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A Specialists' Exhibition.

The Coal Face Machinery Exhibition, to be held in the Drill Hall, Sheffield, from October 2nd to 10th promises to be highly successful. Mr. Evan Williams, President of The Mining Association of Great Britain has kindly promised formally to declare the exhibition open on Friday, October 2nd ; at which ceremony he will be supported by The Lord Mayor of Sheffield, Alderman Harold W. Jackson, and by the Master Cutler, Mr. Peter B. Brown.

A dozen or so of the limited number of leading British firms who specialise in machinery equipments for cutting and clearing at the coal face have joined forces in this trade venture. One has only to scan the lengthy schedule of organised groups of visitors (see page 79) to perceive with satisfaction that the oft-maligned managers and engineers, whose thankless task it is to scrape a film of profit from the mining of coal, are, after all, keenly alert and on the look-out for available practical means of applying the latest economic principles. Up to the time of writing definite arrangements have been made for no fewer than twenty-four of these organised contingents of visitors. They are nationally representative of colliery interests, hailing from as far afield as South Wales. The railways are encouraging the good work by granting cheap travel facilities. This journal has been invited to take an active interest in the scheme and will, in addition to making a suitable display at the exhibition, endeavour effectively to help in spreading by printed page throughout the kingdom and overseas some of the useful lessons offered by the enterprising organisers.

Business men in general will watch carefully the results of this novel venture of a very limited group of engineering specialists. This is, in effect, an exhibition planned by themselves for themselves : they seek to present an undiluted and concentrated demonstration of modern methods of getting coal and the most economical and serviceable equipments for putting those methods into practice. It is gratifying to note that their move has been welcomed with such signal response.

Although, as said, the exhibition has been devised by these engineer manufacturers to serve their own ends, it is obviously impossible that the resultant benefits could only be so restricted ; inevitably the good influence will permeate the whole of the British colliery industry and will be greatly helpful in promoting the renewed vitality which that great industry so sorely needs. Everyone closely concerned with British mining, each according to his circumstance and opportunity, should therefore consider himself bound to support this praiseworthy effort : he will view this exhibition as a progressive step and, moreover, as one which is the more commendable as being a practical application of the bold optimistic spirit which put into forcible effective action as is here the case, will break the clouds of these dark days of trade depression.

Air Breaks and Fuses.

Mining electrical men have always found an inexhaustible field for argument and debate in weighing up the relative merits and drawbacks of air-break and oil-immersed switch and control gear. The ultimate basis of comparison usually resolves itself into the respective limits of safety under heavy current disruption. There are still some who have a preference, under certain conditions of service, for fuses as against automatic circuit breakers and, if only the principles of fuses and safety in fusing were more thoroughly understood and expressible in facts and figures, the stalwarts who stand for the older and simpler form of current interrupter would be on much firmer ground. So it is that such men, be they inclined to favour air or oil, or fuse or breaker, will appreciate the Safety in Mines Research Board Paper No. 67 which is entitled "The Pressure Produced on Blowing Fuse Links ; the Effect of the Surrounding Atmosphere", by G. P. Allsop and P. B. Smith.

The results of tests here shew that when a copper fuse is blown in a gas by direct currents up to 200 amperes at 200 volts, the resultant pressure, arcing time and arcing energy depend essentially on the thermal properties of the gas, unless the gas and the copper vapour can react. The higher the thermal conductivity and the specific heat of the gas, the lower is the pressure produced, the shorter is the arcing period, and the smaller is the arcing energy. When the gas and copper vapour can react, the pressure rise, arcing time, and arcing energy are considerably reduced, irrespective of the thermal characteristics of the gas. Oxygen, for example, is more effective than air in reducing the arcing ; hydrogen is more effective still, but in this gas the extinction of the arc is so rapid that high over-voltages are induced and there is, in consequence, a danger of flashover to the walls of the fuse box.

The interaction of the vaporised metal of the blown fuse and the heated atmospheric surroundings is, therefore, to be counted as a governing principle in the design of improved fuse gear. Probably further research will establish the superiority of certain definite metals or alloys for fuse links in conjunction with certain atmospheric vapours or gases There are distinctly great possibilities in view.

CORRESPONDENCE.

Electric Winders.

The Editor.

Mr. Routledge's letter on this subject in your issue of June 1931 indicates that Mr. Greig is perhaps not quite *au fait* with some of the recent developments in electric winder practice. It should, however, be borne in mind that such papers as that given by Mr. Greig are compiled essentially from technical publications, and as no technical information has yet been published regarding some of the developments referred to by Mr. Routledge it is not surprising that they are not mentioned in the paper. In the near future the new practices in question will receive publicity in complete technical detail.

On reading through Mr. Greig's paper more carefully, one finds numerous other statements that are open to misconstruction, but as the paper does not purport to be a very advanced treatise on the subject it would be rather invidious to introduce technical argument. There is, however, one statement which, if left unqualified, may well cause distinct uneasiness in the minds of many readers, viz. the remark made in the first paragraph on page 358, in connection with reverse current braking, that "It must be remembered though, that for a given resistance in the rotor circuit, the braking torque varies inversley as the speed, so that the greater the speed the less the torque; there is, therefore, some chance of the load getting away with the motor."

What Mr. Greig intended to convey was, presumably, that if the resistance in the rotor circuit be reduced to too low a value when braking by reverse current, the torque characteristic of the motor will no longer be on the "rising" side of the torque-slip curve so that the torque will fall off if the motor speed (and consequently the slip) increases. As, however, all a.c. winder motors with rheostatic (rotor) control have reversing controllers which, on the majority of winders, will pass ample braking current on the first or second step in "reverse," there is practically no risk of the motor being over-run by the load. In the remote event of this occurring the excessive current taken due to the low rotor resistance will operate the overload trip, or the overspeed device will come into operation, thus tripping the main switch and applying the emergency brake.

The only objection that is seriously put forward to regenerative-cum-reverse current braking for lowering loads is that at the end of the full speed period, when changing over from regenerative to reverse current, the electric control lever has to be moved over from full "forward" to early "reverse" and during this operation the retarding effect of the motor is lost. There is, however, no restriction on the rapidity with which the driver may move the lever, and in such a short interval of time the speed of the winder cannot increase appreciably owing to the great inertia of the moving parts. The risk of running away is therefore negligible and can be totally ignored if the winder is equipped with an efficient overwind and overspeed prevention device.

Whilst on this subject, may I take the opportunity to appeal, on behalf of the manufacturers, to all those who are responsible for the issuing of enquiries and specifications for a.c. electric winders to make their braking requirements as definite as possible. Although most a.c. equipments will serve for reverse-current braking on occasion, they are not necessarily suitable for such duty as a regular thing. It is usually assumed that the winder will be pulled up at the end of each wind by the mechanical brakes unaided by the motor, and if electrical braking is required it should be definitely specified in order that the controller may be designed with a suitable range of resistance and sufficient dissipating capacity for such service.

Trafford Park,
17th July, 1931. R. W. WORRALL.

INTERNATIONAL ALUMINIUM COMPETITION.

It will be remembered that, at the beginning of this year, the European producers of Aluminium organised a competition in which prizes were offered for suggestions designed to develop the use of aluminium and its alloys. The British Aluminium Co., Ltd., announce that the Committee of judges has now awarded prizes as follows :—

1. A prize of 25,000 French francs, awarded to Mr. Constantin Szmukler, 1 Rue Chaper, Grenoble (Isere), France, for a contribution on the use of aluminium in leather dressing and tanning.

2. A second prize of 25,000 French francs has been divided equally between :

Dr. H. Hampel, Elsasserstrasse 15, Pojeduch, b. Stettin, Germany, and

Mr. de Haes, 3 Rue de Veeweyde, Bruxelles-Midi, Belgium, for two entries relating to the use of aluminium in radiators for central heating systems.

3. The special prize of 50,000 francs has not been awarded, the judges being of the opinion that no suggestion made was of sufficient importance and exceptional novelty to justify this award.

The competition aroused great interest in technical circles in the majority of countries. Approximately 1000 persons approached the International Aluminium Bureau for information on the competition, and eventually 291 entries were submitted to the judges. For the most part, these entries were highly meritorious and shewed careful study of the properties of the light metals.

The British Aluminium Company has also issued a useful reminder concerning the development of aluminium and light metals for hand-carts, bicycle trailers, conveyor details, and similar handling and transporting facilities. The notes, illustrated by dimensioned sketches, refer more particularly to the extensive adoption of these appliances by the Swiss Post Office, as described by M. von Salis, Chief Inspector of the Swiss Postal Service. The Department has constructed more than 400 handcarts built up of steel tubes with aluminium panelling, with spoked wheels and pneumatic tyres. These vehicles, of which the dead weight is from 40-80 kg., are capable of carrying a useful load of 200-450 hgs. They are now used in place of handcarts of a similar type in wood and steel, which, unloaded, weighed 60-150 kg. The reduction in weight by the use of aluminium has made it unnecessary to increase the personnel in spite of an increase in the quantity of traffic, and has even permitted these handcarts to replace horse carts hitherto used for suburban deliveries.

There are also about 40 bicycle trailers with steel tubes and aluminium panelling. These are used for rural deliveries and permit an increase in the number of parcels transported without decreasing the speed or increasing the number of postmen. The suggestion is made that it would be useful to make tests with the object of seeing whether a still further use of light alloys, such, for example, as for the construction of the chassis and the wheels, would not permit a still further reduction in weight while maintaining an equal strength and an equal cost.

THE CANIVET SYSTEM OF MINE SHAFT SIGNALLING.

D. A. BOWER.

The majority of methods at present employed for shaft signalling involve the use of flexible mechanical or electro-mechanical connections between the cage and the operator, in order that communication may be established whilst the cage is in motion. This flexible connection is always an inherent source of weakness and it is liable to more or less frequent failures caused by the rapid movement of the cage as well as by damage due to material falling down the shaft. An interesting solution of the problem has been carried into effect at the Monceau-Fontaine Collieries, Monceau sur Sambre, Belgium, and the purpose of this article is to describe the patented "Canivet" system which is in successful operation at those collieries.

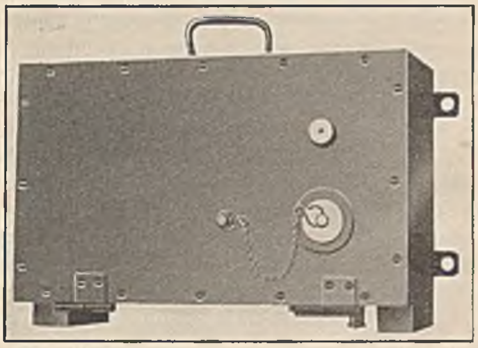

Fig. 1.—The Transmitter.

The most important feature of the Canivet system is that there is no mechanical or direct electrical connection between the transmitting end (the cage) and the receiving end (the engine house). The apparatus used consists essentially of the following:—

(a) A self-contained transmitter (Fig. 1) in each cage.

(b) An electrical transmission system comprising two steel wires looped together at the bottom of the shaft.

(c) A receiving system (Fig. 2) in the engine room capable of reproducing signals and speech.

The transmitter, the circuit connections of which are shewn in the diagrams, Figs. 3 and 4, is of a portable nature and weighs about 45 lbs. It consists of a small cubicle containing :—

(1) A vibrator, V, which is connected in circuit on the depression of a push button, VB.

(2) A flat coil, C, (in the form of a frame aerial) of 100 turns, so mounted in the cubicle that its plane is vertical with the cubicle in its normal upright position. This coil occupies the whole of one side of the transmitter.

(3) A simple microphone, M, which is connected in circuit when a push button, MB, is depressed.

(4) A battery of dry cells, B.

The transmission part of the equipment comprises a pair of insulated steel wires running the full length of the shaft. The wires are held to the shaft walls at intervals and electrically connected at their lower extremities, thus forming an elongated U. Steel wires are used instead of copper conductors in order to obtain the maximum possible tensile strength. Clamping devices are installed at intervals along the shaft to prevent the wires from falling in the event of breakage.

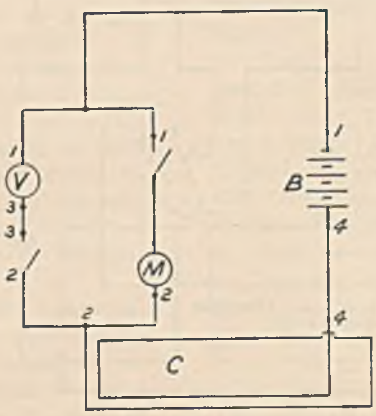

Fig. 3.

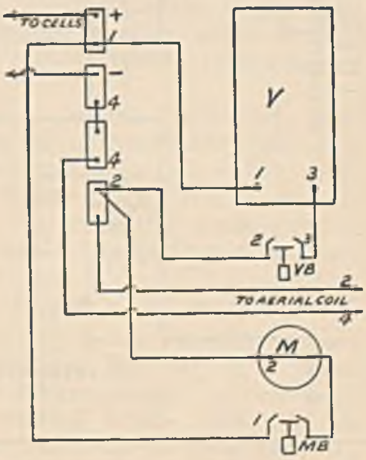

Fig. 4.

Fig. 2.—The Receiving Station.

The two free ends of the wires at the engine house or pit top are connected to a three-valve amplifying unit, which constitutes the receiving station. The amplifier, which is energised by batteries in the usual way, strengthens the signals before passing them on to a loud speaker of conventional design. The diagram, Fig. 5, shews the circuit arrangement of the amplifying unit.

Principle of Operation.

In order to send telegraphic signals from the cage to the engine room, or if it is desired to attract the driver's attention with a view to giving a verbal message, the "Signalling" push button, VB, is pressed. The vibrator circuit is thus energised with current from the dry cells, and oscillating currents are produced in the transmitting coil, or "aerial" coil. As a result, an oscillating electromotive force is induced in the steel shaft wires by electro-magnetic induction. The current produced by this e.m.f. actuates the amplifier, which in turn, supplies the loud speaker near the engine driver, producing a loud buzz, so long as the push-button in the transmitter is held closed. Telegraphic signalling, by the conventional mines code, is thus possible, and is entirely independent of the motion of the cage.

By depressing the push button, MB, controlling the microphone circuit, telephonic communication is established between the cage and the driver. Electro-magnetic induction between the modulated currents in the transmitter coil and the steel wires, induces an e.m.f. in the latter which, after amplification, results in clear speech of ample volume in the loud speaker.

The following beneficial results accrue from the use of a signalling system such as that here briefly described:—

(1) Greater security when winding men, as the signals are instantaneous, and verbal communication is possible.

In the majority of cases, verbal communications are only necessary when the winder is stationary, and speech can be heard perfectly in the engine room under these conditions. By adjusting the amplifier, speech can be heard quite satisfactorily above the noise of the machinery.

(2) Increase in reliability of operation due to the absence of any flexible connection between the cage and signal transmitting gear.

(3) Considerably enhanced facilities of communication between the cage and engine room during shaft inspection and repairs.

The particular installation described was carried out by Messrs. A.C.E.C. (Ateliers de Constructions Electriques de Charleroi), to whom acknowledgment is due for the illustrations.

Standard Specifications.

The British Engineering Standards Association have published several new specifications of particular interest to mining men, including :

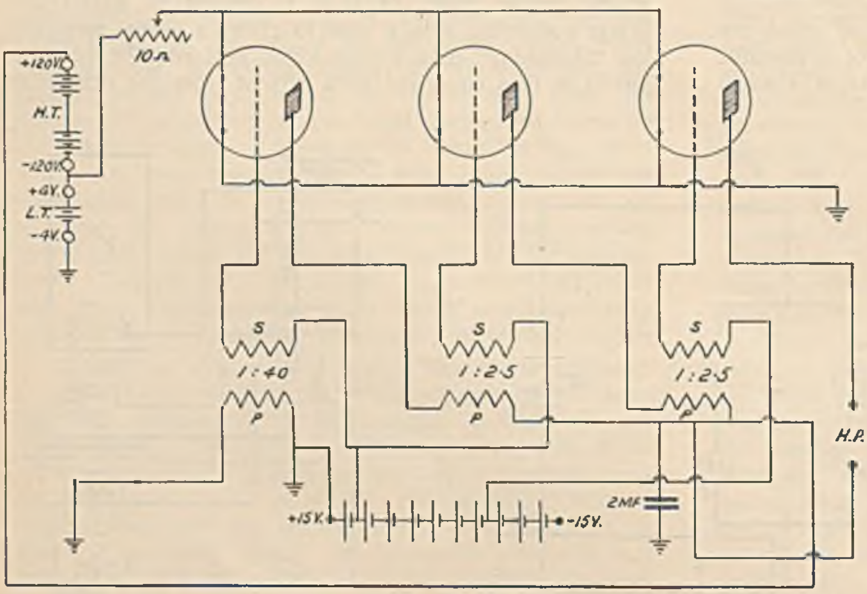

Fig. 5.

B.S.S. No. 418. *Conveyor Troughing for Use Underground in Mines.* This new British Standard, which has been agreed to by all British makers of shaker conveyors, has been prepared with a view to securing interchangeability between the troughing used for the various types of shaker conveyors underground. A specification is also included for the material of the steel plates used in the manufacture of the troughing. Three capacities of troughing have been standardised, but the types have been so designed that they can all three be manufactured from a single set of dies. It is hoped that this will considerably cheapen the cost of the troughing to the users.

B.S.S. No. 223. *The Electrical Performance of High-Voltage Bushing Insulators.* This specification deals with bushing-type insulators for indoor and outdoor use, including cable-terminating bushings, suitable for the range of declared voltages from 600 volts to 200 k.v. In general arrangement, the specification is generally similar to the B. S. Specification No. 137, which deals with insulators for overhead lines. There is, however, an important difference, namely, that the "rating number" assigned to each bushing is equal to the voltage, expressed in kilovolts, used in the One-minute Dry Test, whereas in B.S.S. 137 the rating numbers are based on the voltage used in the Thirty Seconds Rain Test. For this and other reasons it is clearly stated in the specification that it must not be assumed that for a given transmission system the same, or nearly the same, rating number will represent both the appropriate bushing and line insulator.

Each rating number is associated with certain test-voltages (one-minute dry test for indoor and outdoor bushings, 30-seconds wet test for outdoor bushings, and minimum dry flash-over voltage for indoor and outdoor bushings) and information regarding the selection and application of bushings is given by means of notes and "bushing selection tables". The notes deal with such matters as the relative strength of bushings and associated apparatus ; the effect of details and conditions of installation ; and the corrections to be applied for conditions other than the Standard Service Conditions. The bushing selection tables furnish an index of the appropriate bushing rating numbers for various switchgear and transformer applications. Impulse voltage-tests are dealt with in one of several appendices.

B.S.S. No. 420. *Sampling and Analysis of Coal for Inland Purposes.* This specification should be read in conjunction with the Report by Dr. E. S. Grummell and Dr. A. C. Dunningham on the Sampling of Small Fuel up to 3 in.—(B.S.S. No. 403) issued in December of last year—which embodies some general principles of sampling, the explanation in regard to which is important as supplying justification for the, comparatively speaking, small samples specified in this specification. The specification is at present confined to coal passing through a 3 in. diameter perforated plate screen. The sizes of gross sample required are graded in accordance with the average ash percentage and the size of the fuel, and figures have been specified such that a gross sample taken in accordance with the specification should contain an ash percentage within plus or minus one unit of the average ash content of the consignment. Full particulars are given of the method of collection of the gross sample from chutes, conveyors and wagons, and the method of reduction is closely specified.

Proceedings of the Association of Mining Electrical Engineers.

WEST OF SCOTLAND BRANCH.

Leakage Protection.

ALEX. LIGHTBODY.
(MEMBER)

(*Paper read 25th March*, 1931).

Though many have taken in hand to set forth at different times papers on this subject in *The Mining Electrical Engineer*, the author believes that it is one still of much interest, especially to those who, like himself, are comparatively new members and who are not privileged to possess the early volumes of the Proceedings of the Association.

Principal objects of leakage protection are:—
(1) to isolate a circuit upon which a fault to earth has occurred; and (2) to isolate the circuit before the leakage gets time to increase in value sufficiently to become dangerous.

In the Home Office Rules in regard to this subject, Regulation 124 (c) says that every part of a system shall be kept efficiently insulated from earth. But, on the other hand, Regulation 125 (a) say that all metallic sheaths, coverings, handles, joint boxes, instrument covers, etc., shall be earthed. Moreover, in the event of a failure of the insulation, Regulation 128 (c) says that such efficient means shall be provided in respect of each separate circuit for cutting off all pressure automatically from the affected circuit, and complete protection can only be afforded by the adoption of a "Leakage Protective Device."

Leakage protection was at one time looked upon as unnecessary for collieries, but it is now included everywhere as a necessary requirement. A system may have automatic overload protection which may be fitted with graded time lags, but that will only operate with overloads or short circuits. If the installation be fitted with a leakage protective device a faulty circuit may be isolated before the fault develops into a short circuit, say when the fault is about 5 per cent. of the full load current. In passing, leakage indicators are not applicable to a system with one pole permanently earthed, such as the concentric system; with that system the only way to measure the insulation resistance is by shutting off the pressure and then carrying out the usual tests.

Leakage indicators, whatever the type used, give an early warning of a breakdown of the insulation. A chart type leakage recorder is invaluable at a colliery especially on low and medium pressure systems where leakages are often caused by moisture and can be detected in an early stage; also when a flashover to earth happened that would also be recorded and could be remedied before the insulation broke down entirely. They also enable the man in charge to see what has happened in his absence. A recording leakage indicator is the beginning of economy.

The earthing system of an electrical installation should be treated with the same care as the live system and if dealt with in this manner will result in an all round gain in the efficiency of the installation and infrequent breakdowns. Faults to earth are one of the problems the electrical engineer has to contend with in maintenance, for if faults to earth are not quickly put right, they develop into short circuits and a great deal of unnecessary damage is done before the usual simple overload protection can come into action.

There are many points from which this subject could be treated: it is here proposed to approach it in the following order:

(1) To give a brief description of a colliery earthing system recently installed and which operates on a three-phase a.c. earthed neutral system and a d.c. twin insulated system.

(2) To deal with some of the various methods of applying leakage protection.

(3) A method of carrying out tests on same.

Description of an Installation.

When a test was being carried out on the earth bar to a temporary earth plate, in order to test the main earth plate which was buried completely out of sight, a resistance of 18 ohms was obtained The temporary earth connection (a 10-inch C.I. pipe discharging water from the shaft pump into the cooling ponds) was examined and was found in order, but in following the cable leading from the earth bus-bar to the earth plate, which also was partially buried, it was found to terminate suddenly in the ground about 20 yards from power station. This had the effect of introducing a new earthing arrangement or position.

There are several points to be conisdered when installing an earthing system. For instance, the electrical conductivity of the ground varies very much, especially near the surface, so that a most suitable position to provide an efficient earth had to be looked for. This position could only be selected by testing at various points so that a good connection to the mass of earth was obtainable, thus making the earthing system as reliable as the live system. A suitable place was selected between the power station and the cooling ponds. Then the method of connecting to the mass of earth had to be considered; whether it should be by means of plates or pipes, and the advantages and disadvantages of each. In this case plates were not considered, due to the fact that the former earthing system had been of the plate type and the plate being buried completely had, without betraying the fact, become severed from the earth bar. It was, therefore, decided to use pipes.

Two cast iron pipes 16 ins. dia., 12 ft. long, were buried in coke breeze in an upright position 10 yards apart, about 2 ft. of the pipes being left visible above the ground. The top flanges of the two pipes were cleaned and each pipe was tested for conductivity to earth with the cast iron discharge pipe from shaft pump, the test figures were:—

Pipe A ... 2 ohms. Pipe B ... 2.3 ohms.

The top flanges were then connected with a copper bar $2\frac{1}{2}$ ins. by $\frac{1}{2}$ in. and from that bar an insulated cable was led into the power station and connected to an earth bus bar mounted in the wall for distributing to the various feeder cables, generators, etc. This arrangement is shewn in the diagram, Fig. 1. The

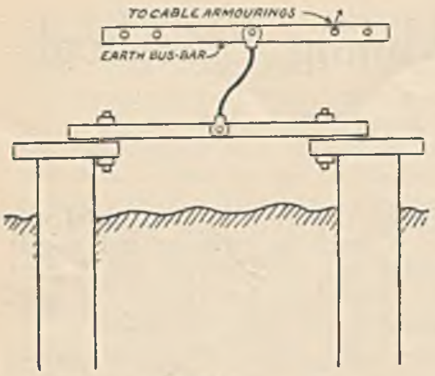

Fig. 1.

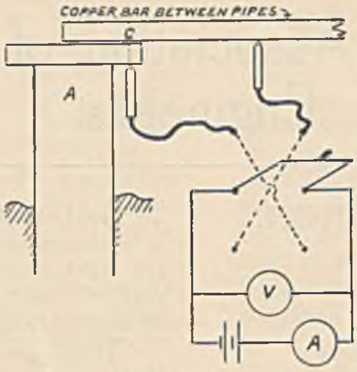

Fig. 2.

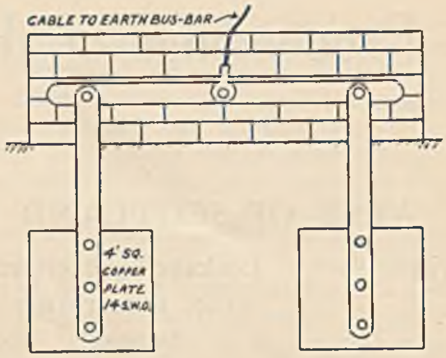

Fig. 3.

object of connecting the pipes in this manner was so that they could be disconnected alternately and tested with the arrangement, shewn in the diagram, Fig. 2 which is the method recommended by H.M. Electrical Inspector of Mines.

With this simple yet efficient arrangement the binding bolt C between the copper bar and the pipe A is taken out, the contact spikes held in position and with a four volt accumulator a current of say four amperes flow, shewing that the earth contact resistance of the pipe A is one ohm.

When installing an earthing system if plates are decided on instead of pipes, the author would suggest that a frame be erected above the plates and copper bars be brought up from them above the surface of the ground; that arrangement would make the connections visible and the cable to the earth bus-bars could then be run in a proper manner. Throughout its entire length a brick wall could also be built round the connections, such as is shewn in Fig. 3.

On the a.c. system a limiting resistance was inserted, made up of grids with a resistance of five ohms, in the neutral point connection to the earth bus-bar, to limit the flow of current in the event of a leakage, the resistance being of such capacity as to allow sufficient current to flow so as to operate the trip on the main switch in the event of a faulty phase.

In the substation at pit bottom a range of oil-break 200 ampere switch panels was erected, each fitted with no-volt release, overload trips, and leakage protection, so that a fault to earth occurring in any section cut off the pressure from the faulty district only. The leakage protection in each pillar was on the core-balance principle which provides instantaneous isolation of a circuit on the occurrence of a fault to earth. The fundamental principle of this aparatus is that if there be no leakage, the algebraic sum of the currents flowing at any moment in the three conductors of a three-phase system is zero, but should a fault occur between one conductor and earth this balance would be upset and a current induced in the tripping circuit which would trip the circuit breaker provided the leakage current exceeded a predetermined amount.

On the d.c. system an indicator was in operation, the principle being as follows. A high resistance of 2000 ohms was connected across the mains, and the instrument of the moving-coil type connected between the mid point of this resistance and earth. The makers supply a table of values with the meter from which the insulation resistance of both mains can be read at a glance.

In passing, it is desirable to mention that lighting systems at collieries and large works should be installed in the same manner as power systems. Reports shew that 75 per cent. of electric shock accidents come from lighting apparatus. At distributing boards very few systems bond conduits together and connect that bonding network to the armour of the incoming feeder. Armoured cable is very suitable for lighting systems and every fitting should be bonded. At the above-mentioned installation a leakage detector was fitted to the lighting switchboard and readings taken daily. A test was made lately at another colliery on a lighting switchboard with conduit and on which no bonds were fitted with the results shewn in Table I.

Method of Leakage Protection.

On a three-phase insulated system, when one phase becomes earthed there is no danger until another phase earths, then it is a short circuit

On a three-phase system with neutral point earthed, one phase becoming earthed causes a short between the earthed phase and the neutral point which acts as a short circuit.

The earliest stage, or the simplest form of a leakage detector or indicators for a three-phase a.c. system, is by means of a set of lamps suitably connected and placed in a prominent position to attract the attention of the attendant. The lamps are connected as shewn in Fig. 4.

On a.c. systems at present the most prominent method of protection against faults to earth is "The Core Balance System", which provides instantaneous isolation of a circuit on the occurrence of a leakage to earth. It is inoperative on ordinary overloads and it also has the advantage that no pilot wires are required. In operation, if at any time the resultant current changes from zero then a current will flow in the secondary circuit and bring the circuit breaker into action. This system can be used on any type of switchgear, and to facilitate the introduction of the necessary apparatus in a compact form into any circuit switchgear manufacturers are supplying a three-phase transformer enclosed

TABLE I.

EARTH LOG SHEET.

Date	*Exact Sectional Position.*	*No. of Feeders.*	*Readings from Ingoing to Outgoing Feeders.*
12/6/30 ...	Pithead	. 6 ...	From Incoming to 1st Outgoing = 30 megohms.
			From Incoming to 2nd Outgoing = 6 megohms.
			From Incoming to 3rd Outgoing = 6 megohms.
			From Incoming to 4th Outgoing = .2 megohm.

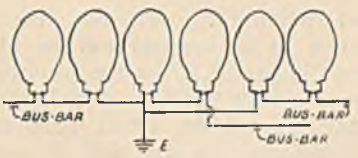

Fig. 4.

in an iron case with convenient terminals. This arrangement could be used on any feeder cable or road cable underground where a fall from the roof may burst the cable and become dangerous, when if core balance protection is in operation, one core becoming earthed causes the transformer to be unbalanced and the switch operates.

The core-balance leakage transformer has a single core wound with three primary windings, each connected in series with one phase of a feeder, and one secondary winding connected either direct to the trip coil or to a relay, the operation of which completes the trip coil circuit.

Fig. 5 illustrates the first method which is directly operated without a relay. With this arrangement and a $2\frac{1}{2}$ ampere trip-coil connected in the secondary circuit, a leakage current to earth equal to approximately 50 per cent. of full load current rating of the core balance transformer, will trip the circuit breaker. With a 5 ampere trip-coil, tripping occurs with a leakage current equal to approximately 100 per cent. of the full load current rating of the core balance transformer.

The connections for this method when operating with a relay are shewn in Fig. 6. This arrangement makes it possible to arrange for tripping with leakage currents varying from 5 per cent. to 100 per cent. of the full load current rating of the core balance transformer. Two types of relays may be used according to the tripping range required. The standard type relay with its two operating coils connected in parallel has a tripping range, adjustable by varying the setting, between 5 per cent. and 8 per cent. approximately. By connecting the coils in series it is possible to increase the range up to 10 per cent. of the normal current rating of the core balance transformer used. The other type of relay is variable having a tripping range adjustable between 25 per cent. and 100 per cent. of the core balance transformer rating.

One objection to core-balance leakage protection is that the current transformers may vary slightly and cause operation without a fault. It is also possible that the current transformers might in course of time grow out of balance due to rust on the iron circuits: it is therefore desirable that the cores should be varnished or oil-immersed.

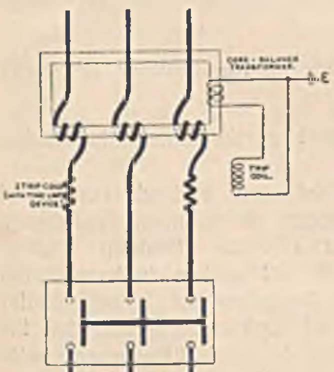
Fig. 5.

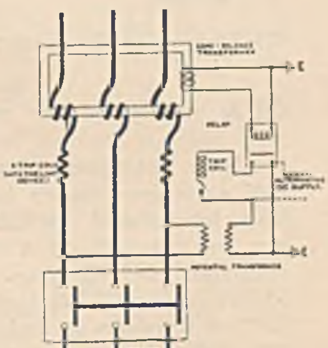
Fig. 6.

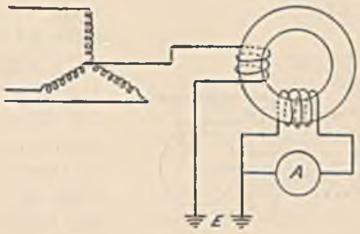

Fig 7.

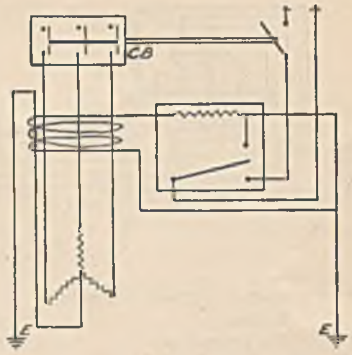

Fig. 8.

Another arrangement commonly used when the neutral point is earthed is to connect a current transformer between the star point and the earth bar and introduce an ammeter in the connection (Fig. 7). An automatic switch is usually provided which cuts out the ameter when a fault occurs and closes contacts provided to ring a warning bell. This arrangement can therefore be adapted to act either as an audible or visible indicator, or both.

Another device known as the "Field" system of earth protection is a simple and efficient arrangement. Connections are taken from the machine winding and pass through one current transformer also through the neutral point before being earthed (Fig. 8). Under ordinary conditions the sum of the currents in the transformer is zero and no current is induced in the secondary winding until a fault to earth upsets the balance, creating a secondary current.

The "Winhey" detector is a self-contained fitment which can be set to operate with maximum leakage current allowed and will operate by the accidental contact of a person touching a live conductor. The device consists of a pair of coils wound on a laminated core connected on one side direct to earth and on the other to a plug board through which connection can be made to the neutral points of the generators or to a leakage indicator which will indicate the amount of leakage. There is also a relay which operates a trip that acts on the main switches of the power system. This detector operates whenever a sufficient current passes through its coils and it can be made extremely sensitive so that it will operate with much less leakage than is permissible under existing regulations. In fact, it will attract its armature when a person comes into contact with a live conductor. This action will immediately cut off the current, thereby preventing severe shocks and fire risks caused through leakage. The armature of the detector has a contact-making piece which serves to close the local circuit of the relay, thus operating a trip. When this latter draws up its armature it closes a 230 volt alternating current circuit which includes the coil of the tripping device. With this arrangement the detector remains inoperative so long as there is no noticeable leakage on the system. This detector can also be adapted to a continuous-current system in which there is no neutral point to be earth connected.

Coalcutter Protection.

It is now recognised that more than overload protection for coalcutters is desired especially on a.c. systems and in view of that leading firms specialising in coalcutters and switchgear for the same are now bringing forward gate-end circuit breakers fitted with earth protection. Anderson Boyes & Co. are fitting a.c. circuit breakers with the Williams-Rowley system of earth circuit protection which overcomes all the difficulties of

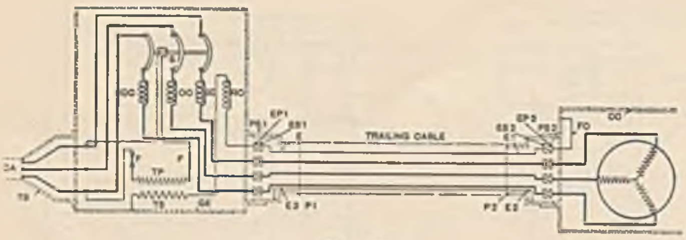

Fig. 9.

GE	Gate-End Circuit Breaker Casing.	**F**	Auxiliary Fuses in Transformer.
CA	Cable Armouring.	**OC**	Overload Trip Coils.
CC	Coal Cutter Frame.	**P1**	Plug Gate-End.
EP1	Pilot Contact Pin Gate-End.	**P2**	Plug Cutter-End.
EP2	Pilot Contact Pin Cutter-End.	**PS1**	Socket Gate-End.
ES1	Pilot Contact Tube Gate-End.	**PS2**	Socket Cutter-End.
ES2	Pilot Contact Tube Cutter-End.	**RC**	Retaining Coil.
E	Pilot Core.	**S**	Auxiliary Switch in Transformer.
E1	Pilot Core.	**TP**	Transformer Primary.
E2	Main Earth Core.	**TS**	Transformer Secondary.
E3	Main Earth Core.	**TB**	Trifurcating Box.
FC	Connection to Cutter Frame.		

efficiently protecting portable machinery and which thus prevents accidents due to defective earthing of coal-cutters and which, furthermore, renders it impossible to withdraw live plugs from their receptacles.

Mounted in the circuit breaker case, Fig. 9, is a potential transformer, T.P., T.S.; the secondary circuit TS is in series with a retaining coil RC, and with contacts necessary for effective earthing. If all of these contacts are not properly made, the functioning of the retaining coil prevents the circuit breaker from being closed. When the plug P_1 of the plug and socket is being attached, it engages with the frame PS_1, this making contact first. When this plug is screwed right home a second set of contacts ES_1 and EP_1, are engaged, which complete the earth connections at the gate-end circuit breaker. It will be seen that in this way the earth connection to frame is made first and broken last. The closing of the circuit breaker depends on the action of the retaining coil RC which is energised only when the plugs at the gate-end circuit breaker and at the coal cutter are both right home. When both plugs are home the earth circuit is established through the retaining coil and the plugs as follows: from EP_1 at the gate-end circuit breaker to ES_1 and then through core E in trailing cable to E_1, ES_2, EP_2, and to the coalcutter frame CC through FC, thence returning through PS_2, P_2 and E_2 to the gate-end circuit breaker as E_3, which connects to P_1, and continuing through PS_1 and the frame GW of the gate-end circuit breaker, completes the circuit through TS and retaining coil RC back to EP_1. The continuity of this circuit is the essence of the device, as a certain amount of current is required to actuate the retaining coil. Should the resistance in the earth circuit be increased above a safe limit, through faulty contacts or a broken earth core, the retaining coil releases the circuit breaker and isolates the circuit immediately. When the supply of current to the gate-end circuit breaker is cut off, the current actuating the retaining device is also cut off, causing the circuit breaker to trip. Again, the same result is produced if any attempt is made to withdraw either of the plugs because one side of the earth circuit is then broken.

D.C. Systems.

On a two-wire insulated direct current system there is no danger attached to an earth on one conductor until the other conductor becomes earthed. This second earth causes a short circuit. A rough indication of the state of the insulation of the system can be obtained by placing two lamps in series across the bus-bars with a central connection to earth ; but beyond giving a warning it gives no indication of the actual extent of the leakage. The usual indicator for d.c. work is composed of two equal resistances connected across the mains and with an indicating instrument placed in the junction of the resistance to earth ; the instrument is of the moving-coil type. A table of values is supplied with the instrument which gives the reading and the relative insulation resistance of both mains.

The ideal leakage protection apparatus should be designed to operate instantaneously on a leakage current equal to a very small fraction of the normal load current. The Metropolitan-Vickers Electrical Co. produce an arrangement to meet this, under the amplified core-balance system. A feeder cable protected by this core-balance system is automatically isolated at once if the leakage current exceeds a very small pre-arranged value that can be adjusted to suit changing conditions. The principle is that in a thoroughly sound two-wire d.c. system the currents in the positive and negative lines of a feeder are equal, but should a fault to earth occur on one pole and a return circuit be available for the fault current, the balance is disturbed. With this system the unbalanced currents in the faulty feeder operate a differential relay that causes the current breaker to open and to isolate the faulty section. To secure the benefit of low energy loss in the earthing resistance, and to make the apparatus sensitive to small leakage currents, a resistance of high ohmic value is connected across the bus-bars and its midpoint is earthed through a very sensitive relay. In effect each pole is normally earthed through this high resistance and relay. When either core of a feeder becomes earthed a small leakage current flows between the faulty cable and the bus-bar of opposite polarity by way of the earth connection. A leakage current of less than one ampere is sufficient to operate the sensitive relay, which causes the bus-bar on the healthy side of the system to be temporary earthed through a low resistance. The leakage current now automatically increases to a high value, limited only by the resistance of the fault and the limiting resistance, and as it flows through only the faulty core of the faulty feeder, the instantaneous relay on that feeder operates, trips the circuit breaker, and isolates the fault. A complete installation of the amplified core balance system for a two-wire supply consists of

(1) A high resistance (known as the economy resistance, connected across the bus-bars).

(2) A sensitive directional relay or master relay.

(3) A main earthing or limiting resistance to carry large currents.

(4) Two magnetic contactors in the limiting resistance circuit.

(5) A push-button for resetting the automatic device.

With this system clear of earth a steady current of half an ampere passes through the economy resistance. This is designed to have a value of about 2 ohms per volt so that on a 500 volt system it has a total resistance of 1000 ohms. Assuming the largest feeder to have a normal full load of 2000 amperes and that the limiting resistance is designed to carry 300 amperes with 500 volts, the resistance would consequently have a value of 1.66 ohms (Table II.).

TABLE II.

Feeder full load current.	Maximum out-of-balance (or fault) current required to operate relay.	Corresponding maximum fault resistance to earth.
AMPERES.	AMPERES.	OHMS.
2000	300	0
1000	150	1.66
500	75	5
200	30	15
100	15	31.66
50	7.5	65

If on such a system a dead earth should occur on the positive side of a 2000 amp. feeder a current of about one ampere will flow from the fault to earth, through the limiting resistance, the master relay and one half of the economy resistance to the negative bus-bar, while the current in the other half of the resistance will fall to zero. The passage of this current will cause the master relay to operate and to cause the contactor to close, which earths the negative bus-bar through the main resistance. A much heavier current (approximately 300 amps.) will then flow momentarily from the positive bus-bar through the fault and by way of the main resistance and contactor to the negative bus-bar; this current flowing through only one core of the feeder and representing an out-of-balance current of 15 per cent. of the full load current causes the differential relay to operate and immediately the faulty feeder is disconnected.

Methods of Testing.

The carrying out of tests of the conductivity of the earthing system must be done in a systematic manner, otherwise they are not likely to be of much use, and an earth log sheet should be regularly filled up, which will shew at a glance the condition of different sections of feeders. For this purpose an ordinary megger is useless as it will shew continuity across a cable end which may be damp. Different types of instruments can now be got suitable for this purpose. For testing the earth pipes a low reading volt-ammeter is suitable to test as shewn in Fig. 2. This Evershed Continuity Tester may be mentioned as an example; that intrument is suitable for measuring low resistances and is supplied to give readings from 0 to 0.5 ohm with two scale readings so that if the resistance of the conductor is too low to be conveniently read upon the high scale, by rearranging the plugs on the tester the reading can be indicated on the lower scale. A current of from 0.5 to 5 amps. can be passed through the conductor, which ensures good continuity.

To test the continuity of the earthing system, it is not a simple matter nor is it convenient to cut the pressure off at a colliery for a long period and it will be found easier to shut down sections separately to carry out a test. In testing a section the furthest in point of one of the cores should be bridged to the earthing gland. The test will then give a reading equal to the resistance of one core plus that of the armour. Next, the resistance of the core is taken from a cable table and by subtracting that from the first reading the resistance of the armour is given; the armour resistance includes all earth bonds and joint boxes on the feeder such as

Feeder for No. 3 Section: 330 yds., 0.1 sq. in. area.
1st Reading: 1 core + armour = 0.35 ohm.
2nd Reading: 1 core = 0.15 ohm.
Resistance of Armour: 0.2 ohm.

MIDLAND BRANCH.

The monthly meeting of the Midland Branch was held in Mansfield, on May 30th, 1931. Mr. J. B. G. Northcott occupied the Chair in the unavoidable absence of the Branch President, who sent a letter of apology. After the Minutes of the last meeting had been read and confirmed, the following were elected to membership of the Branch: Mr. Cecil H. Hooke, Blidworth, colliery electrician; Mr. Donald Armstrong, B.Sc., Heanor, engineer, Shipley Collieries; Mr. A. Ernest Wilber, Denby, colliery manager.

Mr. Wm. Smith submitted the following problem for discussion.

(P) A Turbo-Alternator Problem.

WILLIAM SMITH.

During the routine examination of the turbo-alternator the insulation on the bearing pedestal No. 1 (see diagram) was found to be faulty. This was renewed, after which it was noticed that a shock was received by the attendant if he stood on the bedplate and touched the cap on the bearing. Voltmeter readings between the main shaft and the bedplate shewed voltages varying from 50 to 60 when the turbine was using High Pressure Steam, and 200 to 250 when the turbine was using Exhaust Steam from the Winding Engines. The turbine is 1250 k.w. Mixed Pressure, driving a 2200 volts, 3-phase, 50 cycles alternator.

The insulation resistance of the machine is quite good.

A milliammeter connected in position F. shewed currents varying from 0 to 15 milliamperes. The turbine was opened out for cleaning, etc., after which the above phenomena ceased, but commenced again after the machine had been on load for ten days. The problem is—Where does the current come from and why does it differ so much according to the two supplies of steam?

Discussion.

Mr. R. WILSON said he had been associated with this particular problem, and the particulars as given by Mr. Smith were absolute facts. Naturally they had some ideas of their own on the subject, but they were only ideas and could not be proved. The facts were reported to the makers of the turbine, who were quite candid about it and said they had never heard of anything like it before. The problem was also put to Professor Bulleid of Nottingham, and he was firmly of opinion that it was due primarily to the generation of frictional electricity due to steam passing through the blades. That theory seemed a very possible one but was rather discounted by the fact that when this turbine was opened out for cleaning the effect disappeared altogether, and, as stated in the paper, did not reassert itself until after about ten days of running service. One would have assumed that if it was due to friction it would have been the same

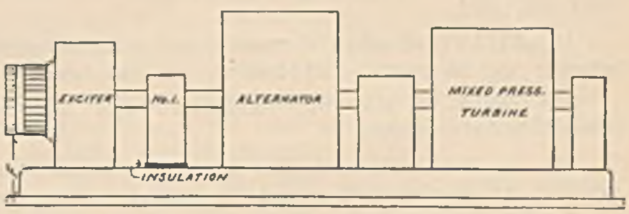

Diagram of the Turbo-Alternator.

one day as another. It was rather interesting to note that the turbine itself has sealing glands on each end of the casing, which were rather different from the majority. The glands have steam sealing of the "Labyrinth" type. The majority of turbines today are fitted with carbon blocks and steam sealed.

An interesting feature to be noted was the large variation in voltage between the two steam supplies. When the turbine was opened up it was really quite clean. There were no signs of any rubbing anywhere, and nothing so far as one could see, could be observed to account for this particular effect.

Mr. FOINETTE asked whether the resistance was measured between the end of the shaft and the bedplate.

Mr. WILSON said they did not try that.

Mr. LANE asked if there was a coupling on the shaft between the exciter and the alternator.

Mr. SMITH.—The exciter was not insulated from the bed plate.

Mr. WILSON said the exciter armature did not come into contact with it at all.

Mr. BALL thought one thing might account for the occurrence disappearing after the turbine being opened up, viz., the blades may have been coated with oxide.

Mr. SMITH said the blading was quite good, shewing very little signs of wear.

Mr. WILSON said they had obtained a static voltmeter from the Nottingham University specially for the job, on the suggestion of the makers. There was another fact, obviously to run the machine under the conditions was very difficult. It was not safe to stand on the bedplate of a 3000 kilowatt machine and get a shock. Every time one touched the bearing one was liable to get hurt, so the shaft was earthed permanently through a brush running on it. It was interesting when the brush was not in position to see the sparking and hear the crackling which occurred between the shaft and the end pillars.

Mr. CHAYTOR asked if he was correct in assuming that the shaft was continuous from the exciter through No. 1 bearing and alternator to the coupling on to the turbine. If so, what was the point in insulating No. 1 bearing? The coupling between the alternator and turbine would give a metal to metal contact and there did not seem any point in insulating No. 1 bearing.

Mr. SMITH said that when the set was running it proved it could not be earthed by their getting this reading.

Mr. CHAYTOR said he could not see any point in insulating No. 1 bearing only, with a continuous metal shaft through the set.

Mr. WILSON said there was a reason for that particular bearing being insulated. It was quite usual to insulate the main frame as a means of ensuring that the iron circuit was broken at one point to prevent getting any circulating currents through the shaft and other bearings. He had one machine with the exciter itself insulated.

Mr. CHAYTOR asked if by any chance the coupling between the alternator and turbine was insulated.

Mr. WILSON said they discovered this business through faulty insulation.

Mr. R. WALKER said that when the turbine was running the whole shaft would be insulated from the bearing by the oil itself. If the bearing was insulated from earth whilst running there would be no shock.

Mr. WRIGHT asked, if the other bearings were insulated by the oil, why was not this one ?

Mr. NORTHCOTT then read an extract from a letter by Mr. Horsley, Chief Electrical Inspector, on the subject, as follows :

"The problem to be presented by Mr. Smith as to the electrostatic charge on the turbo shaft is interesting. Is it not a fact that such electrification is known to be caused much more readily by wet than by dry steam? The remedy would appear to be to earth the rotor shaft to the bedplate by a sliding contact, say a length of chain lying on the shaft. This shaft is more or less insulated, I imagine, by the oil film in the bearings. After standing, during overhaul, this film is broken down, and is again restored when the turbine has been running a short time."

Mr. BULL said he would like an opinion as to the oxide on the blades.

Mr. WILSON said the blading was in such a condition that with the exception of one row they were as clean as new.

Mr. NORTHCOTT asked whether Mr. Smith could say definitely whether this was static electricity or whether it was due to a leakage in the exciter system of the alternator.

Mr. SMITH said he could not think so, as when the load dropped the pressure was gone.

Mr. WILSON said he could not be dogmatic about it, for, after seeing it jump across the shaft he thought the discharge was static, but when it reappeared after ten days he altered his opinion.

Mr. SMITH said he thought the ten days' cessation was due to a tight oil-thrower in one of the bearings.

Mr. HUDSON said with the variation from 50 volts to 200 volts, according to the steam supply, it appeared to be in some way due to the steam.

Mr. WILSON said there was no variation in speed with the change over from one steam to the other.

Mr. SMITH stated the high pressure steam was 150 lbs. and low pressure 3 or 4 lbs. When on very light load the pressure dropped down to as low as 10 volts.

Mr. WILSON said the only guide they had was the crackling sound to be heard on the end cover on the alternator.

Mr. WALKER asked if a moving coil voltmeter gave a reading of 250.

Mr. SMITH said that when the milliammeter was connected in circuit he got a low reading of 2 volts on the change-over. The milliameter reading was maintained for about 24 hours. As soon as the low pressure valve opened, up went the pressure. 250 volts was the highest reading they got both on low pressure and high.

Mr. CHAYTOR said the ten days' period of freedom from the trouble might be accounted for on reassembling the machine, due to the fact that the clearance between shaft and end shields or labyrinth packing was infinitesimal and gave a short path for the discharge to jump direct across to earth at first.

Mr. WILSON said so far as Mr. Horsley's theory was concerned respecting the oil film, he could not quite accept that, and so far as he personally was concerned it was still a problem.

Mr. WILSON said there was another problem ; was the current that they were generating likely to have any harmful effect on the machine itself? That was what they were most concerned about. The trouble had been going on for about six months.

Mr. WALKER said the brush being fitted would not be very helpful to white metal.

Mr. WILSON said so long as the insulation remained good on No. 1 bearing they did not anticipate any trouble from that source. They had put this problem before many people who were likely to be interested, but had not yet elicited any conclusive explanation. Dr. Cotton had expressed the opinion that it was frictional electricity.

Mr. NORTHCOTT said it seemed to be established that it was some effect of the steam. They had had a very interesting discussion, but did not seem able to arrive at any solution.

Mr. WILSON said there was a similar turbine being operated by a firm in London, but not on mixed pressure steam, which had not shewn these effects.

Mr. CHAYTOR asked why not put brass liners under No. 1 bearing instead of insulated liners to prevent, as Mr. Wilson had said they were intended for magnetic circulating currents. He could not see why the frictional electricity, however generated, did not take a path to earth on the one hand through the casing and pipes to earth, and on the other hand, through the shaft and the bearing which was not intentionally insulated, for the thickness of the oil film would not be great enough to prevent sparking over at 200 volts if the journal was properly earthed. It was also possible for the air velocity between rotor and stator of the alternator to generate frictional electricity at high speeds, but this would not account for the difference in potential shewn on the two different classes of steam supply, consequently this could be ruled out in the present instance.

Mr. WALKER asked how long the set had been running.

Mr. SMITH said since 1922 or 1923.

Mr. BULL said it pointed to the fact that the bearing had not been insulated from the bedplate.

Mr. WILSON said it was discovered owing to the fact that the bearing was wearing very badly and pitting. It was now examined regularly and no signs of wear were shewn.

Mr. CHAYTOR proposed a vote of thanks to Mr. Smith, which he said gave him very great pleasure. It was a most interesting problem as evidenced by the lively discussion, but he would have been better satisfied if they had been able to come to a conclusive solution ; not so much as to how the pressure is generated, as this is fairly conclusive from the fact that "the change in steam supply pressure from high pressure to low causes the potential to increase," also the "variation in quantity of steam being consumed makes the stray potential increase with increasing volume of steam used," but as to why it cannot find an easy path to dissipate itself in view of the metallic surroundings connected to earth.

Mr. WRIGHT in seconding said they had had a very enjoyable discussion. They all had ideas of their own and he, too, was sorry they had not solved the problem.

Underground Lighting.

Mr. HUDSON read correspondence on "Underground Lighting," and Mr. Wilson moved a resolution as follows "That the suggested minimum standards as outlined in the memorandum are too low for electric lamps and should be at least doubled." This was seconded by Mr. Wright and carried unanimously.

KENT SUB-BRANCH.

Mine Signalling.

J. G. RUSSELL.

(MEMBER)

(*Paper read 7th February,* 1931.)

Since the earliest days of coal mining some form of signals has been found necessary, and, naturally, until the introduction of electricity the purely mechanical signal held sway. This type of signal even today is extensively used but their use is practically confined to small inbye haulages, mostly of the compressed air "Tugger" type.

Signalling, although in the author's opinion, the cinderella of mining electrical engineering, is a branch which has steadily developed in its own time and along its own lines ; but it is one which has, without a doubt, engaged the attention of some of the best brains of the industry. This fact is never more apparent than when one goes closely into any of the modern systems of shaft signalling.

The author proposes, for the sake of simplicity, to divide his paper into two sections (1) Shaft Signalling, and (2) Plane or Haulage Signalling.

SHAFT SIGNALLING.

There are four points upon which signalling gear should be judged : (1) safety ; (2) simplicity ; (3) robustness ; and (4) ease of operation.

The old type of mechanical rapper certainly possesses the first three of these points : safety, any signal given is given deliberately ; simplicity, the wiring diagram is not too complicated ; and the robustness can hardly be questioned. The point on which they fail is, ease of operation : that is if certain remarks made by onsetters may be taken as evidence.

Dealing with the point of safety, no system has been evolved which can be accurately described as being absolutely safe or foolproof, as the possibility of human failure can never be entirely eliminated. Good class gear of modern design, when properly installed and efficiently maintained, does however appear to be as nearly foolproof as possible.

The next point, simplicity, cannot be too strongly emphasised, and it is the author's opinion that in this respect the modern systems of what might be termed the self-contained type of signals can scarcely be termed simple as their wiring is of necessity very involved. The consequence is that in the event of any trouble arising the electrician responsible for sorting things out is not to be envied with the pit standing, the powers that be asking "What about it ?" and the department stock slumping generally. One might say with all truth that nothing seems to cause such a rapid "breeze-up" as signal failure. The author speaks from experience.

The signals in No. 3 Shaft at Snowdown Colliery are the Sterling Luminous System, which, since its installation approximately five years ago, has given satisfaction. It may, in fact, be said of them that their perfection is their greatest failing as such long periods elapse between faults that the electrician responsible for their maintenance has so little practice in fault finding that he becomes rusty and consequently is not able to locate trouble with the ease with which he could locate a constantly recurring trouble.

It would seem therefore that in modern systems simplicity is compelled to take a secondary position in shaft signalling, but it has its chance and comes to the fore again in haulage work.

The point of robustness is one which has received the close attention of manufacturers and in these days of gear with wide machined flanges, waterproof sealing glands, and generous design, one may be grateful to them for realising that a mining job is one which requires man-size gear.

Ease of operation is a point which has also received close attention, and modern pushes and rappers leave little to be desired. One thing in particular has impressed the author as a credit to the imagination of the designers of several types of rappers: they are designed so that the operator, quite apart from the actual electrical contact made, has a pleasant feeling that he is really doing something. This is usually accomplished by means of a buffer spring, which serves another purpose, and takes the force of the blow if the rapper is violently used.

The high standard of efficiency of modern systems (meaning by this, those systems designed for and used in connection with visual indicators) owe almost everything to the Coal Mines Act of 1911, in Part 2 of which, regulation 92-102, the Home Office laid down the hard and fast rules which are today in force.

To quote the rule which applies in this case, Regulation 95 demands that: "In connection with every winding engine there shall be provided an appliance which shall automatically indicate in a visible manner (in addition to the ordinary signal) the nature of the signal until the signal is complied with."

Prior to this order the winder's job in the average engine house was not a happy one. He had to be continually on the alert, listening intently for any signals given during his wind, whilst the electrician's problem was to discover a bell loud enough to overcome the noise of the engine. The author knows that this difficulty was overcome in a good many cases by lamp arrangements, and considers the electricians of those days, who devised such things on their own initiative, deserve great credit as they had to make shift with any gear available and were not compelled by law to do as we do today.

Following upon the order of 1911, which, in passing, was not enforced until the 1st July, 1914, the mining industry naturally looked to manufacturers for something really well thought out in the way of signalling systems instead of the usual collection of units then in use; it was realised that to meet the requirements of the Act it was necessary to employ apparatus which was really designed for its job and which would withstand that most exacting of tests, viz., working conditions.

The author's first experience of visual signals was with some "Wigan" dial indicators. These indicators are of the accumulative or step-by-step clockface type, and have now been in service for the past fourteen years.

At one time a source of trouble in this type of indicator was the oil dashpot. The oil was sensitive to changes of temperature and quite often an indicator adjusted in the early morning when the oil was cold and sluggish, would by snap-time, when the oil was warm and thin, be registering false signals. This fault has, however, been overcome by the makers who now fit a very efficient air dashpot which is not nearly so temperamental as the old type and which has eliminated the trouble of having frequently to adjust the indicators.

Being of electro-mechanical type, these indicators are dependent upon the ringing of the operators to a greater extent than are the all-electric type, as indicators set for the ringing speed of one operator may be found incorrect for another. This trouble is quite easily overcome by instructing the operators as to the correct ringing speed. By ringing speed is meant the spacing of, or the intervals between, any signal or groups of signals. With this type of indicator failure to maintain a constant working voltage causes more trouble than with an all-electric system as the relays have to perform more mechanical work and are therefore not so sensitive, but in this respect they can hardly be held responsible for neglect on the part of their attendant. One may say that the really efficient working of any system depends very much upon the constant voltage of the power supply.

The "Wigan" people are also the makers of a Luminous Signal Indicator of similar design to the Dials but which is non-accumulative and only displays to the engineman the required signal and not the step-by-step action as in the clockface type.

Another very popular Luminous system which is widely used is the A.T.M. System. An outstanding feature of this system is the ease with which it can be adapted for use with any existing system of audible signals, the alterations required being practically nil. It requires one wire only to each level and a common earth connection, so that it is merely necessary to connect one wire from each level on the indicator to the existing bell line. The indicator can also be readily adapted for use with any existing mechanical pull-bell or rapper system.

The A.T.M. System in its latest form makes a very neat and compact unit, the bottom portion of which contains the switching mechanism and above which rise, one above the other, the eleven luminous panels. The bottom panel indicates the origin of the signal and becomes illuminated with every signal sent from that section or signalling point. The top five panels contain the Home Office code, and the others may be used to suit local conditions. The top panel is divided into two portions marked "Raise" and "Stop" and these respond to one rap, according to the conditions of the engine—whether moving or stationary when the signal is given.

An Emergency "Stop" Signal is fitted to all indicators but the use of this is optional and entails an extra common wire down the shaft to all levels and also extra ringing keys. This would naturally be allowed for when installing a new system but might prove rather awkward if being added to an existing bell circuit.

The one point of this system which more than others commends itself to the author is that it is possible, by depressing a key at the base of the indicator to obtain a luminous repetition of the last signal given. This is exceedingly useful in cases where a signal is disputed and it is a feature which should do much to clear up the origin of those "mysterious" signals which occur in the best of regulated systems.

Before leaving this section of the paper a word or two in connection with the battery arrangements of shaft signals will not be out of place. Controversy still exists as to the relative merits of the central battery and local battery systems. The central battery has much to recommend it as it can be housed in a clean, dry, and convenient position and readily lends itself to frequent inspection. Again, modern practice is to use storage batteries, usually two—one in use and one in the charging—and this idea would be very impracticable in the case of local batteries.

The two chief disadvantages of central batteries are, firstly, if a fault develops the whole of the system is temporarily standing, and, secondly, the full voltage of the battery is ever present in the wiring and shaft cable so that if the insulation of either is down it may lead to electrolysis and leakage. Leakages in the shaft cable may mean the possibility of false signals.

With a well designed system employing local batteries the full voltage is only present when signals are actually being given, and leakage on the shaft cable will not cause false signals if the batteries are arranged correctly.

The author's own opinion is that the advantage of only having to maintain one battery—and that in a convenient and accessible position—easily outweighs the disadvantage (if so it may be termed) of being dependent upon and having to keep up the circuit insulation, which should be an ordinary obligation in any system. The provision of link or terminal boxes at various accessible points in the shaft cable is very good practice, greatly facilitating cable testing and fault locating. It also proves profitable in the long run to take the same care and precautions in installing shaft signal cables as are taken with power cables—in any case the one is not of much use without the other.

PLANE SIGNALLING.

The question of plane, or haulage, signalling is one which has aroused much controversy amongst mining electricians generally, as every individual appears to have his own, in most cases very decided, views upon the matter and is usually quite ready to back his fancy against the other fellow's. As with shaft signalling, however, first cost is a much more important factor than one would at first suppose, especially in these days when the state of the industry is such that all expenses must be fully justified.

The author considers it advisable to commence this section of the paper with a brief outline of the outstanding events in mine signalling during the past few years.

A "Report on Battery Bell Systems 1915" and a "Report on Electric Signalling with Bare Wires 1916" proved that the majority of electric bells then in use caused a breakflash, at the point of contact, quite capable of igniting firedamp. It was found by experiment that this breakflash could be reduced to a safety point by incorporating a safety device in the design of the bell. Of the suggested safety devices for this purpose the three which have come into the most common use are: (1) a non-inductive shunt across the magnet coil; (2) a copper sleeve over the magnet cores; and (3) a closed circuit winding over the magnet core.

Numbers of Bells, after official tests, have been granted the Home Office Certificate of Safety for use with any system up to the maximum pressure of 25 volts permitted by the Regulations (Reg. 134, General Reg. 10/7/13).

Owing to the fact that a great deal of confusion had arisen regarding the interpretation of the term "Certified Bell", a circular No. MD.24 dated 7th July, 1927, was issued by the Home Office which reads as as follows:

"Electric Bells and Relays for Bare Wire Signalling. It has been brought to the notice of the Secretary of State that there is a misapprehension as to the scope of the type tests of electric bells and relays which, on application by the Manufacturers, are carried out at the Mines Department testing station. He desires therefore to make the following statement:—

"The object of these tests is to determine whether a particular type of bell or relay is safe in the sense that the breakflash (whether at the instrument or on the bare wire lines) is incapable of igniting an explosive mixture of firedamp and air, when the source of current is at the maximum pressure permissible for underground signalling, viz., 25 volts. *These tests are carried out with a single bell or relay in the circuit*, and the certificate of safety which is issued if the instrument passes the tests is subject to this limitation. In particular the certificate does not hold good if two or more bells are connected in parallel on the bare wire circuit. In such conditions the breakflash at the bare signal wires is likely to be dangerous, and in any case the margin of safety will be greatly reduced. A different form of circuit, such as will readily suggest itself to electrical engineers, should be adopted in such cases."

This was followed by the "Report on the Safety of Mine Signalling Bells when Connected in Parallel", dated 23/10/28, the publication of which was rather a blow to the bare wire system.

As previously stated expense is nowadays a very important factor, and the initial cheapness and apparent simplicity of maintenance had had much to do with the continued popularity of this system. It does not seem likely that any other system will really oust it from its position for some time to come, although the abolition of bare wires would be followed by a distinct advance in the general efficiency of mine signalling.

One great disadvantage of this system is the constant line leakage which causes deterioration of the battery, and this is greatly aggravated by the increasing use of steel arches on main road and haulage planes.

Another disadvantage is that where a number of bells are connected in parallel, the user is restricted, by the Regulations, to the use of an inferior type of battery and debarred from taking advantage of other sources of power supply which are now coming to the fore.

"A different form of circuit such as will readily suggest itself to electrical engineers" is now the debatable point.

Apart from the three wire bare system incorporating a certified relay, and which actually comes under the heading of "Bare-wire Signalling", these circuits are two in number: (1) the insulated wire system and (2) the electro-mechanical, employing either insulated wires or armoured cables.

From a safety point of view the insulated wire system has much to commend it, but, apart from the difference in cost of the bare and insulated mains, its very great disadvantage is that only from specified stations can signals be transmitted, and one has no hesitation whatever in claiming the necessity of being able to signal from any points of the system along a haulage plane. To enable this to be done on this system would mean the installation of innumerable pushes, which is not a practical proposition, to say nothing of the difficulty of placing them in readily accessible positions.

The second of the suggested circuits is the electro-mechanical system. This is, particularly when employing armoured cable, perhaps the most costly to instal of the three systems dealt with, but it is in the author's opinion very cheaply maintained and extremely efficient.

Maybe the author holds a somewhat biassed view, but he hopes that a brief description of the particular system with which he is familiar may help to strengthen his case.

This system is in operation at Snowdown Colliery and all the necessary fittings have been made on site.

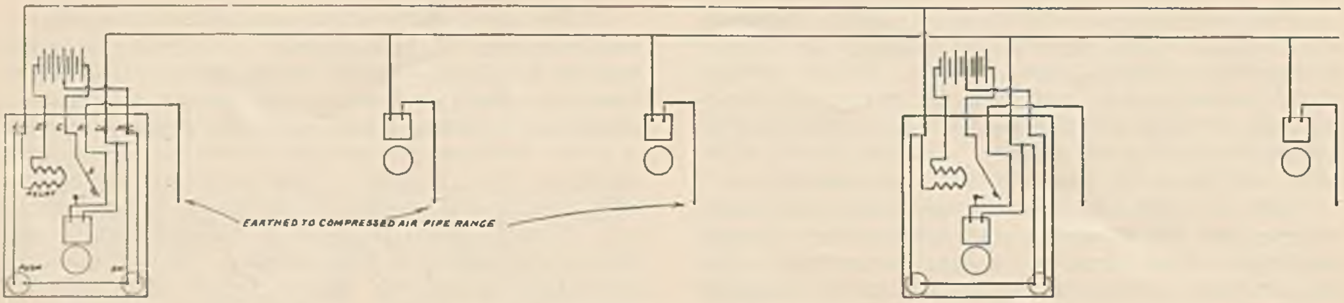

Fig. 1.—Diagram of Two-Wire and Earth Return, with Central Battery.

When haulage signals became necessary it was decided, owing to various reasons, to discard the idea of bare wire signals. The principle reason was that owing to the use of the steel arches and the undulating nature of the roads it was thought that bare wires would be a source of trouble. This belief was, in fact, borne out when the signals were installed on the electro-mechanical principle with insulated wires along the roads, as trouble was caused at various times by the chaffing of the insulation against the arches.

At this time the system was two wire, insulated, using local batteries, relays, and bells at every signalling station. This was changed to a three-wire system with a central battery at the enginehouse and employing only one relay. The contact rappers were connected (as shewn in Fig. 1) across L1 and L2, and the relay brought the bells across L1 and L3. Two wires only were still utilised as L1 and L2, earth return along the compressed air main being used as L3.

This system was maintained until about seven months ago when it became necessary to instal telephones on the districts, and with their installation the present system was adopted and it can quite honestly be said that it has caused little trouble and is very efficient.

When setting out the telephone system it was decided to instal a multi-core cable capable of taking the signals as well as the telephone lines. This cable was run, wherever possible, along the travelling road which, in the case of the West Main Haulage, runs parallel to the haulage plane.

Along some of the roads where the travelling road is not so conveniently situated as on the West District the signal cable follows the track of the power cable along the centre of the road besides the compressed air main.

Ordinary conduit boxes, drilled and fitted with glands in the workshops, were utilised as joint boxes at every junction, and twin armoured cable was taken from these along the connecting roads to the haulage plane (see Fig. 2).

The telephone cable is D.W.A., 10-core or 6-core as the conditions may require, and the armouring is utilised as the earth return (L3) of the three-wire system.

The contact brackets are arranged face-to-face on the junctions, with the pull wires extending along the roads on each side. The junctions being approximately 130 yards apart, the total length of wire operating each rapper is 65 yards and, as shewn in Fig. 2, is kept tensioned by the lead weight on the bell-crank.

The pull wire runs centrally along the road, supported by being slung through reel insulators suspended from the roof, and therefore it is obvious that signals may be given at any point of the haulage plane, from the safest position, i.e., the centre of the road, which, when arches are used, is also the highest point.

The rapper brackets are made in the shops of 1½ ins. by ¼ in. angle iron, the depth of the bracket being 17 inches. The bell-cranks are forged in the smiths' shop and the lead weights are moulded and secured by a bolt through the crank. They are fitted with irons to clamp over the steel arches, a wooden pad, ½ in. in thickness, being fitted between the bracket and the arch to ensure a tight fit. Originally the brackets were made to fit across two arches but, owing to the movement of the arches distorting and twisting the brackets out of alignment, an alteration was made in design and they now clamp over one arch only.

Other methods of fixing are adopted where arches are not used. For timbered roads a plank is run over the bars and the brackets secured by coachscrews; for junctions where girders are used they are secured by clips which grip the flanges of the girders. Fig. 4 shews a bracket of the ordinary type arranged for fixing on arches.

The rappers used are the well known A.T.M. flameproofs mining type, with the handle guard removed to allow the bell-crank to operate. It may be mentioned in passing, that all instruments used are of A.T.M. manufacture. The relay and the bells are of the certified types, No. T3027 and No. T2017 respectively.

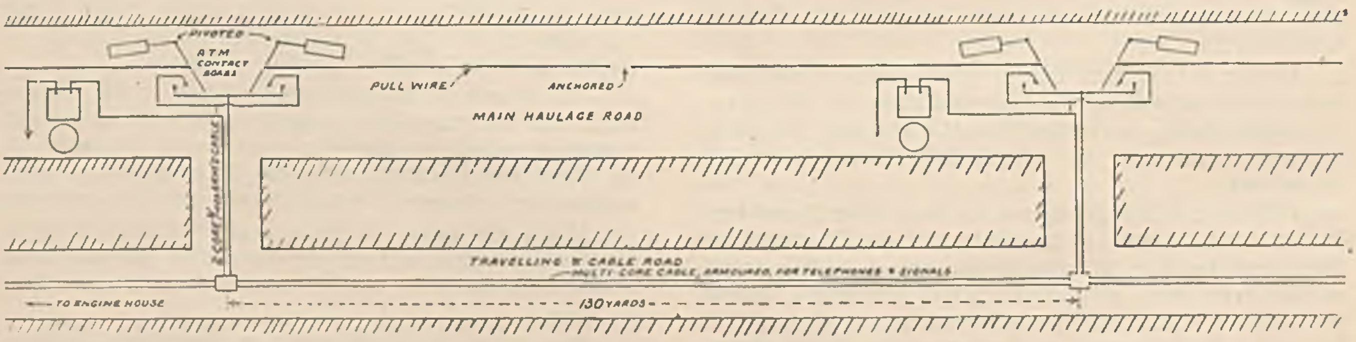

Fig. 2.—Shewing Contact Boxes and Bells at two junctions on Main Haulage Roads

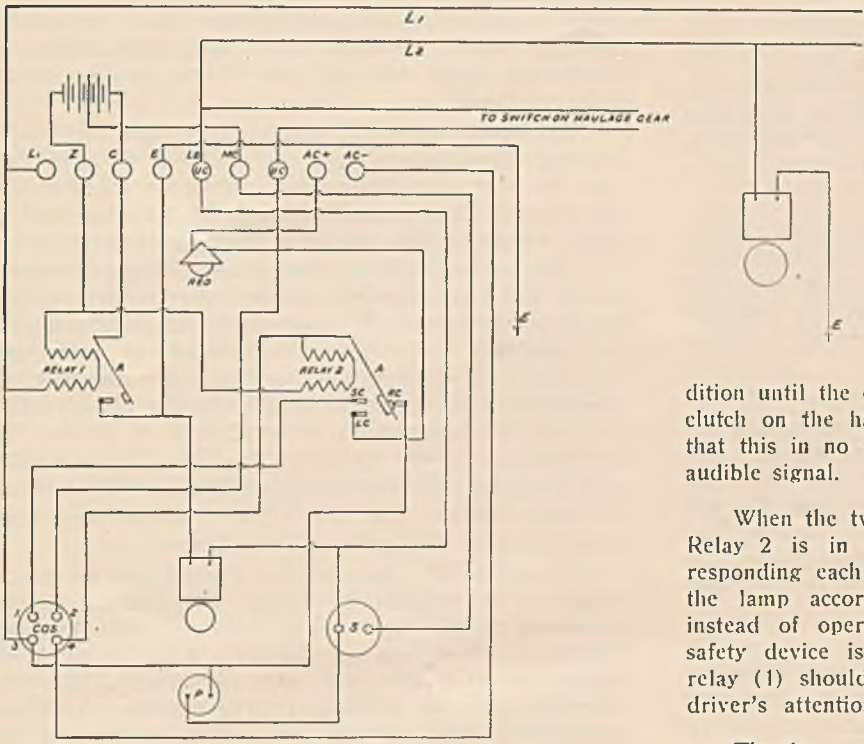

Fig. 3.—Wiring of one board installed in 150 h.p. double drum endless haulage house.

S	Switch.	**P**	Push.
Z	Zinc of Battery.	**SC**	Stick-up Contact.
C	Carbon of Battery.	**LC**	Lamp Contact.
E	Earth.	**UC**	Unlocking Terminals.
MC	4th Carbon from Zinc.	**L1 L2**	Lines.
A	Armature.	**AC +**	Accumulator Pos.
RC	Resting Contact.	**AC—**	Accumulator Neg.
COS	Change over Switch.		

A *and* RC *on Relay* 2 *are made when Relay is at rest and broken when Relay is operated.*

With switch knob of COS *in down position, lamp will be illuminated and remain so until cancelled by haulage.*

With switch knob of COS *up, the lamp will respond to the audible signals.*

The central battery used in the system is housed in a cupboard in the engine house. It is composed of fifteen Leclanché cells, and, should it become necessary owing to the extension of the rope to add to the battery strength, the method of connecting up a boosting battery is as shewn in Fig. 1.

One other point of interest may be worthy of mention. The West Main is served by a 150 h.p. double drum haulage, one drum serves the Main and the other the South-West District. Owing to the noise of the engine there was some risk of the drivers being confused by the two sets of signals necessary for working the two ropes, and so the following scheme was evolved. An additional relay was fitted to each of the signal boards, wired in parallel with the line relays, and this additional relay brought into action coloured lamps. These lamps, coloured red for the Main, and green for the South-West, serve as a visible indicator for the drivers' guidance (See Fig. 3).

When the two top contacts, 1 and 2, on the changeover switch are bridged, a preparing circuit for Relay 2 is provided *via* No. 3 contact of COS, RC, and A on Relay 2. This relay closes when L 1 and L 2 are shorted. When Relay 2 is operated it is held in a locked position by positive current fed from MC, *via* Switch, L 2, Unlocking Switch, and back through contacts 1 and 2 of COS, thereby holding on the light irrespective of any other signals given. It will remain in that condition until the circuit is opened by the operation of the clutch on the haulage; and, moreover, it will be seen that this in no way interferes with the operation of the audible signal.

When the two bottom contacts on COS are bridged, Relay 2 is in simple parallel with Relay 1, thereby responding each time a signal is given and illuminating the lamp accordingly. By paralleling Relays 1 and 2 instead of operating Relay 2 from Relay 1, a further safety device is added to the system, as, if the line relay (1) should fail, the visible signal will attract the driver's attention.

The lamp used in the above system is a two-volt miners' lamp bulb, enclosed by a coloured well glass which is hermetically sealed, and is fed from a two-volt miners' lamp accumulator.

There are many other systems and methods of signalling which naturally cannot be gone into by a paper of this description, but one particularly which is receiving the close attention of mining engineers is the use of a.c. signalling by means of transformers and magneto bells. This, however, is sufficiently interesting in itself to form the subject of another paper.

In conclusion, with haulage signalling as with shaft signalling, a system that is worth installing is worth installing well, and care taken in installation will be amply repaid in maintenance.

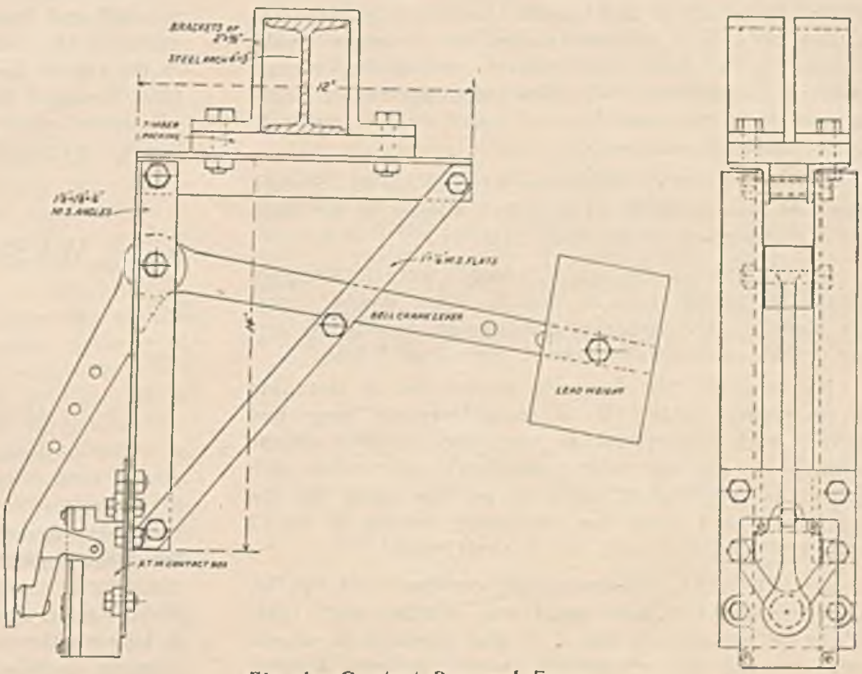

Fig. 4.—Contact Box and Frame.

Discussion.

Mr. COOPER.—Referring to cables for shaft signalling ; it was the usual practice to have an emergency signal. Would Mr. Russell suggest that the lines used for operating the emergency signal were incorporated in the shaft signal cable, or would he prefer to run a separate cable for this purpose ?

Referring to self-recording charts for shaft signals, which record all signals. Many people now fitted these, but he had put the matter before some colliery managers who objected to them on the grounds that they restricted output. He would like to have Mr. Russell's opinion on this subject.

Mr. KING.—Is it the case, in every make of shaft signals, as regards the indicator, that when men are riding they all in some way or another signal "Men on", and this signal remains on from the very commencement of the wind the whole of the time the men are riding in the shaft ? It sometimes happens that while the men are riding somebody rings "One" to stop, does this "One" remain on after the stop irrespective of the action of the engine ?

Mr. BARNEY.—Would Mr. Russell express his opinion as to the merits of purely luminous signalling as opposed to dial signals ? No doubt the first cost of the former was higher, but Mr. Barney considered the extra coal wound would pay for this.

Mr. Barney agreed that the use of a central Battery was good, and he would ask Mr. Russell's opinion as to whether primary batteries or accumulators were preferable.

Would Mr. Russell consider it possible to use wireless for shaft signalling ? This would probably save a good deal of expense and charges for shaft cables. He had personally tested portable wireless sets in Mexico on the oilfields and found them to work satisfactorily. He had read that miners had "listened-in" at the bottom of the pit, so his suggestion was probably workable. No doubt it would still be necessary to have emergency cables as before, but it would be possible to dispense with a quantity of cables.

Mr. HOWARD.—Would Mr. Russell say what, in his opinion, is the best type of rapper as regards safety in mechanical action and making contact. Quoting particulars of a fatal accident caused by a rapper handle catching in a man's coat pocket and giving signals unknown to the man, Mr. Howard suggested it might be possible to put some form of guard on the rapper to obviate such an occurrence.

Mr. GREGORY.—Referring to the A.T.M. System, does this system check its own bell signals in the same way as described with other systems ?

Mr. FORD.—If the signal "Stop" were to be given whilst the engine was in motion, what would cancel this signal ? By virtue of the engine coming to rest would that automatically release the signal "Stop" ?

Referring to Mr. Cooper's remarks as to installing an emergency cable ; it is compulsory to have two shafts in each colliery, and he considered the best scheme would be to put one multi-core signal cable down each shaft ; the No. 1 shaft cable to provide cores for the main signal and cores for emergency signals of No. 2 shaft, and similarly with No. 2 shaft cable.

Mr. RUSSELL, answering the questions put by Mr. Cooper, said : the main point was whether first costs had to be considered, but if it was possible he would prefer to run the emergency signals through another cable. He added that all collieries had two shafts, and he would run cables down each shaft taking the emergency signal for one shaft down the line of the other shaft.

Personally he would adopt any system that would register signals given from any point, as he considered that in many cases it would be the means of absolving an innocent man from blame. It would also tend to make onsetters and banksmen more particular.

The method used was to convert old fire cupboards which had three shelves and the batteries were housed on these shelves. In this case one could see at a glance the condition of the cells, the level of the water, and whether they required cleaning out, etc. He certainly considered that wherever possible it was an advantage to have the batteries so arranged.

Replying to Mr. King, Mr. Russell said the "One" would remain on. He considered it should become part of every system that the "One" should remain on irrespective of the action of the Engine.

Answering Mr. Barney : Mr. Russell said he had no hesitation in deciding in favour of luminous signals. Referring to the type he was connected with, the only trouble they had had was due to a defect in the cable caused by a navvy's pick, and any trouble had been outweighed by the advantages. His own preference was certainly to instal the luminous system whenever it was possible to do so.

He had experienced no trouble with the central battery, and he would always instal this system. The only system which might be preferable would be a power set worked by a motor-generator set.

With regard to wireless, he had personally never heard of any system or invention, neither did he know of any schemes having been experimented with for shaft signals. He did know that in pre-war days at a certain colliery German engineers were experimenting with a system of wireless signalling underground, but he did not know what success was attained. Personally he considered that if such a thing became practicable in a form which could hope to compete with the most expensive of luminous systems it certainly would be a great advantage.

The accident described by Mr. Howard was very unusual and something which could hardly be guarded against. He could not see how a guard could be fitted to the rapper handle unless it was something in the form of a spring. Mr. Russell then gave details of a type of rapper which was now on the market, which incorporated a spring as a form of guard.

WESTERN SUB-BRANCH.

Electrical Drives.

(P)

C. E. YATES.

(MEMBER)

(Paper read 27th January, 1931.)

The problems connected with the transmission of power, form what is probably one of the oldest branches of mechanical science, and the question of harnessing the power developed by the driving unit is still one of the most important of those with which the modern engineer is confronted. Although not strictly an electrical matter, the electrical engineer has to understand it because the efficiency of any motor-driven installation depends largely upon the means adopted to link up the motor with the machine which it has to drive. Furthermore, apart from the question of over-all efficiency, it is necessary to consider the effect which the type of drive adopted may have upon the motor itself. It is an undeniable fact that a considerable percentage of electrical breakdowns are traceable to vibration, transmitted through the coupling medium to the motor.

Vibration is responsible for the core-plates of armatures and rotors becoming loose upon their shafts; in d.c. machines a loose commutator often results from the same cause; broken commutator lugs are also caused by vibration; armature conductors frequently break off from their connection to the commutator lug for the same reason; and vibration, together with the centrifugal tension which the windings of armatures and rotors are subject to when rotating at high speeds, may quite reasonably be held responsible for many insulation failures, apart from the common trouble of spark-wear on commutators and sliprings which vibration produces.

The ideal electrical drive, therefore, would appear to be one which did not create any vibration or shock: and one which did not permit vibration or shock set up in the driven machine to be transmitted to the driving motor. Severely strict adherence to this principle would mean that we should confine ourselves to the use of one of the non-positive group of drives which includes the various kinds of beltings and ropes. That restriction is not practicable as considerations of efficiency and economy of space compel the use of the more positive drives, which comprise toothed gearing, chains, and couplings.

All systems of power transmission possess certain disadvantages, some of which are quite obvious, whilst others are only revealed after the close acquaintance which is brought about by practical experience. The object of this paper is to review the various transmission systems in common use, and leave the members to give in discussion particular accounts of their practical experiences.

The various drives commonly in use may be divided into two main groups; i.e., Non-Positive Drives which include Belting and Ropes, and Positive Drives, comprising Gearing, Chains, and Couplings.

BELTING.

Under the non-positive class the first consideration will be given to what is undoubtedly the oldest form of power transmission—Belting, of which there are six main kinds in common use, i.e.. Leather, Balata, Rubber, Woven Hair, Stitched Cotton and Woven Cotton.

Leather belting is made from ox-hide, the portion used being that which covers the backbone. In process of manufacture the hide is first tanned and afterwards impregnated with cod-oil and tallow, which is applied whilst the leather is still wet from the tanning vats, the subsequent evaporation of the water drawing the oil and tallow into the leather. After scouring and stretching, the leather is left to season in a further dressing of oil and tallow for some months, after which it is cut into strips ready for making up into belting. It is obvious that as no strip of ox-hide can be longer than about 4$\frac{1}{2}$ feet, a leather belt must contain a number of joints, and various jointing methods have been in use including lacing, stitching with copper wire and cementing, but the latest method is to use cementing only which gives a perfectly smooth joint, eminently suitable for high speed electrical drives.

Rubber belting consists of layers of cotton duck, spread thinly with rubber, several layers being placed together and the whole vulcanised under heat and pressure. It is used very extensively as a conveyor belting, but has only a limited use as a driving belt.

Balata belting is built up of layers of cotton duck cemented together with a vegetable gum extracted from trees found in the forests of South America. It has been suggested that the inventors first got the idea by observing the durability of the war shields of certain tribes of South American Indians, which were made of hides, stuck together with Balata gum, and have been found in an excellent state of preservation after centuries of exposure to a tropical climate. The distinguishing properties of Balata belting are toughness, lack of permanent elasticity, weatherproofness and general durability.

Woven hair belting is woven with the warp threads of animal hair, usually from the camel and goat and the weft threads of cotton. The belt is made up of about six plies, and has a cotton face which gives good grip on the pulley faces. It is tremendously strong and is much used for heavy drives in cotton mills, etc. Where a belting is required to resist the action of acid fumes, the cotton weft is omitted and the belt is woven entirely of hair.

Stitched cotton belting is largely used for driving agricultural machinery and is made by stitching together several layers of cotton duck. This belting is reasonable in price, but stretches considerably.

Woven cotton belting is made in exactly the same way as hair belting, but has warp and weft of cotton only. It is very strong, resistent to alkalis, useless in acid fumes, and is inelastic.

The simple diagram, Fig. 1, shews two pulleys coupled together by a drive belt. The forces which act upon the belt in motion are these:

(1) *Driving Tension.*—The right-hand pulley, being the driver, and the direction of rotation that indicated by arrows, the driven pulley is pulled around by the belt as the driver pulley rotates, owing to the frictional grip of belt on the pulley faces. This produces a difference of tension between the tight side of the belt and the slack side, and the ratio of the difference between these two is the effective driving tension, which is the force available to meet the load. It is obviously desirable to make this ratio as high as possible, and this can be done by selecting a belt material of the best possible frictional value, and designing the drive to give the greatest possible arc of contact between belt and pulleys, the accepted minimum being $\frac{3}{8}$ths of the pulley circumference.

(2) *Centrifugal Tension.*—Owing to the weight of the belt, and its speed, centrifugal tension creates the tendency for a belt in motion to fly away from the pulley faces, and if the belt possessed sufficient weight and elasticity, a speed might be reached where the belt would leave the pulleys and no power could be transmitted. The initial tension, i.e., the tension of the belt when stationary, must be sufficiently high to prevent this.

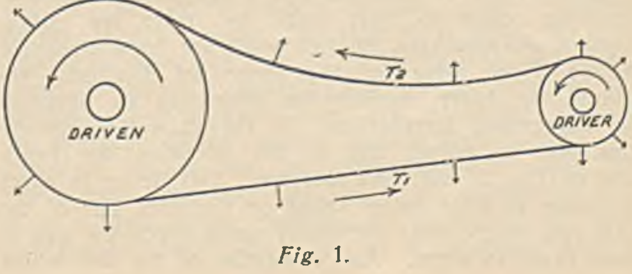

Fig. 1.

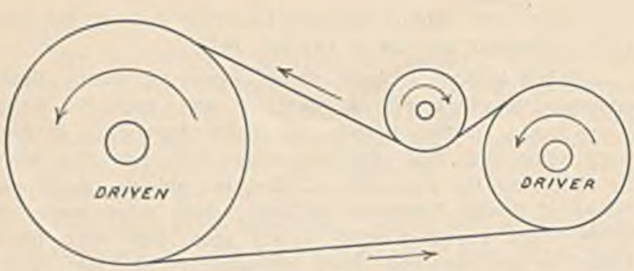

Fig. 2.

(3) *Slip.*—Slip occurs through overloading the belt. If the driven pulley were held stationary and an attempt made to rotate the driver, there would be an increase in the tension T1 and a corresponding decrease in the tension T2. The increase in the difference of the two tension values gives an increased effective driving tension, but if this were persisted in, a point would be reached where the friction grip of belt to pulley would be overcome and we should get slip.

(4) *Creep.*—Creep is an entirely different thing. Considering any section of the belt, that section will be elongated to a greater extent when on the tight side of the belt, than on the slack side. As this section of the belt passes around the pulley it changes its length, and it is just this transition which produces what is known as "creep", which in effect gives a slight relative movement between the pulley face and the belt, and which may be responsible for as much as 1 per cent. transmission loss.

The main points to be observed in designing an electrical drive by means of belting are :—

(1) Design the drive to avoid the necessity for tightening the belt to excess. This means getting sufficient distance between the centres of the driving and driven pulleys (which should never be less than 12 feet for light drives, and 20 feet for heavy drives), and by using a wide, thin, belt. Too tight a belt is a common cause of trouble with rotor bearings, and may result in a bent rotor shaft.

(2) Use pulleys of the largest possible diameters consistent with the recognised maximum limit of belt speed, which is about 5000 feet per minute. This will give better frictional contact than is possible with small pulleys, and a corresponding reduction in losses. The ratio of pulley diameters for all ordinary drives should not be higher than 6 to 1.

(3) Use belt fasteners which will minimise "jump" as the joint passes over the pulley. The author is, personally, not a great believer in spliced endless belts, and has found that a belt joined by means of good fasteners is the most durable and effective for motor drives. The question of jointing is an important one, as the jump of a bad joint is a common cause of electrical trouble. On d.c. machines, flats are formed on commutators as the brushes are jarred each time the belt-joint jumps the pulley. A belt-drive, designed with due observance of these rules is a satisfactory means of coupling motors to their loads, but there are certain obvious disadvantages, chief of which are the non-positive nature of the drive and the amount of floor-space required, the latter consideration restricting its adoption for uderground installations. In the attempt to remedy this, and to reduce slip to the minimum the Lenix system (Fig. 2) has come into use. This device in effect is simply an idler pulley acting on the slack side of the belt, and placed near the pulley upon which the slip is most likely to occur. Any elongation of the belt which would under ordinary circumstances cause the belt to slip, with the Lenix drive merely allows the idler to move nearer the centre line and so increase the arc of contact. For this arrangement the belt-length should be such that the distance between the tight and slack sides at their nearest point is equal to the radius of the smaller pulley. By this method, the pulley ratios, which for ordinary drives should not exceed 6 to 1, have been increased to as much as 30 to 1—an important consideration where a high-speed motor is to be used, and a large reduction in speed required. This method also permits of shorter driving centres. The disadvantages of the Lenix system are, that a smooth joint is essential and the life of the belt is reduced as both sides are under pulley-wear, and there is a constant reversal of bending.

There has recently been introduced a belting which consists of an ordinary balata belt, on the under side of which is rivetted narrow strips of soft chrome-tanned leather in a longitudinal direction. Small spaces are left between the leather strips permitting the free passage of air, and the depression at the rivet points form pockets which, acting as air-suckers, increase the grip on the pulley face. The balata gives the necessary strength, and the soft-leather strips the frictional grip ; the effect is a belt which can be run at a low tension, and with shorter centre distances than are permissible with ordinary balata belting.

COTTON ROPES.

Considering rope drives, these notes will be restricted to a description of drives using cotton ropes, with a brief reference to one or two textile ropes which are receiving some attention at the present time. Whilst hemp and manilla ropes may be employed, the principles are the same as those which govern the use of cotton ropes, and it is not necessary to discourse upon the respective merits of the materials which may be employed. Belting transmits power, by the resistance due to frictional contact between belt and pulley-faces. In rope drives this resistance is increased by the wedging action of the round rope in the angular pulley-groove, and this factor alone makes the rope-drive a more positive agent for the transmission of power than any belt-drive can be. This will be more readily understood by reference to Fig. 3. The four forms of groove in this illustration are all dimensioned to accommodate a 1½ in. diameter rope. The first one is a curved-side groove, supposed to facilitate the easy withdrawal of the rope. It has however the disadvantage of giving insufficient grip to the rope and is not used to any great extent. The next sketch shews a flanged groove of narrow pitch, which gives good rope-grip. It is claimed that the flange gives direction to the rope, but modern practice favours the use of flangeless grooves such as are shewn in the lower sketches, one having a 45 degs. angle, and the other one of 40 degs., the former being the angle most usually adopted for all rope diameters over one inch. For smaller ropes 30 degs. grooves may be employed. The question of groove shape and angle is one of the greatest importance : it will be appreciated that if too wide an angle gives insufficient rope-grip, then too sharp an angle may cause a considerable loss of power by gripping the rope so tightly that it cannot leave the pulley freely, and power is lost in pulling it out as the pulley rotates.

The generally accepted maximum rope speed in feet per minute is 5000. Speeds of 7000 feet have been arranged, but at very high speeds centrifugal tension tends to counteract the wedging action of the rope in the pulley-groove and introduces the possibility of losses through slip.

Thirty times the rope diameter is the accepted minimum pulley diameter; for a 1 in. rope the pulley will not be less than 2 ft. 6 ins. and if a reduction ratio of 5 to 1 is required, the driven pulley will be 12 ft. 6ins. in diameter. Apparently this question of pulley sizes will limit the adoption of rope drives to such installations as ventilating fans where space is usually obtainable, but numerous cases are recorded where good results were obtained from drives with pulleys as small as fourteen times the rope diameter.

The rules governing driving centres are also very flexible. An arc of contact of not less than 170 degs. between the rope and the smaller pulley is recommended, but if the driving centres are so short that this cannot be obtained, compensation for the reduction in contact can be got by fitting more ropes. It is certain that short-centre drives can be carried out more successfully with rope drives than with belting, and as an example of what may be done in this direction, a case is quoted of a motor driving a small air-compressor, the particulars being as follows:

Driving Pulley: 4 ins. diameter, 1228 r.p.m.
Driven Pulley: 14 ins. diameter.
Centre Distance: 20 ins.
Three Ropes: ⅜ in. diameter.
H.P.: 4.
Measured Speed of Compressor: 346 r.p.m.
Calculated Speed of Compressor: 350 r.p.m.
Slip and Creep: 4 r.p.m. (1.14%).
Efficiency: 97%.

This drive is proportioned as a distinct departure from accepted rules, but it is an example of what can be done in the application of rope driving to small motor-driven machinery: it is extremely doubtful whether a belt drive could have been arranged to give this efficiency with such a short centre distance but it must be borne in mind that the advantage of a short centre drive must be paid for in some way. Since an important factor in in power transmission by ropes is the initial tension; i.e., the tension of the rope when idle, and since this tension is that imposed by the weight of the rope between pulleys, it follows that the loss of this tension must be compensated for by giving an artificial tension to ropes on short centre drives, and arrangements must be made for a movement of either the driven or driver pulleys to adjust rope tension and to compensate for rope stretching.

It must be conceded that as an electrical drive, transmission by cotton ropes has many advantages. Smooth running is secured, the ropes taking up any shock which may originate in the driven machine, and in the case of multiple rope drives there is a freedom from breakdown, as the failure of one rope need not cause a stoppage of the machinery and is immediately evident.

There are other rope drives than by means of cotton rope: they are principally intended to produce a drive rope for short centre driving, the material used having a higher co-efficient of friction than cotton. One of these is in the form of a wedge-shaped drive rope, with a cotton base, impregnated and imbedded in rubber, which can be used on standard V-grooved pulleys. The makers claim that it can be run in either direction, with the slack rope on top or at the bottom; and, what is more important, they claim that a drive is of good proportions if the centre distance equals the diameter of the larger pulley. The ropes are supplied endless, but it is recommended that arrangement should be made in the form of slide rails, to allow of slack being given to facilitate the

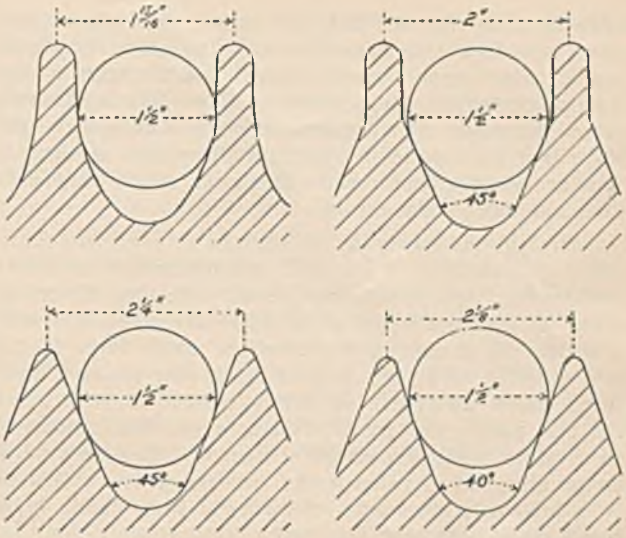

Fig. 3.

removal of ropes. At the maximum velocity of 5000 feet per minute, the h.p. rating, per rope, ranges from 4.5 h.p. for ½ in. rope to 23.5 h.p. for 1½ in. rope and the smallest recommended diameter of pulleys is 4 ins. for the ½ in. rope and 22 ins. for 1½ in. rope. It would appear from these particulars, that this type of rope is more suitable than stranded cotton rope for small electrical drives, possessing most of the advantages of the cotton rope; on short centre drives with small diameter pulleys it should certainly be more efficient. The figures of horse power per rope just quoted, are approximately the same as for equivalent cotton rope section in the smaller sizes, but on larger sizes cotton gives a better figure.

Another form of rope consists of a wedge-shaped band of cotton duck impregnated with balata gum, and on the face of this band are moulded wedge-shaped blocks of the same material, the blocks being cemented and rivetted to the band. These blocks are tapered laterally so that they form a continuation of the sides of the band, and they are also tapered at their ends in order that the faces of adjacent blocks may close together as the rope is bent in passing around the pulley. In this way, the blocks reinforce each other and practically form a second band which gives grip on the pulley groove over the whole arc of contact. It is claimed for this rope, that, owing to the great strength of the material as compared with cotton, one rope will do the work of two cotton ropes. Other advantages claimed are that the rope can be used on short centre drives at speeds up to 7500 feet per minute; that the method of splicing, which is much simpler than cotton rope splicing, will give a joint which is uniform with the rope itself; and that, owing to the smaller number of grooves required, the initial pulley cost is low.

TOOTHED GEARING.

Power transmission by means of toothed gearing is one of the most common of the driving systems in use at the present time, but it is also the most prolific producer and transmitter of vibration and shock. Generally speaking, straight-tooth metallic gears of the ordinary involute tooth form are unsuitable for use on electrical drives, mainly because tooth-to-tooth engagement applies the load instantaneously along the whole tooth face, and this impact of engagement produces a shock which, multiplied by the number of teeth, and the peripheral speed, sets up a vibration. This is aggravated by the fact that the impact of tooth engagement is sufficient to cause uneven wear upon the tooth profile, which soon becomes distorted and causes a destructive chattering. In addition to these defects of application there are certain inaccuracies of manufacture, and any slight inaccuracies of tooth profile causes changes in angular velocity, and results in shocks which vary with the magnitude of the errors.

Straight-tooth gearing of extreme accuracy can howevere be obtained. Scientific manufacturing processes and testing instruments capable of detecting dimension errors of one-thousandth of a millimetre, combined with a system of correcting the standard tooth form to the best possible form for any gear ratio, now produce high-speed gears which are as nearly perfect as such gears can be. Such gears are finished by a grinding process to an accuracy within the specified limit of 1/1000 of a millimetre after the case-hardening process which of course is liable to leave some distortion. For small, high-speed gears both spur and pinion are case-hardened, but for gears of the larger sizes, only the pinion is hardened, and the burnishing effect of the hard pinion tooth upon the relatively soft spur teeth is found to be beneficial.

It is, of course standard practice to fit mating gear wheels of different materials, common combinations being —cast-iron spurs with pinions of forged steel, cast steel, paper, rawhide, or other non-metallic compositions. Forged steel can be mated with high-carbon steel, and phosphor-bronze with forged steel.

For electrical drives it is usual to have to consider the selection of a suitable motor pinion to mate with a cast-iron spur, and since, for reasons already stated, a steel pinion would be undesirable, the choice rests between one of the various non-metallic wheels, paper and rawhide being the most commonly employed.

Non-Metallic Pinions.

The essential features of non-metallic gear material are briefly as follows :

(1) Deterioration should not take place under the action of fresh or salt water, or oil, either hot or cold, and the material should be inert to chemical fumes.

(2) The co-efficient of expansion to temperature should be small and the material should not shrink or expand appreciably when exposed to a dry or damp atmosphere.

(3) It should be slightly elastic so as to permit the teeth to mesh evenly over the whole face and to absorb shocks, vibration and noise.

(4) It should possess great mechanical strength, and stand up to wear and tear.

Paper and rawhide pinions are manufactured today to meet most of these requirements, but in the author's experience they fail to meet the last, having a very short life under normal load conditions. Pinions, known as "Fabroil", which comply with all these requirements, are built up of layers of cotton, compressed under hydraulic pressure of several tons per square inch, and impregnated with oil. They are usually shrouded with steel plates, and rivetted, but if required can be supplied without shrouds, the bonding material then being a synthetic resin. A more recent production in the way of non-metallic gearing is manufactured by Messrs. George Ellison, who use their well-known Tufnol insulating material for this purpose, but with a fabric base instead of paper. The sheet material consists of layers of specially woven fabric cloth thoroughly impregnated with a synthetic resin, and baked to a permanent state under hydraulic pressure.

Fabric gears may be used either shrouded or unshrouded and the unshrouded "Fabric Tufnol" gear is equivalent to the strength of a cast-iron gear with machine-cut teeth.

The following notes are applicable to all non-metallic pinions.

(1) When fitting shrouded pinions it is important to allow sufficient width of the material between shrouds to provide for end-play in shafting. This is a point which which is frequently overlooked and a noisy drive results from the spur wheel teeth engaging with the steel shroud intermittently. The key securing the pinion must be driven through both shrouds to prevent any twisting action.

(2) Non-metallic pinions should only be used in conjunction with well-cut metal gears. It is unfair to expect durability from these pinions if mated with unmachined or badly worn metal gears.

(3) The makers' instructions as to lubrication should be strictly adhered to. New Fabroil pinions require a dressing of graphite and vaseline before being put into use, and Tufnol a first dressing of good machine oil or grease, afterwards being treated as metal wheels.

Metallic Pinions.

Generally speaking then, electrical drives through straight toothed gearing, can be carried out with a reasonable measure of success, by means of the types of pinions referred to, but on heavy drives such as haulages of 60 h.p. and over, it is far better to fit a pair of double-helical wheels, as these are now produced with a high degree of accuracy, and at a reasonable price, owing to the vast strides which have been made during recent years in the processes of manufacture. The advantages of double-helical gearing for electrical drives may be briefly stated to be :

(1) Silent running—owing to the fact that the teeth come into engagement gradually, with an action which is a combination of rolling and sliding. There is, therefore, no impact, and a noticeable absence of back-lash, shock, and vibration. In this respect they compare favourably with the gears with pinions of soft non-metallic materials.

(2) Efficiency.—results obtained by the Hopkinson tests gave a minimum of 98%.

(3)Great strength, owing to the load pressure being equally divided over the whole arc of contact, and also to the relatively small height of the teeth.

(4) High ratios are possible : double-helical pinions are cut with as few as four teeth, and single reductions with a ratio of 20—1 are possible.

(5) Durability.—As friction and shock are reduced to a negligible quantity, double-helical gears have a very long life. The author has gears of this type in use on busy haulages, and they shew very little wear after ten years' service.

For non-reversing drives, double helical wheels are suitable, the direction of rotation being arranged so that the strongest part of the tooth, i.e., the apex, takes the load first. For reversing drives, the gears should be of herring-bone tooth formation, which gives a tooth apex to meet the load in either direction of rotation, and which also helps to equalise the load upon the gears.

In using double-helical gears it is essential that the spur wheel be mounted and maintained so that there is no lateral movement, otherwise if the pinion is keyed upon the rotor shaft any such movement will be transmitted directly to the rotor. This point is mentioned because a bent countershaft on an underground haulage is not an uncommon occurrence ; and, although the shaft may be taken out and straightened, experience shews that one rarely gets true running of the countershaft spur after this has happened, and the resultant end-thrust upon the rotor shaft is undesirable, even if it does not cause serious trouble.

Gearing for Large Reductions.

From motives of economy high speed motors are often used, and where it is desired to fit these machines to a shaft which has to be driven at a low speed, special reduction methods must be employed. In the ordinary way multiple stages of reducing gearing would be inefficient, cumbersome, and costly, but several manufacturing firms have gear units on the market to-day which solve the problem in a convenient manner.

Generally, they consist of double-helical gears, mounted in enclosed gear cases, and they can be obtained in a range of sizes to transmit any horse power to meet ordinary requirements. Reduction ratios up to 15—1 are provided for by single reduction, and up to 50—1 by double reduction.

Overall efficiencies of 97% to 98% are claimed for these gear units which are built throughout of the finest materials obtainable and finished to the highest possible standards of accuracy.

This problem has been faced by at least one firm who market a self-contained geared motor unit. This has a speed-reduction gear box as an integral part of the motor end-cover, and can be supplied with single reduction ratios to 5—1, double reduction to 20—1 and a triple reduction to a maximum of 100—1. For direct coupling, the shafting to be driven is coupled to the low speed shaft which protrudes from the gear-case, but for pulley, chain, or pinion drives, the assembly provides an extended shaft, outboard bearing, and base-plate. The gear-case is a cast-iron box, split vertically, one half being bolted to the motor frame, the other half carrying the low speed shaft bearings. The case is oil-tight, and the gears run in oil, all shaft bearings being of the ball or roller type. The gear wheels are made of tough gear steel and the teeth are generated by machine which ensure accuracy. The method of producing the pinions is interesting. They are made of "Nitralloy" steel, hardened and tempered to 70 tons per square inch tensile. After cutting and machining the pinions are heated to 500 degs. C. in a stream of ammonia gas for 80—90 hours. At this temperature, nitrogen is absorbed into the steel and the surface attains a degree of hardness nearly equal to a diamond, whilst the core remains at 70 tons tensile. This method produces a pinion which has an indefinitely long life, and is practically unwearable. The outstanding advantage to be gained by a self-contained unit of this description, is that it makes possible the use of the comparatively cheap high-speed motor for purposes where a very low speed is required at the driven shaft. The maximum listed reduction allows for a motor running at 1400 r.p.m., and gives a reduction through the gear-box to a final 14 r.p.m. at the output shaft.

Beckett and Anderson Ltd. are makers of enclosed gear-units, and also specialise in the production of electric haulage gears which embody these units for insertion between the motor and drum shaft. The use of such gear units eliminates the usual long countershaft, and ensures correct alignment of gears, with a general improvement in overall efficiency. Double-helical gears are used in the first reduction, and straight-tooth wheels for the other stages. The pinions are formed solid with their shafts from high tensile steel. Considering the use of these gears for underground haulages, it occurs to the author that the general layout would necessitate considerable alteration in engine-house design, since the "Becander" assembly places the motor, gear-box, and drum shaft almost in axial alignment and the engine-house would require greater width than length.

For single-drum haulages up to 30 h.p. the same company supply an arrangement in which the reduction gears are contained in the drum, and run in an oil bath. These small units occupy very small space, have no exposed gearing, and are fitted with a clutch which enables the operator to vary the speed of the drum from the full speed to standstill, without altering the speed of the motor, which can be left running whilst the drum is stationary.

In the erection of all types of gear-drives, the points which will need strict attention may be summarised as follows:

(1) All shafts must run true and parallel to each other, otherwise uniform tooth engagement will be impossible.

(2) Wheels must be bored accurately to shaft diameters, otherwise the keying may lift the wheel out of truth. It has been the author's experience that faulty running of spur wheels was, in the majority of cases due to lack of strict attention to this rule.

(3) See that the pitch lines of mating wheels coincide. Some manufacturers scribe the pitch line on all their gears, and this practice should be universal, since it facilitates erection, and is a guide to correct tooth clearance.

CHAIN GEARING.

If a drive problem arises where centre-distances are too short or the reduction too great for belting, or the centres too long for gearing, the answer appears to be: use chains. After 40 years of manufacturing progress, the modern roller and inverted-tooth chain has secured recognition in the engineering world as a medium for the transmission of power, and undoubtedly has a field of application on electrical drives, but before deciding to use a chain for any particular drive, it is necessary to consider carefully the nature of the load, and the conditions under which the chain will have to work.

The inverted-tooth chain is made up of a number of flat plates having angular projections which are ground to angles of 60 degs. and 75 degs. according to the chain pitch. These plates are pierced with holes to take hardened steel bushes, and the requisite number of plates is assembled on hardened steel rivets to form the complete chain.

The complete chain may be fitted with outside guide-plates, centre guide-plates, or in cases where the chain is required to run on flanged wheels—without guide-plates at all. The complete chain gives a tooth-to-tooth engagement with the chain wheel over a considerable portion of the wheel diameter. The drive is therefore a positive one, whilst still retaining the advantages of flexibility as to centre distances. It is also claimed that a drive chain is elastic, but as this quality will be that produced by the film of oil on each link bearing multiplied by the number of links in the chain, the total amount of elasticity will be very small and cannot do more than provide a slight cushioning effect to damp down shock It is obvious therefore that the amount of elasticity will depend upon the efficiency of lubrication, and it is advisable to enclose the chain in a casing with an oil bath.

A brief summary of the points to be observed when designing and installing a chain-drive is as follows:

(1) The safe working maximum speed for both roller and inverted-tooth chains is 2000 feet per minute.

(2) The chain wheels should be as large as may be conveniently possible, since the chain life is considerably reduced by the additional wear upon bearings caused by passing around small wheels.

(3) Drives should be arranged with the tight side of the chain at the top.

(4) The normal driving centres may be calculated by multiplying the pitch of the chain by 40, the minimum possible is simply to provide clearance between the wheels, and the maximum in inches can be calculated by dividing 1000 by the square root of the speed of the slower shaft. These figures form a rough guide, but are subject to revision where abnormal conditions are to be met.

(5) For efficient working the gear ratio should not exceed 7 to 1 for both types of chain.

The efficiency of a well designed chain-drive is about 98% and the outstanding advantage claimed is that this efficiency is maintained throughout the life of the chain mainly due to the fact that when wear takes place to cause an elongation of link centres, the chain simply takes up a position at a higher point upon the wheel teeth.

The main disadvantage of chain-gear driving is that any torque irregularities or periodic irregularities of load, may set up what is commonly called "chain-snatch," which shews itself in a violent "plucking" of the chain. This fault limits the application of chains to the driving of such loads as ventilating fans where irregularities are unlikely to occur, such drives being quite successful with constant-speed motors.

There are three methods in common use for dealing with chain-snatch. In certain cases, the fitting of a flywheel will prove effective. In other cases the trouble has been cured by the use of a toothed jockey-wheel engaging on the slack side of the chain, with the disadvantage of added frictional losses and increased chain wear. The third method is to fit a spring-wheel, usually on the driven shaft, these wheels being fitted with a set of strong spiral springs which are inserted between the wheel rim and the shaft to transmit the drive, and another set of springs to act as buffers to take up the recoil.

FLEXIBLE COUPLINGS.

In cases where the motor can be placed in alignment with the driven shaft and that shaft can be driven at the motor speed, we have the conditions suitable for the most efficient type of drive, but even in these conditions it is necessary to exercise care in the selection of a suitable coupling, as it is possible for a coupling to be responsible for greater losses than those occasioned by a well-designed gear or belt drive.

For direct-driving a flexible coupling is used for two reasons: (1) To compensate for any errors of alignment, and (2) to absorb any shock or vibration generated in the driven machine. For this second reason, it is often advisable to fit such a coupling even in cases where the motor and the driven machine are mounted upon a common bedplate, and it is possible to get the shafts into perfect alignment.

A flexible coupling has to deal with three possible forms of mis-alignment.

(1) Angular mis-alignment, where shafts are in line but not parallel.

(2) Offset mis-alignment, where shafts are parallel but not in line.

(3) Angular and offset mis-alignment, where shafts are neither in line nor parallel.

If an ordinary rigid coupling were used and either of these forms of mis-alignment existed, flexural stresses would be imposed on the shafting, such stresses being reversed during each half revolution of the shaft, metal which was under tensile stress at one point being under compression as it reached the opposite point. Apart from injurious effect upon the shafting of these stresses, there is a certainty of overload upon bearings, which will run hot or fail altogether.

An interesting coupling suitable for electrical drives is that made by Hans Renold Ltd. which consists of a toothed chain wheel keyed to each shaft, and coupled by a duplex bush-roller-chain. It is simple, and allows of sufficient lateral movement to correct alignment errors. A leather cover is usually fitted over this coupling, this cover being fitted with lubricating nipples.

A coupling, extensively used in America, comprises a toothed wheel for mounting on each shaft, the coupling medium being a sleeve having internal teeth which engage with the teeth of the two wheels. The rotation of the driver-shaft rotates the sleeve, which in turn rotates the driven shaft. The slight tooth clearances allow sufficient movement to correct alignment errors and the lubrication system ensures a film of oil being maintained which besides reducing wear, gives a slight cushioning effect.

The most satisfactory coupling is one which has a resilient component upon which the load can float. This is essential for the absorption of shock. In one type flexibility is obtained by means of a number of flat steel springs supported by a carrier-ring; the steel springs engaging in the slots cut in the edges of the two portions of the coupling which are mounted upon the driver and driven shafts. Deflection under load causes the springs to assume a parabolic form, and by shaping the sides of the grooves to the same formation there is a progressive shortening of the springs under load with a corresponding increase in the permissive load. As the springs do not restrict the movement of the two halves of the coupling in an axial direction, longitudinal movement is provided for within the limits of the cover rings, and angular and offset mis-alignment is taken up by the carrier-ring which will assume a mean position under all conditions of alignment error. To retain the resilient feature of the coupling, care should be taken to fit a size suitable for the horse-power to be transmitted as an overloaded coupling means that the springs will be in an overloaded position on normal load, and much of the shock-absorbing properties of the coupling will be lost.

A coupling which has proved successful on high speed drives employs two grooved discs connected by steel springs having an elastic limit of 200,000 lbs. per square inch, when hardened and tempered to their correct shape. The grooves are flared so that at normal load the spring has a long flexible span to absorb vibration, but under overload the span is decreased and the strength of the spring increased. In the complete coupling the springs are totally enclosed in a grease-tight casing. Such couplings are made in all sizes up to 60,000 horse-power. In the smaller sizes the springs are in one piece, but in the larger sizes may be in several sections in order to facilitate removal. One advantage of this type of coupling is the ease with which the shafts can be uncoupled, it being necessary only to remove the cover and strip the springs from the grooves. Vibrographs of the performance of this coupling as compared with the ordinary claw-type, gave an amplitude of shock of 16 units against 50 units with the claw.

The Paper was illustrated throughout by many lantern slides mainly lent by the makers of the specialities to which the author referred—and for the use of which the author expressed his thanks to the respective firms.

Discussion.

Mr. W. M. THOMAS congratulated the author for the excellent paper, more particularly because he had dealt with his subject so closely in its relation to the colliery electrical man. Occasionally the mechanic and electrician were at loggerheads on this important connecting link of the drive between the electrical and mechanical parts of a machine, and this paper would serve a very good purpose in smoothing out those differences, in improving the efficiency of installations and in reducing the liability to breakdowns.

A careful analysis of electrical breakdowns over several years led Mr. Thomas to conclude that, apart from overloading, for which adequate protection was the obvious remedy, by far the most frequent cause of breakdown had been a defective connecting link between the motor and the mechanical part of the machine. He had in mind, pumps, haulages and other units on a colliery, which at some time or other had broken down.

The author had dealt with the forms of transmission in a very comprehensive way, and a few of many questions that Mr. Thomas would like to put were :

What are the comparative strengths of balata and leather belting, also figures of their comparative frictional co-efficients on iron pulleys ?

What is the effect of alternate working with a rope drive, such as a fan on rope drive for one period of the day and a direct motor drive for another portion of the day ?

Is there a danger of fire resulting from the ignition of particles of frayed rope which become lodged in motors and generators on rope drives ?

What are the comparative prices of the types of soft pinions mentioned ?

Why two angles for teeth of inverted tooth chains, viz., 60 and 70 degrees ?

In an average chain drive what is the method of calculating the total chain tension under load ?

Mr. Thomas took the opportunity of paying a special tribute to the author for his services to the Western Sub-Branch. Mr. Yates was one of the founders of this Sub-Branch, when some half dozen or so persons interested themselves in mining electrical work in the district. He had worked assiduously all through the years, having been Secretary, Treasurer, and Chairman ; he had been a very able contributor to the transactions of the Association by the several papers he had given, by the part he had taken in the discussions, and by his influence among his staff, all of whom were either members or associates of the Association of Mining Electrical Engineers.

Mr. COPE said no one could disagree that vibration was a great cause of breakdowns. In the colliery with which he was connected the installation was small and the breakdowns on one particular haulage at one time were alarming. The only thing possible, in his opinion, was a rope drive and he did not think a stoppage has occurred from that haulage since it was fitted with a rope drive 15 years ago. Whenever possible, he advocated rope drives ; he knew it was difficult to convince mining engineers that it was worth while cutting the necessary space, but it did pay. He was interested in the element balata belting, and had adopted that type after the 1926 strike, and at the same time had put ropes on to a 350 h.p. haulage just for the purpose of comparison. He did not expect more than another six months' work from the rope drive, but the balata belt was still as good as the day it was put in.

Mr. Cope thought a good deal of misapprehension existed as to the permissible load for a rawhide pinion. He wished Mr. Yates could give them some comparative figures of the different types of pinions. He had had a little experience of the spring coupling at a tin works, and the thing that struck him most was the prohibitive price. He would like comparative costs of couplings, also, if possible.

Mr. ISAACS said he rather gathered that Mr. Yates was suggesting that rope drives ought to be used more than they were for small drives. In that connection he noticed that the author gave the efficiency of the drives mentioned, except belts. He was recently interested in a belt drive for a small motor where they did not seem to be getting the proper output from the motor under normal conditions. Wanting to get down to figures, he made enquiries from mechanical engineers and found that it was very difficult to measure but that the loss in the belt was almost independent of the load.

Mr. DAWTREY said breakdowns were often caused by vibration. In a number of these cases the mechanical people did not appreciate what was required from the electrical side.

The question of belt fasteners was very important. In rope drives, he thought the condition of the atmosphere affected the drive very much.

Mr. GOWER considered that Mr. Yates had dealt with the subject very happily from beginning to end. Drives were important today, especially in view of the state of trade. He thought the belt drive the most useful, as it could be so very readily adapted to bring in a suitable motor should there be a breakdown. He had known of belts running for twelve years every day. Climatic conditions had a great bearing on the life of balata belts. In the case of rope drives he had found they required more attention owing to the heavy swing of the ropes. The cost of maintenance of control gear was usually much greater on a direct driven equipment : could Mr. Yates give any figures of comparison for the maintenance of control gear. As to the variation of the length of ropes, he suggested laying idle one rope, taking down the rope that elongates most, and replacing it with another rope. He had found the changing of ropes to be very costly.

Mr. YATES, in reply, to the several questions submitted by Mr. Thomas, said that the strength of belting may be called the breaking-strain, and this, for good leather belting was 3750 lbs. per square inch: the corresponding figure for Balata was 11,500 lbs. Regarding the frictional co-efficient of belting on iron pulleys, there appeared to be a difference of opinion amongst authorities as to the figure for balata. Some put it as high as 0.25, others as 0.1, but they would appear to agree upon a figure of 0.3 for leather.

At first sight it would appear that there should be less rapid deterioration of ropes when idle than when working. When working, the ropes are subject to detrimental effects due to atmospheric conditions, and also to bending and tension stresses. When idle, assuming atmospheric conditions to be the same, the free portions of the ropes hanging between the pulleys would be only under the stress of initial tension, but the portions in contact with the pulley-grooves would be under compression on their inner surfaces, with a corresponding extension of their outer peripheries. That was the natural action upon the ropes when working, but then it was only a momentary stress which could be taken up by the elasticity of the cotton fibres, and it was possible that the effect upon idle ropes would be that a permanent set would be given which would weaken the fibres and cause the ropes to crack.

It was well known that serious fires had occurred where cotton rope drives were in use, but that risk was preventible as the fraying of cotton ropes was either due to faults of manufacture, installation or maintenance. With a good quality rope and the drive installed so that there was no undue friction to cause excessive chafing of the outer strands, there was only one point left to watch, and that was lubrication. All ropes should be occasionally lubricated with a good rope dressing, and when that was done, there was very little risk of fraying and, therefore, very little risk of causing fires.

As to the comparative cost of the different types of soft pinions, Mr. Yates said that as far as his memory went, if a good rawhide pinion cost £1, an equivalent "Fabroil" would cost £1 15s. 0d., and a "Tufnol" would cost £2 15s. 0d. Replying to the question concerning the two angles in common use for inverted tooth chain teeth, it was standard practice to use teeth with a 60 deg. angle for all ordinary drives, but for certain heavy-duty drives the 75 degs. angle plates allowed greater rivet-wearing area with increased strength. They could not, however, be used on drives with a gear ratio exceeding 3 to 1.

The usual method of calculating the total tension of a chain under load, was first to find the tension due to the drive by dividing the horse-power by the chain-speed in feet per minute and multiplying the result by 33,000. The tension due to centrifugal force must then be found by squaring the chain-speed, dividing by 1000 and multiplying by 8.6 times the weight of the chain in lbs. per square foot. The tension due to catenary pull must then be found. For horizontal drives an average value is:— Centre distance of wheels in feet, × 2.5 times the weight of chain. The total tension is the sum of these three tension values.

Referring to the remarks by Mr. Cope it was pleasing to hear that he had found rope drives to give satisfactory service. Revolving ropes were often met with, and the experts seemed unable to account for this. In a multiple drive there may be two out of a dozen ropes which would revolve as they run, but there did not appear to be any loss of efficiency or increased wear in connection with the ropes which exhibited this peculiarity. It had been suggested that the cause was that there was some slight errors in the formation of the pulley-grooves, but he did not know if there was any confimation of this theory.

With regard to the load upon Fabroil and Tufnol gears, a safe working stress per inch for Fabroil was 3500 lbs. and for Tufnol, 6000 lbs.

He was surprised to hear that Mr. Cope considered the Bibby coupling expensive. The initial cost might be rather high in comparison with an ordinary claw coupling, but it compared favourably with other couplings of the resilient type.

In reply to Mr. Edmunds, Mr. Yates said he had always been rather suspicious of composite rubber belting. It should be efficient on the Lenix drive, but even then he thought that the slight gain in flexibility would be more than offset by the shorter life. On the Lenix drive, balata would stand up to any amount of hard service provided that as thin and wide a belt as possible, consistent with the power which has to be transmitted, was adopted.

Mr. Gower had spoken of swinging ropes. Investigation of this and many other curious faults in rope-drives pointed to the same cause, viz., a tendency to over-rope a drive.

As to the comparative maintenance cost of electrical control gear, he could say without hesitation, that such costs were generally higher with a gear-driven installation than with any other form of drive which he had mentioned.

Mr. T. J. REECE, in proposing a hearty vote of thanks to Mr. Yates, said he had been much interested in the paper, from which he had learned a good deal, and he was obliged also to the members who had contributed to the discussion.

Mr. STANAWAY, in seconding the vote of thanks, said he had much enjoyed Mr. Yates' informative paper. He also wished to say how much assistance he had received from Mr. Yates since he had been Secretary of the Sub-Branch.

SOUTH WALES BRANCH.

At the meeting of the South Wales Branch held in Cardiff on 14th March last, Mr. A. C. MacWhirter occupied the chair, owing to the unavoidable absence of the Branch President, Sir Arthur Whitten Brown. The minutes of the previous meeting having been adopted, the following new members were elected:—

Members: James Macleod Carey, Cardiff; James Amrey Jones, Treherbert; David Christopher Thomas, Abercanaid; Augustus Clement Watkins, Maesteg; and John Williams, Aberdare. Associates: Henry George Cooke, Aberbeeg; and Donald Crowther Spicer, Cardiff. Students: James T. Harries, New Tredegar; David Francis Newbridge; and John Llewellyn Williams, Abertillery. Also the following candidates were elected to membership of the Western Sub-Branch:— Members: John William Davidson, Gowerton; James Jones, Llanelly, Ieuan Hopkins, Resolven; Sidney Horatio Jones, Neath; Emrys Lewis, Port Talbot; Augustus Rees, Swansea; Morgan Rees, Glyncorrwg; John Ernest Wilkinson, Swansea; and Walter Melvin Wilson, Swansea. Student: John Elwyn Price, Seven Sisters.

A Paper was read by Major W. Roberts entitled "Mining Type Control Gear" which was suitably illustrated by lantern slides. The text of the paper with selected illustrations was published in *The Mining Electrical Engineer,* May and June, 1931.

Mining Type Control Gear.

Discussion.

Mr. IDRIS JONES.—Whilst the title suggests that oil-immersed and also air-break control gear might be dealt with, the author endeavoured very strongly to make out the case for the general use of air-break control gear. In the first part of the paper dealing with air-break gear he put forward arguments to substantiate his view that air-break was really safer and more reliable than oil-break gear, and that it was difficult to design oil tanks to withstand a greater pressure than 110 lbs. per sq. in. and yet be easily accessible. Surely he would know that a number of switchgear manufacturers provide oil tanks designed to withstand quite easily three or four times that pressure even without efficient means of relief and which were also quite easily handled. If pressures higher than 110 lbs. per sq. in. were never to be met in oil-break gear, there would be very little to worry about.

Mr. Jones said that though he would advocate air-break gear for certain control and starting gear, he had yet to see air-break gear that would operate satistorily under the most severe conditions as the author mentioned. The ultimate limit to the use of air-break gear was its rupturing capacity, and on a fairly large system, such as the one with which he, Mr. Jones, was connected, where air-break gear is used on a number of large a.c. winders, it was absolutely essential that high rupturing capacity oil-break circuit breakers should be installed as a protection against short circuits which may occur on the apparatus which the air-break gear controls. That applies chiefly on E.H.T. systems where the short circuit k.v.a. was very much greater than on the medium tension system; it was possible on the latter system to make further use of air-break gear for feeder switches.

The installation of electrically operated or electro-pneumatically operated air-break reversing controllers on large a.c. winders, had easily justified their use, and had reduced the cost of maintenance to less than 20% of that necessary for oil-break reversing controllers for the same duty.

With regard to the author's remarks on switching squirrel cage motors direct on the line, Mr. Jones said they had a number in use from 100 h.p. up to 200 h.p. which were coupled to turbine pumps, but the motors were four-pole machines and had the stator coils braced to withstand the short circuit current effects on switching in, some of the motors had rotors of the ordinary squirrel cage type and others had the Boucherot type of squirrel cage rotor windings. Trouble had been experienced with one make of the latter type, but that was overcome by altering the method of brazing the high resistance windings to the end rings.

With regard to using auto-transformers for starting large squirrel cage motors, it was more economical to purchase a slipring motor and rotor starter, than to purchase a squirrel cage motor and auto-transformer; in Mr. Jones' case they only used auto-transformers for starting salient pole type synchronous motors with squirrel cage windings in the pole tips, from 300 h.p. up to 2000 h.p. These motors were used for driving air compressors and the motor generator sets used for Ward-Leonard d.c. winders. There were troubles with the switches and auto-transformers in the early stages, they had been overcome by using interlocked switches with a definite sequence in operation so as to avoid short circuiting the system through the auto-transformer.

S. B. HASLAM said that though he was by no means in full agreement with the opinions expressed by Major Roberts that did not in any way detract from his appreciation of an excellent paper. It would appear that the author had based a good many of his claims, especially on the chemical side, on the summarising report by Messrs. I. C. F. Statham and R. Y. Wheeler, on "Flame-proof Electrical Apparatus, for use in coal mines" (Safety in Mines Research Report Paper No. 60): that being so, his attention might be directed to page 59 of the same report, where it is stated that—

"Statistics do not disclose any instance of an explosion due to an oil switch functioning as such. Two explosions of firedamp have, however, been caused by oil switches which were improperly maintained. The inherent safety of oil-immersed gear, whatever the standard of installation of maintenance, must not be taken for granted."

The main consideration, which had already been touched on by Mr. Idris Jones, was the energy breaking capacity of switchgear and Mr. Haslam considered that with air-break switchgear within reasonable limits of size and weight, this breaking capacity was strictly limited. The author had referred to some air-break gear in America and Mr. Haslam said he would like to know whether the particular gear mentioned was flame-proof. The author had emphasised flame-proofness in the paper and Mr. Haslam suggested that it was rather misleading if Major Roberts meant to refer to breaking capacity tests of non-flame-proof gear. When discussing the question of gases coming from oil in oil-break gear, one was obviously discussing flame-proof gear and it was a pity that the reference to the U.S.A. air-break gear was made at all in that connection. Mr. Haslam said he would suggest that the economical limit for breaking capacity of air-break gear was very low—in the neighbourhood of 2000/2500 k.v.a.—though he believed that some claims were made for a higher capacity than that.

The question of voltage had been rather overlooked: he did not know whether the author was putting forward air-break gear for 3000 v., especially with a good load and the possibilities of a substantial kick, or whether he was chiefly interested in L.T. gear. If so, Mr. Haslam would suggest that in a great many situations, even underground, L.T. gear was not an economical proposition. In his opinion the advantages for oil-immersed circuit breakers could be stated as:—better insulation; in addition to the enclosure, the oil itself, excludes dust from the working parts; less danger of sustained arcing. The author himself had admitted, towards the end of the paper, that oil was used to damp the arc and to increase the rupturing capacity: he also admitted that the use of oil allowed of a reduction in air space. Those were two very important points, and seemed to confirm the impression of Mr. Haslam that with air-break gear, a rupturing capacity cannot be obtained without excessive size and spacing.

Mr. Haslam said he thought everyone would agree that the use of oil was a very distinct advantage in damping an arc and that there was far less likelihood of sustaining an arc in oil than in air; he therefore could not quite appreciate the statement of the author, that the experience of a large colliery company in that district, with heavy duty winding engines, over a number of years, had established the fact that on similar duties the pitting due to arcing on the contact tips of oil-immersed contactors was more than three times as bad as on air-break contactors. Mr. Haslam could not understand why that should be unless it was that the comparison was between overloaded oil-break gear and underloaded air-break gear; his, and general, experience over a good many years in the use of oil-break gear had proved that the very fact of the presence of oil would damp the arc and that was far less likely to be pitting with arcs damped immediately than with an arc sustained as it might well be in air-break gear.

Dealing with the quesion of pressures, Major Roberts had suggested that it was not practicable to design oil tanks which would withstand internal pressures exceeding 110 lbs. per square inch. The fact was that a standard pressure of 120 lbs. per square inch with a factor of safety of three was common practice. Mr. Haslam said he knew of a definite case where a standard boiler plate tank, actually withstood 1000 lbs. per square inch impulse pressure on a breaking capacity test : though he would not for one minute suggest that that could always be reckoned on, he would suggest that a figure between that and the one mentioned by Major Roberts could be accepted as reasonable.

Continuing, Mr. Haslam said he was glad to be in agreement with the author in regard to the necessity for all types of gear to be robust as far as concerned the external parts : but even there he considered that it was far easier to get the necessary robustness with the smaller type of gear which could be used with an oil-break than with the admittedly larger dimensioned gear required by air-break.

Comparisons were, however, very difficult. There were many cases of oil-break gear in that and other coalfields where the gear was successfully standing up to loads far in excess of what they were designed and supplied for in the first case : but air-break gear, being of comparatively recent practice, did not labour under similar conditions. He, for one, would hesitate very much before installing anything but oil-break gear underground in a position where the short circuit current might even approach to the rated capacity of the switch ; and, further, he would take very great care that the switch was rated on very conservative lines.

Mr. J. B. G. LEWIS referred to the author's remarks as to the U.S.A. practice, in connection with air-break switches for feeder work, and said he probably had in mind the Slepian breaker. If so it was interesting to note that that particular circuit breaker has been used as an oil-immersed breaker and, as such, had successfully ruptured 1.5 million k.v.a. Mr. Lewis said he believed that it would be introduced into this country at no distant date.

The author had suggested that the use of time lags was unneccesary during the starting of the range of starters under discussion. That might be so, but it would be admitted that time lags were very necessary during the running period on loads of a " peaky " nature. A restraining device was on the market which did not need the use of any additional operating gear beyond the ordinary starting handle, and another device was also in use which prevented the operator from " creeping " the starter or switch into the starting position, in other words, the apparatus must be in either a definitely " on " or definitely " off " position.

A point of considerable interest, and some surprising to hear was that about 80% of motor burn-outs were due to single-phasing. It could only be supposed that the vast majority of those burnt-out motors were protected by switch fuse units, and not by circuit breakers or starters with overload protection, as surely the protection of each phase by an overload coil would very materially reduce the figure mentioned.

Under the heading of resistances the author had stated that the Mines Dept. have modified their views on the use of open type resistances, and it would be interesting to know whether the author had had any official intimation of this, or whether it was to be accepted as the interpretation of the Act by individual inspectors in a particular district.

Major Roberts believed that a new term other than " continuous " should be used for resistances that could not be used continuously. The term " crane continuous " was one which probably complied with the conditions to which he referred. That term had been in use for some considerable time, and it was generally applied to a resistance composed of a true continuous rating for that portion required to give, say, 50% speed at full load, while the remaining steps might be of 5 minute rating.

Cadmium plating has been used in the U.S.A. and Germany for some considerable time, with varying success, but Mr. Lewis believed it had been found that the oxide had a high resistance, which was a disadvantage so far as contacts or contact surfaces were concerned.

Regarding the author's references to General Regulation No. 131 G: the question of earthing was one which exercised the interest of both users and manufacturers at the present moment, but it would appear that the Mines Department were at the moment confining their attention largely to H.T. apparatus. Manufacturers generally were using their best efforts to meet requirements on the point but, as previous speakers had mentioned, there were occasions when the arrangement was detrimental to both the operator and the gear. The methods adopted to carry out the Regulation could easily result in further complications of gear which might still further serve to defeat the ideal of keeping such gear as Mining Apparatus which had to be operated in a confined and cramped space simple in design and easy to handle.

In general, the policy embodied in the paper was a justification for air-break switchgear as against oil-immersed gear, under most conditions, but Mr. Lewis considered that the author's statements were, in general, far too sweeping on that point. Whilst there were certainly, conditions where air-break gear was more satisfactory, such as at the coal face, where portability and the avoidance of oil spilling from tanks were perhaps among the chief features, and where a high rupturing capacity was not necessary owing to the resistance of the cables behind the gear, there were certainly many points in an underground system where breakers of high rupturing capacity were essential. In such cases the oil-immersed type of apparatus would probably be greatly superior to the air-break type for some time to come. Mr. Lewis said he had been long enough in the electrical industry to know that it was subject to fashion so far as the design and manufacture of the electrical apparutes of the type under discussion was concerned; and whilst he would not, for a moment, intend to intimate that air-break flame-proof electrical apparatus was a passing fashion, he did not think that the time had yet arrived when it could be proved to the satisfaction of practical engineers that it was superior to the oil-immersed type of gear in general use, or when the intelligent engineer would throw out all his oil-immersed apparatus and instal air-break in its place. The possibilities of air-break apparatus in general were exercising the minds of designers as a whole, and the manufacturers with whom he, Mr. Lewis, was connected were certainly amongst those who fully realised the importance of developments in that direction. At the same time, the oil-immersed type of gear presented so many obvious advantages that it would, in his opinion, be premature, to say the least of it, to agree with the author's remarks that oil is at present used as a cover for what may be termed faulty design.

Major Roberts' paper had given them an opportunity of ventilating different opinions on a most important subject.

Mr. J. B. J. HIGHAM said that the paper afforded the members another opportunity for discussing the relative merits of oil and air break switches from the point of view of the user. He found it extremely difficult when dealing with such matters with students to be able to say definitely what were the real advantages or disadvantages of the various types. The claims of manufacturers were not always supported by those responsible for the operation and maintenance of such gear. To be quite candid with students one could only point out features and supposed advantages and quote authoritative agreement or otherwise. One could not be too dogmatic and it must be extremely difficult for a student to come to a decision particularly when faced with examination questions involving statements as to advantages and disadvantages.

One of the reasons why he, Mr. Higham, was such a keen supporter of this Association was that in discussions, such as had taken place that evening, various views were expressed by some critical users. The advantage a student had, if only he would attend these meetings, was that he could gather more useful information in half-an-hour than he could glean from a score of text-books or makers' pamphlets.

Major Roberts had dealt with many aspects of control and the table referring to three-phase motors was most useful. As to the high-torque motor, Mr. Higham would like to know if the author or anyone present had had any experience of this type of motor failing to come up to scratch in the matter of high starting torque. He had, the previous week, visited a colliery where there were several comparatively small high torque motors in use. The engineer had told him that so far as he was concerned they were a" washout." Mr. Higham was surprised because the conditions did not appear to be abnormal and in only one or two instances did there appear to be any real demand for high torque at start; yet quite a number of these motors were fitted with centrifugal clutches. Why should a high torque motor require such a clutch? From what he could gather the clutch was so critical that it often happened that the motor was well up to speed before the clutch attempted to pick up and then it did so with a terrific jerk and the motor torque was not even then sufficient to get the job going. This occurred on screen where the cranks got on a dead centre at times.

In the motors employed at that colliery quite a lot of trouble had been experienced with the rotor conductors; not those of the small high resistance cage type as one would expect, but with the large low resistance cage rotors. The bars of these were sweated to the end rings and gave trouble by persistently unsweating themselves. Welded or solid construction should be employed, soldered joints were not suitable but it would appear still to be employed by some makers.

The author had stated that no portion of the active resistance should in any circumstances be enclosed by, or be in contact with, insulating material. It was rather difficult to see how the wire or strip could be retained in position without being in contact somewhere with the resistance material unless supported and assembled on special washers which in turn would be insulated. Perhaps Major Roberts had a sample or illustration which shewed how this was accomplished.

With regard to the earthing of a circuit while work was being carried out on it, Mr. Higham said he could imagine something would happen to the switch, and the operator, if a cable alive at the other end were to be earthed in order to discharge it prior to test or repair; a condition easily possible if the cable formed part of a ring main. He would like to be sure whether Major Roberts really meant to suggest that a switch to do this would be a safe proposition.

With reference to feeder switches, Mr. Higham could not see how any manufacturer could claim that the risk of flashing over was avoided by the use of air-break switches. His experience of air-break switches was that they were all liable to flash over between phases when breaking; the fact was that oil was used definitely to reduce the possibility of such an occurrence. Flame could not endure when it was cooled and thereby deionised: he believed that in the new American switch special means were provided for cooling the arc by splitting it up into a large number of arcs in series, each of which was effectively cooled by copper discs which provided ample heat dissipation. If the temperature of the arc were reduced sufficiently it was bound to be extinguished and oil helped in that respect.

For equal rupturing capacity the air-break switch was larger than the oil switch and, even if the total weight be less, the handling of the lighter but more cumbersome switch in confined places was a decided disadvantage. It was not the weight, but the awkwardness of the contraption that counted. He considered also that, of the two switches the air-break switch had a much greater cubic capacity; that is, that it could hold a greater volume of explosive gases than the oil switch, which meant that a greater amount of heat would be generated should an explosion occur internally. Against this contention one had to consider the ever present chance of the oil becoming vaporised in an oil switch and therefore increasing the danger of an internal explosion resulting from the ignition of coal gas.

Mr. C. F. FREEBORN was inclined to agree with Mr. Roberts in regard to the question of air-break gear, but only so far as medium tension gear was concerned: flame-proof air-break gear of normal capacity up to 750 volts had been developed witch considerable success, and for drum controllers, was undoubtedly the superior construction. For higher voltages, however, space and price had considerable influence and whilst he was prepared to agree that satisfactory air-break reversing switches for haulages up to 250 amperes could be made in flame-proof enclosure, so much greater clearance, involving a larger construction throughout, would be necessary to afford the same margin of safety that, in spite of the claims of certain manufacturers, an unnecessarily bulky and costly piece of apparatus resulted.

With regard to the use of vents, which, protruding beyond the general outline of the casing, were liable to become damaged and were only too frequently allowed to become choked with dust, he considered it better to provide sufficient pressure dissipation in the flange construction of the casing; again, the use of ordinary cast iron in the making of any form of flame-proof casing was to be deplored; unless every single casing were submitted to a rigorous test, it was impossible to say that every casting was without a flaw: welded boiler plate provided a more consistent and generally a lighter and less cumbersome article.

In comparing contactors and, or, reversers of different types, one must not forget that only with motors having precisely similar characteristics as to power factor, etc., could a true comparison be made, but he could confirm that when old-pattern, oil-immersed reversers were replaced by specially designed air-break, *open type* contactors, an economy such as Major Roberts had mentioned was obtained, but the new and old reversers were of quite different patterns.

On medium tension circuits considerable use had recently been made of cam-operated, contactor controllers; these gave all the arc breaking properties of the contactor without the auxiliary circuits that were otherwise necessary, and as on the latest designs the bulk and power required for operation had both been greatly reduced, this type formed a very useful step between the ordinary drum controller and the contactor controller. He agreed with Major Roberts in regard to the necessity for great care in the construction of the operating spindle and handle on all controllers : even a flat on the spindle was preferable to the grub screw method.

Induction controllers had great disadvantages, said Mr. Freeborn. Although they had proved satisfactory on certain applications, their action was such as to have an unstable effect upon the motor, unless the same had been specially designed, in regard to its torque-speed curve, for use with the induction controller ; actually, the introduction of reactance into the rotor circuit had almost the same effect as putting resistance into the stator winding, that of reducing the capacity of the machine.

Auto-transformers were being used in ever-decreasing quantities owing to the gradual removal of starting current restrictions, and the presence of an insulated winding, subjected to sudden loading, was only another link in the chain which one would gladly do without if possible.

In the matter of insulation, great advances had been made and were still being made, gradually the use of materials which absorb moisture or disintegrate under continued stress of heat and, or, potential is being abandoned. Mr. Freeborn said that, moreover, it is at last being realised that insulation should not only be effective with regard to resisting electric flux but should, if possible, be the reverse as regards heat flow; those forms of insulation which would conduct heat away best, whether it be from resistances, or transformer windings, or the actual current carrying parts of a switch or starter, would displace all other types eventually.

Mention was made of cadmium plating, and Mr. Freeborn said he could confirm that for the protection of springs and parts of switches other than the actual contacts, it had been found very satisfactory on air-break gear subject to the attack of damp air, or mildly corrosive fumes ; cadmium plating of the actual contacts was however, not so definitely established, and in this connection he would ask Mr. Roberts what he would suggest for the protection of copper contacts in mining and similar work. Mr. Freeborn had experience of contacts developing an oxide film and overheating to an astonishing degree.

On the subject of earthing, he was pleased to learn that Mr. Roberts supported the view that a motor control unit need not be provided with an earthing device ; in view of the fact that the gear could not easily become recharged, it seemed quite unnecessary ; it was to be regretted that in certain quarters the opposite attitude had been adopted.

Mr. A. C. MacWHIRTER having mentioned that Major Roberts inferred that he was going to reduce maintenance to practically nil by means of fool-proof devices, protection on all phases, etc., ventured to criticise some of the constructional details. One of his principal objections had reference to the number of bolts carried on the face of the switch. In one case there were no fewer than 24 set screws. It was not difficult to imagine what would happen when the harassed electrician had to take them out. Some of the screws and fixings would be sure to be left and lost.

Major WILLIAM ROBERTS, in reply, said he would like to make clear the point that his paper dealt with control gear and not with switchgear. He did not suggest that at the present moment Barking Power Station could be controlled by airbreak gear, and did not think that control gear should be expected to deal with short circuits.

In reply to Mr. Idris Jones suggestion that the requirements called for by the Act were more stringent than was necessary, he would not venture to cross swords with him on that point, because of the very much wider experience of Mr. Jones ; he could only say that the manufacturers were trying to do what the Mines Dept. call for. Whether the requirements were needed or not was not their responsibility. Major Roberts was quite aware that switchgear was in use having tanks that would stand pressures greatly in excess of 110 lbs. per square inch, but they were generally on what was classed as switchgear and not on control gear. The best way of making sure that internal pressures did not become higher than 110 lbs. was to eliminate oil, which was the sole agent by means of which higher pressures were possible.

Mr. Haslam had quoted a paragraph from Messrs. Statham & Wheelers' report which supports his view. Major Roberts in reply might be permitted to submit another quotation from the same source in support of his views : "There is little doubt that these stresses are greater in oil-immersed than in air-break gear. Oil immersion of contacts has sometimes apparently been regarded as a sufficient precaution against the ignition of firedamp by the arc produced on rupture of the circuit, the flame-proof enclosure of oil-immersed gear being looked upon as an unnecessary refinement."

"That this is a mistake is shewn by the occurrence in the past, of ignitions of firedamp at oil-immersed gear directly attributable to insufficient depth of oil above the contacts, or to exposure of the contacts by accidental tilting of the casing, eventualities which must be considered likely under the conditions of use underground. It cannot be too strongly emphasised that oil-immersion alone does not provide a safeguard against the ignition of an external firedamp-air mixture. Even when there is both oil-immersion of the contacts and the employment of casings designed to prevent the passage of the flame of a firedamp explosion, full security is not necessarily obtained. According to our present knowledge, nothing short of total enclosure in specially strong casings can be considered as satisfactory for oil-immersed gear for use in positions where firedamp may occur. We have stated that the oil itself has little or no effect so far as the quenching of the arc is concerned."

"......, at the same time the element of danger introduced by the presence of hydrogen and acetylene outweighs this advantage so far as electrical gear for use in those parts of Coal Mines where firedamp may accumulate."

"Until a satisfactory type of safe pressure-release has been designed, the use of oil-immersed gear at or near the coal face is to be deprecated."

Major Roberts then referred to the American circuit breaker indicating that it was not flame-proof, and was simply quoted as an ideal. Mr. Haslam's figures of breaking capacity were much too low ; within his, Major Roberts', knowledge there was air-break gear installed with a rupturing capacity of 15,000 k.v.a. ; air-break gear was in use both as control gear and as feeder switches in many places in this country on 3300 volts, and there was a 6600volt air-break installation at the Cardiff Docks.

Dealing with the three advantages which Mr. Haslam suggested for oil-immersed gear, Major Roberts commented:—

(1) A false sense of security is obtained by depending upon the oil; (2) Agreed; (3) Arc damping devices are provided on air-break gear.

Major Roberts agreed that air-break gear for a given capacity was larger than oil-immersed. The actual sizes of one of the gate-end switches is 18½ ins. × 18 ins. × 9 ins. high. With the skids these dimensions became 40½ ins. × 19½ ins. × 11½ ins. The comparative figures which he had quoted of air-break contactors against oil-immersed had been supplied to him by Mr. Idris Jones of the Powell Duffryn Company, and Mr. Jones had that evening confirmed them.

In reply to the points raised by Mr. J. B. G. Lewis, there were, of course, many installations that required time lags in the running position, and, as Mr. Lewis suggested, there was more than one way of giving that form of protection. The figure of 80% of burn-outs due to single-phasing was supplied in answer to a questionnaire sent out to motor makers and insurance companies about four years ago, and he was inclined to think that they were based upon fuse practice, although he would point out that overload trips were not always effective in preventing single-phasing. He had no authority for any statement that the Mines Dept. would accept air-cooled resistances with flame-proof controllers, but he had knowledge of one definite case where such permission was granted after the apparatus makers' case had been submitted. The references to Cadmium plating had only been relevant to mechanical parts, not to its use for contacts, etc. Air-break gear had been tested under actual working conditions by some manufacturers for the past three years, and as a result Major Roberts had formed the opinion that it would be more extensively used as time goes on.

Major Roberts said he rather liked Mr. Higham's attitude of "sitting on a fence and seeing who is going to win." He thought, however, that to evoke a useful discussion one should be provocative on one side or the other. As regards his quandary with students, he might point out the good and bad features of both types of gear in varying conditions, and let each student make up his own mind.

He hoped Mr. Higham would excuse him from dealing with the trouble with high torque motors, but he did not think he was getting out of his depth in saying quite definitely that genuine high torque motors should not need centrifugal clutches. The construction of the resistance was exactly as Mr. Higham described. It was not intended to suggest that a live feeder should be put to earth. It should only be possible to earth a circuit after it had been made dead. The reason for locking out the overloads was to prevent the switch tripping and coming back to the "off" position should someone at the other end of the line accidentally attempt to make alive a circuit that had been earthed. If the trips were operative the breaker would come "off," and the whole purpose of the "earthed" position would be lost. Arc chutes for de-ionising the arc, exactly as Mr. Higham described were fitted on air-break gear. Air-break gear was larger than oil-immersed gear for the same capacity, but in spite of its larger cubic capacity, it had a smaller capacity for damage. A point to remember when dealing with the handling underground was that oil-immersed gear needed oil and that added considerably to the weight.

In reply to Mr. Freeborn, Sheffield University figures agree with the contention that a greater percentage of enclosures to-day are of the unvented type. He would agree that cast iron was not in any way comparable with welded boiler plate. Induction controllers were ideal for speed control when used with suitable motors, and Major Roberts felt quite sure that that simple method of starting and regulating was coming into favour. Regarding the film on contacts, oxidisation always occurred when copper was exposed to the atmosphere, but normally its rate of progress was slow. This trouble was serious when contacts were over-heated and, speaking generally, excessive oxidisation was due to some attendant cause, such as overloading, inadequate contact pressure, or bad joints.

In conclusion, Major Roberts said he now understood why Mr. MacWhirter had been so cool with him when they first discussed these safety devices. Some of the apparatus shewn had a considerable number of bolts but, after all, if the screws have to be taken off for inspection less frequently than before, there should be no great objection on that score.

Association of Mining Electrical Engineers.

EXAMINATION PAPERS, 1931.

SECOND CLASS CERTIFICATE.

1.—*Lighting, Signalling and General Regulations.*

(1) What size of feeder cable would you instal to supply current for the lighting of the screens and washery at a colliery, assuming that 10-60 watt lamps and 50-100 watt lamps are to be used? The screen and washery house is 200 yards from the power station and the supply voltage at the power station is 105 volts.

What difference would it make to your answer if the supply voltage were 210 volts?

(2) What are the requirements of the General Regulations in respect to electric lighting underground?

Give a wiring diagram for lighting underground stables the lighting of which is to be controlled from both ends.

(3) Describe (a) a trembler bell, (b) a relay, both suitable for use for underground signalling.

Under what circumstances are relays employed in signalling?

(4) What is the maximum voltage permissible for use in signalling underground? Why has this maximum been fixed?

Describe a type of battery suitable for use for signalling on a long haulage road. Shew by a sketch how you would connect the various cells.

(5) Explain the principle of action of a telephone transmitter. Why is a microphone battery used on a magneto telephone?

What happens when the telephone is taken off and when it is replaced?

(6) What is meant by "low pressure," "medium pressure," "high pressure," and "extra high pressure"?

What are the common pressures employed for various purposes underground?

What limitations are imposed by the General Regulations upon the pressures to be employed in certain cases?

(7) Describe briefly how you would proceed to carry out any two of the following inspections:—

1. Inspection of cables from the shaft to an inbye point.
2. Inspection of switchgear at a distribution centre.
3. Inspection of a main and tail haulage motor.
4. Inspection of a gate-end panel and coalcutter.
5. Inspection of a trailing cable.

(8) What is meant by the terms "open sparking," and "flame-proof enclosure"?

What are the limiting values for the following dimensions in flame-proof enclosures for use in mines:—

1. Breadth of flanges.
2. Gap or vent between flanges.
3. Diametrical clearance for spindle or shaft bearings?

(9) Why is it necessary to earth electrical apparatus? What are the requirements of the General Regulations in respect to earthing of apparatus and earthing conductors?

(10) Give the requirements of the General Regulations in respect to the protection of transformer systems, live parts and insulated cables and the isolation of faulty circuits?

2.—*Direct and Alternating Current.*

(1) State Ohm's Law.

Explain the terms:—ohm, megohm, millivolt, watt, kilowatt and kilovolt-ampere.

If a current of 40 amperes flows through a circuit with a pressure of 220 volts find the resistance.

How many kilowatts are equivalent to 75 Horse-power?

(2) What is meant by the term "insulation resistance"?

Explain how you would measure the resistance of an armour bond. Name and briefly describe the instruments you would employ.

(3) Describe the construction and action of either a voltmeter or an ammeter suitable for use on a d.c. circuit.

Shew by diagrams how you would connect an ammeter and a voltmeter in circuit

If you had only a 10 ampere instrument how would you measure a current of approximately 50 amperes?

(4) Figs. 1, 2 and 3 (on the separate sheet) show the mains, the motor terminals, the field windings and the starter for a series, shunt and compound motor respectively. Indicate on the diagrams, which must be handed in, how you would connect each of these machines in practice.

Describe a starter for a d.c. motor. Why is it necessary to use a starter?

(5) A d.c. motor has been running for some time with the ammeter reading 65 amperes and the voltmeter 480 volts; the load has increased and the readings are 98 amperes and 460 volts. What is the increased input to the motor expressed in Horsepower?

Assuming that the pressure at the generator terminals is 500 volts in both cases, how do you explain the drop in pressure at the motor when taking the larger current?

(6) What is meant by the term "power factor"?

What disadvantages attach to a low power factor?

A three-phase motor takes 55 amperes at 480 volts with a power factor of 0.8. Calculate the kilowatt input to the machine.

If the efficiency is 85 per cent. calculate the output of the motor in Horse-power.

(7) Describe the principle of a static transformer and explain its construction.

A transformer has 945 primary turns and 63 secondary turns, its output is 40 amperes at 100 volts. Find the voltage in the primary and the ratio of transformation, neglecting losses.

(8) Describe briefly and state the uses of the following:—

(a) An overload release.

(b) A no-volt release.

How would you satisfy yourself that each of these was in order?

(9) Sketch and describe the lay-out for one of the following:—

1. A double face unit (one right-hand and one left-hand face), each face having one coalcutter and one conveyor.
2. A single face unit having one coalcutter, one conveyor and one gate-end loader.

Details of the type and size of gear should be indicated on your diagram.

(10) Explain the principles underlying the following:—

(a) A star-delta starter.

(b) An auto starter.

(c) A liquid starter.

What are the objects of these devices? Mention the various uses for which each is employed.

FIRST CLASS CERTIFICATE.

1.—*Direct Current.*

(1) Given that the specific resistance of copper is 0.66 microhm per inch cube, calculate the resistance of one mile of 19/14 cable having an effective area of 0.0976 sq. in.

Find the drop in volts per mile and the watts lost per mile when such a cable transmits a current of 90 amperes at 500 volts. Assuming Joules' equivalent to be 778 foot pounds per B.Th.U., find the rate of generation of heat in the cable.

(2) Enumerate the various causes of sparking at the brushes of d.c. generators. Indicate how you would ascertain the cause in practice and specify the remedy for each case.

(3) What easily variable factors determine (a) the e.m.f. generated by a dynamo, (b) the speed at which a d.c. motor will run?

A shunt-wound dynamo when running at 900 r.p.m. supplies to an external circuit a current of 180 amperes at a P.D. of 460 volts. The shunt current of the machine is 5 amperes and the resistance of the armature is 0.05 ohm. Find the speed at which the same machine will run as a motor on a 460 volt supply when taking a current of 150 amperes.

(4) Sketch the characteristics of the various types of d.c. motors. Give diagrams shewing the connections, including the starter for each type.

Describe the arrangements you would make for reversing each type.

(5) Sketch and describe a voltmeter suitable for use on d.c. circuits. How does such an instrument differ from an ammeter? How may an ammeter be used to measure voltages, and how may a 10 ampere instrument be used to measure larger currents?

(6) Outline briefly the various methods of testing the efficiency of d.c. motors and describe fully how you would proceed to determine the b.h.p. and efficiency of a series wound motor by direct measurement. A

motor takes 40 amperes at 500 volts when running at a speed of 600 r.p.m. If the torque measured is 220 pounds-feet determine the b.h.p. and the efficiency of the motor.

(7) Explain how you would determine the current distribution in a network of conductors. Four stations A.B.C. and D. are connected by five mains AB, BC, CA, AD and DC the respective resistances of which are 5.0, 2.0, 4.0, 1.0 and 3.0 ohms. If 120 amperes are fed in at A and 60 amperes at B, and the whole current is taken out at C, find the distribution of the current in the network and the potential difference between A and C.

(8) Describe the Murray Loop Test for the location of a fault in a feeder cable.

In such a test on a two-wire feeder cable 1000 yards in length and which had developed an earth fault on the positive lead, balance was obtained when the resistance in the two arms of the testing apparatus was 1000 and 1484 ohms respectively. Determine the position of the fault.

2.—*Alternating Current.*

(1) Define the terms "power factor" and "wattless current." Enumerate the disadvantages of low power factor and the most common causes of low power factor in colliery installations. Indicate briefly the methods used for power factor improvement.

(2) Three-phase current at 3000 volts is to be taken down a mine shaft 800 yads in depth. Assuming that the underground power requirements amount to 1000 k.w. at a power factor of 0.7 and that the distance from the surface power station to the underground sub-station is 1000 yards, specify the size and type of cable you would instal. The shaft is fairly wet and the water is slightly acid. In calculating the size of cable the effects of induction may be neglected but you must shew clearly all the assumptions made for the purposes of arriving at your answer. Indicate what difference it would make to your answer if inductive effects were taken into account.

(3) What type of motor would you employ for (a) an electrical coalcutting machine, (b) a shaker conveyor, and (c) a belt conveyor? Give reasons for your choice.

Commencing from the main cable draw a diagram of the equipment and connections for a three-phase coalcutting machine.

(4) Name, and indicate the essential points of difference between the various types of static transformers used for mining. Give a brief description of a transformer suitable for stepping down from 3300 to 550 volts in a pit bottom sub-station.

Why is it necessary to cool transformers and what methods are adopted for this on the surface and underground?

What are the B.E.S.A. requirements with respect to temperature rise in transformers?

(5) Explain by the aid of diagrams the meaning of the terms "star connection" and "mesh connection." For what reasons, and in what types of plant is it customary to incorporate means for connecting in both these ways?

A three-phase motor delivers 75 horsepower at 400 volts at a power factor of 0.7 and a motor efficiency of 95 per cent. Assuming a mesh winding find:—

(a) the current in each phase winding of the motor.

(b) the current in the mains.

(6) What do you understand by the terms "charging current" and "capacity" as applied to an a.c. cable?

What is the charging current in an unloaded single-phase feeder cable of 7 microfads capacity if the applied voltage is 3000 and the frequency is 50 cycles per second?

How may the capacity of a cable be measured, and in what way is it influenced by the character of the insulating material?

(7) Describe three methods of starting up a squirrel-cage motor under load giving diagrams of the connections.

Under what circumstances would you employ the various methods which you describe?

(8) Name, and indicate the functions of the requisite instruments to be provided on the control panel of an a.c. generating station having three 10,000 k.v.a. alternators generating current at 6000 volts?

Sketch and describe any one of the instruments named.

(*To be continued.*)

COAL FACE MACHINERY EXHIBITION, SHEFFIELD.

2nd—10th October, 1931.

ORGANISED PARTIES ARRANGED IN CONNECTION WITH THE EXHIBITION.

Friday, October 2nd.

Mining Students from Sheffield University.

Saturday, October 3rd.

Midland Branch, National Association of Colliery Managers, to be followed by Joint Meeting with Yorkshire Branch specially fixed for Sheffield.

Yorkshire Branch, National Association of Colliery Managers.

South Staffs., Warwickshire & Worcestershire Branch, National Association of Colliery Managers.

North of England Branch, National Association of Colliery Managers.

Advanced Students from the Wigan & District Mining & Technical College.

Mining & Mining Electrical Students from Mexboro & Wombwell Technical Schools.

Mining Students, Notts Education Committee, Nottingham.

Officials' and Men's Society from Park Mill & Emley Moor Collieries.

Monday, October 5th.

Members of Chesterfield Branch, Derbyshire Mining Students Association.

Wednesday, October 7th.

Yorkshire Branch, Institution of Mechanical Engineers. Paper to be read by Professor Statham.

Members of Machine Mining Course, Technical College, Chesterfield.

Thursday, October 8th.

South Wales Institute of Engineers, followed by discussion in Sheffield on two papers "Modern Belt Conveyor Practice" and "Longwall work in the red vein (Anthracite)."

Friday, October 9th.

Meeting of the Association of Organisers & Chief Instructors of Mining Education to be held in the Sheffield University in conjunction with an organised visit to the Exhibition.

Saturday, October 10th.

General Council Meeting in Sheffield of the Association of Mining Electrical Engineers to be followed by a visit to the Exhibition.

Yorkshire Branch, Association of Mining Electrical Engineers, to be followed by a Branch Meeting for discussion on Coal Face Machinery.

Mining Students from Castleford, Normanton & District Mining & Technical Institute.

Doncaster & District Mining Society.

Batley & District Mining & Engineering Society.

Members of Clown Branch, Derbyshire Mining Students Association.

Members of Heanor Branch, Derbyshire Mining Students Association.

Dates Unfixed.

Advanced Mining Students, Denbighshire Technical College, Wrexham.

Mining Students, Carmarthenshire Mining & Technical Institute, Llanelly.

Mining Students, County Mining College, Cannock.

MANCHESTER COAL RESEARCH.

It is announced that the new research laboratory of the Lancashire and Cheshire Coal Association, recently transferred from the College of Technology to splendidly-equipped premises at 7 Park Street, Cheetham, Manchester, will be formally opened on September 22 by Mr. Robert A. Burrows, supported by many representatives of the technical and scientific branches of the mining industry.

Mr. Burrows was a pioneer of coalfield research, having been the first president and hon. secretary of the Lancashire and Cheshire Coal Research Association. In October, 1930, the Research Association was taken over by the Lancashire and Cheshire Coal Association.

Among the most interesting phases of the work, investigations of low temperature carbonisation may be mentioned. The Research Association's staff in Manchester evolved an improved assay plant that could be used with any coal, and that gave byproducts in quantities large enough to permit of accurate estimation. In this matter the Lancashire and Cheshire Coal Research Association may claim to be in the forefront of research in this country.

VICKERS-ARMSTRONGS' WORKS.

Continuing their policy of concentration of production the Board of Vickers-Armstrongs Limited have decided to transfer from their Erith Works the manufacture of the products at present being carried on there. The manufacture of the heavier products of these works has already been transferred to the Company's Northern Works at Newcastle and Barrow-in-Furness, and the Company now intend to concentrate the lighter products in their Crayford and Dartford Works. Owing to the proximity of the three works the Company do not consider that there will, in consequence of this rearrangement, be any serious disturbance of employment in the district.

NEW CATALOGUES.

HASLAM & STRETTON Ltd., 37 The Hayes, Cardiff.—A folder gives particulars and a series of illustrations together with prices of the "Allgrip" Steel Arch Clip for underground mining service.

AUTOMATIC TELEPHONE MANUFACTURING Co., Ltd., Melbourne House, Aldwych, London, W.C. 2.—An illustrated leaflet directs attention to the "Strowgerphone", the simple automatic telephone system which the Company is prepared to demonstrate to anyone interested free of cost. These telephones can be supplied on rental terms from 1s. 0d. per week per 'phone for use in association with exchange installations.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2.—Magnet Electric Furnaces and Ovens are dealt with in the very complete and interesting catalogue No. H.O.5884. The use of electric furnaces for annealing and hardening, as well as for melting, metals is rapidly developing and a number of interesting equipments of this character are shewn in this catalogue.

Transformer Accessories form the subect of the G.E.C. Technical Descriptions No. 311 and 312; Section No. 4 deals with Oil Gauges for transformers and section No. 5 with Off-Load Type Tapping Switches.

HEYES & Co., Ltd., Water-Heyes Electrical Works, Wigan.—The recent issues of the "Wigan Review" include "Interesting Installations" concerning the Winter Gardens, Blackpool and the Player's Tobacco Works in both of which Wigan lighting fittings are used.

BRITISH INSULATED CABLES Ltd., Prescot, Lancs.—The publication P 258 runs to nearly 50 pages and constitutes a permanently useful reference book for the Mains Engineer; fully dimensioned, outline and detailed drawings give all necessary particulars of the range of B.I. Disconnecting Boxes.

The B.I. Co., have also issued a folder giving a a list of the E.H.T. Cables supplied by them for a.c. working pressures of 66 k.v. and 33 k.v.

BRITISH THOMSON-HOUSTON Co., Ltd., Rugby.—The attractive little catalogue "Fractional H.P. Motors" shews that the B.T.H. Co. were the pioneers of British built machines of this type. Dimensions, rating and prices are included and a series of illustions shews the motors being manufactured at the makers' works.

ELECTRICAL APPARATUS Co., Ltd., Vauxhall Works, South Lambeth Road, London, S.W. 8.—A series of new catalogues recently issued by this Company includes: No. E 120, D.C. Magnetically operated Contactors; No. E 124, D.C. Automatic Contactor Starters; No. F 140/A, A.C. Contactors and Contactor Starters; No. F 141, A.C. Auto Switches and Small Contactor Starters.

CHLORIDE ELECTRICAL STORAGE Co., Ltd., Clifton Junction, Manchester.—The Chloride Chronicle and Exide News, No. 49, is an exceptionally interesting issue. The technical notes include an article by Mr. E. C. McKinnon, who deals with charging batteries through rectifier valves, effects of over charging, battery rating, etc. The remarkable popularity of the Annual Exide Service Convention is evident from the broad sheet of photographic views bound into this publication.

W. T. HENLEY'S TELEGRAPH WORKS Co., Ltd., Holborn Viaduct, London, E.C. 1.—A pocket price list shews the reduced prices, and gives general particulars of the packings, etc., of "Henley" Insulating Tape.