The Mining Electrical Engineer.
OFFICIAL JOURNAL OF THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS.
EDITED BY E. DINSDALE PHILLIPS.

Vol. XII. JUNE, 1932. No. 141.

## Latest Convention News.

Writing as it were on the eve of the A.M.E.E. Convention and having before us a little batch of last minute notes from Mr. Gibb the energetic organising secretary, we find there are still one or two points calling for specific mention. The official programme is again set out at length in our advertisement pages. Readers are asked to note that the visit on the Tuesday morning to the Yoker Works of Messrs. Drysdale & Company will be fittingly consummated by the Company entertaining the visitors at luncheon. Another point is that the Pullman Company have been so good as to arrange for one of their sumptious cars to be attached to the train on the return journey from Edinburgh to Glasgow on the Wednesday; this will ensure the party the privilege of taking tea and light refreshment together under comfortable and happy conditions. The members of the Lothians Branch and others who reside or may be placed near to Edinburgh will be glad to know that they will be excused four shillings on account of their not requiring to travel to and from Glasgow.

It is with particular gratification that we announce the names of some of the principal guests who will honour the Association by attending the Annual Dinner on the Friday. Major the Right Hon. Walter Elliot, M.C., M.P., M.B., Ch.B., D.Sc., Financial Secretary to the Treasury, has consented to be present and to propose the toast of "The Association." The Lord Provost of Glasgow, Sir Thomas Kelly, will be present and has promised to reply to the toast of "The Corporation of the City." Mr. Robert Forrester, President of the Lanarkshire Coal Miners' Association, will also attend the dinner and he has undertaken to reply to the toast of "Our Guests."

The programme is remarkably good, full of the promise and generous intentions of the A.M.E.E. men over the border and brightly reflective of the enthusiasm and hospitality proverbially inseparable from the Scottish temperament. Supplementary to the cordiality of its people, and perhaps in some benign way responsible for the national trait, comes the never failing charm of the grandeur and romance of the cities and towns, the lochs and the glens, to make perfect the welcome awaiting the visitor. At this near date practically every member of the Association will have decided whether or no he will attend the Convention: but there may still be a few hesitant and doubtful. Shall we ask them: who is it would turn aside deliberately from this golden opportunity of a glorious week in June?

## British Industries Fair.

There is satisfaction to be found in the published returns which compare the Leipzig Fair with our own British Industries Fair. The British manufacturer will, furthermore, surely perceive in these figures a compelling incentive and encouragement to use more freely the unique and increasingly powerful business opportunities for which the B.I.F. exists. Briefly, the relative statistics shew that in 1930 the British Fair had 1979 exhibitors and attracted 3000 foreign buyers; in 1932 there were 2348 exhibitors and 10,066 foreign buyers attended. The corresponding figures for Leipzig are: for 1930, 9540 exhibitors and 32,420 buyers; for 1932, 7622 exhibitors and 16,385 foreign buyers. There are, of course, many factors entering into a true consideration and analysis of the causes and significance of the Leipzig decline and the growth of the British Fair. No matter why or how particular circumstances may have affected the question, there is the fact, by far the most important to us, that there were more than three times as many over-seas buyers at our Fair this year than there were two years ago. The indication is obvious.

It has all along been rightly complained that the British electrical, including the more specific mining electrical, manufacturer has never since the B.I.F. was instituted lent to it his active participation nor made a real endeavour to use it properly to anything like the extent compatible with his avowed aspirations and fervently expressed intentions concerning home and export trade. Whether this apparent neglect may have been due to incredulity, or an apathetic disbelief in the promises of benefit, or to any deliberate impedance, or to a mixture of some such deterrents, is no longer to the point in face of this indisputable evidence of the real and great worth of the B.I.F. in bringing trade to this country.

We must, therefore, commend to our manufacturer friends, and indeed to all interested in mining electrical development, that they should at once get down to the consideration of ways and means of how they can best use next year's Fair—use it to their own advantage. From now until next March is but a little time for preparing work of this kind. The management of the Fair have consistently shewn that they are always ready to meet the traders' requirements in regard to the exhibits themselves and to ensure that the right kind of men will be brought together to see and examine and to buy. There are certain matters such as, for example, the grouping of exhibits, the supply of power and the scope for shewing plant or process in operation, special publicity and advertising, in which the Fair management are largely dependent upon the initiative and request of exhibitors. The management of the Fair have proved their unremitting attention to the expressed needs of exhibitors; they have re-modelled and rebuilt, they have acquired much more land and erected vast new buildings; they have enormously increased the scope of their over-seas and homeland mailing lists to bring together by express invitation the buyers of particular classes of goods. These are points calling for the maximum degree of co-operation between the Fair authorities and British manufacturers and which require many months for growth to fruition. So, though it may seem in these Summer Days a long outlook to Spring and next year's Fair, there is here real need for urgency.

## CORRESPONDENCE.

The Editor.

### A Colliery Visit.

A few weeks ago our Chief Sales' Engineer came back from a colliery and reported that he had been greeted with the same comment from the electrical engineer which sales' engineers of all descriptions of mining plant have heard over and over again—"if only the people who design and make the stuff had to come down the pit and work it they would soon . . . . etc., etc."

The reply from our staff was—"How many of us ever get the chance to go down a pit" and the outcome was the visit by fourteen of our people (the party was necessarily limited) described in the article herewith by a young member of our Sales Department.*

Should you make use of this article, we desire to impress upon you that in this instance we are not seeking publicity for ourselves. We would much prefer the matter to be dealt with from the point of view of the enterprise of a Colliery Company in arranging for a very valuable and instructive lesson to a manufacturer's staff and workpeople and impressing them, as they certainly have been impressed, with a sense of responsibility when designing, making, testing and selling electrical plant for mines.

1*st June*, 1932. A MANUFACTURER.

The Editor.

### The Testing of High Rupturing Capacity Circuit Breakers.

In these days of large colliery amalgamations with huge centralised sources of supply or several power stations in parallel, or where collieries are directly connected to the National Grid, the above subject is of paramount importance.

There are no standard designs for the different breaking capacities; they are left to the ideas of consultants and manufacturers whose methods of approaching the problems are unfortunately handicapped at the outset by prices.

Colliery buyers of main switchgear, once they realise the vital importance of these items, will probably not be satisfied with a mere statement from the makers that a certain switch has a rupturing capacity of so many k.v.a., but will require a test certificate and what is more important, will insist upon witnessing the actual tests. According to B.E.S.A. Specificaition No. 116: "a breaker shall interrupt its rated k.v.a. breaking capacity twice at a two-minute interval, and shall then be in a sufficiently good condition to be closed again and to carry its normal rated current." This seems hardly stringent enough, as the sparking tips may be destroyed and permanent distortion of parts may have occurred and still the switch carries on after the specified test and therefore passes the test, but in such circumstances could not be relied upon.

I notice that in Britain we have recently built several giant circuit breakers which each have a rupturing capacity of 2,500,000 k.v.a. This is an admirable performance, but prompts one to ask how the breaking value was arrived at. Is it the result of part test and part calculation, or a purely theoretical statement? To carry out actual tests on these switches requires exceptional supply facilities. No confidence should be given to purely theoretical statements when buying circuit breakers but perhaps some reader will explain the methods adopted by manufacturers when testing large switches. The subject certainly needs ventilation and many engineers would welcome complete information on this matter of ever increasing importance.

*Morpeth*, GEORGE BARNARD.
22*nd May*, 1932. (Member, A.M.E.E.)

## New Oil and Coal Fuel.

Experts of the Cunard Company have produced a new liquid fuel consisting of some 60 per cent. of crude oil and 40 per cent. of bituminous coal which is being tried out on the "Scythia." It is stated that large-scale tests have been carried out at the works of the Wallsend Slipway and Engineering Company on the Tyne, and various types of Northumberland, Durham, and Yorkshire coal have been used with ordinary first-grade fuel oil. The resultant product is of a colloidal nature and compared volume for volume with oil has proved to be cheaper and of greater heating efficiency.

To test it under working conditions four of the liner's furnaces are being exclusively fired with it on the round trip to New York and back.

The engineers have reported, on the arrival of the "Scythia" at Queenstown, that they were entirely satisfied with the results of the tests at the end of her first day's run on the new fuel.

Estimates shew that a plant costing no more than £250,000 would be sufficient to provide for all the requirements of the Cunard Company—2000 tons a day.

The cost of mixing the fuel, allowing for all overhead and establishment charges, would be 2s. a ton at a large installation.

* See page 448.

# LEAKAGE PROTECTION.

G. W. STUBBINGS, B.Sc.

The function of what is usually known as protective gear is to protect electric cables and machinery from the destructive effects of excessive currents which are set up by insulation failures. The earliest examples of gear of this kind are exemplified by fuses and the various forms of overcurrent tripping devices which are still in extensive use. The outstanding defect of apparatus of these types is that the difference in the conditions, with respect to the apparatus, between fault circumstances and those normal, is one of degree only, and therefore in the adjustment of apparatus of this kind, regard must be had for the occurrence of temporarily excessive normal currents not arising from faults. A great advance was made in the technique of automatic protection, when a circuit arrangement was devised in which current only appeared in the trip coil or protective relay when an actual breakdown of insulation had taken place. With this arrangement it became no longer necessary to have regard to excessive currents which might occur in normal working and from causes other than insulation failures, so that the sensivity of the protective apparatus could, apart from some other minor considerations, be made as great as might be deemed advisable. The earliest of this type of protective circuit was that commonly known as the leakage or core-balance system and, applied to three-phase a.c. circuits, this is one of the most widely used and most effective and simple of all the schemes of protection still available.

The principle underlying the leakage system of protection is very simple: in a few words, it is that the instantaneous sum of the currents in all the lines or wires of an insulated system, in which there is not any leakage, must at all times be zero. This principle, which is so simple as to be obvious, applies equally to d.c. circuits, but the application of the principle is most useful in the a.c. field because of the ease with which alternating currents can be transformed to a reduced value in an insulated secondary induction circuit. The simplest application of the leakage protection principle, as applied to three-phase circuits, consists of a transformer core provided with a secondary winding, and enveloping all three conductors of a three-phase three-wire circuit. So long as conditions of insulation are normal, the instantaneous sum of the three line currents will always be zero. There will be no flux set up in the core, and no voltage will be induced in the secondary circuit of the transformer. If an insulation failure develops at a point on the supply system on the load side of the transformer, then part of the current proceeding from the point of supply will return by a the shunted earth path which is not enveloped by the transformer core. The instantaneous algebraic sum of the currents through the core will therefore no longer be zero, and the residual current will induce a voltage in the secondary winding which can be employed to operate a relay and which in turn, can trip the circuit breaker controlling the faulty circuit.

The usual application of the system of leakage protection to three-phase circuits is shewn in Fig. 1. Here three current transformers are used, one in each of the primary conductors, and the secondary leads of these transformers, after being connected through the indicating and registering instruments, are joined to a common return conductor, in which the leakage relay or leakage trip coil is connected. So long as there is no leakage to earth, and all the currents in the circuit are confined to

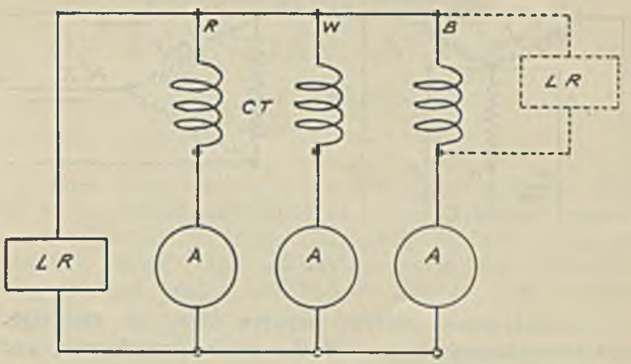


*Fig.* 1.

the three lines, then the secondary currents meeting in the common return will cancel and the resultant current in the leakage relay will be zero. If, however, there is an earth fault on the circuit, and some of the current proceeding outwards through any of the lines does not return through the other two, then the secondary currents will not cancel in the common return leakage relay wire, and the relay will receive a current which is a secondary copy of the current in the earth (fault) circuit.

The reason for the connection of a leakage relay to a system of current transformers is not found self-evident by many engineers, especially when this connection is made in an unusual way. Apart from considerations relating to the imperfections of the current transformers, the point of connection of the leakage relay terminal, which is remote from the common connection of the transformer windings, is indifferent, and this connection may be made as is shewn by the dotted lines in the diagram, Fig. 1. Connected in this way, it appears that the leakage relay will short-circuit the secondary winding of the blue phase current transformer, and that in normal circumstances current will appear in this relay. It must always be remembered, however, that apart from transformer imperfections there can be no current in the common connection of the transformer secondary windings, and that with the alternative connection for the leakage relay shewn on the diagram, the currents from the red and white transformers combine at the common connection to the instruments, and this resultant current meets the blue phase current at the leakage relay connection, and cancels it.

There is a further point respecting the connection for leakage protection on which there is misunderstanding on the part of some engineers. It is often said that an out-of-balance in the primary circuit will tend to operate a leakage relay. To understand that this is not the case, we need only recollect that any unbalanced three-phase circuit can be considered to be the result of superimposing a single-phase load on one which is balanced, and that pure single-phase loading is representative of the extreme condition of unbalance. Considering this condition, we easily see that if the only currents in the three-phase system are due to a single-phase load taken between red and blue phases, then the secondary currents corresponding will be equal in magnitude, and opposite in direction, and will accordingly cancel at the point of connection of the leakage relay.

The question is sometimes asked as to whether an earth fault on a low-pressure four-wire system will operate the leakage relay on the high-pressure side of the supply transformer. The vector diagram, Fig. 2, shews that the earth fault on the four-wire side, appe-

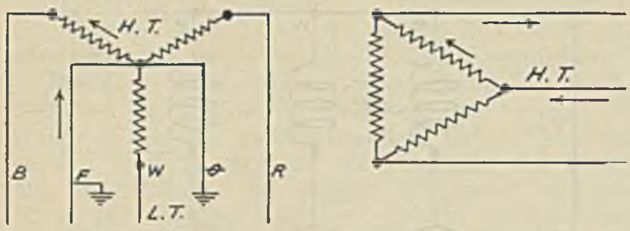


*Fig.* 2.

as a single-phase current between lines on the high-pressure three-wire side of the power transformer, and that, in accordance with what has been said above, there will be no tendency for the leakage relay on the high pressure side to operate. The only condition which can give rise to the operation of a leakage relay, other than current transformer defects, is that of a current flowing from the system into earth. The leakage relay wire is a secondary copy of the earth circuit on the primary side, and only carries current when there is a fault current flowing in the earth. The secondary current which corresponds to the fault current, is usually known as the residual current. This residual current flows in the leakage relay circuit, in preference to returning through the secondary windings of the other transformers, because those windings offer a very high impedance to the flow of any current which is not balanced by a corresponding current on the primary side; these windings, as a matter of fact, behave as a choke coil with a closed iron magnetic circuit.

We have already referred to imperfections of the current transformers used for leakage protection. It is well known that in all current transformers there is a slight difference between the actual and the nominal values of the secondary current, and that this difference increases as the impedance of the secondary circuit is increased and also when the primary current assumes very high overload values. It is easy to see that if these unavoidable errors of transformation are not the same in all three transformers there will be a small residual current in the leakage relay, even though there is no fault current flowing in the primary circuit. At heavy overloads these residual currents are liable to increase rapidly because the transformation errors also tend to become large, and so it is possible for the residual current to become sufficient to operate the relay without there being any earth fault on the circuit.

It is sometimes useful for the leakage relay to operate with heavy overload currents, such as would be set up by short circuits between phases but, as a rule, it is considered desirable for the leakage relay to be responsive to earth faults only. The tendency to improper operation will be accentuated if the impedances of the instruments connected to the three transformers differ considerably, since this will tend to set up a residual current at normal loads and will increase the tendency

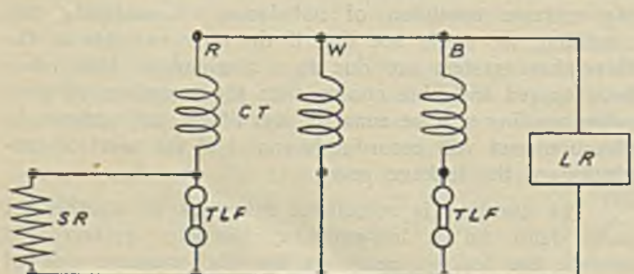


*Fig.* 3.

to large differences in the errors of transformation when overloads are experienced. The tendency to improper operation of a leakage relay can be reduced by carefully choosing a suitable value for the impedance of the fourth wire of the secondary circuit of the current transformers. Although a fair amount of impedance in the leakage relay circuit will have a very small effect on its operation when the currents in the main conductors are not very large, its effect will be very beneficial in contions of heavy overloads, as the effect of the excessive currents in the transformer windings is greatly to diminish their impedance to the flow of extraneous currents. The high residual currents which may occur in overload conditions will tend to flow partly in the secondary windings of the transformers which are supplying the smaller secondary currents, and the diverting effect will naturally increase as the relay impedance is increased.

It is evident that the leakage relay impedance must not be increased unduly, or the shunting effect of the transformer secondary windings will become effective on the occurrence of an earth fault, when the currents have moderate values only. In these circumstances this shunting effect will result in a greater fault current being required to operate the relay than the value which corresponds to the setting of the relay. The effect of the relay impedance in increasing the primary current fault setting can be conveniently checked by determining the current required to operate the relay; firstly, when it is disconnected from the current transformer circuit and, secondly, with this circuit and wiring connected. In the second test, the current transformers will divert a certain amount of current from the relay winding, so that a slightly greater amount of current has to be supplied from the testing circuit to cause operation. This shunting effect corresponds very closely with that which actually occurs when the relay is operated by fault current in the primary circuit. There should not be more than ten per cent. difference between the two values of the current and any value of the leakage relay impedance which does not give rise to a greater difference than this will be beneficial in giving stability in conditions of heavy overload.

We have referred to the fact that an unstable leakage relay is the same as an overcurrent relay with a high, but indefinite, setting. Although this indefiniteness usually renders instability undesirable, it is possible to use a leakage relay for overcurrent protection by means of the simple circuit shewn in Fig. 3. Here two time limit fuses are used, one in each wire from two of the current transformers, and one of these fuses is shunted by a resistance. By means of this circuit, the leakage relay can be caused to operate at a value of the current in the primary circuit which is determined solely by the time limit fuses. Let us consider the effect of short circuits between each pair of phases. A short circuit between white and blue will give a high value of the secondary in the blue transformer which will blow the time limit fuse. The white phase current will then pass into the leakage relay. With a short circuit between red and blue phases both of the fuses may be blown. Red phase secondary circuit is not, however, completely interrupted, and current from the transformer on this phase will flow through the resistance shunting the fuse into the leakage relay. If a short circuit occurs between red and white, the red fuse will be blown, and due to the resistance which will now be interposed in this circuit, the value of the current from the red phase transformer will be reduced. The current from the white phase transformer will, however, be unaffected, and the difference between the two currents will flow

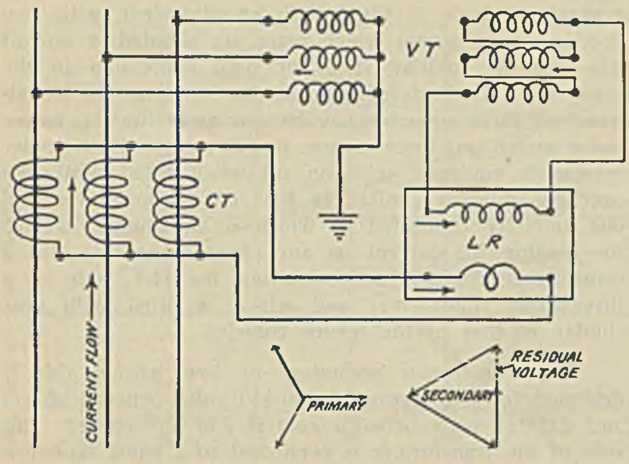


*Fig.* 4.

into the leakage relay. The efficacy of the scheme depend upon a proper value being given to the resistance which shunts the red time limit fuse. It is not difficult to determine the correct value for this resistance experimentally, and this value having been obtained the arrangement gives a very cheap and effective system of overload and leakage protection with the use of one relay element only.

For many years after its original introduction the leakage system of protection was essentially non-directional in that there was no ready means available for distinguishing between leakage currents flowing in opposite directions in an interconnector cable. It is evident that as the current in a leakage relay may be derived from either of the three phases, none of the system voltages can be used to determine the direction of this current. What is required for the determination of the direction of a leakage current is a voltage which is automatically associated with the phase in which the fault current is flowing. The voltage can be obtained by the very simple device which is illustrated in Fig. 4. The directional relay is of the wattmeter type with its current coil connected to a sytem of current transformers in the same way as an ordinary non-directional relay. For supplying the voltage circuit of the relay a star-delta voltage transformer is used, the primary .star point of which is earthed, and the secondary delta open. In normal conditions, with no current flowing in the earthed neutral at the point of supply, the vectors of the star voltages form a closed triangle, and the-e is no residual voltage in the secondary delta. Suppose now that an earth fault occurs on one of the main conductors, the potential of this conductor with respect to earth will be reduced, and due to the voltage drop in the earthing resistance at the point of supply, the potential of the star point of the voltage transformer will no longer correspond to the potential of the neutral of the system. The vectors of the primary voltages on the transformer will not form a closed triangle, and a residual voltage will appear in the secondary delta. Moreover, this residual voltage will evidently be proportional to and approximately in phase with the fall in the voltage to earth of the faulty line.

We thus have, in the directional relay, a current proportional to and in phase with the fault current which is associated with a voltage also in approximate phase with this current. The conditions for directional operation are thus satisfied, and a relay connected as shewn in the diagram, Fig. 4, can be made responsive only to leakage currents which flow into an interconnector cable.

# ELECTRIFICATION OF AN INDIAN SALT MINE.

I. E. PETERSON.

(*Khewra, Punjab, India*).

Over three hundred years ago, prior to British rule in India, mining operations in a very primitive manner were undertaken at a spot in a range of hills known as the Salt Range. That district has since been developed and the old mining site is now a large and valuable salt mine of considerable importance.

The seams of rock salt vary in thickness up to 200 feet and the system of mining now in force is that known as the pillar and stall or, what is locally known as the pillar and room method. The pillars are left thirty feet in width and the rooms span a distance of forty feet from pillar to pillar. This large span indicates clearly forcibly the tremendous strength of homogenous rock salt. The variety of rock salt procured from these mines is nearly pure salt: analyses prove it to consist of practically 99% of sodium chloride.

With the advance of time more modern methods and appliances have been gradually introduced for both excavation and transport until, a few years ago, the notable development of electrification was decided upon.

Since steam coal is not available in this district of Northern India and could only be procured from Bengal, a distance of nearly 1200 miles; and since high freight charges on crude oil coupled with the fact of a non-abundant water supply made steam generation in boilers unattractive. Diesel engines were considered to offer the most economical and practical solution of the question of prime movers. They were consequently decided upon and over a period of five years very little trouble has been experienced with them. By the renovation of existing parts, which was effected locally, the purchase of new spares has been reduced to a minimum. The consumption of fuel and lubricating oils is comparatively low. The thermal efficiency of the engines is fairly high, about 26% per k.w. hour over a period of 24 hours under varying local conditions; and, although the engines require a fairly considerable amount of attention, labour charges are not really excessive, whilst the volume of water consumed is practically negligible.

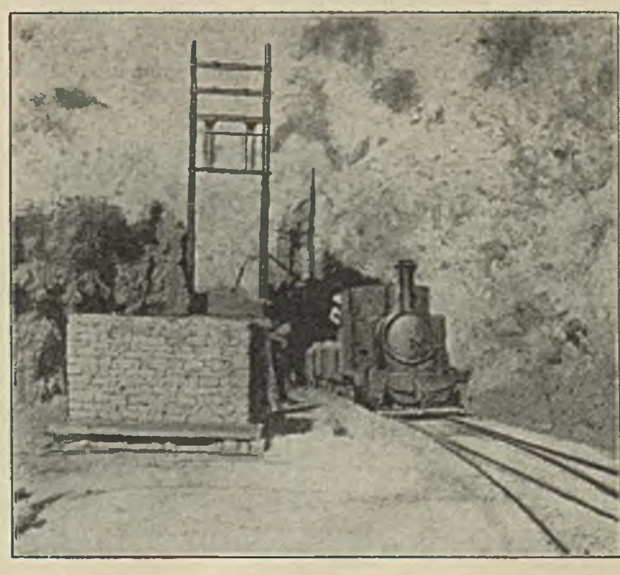

*Fig.* 1.—*Main Entrance to the Mines.*

*Fig. 2.—Typical Indian Salt Miners.*

A masonry reservoir was constructed as near to the railway siding as possible for the storage of fuel oil and into which railway tank wagons empty their contents. From this reservoir the fuel oil is transferred by an electrically driven centrifugal pump to suitable circular iron tanks mounted on a steel frame structure. This structure also supports two pressed steel water tanks, each of 6400 gallon capacity, for engine cylinder cooling purposes. The structure is so built that both the oil tanks and the water tanks are sufficiently high to enable the oil and water to gravitate to the engines. The water passes from the tanks through the engine cylinders to coolers wherein it is cooled and then passes away into a concrete sump. Centrifugal pumps in constant operation lift the cooled water back into the high service tanks on the structure and thus complete the cylinder cooling water circulating arrangements. The electric motor coupled to the pump also drives, through a belt, the fan inside the cooler.

The three-phase, salient pole, H.T. alternators are coupled direct to the Diesel engines through rigid couplings and are of the ordinary type with self-contained exciters.

The electrical energy generated is controlled by a truck type, totally-enclosed, ironclad switchboard. Each generator cubicle is fitted with an oil-switch, with two overload trips across which fuses are shunted, a no-volt trip and an auxiliary trip for field supression in the event of a fault developing in the windings of an alternator; three ammeters, an integrating wattmeter, power factor meter and three reverse power relays. Each feeder cubicle is equipped with an oil-switch fitted with two overload releases similar to that of the generator and one ammeter connected to which is an ammeter switch for reading the current on any phase. There is also a transformer cubicle for controlling the H.T. side of a three-phase transformer and which is fitted with gear similar to that of the feeder cubicles.

The transformer secondary or low tension side is designed for a pressure of 400/440 volts between phases and 231/254 volts between neutral and any phase. This side of the transformer is connected to a panel type low tension switchboard, also situated in the power station; the slate panels are fitted with an oil switch for the three-phase mains coming in from the transformer, and air-break, three-pole switches and ammeters for the various low tension circuits on the surface. The 400/440 voltage is used three-phase for power and the 231/254 volts single-phase for lighting.

The neutral point of the secondary side of the transformer is earthed direct through an isolating switch mounted on this switchboard. The neutral points of each alternator are earthed through separate single-phase oil switches and grid resistances.

A single-pole construction transmission line carrying two three-phase high tension overhead lines terminates at a two-pole structure at the mine entrance and conveys the generated energy from the power station to this point. From here the service continues through armoured cable for about a mile underground to a mine sub-station and an air-compressor chamber, respectively. Two reciprocating compressors, originally driven by oil-engines, are installed in this chamber. This arrangement is rather unique as it is unusual to instal compressor plant inside a mine. The chambers or rooms in the mine being quite large and clean no difficulty was encountered in the erection of the plant and the site selected offered special advantages. The length of the compressed air main comprising large and expensive pipes was considerably reduced, thus curtailing initial expenditure and the corresponding subsequent depreciation and interest charges.

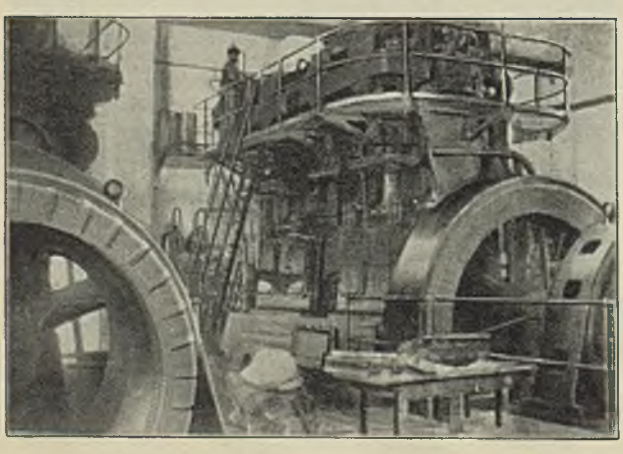

*Fig. 3.—Diesel-Electric Generators under erection.*

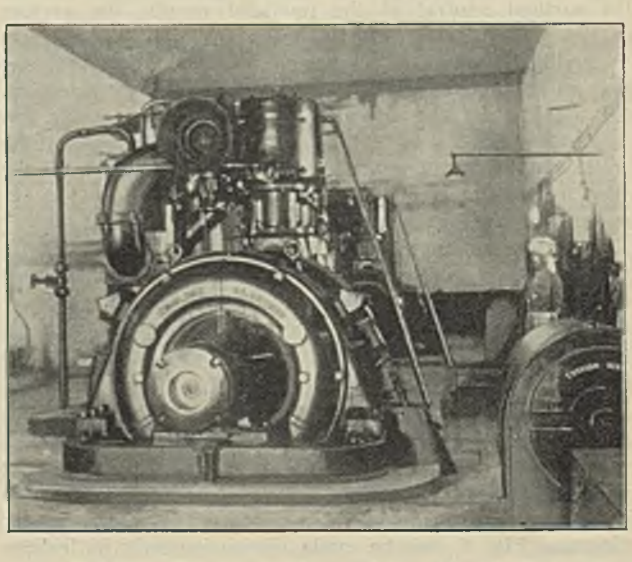

*Fig. 4.—Electrical Compressors underground.*

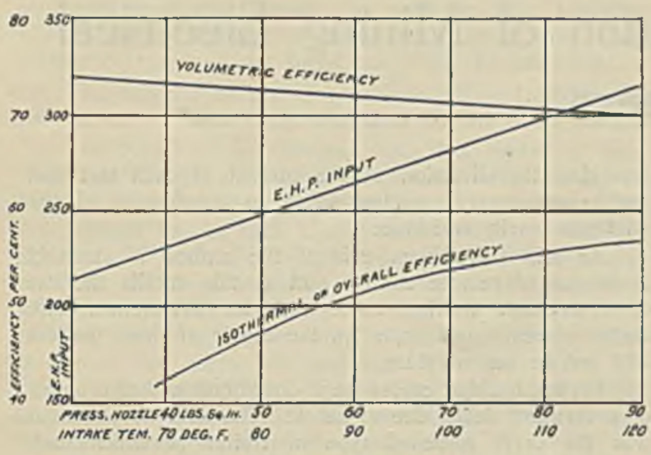


*Fig. 5.—Performance of Electric Compressors.*

The loss in air pressure by pipe transmission was decreased and better results were obtained from the pneumatic undercutting and boring machines. With one compressor in commission, fifteen of the former and four of the latter machines can be operated: the former machines doing approximately 33 square feet of undercut in an eight-hour shift. Better results are of course regularly obtained with the same type of machine when cutting in coal, but rock salt is probably about twice as hard to cut. The performance curves were plotted from the figures obtained on a test taken when the compressors were about eight years old. The original oil engines were replaced by electric motors and the compressors speeded up by 30% which gave a corresponding increase in output of approximately 25% of that specified when the machines were originally purchased along with the oil engines. The test in question was effected with the help of nozzles of different sizes so as to vary the pressure. Simultaneously electrical input readings were taken and the temperature at the intake of the compressors was recorded. The weight of air was calculated from the elevation and temperature and, finally, the curves were plotted from figures thus procured. The ratio of compression was varied to correspond with the different pressures at the nozzles. The curves obviously leave a good deal to be desired from the point of view of good compressor performance, but when the age, working conditions, the elevation of 1000 feet above sea level, and the fact that beyond a couple or three air valves, no other parts have been renewed up to the time the tests were made; when all these points are taken into due consideration, the curves in question will become rather more interesting.

In the mine substation previously referred to both high tension and low tension mining type switchgear is installed. The incoming H.T. mains after passing through the H.T. switchgear are connected with the H.T. side of a three-phase transformer. The L.T. side of the transformer is connected up to an ironclad switchboard from which all the outgoing circuits for both power and lighting are controlled. Electricity is used for haulages, pumps, ventilating fans, etc. and all main roads are electrically lighted, 60 watt half-watt lamps being used for the purpose.

Unfortunately steam locomotives are still in use for main surface haulage purposes between the mine and the despatch depot, but a scheme for the substitution of them by an electric traction system is under consideration: and very likely to mature in the near future.

## Sands, Clays and Minerals.

Under this title the first issue of a new quarterly magazine is published by Mr. Algernon Lewin Curtis of Chatteris, Cambs. The editor, Mr. N. E. Cutting, is to be congratulated on having produced an attractive and interesting first number, in which particularly effective use has been made of many illustrations, some colour-printed. The analysis of clays is dealt with in a concise form to enable the industrial chemist to carry out quickly an accurate ultimate analysis of the essential elements. An article on lithoplate abrasives contains much useful technical data and the photomicrographs reproduced will prove of more than ordinary value to those engaged in the lithographic printing trade. Other special articles deal respectively with "Sampling of Ores," "Slate," "Precious Stones," "Manufacture of Portland Cement," etc. A special feature of the first issue is the reproduction in colours of a representative selection of the Trade Marks of leading brands of British Cements. The Annual Subscription is Five Shillings, Post Free.

## NEW CATALOGUES.

GENERAL ELECTRIC Co. Ltd., Magnet House, Kingsway, London, W.C. 2.—The Installation Leaflet No. 9 is an interesting description of the complete electrification of the Chemical and Insulating Company's Works, Darlington, which manufacture such materials as Carbonate of Magnesia and Calcined Magnesia. The processes involved include burning, crushing, hydrating, pumping, drying, etc. for which compressed air and gas supplies are necessary. An unusual feature is the use of a trolley system electric locomotive for yard haulages.

The Leaflet No. X 6163 describes a new system of Control for Emergency Lighting, which embodies original features protected by patent.

MIDLAND ELECTRIC MANUFACTURING Co. Ltd., Barford Street, Birmingham.—The "Memdix" combined Switch and Fuses is a small push and pull switch rated at 10 amperes and so reasonably priced as to permit of its general use for domestic and other small current services.

A. REYROLLE & Co. Ltd., Hebburn-on-Tyne.—Pamphlet No. 841 is an illustrated technical description of the Reyrolle on-load Tap-changing Switchgear. It will be found extremely useful as dealing specifically with the construction and performance of transformers built for the "Grid" by Messrs. C. A. Parsons in conjunction with Messrs. Reyrolle.

A Leaflet No. 765 gives a series of illustrations and pointed paragraphs concerning Portable Electrical Distribution for Mines, being in effect descriptive of "Mothergate" Gears of standard ratings for 60 amperes and 100 amperes. A similar Leaflet amusingly tells a story concerning Reyrolle Metalclad Plugs and Sockets.

Another Reyrolle Leaflet gives a striking illustration in colour of a 4000 ampere, 12,000 volt Switch.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—This Company have issued colour printed Post Cards telling of B.I. Enamelled Wires and facilities for the deliveries of cables from stock.

The completion of the Shakespeare Memorial Theatre provides the opportunity for the production of an illustrated leaflet which, giving a general account of the Theatre building, mentions that some 40 miles of B.I. insulated wire were used for the electrical insulation.

The catalogue C.I.J. is an A.C. Metres Section for incorporating in the main general catalogue of the Company.

Under the title "From Sea to Sea," an account of B.I. worldwide development is supplemented with many striking photographic views.

BRITISH ALUMINIUM Co. Ltd., Adelaide House, King William Street, London, E.C. 4.—The history of aluminium as an industrial metal is well covered in the book entitled "Aluminium, its Production, Properties and Applications." This book is well produced; it runs to about 50 pages and has a series of 36 very diverse and useful photographic illustrations.

# Proceedings of the Association of Mining Electrical Engineers.

## WARWICKSHIRE & SOUTH STAFFS. BRANCH.

### Ⓟ The Protection of Coal Face Machinery and the Safety of the Coal Face Workers.

F. W. MAYNARD.
(Associate Member).

(*Continued from page* 412).

This Branch met in Cannock on February 18th to hear a paper read by Mr. F. W. Maynard entitled: "The Protection of Coal-Face Machinery and the Safety of the Coal-Face Workers." The speaker opened with an historical survey of the methods employed prior to the application of electricity to coal face machines. Many lantern slides illustrating such apparatus and also of machines now in common use were shewn. Photographs of open arcing on trailing cables when subjected to a variety of tests equivalent to practical faults were displayed and the author maintained that the results confirmed his opinion that many present methods of protection were still inadequate.

Trailers in many types were exhibited including a twin, separately insulated ferflex sheathed Cable with which it was claimed that it had not been possible to effect open sparking when the cable was connected in the manner he outlined. Mr. Maynard considered that the cost of this cable was reasonable in that the small additional expense was fully warranted by the consequent safety of life ensured.

Mr. Dixon opened the discussion when the Branch again met in Nuneaton on April 14th and the author was both challenged and supported during the evening by numerous members who had given careful thought to the subject.

Mr. Roberts moved the vote of thanks which was supported by Mr. Hopley and Mr. W. T. Anderson.

Mr. Maynard added that the interest taken in the paper had fully compensated him for the time he had been compelled to occupy in its preparation.

The first part of the Paper was published last month together with a selection of the illustrations exhibited on the lantern: the completion follows.

The words earth and earthing occur so frequently in protective circuits that we should have some understanding of what a good earth is. Whether copper or iron is used for the main earth plates, the ground where they are placed should be prepared specially. Information on this point is contained in the memorandum, and also a means of testing the earth plates themselves. One plate alone should not be relied upon but two or more, spaced not less than 20 yards apart. These should be connected to a common earth bar which should be accessible for testing at any time) by cables of not less than 0.25 sq. in. area, and removable links provided so that each plate may be tested. An earth plate having a resistance of 0.5 ohm should be considered efficient provided it is large enough to dissipate a bad fault current. A test panel developed by Metropolitan Vickers is shewn in the illustration Fig. 12: this together with an accumulator allows the earth plates to be tested at any time without completely disconnecting the whole earthing system. Two or more readings should be taken, reversing the direction of the current at each test and the lowest current reading taken as a criterion of the minimum earth resistance.

As will have been evident the author is strongly in favour of remote control and as this entails the use of a five-core trailing cable and, for preference, with earth screens a few notes on the repair of these trailers will not be out of place.

Ferflex braided cables were developed with the object of preventing death due to shock. The next development was the earth screened type of trailer in which each power core is completely screened by a complete roped copper sheath. When this type has been mixed up with the coalcutter picks it certainly does look a mess and seems hopeless to repair. Having used this type of trailer for some years and having had damage of all descriptions the author does state definitely that the bogey of repair of this type is very much exaggerated. One fact revealed itself quite early and that was that the length of the repair, with damage of equal dimensions, was greater with the earth shrouded type than with the plain four-core or five-core type. The details on repairs apply generally to all complex types of trailers, including the double screened type.

Particular attention is drawn to the necessity for maintaining cleanliness during all repair work. Dust, dirt or foreign matter on the hands, tools or materials will result in an unsatisfactory job.

The design of trailing cables is so varied that it would not be possible to deal with all types now in use, and it is proposed only to describe methods of repair for a design now extensively used, and one which embodies most of the desirable protective features.

Assuming the faulty section has been located, the cable should be suitably supported and held taut at a convenient height for working. The superficial dirt, etc. should be removed before the sheathing is opened out.

The removal of the outer sheath requires considerable care, otherwise the underlying cores may be damaged. Very often the tough rubber is torn away by brute force; this is quite unnecessary if the following instructions are carefully carried out.

Take a sharp knife, and holding this at about 30 degs. to the surface of the cable, lightly slice the sheathing, facing the cut of the knife in the direction of the fault. Use a sawing action and cut through the sheath not quite so deeply as to reach the cores. The piece of sheathing so released can be gripped with a pair of pliers. Firmly gripping the pliers and steadily pulling at the sheathing should be sufficient to tear it away.

The removal of the sheath should, of course, be assisted by the use of the knife. Having now removed one strip of the sheathing the remaining portion may be stripped, gripping the edges with the pliers or fingers, and using the knife where necessary, always remembering to keep the edge of the knife facing away from the good length of cable.

Cables having ferflex or wire braid embedded in the sheathing often present difficulties in repairing, not the least of these being the removal of the braid, which is usually securely held by the sheathing. In such cases, having removed the outer sheathing, exposing the wire braid, take an ordinary engineer's 12-inch flat bastard file and use it as if to file a "flat" on the cable. This will effectively cut through the braid and the adhering C.T.S. without damage to the cores. Being now completely cut through the braid can easily be removed.

The removal of the inner sheath will, of course, be carried out in the manner described for the outer sheath.

The cable we are dealing with has layers of tape over the laid-up cores and these tapes will of course have to be removed in order to expose the cores. This tape should be cut back almost to the edges of the cut sheathing. Assuming that, having reached this stage, we find the core insulation is damaged and requiring repair, it will be necessary to open up the cores by twisting one end of the cable in the opposite direction to which the cores are laid up. This will have the effect of separating the cores. The faulty core being isolated the remainder can be bound together so as not to obstruct the work on the faulty core.

A popular type of cable has a metallic screen round each phase core, and this spirally wrapped stranded copper wire must be removed in order to make a repair to the core insulation. This metallic screen is often regarded as being somewhat of a problem when core repairs have to be made. There should, however, be no difficulty in removing and replacing these wires if the following procedure is adopted.

A binding of 26 S.W.G. tinned copper wire should be placed around the metallic screen at each end of faulty portion ; then, with scissors, completely cut the screen wires at one end only and lay them back along the core. This will expose the coloured tape, which should be removed. The conductor should be examined to ascertain if the fault has resulted in any of the fine wires being burned or broken. If the damage is confined to a few of the wires only, these may easily be jointed by floating a little solder over the surface of the strand. Should, however, the damage to the conductor be extensive, then it will be necessary to fit a ferrule.

A useful type for the purpose is that known as the "Weakback" ferrule. This has a groove along the length, which enables the ferrule to be opened out, slipped over the conductor, and reclosed with a pair of pliers, the ferrule being then sweated on solid in the usual way.

Having now completed any repair to the conductor which may have been necessary, and having cut away all insulation which had been burned or deteriorated, the ends of the insulation should be pared down with a sharp knife, tapering towards the conductor.

We now come to that part of the operation which is of primary importance, and may either make or mar a good job. That is the cleaning and preparation of the surface of the insulation. Take a piece of clean cloth, well soaked with petrol, naptha, or some other rubber solvent, and carefully clean the prepared surface or that part of the insulation over which it is intended to apply the repair tape. The action of the rubber solvent will be not only to remove grease or dirt but also to give a tacky surface to the insulation to which the repair tape will readily adhere. Before the solvent has completely evaporated, apply the repair strip or tape. After cleaning the hands take a narrow strip, approximately $\frac{3}{8}$ inch wide, and wind it evenly round the core with as much tension as possible. Build up to slightly more than the original thickness, by applying layers in reverse directions. It must of course be borne in mind that if a ferrule has been used on the conductor a corresponding increase in diameter of the finished repair will result. The repaired section should be lightly dusted with french chalk and then completely covered with three layers of rubber-coated cotton tape, applied in alternate directions.

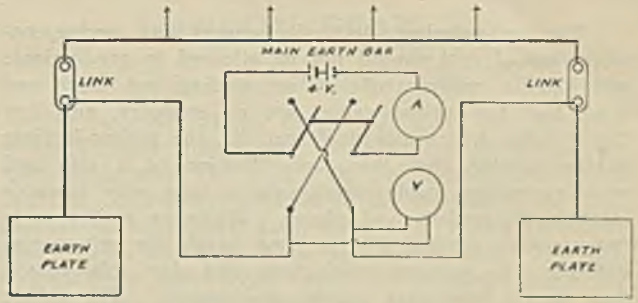


*Fig. 12.—Diagram of Met.-Vick. Earth Testing Panel.*

If these tapes are applied with the utmost tension a solid repair will be obtained, free from porosity or blowholes which often result from incorrectly made joints.

The repair is now ready for vulcanising, and heat should be applied by a blow lamp or other suitable means, to the taped repair. The correct temperature and time required will depend primarily upon the characteristics of the repair tape, and for the best results the makers' instructions should be followed implicitly.

After the repair has cooled, remove two of the outer tapes, leaving the other in position. The metallic screening wires can now be replaced, having repaired any which have been burned or damaged due to the failure. Care should be taken to replace the wires in their original formation and they should be butted and bound with 26 S.W.G. tinned copper wires for a distance of say half an inch, the binding wires being spot soldered with a soldering iron.

Now release the cable and twist in the direction of the lay, in order to bring the cores back to their original position. Next replace the over-core tapes.

It will be remembered that the ends of the sheathing were left rough ; these will now require to be tapered down in a manner similar to the core installation.

The over-core tape should now be lightly dusted with french chalk. The prepared ends of the sheathing must be cleaned in a similar manner to that adopted for the core insulation, the cleaning to extend a little beyond the tapered portion. Now apply the repair tape, which should be 1 inch wide, winding with appreciable tension and taking care that the laps are even and in reverse directions. Build up in this manner until the normal overall diameter of the cable is slightly exceeded. Dust lightly with french chalk contained in a muslin bag. Care should be taken not to drag or rub the chalk bag across the surface of the cable, but merely dust. Now apply, as tightly as possible, five layers of rubber-coated cotton tape, to extend at least three inches on either side of the repair, or, if for vulcanising in a wax-bath, the tape should extend over the whole of the length of cable which will be immersed in the wax. After vulcanising allow the cable to cool thoroughly and remove all the tape.

*Fig. 13.—The Glover Repair Sheath.*

The trailer being admittedly a weak link, undue consideration of cost should not be allowed to predominate and happily colliery officials are finding out more and more that low priced cables are no economy, and that "it is better to be sure than sorry." The author inclines to the opinion that the standardisation of a safe and reliable trailing cable would go a long way towards meeting all pockets and places. Whatever trailer is in use constant flexing will in time break the wires constituting the various conductors and for this reason they should have very careful maintenance. The author holds that no place should be run without a spare trailing cable and that these should be sent to bank in rotation before any fault actually occurs. The sheath can then be thoroughly examined and all small incisions vulcanised. The plugs at each end should be opened up and the connections remade, as a loose connection in the plug may lead to a serious breakdown of the insulation. Careful balancing of the cores and metallic screens and comparing these with those supplied by the maker, when the cable was supplied, will shew up the breaking of wires and will give a much better indication of a cable's condition than just a mere megger test.

A very useful addition for the repair of complex types of trailers is the repair sheath, Fig. 13, recently introduced by W. T. Glover & Co.

It is most important to bear in mind when repairing complex trailing cables, not try to repair a fault in as little cable length space as possible: remove a good length of the sheath, make a sound job, and there will be no further trouble at the repaired part. Do not try to save a little material, and in doing so create a weak spot liable to breakdown again, for it must be remembered that if the faulty part of the cable has a small piece of burned copper lying loose then this must be removed. It is essential to open up the cable properly to find these minute globules, which if not removed will cause trouble later.

Perhaps the method of finding a concealed fault on the shrouded type of trailer presents some difficulty and the method used by the author though possibly crude is certainly effective.

A trailer trips a gate-end breaker on earth leakage but only intermittently. This would appear the very limit to locate. The cable is brought to bank and is tried first by means of a lamp in series, the cable being kinked in an attempt to produce the earth connection, this proves to be no good, the fault cannot be put on again, so then all the cores are connected to one side of a transformer giving 2000 volts and the earth cores to the other side. A five ampere fuse is put in circuit. When power is switched on the fuse blows this means that the higher voltage has flashed over at the point of intermittent contact, should the flash be under the sheath of the cable a current of 40 to 50 amps. d.c. is then passed through the now established fault and after a second a puff of smoke appears at the source of the trouble. This method has never failed to find the most elusive of faults after all sorts of balancing and loop tests have only filled a page with figures.

The load of 40 amps. is incidentally provided for by the vulcaniser, so that a wax bath really serves two useful purposes, i.e., finding the place of damage and "curing" it afterwards.

There are several types of test set which have been developed for fault finding on trailing cables some employing a spark coil which causes a difference in note of the spark or a spark on to the sheath when the fault is reached but the author has had no actual experience of these although some years ago he used a helix of wire and an induction coil to find faults on the old four-core simple trailer. The faulty cable being passed through the helix.

With the idea of devising some means of making trailing cables more safe, and if possible, to obviate open sparking from the trailer, the author carried out tests to ascertain the open sparking that was possible with existing types and with different systems of protection. How far he has been successful, may be judged by the latter part of the paper. After the tests, it was proved that open sparking with any type of existing trailer was more likely to happen with plain overload protection, especially with fuses as the cut-out medium, than where leakage protection was used. Earth leakage protection on trailing cables should in the author's opinion be compulsory. Tests were taken, by creating artificial faults and observing the sparking produced when various systems of protection were used. Even when earth leakage protection was used, sparking was seen under some conditions. The last set of tests were taken on a new type of cable, and with an extra safety feature not before used in mines. This consists briefly of the following, the cable consists of a pair of flexible, concentric metallic screens, completely surrounding the conductors as a whole, the screens being insulated from the main conductors and from each other, and in use the outer screen is earthed, whilst the inner one is kept at a slight potential above earth, the two screens being interconnected by a relay or trip mechanism, controlling a switch in the circuit containing the main conductors. In the event of mechanical injury to the cable the system containing the two screens is affected before the injury can extend to the main conductors, and the main switch is opened instantaneously before a dangerous condition can be set up, due to penetration, or exposure of the main conductors. With similar tests to those carried out with other protection, and in an exactly similar manner, sparking of no kind could be produced.

Samples of this type of cable which have been cut through with the power on all cores, may be examined, and it will be observed that no signs of burning or sparking can be found. The cable has been punctured with a collier's pick, and even cut through with an axe without any signs of sparks or burning. Several facts were established by the tests, amongst them being, that the thicker the sheath, the less the liability of open sparking, and the author holds that the minimum sheath should be 250 mils: also that very small incisions in the sheath are a source of real danger, as flame was expelled from a small incision about 3 inches removed from the actual fault; further, a small incision to which water has access is dangerous, as this type of spark, is maintained at about one ampere which the ordinary leakage trip will take no notice of. That the complex type of trailer will stand a large amount of abuse, was evidenced by the fact that 390 blows with a 7 lbs. hammer did

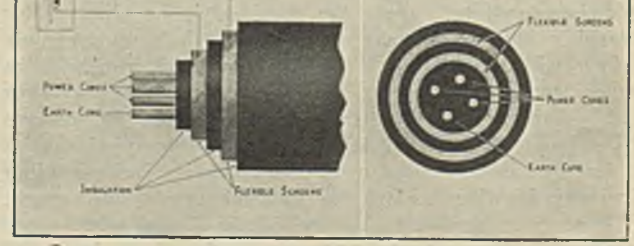

*Fig. 14.—Double Screened Trailer and Connections.*

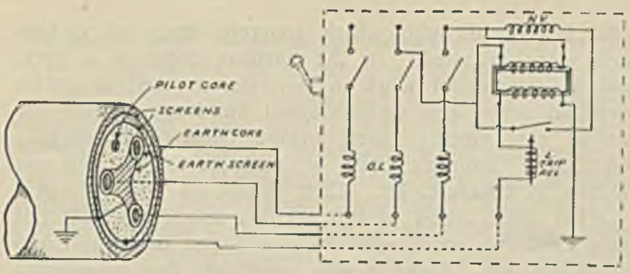


*Fig. 15.—Gate-End Breaker adapted for use with Double Screened Trailer.*

not produce a fault. Faults between phases, or between phase and earth will not result in sparking, as long as the outer sheath is intact, and whilst sparking will occur if the cable is cut through with some sharp instrument, it can be lessened by the use of leakage protection, and if a double screened type of cable is in use, the cable may have damage of any sort inflicted upon it, even to cutting it through with a sharp axe without producing open sparking, due to limiting the power input into the double screen system. The screen system is worked at six volts and one-tenth of an ampere as the maximum current.

The illustrations, Figs. 14 and 15, shew various makes of breaker adapted for this type of protection, and several well-known firms are prepared to supply suitable gear for its use ; cable makers too will double screen ordinary trailers of their standard types.

The object of all mining men is the safe and economical winning of coal and the author hopes that the facts given will provoke discussion to further this object. The aim of every maintenance engineer should be to forestall trouble and danger as far as possible and to be on the look-out to stop things going wrong to maintain apparatus by regular inspection and not merely be equipped to make repairs after failures. Industrial development is chiefly due to the active striving of the will and the encounter with difficulty, which we call effort, and it is surprising to find how often results apparently impracticable are thus made possible. This paper should emphasise that there is no lack of choice of safe type of control gear for coal face machines and that the maintenance of this gear does not present the difficulty which some would have us believe. Mr. J. A. B. Horsley, H.M. Electrical Inspector of Mines, is said to be a strong advocate for the use of remote control and in that the author is in complete agreement ; for, after many years, experience with remote control and safe type trailing cables he can confirm that it is the lowest in cost of maintenance and, with the advent of the double screened cables as set out, gives that deg ee of safety which is essential to the safely protected coal face worker and machine.

The early part of this paper passed quickly over the advance made in machine and apparatus and it is now definitely possible to cut and convey coal as safely by electrical means as with any other. The risk of shock should be non-existent, and the risk from open sparking at the coal face can be eliminated by those methods which have been set out herein. The author looks forward to the time, not far distant, when disastrous accidents will be entirely unheard of, and he would ask all concerned not to be backward individually in pioneering the cause of safety as great things were never achieved by those who moved in crowds.

The author would express his thanks to the several firms who provided illustrations and details: to Mr. W. T. Anderson for his personal help: and to Mr. D. Kingsbury for his very able service with the lantern.

## LONDON BRANCH.

### Visit to Cement Works.

On Saturday, March 12th, 1932, about fifty members of the London Branch and the Kent Sub-Branch of the Association were the guests of The Cement Marketing Co., Ltd., selling organisation of the Associated Portland Cement Manufacturers, Ltd., when they visited the Company's Kent Works at Stone, near Greenhithe. The visit was of great educational value, for at these works the visitors were able to inspect not only the various processes in the preparation of the raw materials and the manufacture of the cement, but also the permanent exhibition of concrete work established there to shew the many and varied uses to which cement is put.

Members travelling from London were conveyed by motor coaches, kindly provided by the hosts, from the Company's headquarters (Portland House, Tothill Street, Westminster) to Greenhithe, and were joined there by the contingent from the Kent Sub-Branch. On arrival, the visitors were equipped with protective coverings of white overalls, tweed hats and caps, and proceeded at once, in small parties, to inspect the works, under the guidance of members of the staff.

The first manufacturing operation is the making of the cement slurry by mixing the chalk and clay with water, in the washmills. The Company has its own chalk pits. Some of the clay used comes from the Medway, and some from marshes situated about a mile from the works, this latter being pumped in liquid form direct to the washmills. The other clay, and the chalk, are delivered to the washmills in railway trucks ; these trucks are tipped hydraulically, and deliver the materials direct to the mills. There are three preliminary washmills, 30 ft. in diameter, and each mill will mix 50 tons of raw material per hour.

The cement slurry, after leaving the preliminary mills, passes through separating plant and tube mills to slurry mixing and storage tanks. The slurry, when of the proper consistency, is thrown out through the walls of the separators by means of a revolving propeller, but if it is not sufficiently reduced it passes down the centre and returns to the mills. It passes by gravity to the tube mills, which latter contain about 12 tons of small steel pellets.

The visitors then inspected the slurry mixing and storage tanks. One of these contains clay slurry (i.e., a mixture of clay and water), and four others contain cement slurry (i.e., a mixture of chalk, clay, and water). Each holds sufficient slurry for 500 tons of cement. Across each mixer is a girder, revolving slowly on a central pivot, and below it are suspended stirrers driven by motors. The movement of the long girder is due to the friction arising from the stirrers revolving in the slurry.

From these mixers the slurry is pumped to the kiln house, where there are two rotary kilns, each 245 ft. long by 10 to 11 ft. in diameter. The output of clinker is 600 tons per day. The wet slurry enters at the higher (or chimney) end of the kiln through a water-jacketed pipe, and travels slowly down the kiln towards the burning end, being subjected to gradually increasing temperature, reaching a maximum at the burning end of about 2750° F. The height of the kiln drops about 10 ft. in its length of 245 ft., and there are curtains of chains inside the kiln to prevent the slurry adhering to the sides as the kiln revolves. The kiln is fired by powdered coal at the bottom, or burning, end and the gases are subjected to water spray at the bottom of the chimney stack at the higher end of the kiln, to arrest dust and prevent its emission to the atmosphere. The visitors inspected the interior of the kiln at the burning end by the aid of blue glasses and could see the clinker cascading from the kiln to the cooling plant. The clinker is delivered from the kilns by conveyor to the clinker store, where it is kept until it is required for grinding.

For grinding the cement there are four mills, 36 ft. long by 6 ft. diameter, each driven by a 500 h.p. motor, the cold clinker being conveyed to the mills by means of a bucket conveyor. The mills are in three sections, the first containing steel balls of about 3½ in. or 4 ins. diameter, the second containing steel balls of about 2 ins. diameter, and the third small pellets. Gypsum is added to the clinker as and when required before entering the mills. The ground cement is transported to the silos by means of conveyors.

On the way to the power house, the visitors were able to see the means used for unloading coal through trap doors at the bottoms of the railway trucks into a pit, from which it is elevated to the top of the building. The pulverising plant could also be seen, as well as the coal hoppers and the pipes for supplying air and powdered coal to the kiln burners.

The electric power generating station was a source of great interest, with its three turbines, one of 5000 k.w. and two of 4250 k.w., all generating current at 3300 volts, and the switchboards, and instrument boards indicating steam flow to the boilers, feed water flow, steam pressure and temperature, etc. This generating station also supplies an adjacent works of the Company at 3300 volts, and the load factor on the H.T. side remains practically constant at about 93 per cent. The switchgear at the turbine room floor level operates circuit breakers on the floor below. These circuit breakers, having a rupturing capacity of 100,000 k.v.a., are fitted into sheet steel cubicles.

Next the visitors inspected the boiler house, where there are six water tube boilers, with a total rated capacity of 200,000 lbs. of steam per hour, and fired by underfeed stokers.

The works has a locomotive shed and a jetty running out into the river Thames, where coal, clay, gypsum and other materials are unloaded, and from which finished cement is despatched. Ships of 3000 tons capacity can be accommodated there.

The cement packing platform and storage silos were then inspected. There are ten silos, each of 10 metres diameter, and 20 metres high, each holding 1750 tons of cement: a total of 17,500 tons. A machine was seen by which sacks are filled with cement by the application of a vacuum, there being weights attached to the back of the machine to govern the weight of cement filled into the sacks. One of these machines can fill sacks at the rate of 40 tons per hour. Some of the sacks are filled through a valve in the bottom corners, the tops of the sacks being tied before-hand. The bottom corner of each sack, which is fitted with a flap, is placed over the end of a pipe from the silo through which pipe the cement is delivered. When the correct weight of cement is filled into the sack it is detached from the delivery pipe, and the vacuum has the effect of tucking in the flap so that none of the cement escapes. By pulling a lever, the operator throws each sack, as it is filled, on to a conveyor, which conveys them to the point at which the sacks are handled by means of overhead cranes. Stocks of paper bags, which are also used for packing cement, were also seen.

Leaving the works, the visitors proceeded to the pavilion in which is housed the permanent exhibition of cement and concrete work. They passed over a concrete bridge, through which concrete ducts of various sizes were installed. In the gardens there is a good deal of ornamental work in concrete, as well as tennis surround posts, and various small buildings. There are various cast stone figures, bridge balustrades, pergola columns, a fountain built of concrete bricks, various pavings in concrete, etc. Cast stonework enters largely into the construction of the pavilion itself, this material being used for walls, window frames and doorways, and for pillars, etc. There is also some very fine ornamental work in various coloured concretes, and the ceilings are of cement asbestos, the floors being of concrete tiles. Some of the tiles exhibited have an ordinary concrete base, on the top of which is a layer of the white "Snowcrete" or a coloured concrete, into the surface of which is embedded pieces of coloured glass. These are particularly attractive.

There is also, of course, a laboratory at the works and the process of manufacture of the cement is scientifically controlled throughout. Some information concerning the tests to which the cement is subjected was given to the visitors by the works chemist, who pointed out that the whole of the products must conform to the British Standard Specification. The maximum residue allowed by the Specification on 170 mesh sieve is 10 per cent. This sieve is so fine that it will actually retain water, by reason of its surface tension. The ordinary "Blue Circle" Portland cement, however, is ground so that the residue on this sieve is less than 4 per cent., and the residue from the more finely ground "Ferrocrete", which is a rapid-hardening cement, is even less than 1%. The "Blue Circle" cement reaches its initial set in 3 hours and the final set in from 4½ to 5 hours; "Ferrocrete" reaches initial set in 1¾ to 2 hours, and final set in about 3 hours. It was emphasised, however, that "Ferrocrete" is not claimed to be a quick-setting, but a rapid-hardening cement.

One of the physical tests which was described was an accelerated test, carried out by means of a Le Chatelier mould, to ascertain whether the volume of the cement altered during the process of hardening. The mould was formed by a strip of metal rounded to form a circle, the two ends meeting, and callipers were attached to the ends. Cement was filled into the mould, a glass was placed at the top and bottom, and it was then allowed to set under water for 24 hours, after which the glass was removed and the distance between the calliper points was measured. The mould was then placed in water and boiled for three hours, and the distance between the calliper points again measured, the difference between the two measurements representing the expansion in millimetres. The expansion of the cement despatched from the works does not exceed 3 mm., whereas the maximum allowed by the Specification is 10 mm.

A tensile test on a standard mortar sample was demonstrated, the sample containing three parts of Leighton Buzzard standard sand and one part of "Ferrocrete", with about eight per cent. of water. At the time of testing it was 24 hours old, and the load at fracture was 665 lbs. per sq. inch. The minimum requirements of the British Standard Specification are 300 lbs. per sq. inch at three days and 375 lbs. per sq. inch at seven days. Thus, the tensile strength of the sample tested was more than double, at 24 hours, the minimum requirement of the Specification for mortar three days old.

A compression test was then conducted on a 3 ins. cube consisting of three parts of standard sand and one of "Ferrocrete", 24 hours old. The specimen was crushed at 3500 lbs. per sq. inch, equivalent to 12½ tons total pressure on the specimen, or 225 tons per sq. foot.

The Specification does not yet contain a clause relating to compression, but the matter is under consideration.

The visitors were entertained to tea in the works canteen before leaving, and there Mr. J. R. Cowie (Hon. Secretary of the London Branch) took the opportunity to express thanks to the Associated Portland Cement Manufacturers, Ltd., the Cement Marketing Company, Ltd., and the members of the staff, under Mr. A. Double, works manager, for their hospitality and for having made the tour of the works so interesting and instructive. He pointed out that this was the fifth consecutive Saturday on which members of the staff had conducted visitors over the works. All the visitors, he added, were engineers, and had to use cement, and they were grateful for what they had learned.

Mr. S. SMITH, in a brief response, said that if the visitors had been interested, he and his colleagues were happy to have been able to do what they could. He added that these cement works were only ten years old, and were as up-to-date as any in the country. The Cement Marketing Co. Ltd. were prepared to help all who may be interested in concrete work in any way. Qualified engineers who were thoroughly conversant with all types of concrete work would, when desired, give advice on any question connected with the use of cement or concrete.

# KENT SUB-BRANCH.

## The Installation of Colliery Electrical Plant.

L. BARNEY and H. LOWE.

(*Paper read 2nd January,* 1932.)

These few notes are given in the hope that they may assist some of the members in their everyday work, anything highly technical is excluded and the practical side is only covered. The particulars given concern only the installation and preliminary tests after erection of new plant, rather than the maintenance of old plant which is quite another subject.

Generally speaking it is sound practice to deal with the first installation of plant in a systematic manner, and this, properly erected and tested, stands a much better chance of giving satisfactory service during its life than that which has been put up "just anyhow" as is unfortunately the case at some collieries.

In the first instance a few notes on the preliminary specifications, ordering, and works tests may not be out of place as these are very important matters.

### SPECIFICATIONS.

These should be drawn up carefully and all essential details covered ; it is possible to make a general specification for such things as motors, starters, transformers and cables with slight modifications as each case calls for. The standardisation of plant can be carried out to a great extent, the same make of plant used, frame sizes and speeds of motors brought into line, outputs of transformers graded, stock sizes of cable kept etc. ; in this way the spare problem is greatly simplified.

As previously mentioned the fullest details should be given on a specification, this will save much correspondence after an order has been placed. For example, when ordering switchgear, in addition to the general details as to type and size, the kind of cable should be given, with diameter over strand, diameter over lead or bitumen sheath, and diameter over armour, this will give the makers all the sizes required to enable them to drill the cable boxes correctly and will save much time on jointing, and unsatisfactory makeshifts with packing pieces, etc., are avoided. In cases of doubt on this matter it sometimes pays to send the makers a small sample of the actual cables to be used and then they have simply no excuse for going wrong on this small but important matter. Some of even the most reputable makers are rather slack in this respect and any help given to them to get the boxes right at the works is well repaid when it comes to erection.

The setting of overloads for each switch should be given, and if instantaneous or time lag is required, as well as the method of protection, i.e., pure overload, core balance leakage, split conductor, etc.

Similarly a transformer specification should give the exact ratio at no load ; if tappings are required to adjust voltage, particulars of these should be stated with careful consideration of future requirements, these tappings are usually arranged on the H.T. side, the ampere load being lighter and thus avoiding heavy links.

If the transformer has to work in parallel with an existing transformer or transformers the fullest details of these should be given as some old type transformers do not parallel well with more modern types. The makers should be consulted if there is any doubt on the matter, and, in this connection it will be found that it pays to take the makers fully into one's confidence on matters of doubt, they have a vast experience to draw from and are only too pleased to help, for it must be remembered that no one can be an expert on everything.

*Works Tests.*

All good class manufacturers test their products in line with B.E.S.A. specification : this should be stated on orders, and copies of test certificates insisted on. In the case of large plant or orders it is a good policy to send an engineer to witness such tests as he becomes familiar with the working of the gear before erection and he can check over connections, etc. on the test plate, and so make sure everything is in order before despatch to the colliery.

Cables should be fully tested and a certificate of these tests supplied, including particulars of copper resistance which may be useful later in fault locating, etc.: in the case of armoured cables the resistance of the armour should be given to ensure that this is in line with the Regulations for use in mines.

Transformers should have a full load test at works and the order should insist that these are dried out at the makers' works and delivered in tank with oil over the windings to be sure that they arrive in a dry condition.

Switchgear should be erected at works and pressure tested, all instruments, current transformers, etc., should have certificates of accuracy. In connection with starting gear unless this is small or ordered separately the starter should be tested with the particular motor it is to be used with : in this way much time is saved in erection on site. All good makers will do this if asked, but probably not otherwise as it usually means sending the starting gear to the motor works rather than direct to the colliery.

Similarly, pumping sets should be erected at the pump makers' works and given a complete combined test for efficiency, temperature rise, etc.

Naturally the same procedure applies to turbo-alternators and engine driven sets : these should be completely erected at works and where possible given a run : in the case of the larger sets it is of course not possible to get a full load test at the works, but this should be specified on the order as a final test after erection on site and before handing over. It is worth while to go to a little trouble in rigging up a load tank in order to get full load on site if this cannot be obtained in the ordinary way. It should be quite clear that a new set is satisfactory before the erection engineer leaves.

## ERECTION ON SITE.

A detailed description of the erection on site of the following plant is given: Motors and starting gear: Transformers: Switchgear: Cables.

*Motors and Starting Gear.*

On receipt of motor and starter these should be tested with a megger in order to ascertain if any damage has been sustained in transit. If any serious defect is found the maker should at once be advised. The handling of motor and starter from store to site should be carefully looked into and each case considered on its own merits.

The position of the motor and starter should be carefully thought out, they should be placed well out of the way of damage and yet easy of access for maintenance and repairs.

First, slide rails should be carefully levelled and the motor tried in place to make sure it runs true on rails through the full length of travel; the same applies to the type where the motor incorporates a sliding base.

Next the starter fixed in place, care being taken that the tank can be lowered without fouling anything, and that the gear is accessible all round.

If cable is used for connecting up, all boxes should be filled with compound; this applies even to the rubber types of cable as it is important that the ends of multicore cables should be sealed off.

The clamping of armour is an important job, the armour should be carried right through the clamp and bent over at the ends; in the case of a conduit job a copper clip should be made on to the tube and this connected by copper strand and a soldered lug to the frame of the machine.

After connecting up, the complete motor and starter should be tested with a megger; ideas differ as to the safe insulation resistance for new machines, it is however safe to err on the strict side as it is much cheaper to dry out a motor with a doubtful insulation resitance than it is to have it rewound. For a low voltage machine of an average size a safe figure is not to go below one megohm, and for H.T. machines up to 3300 volts not to go below two megohms.

The oil tank should be filled to the correct level with a good class switch oil, the overload trips tried by hand and, for a start, set at the lowest setting in order to be sure that the switch will open at once in the case of a fault in the connections. It is an easy matter to set these up a little at a time till the correct minimum setting to get the motor away is found.

In the case of H.T. motors it is good practice to give these their first run on a low tension supply, if available, the motor being run light long enough to get it thoroughly dry before switching it on to the H.T. supply; for instance, a motor designed for 3300 volts should be run light off a 400 volt to 550 volt supply. A new motor should always be turned round by hand to make sure everything is free, and run light for its first run.

When the motor is fully dried out a note should be made of all insulation resistances, setting of trips, and other details which will be useful for reference.

The section of cable leads should err on the large side, and it is useful to remember that the rotor current of slipring motors is much heavier than that of the stator, if there is any doubt as to the rotor current and this is not marked on the name plate the makers will give this; also remember that when several leads are drawn into conduit or tube, the safe current carrying capacity is considerably reduced.

In the case of direct current plant the commutators should be carefully examined, if they have become rough at the works tests it is worth while taking the armatures out and cleaning up the commutators in a lathe with fine glass paper; remember that emery should never be used on commutators, some makers do not leave a very deep slot in the mica, some do not even slot the mica at all, in nearly all cases it is safe to cut a fairly deep slot between the bars of the commutators, very useful slotters can be obtained for this purpose, which are much quicker and better than the old-fashioned method of using a hacksaw blade.

When re-assembling a machine each brush should be carefully bedded on to the commutator, by placing a strip of emery cloth under the brush and moving this to and fro, taking care that the radius of the commutator is followed or the brush will not get the true curve of commutator.

It is worth trying the spacing of the brushes, this can be tested by passing a strip of paper round the commutator with the brushes in place and marking with a pencil the leading edges of each brush, when the paper is removed and spread out flat the distance between each mark should be equal, if it is found that a brush is a little out it can usually be adjusted by packing under the holder. As the commutator of a d.c. machine is the part which gives by far the most trouble in service it is well worth while to see that it has as good a start off as possible.

If the machine is fitted with a variable shunt resistance, make sure that this is connected up the right way, most resistances are marked for direction to raise or lower; if not so marked a lamp or voltmeter can be used to check this.

It is essential that foundations are rigid, particularly for high speed or geared machines. Bedplates require to be rigidly supported under bearing pedestals and motor feet, when rails or girders are used as foundations they should be fixed across the axis of the shaft and not parallel to it.

Ball bearings should not have more grease added, makers send these out with enough grease to run for months; more trouble is caused on ball or roller bearings by too much grease rather than not enough.

Remember that smooth drives tend to safety and economy. On belt drives use endless belts with the tight side at the bottom, if split belts are unavoidable, do not use heavy belt fasteners.

*Transformers.*

The installation of a modern transformer is a fairly simple matter, if this has been dried out at works as suggested under "Specifications" then drying out before installation is hardly necessary. If, however, when a transformer is received it shews a low resistance (insulation) some form of drying out is essential. The place for drying out should be carefully chosen, it should be free from dust, moisture etc. and if the electrical method is adopted the transformer should be fenced off from any interference.

One method of drying out is by the application of external heat; in the first place it is essential that the lid is slightly raised to allow any moisture to escape, this method of drying is only of use for small transformers up to about 25 k.v.a.; some form of braziers are arranged round the transformer to warm it up and drive off the moisture.

For transformers of over 25 k.v.a. this method is not of much use as it is practically impossible to warm a transformer sufficiently to drive out the moisture, although the external tubes and parts might appear warm, there would not be enough heat right through the transformer to dry it properly.

The electrical method is the only really satisfactory one for drying large transformers, this method consists of circulating a heavy current at a low voltage usually through the low tension windings, a low voltage is used in order to reduce the risk of breakdown of windings with low resistance (insulation) during drying out. The H.T. windings are short circuited, an ammeter being connected in one phase, and current passed through the L.T. windings, a resistance if necessary being used till full load H.T. current is shewn on the ammeter.

With this method it is essential that a.c. of the same frequency as the transformer is used. If only low tension d.c. is available, a method adopted by the writers was to connect up the H.T. and L.T. windings in series (the number of windings that can be used has to be tried out by experiment, as it may be found that some have to be omitted) with the d.c. supply available till the required load is obtained, this is necessarily rather slow as the usually small section of the H.T. windings limits the amount of load that can be passed.

In all these methods careful records of the following details should be taken at frequent intervals :—The temperature of the oil, this should never be allowed to reach too high a figure. The insulation resistance of both H.T. and L.T. windings to earth.

It will usually be found that the insulation resistance of the windings drops in the early stages of drying out ; no alarm need be felt at this, as it is caused by the moisture being driven out of the windings, these low readings may continue for two or three days in the case of large transformers.

After practically all the moisture has been expelled the insulation resistances should gradually rise. When these have reached and retain a steady value for some time, depending on the size of the transformer, drying out should be considered complete.

During drying out the oil temperature should be carefully watched in order to make sure that the transformer does not become overheated, this oil temperature should not exceed 80° C. "ordinary" or 100° C. "non-slug." For this method of drying it is advisable to remove the transformer lid clear of the sides to allow moisture to escape freely ; the lid being kept over the windings to avoid danger from falling material, the lid should be removed and wiped inside after the drying out is completed.

Another useful method of warming a transformer for drying out purposes is to lower into the oil, immersion heaters. If possible these should be lowered to the bottom of the tank in order to improve the circulation of the oil.

Finally a transformer should never be left unwatched during drying out.

If a crane is available it is advisable to lift the transformer from its tank and go over all connections and clamps to be sure these are satisfactory.

The question of phasing out on modern systems does not present much difficulty ; if colours of cables are followed the polarity should be correct, the polarity can be tested by switching both transformers on the H.T. side and leaving the L.T. side open, when tests between similar colours should give no voltage.

It is essential that the open circuit voltage on the low tension side of a new transformer should be equal to that of the system it is to supply (this applies to transformers stepping down the pressure) most transformers have adjustable tappings which should be set to give the same L.T. as that with which they are to work.

When working in or over the tank of a transformer it is a good practice to insist that men tie all tools to a piece of string or tape to prevent these being dropped to the bottom of the tank.

Transformers fitted with rollers should have these scotched to prevent movement, this particularly applies to those connected up with paper lead cables where the slightest movement is likely to strain the lead and crack the plumb.

*Switchgear.*

Switchgear can be divided into two groups, indoor and outdoor. Indoor gear covers all switchgear, from the largest type controlling a generating station down to the smallest set of switches for a few lighting points.

It is not proposed to deal with the large station switchgear as in this country it is usual for the manufacturer to install this, although with the modern ironclad factory assembled class the erection of this type is a fairly simple matter.

The erection of switchgear falls under two headings the mechanical and the electrical ; the mechanical erection includes the levelling of the foundations, the preliminary marking off of these and the cable trenches, the laying of ducts, etc.

Plenty of room should be allowed at the back and sides of all switch gear, cable ducts and trenches should be of ample size and room allowed for more cables than those actually to be dealt with, in view of extensions. It will be found, where possible, that trenches with covering plates are preferable to ducts for the connections of large plant. The radius of bends in all cases should be large.

The board should be assembled in place with holes in concrete foundations left for holding down bolts ; after the board has been finally levelled and lined up the holding down bolts can be grouted in.

Switchgear for underground use is best erected on steel joists running the whole length of the board, so that if there is any ground movement the whole board moves with the joists thus avoiding straining the busbar sections and other parts. The complete board can be erected on these joists in the shops on the surface, all holes drilled and bolts fitted ; the board is then dismantled and the fitting up underground is a simple matter.

The electrical work covers the connecting up of cables, busbars, etc. as well as the small wiring. In underground ironclad gear it is essential to fill the busbar chambers with compound, a compound that is often used for this work is that which does not become brittle when set and which is therefore easier to remove when extensions are necessary.

All connections should be well cleaned before connecting up, and for a.c. work spring washers or lock nuts are now considered essential on account of the way nuts, etc. tend to slack off under a.c. conditions. The small wiring should be checked against the connection diagram.

Before switching on, test the board with a megger, be sure oil tanks are all filled to the proper level with good class switch oil and try each switch, with tank lowered, for blades making good contact with a feeler gauge; this is an important matter as a switch making bad contact will tend to get hot in service.

*Outdoor Switchgear.*

This type of gear is rather unusual at present on collieries, two of the local pits have some heavy 33 k.v. gear and the advent of the grid may lead to some collieries taking a bulk supply in which case outdoor switchgear may come more into use.

In erecting outdoor switchgear the fact that everything will be exposed to all sorts of weather should be remembered, all joints in relay boxes, conduit, etc. must be made water-tight; in this connection it is useful to know that it is essential that all relay boxes and enclosed gear should be watertight but not air tight, in fact ventilating arrangements must be arranged for, or internal gear will become rusty and leads covered with mould. All open switch blades and moving parts should be well smeared with vaseline before being put into service or trouble will occur on some frosty day when it is wished to open a switch.

The actual erection of this class of gear is generally similar to indoor gear. In erecting pole type transformer sub-stations care should be taken to make sure that air-break switches are strongly braced to the pole or poles or trouble will develop due to the framework on which the switch is mounted springing and blades not closing truly on the fixed portion of the switch; similarly the control rod should have guides fixed at close intervals.

In pole substations the switch should not be mounted so close to the transformer top that there is any risk of a man examining the transformer, with the lid removed, getting too close to the live contacts of the switch.

*Cables.*

Particular attention to details in the installation of cables is absolutely essential. It will be assumed that the conditions under which the cable will work have been thoroughly investigated and that the correct type of cable has been chosen for the particular job which it has to do. A certain amount of diversity of opinion exists on the matter of type of cable for certain classes of work but the authors do not propose to renew this controversy.

The cable having been delivered on site, the first job is to get it unloaded and put into some position where it will be free from damage. In passing, it would probably be well to mention that the arrow and directions as to rolling are painted on the drums, and should not on any account be overlooked. The reason is this. The cable having been wound on the drum from the machine takes up a stable position during the process and does not alter this position providing the drum is always turned round in the same direction. If, however, the drum is rolled or rotated in the opposite direction the slight amount of slack, which is bound to be existent, at the free or outside end will work its way to the inner turns and make the whole series of turns and layers of cable in a loose state. The result is that in all probability, trouble will occur when installing the cable because of successive layers getting fouled with their neighbours.

Passing now to the storage of cable, no matter what type the cable, it should, if possibe, be kept for at least a week where it will tend to absorb a certain amount of warmth. The object is to make the dielectric or insulating material of the cable more flexible than it would be if dead cold, in which state it is far more likely and liable to crack during handling. Further, it serves a useful purpose in that the cable being more flexible is less likely to kink or birdcage.

As previously mentioned these remarks apply to all classes of cables but particularly to Bitumen or Bitumen-sheathed which are comparatively brittle when starved. The authors have, on occasion, when this type has had to be installed had a ring of braziers or fire-buckets put round the drums, which were stored in the open, to keep out the frost and slightly warm the bitumen.

*Shaft Cables.*

In regard to cable cleats, these in nearly all cases are bored to dimensions of the overall size of the cable as given by the cable makers. It is always well though to unlag a drum and fit a cleat against the cable. This should not be done at the extreme end of the cable as this is often somewhat bigger than it ought to be owing to the armouring being a trifle slack and the outer serving somewhat loose. If then, eight or ten feet are unwound from the drum and the cleat fitted on a good straight length it will be seen whether the clamp is going to be a successful fit when installed in the shaft.

Another very important point is that some shaft cables are given two outer servings of impregnated jute —this is generally only in cases of corrosive waters being known to exist in the shaft—in which case a slightly greater gap between the back and front of the clamp should be allowed for tightening than would be required with single served cables.

The timber from which cleats are made should be of a nature that does not have a corrosive effect on metals. Oak is a wood which does and should be avoided. Pitchpine is particularly suitable, being of a tough stringy nature, containing a large amount of natural preservative and nothing which attacks metals, even under water.

All clamps should be thoroughly examined for flaws in the timber and also to see that each has its requisite number of nuts and bolts and that these are well greased and free running.

There are quite a number of methods of installing shaft cables which can be employed with equal success but it is proposed to deal here with only the two most generally adopted. These are:

(1) Lowering the cable by means of a winch and rope from the top of the shaft, and

(2) Fixing the drum either on or in the cage and securing the cable in its cleats as each is arrived at.

Method (1) has the following advantages:

(a) Admirable control of the lowering of the cable during the whole process.

(b) Freedom of cage in shaft to run up and down if any hitch occurs.

(c) The fact that supervision of the whole length of cable can be given at any time during lowering.

The disadvantages of Method (1) are:

(d) To do this sort of cable lowering properly a man should be put on a platform about 15 feet or 20 feet down the shaft to tie the cable to the lowering rope.

(e) The twisting of the cable and rope as lowering continues.

(f) The fact that the whole length of cable is eventually suspended from the lowering rope by means of spun-yarn only.

The Method (2) offers the following advantages which are these.

(a) The cable is secured in its final position as each cleat is reached, which entails one handling of the cable only.

(b) No twisting is likely to occur.

(c) No supervision of the cable other than of that length coming immediately off the drum is required.

The disadvantages of Method (2) are:

(d) The cage is tied once the cable is secured in the first cleat.

(e) That signalling to the winder can only be accomplished through the medium of Banksman or Onsetter which is a potential source of trouble if the cable should happen to get entangled.

(f) The danger to the ten or twelve men necessary in the cage should anything in the way of an accident occur.

It will now be assumed that we are installing a shaft cable by the first method and that the drum is mounted at the top of the pit and is fitted with a reliable and substantial brake. A plank on a block of wood is very useful and may serve all requirements but the plank has a habit, just when most required, of falling off the block or lifting the drum, when nearly all the cable is run off, with dire results. It is this type of mishap which should be guarded against and which can be easily obviated when reasonable forethought is given to details and ordinary common sense exercised.

The end of the cable is run out and wrapped with sacking, as a precautionary measure against damage, after which it is securely hitched with spun-yarn to the winch rope. Spun-yarn is the best material for the job of securing cable to a steel wire rope; it being of a flexible nature, affording a good grip of both cable and rope, and it is at the same time strong and dependable.

A reliable man, who thoroughly understands the job of hitching the cable to the rope, is then stationed on his little platform in the shaft with his bundle of ties cut off to length. The cable is then lowered with the rope and tied at frequent intervals, the lowering process naturally being stopped whilst the tying is being done.

During lowering a close inspection should be given from the shaft cage to see that all twists of the cable round the rope are taken out by twisting in an opposite direction, which needs careful doing in order not to release the weight from the yarn hitches.

The next job, when all the cable is paid out, is that of securing the cable in its cleats, which is a process of transferring the cable from the rope to the cleats. This work is, naturally, best done from the top downwards for two specific reasons: Security is obtained and increased as each successive cleat is bolted up, from the top downwards; and, any slight amount of slack which might accumulate is going in the right direction, that is to say, downwards.

Now, consider a cable to be installed by the second method, that is with the cable drum mounted in the shaft cage. It is essential in this method to have the top taken off the cage in order to give the cable a nice easy bend when coming off the drum.

The first cleat is fixed on the cable and the cage gently lowered, the drum being rotated by hand and a certain amount of slack being fed out the whole time to provide against the slight irregularities in winding speed. As in the other case a good brake is essential for controlling the speed of the drum.

As each clamp is reached the cable is secured and so on to the end of the cable. When this is completed the clamps should each in turn be inspected and again given a good screwing up with a long handled spanner, as the tendency is, when fixing the cleats originally, for the cable to be in the form of a very slight radius, owing to its having left a circular drum. If the cable is of fairly big section and double wire-armoured it is consequently stiff and is very liable to give a false impression of being secure when it is only its slightly bent shape which makes the front of the cleat feel as though it were well home. It is always as well on such jobs as this to have a carpenter and a fitter, each with a kit of tools. These men can help very materially when difficulties arise and in any case can always make themselves generally useful.

Another method of installing shaft cables, which has been used with success, is that of employing a locomotive, but as to all intents and purposes this is the same as the capstan or winch method it is not necessary here to go further into details.

*Underground Cables.*

It is proposed to deal only with roadway cables, for which the drum should be mounted in the ordinary way and the end pulled out and wrapped. There is a very important point which should be brought forward relating to the way in which successive drums are run out. The beginning ends should always be brought to the finishing end of the last laid length. Or in other words, starting ends of the various drums should never be run out in opposite directions. The reason that this is important is that it affects the way in which the cores of the cable lie for jointing. It applies to all classes of cable and should never be forgotten.

Sufficient length is then unrolled and laid on pit-tubs, which are either pushed or hauled along. As many tubs as possible should be employed to carry the cable and on no account should there be sufficient room between them for the cable to sag and rub along the roadway.

When the cable is run out it remains to be slung. This should be done at a height which will ensure that it will not be fouled by passing tubs and, if in timbered roadways, suspended by means of amberline or some similar sort of cord in order that the cable can easily break away from its suspenders when falls of roof occur.

One of the best methods of hanging is probably that of knocking a flat tanged roadnail into the prop and hooking the sling over this. The disadvantage of slinging to the bars is that when "weight" comes onto them the slings are liable to be severed, thus dropping the cable. Moreover, slinging to the props ensures the cable being kept well at the side of the road where it will be safe from the lashing of the haulage rope, which occurs when tubs come off the road or when tubs are "rived" on the road at landings. Further, the flat tanged nail will stand the ordinary weight of the cable but will easily come out if a tub runs into a prop, thus freeing the cable at that point and inflicting no damage to it at all.

In archways, webbing or pigskin slings can be used with safety as the likelihood of falls is remote.

*Surface Cables.*

The two best methods of installing surface cables are: drawn into ducts, or supported on a catenary wire. Owing to the ground in and around a colliery being usually made up of materials such as cinders and acid containing matter it is unsafe to lay cables direct as sooner or later they will be attacked by the acid.

Duct runs should be as straight as possible and where bends have to be negotiated these should be as easy as possible. The better method at corners is to have manholes with ample room to facilitate pulling in from this point if required. Another point is that once the weight has been taken on the "stocking" used for pulling in, it should not be slacked off as it may tend to slip when next the strain is taken.

The direction of laying of the ducts should not be overlooked, all the spigot ends being laid in a way that the cable will emerge from these rather than enter at this end. This is done in order that the cable will slide along a smooth surface rather than that it should be rubbing up against the sharp ends of the pipes which would bite into the serving and tend to ruckle it up.

Where manholes are used a pulley should be employed at the outlet of the first length and the inlet of the second length of pipes, again to avoid damage to the serving of the cable. Also, further to protect the cable and make drawing into the ducts easy, plenty of petroleum jelly should be plastered on as it leaves the drum.

There is a right and a wrong way of mounting a drum for pulling into ducts, the right way being to mount the drum directly over the end of the duct into which the cable is to be pulled, the end coming off the top naturally, and bowling into the duct in a perfectly easy bend. The wrong way is to mount the drum as if the cable were going to be laid in a trench, this inflicting the cable with two bends in opposite directions, which is undesirable.

The suspension method, from catenary wires, is much favoured by colliery people as the cables are then visible for the whole of their length. This is a very good scheme but it has an objection in that locomotive or travelling cranes are liable to foul when passing under.

It is, however, not intended to discuss the respective merits of various schemes but rather to give useful hints as to installation and erection of gear. When pole lines are erected it is usually thought that the overall cost of the job on underground works of a similar capacity will be cheapened ; but catenary cables, which, after all, amount to a rather elaborate form of overhead construction, do not necessarily fulfil this hope : excepting that, in some cases, shorter routes can be taken than would be possible with underground mains. At the same time it must be remarked that cheapness, however desirable, is not always the primary factor to be looked to. Reliability is the governing factor and to obtain this good materials have to be used and the workmanship put into jobs beyond suspicion. Overhead work, especially with catenary cables, demonstrate this remark as any shoddy workmanship is continually before the eye. It is essential, therefore, that such work is made as sightly as possible and that all details are strictly attended to.

The first job to be done is that of examining poles for straightness and truth of grain of the timber. Some trees grow with a complete twist in their fibre due to either a freak of nature or conditions of light in the forest. These twisted poles should never be used as they are mechanically much weaker than straight poles and furthermore, they will, when subjected to the weather take up most peculiar shapes of their own, with consequent weakening of the line.

Next, all poles should be drilled and sawn to template for the brackets and pole roofs which they will have to carry when erected, the cut portions of the pole being liberally painted with creosote to prevent moisture attacking the wood. A better plan is to have the drilling and cutting done by the people who supply the poles before the impregnating is done, as then all portions of the pole which will be exposed to the atmosphere are thoroughly pickled under pressure.

Excavation should then take place and it is a good plan before this is done to put a wooden peg six feet to ten feet on either side of the pole peg, in the direction of the line, by which to sight the pole when erected, thus ensuring it being in its proper position.

The erection of the poles then takes place. This can be done by one of several methods. The simplest method is that of using a ladder. For this the pole is laid out along the ground with its butt resting over the hole, which, by the way, should be dug along the line and be as narrow as possible in order to obtain maximum strength and stiffness in the crosswise direction. Three guy ropes are then attached to the top of the pole after which the pole can be lifted by hand until a short ladder, with a wire rung in place of its top wooden rung, can be put underneath. When this is done the ladder can be used as a means to lift the pole, at the same time two men being put on to each guy to steady the pole during lifting. When the short ladder is nearly vertical a longer ladder, also with a wire rung at the top, should be put in its place and the lifting process continued. Whilst this is being done the butt should be eased down into the hole with a plank to avoid the butt sticking into the side of the hole and dropping with a bump when nearly vertical.

Finally when the pole is nearly upright it can be easily controlled and plumbed by means of the guy ropes. Filling in and ramming or punning should then be done, the pole being plumbed several times and adjusted by means of the ropes if necessary.

If "A" or strutted poles have to be erected at angle or terminal positions these can be erected in just the same way as for straight line poles just described except that a kicking block is bolted to the bottom of the poles before erection.

Slinging the catenary wire is the next operation. The wire is best mounted on a drum in a similar way to cable and run out straight along the line. It is then lifted and secured in the eye bolts at the top of the poles and made off at the terminals on to the straining arrangements. The straining is then carried out after which the job is ready for the cable.

Specially made rollers are fitted on to the catenary and have a pulling rope run over them. When this is done a "stocking" can be attached to the cable and the pulling rope tied to it and pulled from the far end. It is possible to run the cable out along the ground and lift it afterwards but it is a cumbersome method and liable to damage the cable.

The pigskin slings are next fitted to the cable and clipped on to the catenary thus transferring the weight of the cable from the rollers. When in position the catenary slings and the wire itself should be well smeared with tallow.

Where the cable leaves the wire and begins to run down the terminal pole a wooden quadrant should be fitted and the cable laid on it in order to ensure and maintain a nice easy bend. At the bottom of the pole the cable should be protected against damage by running it through a piece of W.I. pipe which extends about six to seven feet up the pole and two feet under the ground. If the cable is run straight through a wall from the wire, as in most cases of this sort it is, then a glazed earthenware duct of some sort should be first grouted into the wall at the point of entry.

*Jointing Cables.*

The subject of cable jointing is very wide and only a brief review can be given here. The first essential in this work is cleanliness. It is well known, of course, that thousands of dirty joints have been made and have worked for years, but it is very certain that 90 per cent. of faulty joints are caused through uncleanliness. By this is meant foreign matter and moisture from the hands as well as not cleaning conductors of their insulating material. It is always advisable to have a pot of paraffin close at hand to dip the hands into from time to time. Paraffin is a wonderful cleansing agent and if a fairly large pot is used it will keep cool whilst the hands are washed in it thus cooling the hands and keeping back the natural perspiration. This does not necessarily apply to jointers working on paper cables only, as the conductors as well as the insulation are effected by moisture from the hands. This moisture is slightly acid and will attack insulation and corrode copper far more than is commonly realised.

Dealing now with jointing proper, it is always as well if possible to put the joint box actually under the cables and mark off from the box itself any cuttings which have to be made. First there is the outer serving which should be bound just at the back of where it is to be cut. When this is stripped off the armouring should be bound round on both sides of where it is to be sawn. The free side binder is then taken off and the armouring removed. In the case of bitumen or paper-bitumen cables the overall covering of the cores will now be exposed and this, and especially the exposed copper at the end, should be taped up with dry linen tape until the remaining operations are completed.

If the cable is lead sheathed it should be warmed with a blow lamp and wiped perfectly clean with a piece of paraffin rag. Any plates, cones, glands or lead sleeves should then be slipped on the cable, well out of the way, and the two ends of the cable packed up to the position they will occupy when the joint is completed. The cast iron shell should then be placed underneath again to observe that the armouring lengths, etc. are correct.

The next procedure is that of exposing the cores, stripping back the insulation, and jointing the conductors These three jobs always come together and should be left until all other work which can, has been done. They should then be proceeded with as quickly as possible in order that the atmosphere shall be in contact with the insulation no longer than is absolutely necessary.

The lead of lead cables should be carefully nicked at the point where it will finish, care being taken that it is not cut right through and then a hack knife is used with a small hammer to cut from this point to the end. This cutting should be done at the side of the cable, the knife being held upright, this avoids damaging the paper insulation and also serves as a wedge, thus opening the lead sheath slightly and making it easy to draw off.

The outer covering of the bunched cores is then taped up with linen tape as far from what will be the cone end of the job as is necessary, this prevents stripping too far back and also helps to keep dirt and moisture from coming into contact, and the covering can then be peeled off. The cores are now exposed and should also be taped up to where the jointing ferrules or connecters will come. The cores should be cut off in a staggered fashion so that the ferrules will not form a bulky mass, as they would if all were cut off level. Care should be taken to get core colours corresponding. This is not essential, if the cable is phased out afterwards, as without doubt it ought to be, but it is satisfactory to know that phases are correctly coloured all the way through ; it would, however, be unwise forcibly to twist the cores to achieve this object, particularly with E.H.T. cables.

To proceed, the insulation is cut back on the core, and in the case of bitumen cables all the bits scraped out of the interstices between the wires of the core, and the ends fitted with the ferrules or connectors. If possible the ferrule and its conductor should be sweated together with tinman's solder, in which case nothing but pure resin should be used as a flux. If and while each core is being soldered, it is good practice to isolate it from its fellows by putting a piece of dry cardboard behind it to prevent bits of molten solder adhering to the other cores. It might be worth noting that the method of soldering is to use two ladles and a pot of metal. The pot of metal is heated on the fire until the molten metal will thoroughly scorch a piece of dry newspaper, but not to be so hot as to set it alight. This may appear to be a fad but it is well proved to be the best temperature ; anything above tending for one thing to burn the tin in the solder and for another to burn, or scorch, the insulation ; whilst, at any lower temperature, the chances of getting the copper of the conductor to tin quickly without oxidising are greatly reduced.

A ladle of metal is then taken and poured over the ferrule and conductor, first liberally covered with powdered resin, to be caught by a second ladle held underneath. This ladle-full of metal will now be considerably cooled off so it should be put back into the pot and a fresh ladle-full taken. Pouring is then continued over the ferrule and when the job appears to be properly tinned the same ladle-full is poured backwards over the job until the solder is getting slightly sluggish. The ferrule should then be quickly wiped over with a piece of clean cloth in such a manner as to fill any space which might exist at the ends of the ferrule and also wipe away the blobs of excess solder which are liable to form underneath.

When all the cores have been treated like this they should be examined for sharp points of solder and if any exist these should be carefully filed away.

The dry tape wrapped round the insulation can now be taken away and it is advisable to tie the end of the paper with a length of cotton taken from a piece of linen tape to prevent the paper from unravelling. Either paper or linen tape, boiled out in resin oil, can then be used for covering the ferrules. The insulated cores are then pulled together with several turns of boiled tape, the end being tucked under the last turn to secure it.

The old fashioned practice of basting out the joint with resin oil is no longer used. Its object was to evaporate any moisture which might have collected in the insulation during jointing but the present feeling is that this is so small as to be negligible and furthermore the effect of hot oil is to drive the oil from the paper of the cores into the crutch, thus leaving a comparatively dry paper around the core itself. This is the opinion of the cable makers, but at the same time the authors believe that, under certain conditions of stormy weather when it is practically impossible to keep one or two spots of rain out of the jointer's tent and it is absolutely impossible to keep the moisture laden atmosphere from coming into contact with the insulation, it is still the lesser of two evils to resort to hot basting with resin oil.

The next job with lead cables is that of beating down the lead sleeve at its two ends for the purpose of plumbing. The sleeve before being put on to the cable is thoroughly cleaned with a wire brush and blacked with plumber's black to within about two inches from each end. When the time comes for beating down, these unblacked ends are drawn down with a dresser until the lead sleeve looks like a double ended shell. The two ends are then scraped perfectly clean and the lead of the cable is treated to a similar cleaning. About 1½ inches of the cable lead are then wrapped with white tape and plumber's black applied to the lead which can still be seen. The object of the tape is to keep the lead which will be plumbed perfectly clean and the object of the plumber's black to prevent metal adhering to the lead sheath where it is not required. The tape is then removed and the joint ready for plumbing. The clean ends of lead should then be thoroughly smeared with tallow.

As in the case of soldering, the metal should be at a temperature sufficient to scorch newspaper easily but not to burn it. It is a good plan, however, to have the pot of metal at a slightly higher temperature than required at the commencement of the wipe and for the jointer to take up a ladle-full, the mate having a stick of plumber's metal in one hand, which he melts into the ladle of molten metal, whilst in the other hand he has a piece of paper which he dips in the ladle from time to time, until the right temperature is obtained. This ladle-full of metal is then gently poured over the tallowed ends of lead sleeve and cable whilst a moleskin cloth is held underneath. This first stage is only to tin the lead, and with the aid of the cloth practically all the metal is wiped back into the ladle, which is held underneath.

A second ladle-full is then taken up and the process repeated. This is done until the jointer is satisfied that both sleeve and cable are nicely tinned after which he can proceed to build up his plumb. This is done by pouring metal on to the job whilst with his cloth he moulds the metal to the required shape.

Due to the metal being in a butter like state and also the fact that successive layers are added, a solid mass of metal results without pin or blow holes.

The ladle is put down and a blow lamp is taken up, the flame of the lamp being played on the plumb for just a sufficient time to melt the surface metal after which the cloth is used to ensure a clean smooth surface and to give the job a finished appearance.

The metal has by this time taken up a putty like consistency and a piece of tallow should be brought along the lead sleeve towards and eventually on to the plumb itself. This is done to bring the molecules of tin to the surface of the wipe and so form a relatively hard protective skin. It is unwise to bring the tallow into immediate contact with the wipe since sudden chilling is liable to crack the hardening metal by rapid contraction.

This last mentioned job in the case of bitumen cables will be replaced by that of fitting the C.I. box. There is little to be said about this except that cones and glands should be carefully tightened up, the box having been first wiped out and warmed up by the side of the fire or with a blow lamp.

The box, when fitted, is then ready for the earth bonding which should be done with even more care, if possible, than the internal electrical parts. This is so since any fault in the internal work will quickly shew itself when the cable is put into commission but a fault in the bonding will not be noticed until trouble occurs, it then fails to do its duty just when most required.

Filling a box with compound is generally looked upon as the soft part of the job, which it most certainly is, but nevertheless it is a job which requires patience. How many have asked themselves why boxes are filled with compound? It is usual to dismiss the question with a single answer; that it is there to keep out the moisture, or maybe a supplementary reply that it is there to insulate the cores from one another. There, however, is another useful function served by the compound, during the process of filling it drives out air and keeps its excluded afterwards. That is why it is so important to fill up the boxes properly with one plug hole as an air vent and the other as a filling hole. A box should never be filled by pouring first into one plughole and then the other; bubbles are bound to result, thus defeating one of the main objects of the filling of the box. Air when not allowed to circulate freely and when subjected to changes of temperature, even though ever so slight, condenses and forms moisture. A typical effect of this is seen in houses which have no, or not sufficient, ventilation under the floors; rot sets in, dry rot it is usually called, but it is always first caused by moisture, due exactly to the same reason as a fault in an air locked joint box. The air is trapped under the floor, changes of temperature occur and the moisture condenses on the timber and eventually starts decay.

It is highly important also that the compound be hot enough when poured to vaporise and drive out any moisture which might have settled during jointing. This is another of its several functions. A special point, however, should be made of the fact that when boxes fitted with insulators, such as trifurcating or transformer sealing ends, are being filled, the compound should not be too hot. The chances are that the insulators will crack, meaning, if noticed, that the sealing end has to be broken down and completely remade. If not noticed the joint will almost certainly break down after being put into commission.

Combining then the facts that the compound for certain reasons must not be too cold and for certain other reasons not be too hot, it simply means that the temperature must be just right. Naturally it can only be ascertained by the use of a thermometer and as these can be bought, in a special form, marked at points for the pouring temperatures of various kinds of compounds, there is, consequently, no difficulty in being correct.

One further and most important point to be attended to is that of stirring the compound before pouring. Naturally whilst being heated the compound becomes filled with gas and air bubbles, which, if not broken up and dispersed have the bad effects spoken of in the last paragraph. In order, therefore, to obviate the possibility of trouble from this source and at same time to be certain of the compound being poured at the correct temperature the double purpose can be served by the use of the thermometer, which, whilst being immersed for the purpose of testing the temperature can be used as a stirring rod for which it is usually suitably constructed.

## Discussion.

Mr. GALLAGHER asked why emery paper could not be used for the purpose of cleaning commutators and also for grinding in brushes.

Mr. BEASLEY said that he had always been told to use the emery cloth in one direction only when grinding brushes, as the tendency was to produce two faces if used in two directions; he would like Mr. Lowe to give his opinion on the matter.

Mr. KING referring to the transporting of cables inbye in a pit, asked Mr. Lowe whether he considered the method described in the paper was better than employing man power.

Mr. WOOD wished to know how the authors would locate a high resistance joint in an installed cable, and what instruments they would employ.

Mr. GILCHRIST referring to outdoor switchgear said that the authors advised the smearing of moving parts with vaseline, and asked if they did not think that despite the vaseline the gear would get full of dust and dirt.

Mr. GREGORY asked whether chromium plating had ever been used on contacts such as those at present under discussion. Continuing, he said that being of a non-rusting nature, he believed it would be a sure way of surmounting the difficulty of the striking contacts.

Mr. THOMPSON asked what the authors considered should be the lowest insulation resistance on a motor before permitting it to be put into commission.

Mr. DAWSON said that he found that a high insulation resistance was often got on a small piece of apparatus but not always on a cable network: he would like to know what, in the opinion of the authors, was the lowest insulation resistance tests on individual and coupled lengths of cables they considered safe.

Mr. FORD asked, regarding the phasing-out of transformers, whether the conditions such as the authors had spoken of would exist in the event of the neutrals being insulated. Mr. Ford also wished to know the best method of taking in the slack after a cable had been installed in a pit shaft for about a month.

Mr. LOWE, in reply to Mr. Gallagher, said that owing to the free particles of emery finding their way into the commutator slots, and thereby setting up a potential source of trouble, it was inadvisable to use emery cloth for cleaning commutators. He agreed with Mr. Beasley, and considered the method of one direction grinding-in very good.

In reply to Mr. King, Mr. Lowe said he considered that, if available, man power was by far the best but the difficulty lay in that usually there was not a sufficient number of men at hand.

Replying to Mr. Wood he pointed out that from the test certificates supplied with the cables the conductor resistances could be found, which resistance would have to be deducted from an "all in" resistance test when the cables had been laid and jointed. Any difference between the original combined conductor resistance and the installed conductor resistance would shew joint resistance. The instruments to use to make this test were a low reading ammeter and voltmeter. In the event of a high resistance joint being indicated some form of potentiometer or capacity test would have to be made, as on a faulty cable, to locate the bad joint.

Mr. Gilchrist had claimed that dust would not get between the points of contact, but that it might collect around and yet not get inside. The chief object of the vaseline, however, was to exclude the possibility of moisture settling on the gear and freezing up solid in cold weather.

With regard to the suggestion of using chromium plated contacts, Mr. Lowe said that chromium had a high resistance and should thus, he felt, be avoided. To illustrate the point he said that it was of the nickel family of metals, which were (electrically) used exclusively as resistance elements. Furthermore, the plating method would not overcome the problem of the blades freezing up.

Mr. Lowe considered that any motor should shew a minimum insulation resistance of at least one megohm As to cables, an individual length up to about 400 yards should give an insulation resistance reading of at least 100 megohms, whilst a network of any dimensions, having many branches, could with safety be made alive even when the test shewed practically no reading, providing of course, that a "dead earth" was not indicated.

In reply to the query which Mr. Ford had raised, Mr. Lowe explained that in the case of earthed systems the neutrals would have to be earthed, but on insulated systems an artificial circuit could be made by using two voltmeters across similar colours at the same time. For taking up the slack of shaft cables, Mr. Lowe indicated that there were many methods, but suggested that he preferred one which dispensed with the necessity of slacking off the cleats.

Mr. COOPER, Chairman, said that it was a difficult task to prepare a paper and read it before such a critical audience, but it was even more difficult to answer impromptu the questions brought forward in discussion. This paper had provoked one of the best discussions the Branch had ever had, and was worthy of a good deal of praise on that account alone.

Mr. GREGORY said that it gave him great pleasure to propose a vote of thanks to Mr. Barney and Mr. Lowe for their paper. He had hardly appreciated that there was such a lot to write about colliery gear, and the younger men in particular did not often realise the amount of plant with which they had to work.

Mr. GALLAGHER, in seconding, said the paper had been extremely interesting and useful. Papers of the kind they had heard and discussed that evening were exceptionally useful in that they brought up many practical points that were new or made clearer.

Mr. LOWE, in acknowledgment, said that on behalf of Mr. Barney and himself he wished to thank them for the generous praise. The paper, in its preparation, far from being a labour, had been a source of great pleasure both to Mr. Barney and himself, and furthermore it had been, in no small measure, instructive to the authors. This was so since facts had had to be verified, and especially in the case of a joint paper such as this was, opinions must be carefully discussed and ideas brought into line.

They had realised in advance that the subject with which they were dealing was one which bristled with debatable points, in fact, it was with the idea of exposing controversial matter that they had set out to design their efforts.

Whilst they understood that many members would hold entirely different views than they themselves did, they felt that there were certain remarks which to a few people present, must have been in some small degree enlightening.

If as they trusted this was so, and only one person amongst them had gained only one small piece of knowledge, which would be of use to him, either in the immediate future or in years to come, they had fulfilled what they set out to accomplish and felt more than repaid for the comparatively light work which the preparation of the paper had entailed.

# NORTH OF ENGLAND BRANCH.

## Notes on Colliery Pumping Plant: with Reference to Change of Electrical Frequency.

J. EMMENS.

*(Paper read 13th February, 1932).*

Now-a-days to a very large degree in colliery working the centrifugal pump has replaced the direct acting type, but there are occasions when the latter can be and is used effectively and although these notes are mainly concerned with the centrifugal type of pump a brief reference to the reciprocating pump will be of interest. In point of fact the reciprocating pump has still some strong adherents even for main shaft pumping and the illustration Fig. 1 shews one of two three-throw ram pumps of similar design installed during the last few months for main shaft pumping duty by Lambton, Hetton & Joicey Collieries and by the Co-operative Wholesale Society.

The first was a unit 9 ins. by 10 ins. delivering 250 gallons per minute against 500 feet and the latter an 8 ins. by 12 ins. delivering 220 gallons per minute against 650 feet. Both these pumps were interfrequency units, both motors being arranged for 580/725 revolutions per minute on 40/50 cycles.

In the case of the pump for Lambton, Hetton & Joicey, which was provided with an oil-tight gear case, it was decided to maintain the centres between the motor and the gear shaft so that the position of the former would not be altered at the time of the change of frequency. In this case the pair of first reduction gear wheels will both be replaced to suit the higher motor speed when on 50 cycles. The latter pump will work on 40 cycles for a short time only at reduced speed and only come up to normal speed when the frequency change takes place.

A large number of small ram pumps are still installed for working inbye and generally in these cases the method is adopted of fitting a smaller pinion to the motor when changed to 50 cycles, this necessitating, of course, moving the latter closer in to the gear shaft, the necessary additional holding down bolt holes being, of course, drilled before the pumps are despatched from works. Both centrifugal and reciprocating pumps are used inbye but generally the head quantity ratio does not make it feasible to obtain a very high efficiency from the former type of pump and very frequently the reciprocating pump will have a higher efficiency.

Here, as in all cases when the two types seem to come into consideration, it is suggested that each case should be considered on its merits taking all factors involved, such as space occupied, probable cost of maintenance, general convenience and current cost. Often the matter of convenience would indicate a centrifugal pump as the more desirable, while frequently the reciprocating pump makes possible savings in current sufficient to induce the adoption of this type. It is rather invidious for a pump maker to make a general suggestion as to which type is the better, and the engineer who has to make the decision will be well advised to obtain all relative information and make his own individual decision on the merits of each particular case.

The illustration, Fig. 2, shews a rather interesting installation of main shaft high-lift ram pumps installed by Londonderry Collieries who have two units, comprising a 6¼ ins. by 15 ins. pump delivering 150 gallons per minute against 1600 ft. and a 9 ins. by 18 ins. delivering 300 gallons per minute against 1896 feet.

Turning to the centrifugal pump it is perhaps of interest first to consider a typical characteristic curve. This is shewn on illustration Fig. 3. This characteristic is of what could be called an average centrifugal pump, in which due consideration is given to all features such as efficiency, suction power, head at starting and so on. Sometimes exception is taken to the rise in head from the zero gallons point but the only point of importance here is that the pump should start up and even when, as may happen in special circumstances, the head with closed stop valve is below the normal working point, the pump can always be got away by fitting a small bye-pass from the delivery back into the sump so that the pump delivers a little water before the main stop valve is opened. For boiler feeding it is usually stipulated that there should be no drop in the head towards the zero gallons point.

It will be observed that the power curve rises throughout the range of the pump and it is sometimes demanded that there shall be no rise, or only a slight rise, in the power curve after the normal working point

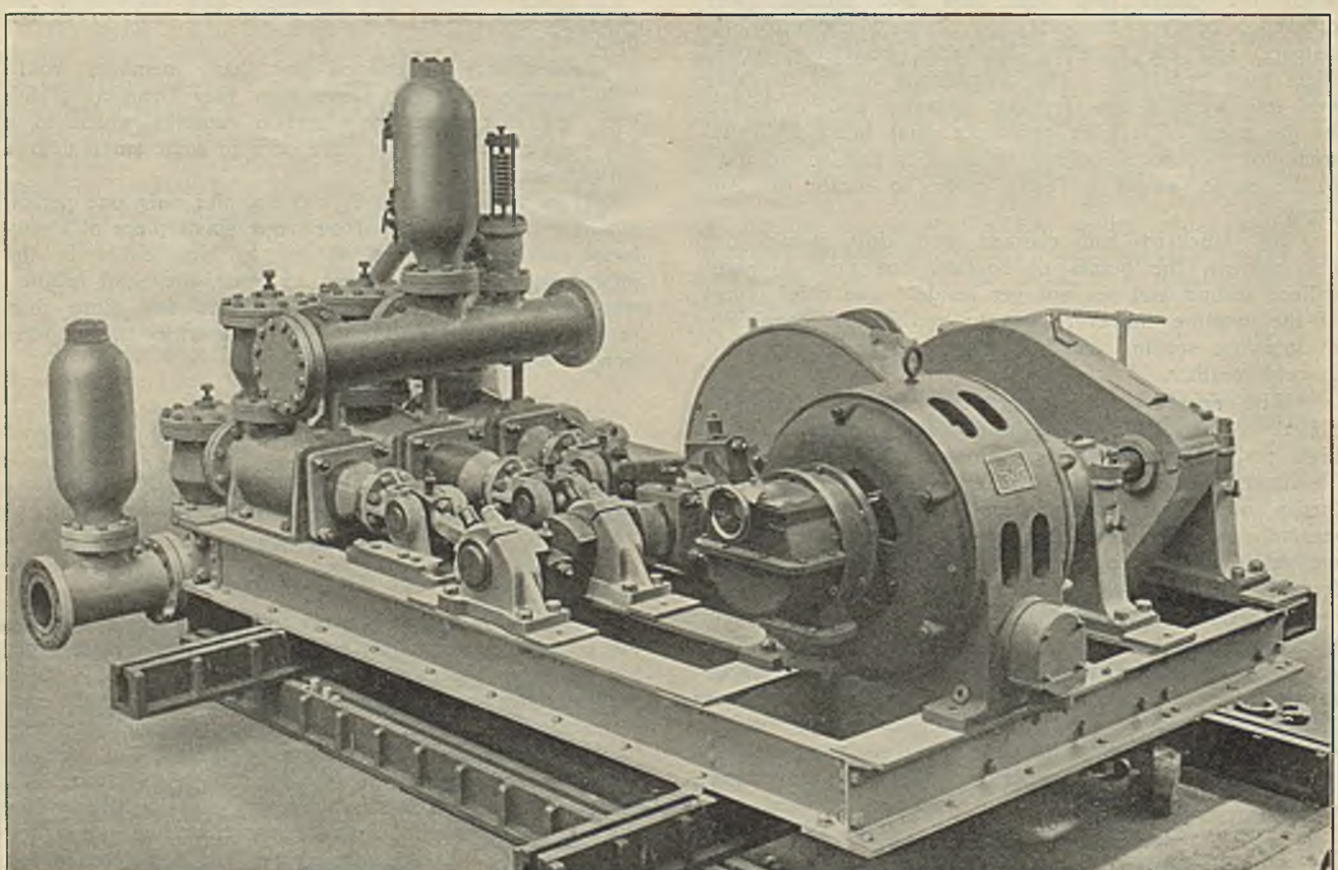

*Fig.* 1.

has been reached, to give what is generally called a non-overloading characteristic. It can be taken for granted, however, that when such stipulations are made the balance of conditions will be upset and some other factor will be involved. It is very desirable when the user intends to make a special stipulation that he should in his own interest advise the pump maker of all the relative circumstances, otherwise some unnecessary sacrifice of perhaps efficiency or of suction power may be involved to suit some condition which the pump designer can meet in some other manner.

It is particularly desirable in the case of interfrequency pumps that all relative information should be at the disposal of the pump designer since he has to deal with a pump which is to operate over a quantity range which is represented by the speed range. For example, a pump speeded up from 1170 to 1450 revolutions per minute would normally throw 24% more water at the same relative point on the efficiency curve. An interfrequency pump, however, has to deliver the same or approximately the same quantity of water at both speeds: it is therefore obvious that it will, unless all or some of the impellers are changed, operate at two points pretty widely separated on its characteristic and it is clear from consideration of the curve, illustration Fig. 3, that considerably different conditions will exist at the two points. How these normally widely varying conditions will be met depends altogether on the type of pump and the actual duty: the pump designer has quite a number of variables.

One of the simplest possible types of centrifugal pumps is shewn in the illustration, Fig. 4, which is of a single-stage volute type centrifugal pump. Although the action of a centrifugal pump is widely known it may perhaps be permissible just to run over the salient points. The impeller, runner or wheel as it is variously called, is seen keyed on the shaft and into this impeller the water is drawn through the eye shewn on one side. As will be seen the impeller consists of two shrouds which are jointed together by vanes of curved shape forming a number of ports or passages through which the water flows to be discharged at the periphery into the delivery passage or volute. The volute has a section enlarging towards the delivery branch and in it the kinetic energy of the high velocity water leaving the impeller is converted into pressure, the water being, of course, discharged from the delivery branch at a velocity much lower than it possesses when leaving the impeller. As no definite sealing can be provided to prevent pressure water in the volute from leaking past the impeller it will be appreciated that a pressure superior to that in the inlet of the impeller will exist in the space between the impeller shrouds and the two sides of the casing. To control the serious leakages which would otherwise occur the impeller is provided on the suction side with a running ring which is a close fit in the cover. The provision of such a running or packing ring on the suction side or front side only of the impeller with a back packing ring on the boss of the impeller is customary practice and this is seen in the illustration, Fig. 5, which is of a multi-stage turbine pump.

It will be observed that on the suction side of the impeller a less area is exposed to the delivery pressure than on the delivery side owing to the relative sizes of the running or packing rings and there will obviously be developed in pumps of this single inlet impeller type, a thrust towards the suction end.

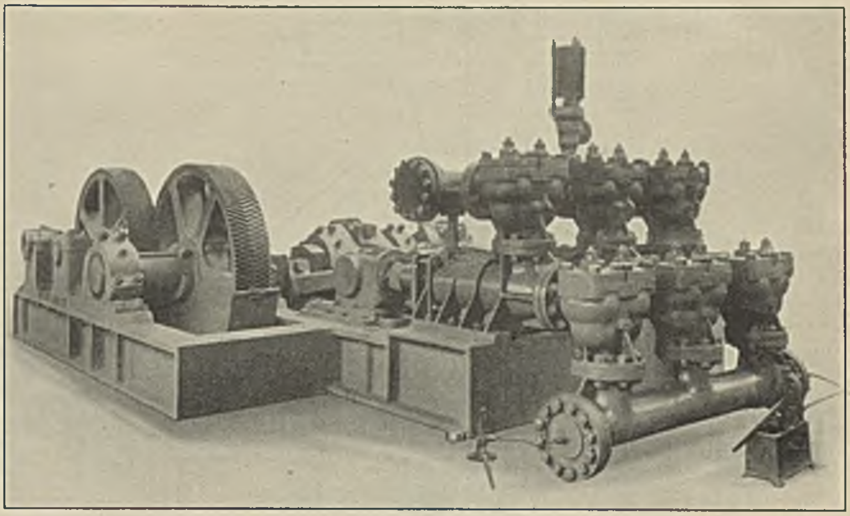

*Fig.* 2.

Further reference to illustration Fig. 4 shews one method of dealing with this. A running ring is provided on the back of the impeller as well as on the front and the chamber thus formed inside this back ring is opened to the eye of the impeller by a series of holes. By suitably dimensioning the back and front rings a state of practical balance can be obtained.

With a pump of this type various methods of interfrequency working can be adopted. It is possible, for example, to modify the angle of the impeller vanes so that the impeller for 50 cycle working gives at the same speed a smaller discharge both in respect to head and quantity than the 40 cycle impeller.

Sometimes with small pumps the user regards the water quantity as a not altogether rigid figure and it may be possible in such cases to meet requirements by providing a 50 cycle impeller similar to that for 40 cycle working but having the vanes reduced somewhat, which has the effect of reducing the effective diameter of the impeller and the head and quantity which it will throw.

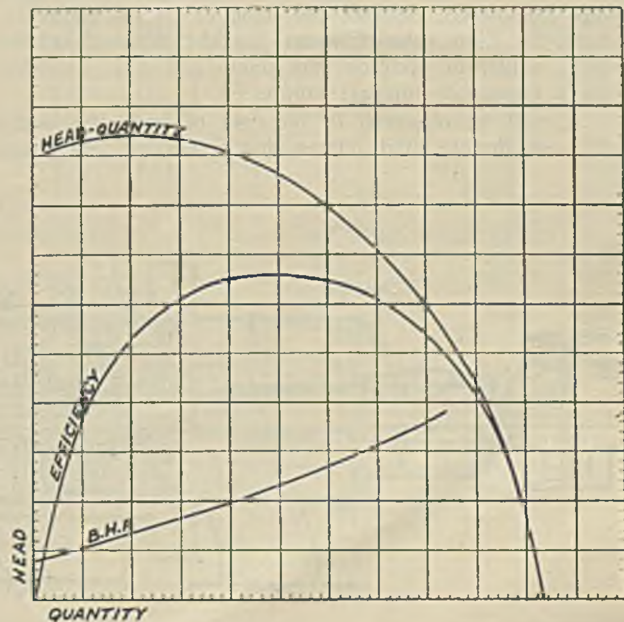


*Fig.* 3.

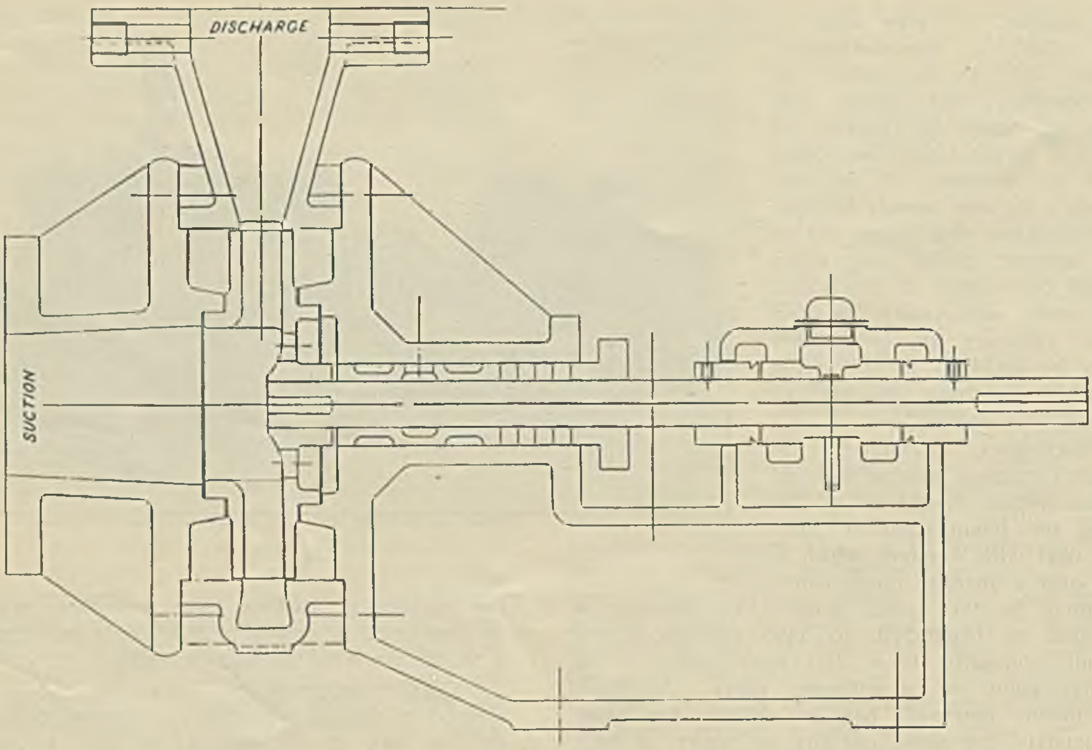


*Fig.* 4.

Obviously, with a pump of the type illustrated it would not be a very expensive job to replace both impeller and casing and there are still other possibilities.

A type of pump coming into greater prominence now-a-days owing to the increasing development of coal washing is the slurry or washery pump constructed for handling gritty water of an abrasive nature. These pumps are usually required for modest heads so that a single stage centrifugal pump meets duty requirements. Depending on the nature of the water to be pumped a number of types come into consideration, the variation being mainly in respect to the degree to which the provision of renewable parts is carried.

The illustrations, Figs. 6 and 7, shew large and medium size pumps of this type, and it will be observed that the casing is protected by renewable sideplates which completely embrace the impeller on its periphery, where the high velocity water has the greatest erosive effect; while, in addition, the pump casing is provided with a renewable internal volute.

It will be observed in the case of both the single inlet and double inlet pumps that removable liners are provided in front of the sideplates so that these latter can be closed in towards the impeller to keep the inlet to the volute continuously protected as the tips of the sideplates wear, where the water from the impeller impinges on them.

Probably more trouble has occurred at the neck bushes of pumps handling gritty water than anywhere else and because of the heavy weight of the impellers fitted in pumps of this type, which become no longer properly supported when the neck bushes wear, the use of a pump with two adjustable bearings, generally of the double inlet impeller type, is becoming more common.

It is strongly recommended that with all pumps handling abrasives a supply of clean pressure water be carried to a lantern in the neck of the pump so that clean water is continually leaking into the pump, lubricating the internal bearing and preventing the ingress of dirty water to the bearing faces.

In the case of overhung impeller pumps, however, very satisfactory results can be obtained when the pump is fitted with a rubber sealing ring as shewn in the

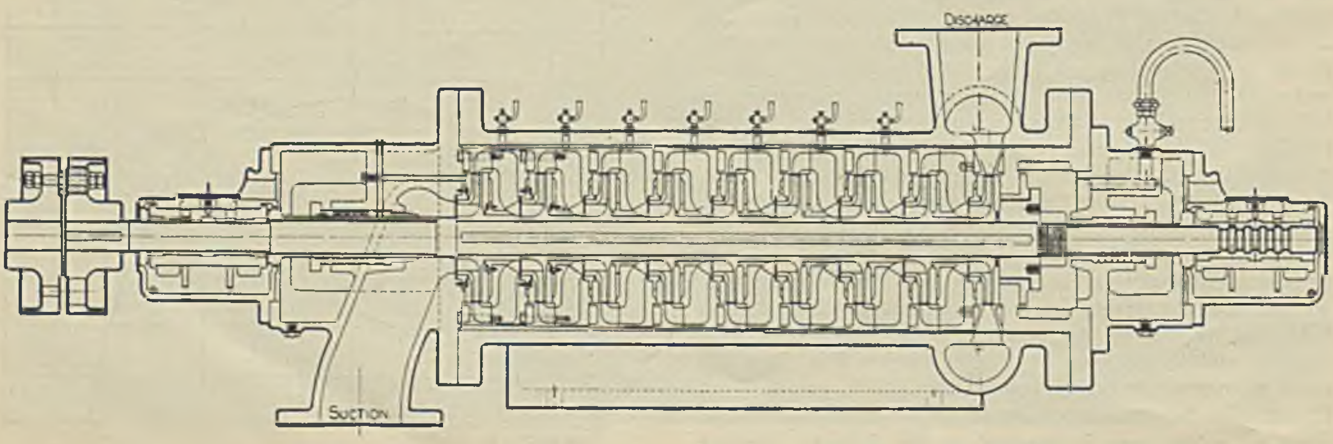


*Fig.* 5.

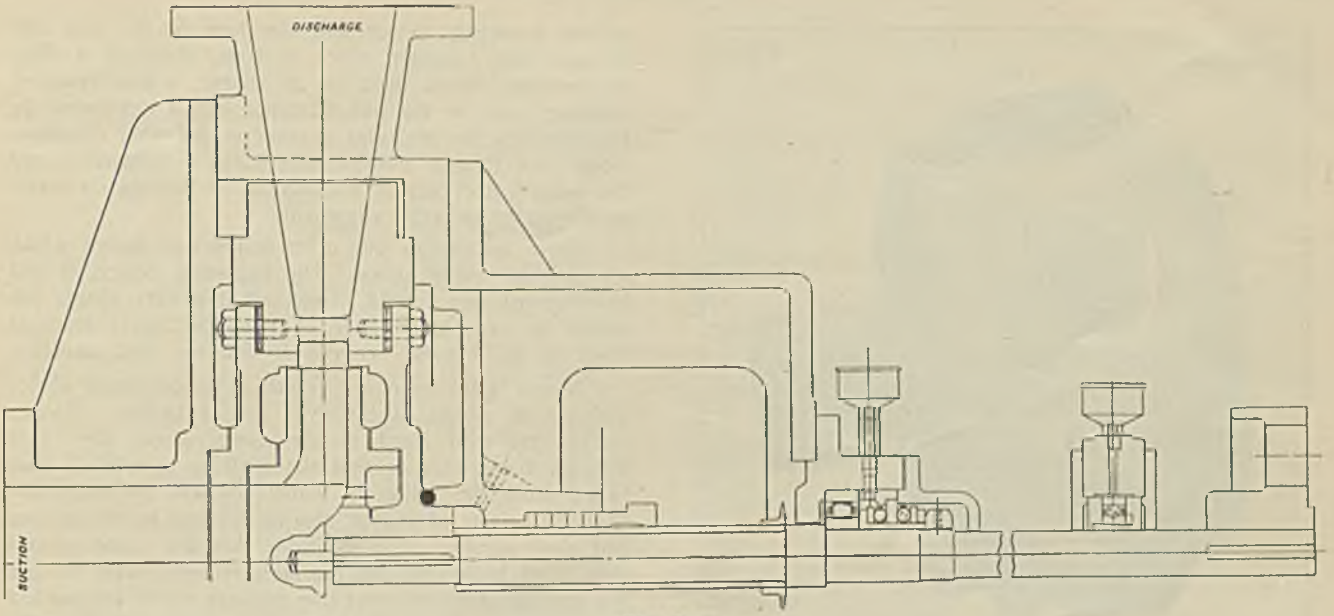


*Fig. 6.*

illustration, Fig. 6. The internal chamber thus formed can be filled either with clean pressure water or grease so that the bearing surfaces are lubriacted and the ingress of dirty water is prevented.

The illustration, Fig. 8, shews a single inlet impeller from a slurry pump, the vanes and shrouds of which are practically worn to shreds whereas the neck of the impeller which forms the bearing is in perfect condition and on the actual impeller towards the inner end faint traces of tool marks are still visible. Washery pumps are, of course, constructed of special abrasive resisting materials selected to suit the nature of the slurry.

In the case of an inter-frequency washery pump all the facilities available with the single-stage volute pump already referred to are available, while in addition there is the fact that both impeller and volute can be changed: as this results in making what is, when changed over, so far as its working is concerned, a straight 50 cycle pump, this seems to be indicated as the desirable course to follow.

Fig. 5 shews a section of a multi-stage centrifugal or turbine pump which comprises a series of impellers mounted on one shaft, each delivering through suitable passages into the eye of the following impeller, the last delivering into a discharge chamber.

Generally, the remarks made in reference to single-stage volute pumps apply except that each impeller instead of delivering into a volute, discharges through a guide wheel or diffuser in which are a number of ports, these registering with other ports in a diaphragm or overflow piece which latter returns the water to the eye of the following impeller.

Illustration Fig. 9 shews by line drawing a guide wheel and diaphragm. It will be plainly seen that with this particular design the water follows what might be called a plain semi-circular path from its discharge at the periphery of the one impeller into the eye of the next following. There are no sudden changes of direction of flow. The last impeller in the pump illustrated, which it will be observed is of the casing type, delivers the

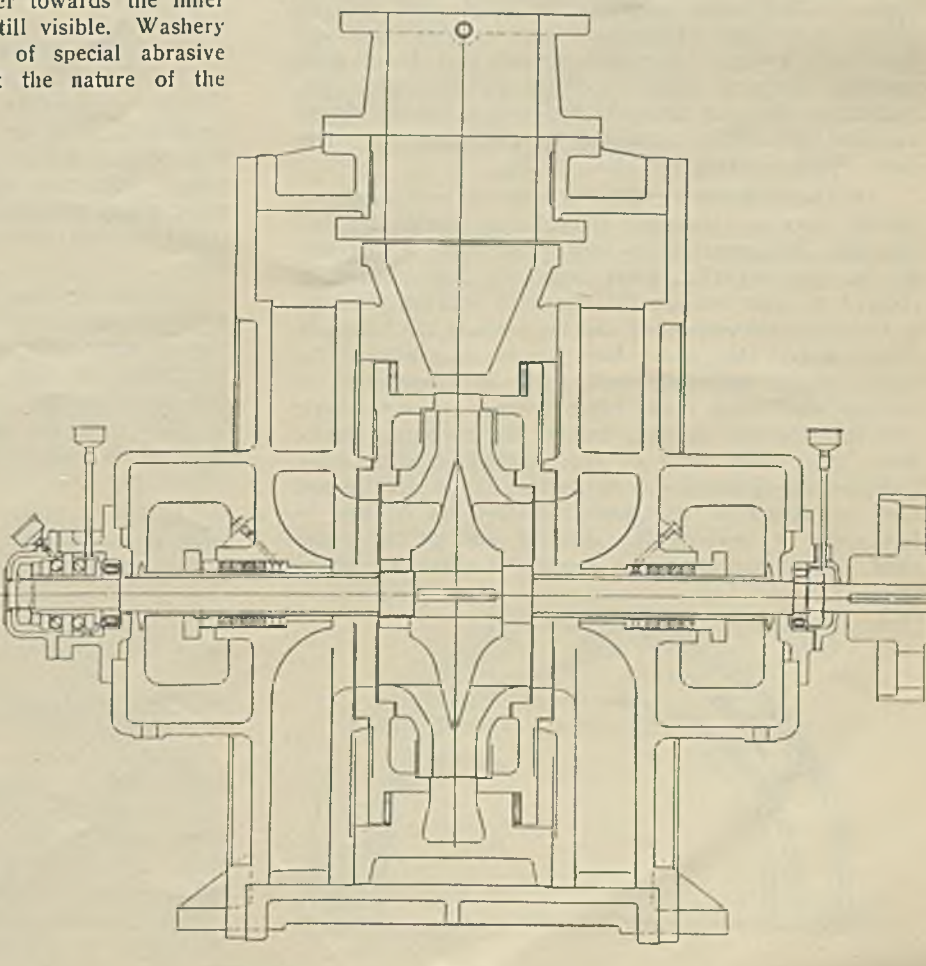

*Fig. 7.*

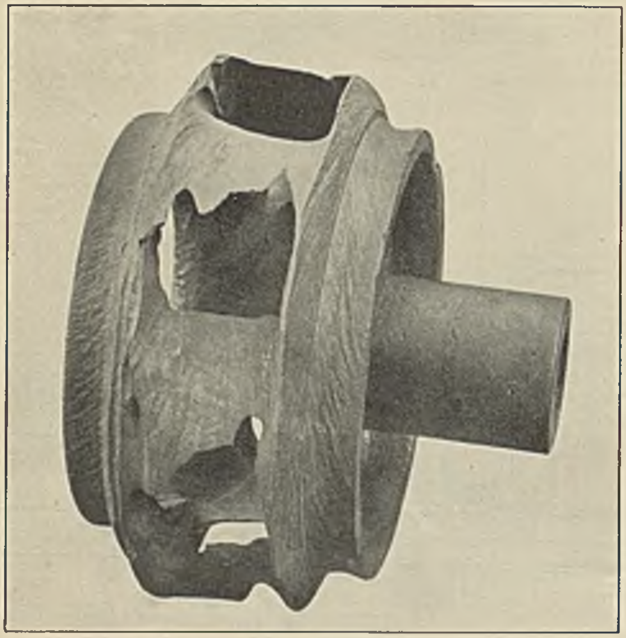

*Fig.* 8.

water outwards into a discharge chamber exterior to the barrel of the casing.

The remarks made regarding the axial thrust developed, due to the sides of the impeller being unbalanced in respect to pressure, apply also to the multistage pump where the impellers are of the single inlet type. In this case, however, the axial load will be related to the total pressure developed in the pump and may reach a very high value, several tons being quite possible. To deal with this thrust was a considerable problem in the past until the hydraulic balancing device was first brought out and this is now practically standard practice throughout the world.

In the illustration, Fig. 5, the balancing device will be seen on the shaft immediately behind the last impeller. Its operation is very simple and it functions due to the fact that water from the last impeller is allowed to leak through the clearance between the bore of the end diaphragm plate and the body of the balancing device disc. This water then passes out between the flange of the balancing device and the outer face of the last diaphragm plate, being released at atmospheric pressure into the chamber behind the balancing device disc. The entire rotor of the pump is free to move endways within limits and the balance is so proportioned that the action of the water pressure on it does in fact move it towards the delivery end of the pump until, due to the increasing opening between the flange of the balancing device and the face of the end diaphragm plate against which it runs, there is a drop of pressure; when there is, of course, a counter-acting tendency, due to the out-of-balance thrust developed by the impellers, for the rotor to move in the other direction. These two thrusts automatically balance themselves and the pump rotor runs in a condition of floating on water in respect to its axial alignment.

There are one or two other features of design which are perhaps worth notice. The balancing device, it will be observed, has a solid flange but it is very simply adjusted as wear takes place by removing liners from in front of it, that is, between it and the last impeller.

Normally the impellers as well as the balancing device and nut in pumps of this type are of bronze. Bronze sleeves are also fitted to the shafts where they pass through the covers so that the shaft is completely protected from the action of water. Where necessary the shaft collar can, of course, also be covered by the suction end shaft sleeve. It is desirable that the guide wheels also be of bronze so that the high velocity water leaving the impeller does not meet iron surfaces which are subject to corrosion. For bad waters it is customary to make all bronzes acid resisting where exposed to water. Stainless steel is also much used.

It is a practical point to observe the position of the shaft collar. With the arrangement shewn the suction end sleeve can be removed from the suction end, failing which it is necessary completely to dismantle the whole pump, which is undesirable since these sleeves are often, due to dirty water or to the lack of proper attention, subject to fairly rapid wear.

It will be observed that the pump barrel is provided with a liner which is of brass and bored out in steps so that each stage of the pump registers into a step in the barrel liner. This, of course, considerably facilitates dismantling as the parts have not to be drawn the full length of the barrel. In the case of large pumps it is often a difficult matter to draw even the impellers and in these cases the shaft itself is also stepped. The guide wheel and diaphragm of each particular stage are bolted together and are fitted in and withdrawn as one piece.

As in the case of pumps for non-corrosive liquids the diaphragm is of cast iron, it is a practice with this type of construction to make it a clearance diameter in the casing so that the bronze guide wheel only fits, thus avoiding the possibility of parts being held due to rusting of the cast iron diaphragms. This design also has the advantage that as a guide wheel with its diffuser are drawn they will pull an impeller with them.

It will be observed that an internal sealing arrangement is provided to a lantern bush at the neck of the suction end stuffing-box. This water, it will be observed,

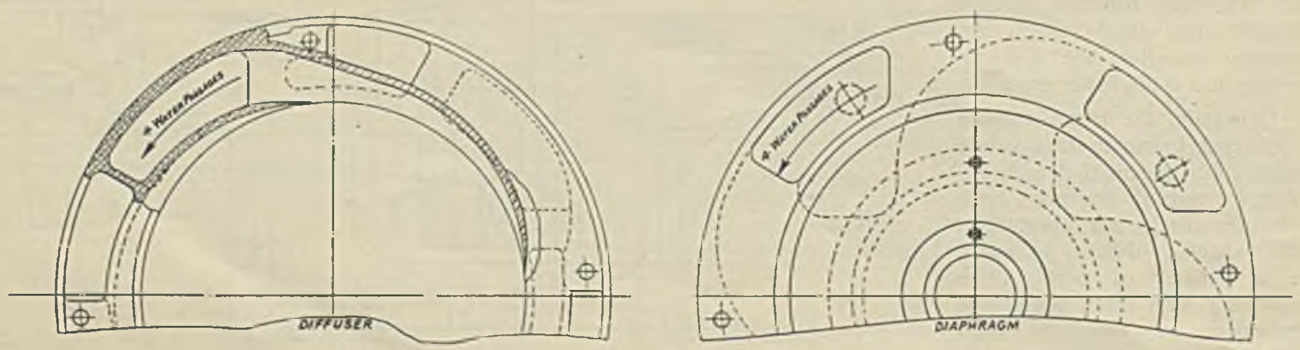


*Fig.* 9.

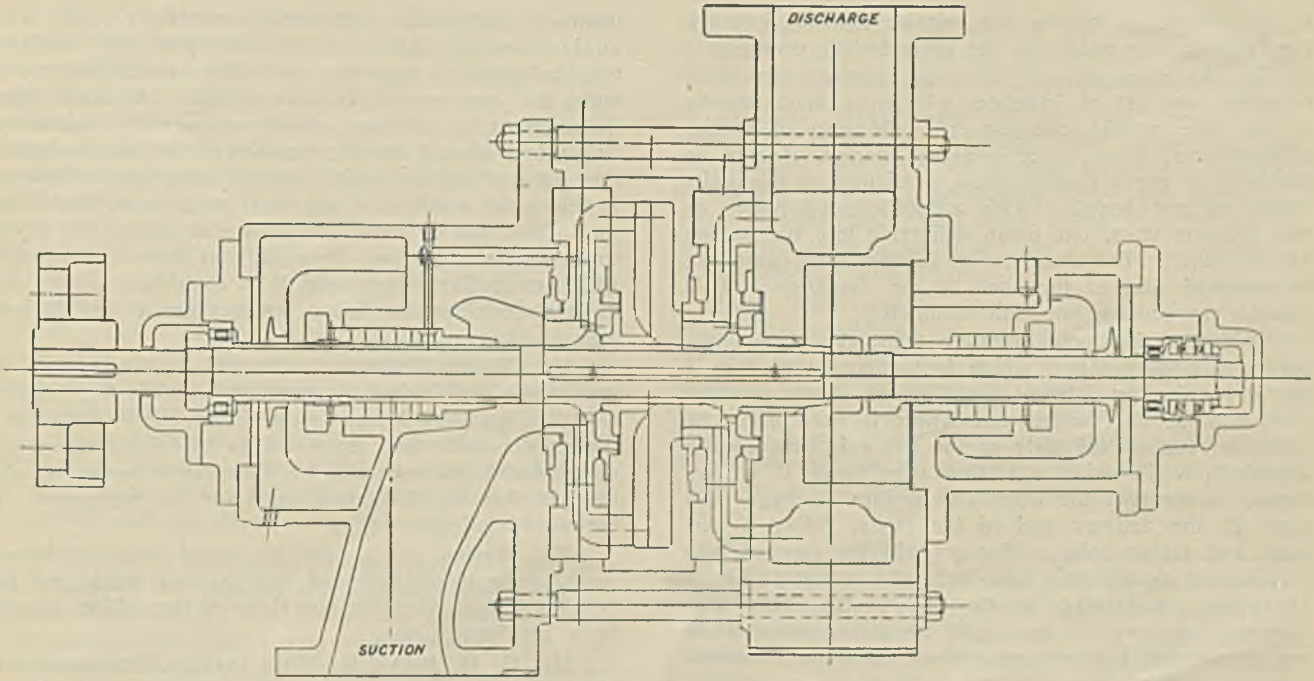


*Fig.* 10.

is under pressure due to its having passed the first impeller and its function is to prevent the ingress of air. The delivery end of the pump is, of course, automatically sealed.

The ample area and streamline form of the suction passage is worthy of note. Such an entry is very desirable and ensures high suction power, reduced losses and prevents cavitation which, due to the resultant emission of nascent oxygen, can have very corrosive effects, apart from causing noisy operation.

The illustration, Fig. 10, shews a section type high-lift pump which, apart from the obvious difference that the various stages are held together by through bolts instead of by a one-piece casing, follows the general design of the casing pump to which detailed reference has already been made. It will be observed that as the section type pump illustrated has not many stages the axial thrust is sufficiently low to be carried by balancing rings on the backs of the impellers and a ball thrust.

In the case of multi-stage inter-frequency pumps the designer has, of course, much more flexible conditions than with single-stage units in as much as he may vary the number of stages to be used at the two frequencies.

As the efficiency curve of a centrifugal pump has a fairly flat top over quite a fair quantity range the designer can so adjust his working conditions that his two points straddle the top of the curve; or he can, when the time of working at 40 cycle speed is short, or to meet the user's ideas, arrange for the 50 cycle working condition to be at the top of the curve, in which case, of course, the 40 cycle working will be definitely below the best efficiency point towards the right.

The illustration, Fig. 11, shews the head quantity and efficiency curves at 40 cycle speed, marked A and B respectively, similar curves for 50 cycle speed being marked C and D. The working point has been marked by an arrow. The 40 cycle curves relate to a seven-stage pump at 1160 r.p.m. and the 50 cycle curves to the same pump as a four-stage unit at 1470 r.p.m. This curve should be fairly self-explanatory in view of the preceding notes: it has been specially prepared to illustrate in a simple manner the principle of inter-frequency working. Unfortunately in practice the matter is not quite so easy for the designer and he does not generally find that the problem solves itself by merely removing a few stages from the 40 cycle pump. When, however, both curves do not pass through the working point, or the 50 cycle efficiency is too low (which generally means that the working point is somewhat down the front side of the curve) it is possible, of course, to provide one or more narrower impellers, impellers having their vanes turned down or of a different type, as the particular conditions of the case may necessitate, for fitting at the time of the change-over.

It is sometimes quite a convenience to be able to vary the quantity of water slightly at the two speeds, giving a little less at 40 cycle speed—the effect of this

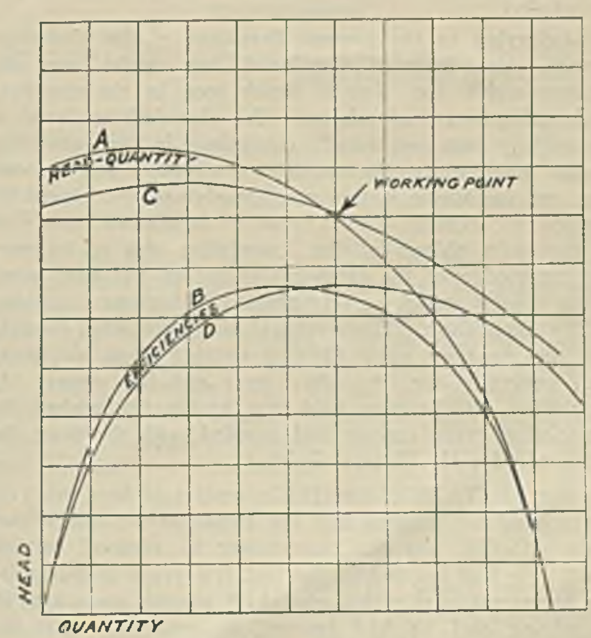


*Fig.* 11.

is, of course, to narrow the relative distance between the two working points on the characteristic curves.

In abnormal cases it may be necessary to fit a complete new set of impellers with their guide wheels at the time of the change-over, while also in special circumstances, when space and cost permit, it may be desirable to use a double pump, consisting of two units either on one bedplate with a double-ended motor or two separate units, one pump delivering into the suction of the other. The stage ratios in this latter case are so adjusted that at the time of the change-over it is possible to remove one unit completely.

With a casing type of pump when the change-over occurs a dummy stage, which is nothing more than a sleeve forming an internal pipe for the water, is fitted preferably at the suction end where it need never be disturbed (unless the duty of the pump is subsequently modified), while with a section type pump it is customary to remove the necessary number of stages and close in the delivery end of the pump, fitting a new shaft and casing bolts. Of course, in the case of both section and double unit inter-frequency pumps pipe-work alterations are involved at the time of the change-over whereas this does not arise with the casing pump which can be completely dismantled without disturbing pipework.

## YORKSHIRE BRANCH.

### Annual Dinner.

The Annual Dinner of the Yorkshire Branch was held at the Danum Hotel, Doncaster, on Saturday, 5th March last. The Chair was occupied by Mr. H. Watson Smith, Branch President, and some sixty members and friends were present.

Mr. BRAMLEY, in proposing "The Yorkshire Branch of the Association of Mining Electrical Engineers", said it was to be regretted that the President of the Association, Major Ivor David, was indisposed and unable to be present, as it was originally intended that he, Major David, should be entrusted with this toast. Mr. Bramley added that he was of the opinion that if the electrician of the colliery had to be certificated in the same way as the managers are, it would be a great stimulus to the Association.

Referring to the present President of the Yorkshire Branch, Mr. Bramley mentioned how great was the interest which Mr. Watson Smith took in the electrical engineering phase of mining. The electrical engineer of the colliery was not usually recognised in the same way as the manager or the mechanical engineer and so one was apt to overlook the great usefulness of electricity applied to Mining. Mr. Bramley mentioned that one of the main objects of the Association was to improve the knowledge of the electrical engineers and that being so he himself would be very pleased to become a member of the Association. The electrical engineers often thought that the managers knew little or nothing about electricity and, generally speaking, they were not far wrong. In conclusion Mr. Bramley said that he heartily wished the Association every success and coupled with the toast the name of Mr. H. Watson Smith.

Mr. H. WATSON SMITH in reply said how much he appreciated his position and the circumstances which that night afforded him the opportunity to respond to this toast. He had learned in the last few years to recognise the important part which electricity played when applied to mining and he had learned to appreciate that the safety in mines to-day depended in far greater measure upon the application and use of electricity. He was afraid his knowledge of the subject was very limited, but he hoped his connection with the Association would make for improvement in that respect. He hoped the Management of collieries would not seek the minimum wages they should pay the electricians but the maximum they could afford to pay in order to have safety in mines. It might be possible to get away with something that was cheap for a time but it would prove far more costly in the long run. Personally he had no sympathy with any colliery that said they could not afford to pay the electrician a sufficient remuneration to get a good man.

Mr. Watson Smith then referred to the matter of membership and invited all those employed in the colliery electrical world to become members of this Association: the greater and more representative the membership the more would Managements be encouraged to appreciate the fact that the Asociation stood for the betterment of the whole industry.

Mr. Watson Smith said he hoped the Association would grow in strength and that the day would not be very far distant when the electrician of the colliery would be a certificated man.

Mr. E. H. FRAZER, H.M. Divisional Inspector of Mines, in proposing the "Coal Trade" thanked the Association for allowing him to propose what was in his opinion the main toast of the evening. There was no getting away from the fact that the coal trade was in a bad way and that coal mining in Yorkshire had seen a serious decline in the last two years. As a matter of fact the output in the last two years had decreased by 11%, but the h.p. of motors installed had increased by 7% in the same period which in itself proved that the collieries were using more electrical energy. In his opinion electricity was going to play an important part in the return of prosperity in the coal trade to which they were all eagerly looking forward.

At the moment there was the important subject of coal face lighting. The big question was: Would it be safe? It offered the electrical engineer a big chance to make a success of it. He certainly hoped it would be a success, and was certain that if it should not succeed the failure could be put down to natural circumstances. Coal face lighting was one of the pressing problems of the moment for the colliery electrical engineer and, in his opinion it would help a great deal in making mines safer.

As a matter of interest Mr. Frazer mentioned that he, personally, had so much confidence for the future of electricity that he had put his own boy to be an electrical engineer and already he had begun to teach him (Mr. Frazer) quite a lot of things he did not know and, perhaps, did not particularly want to know.

Mr. Frazer said he did not propose to say anything about the status of the colliery electrical engineer; the Branch President had already dealt with that matter in his Presidential Address. As to the certification of electrical engineers, if the Association were to institute and issue a certificate of proficiency it might be possible to get the managers to give the holders preferential treatment by virtue of the fact that he held that certificate. So far as the Coal Mines Act and the General Regulations were concerned the electrical engineer was non-existent, but no doubt some satisfaction would have been gained from the fact that junior electrical inspectors of mines had recently been appointed.

Mr. WEBSTER, in reply, thanked the Association for inviting him to their function that evening and mentioned that he himself was a member of the Association some twelve years ago. He related he was very anxious to have some information in connection with some electrical machinery and he was advised to write to the Secretary of one of the Association's Branches. Not only did he give him (Mr. Webster) all the information he desired but he invited him to become a member of the Association. He could assure those present how much the Managements owed to them in the very trying times which the Coal Trade was up against. The outlook for the coal trade was very bad, as our foreign competitors had developed their coal mines to such an extent that we could not compete with them in price. This with the trade depression and the fall in consumption in the home markets had caused them grave concern and so far as he could see there would have to be some other outlet for coal before prosperous times would come back again. If the colliery electrician could make a sound job of coal face lighting then he would materially assist in reducing the cost of production, which would help the owners to compete with our foreign competitors.

Mr. ROSLYN HOLIDAY, Treasurer of the Association, proposed the toast of the "Kindred Associations" and mentioned that he was one of the earliest members of the Association. Mr. Frazer had mentioned that this Association was quite a young one, and so it was as compared with the other Associations, but as this was the twentyfirst year of the Association they had now reached their majority and were looking forward to bigger things.

The Association of Mining Electrical Engineers owed much to the Colliery Managers and Mechanical Engineers Associations, but he did not think the A.M.E.E. got quite the amount of sympathy which it ought to receive from them. Mr. Holiday mentioned that when the Association was first formed the Mechanical Engineers did not take very kindly to it, but he was very pleased to be able to say that the position had greatly improved since then. Mr. Holiday mentioned that he was the first officially appointed electrical engineer of a colliery in 1891.

To the young ones he would say that the recognition of status was in their own hands, it was not only necessary to come to the meetings; they should obtain the Association's certificate. Mr. Holiday stated how much the gathering that evening appreciated the attendance of Professor Wheeler, and he would like to thank him on behalf of this particular branch for the great work which he was doing for the coal industry at the moment. He submitted the toast of "Kindred Associations" coupled with the name of Professor Wheeler.

Professor R. V. WHEELER, D.Sc., said that one thing that had impressed him very much in speeches that evening was the tone of pessimism so far as the coal trade was concerned, and he could not for the life of him see why that should be so. To the members of the Association he would say that the industry could not do without them.

Professor Wheeler added that the Mines Department might do well to revise the rules and regulations relating to the use of electrical apparatus underground, which were made years ago. At this present moment he could not see the necessity of the restrictions imposed. Professor Wheeler would suggest that the Colliery Electrical Engineers should become members of the Midland Institute of Mining Engineers because the use of electrical apparatus underground was growing and would grow and, as he had stated, the mining world could not do without the electrical engineers who would be necessary to give their technical assistance and direction in many matters. He was replying to the toast of the "Kindred Associations", one of which was the Midland Institute of Mining Engineers, and one which would welcome the members of the Association of Mining Electrical Engineers.

Professor Wheeler said he also could reply to the toast as a Chemist, and he could again assure them that the Chemists could not do without them. He went on to say that he was in the United States only last year: the depression there was much worse than it was in this country, and he could not see why the pessimism in in this country should exist.

Prof. Wheeler said he had centred great hopes around the possibilities of coal face lighting despite the fact that the Mines Department were contemplating the laying down of stringent restrictions; he was of the opinion that coal face lighting would be universal before long. On behalf of the Associations mentioned he wished to say how pleased he was with the kindly and enthusiastic manner in which the toast had been proposed and received.

Mr. J. STAFFORD, in proposing the toast of "Our Guests", mentioned that he was acting on behalf of Mr. T. H. Williams the President of the Doncaster Sub-Branch who was unfortunately indisposed. On behalf of the Yorkshire Branch of the Association of Mining Electrical Engineers he would like to thank all the guests present if only for their interests in the Association by their attendance. Primarily he would like to mention Dr. Wheeler who as everyone knew was a very busy man and he would like to thank him for the sterling work he was doing on behalf of the coal industry. He believed that the work Dr. Wheeler was doing was infinitely more valuable than all the tonnage quota schemes put together. Then there was Mr. Frazer, H.M. Divisional Inspector of Mines whose knowledge and advice they as mining electrical men could not do without. Also he would like to mention Mr. Bramley and Mr. Webster. Again, there was Mr. Hardy of Denaby whom he had known personally for a considerable time and with whose name this toast was coupled.

Mr. E. HARDY on behalf of the guests thanked the Association for the invitation to the gathering that evening. He said he too would be very pleased to become a member of the Association.

## WEST OF SCOTLAND BRANCH.

At a meeting of this Branch held in the Royal Technical College, Glasgow, on 17th February last, Mr. Arthur Dixon, Branch President, occupied the Chair, with Mr. John A. Brown acting Secretary in the absence of Mr. W. G. Gibb.

After the Minutes of the previous meeting had been read, and apologies for absence intimated, the following applications for membership, approved by Council, were passed: Mr. William Lindsay, Kasunda P.O. Manbhum Dist. E.I.R. India; Mr. Earnest Earnshaw, 202 Copeland Road, Ibrox, Glasgow; Mr. Fredk. B. Richardson, 6 Kirkintilloch Road, Lenzie, Glasgow; Mr. Wm. M. Morgan, 152 Kings Park Road, Cathcart, Glasgow; Mr. James McAlpine, 14 Kelbourne Terrace, Bellshill; Mr. Wm. D. Murray, 21 Dryburgh Avenue, Rutherglen; Mr. Kenneth M. Street, 66 Springfield Park Road, Burnside.

Thereafter Mr. Kidston read his paper on "Reconditioning of Electrical Apparatus" followed by a discussion of various points in this paper by several of the members present.

## Re-conditioning of Electrical Apparatus.*

### Discussion.

Mr. G. N. HOLMES said he would like to thank Mr. Kidston for this paper of personal experience: it was of the type which particularly appealed to the members of the Association. Mr. Holmes then referred to the machine which was for winding wires from 0.0076 in. to 0.232 in. It was very difficult to wind soft copper wires without considerable strain on the wire up to 0.0366. The adjustment of that machine must be exceptionally fine.

With regard to some of the troubles described by the author, it would appear they were probably due to overheating and that most of the repairs applied to cotton covered wire. For some time there had been on the market a 'rockbestos' cover which was very valuable in the case of overheating machines. Some motors for coalcutters were regularly run very hot, and Mr. Holmes suggested that this rockbestos material would probably be the right thing for them.

With regard to the impregnation of the machine, did Mr. Kidston believe in single or double impregnation, and in vacuum drying and impregnation, or otherwise?

A lot of troubles with varnish were due to the low temperature at which the things were stoved. It should be impressed upon all colliery managers that they should use at least 212 degs. to 220 degs. F. on all varnishes irrespective of manufacture. Mr. Holmes believed that would prevent many breakdowns.

Mr. J. BENTLEY referred to the pressure used in forcing shafts into the armatures of coalcutting machines —20 lbs. per square inch. He thought it was unwise to press a shaft into a sleeve without first ascertaining the stresses imposed on the sleeve.

Mr. Kidston had mentioned the difficulty he had in getting armature coils into the slots with micanite insulation. In the early days of micanite insulation a lot of experiments were gone into with this type of insulation and it was found that it was not so much a question of electrical strength of the micanite but more a question of mechanical strength, and therefore it was decided that it was only a matter of arranging small thicknesses of the micanite and pressing them together to make it strong. Anyone using it must see that it was pressed tight until quite hard.

Micanite turns to a white powder if it is worked about in any way and it is dangerous insulation if wrongly used: used rightly in the right place it is most suitable and reliable. As regards using leatheroid Mr. Bentley did not think that manufacturers would seriously consider its use instead of micanite.

Referring to the subject of oiling bearings, Mr. Bentley was surprised to hear that there was any trouble because most manufacturers design the sleeve bearings with an overflow which automatically prevents any excessive quantity of oil remaining in the bearings. He believed the real difficulty was with ball or roller bearings: people would stick to the idea that they must put grease into them, which is the very thing that should be avoided. The packed grease simply gets hot: the bearings only need sufficient to keep them from rusting.

The author had stated that it was better to impregnate coils. Mr. Bentley agreed but would remind anyone who proposed to re-wind with pre-impregnated windings that they would find the insulation factor had gone down 5 per cent. and that they would not be able to get the new coils into the slot if the original winding had been put in dry and then impregnated.

As regards impregnation generally, which had brought up by the previous speaker, there had been much discussion as to whether impregnation was useful or not: he, Mr. Bentley had personally no doubt as to its value for electrical machinery. The process eradicated all moisture, and even micanite was a great absorber of water. The damp was substituted by the varnish, and it was important to dry the varnish at low temperature very slowly. The longer the time taken for drying the better the result.

Referring to the coils of the 200 k.w. dynamo, Mr. Bentley thought it must have been a very old type of machine: he did not think manufacturers would use that type to-day.

Mr. J. HOWAT.—Referring to the repairing of the poles carrying the overhead lines, Mr. Howatt got the impression that the work described was only of a temporary character. To bore holes in the pole just above the affected part would appear to be further weakening the poles where they had already been interfered with. Mr. Howat did not know the voltage of the overhead lines, but within the limit of time, he would have thought that to put up two poles would have been better: it could have been done in a very short time, and would have given a sounder job, more complete and with less expenditure.

Mr. NAPIER said he was interested in the machine he showed for pushing ball bearings on the shafts, but the greatest practical difficulty in collieries was to take off the ball bearings. Had Mr. Kidston any machine or appliance for taking them off?

Mr. A. DIXON (Chairman) said it seemed to him that some of the arrangements described by Mr. Kidston were rather up against the regulations. For instance, the lighting board with both a.c. and d.c.. on the same board. The 50 h.p. motor was in a hole below the ground level where it could not be properly got at. There was a compressor motor in connection with the sand-blast which could be shot at by the pellets. There seemed to be one or two things which as described, in the paper could be taken exception to by a factory inspector.

On the lighting system would Mr. Kidston say what he had experienced as to the life of the lamps in changing over from a.c. to d.c. Mr. Dixon believed it was usually not considered to be very satisfactory. There was no doubt that Mr. Kidston and his people were quite ambitious in the things they did: Mr. Dixon would like to learn more of the equipment available.

Mr. Dixon quite agreed that impregnation was very desirable. The author had unintentionally paid himself and his company a compliment on the quality of the repairs as, like one of the speakers had already mentioned, they had some old motors. For instance, mention was made of fixing the short circuiting rings on rotors with screws: it was doubtful whether anyone ever made rotor end connections in that way nowadays. The author did say he preferred brazing, but even that was not sufficiently good: it still gave way under the effects of vibration. The best method was to cast them solid and that was the standard practice with quite a number to-day.

Mr. Kidston had used fibre wedges, and Mr. Dixon would like to know if they had been found quite satisfactory: he was under the impression that hard wood was probably not so hygroscopic and not so likely to warp.

Referring to the author's expressed preference for contactor type starters and push button control, Mr. Dixon confessed that he had the feeling that contactors

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* See *The Mining Electrical Engineer*, May, 1932, p. 396.

were still a box-of-tricks, and the more complications there were the more chance was there of getting trouble.

Mr. J. WALKER (Lothians Branch).—Mr. Kidston spoke about the method of making wood formers and put it down as an old-fashioned method: he, Mr. Walker, could assure him if he were to take a walk through some of the modern concerns he would find those old-fashioned wood formers still being made. Mr. Kidston had said that the better plan in insulating coils and core slots was to impregnate the wire itself before the coils were made: that could not make standard practice for the repair shop because there were hardly ever two slots alike. As to micanite, said Mr. Walker, there is micanite and micanite. Forty or fifty years ago it was dependable, but to-day, when buying micanite himself, he insisted on the salesman bending it (Mr. Walker demonstrated the bending action with a piece of paper). It should not break.

With regard to rockbestos, he could only say that when the makers could supply that stuff to correspond to DC cotton size he would be pleased to use it.

About field coils and wrong size of the pole piece, it is quite typical of some manufacturers who, writing back, would actually try to make you believe that you did not know what was the size of the pole piece you were using.

Mr. Kidston had shewn two line poles, one of them had a stump leg; why were not the two legs done at the same time? Mr. Walker thought it would have been far cheaper to have done the two at the same time.

Mr. Walker was quite interested in the 55 h.p. motor, but was not at all sure that the author's way was a paying business for a commercial shop altogether, to the extent of making up those big flanges for one job alone. It might pass in a big factory where time did not count to the same proportional extent.

Mr. Kidston had been quite anxious to stress the repairing of motors, but he, Mr. Walker, would gently remind him that motors to-day were built for sale and not for repair.

Mr. L. WOLLISON said the paper was exceptionally interesting to him as being a representative of a manufacturing firm. He had greatly enjoyed the paper and the fact that Mr. Kidston had been dealing with his own experiences added greatly to its practical value of the paper; Mr. Kidston had shewn much ingenuity in dealing with the difficulties which had come his way.

Mention had been made of the new rockbestos insulation, and Mr. Wollison said it could be recommended where temperature was a matter of importance. He would like to tell Mr. Walker that he could now get rockbestos in the dimensions referred to. The makers of that type of insulation had introduced considerable improvements in the last fifteen months and it was now available within the usual dimensions.

Mr. Wollison was interested in the Chairman's remarks about the brazing of rotor bars: personally, he preferred the brazing, and if properly done, there was absolutely nothing wrong with it. It could be done with comparatively little difficulty by ordinary methods. Most firms who had tried casting on rings had run up against trouble. Usually the bars shewed a tendency to break short—a form of crystallisation having been produced. A well brazed joint should give absolutely no trouble: he, Mr. Wollison, had personally handled hundreds of that type of motor and he had not heard of one complaint.

Mr. Walker had a dig at the manufacturers for being old-fashioned and not coming up to scratch in adopting new machines. It should however be remembered that in certain lines of manufacture the manufacturers had sunk a great deal of money in the plant for the making of formers, and in some cases, it was very doubtful whether the manufacturer would gain by introducing machines of the type referred to. Where the quicker way scored was where it was required to set up different sizes from time to time—it was then justifiable and it did wind a very good coil. Personally he would like to use that machine wherever possible.

The matter of impregnation had taken a prominent part in the discussion and, as most of them knew there were two schools of thought on that score. The one maintained that vacuum was the better way, and the other that dipping into hot varnish was better. The comparison seemed to hang on the point of getting the varnishes properly oxidised. The varnish must be pre-heated and the moisture driven out. It is preheated to drive out the moisture, but unless the varnish is also thoroughly oxidised it will again absorb moisture; the oxidising of the internal varnished parts presents the difficulty. He thought that colliery engineers would be generally agreed that vacuum impregnation was the better method. It required prolonged stoving afterwards, and the particular make of varnish had to be considered but most makers of varnish would recommend that the temperature should be about 225 degrees. Long stoving and free circulation of air to permit oxidisation to take place thoroughly were necessary.

Mr. A. DIXON, Chairman, in closing the meeting said this was the first paper read by Mr. Kidston, and they would all agree that it was very good, and that the author must feel gratified at the reception his paper had received and the most useful discussion which it had brought out. The paper was well up to standard and the many lantern slides had been a great help. Mr. Kidston's replies to the several points raised in the discussion would be provided for printing with the report of the discussion.

Mr. KIDSTON, in reply to Mr. Dixon said that if a lamp were switched alternately on a.c. and d.c. at lengthy intervals between each switching period, no difference in its life would be noticeable, but to switch off and on a.c. and d.c. rapidly would probably soon break down the lamp filament.

The arrangement of the dual type of switchboard, having a.c. and d.c. on the one panel, was only intended for a standby measure and would only be supplied by either a.c. or d.c., but never both at the same time, and as each circuit was provided with a double-pole change-over switch, Mr. Kidston did not think its use would constitute a breach of the C.M.A.

In Mr. Kidston's opinion, though contactor gear may seem to be rather complicated they were certainly much better than formerly: the trouble was that contactor gears usually did not receive enough attention: if they were systematically inspected at regular intervals, there was no reason why they should not give every satisfaction.

Referring to the repair to poles, and particularly regarding the cutting away of the defective part and replacing it with a concrete base, Mr. Kidston said he did not consider the repair as a temporary measure; the pole, in his opinion had been greatly strengthened by the concrete base. As to preparation being made to have a new pole erected, an H pole had been fully mounted but, owing to the proximity of a railway and due to the fact that the power could only be off for a very limited period, which at the most was one hour, it would be appreciated that very little could be done in that time.

Mr. Howat had further suggested that the method of boring the pole above the affected part and treating it with creosote would tend to weaken the pole. Mr. Kidston could not agree: as this part of the pole was in good condition and the outer shell of the pole was the strongest part, the holes which were not bored right through and being at different parts, would not have a weakening effect on the pole. They were afterwards plugged with hard wood plugs, which gave additional strength to the pole.

Referring to the criticisms by Mr. Walker, Mr. Kidston agreed that the old method of forming coils might still be seen in modern repair shops, but the number of manufacturers now using these types of automatic winding machines proved conclusively that there must be special merits in them. Some of the advantages were: the ease with which different types and forms of coils could be wound, and the time saved in setting up the machine must be apparent to everyone; also, every coil made was exactly alike and coils could be made and despatched to collieries and workshops, knowing full well that they would be the proper size.

As to Mr. Walker's question whether it would not have been better to have done both sections of the two-membered pole at the same time, it should be noted that the other limb of the two-membered pole was in good condition: if it had shewn signs of deterioration, certainly it would have paid to have both sections done at the one time.

Mr. Napier had asked whether the method of pressing ball races off could be adopted for coalcutter armatures.

The type shewn was, however, only suitable for very small armatures, those of vacuum cleaners, small fans, etc. Mr. Kidston agreed with Mr. Napier that if something of the kind could be adopted for coalcutter armatures a great deal of time and worry would be saved.

Mr. Holmes had asked for further information as to the method of winding described and the gear for keeping each turn in its proper place. This was accomplished in a manner similar to the screw cutting thread on a lathe. The clutch was in two halves and in addition to there was a fine vernier adjustment which could be set to the proper distance.

As to the amount of elongation of a .0076 (N 36) D.C.C. copper wire wound on the machine: on a length of 50 ft. of that size of wire the elongation was found to be less than ⅛ in.

The great drawback of rockbestos covered wire was the difference in the overall sizes of the insulation: the difference was in many cases being prohibitive, but since that defect was now being overcome, Mr. Kidston would be quite willing to test the latest form and judge its possibilities.

Mr. Dinnen had said he would be very chary about using a pressure of 20 tons for fitting shafts and thought the makers ought to be consulted as to whether that amount could be used without fear of damage to the hub. The figure of 20 tons mentioned in the paper was to be taken as a maximum, average pressure necessary would be about half that amount. The hubs in most cases were made of cast steel which would stand a much higher pressure than cast iron.

The brass former for field coils as shewn was indeed a very old one, being more than 30 years old. What was intended was to shew the method of ironing on the insulation.

## A MANUFACTURER'S STAFF SEES UNDERGROUND.

By the courtesy of Mr. E. L. Milward of the Wigan Coal Corporation Ltd., a representative party of our Staff* (Foremen, Designers, Draughtsmen, etc.) visited Chisnall Hall Colliery (Coppull) on May 24th, and spent a very interesting and enjoyable day.

On arrival we were most kindly received by Mr. Whittaker, the Colliery Company's Agent, and Mr. Lowe, the manager.

After receiving the customary precautions (and the accessories peculiar to coal mining), we descended the 450 yards shaft, under the charge of Mr. Whittaker. It was interesting to note that the Davey lamp was still in use in spite of the much boomed electric lamp ; doubtless initial expenditure prevents the changeover.

As the cage commenced its journey one's thoughts, excited by the swift travelling and changing air in the shaft, raced over all the things that could possibly happen in the darkness below, but any fears that might have prevailed were quickly dispelled by the smooth coming to rest of the cage and the onsetter's cheerful "good morning" as we emerged. Here followed the usual search and lamp inspection which left no doubt that some rules of His Majesty's Government are carried out to the letter. Thus, with the feeling of safety and the will to see all, we started our journey along the main road, passing many well loaded tubs marshalled by boys on the way. Reaching the Under-Manager's office we removed all unnecessary clothing ; the wisdom of this being very apparent later.

After inspection of the Main Switchgear and Haulage Gear, which were of the usual types, commendable for compact arrangement, the party set off for the low-level seam. This journey introduced the first of the miner's hardships, for the headroom lessened considerably, and progress was only possible with backs bent and heads low. To this discomfort add the effect of the slight rise of the road and frequent battling with cloth air traps, and it will not be difficult to imagine in what condition we arrived at the coal face half an hour later. A number of halts were made, of course, to examine the roof, propping, surveyor's marks, etc., all of which proved very interesting and shewed the importance of thorough workmanship in this section of mining.

To reach the coal face necessitated crawling on all fours over heaps of rough coal and past wooden props spaced at intervals of four feet—no child's play this ! The coal seam is approximately 1 ft. 10 ins. thick and the face is some 260 yards in length, with a slight dip. We were informed that 20 men operate on the coal face. The face is cut in the dirt at the bottom and then broken away from the roof by shot firing. The coal, which appeared dry and comparatively clean, was quickly transferred by aid of pick and shovel to an electrically driven shaker conveyor running parallel to the face. The miners worked rapidly considering their cramped position ; they shovelled with back bent and legs squat, and the conveyor appeared well loaded all the time. This face yields about 200 tons per day, and advances at the rate of four feet per day. The shaker conveyor lies between the avenue of props set at the last shift, and runs the full length of the face : actually there are two conveyors working in tandem. At the lower level the coal drops from the shaker on to a belt conveyor driven by an 8 h.p. motor. We thought this conveyor, which runs

* See letter page 418.

at right angles to the face, of particular interest. The conveyor is at present 200 yards long and will increase in length about four feet each day, as the coal face advances, up to 300 yards. The rubber belt passes over steel tubes running on ball bearings, and moves at a good speed, with remarkable smoothness considering its heavy load and the road gradient. This in turn delivers on to a 120 yard belt conveyor and thence to the main haulage road.

It was noteworthy that the coal arrived at the surface in a remarkably short time from its being loaded on the face conveyors, a feat which is made possible by an up-to-date scheme of electrification. After leaving the face we journeyed to another section of the pit and inspected one of our Gate-End Switches controlling a coalcutter and a conveyor. The cutter, of the Anderson Boyes 50 h.p. chain type, was in operation and all were impressed by the way in which the picks cut under the coal seam as the machine hugged the face on its slow journey.

After inspecting drilling operations and also distribution switchgear, at several points, the party returned to the under-manager's office and from there to the shaft bottom, where an explanation of signal and telephone arrangements was given.

On reaching the surface the party concentrated in the Manager's office, and made good use of his bathroom. Then came a very generous lunch kindly provided by the Colliery Company.

During lunch a lively discussion took place, and much valuable information was imparted by Mr. Whittaker and also Mr. Lowe, on all phases of coal mining, and particularly the ethics of mechanisation.

After lunch the surface plant was inspected, including the power house, winding and fan engines, and the screens, which proved most interesting.

To record all we saw would take a long time, but mention must be made of the fine spirit of goodwill that prevails among the workers from the agent to the smallest tub boy. Coal mining is obviously a hazardous occupation, but the cheerfulness of the men make the difficult tasks lighter.

Before we left the colliery an expression of our gratitude was made to Mr. Whittaker and Mr. Lowe. Their collective reply was "Its a pleasure" which gave some indication of kindness shewn to us.

As we journeyed home one felt that a better grasp of the conditions under which mining equipment has to operate had been obtained; and also, that in spite of the advances made possible by electricity, there is still plenty of scope for the electrical engineer's ingenuity.

## THE EFFICIENCY OF PUMP GEARS.

The current (June) issue of *The Metropolitan-Vickers Gazette* contains a long illustrated article describing the extensive land reclamation scheme undertaken by the Egyptian Government, and by which it is expected to add some 2000 square miles to the productively fertile area of the Nile Delta. The Metropolitan-Vickers Electrical Co. Ltd., are sub-contractors for the whole of the electrical generation and transmission system required for serving fifteen pumping stations; the equipment of the pumping stations has jointly been entrusted to the Metropolitan-Vickers Company and to Vickers-Armstrongs Ltd. There is a total number of 68 pumps in the 15 stations, four of which are each of a capacity of 353 cu. ft. per second, 30 of 176.5 cu. ft. per second, and 34 of 88.25 cu. ft. per second. The pumps are of the axial flow propellor type mounted with the spindles at an angle of 45 degrees. All are individually driven, through single reduction double helical gears, by slipring induction motors, all of which except the smallest motor in each station are equipped with brush lifting and short circuiting gear, operated by hand, and interlocked with oil-immersed starters. Owing to the diverse conditions of head and quantity at the several pumping stations a large range of motor powers, varying from 80 h.p. up to 430 h.p. has been necessary: but all motors are wound for 650 volts at 975 r.p.m. and have a gear ratio averaging about 5-1.

The double helical gears, made at the Metropolitan-Vickers works shew exceptionally efficient test figures. These particular pump gears, according to b.h.p. ratings have centres of 14, 20 and 28 inches respectively. Roller bearings are fitted to both pinions and wheel shafts, and, due to the inclination of the units at 45 degrees, the gear wheels are provided with ball thrust races which are fitted at their upper end. The gears are lubricated by a system of forced lubrication, each unit being fitted with a separate rotary pump driven from the lower end of the pinion. The power taken by this pump is included in the test figures quoted here. The tests were made under load by coupling together the low speed couplings of a pair of similar gears and coupling the pinion of one gear to an electric motor and the pinion of the other gear to a generator. The motor and the generator were subjected beforehand to accurate tests for efficiency. For testing the gears the generater output was fed back to the motor, and accurate measurement made of the make-up power fed to the circuit to overcome electrical and gear losses, and thus a combined efficiency was obtained covering the motor and generator with the two sets of gears.

The efficiency of the motor and one gear was found by taking the square root of the combined efficiency and from this result the efficiency of one gear is given by the ratio:—

$$\frac{\text{Efficiency of one gear and motor}}{\text{Efficiency of motor.}}$$

Tests were taken on a number of gears of each size.

The result of one of the tests on the smaller size, 14 inch centres, shew that the efficiency was as high as 98.6% at the full load of 145 h.p. It was not possible to carry the load on the larger gears to the full rating owing to the limitations of the test motor and generator available at the time, but it may be noted that at a load of 225 h.p., or 52% of full load, the gears shewed an efficiency of 98.93%. The general characteristic curve of gear efficiency indicates that this gear at full load would have an efficiency of at least 99.2%.

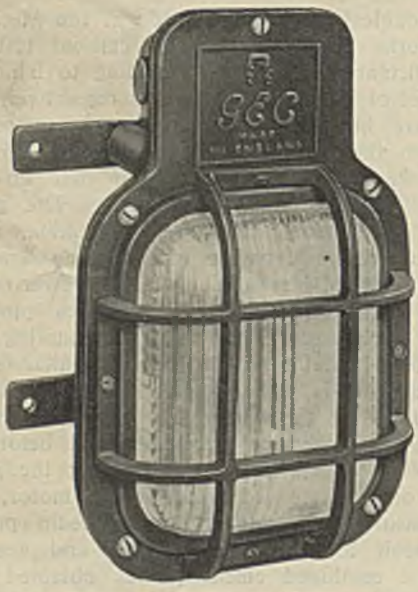
## Electrical Shotfiring Apparatus.

The Secretary for Mines announces that, in pursuance of the Explosives in Coal Mines (Electrical Shotfiring Apparatus) Order, 1932, the Magnet (1932) High Tension Magneto Electric Exploder, submitted for test by The General Electric Co., Limited, and the Helsby (1932) High Tension Magneto Electric Exploder, submitted for test by British Insulated Cables Ltd., have been approved for use in all coal mines to which Part II. of the Explosives in Coal Mines Order of the 1st September, 1913, applies.

# Manufacturers' Specialities.

## New Prismatic Bulkhead Fitting.

The illustration given shews the new type of bulkhead fitting with rectangular prismatic glass which has just been developed by the General Electric Co., Ltd. This fitting is of the substantial design particularly suitable for mining and heavy industrial services under arduous conditions of exposure and risks of mechanical damage. It is suitable for use with 40 or 60 watt Osram



*Prismatic Bulkhead Fitting.*

gasfilled lamps and is available either with or without the malleable iron guards. An important feature is that a wiring chamber is incorporated, tapped with three inlets, and plugs are supplied for use when only one-way entry is desired. The standard tapping of the box is ¾" E.T. for use with screwed conduit, but watertight or armoured cable glands can be supplied as an alternative if desired. Porcelain B.C. or E.S. lampholders are fitted.

## M. & C. Joy Loaders.

Mavor & Coulson Ltd., have recently taken up the manufacture, development and exploitation of the M. & C. Joy Loader. There is probably no work on which so much manual effort is expended as on hand-shovelling. Where large volumes of bulk material are dealt with, it is probable that the cost of hand-shovelling is greater than that of any other industrial operation. Important developments have been made in recent years, but it is obvious that enormous scope remains for progress in this direction.

Coal mining presents a special problem. Great Britain produces annually about 250,000,000 tons of coal, and practically every ton of this immense quantity is hand-shovelled at the coal face, some of it twice, some of it three times. The recent remarkable progress in the use of underground conveyors in the vicinity of the coal face has not materially reduced manual shovelling, because the conveyors and the loading machines at present in use mostly require to be fed by hand shovel.

In the early days of mechanical coalcutting, Mavor & Coulson began to make coalcutters. Later, when coalcutters brought face conveyors, loaders, and gate-road conveyors to deal with the increased output, the new M. & C. conveyor works at East Kilbride were equipped to meet the demand. The time has now come to tackle seriously the mechanical loading into conveyors, so completing mechanically the chain of operations and eliminating as far as possible the laborious process of hand-shovelling.

In the United States, where the coal seams are thick and the mining conditions are favourable, mechanical loading is much practised and mechanical loaders have been developed for the service. The aim of Mavor & Coulson is to avail themselves of this previous experience, and to adapt and develop the loaders for much more difficult conditions, beginning with the thicker and more favourable seams. This must be a gradual process, but the principle of mechanical loading will be applied to a steadily increasing range of the coal seams in this country.

The first step has been to make an arrangement with the Joy Manufacturing Company of Franklin, Pennsylvania, whose loaders load over 60 per cent. of all the coal loaded underground in U.S.A. These loaders embody many ingenious features: they can be applied not only underground, but also for dealing with materials in bulk on the surface.

The arrangement with the Joy Manufacturing Company in no way affects the constitution or structure of either of the two quite independent companies; it is concerned solely with the exchange of facilities and manufacturing information to enable each to produce the other's specialities. Mavor & Coulson have given the Joy Company sole and exclusive rights to their U.S. patents which enable Joy to make and sell M. & C. coalcutters and conveyors in that country; and Joy have given to M. & C. sole and exclusive rights to all their foreign patents, which enable the M. & C. Joy Loaders to be made here for sale throughout the world except in the United States. The existing sales organisations of the two Companies will deal with the new products.

The first half-dozen M. & C. Joy Loaders are approaching completion, some for underground and some for surface service. The gearing and other mechanical parts are made at the Broad Street Works and the structures at the East Kilbride Works which are eminently adapted for the purpose.

## Small Flame-proof Switches and Fuses.

The switches and fuses illustrated herein are made by M. & C. Switchgear Ltd., and will commend themselves as being just what the mining electrican has long looked for. Rated as for 10 amps., 250 volts, the designs are robust and simple, and the prices reasonable. The illustration, Fig. 1, shews a simple switch fitted with armouring glands. The switch, enclosed in the flame-proof case, is of the quick make-and-break tumbler pattern having an ordinary commercial rating of 15 amps. The cover is fully interlocked so that the switch cannot be closed with the cover open nor can the cover be opened except when the switch is in the "off" position. Means are provided for the disengagement of the interlock by an authorised person