather pleasing to learn that he at length secured "the solution of the whole problem" by receiving a copy of a paper which had been read before the American Society of Mechanical Engineers, which apparently had supplied to the English public, for the first time, data as to the comparative efficiency of spur gearing and worm gearing.

It seems hardly possible that Mr. Walker, in his paper, has described practice in electrical engineering which is common in England; and yet one cannot avoid the inference that he himself believes so. In view of the publications in the American journals—some of which have been copied in the English journals—regarding the character of mine installations in America, it seems entirely unnecessary to make any comparison between the kind of work which is done here, and the kind of work which is described by Mr. Walker. I can only say that no one of the difficulties which Mr. Walker has pointed out as the principal ones to be met with in mining has been considered as such by the Edison company, and that the actual important difficulties which are met with in replacing other power by electric power in mining installations have apparently been overlooked entirely by Mr. Walker. The transmission of a large amount of power over several miles and its utilization at the point of use for the purpose of operating concentrators, arc lights, incandescent lights, hoists, pumps, locomotives and mining drills—both rotary and percussion—involves problems in electrical engineering beside which the difficulties which Mr. Walker has touched upon fall into utter insignificance; and yet it is work of this character which is going on daily in this country by more than one of the leading companies.