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Miners' Welfare Reports.

To study the moods and modes of the industrial population in bulk—the "mass-complex" of the ultra philosopher—is one of the most evasive and fascinating pursuits. Those particularly interested in the subject will be considerably enlightened by a careful perusal of the new reports concerning last year's work of the Miners' Welfare Fund Committees. The volume just published contains the Tenth Report of the Committee Allocating the Fund and the Fifth Report of the Committee which Administers the Scholarship Scheme. The mining population of this country runs into millions and it constitutes such an extremely large proportion of the people that the attitude prevalent in that great group in regard to modern ideas of general welfare can be accepted as representing an important phase of the nation's character.

It is only possible here to dip into the reports and to mention one or two points taken more or less haphazard from the multitude, points which may perhaps prompt the reader to pursue the several themes at length and to study the reports from various interesting angles. In the first five years of the scheme twice as much money from the district funds was allocated for recreation as for health: the second quinquennial figures shew that the demand for the amenities of recreation has fallen by about half-a-million pounds and the call for health schemes has increased by almost as much.

The district allocations for education were doubled during the second period but, even then, the amount so spent represented not more than about one per cent. of the total allocations. Grants for deserving students were strongly advocated by the Committee but the suggestion appears to have received only a half-hearted response. No new form of educational activity was initiated from the district funds. There was, moreover, only a very disappointing reply to the Committee's encouragement towards establishing district schemes for non-vocational lectures. Yet we know that the recent Safety Conferences organised by the Mines Department were remarkably sucessful and that the attendances in all cases were overwhelming and exceeding even the capacities of the largest city halls available. Why this extraordinary difference, between the apathetic neglect of "welfare fund" lectures and the hot enthusiasm of "official" addresses and debates? Must the subject, date and place of meeting, selection of speakers, etc. all be cut and dried ready? The comparison tends to give the impression that whilst the miner is quick to enjoy a spread intellectual feast, he lacks something in the way of initiative or incentive to the preparation of good further fare of this kind. During 1931 the total of allocations from the district funds amounted to over £500,000; of this only about £11,000 was for educational purposes—and that was less by half of the amount allocated in 1930 for education. This money, from the district funds, was spent in the way of special grants to students, lectures, library books, studentships, student societies, safety-first badges, etc.

The buildings and equipment for mining education of universities and technical colleges have drawn some £540,000 from the General Fund during the ten-year period.

Having learnt of the educational facilities provided, the costs involved and the general attitude of mind or re-action of the miners to the golden opportunities extended, it is doubly interesting to read the report of the Scholarships' Committee. The candidates for scholarships are classified as "A," workers in about collieries; and "B," children of such workers. Last year there were 170 "A" and 502 "B" candidates: these were, after careful and thorough investigations reduced by stages until 20 "A" and 33 "B" candidates were selected for personal interview: finally, 6 "A" and 9 "B" were awarded scholarships. The general standard of "A" candidates was not so high as the Committee would have liked; the "B" candidates were of very high quality. It is to be noted that only 34 per cent. of the "A" candidates had been to secondary schools, whereas 67 per cent. of the "B" candidates had attended secondary schools. Of the "A" candidates only 32 proposed to remain in the mining industry as managers, engineers, officials or inspectors—but 67 of them aspired to the teaching profession. No less than 328 of the "B" candidates were would-be teachers! Of the remainder, one each proposed to become mine manager, mining engineer and inspector of mines! The report contains a list of the twenty scholars who have completed their scholarships. Of the eleven "A" scholars only one would appear to be engaged in mining work: he has been appointed research worker by the Safety Mines Research Board. Of the "B" scholars all, without exception, are apparently engaged as teachers, or will be.

We see the Welfare Fund spent to the extent of hundreds of thousands to create greater facilities for education in mining science and technology, and for the provision of scholarships. The curious position, up to the present, is that the candidates for the scholarships have no use for, or apparently are declining to make use of, the special mining educational means now provided so lavishly by university and college.

The report of the Scholarships Committee concludes with a note of regret that from 800,000 miners at work and many others unemployed, only so very few should offer themselves as candidates for scholarships. It is pointed out that there are now very wide educational facilities in every coalfield, that personal equipment for higher posts or other occupations is most obviously of great value, and only about one hundred men come forward for these scholarships. The Committee state "We are unable to suggest any explanation, but we feel the matter is one worthy of further consideration among those responsible for the provisions of further education in the mining districts."

Of the "A" candidates (all men engaged in mining) last year, 32 wished to remain in mining and 67 wished to be teachers: of the scholarships completed since the inception of the scheme, only one scholar is engaged in mining work, all the others are teachers or the equivalent. These figures may contain the germ of one possible explanation.

Regulations for Mines Lighting.

The General Secretary of the National Association of Colliery Managers has issued for publication a letter intimating that, as a result of a joint interview of the N.A.C.M. and the Mining Association with the Secretary for Mines, the latter has undertaken to suspend for at least twelve months the consideration as to issuing Regulations concerning Mines Lighting. The position will then be reviewed. This undertaking was given on the express agreed understanding that colliery managers and engineers would, in the meantime, energetically press forward better lighting in mines throughout the whole mining industry.

The contention is that progress in this direction is more likely to be hindered than helped by hurried legislation. There are so many promising systems and ideas ripe for trial and yet unproved that the free and untrammelled co-operation of mines' managers, engineers, manufacturers and the inspectorate is highly desirable to ensure quick progress on the right lines. Electrical men will welcome the concession of the Secretary for Mines and will observe his stipulation to move forward energetically and to good purpose during the twelve months' respite.

A.M.E.E. Council Meeting.

A meeting of the General Council of the Association of Mining Electrical Engineers will be held on Saturday, February 27th, 1932, at the Queen's Hotel, Birmingham. The usual matters of finance, progress of branches, examinations, awards for papers read, publications, etc. will be dealt with. The Council will also receive reports concerning the repair of trailing cables, underground and surface lighting for mines, and other special subjects upon which various committees have been engaged. Nominations for the offices of President, Vice-Presidents and Treasurer of the Association for the Session 1932-33 will be received and attention given to the general arrangements for the next General Council Meeting and Annual General Meeting due to be held this year in Scotland.

NEW BOOKS.

H.M. STATIONERY OFFICE.

The following, printed and published by His Majesty's Stationery Office, can be purchased through any bookseller or directly from H.M. Stationery Office at the following addresses: Adastral House, Kingsway, London, W.C. 2; York Street, Manchester; 1 St. Andrew's Crescent, Cardiff; 120 George Street, Edinburgh; or 15 Donegall Square, W., Belfast.

Mines Department.—MINERS' WELFARE FUND, Tenth Report of the Committee for the Allocation of the Fund; and Fifth Report of the Selection Committee for the Administration of the Miners' Welfare National Scholarship Scheme, 1931. Price 1s. 6d. nett.

Mines Department.—LIST OF MINES in Great Britain and the Isle of Man. Prepared by H.M. Inspectors of Mines. Price 10s. nett.

The List includes sections as follows:

(1) Divisional Lists (a) of Mines under the Coal Mines Act, and (b) of Mines under the Metalliferous Mines Regulation Acts, arranged according to the name of owner, and giving the name and postal address of the owner, the name and situation of the mine, the names of manager and under-manager, number employed minerals worked, etc.

(2) A General Index of all Mines.

(3) An Index of all Owners of Mines.

(4) A separate Index of all Mines producing minerals other than coal, arranged according to the mineral obtained.

(5) A County Index which precedes the Divisional Index.

MINING EXAMINATION PAPERS.—Board for Mining Examinations, Certificates of Competency (First and Second Class) and Surveyors' Certificates—Papers set 25th and 26th November, 1931. Price 1s. 6d. nett.

Mines Department.—OUTPUT AND EMPLOYMENT AT METALLIFEROUS MINES, QUARRIES, etc. during the Quarter ended 30th September, 1931. Price 4d. nett.

Mines Department.—THE EXPLOSIVES IN COAL MINES ORDER of 21st December, 1931. Price 2d. nett.

This Order adds to the List of Permitted Explosives to be used in certain classes of mines the following explosives: (a) "Fortex," manufactured by Explosives and Chemical Products Limited; (b) "Nitro-Baelenite No. 3," manufactured by Poudreries Reunies de Belgique S.A. The Order also removes from the Permitted List certain explosives which are no longer manufactured or used.

CONVERTING A BUSINESS INTO A PRIVATE COMPANY by Herbert W. Jordan. London: Jordan & Sons, Ltd., Chancery Lane, W.C. 2.—Price 1s. 6d. nett.

This is the Tenth Edition of a little Book which for about twenty years has been a popular guide to people owning private businesses. The subject is treated in a simple and concise manner; easy to follow and dependable in character.

PITMAN'S ELECTRICAL EDUCATOR, edited by Sir Ambrose Fleming, M.A., D.Sc., F.R.S. Three volumes, Second Edition. London: Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, W.C. 2. Price 72s. nett.

THE BLUE BOOK: The Electrical Trades Directory and Handbook of the Electrical Engineering and Allied Trades, 1932. Fiftieth Edition. London: Ernest Benn Ltd., Bouverie House, Fleet Street, E.C. 4. Price 25s. nett.

Proceedings of the Association of Mining Electrical Engineers.

SOUTH WALES BRANCH.

Ⓟ Fault Protection.

JOSEPH JONES.

(*Paper read* 18*th April*, 1931.)

The meaning of the term "Protective Gear" is well understood by those who are intimately concerned with the generation, transmission, and utilisation of electrical power. This paper is not intended to deal generally with every type of protective device; but to centre upon the principles of a number which have been tested under practical working conditions. Electrical Energy has become such an essential factor in the life and prosperity of the mining industry, that a very heavy responsibility rests upon the electrical engineer to maintain the supply under all conditions. This becomes ever more difficult with the amalgamation of groups of collieries and the growth in size of generating plant, because of the larger short circuit currents possible, and the continual extension of the system. A failure of insulation at any point on such large systems may cause widespread disturbance and dislocation of supply, unless the faulty unit is rapidly isolated. This can only be achieved by a carefully considered lay-out of the network, and the correct choice and application of the protective gear. Its main, and probably its only, disadvantage is that of expense, an argument occasionally urged against its adoption.

It is true that when protective gear is added to an existing system, additional expense has to be faced; but this point of view does not take into account the entries that ought to be placed on the other side of the balance sheet. If both sides of the question are considered, it will be realised that, so far from the adoption of this apparatus being a source of expense, it is actually a means of securing economy. If it resulted in no other gain, the cost might at least be regarded as a very effective form of insurance, since it decreases almost to vanishing point the chances of destruction of the piece of equipment to which it is applied; but it introduces more direct economies than this. In particular, the ring main principle can be used to a very much greater extent than is justifiable without fault protection, so that the whole capital expended in copper is being utilised. What is known as the "chessboard" system of distribution has come into use in some parts of the world, and its possibility is due to the important services of protective apparatus in preventing a local disturbance from becoming general. Before dealing with the gear that is to clear faults, it is important to consider briefly the actual nature of faults. Broadly speaking, they fall into two categories, viz., local faults, i.e., those in the apparatus being protected and, secondly, through faults consisting of a heavy overload due to a breakdown in another part of the system, which should pass through the particular section in question without operating the breaker. Now it is the first requirement of an efficient protective gear that it shall be unaffected by through faults. In other words, the apparatus must possess stability.

The manner in which a fault actually occurs and develops is also of great importance in determining the requirements of protective apparatus. If mechanical faults are excluded, viz., those that are caused by some such means as a blow from a pick-axe, they can be said to be of slow growth, taking a number of days or weeks to develop. For example, a fault in the winding of an electrical machine would in a large number of cases begin as an air film in the slot insulation; such a film, occurring in the body of insulation of greater dielectric strength, will break down at a very much lower voltage than the rest of the insulation, and will do so by sparking slowly from face to face of the film. Nitric acid is produced as a result and begins to attack the insulation chemically. After a period, frequently of considerable duration, sufficient current passes through the weak point to develop a small amount of heat, which adds its effect to the deteriorating influences. Overheating and charring follows, and since the power increases with the square of the current, the growth of the leak develops with increasing rapidity until in the end it ultimately rises to a short circuit. In the case of an unprotected turbo-alternator of say 5000 k.v.a., which incorporates a blower for cooling purposes, only a short time is required after actual ignition has occurred for the whole of the insulation in the rotor and stator to be destroyed, leaving the metallic parts unapproachable for several hours.

The above illustration is one that has been experienced in the past, and it indicates vividly the need for protective gear in connection with this type of plant; for a disaster that is all over in so short a time, cannot be saved by any form of manual switching. Much the same argument applies to faults in both transformers and feeders. In the former, faults nearly always occur first as leaks between adjacent turns, and as such they do not cause a sufficient loss in voltage to produce much disturbance in the external circuit. If a type of protection is employed which requires a considerable change in the current passing into the apparatus, the fault will have to go on burning the insulation and doing damage until the evil is sufficiently widespread to be appreciable. With feeders also, the fault generally is of slow growth, and is frequently, as a matter of fact, perceived by the detectors, quite a long time before it reaches serious proportions. It will therefore be seen from these illustrations that the protective gear will be most efficient, and will endow the equipment with the greatest reliability, when its sensitiveness is of the highest possible order. Thus, in addition to being staple, the apparatus must be sensitive.

These two requirements at first sight appear to conflict with each other, and they would actually do so if an ordinary relay were used, consisting of a simple solenoid lifting a plunger or armature, and so releasing the trip mechanism or causing the trip contacts to come together, for the first consideration demands that the relay shall not be operated for an out-of-balance current under overload conditions, while the second requires that the relay shall be operated for as small a current as possible out of balance under fault conditions. With

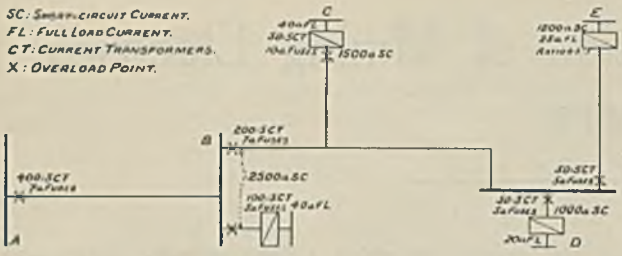


Fig. 1.

such a relay it is necessary that the sensitiveness shall be made of such an order that no possible unbalancing at any degree of overload is likely to cause tripping; and with certain feeder protective schemes this condition entails a fault setting of as high as two or three times normal.

In the case of Overload Protection, the operation of which is generally well-known, unless the trip coils remain inoperative on feeders and transformers until the fault current reaches say 200% to 250% of the normal full load value, the protective apparatus will not remain staple. Such protection does not reach a high order of efficiency. In fact plant has been burnt out in the past, by faults which were unable to cause tripping with only overload protection fitted.

For feeder protection, overloads in series are best cut down to a minimum. It is not always an easy matter to arrange the settings of several overloads in series, with a view to obtaining discrimination, especially when different types of time limit devices are used. Some idea of the short circuit current liable to occur on any particular circuit should be known before any degree of satisfactory operation can be obtained, even when tapered time-limit fuses or graded mechanical time-limits are used.

Fig. 1 is an example of such settings, from which it will be seen that a short circuit on the terminals of the transformer at C or D would operate the overload gear of these transformers quick enough to prevent any of the other switches tripping. This is also the case if a short circuit on the terminals of the transformer at B occurred. The transformer switches are set at anything from 2 to 2½ times full load, but the feeder switches are set high enough to hold in for an

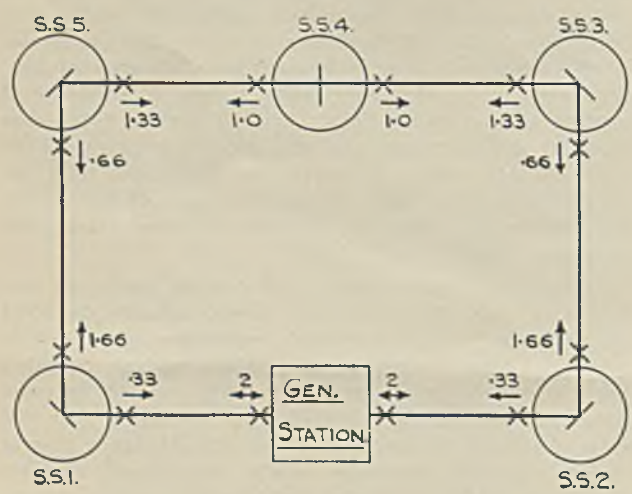


Fig. 2.

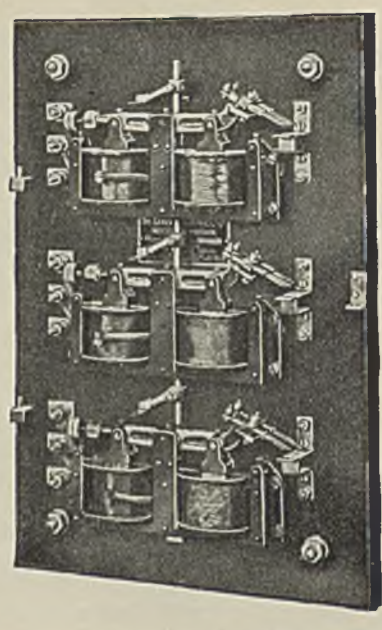


Fig. 3.—*Standard Beam Relay, with cover removed.*

appreciable time on the occurrence of short circuits covered by the transformer overload gear.

Such a scheme comes very far from satisfying the condition as to sensitiveness. Fig. 2 shews the graded relay protection applied to a Ring Main System. The two requirements, stability and sensitiveness, can, however, be made compatible if what is known as a biassed scheme be adopted. This may be realised when the problem is restated as amounting to the securing of a low setting at light and normal loadings and a proportionately high setting for heavy overloads. If, therefore, a relay can be employed which increases its fault setting automatically as the load rises, the required conditions will be fulfilled.

An illustration is given in Fig. 3 of a biassed beam relay, which will assist in the understanding of the subject. In this, there is not only an operating coil, which tends to pull the contacts together, but there is a restraining coil at the opposite end of the beam, through which a current proportional to the load constantly passes. Since the latter controls the operation of the relay, the sensitiveness of this device will be seen to decrease literally with the magnitude of the load flowing in the apparatus.

The value of this provision will be made clear when the cause of instability is considered. All balanced a.c.

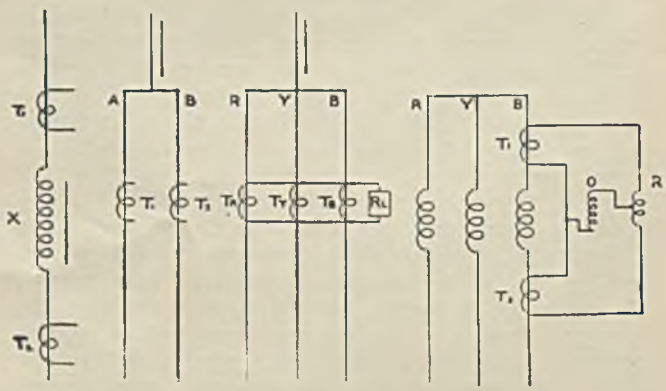


Fig. 4.—*Various Types of Fault Protection.*

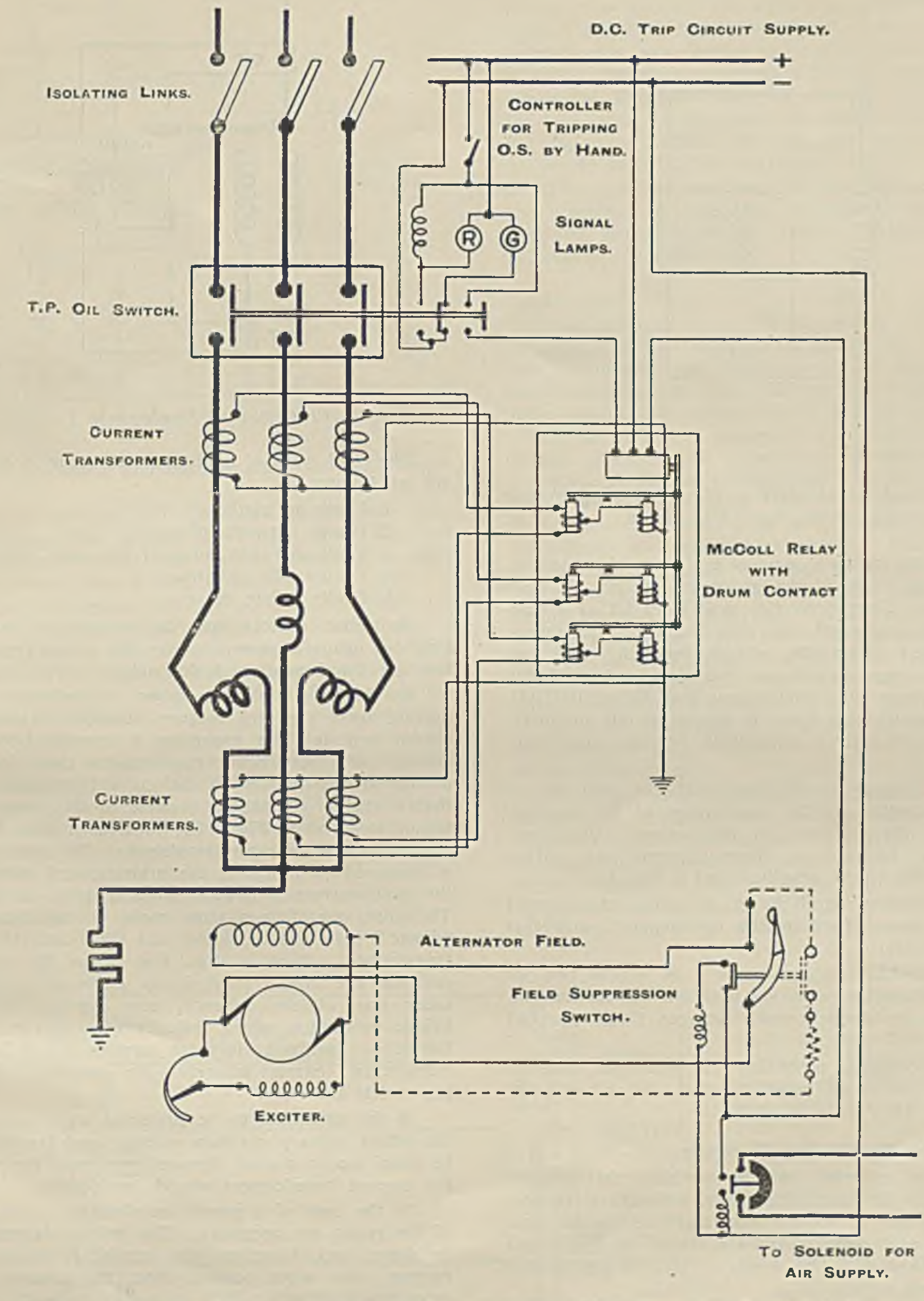


Fig. 5.—Typical Diagram shewing complete arrangement of Alternator Protective Equipment. The "discharge" circuit indicated by dotted lines is not ordinarily required, as complete open-circuiting of the field, affording the most rapid suppression, is quite safe.

protective schemes depend upon current transformers for the secondary currents that operate the relays, these being connected in various selected points of the network and drawing off currents proportional to those flowing in the primaries; the secondary currents being then compared by means of relays. Now, it is an easy matter to design current transformers to give an exact balance at normal loads. When, however, large overloads occur, sufficient to saturate the cores of the current transformers, the ratios of the latter are apt to become unequal, and to pass a "difference" current through the relays exactly as though a fault were present in the equipment. This unstability may be countered without in any way sacrificing the sensitiveness of the protection, by the biassing method, which has proved a valuable attribute to a protective scheme.

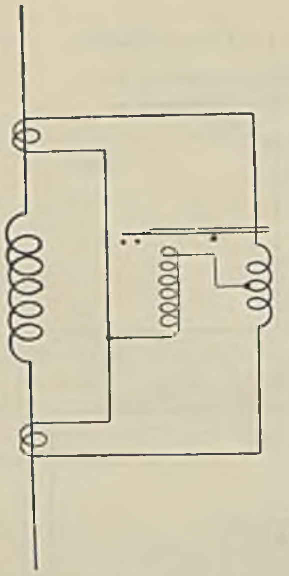


Fig. 6.—Alternator equipped with Biassed Beam Pretective Relay. One phase only shewn.

Before dealing with some of the types of protection, the mechanical side of the apparatus deserves a brief consideration. Since protective gear is to act as a safeguard to the equipment, and thus to increase reliability, it must itself attain the utmost reliability that can possibly be secured, and not introduce any weakness which may prove more troublesome than the actual fault. The design must, therefore, be robust, simple in operation, and all possibilities of fracture, bending, or sticking obviated.

It has already been stated that the principle of balanced protection is the comparison of the currents flowing in different parts of the system. Such comparisons may be made in three different ways giving rise to the following types illustrated in Fig. 4.

(1) End-balance protection ; in which the current entering a piece of equipment is compared with that emerging from it.

(2) Parallel-balance protection ; in which two or more exactly similar paths are provided for the current, and this should divide equally between them when all is in order.

(3) Phase-balance protection ; in which the currents in the three phases are added together, the sum amounting to zero when there is no fault.

Generator and Transformer Protection.

The most important rotating machines that demand protection are the main alternators, although it is now standard practice to provide generators with some form of balanced protection, whereby a faulty machine is cut off the busbars with the minimum risk of disturbance to the normal supply.

A peculiarity of generator faults must also be recognised, namely, that these machines produce their own power, and that a leak, therefore, is not cut off by merely opening the circuit breaker. Thus generator protective gear for a turbo alternator must provide for the instant killing of the excitation, the closing of the ventilating doors, and also when desired, the tripping of the emergency stop-valve.

Fig. 5 illustrates a Biassed Beam Relay Scheme, the method of operation of which can be followed from Fig. 6, which shews the complete connections for one phase.

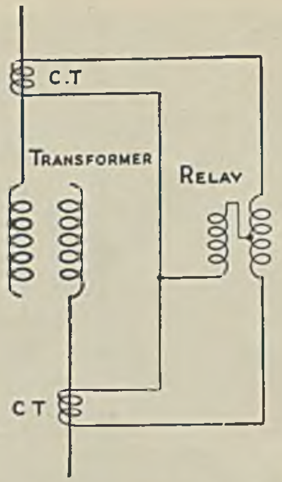


Fig. 7.—Protection of Single-phase Transformer.

The chief types of faults that can occur in generators are as follows :—

1. Faults to earth.
2. Faults between phases.
3. Faults between turns of the same phase.
4. Failure of Excitation.
5. Faulty prime mover.

Protective devices may be included to cover the five, but many engineers prefer the protective gear to function for insulation faults only.

By far the greater number of protective devices operate upon the end balance principle, in which the current entering the apparatus is compared with that coming out, these being equal unless there is a fault of any description, when the current entering exceeds that emerging. A simple example of this form of protection is shewn in Fig. 7 in which the method is shewn applied to a single-phase transformer. The upper winding is supposed to represent the primary, and consequently the main current is flowing downwards in the diagram. The upper transformer then would be the incoming or "home" unit, and the lower one the "distant" current transformer. It is evident that when the secondary currents are equal, they simply circulate through the outer ring of the network, none passing across the bridge connection which includes the operating coil of the relay. Inequality in these currents would lead to a "difference" current traversing the operating coil, tending to trip the relay.

If the apparatus to be protected were a generator, the actual primary currents entering and leaving would be equal under normal circumstances, and the ratios of the current transformers would be identical.

In the case of a power transformer, a modification of the ratios are necessary. The voltage is stepped up or down, and, therefore, the current is varied in the reverse ratio when passing from the primary to the secondary terminals. This inequality is easily compensated for by designing the current transformer ratios to counteract exactly the current ratio of the power transformer, also allowing for loss in the transformer itself. If the restraining coil in the main secondary ring be omitted, the relay has the same sensitiveness at all loads, and would suffer from instability as previously mentioned. But, if a beam relay is used, with operating and restraining coils as shewn surrounding opposite plungers. The operating coil having ten times the number of turns of the restraining coil, it will easily be seen that the pulls on either side of the beam will balance when the leak is equal to one-tenth of the load

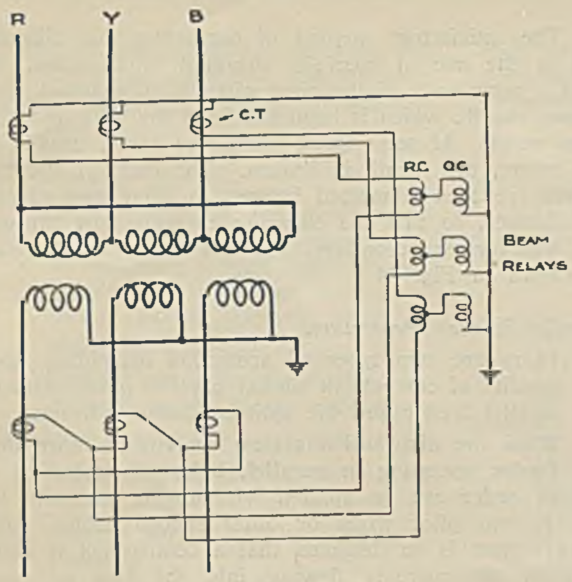


Fig. 8.—Protection of Star Delta or Delta/Star Transformer.

passing. A 10% leak will, therefore, balance the relay, and a very slight increase over and above the 10% will cause the relay to trip. In this manner the setting of this form of biassed relay is fixed.

With transformers there is no need for protection against reverse currents as with generators, and a directional relay is therefore not required. But if, owing to a very severe fault, the current in an outgoing lead reverses, the whole secondary current from the transformers at both ends is diverted into the operating coil, producing very forcible and rapid tripping of the switches. Since the great majority of transformer faults begin as leaks between adjacent turns of the same phase, thus bringing about only a small unbalance. It is an essential feature that the protection should have a low fault setting. The transformer being but little damaged, can quickly be put into commission again. If, however, the fault has to keep on burning until a heavy out-of-balance is effected, before an insensitive relay is tripped, then it is very likely that one phase of the transformer may require complete rewinding. Most polyphase transformers or groups are differently connected at the primary and secondary terminals, star/delta and delta/star arrangements being by far the most common. The effect of these differences is corrected both in phase and magnitude by interconnecting the current transformers at the two ends in the converse manner, and adjusting the ratio to maintain the standard current of about 5 amperes in the pilot ring circuits (Fig. 8).

Time element fuses may be connected in nearly all the protective schemes, thus adding inverse time-limit-overload protection to the existing instantaneous fault protection when desired.

Feeder Protection.

The adequate protection of feeders comes next in importance to the protection of generators ; feeders convey the power from the generator to the sub-stations and consumers, and whilst the complete failure of one of them would not cause such a general shut-down as would the failure of a generator, it would, nevertheless, cut off a number of consumers. By installing suitable protective devices on a feeder, faults cannot be prevented, but, when they do occur, their effect can be minimised by immediate isolation of the faulty feeder, thus localising the damage and reducing the shock to the system.

In many respects adequate protection of feeders represents greater difficulties than the protection of individual pieces of apparatus. Whatever form of protection is used for single pieces of equipment, the relay circuits and pilot wires are all short, and accidental tripping due to capacity currents or to faults on the pilot wires themselves is most unlikely. Feeder protection on the other hand, calls for very careful consideration of the constants and construction of the pilot wires and all associated gear.

In many cases feeder networks, instead of receiving, as formerly a supply from a single point, have now a number of feeding points, and as a result the direction in which fault currents may flow in certain of the feeders depends upon the position of the fault on the network. The increasing complexity of feeder networks also introduces new difficulties into the forecasting of the distribution of fault currents, and very careful computations are necessary in many cases. The protection of a number of feeder networks operates on the Merz-Price principle. Fundamentally, this system of protection compares the current entering a feeder with the current leaving it. Under fault conditions the two currents will not be identical, and the difference is used to operate relays, which, in turn trip out the faulty sections at the points of entry and exit.

In practice, current transformers are connected in each end of the feeder (Fig. 9). The secondary windings of the current transformers are connected together by means of pilot cables in such a way that the E.M.F.'s generated oppose each other. If the feeder is in a healthy condition, the E.M.F.'s generated in the secondaries at each end of the feeder will be equal, and no

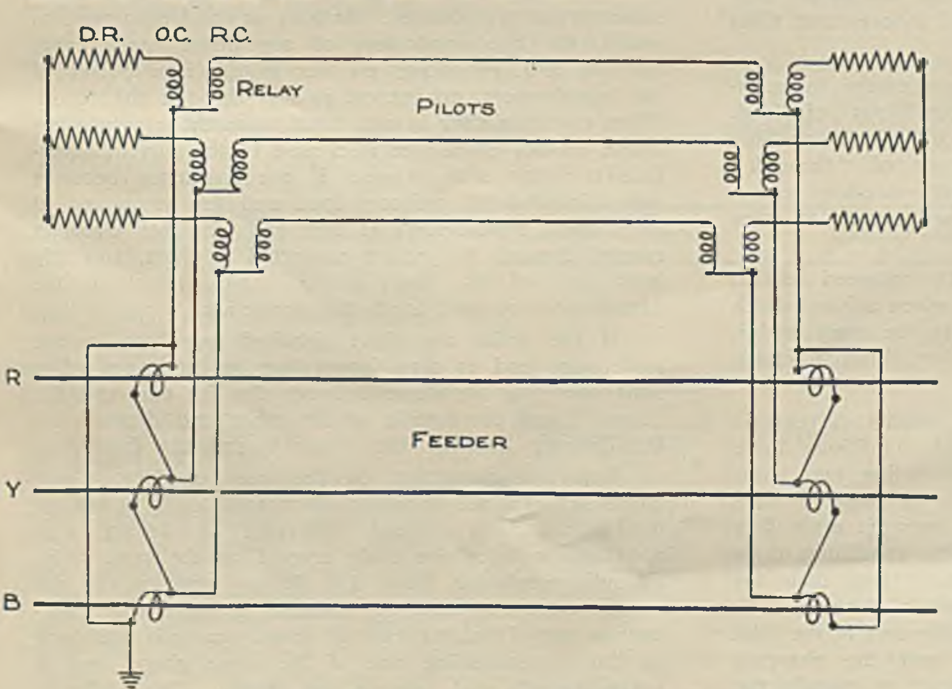


Fig. 9.—Delta-connected Protective Scheme, earthed at one end only.

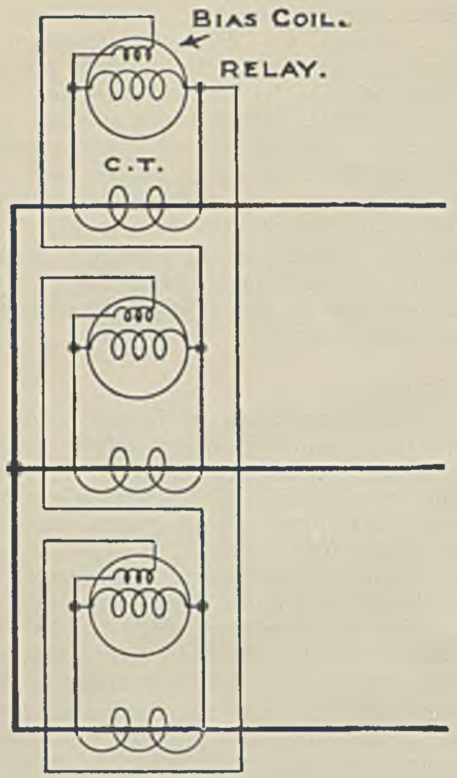


Fig. 10.—*Protection of Parallel Interconnectors (Auxiliary Contacts omitted).*

current will flow through the pilot wires. Relays are connected in series with the secondaries at each end of the feeder. Under fault conditions, the opposing E.M.F's. do not balance, and the resulting current operates the relays, which by means of the circuit breakers, trip out the faulty section.

Unfortunately, in practice, this system possesses several defects. They have all been attacked in different ways, but almost every solution of one problem introduces other difficulties. The defects of Merz-Price protection and the various methods used to overcome them may be summarised as follows :—

(1) Failure of the pairs of transformers to maintain perfect balance under all conditions of load. Incorrect balancing at large overloads is a possible cause for incorrect tripping at times of "through" faults. On such occasions, a perfectly healthy feeder, called upon to supply a heavy overload current to some other faulty section may be tripped.

To eliminate this defect, carefully balanced current transformers are used, and the relay given a bias, which varies in proportion to the current in the main feeder, thus giving stability on overloads or through faults. This is illustrated in Fig. 10.

(2) Unjustified tripping, due to capacity currents in the pilot cables. Under all normal conditions there exists a difference of potential between the two wires of the pilot cable. The intercapacity of these is often of a large order, and the charging currents must flow through the relay coils. Under healthy conditions these charging currents will be considerably less than the settings of the relays, but, with heavy through fault current in the feeders, the potential difference in the pilot wires will rise very considerably and the charging currents may then be sufficiently large to operate the relays.

The satisfactory method of combating this difficulty lies in the use of specially sheathed pilot cables. In such a cable each of the pilot wires is surrounded by a copper sheath, which is insulated from the wire and also from earth. At some point along the cable, usually in the centre, the sheath is broken. The ends of the two halves are then connected between a relay and current transformer, so that the charging currents flow through the transformer secondary, but not through the relay, as shewn in Fig. 14.

Parallel-Balance Protection.

There are two types of protection depending upon the equality of currents in similar parallel paths, namely, the parallel feeder and the split conductor schemes.

When the distribution system consists of more than one feeder operating in parallel, balanced protection of a high order can be applied without the necessity for end to end pilot wires or other special cables. The relay system is so designed that a comparison is made between the currents flowing into the two or more paths. Since the normal distribution between the several paths is upset by the existence of a fault, an easy and certain method is offered for tripping out the faulty feeder. So great are the claims of parallel feeder schemes of protection that it is nearly always adopted when lines are run in multiple, except in the unusual cases where reactors or special switches are introduced between divided busbars at either end. With certain modifications this system may be used for the protection of parallel interconnectors. The three main principles of the system are that it is (1) balanced, (2) biassed, and (3) selective.

Split Conductor Protection.

The split conductor protection has been favoured by many engineers because of its simplicity and easy application for the protection of Ring Mains, etc. It is losing that favour on higher voltages, above 20,000 volts, due to costly cable construction and switchgear. With this form of balanced protection no pilots are required. The feeders have two identical conductors per phase which are connected to two primaries oppositely wound on the same current transformer. As long as the feeder remains sound, the two conductors of any phase carry equal currents and, producing no flux in the iron circuit of the transformers, no current is sent through the relays. When one conductor breaks down to earth or to another phase, an out of balance is created in the current transformers ; this also happens if one conductor becomes open circuited on ordinary load and the secondary of the current transformers at each end will then circulate current through the relays connected to them, and trip both ends of the faulty section. Fig. 11 shews the arrangement of split conductor protection.

If the splits are short circuited anywhere in the route, one end is then inoperative in the event of a fault occurring anywhere between the far end and the "short" and the setting at the other end depends on the distance between the "short" and the fault.

Imperfect connection on the main conductors will create sufficient out of balance on normal loads to operate the gear. Fault current traversing a catenary wire carrying the telephone cable erected on the same poles as split conductor lines will induce pressure in the nearest conductor and this induced pressure will circulate an out of balance current down one split and back on the corresponding one of the same phase, and if heavy enough will operate the relays. This difficulty is overcome by transposing the catenary or the line.

The leading differences between the balanced voltage protection and the split conductor protection may be summarised as follows:

Split Conductor System.

1. Is very sensitive. If desired, as low a setting as 25 amperes can be obtained, though operating engineers usually prefer the higher setting on 50 amperes, which is about the standard.
2. Remains stable for straight through currents up to 30,000 amperes.
3. Does not require pilot wires.
4. Requires special cables, limiting its use on higher voltage systems.
5. Requires special switches with split contacts.
6. Costs approximately 15% extra, as compared with plain overload protection.

Balanced Voltage System.

1. Is not so sensitive. The standard setting for a feeder 6 miles long is 200 amperes. This figure varies up or down, according to the length of feeder.
2. Requires pilot wires.
3. Does not require special switches.
4. Does not require special cables.
5. Costs approximately 22% extra with ordinary pilot cables up to 40% with specially sheathed cables, as compared with plain overload protection.

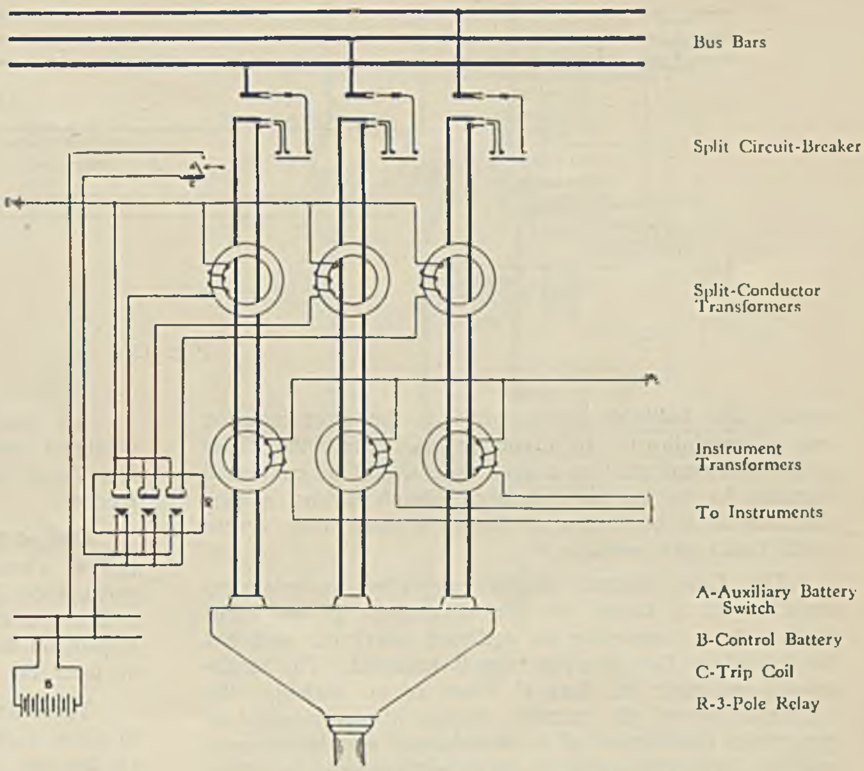


Fig. 11.

Several systems have recently been developed which do not possess in practice any of the disadvantages of of instability as experienced by the balanced systems of protection described. It would necessitate a separate paper to deal with each in detail, so only the principles of three are dealt with.

The Translay System.

This system is an important advance, and it has proved itself to be thoroughly reliable for difficult conditions under which other systems have failed. Fig. 12 illustrates the principles of operation of a Translay relay in the case of a single-phase feeder, which provides complete protection against both phase and earth faults.

The Split Pilot System.

In an eminently simple way, this system achieved both the stability and sensitivity so essential on modern power systems. The important parts, together with the method of connection are shewn in Fig. 13, as applied for giving protection to a plain link between two points, when only one set of transformers, is required at each end of the link.

The Two Core Pilot Voltage Balance with Diverter Relay.

This gives complete fault protection with very low settings, and stability with straight through currents up to 10,000 amps. without the use of compensated pilots.

Such an arrangement gives combined M.P. Self-Balance and Leakage Balance protection to Power Transformer line. The relays, which are connected in the secondary circuits are of special construction and are inoperative within the limits of normal commercial balance.

Earth Leakage Protection.

This form of protection is usually associated with overload protection, and is used to obtain sensitive

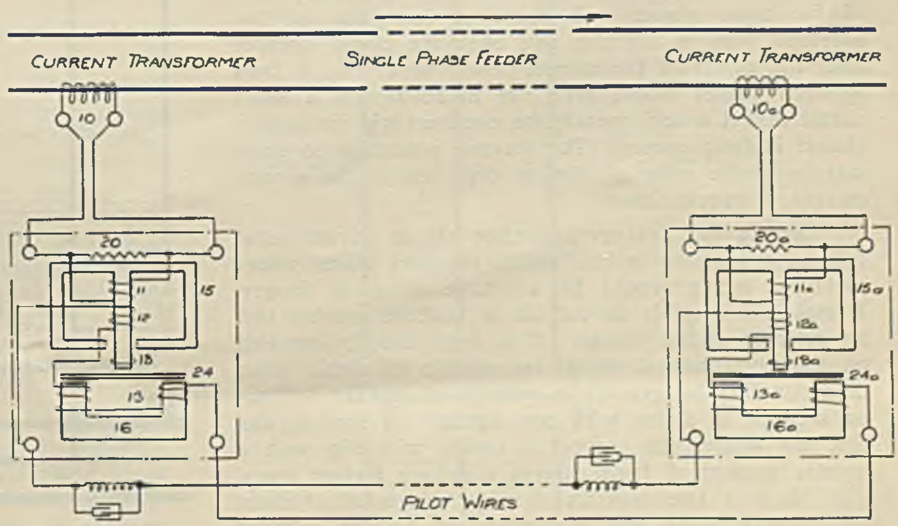


Fig. 12.

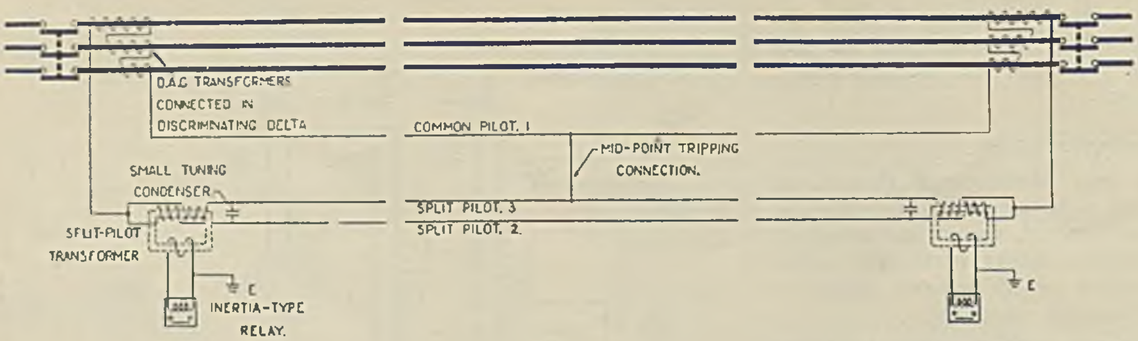


Fig. 13.

settings for faults to earth, which is the most common type of breakdown. In mining practice where the whole of the electrical gear on a given site would be connected together by an earthing strip or sheath having a conductivity of at least 50% of the main conductors, severe earth faults are possible.

The Core Balance System provides instantaneous isolation of a circuit on the occurrence of an earth fault. It is inoperative on ordinary overloads and has the advantage that no pilot wire is required. The fundamental principle is, that if there is no leakage, the algebraic sum of the currents flowing at any moment in the three conductors of a three-phase system is zero, and no current flows in the trip coil or relay winding. This condition is disturbed as soon as there is leakage to earth on one of the phases, and the circuit breaker is tripped, provided the leakage exceeds a predetermined amount. The core balance leakage transformer has a single core, wound with three primaries in series with one phase of a feeder, and one secondary winding connected to either a trip coil direct, as in Fig. 15, or to a relay, the operation of which completes the trip coil circuit as in Fig. 16. When this arrangement is used it is possible to arrange for tripping with leakage currents varying from 5% to 100% of the full load rating of the core balance transformer. There is another scheme in which three separate wound transformers are used instead of the core balance transformer, their secondary windings being connected in parallel. This arrangement is shewn in Fig. 17, in which the position of the relay in parallel with the three secondaries is indicated; also two overload trip coils, shunted by fuses to give them an inverse time element characteristic, and finally the leakage trip coil. An overload in any one of the three phases will cause at least one of the overload trips to function and open the circuit breaker after the expiry of the correct period of delay. A fault between phases would give rise to so violent a short circuit that it would operate the overload trip mechanism almost instantaneously. The leakage protection to earth may be of the order of 10% or even less of the normal current in special cases.

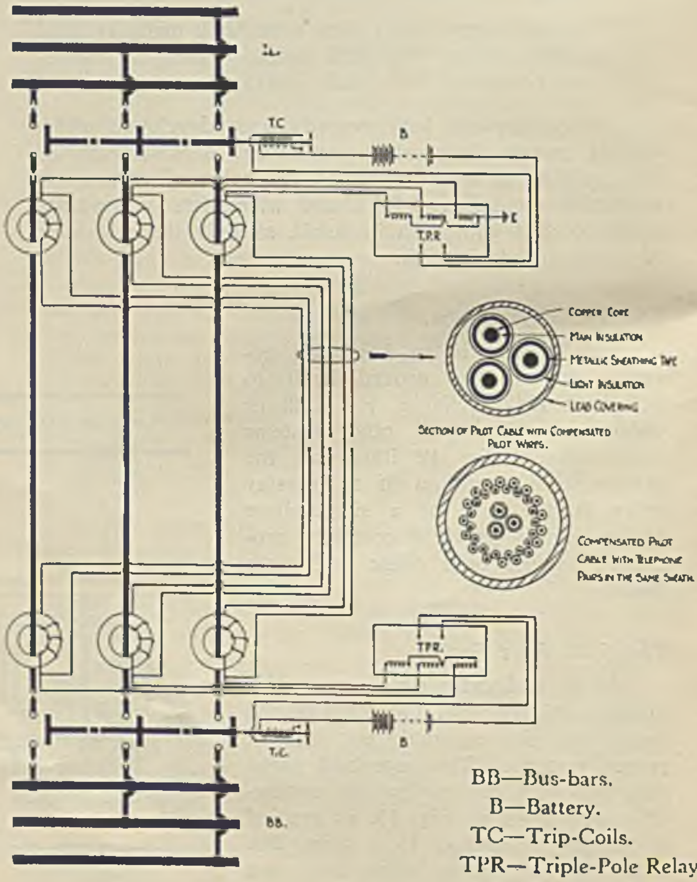
Core balance leakage protection has an advantageous field of application in coal mines, or other places where sustained arcing would be a source of great danger. It makes it possible to cut out a fault so quickly that no external arcing occurs. It is most usually installed on tail end feeders, but it is possible to obtain some discrimination by grading a number of leakage settings on sections in series with one another, in such a way that one nearer the source of supply will trip with a greater amount of fault current than one further away. Fig. 18 is a line diagram shewing suggested gradings for colliery work and particulars of leakage settings with core balance leakage protection.

All shaft and inbye feeders should certainly be equipped with earth leakage protection, and reactors introduced to limit the short circuit k.v.a. in each pit feeder.

One of the objections to an Insulated Neutral System is that when a fault takes place between one phase and earth, there is usually insufficient fault current to operate ordinary overcurrent relays, and therefore the earth must remain on the system until cleared by manual switching, or until the fault develops into a fault between phases.

There are two distinct reasons why it is undesirable to allow earth faults to remain on a shaft supply system, (a) because an "arcing earth" can cause a considerable voltage rise on the healthy phases; (b) because an arc can also cause unnecessary damage by burning.

With the core balance system the neutral point is of necessity earthed, or the protection system would not act.



BB—Bus-bars.
B—Battery.
TC—Trip-Coils.
TPR—Triple-Pole Relay
E—Earth.

Fig. 14.

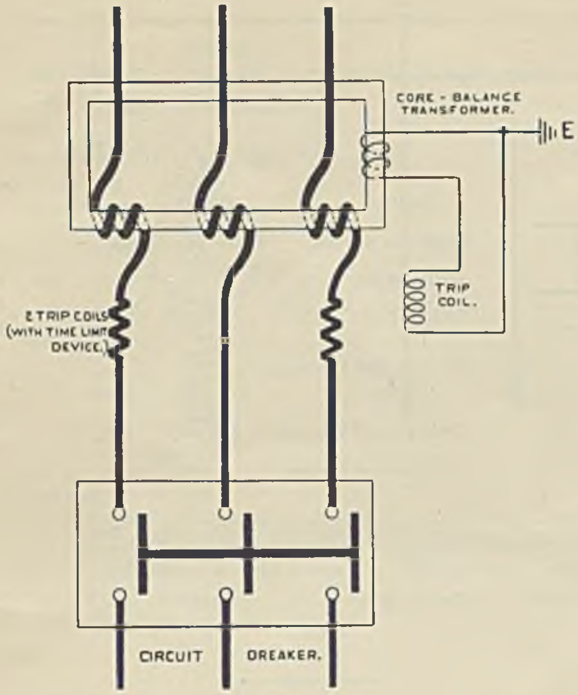


Fig. 15.

D.C. Feeder Leakage Protection.

In a thoroughly sound 2-wire d.c. system the currents in the positive and negative lines of a feeder are equal ; but should a fault to earth occur on one pole, and a return circuit be available for the fault current, the balance is disturbed.

With the core balance system, the unbalanced currents in the faulty feeder operate a differential relay that causes the feeder circuit breaker to open and to isolate the faulty section. This system is fully illustrated in Figs. 19 and 20, the operation of which can be followed by referring to Fig. 20.

So long as the distributing system is healthy no current flows to earth, but a steady current of approximately half an ampere passes through the economy resistance a, b, c. This is designed to have a value of approximately 2 ohms per volt so that on a 500 volt circuit it has a total resistance of 1000 ohms and dissipates only 250 watts.

To restore the protective gear to its normal state in readiness to clear another fault, it is only necessary to press the push button. The differential relay installed on each feeder has two windings energised from shunts in opposite poles of the feeder to be protected. The two windings are connected to be magnetically opposed, so that when carrying equal currents they produce no resultant magnetic effect on the armature. If the currents in the two coils differ by as much as 15% of normal full load the relay operates to close its tripping circuit ; opens the circuit breaker and instantly isolates the fault.

SUMMARY AND CONCLUSION.

Electrical protective devices indiscriminately installed will not give satisfactory results. In introducing protective gear one must be careful not to introduce more dangers than the apparatus is intended to remove. The gear must only operate for faults within the section protected and must not be affected by through faults.

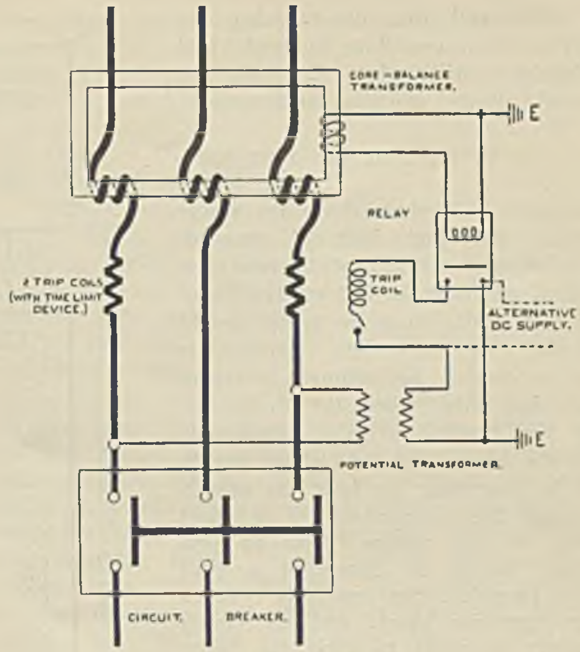


Fig. 16.

The introduction of reactances in different parts of a system is often helpful in limiting the short circuit current which would otherwise be heavy enough to cause disturbance to the whole system and damage to the switchgear. The use of reactors is becoming more common, particularly at tie points, where the effect upon the voltage regulation of the system is less pronounced than if reactors were used in series with individual feeders. The author would refer any student who desires information on the use of reactors to the paper on "Protection of A.C. Systems against Short Circuits" printed in *The Mining Electrical Engineer*, October, 1926.

There is still some difference of opinion as to the relative merits of an insulated versus an earthed neutral. The practice in this country is to earth the neutral point, and current limiting resistances are largely used for this purpose on E.H.T. systems up to 33 k.v. This is done on the assumption that most faults start as faults

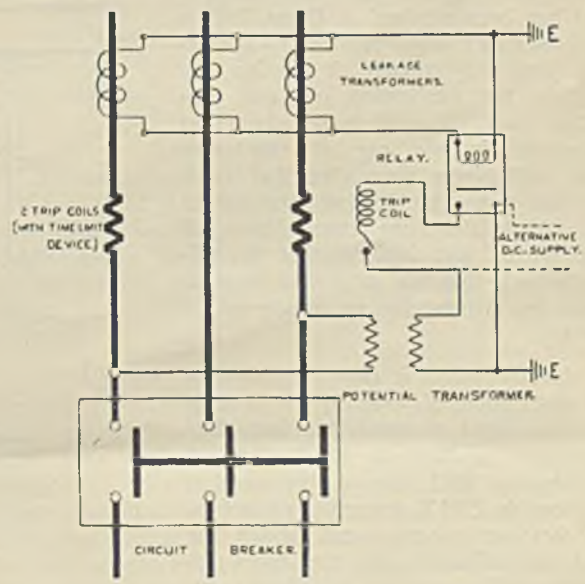
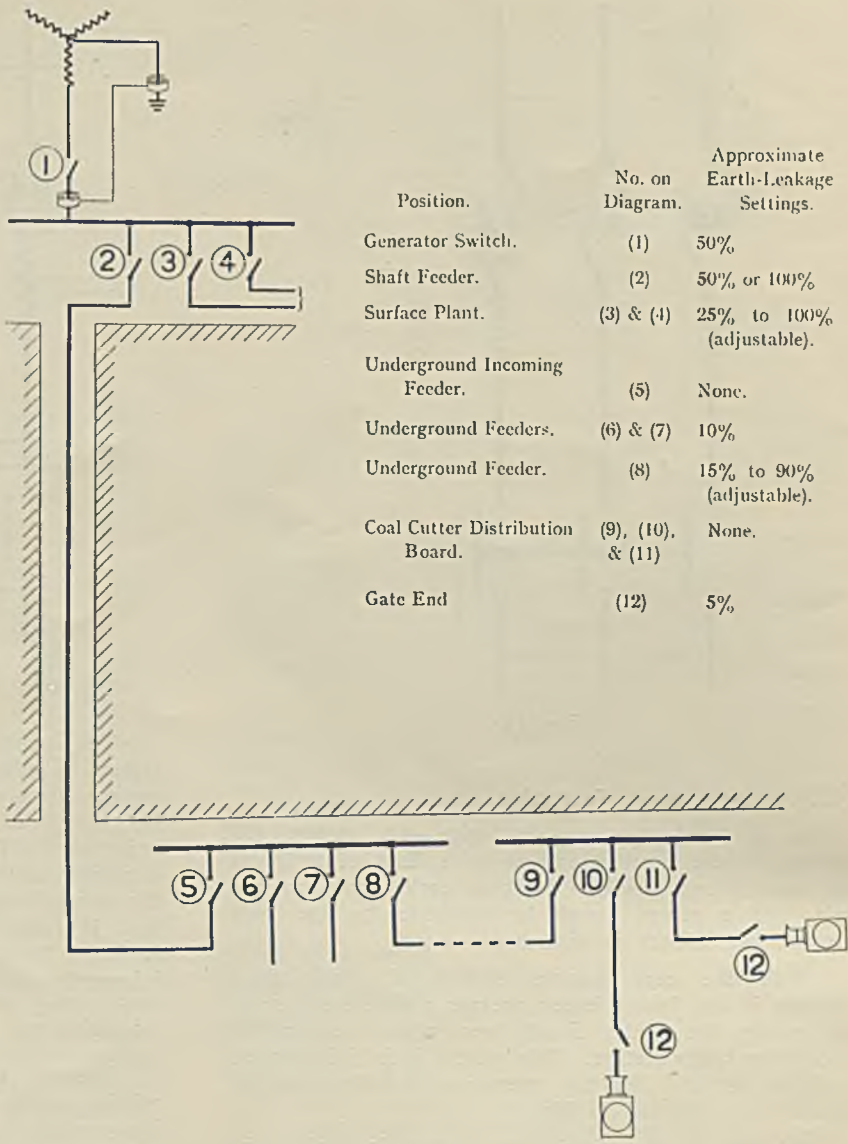


Fig. 17.

to earth, and that by reducing the current which can flow to earth, less disturbance will arise. Earthing the neutral allows one to insulate only for $\frac{E}{\sqrt{3}}$ volts, while on the other hand, one earth fault shuts down the whole section until that fault is removed. With an insulated neutral the insulation must stand up to the full voltage E and a single fault, phase to earth, would not shut down the system. Earth faults can be cleared by ordinary overload protection only, when the earth current has reached a value comparable with the normal full load of the circuit, and by that time the fault has usually assumed the proportions of a short circuit on the system. Thus by protecting so as to disconnect a fault at its inception, the system is relieved from excessive shock, and the circuit breakers operated to clear the faulty section without affecting the synchronous plant, or disturbing the stability of the system. The maximum time that can elapse between a short circuit occurring and the operation of the circuit breaker, without causing the synchronous plant to shut down is usually assumed to be of the order of two seconds. This figure, however, is quite arbitrary, because the effect of every short circuit is influenced by so many factors in the design and layout of the distribution system, and also by the number of feeding points. In many cases numerous faults of the most severe description have been isolated without visible shock to the system, and, better still, without opening healthy sections even though switches were closed repeatedly on the already matured fault.

It is typical of the high standard that has been attained in Great Britain for reliability and continuity of service that this country is leading the way in the application of fault protective gear. The phenomenally rapid expansion in the use of this gear since 1920 is a sure sign that it is carrying out what it was intended to do, in obviating the consequences of breakdowns, and in increasing the efficiency and economy of power installations, by maintaining an uninterrupted supply.

In conclusion, it must be said that the description of some of the systems are somewhat abbreviated, but they have been written to focus attention on what is still one of the greatest problems in E.H.T. transmission, believing that we progress and obtain the maximum efficiency by the free discussion and summation of all our experiences.



Position.	No. on Diagram.	Approximate Earth-Leakage Settings.
Generator Switch.	(1)	50%
Shaft Feeder.	(2)	50% or 100%
Surface Plant.	(3) & (4)	25% to 100% (adjustable).
Underground Incoming Feeder.	(5)	None.
Underground Feeders.	(6) & (7)	10%
Underground Feeder.	(8)	15% to 90% (adjustable).
Coal Cutter Distribution Board.	(9), (10), & (11)	None.
Gate End	(12)	5%

Fig. 18.

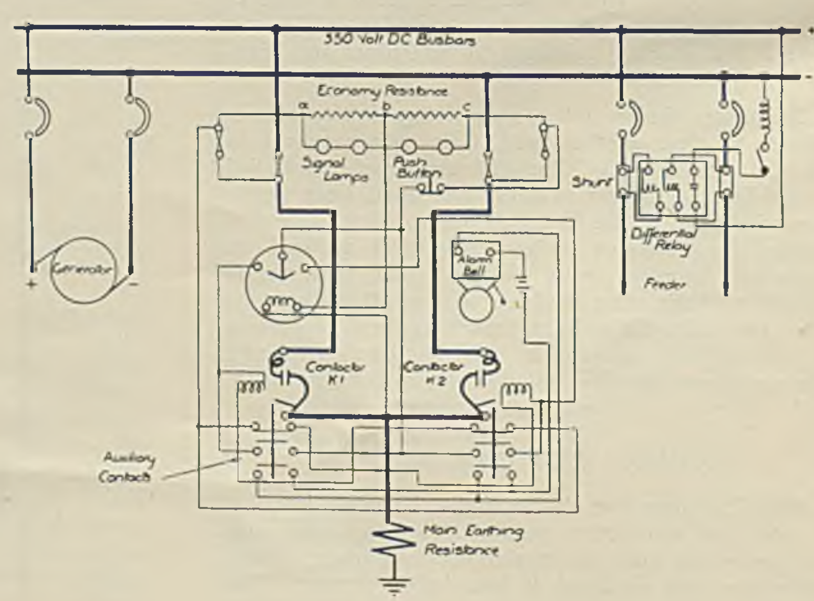


Fig. 19.

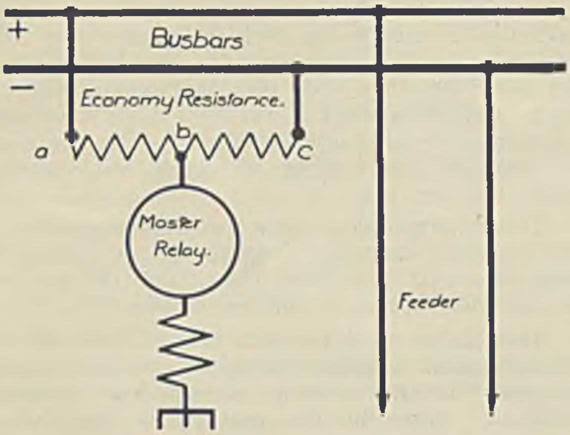


Fig. 20.

The author wishes to express his thanks to Reyrolle & Co. Ltd., General Electric Co. Ltd., and Metropolitan-Vickers Electrical Co. Ltd., for the use of their slides; and to British Steel Co. Ltd. (Guest, Keen & Baldwins), for permission to read the paper.

YORKSHIRE BRANCH.

The monthly meeting of the Yorkshire Branch was held in Barnsley, on Saturday, the 7th November, 1931, when Mr. H. Watson Smith, the Branch President, delivered his presidential address.

Afterwards, a long discussion took place upon Mr. Mann's paper, read at the meeting held last January, upon "Protection of Machines and Personnel at the Coal Face."

Presidential Address.

The Status of the Mining Electrical Man.

H. WATSON SMITH.

Introduction.

The President introduced his address by remarking that when he commenced his apprenticeship to coal mining in the year 1901, whatever his ambitions might have been, and probably they were many, there was not the slightest thought, let alone ambition, that he should have the honour of being President of a Branch of an Association of Mining Electrical Engineers.

Looking back to those days, it seemed now to be of more than ordinary interest to remember that at the colliery where he was at, they were engaged upon a generating and electrification scheme for underground in-bye haulages, pumping, lighting, etc. The electric supply was a.c. three-phase, 440 volts.

That was thirty years ago and in view of matters which he proposed to follow in this address, it would be appreciated as appropriate why he came to mention that the most regrettable circumstance of that scheme was the electrocution of a haulage motor attendant on the first day of starting up, by an act of incompetence on the part of the electrician in charge.

Whilst very conscious of his limited electrical qualifications, Mr. Watson Smith said he could but appreciate with modest pride that something had happened since 1901, either by effort or otherwise to bring to him the honour the members had bestowed on him. In thinking over what subject to deal with as a suitable and, he trusted, useful contribution to the Annals of the Association, he felt that he might take the one which had influenced him to join the Association.

The Status of the Mining Electrical Engineer and Mining Electrician.

History tells us that Coal Mining was in existence as far back as the year 1217, but that it was not until the year 1850 that Parliament introduced Legislation dealing with same. The 1850 Act established the principle that the State could interfere in the interests of safety, and to this end Inspectors were appointed, but with very little power.

It was in 1852 that the Trades Union pressed that the Inspectors should have more power to enforce what was then considered a code of desirable safety measures. This agitation did not have any practical effect until 1872, when an Act was passed which amongst other things, included that every mine must have a Manager who was the holder of a Certificate of Competency obtained in a State Examination. It should be mentioned in this connection, that persons employed as Managers in 1872, and those who could prove previous satisfactory management were given Service Certificates of Competency and exempted from taking the State Examination.

It took therefore from 1850 to 1872, or 22 years to establish Certificates of Competency connected with Mine Management.

The next step towards certification was in the Mines Act of 1887, when certificates and qualifications were divided into two classes, viz., 1st Class for Managers, and 2nd Class for Undermanagers. Here again Service Certificates were given to Undermanagers in a similar way as the 1872 Act dealt with Managers.

Then, from 1887, came the Coal Mines Act of 1911. This Act and its Regulations to date govern the Mining Operations under which we are at present working.

With regard to Certification, the 1911 Act includes:—

(1) An elaboration and extension of qualifications necessary for persons requiring to sit for 1st and 2nd Class Certificates. Particularly enforcing practical underground mining experience.

(2) That Surveyors must be certificated by State Examination, except for those acting as Surveyors at the passing of the Act.

(3) Certification of Deputies and Firemen by State Examination, except for those acting as such at the passing of the Act.

Certificates of Competency.

A survey therefore of the Legislation dealing with Certificates of Competency to date, reveals that the underlying reasoning has been to enforce certificated competence on the purely mining side only of the mine (except for the inclusion in the 1st and 2nd Class Competency examinations of Electrical and other Engineering subjects).

No fresh certification for competence has been introduced since 1911.

It may be asked what connection is there between these facts and the Status of the Mining Electrical Engineer? The answer is that, since 1850 when legislation was introduced in the interests of safety, since 1872 when certificates of competency were introduced in the further interests of safety; methods of mining have been changed and revolutionised, by the application of machinery.

From the aspect of safety and efficiency associated with machinery certificates of competency on the personal side have obviously not been adequately provided for.

The old days of mining by manual labour and beast, have been superseded by an age of machinery—surface and underground—extending rapidly in science, adaptability and quantity, day by day. Records and statistics plainly shew the position.

How very necessary it is therefore in the interests of safety and efficiency that the position should be properly recognised. These remarks apply to all plant, machinery and apparatus, both mechanical and electrical.

If we peruse the Mines Act, the only qualification we can find as applying to persons in connection with plant and machinery is 'Competent Person.'

If we consider seriously: (1) The type and amount of present day colliery plant and machinery: and (2) The educational facilities at Universities, Technical Schools, Evening Classes, and the cost of the same to the Industry, not forgetting the Technical Publications, and the Technical Associations such as the Mining Electrical, it is surely common sense and logic to ask that all persons in their different grades, responsible for the installation, supervision, and maintenance of colliery plant (mechanical and electrical) should have a definite qualification of competency established by the State or other officially recognised examination body. The term 'Competent Person' is a most indefinite qualification.

There would appear to be a strong case for this contention, especially when amongst other things, it is noted: (1) That a deputy in charge of an area of underground workings has to be certificated; and (2) that boy labour now entering the industry is being awarded a Medal Badge of Competency for proficiency after attending a course of Safety First Principles.

The speaker would also venture to suggest that many of the present Regulations applying to Mechanical and Electrical Plant, have been unnecessarily elaborated into hard and fast rules, unsuitable in many cases to meet the varying conditions; because of the fear arising from the appreciation that there was no adequate standard of competence of the responsible personnel.

Mining Electrical Competence.

Since about 1890 electricity has been introduced and installed in and about mines in ever increasing ways and quantities. One could say that it is being literally poured into them. Furthermore, it can be no exaggeration to say that electricity has a bigger share in the efficient working of the average mine than any other factor and until we pause to think we often have no real conception of what has been accomplished. Colliery power stations, and super power stations with H.T. ring transmission mains and high voltage are a striking example of progress compared to the generating plant of thirty years ago. There is not a phase of colliery work to which electricity has not been applied, and we could have an all-electric power pit.

Generally speaking there is no doubt that electricity has, besides introducing efficiency, reduced the accident rate per ton at the mines, if only because it has been the means of substituting labour. Yet, despite that fact, it has in itself introduced a danger. Its danger is of a peculiar type in that it cannot be detected by the eye (except indirectly through instruments). It introduces the risk of ignition, causing fire and explosion. That the danger is recognised is evidenced by the fact that the Mines Act provides that electricity shall not be introduced to any place underground excepting after application is made to the Divisional Inspector of Mines, and he raises no objection. Its introduction at the coal face (depending upon the conditions) always gives rise to a certain amount of anxiety and the most careful consideration by all parties; and yet it is to this application that its future great usefulness and consequent greater efficiency lies.

The problem with us, is how to deal most effectively with the whole situation. Obviously the two indispensable needs are: (a) first class plant; and (b) first class personnel for supervision and maintenance.

There is no need to dwell on (a). We all know that such plant is manufactured, and that manufacturers and others are by research and experience aiming for perfection. It is to the requirement (b) that the remainder of these notes will be directed.

The first recognition of electricity as applied to mining was the framing in 1905 of Special Rules under the Mines Act of 1887. These rules were not very elaborate, and the only descriptive qualification they contained with regard to those actually employed on the supervision and maintenance of electrical plant was a 'Competent Person.'

The first 'Competent Person' that the speaker knew, and who was placed in charge of a 500 k.w. installation, was a man who had previously been employed on telephones and leclanché cell signals, his assistants were drawn from fitters' apprentices.

The next Legislation was the General Regulations and the subsequent Regulations under the 1911 Mines Act, which are at present in force. These Regulations are fairly extensive and shew an appreciation of the growth of electricity in and about mines. They illustrate that the observing of them necessitates technical and practical qualifications; but they are weak in one vital respect, they do not fix a definite standard qualification of competence, nor do they attach a definite standing and responsibility under the Mines Act to those in charge of the Electrical Plant.

The only person mentioned is 'Electrician' and he is vaguely described as 'a person competent for the purpose.' If the interpretation of competence can be left to lay opinion, it is not illogical to suggest that all the other regulations are unnecessary, and all that is required is an all-embracing regulation. 'All Plant, Cables and Apparatus shall be competent for the purpose.'

If we look at the General Regulations we see much elaboration, specifications, instructions and safeguards. We probably agree with most, but on the other hand we appreciate that the consequences of one act of incompetence on the human side can do more harm in one minute than the good done by all the regulations in one year. Surely there is obvious inconsistency.

It should not be inferred that the speaker casts wholesale reflections on the competence or ability of those who hold the positions of colliery electrical engineers or electricians: far from it, this criticism is offered with the sincere hope that the near future will see a satisfactory recognition of their status, coupled with a clearly defined direct responsibility under the Mines Act. This statement is made with a full appreciation of just where and how far it may travel—the State has not yet fully grasped the position in regard to electricity in mining to-day. It has not seen the importance of combating incompetence on the personnel of the electrical side, in the same way as it has combated it on the mining side. Managers, Undermanagers, Deputies and Surveyors are all subject to a State

Examination as the qualification of competency. The electrical side of mining being now so important, scientific and highly technical, should in the interests of all parties and particularly to ensure safety and efficiency, also have its personnel placed on a proper footing.

In this direction the speaker would suggest that there be three grades of position and competency by State Examination:—

1st Class Mining Electrical Engineer.

2nd Class Mining Head Electrician.

3rd Class Mining Electrician.

Those who are already employed in positions of colliery electrical engineers or electricians would probably be given Service Certificates, as is usual and equitable when changes of this kind are first made.

It is not intended here to enter into the details of duties etc. for the various grades excepting briefly to suggest that the various appointments would be determined by the size of the Mining Undertaking, and the extent to which electrical plant was installed.

The "Mining Electrical Engineer" would be an appointment for one or more mines; he would be appointed by, and be responsible to the Mining Agent. There would be no reason why, if competent, he should not discharge the combined duties of Electrical and Mechanical Engineer.

The "Mining Head Electrician" would be in charge of one mine, and under the control of the Manager, but would also be under the supervision of the Mining Electrical Engineer.

The "Mining Electricians" would be assistants to the Head Electrician in charge of one working shift, either on the surface; or the whole or part of the underground plant.

All grades to be liable to suffer cancellation of their Certificates by reason of incompetency, etc. under Section XI of the Coal Mines Act.

The speaker feels convinced that, with few exceptions, the Inspectorate (Electrical and Mining) and all engaged in Mine Management, particularly the Managers, would welcome whole heartedly the proposals briefly outlined here. In many cases Mining Agents, or Managers, have not the technical knowledge to enable them properly to supervise and control all the electrical plant in and about a mine: and, secondly, in these days of so many multifarious duties, neither have they the time to devote to the work. Managers and Agents place their faith in the 'Electrician' and carry out an unfair responsibility. The author speaks from experience when he says that the Mining Agent and the Manager would consider it a great relief if they knew that the personnel on the electrical side had a 'Hall-Mark' of competency; and, further, had a direct responsibility under the Mines Act for the examination and efficient maintenance of the electrical plant.

Some line of action is absolutely imperative if we are to deal satisfactorily with the position as it is to-day, and more important still, cater for the immense possibilities of extension in the future: included in which it is devoutly hoped, will be coal face lighting. Colliery owners and those in high administrative positions in mines management should perforce give whole-hearted support to anything which will bring greater safety and higher efficiency to mining operations. There ought to be no hesitation on the grounds that Status by Certificated Qualification may mean consideration in other ways. If consideration be given to the development of electrical engineering since it was first introduced in mines, it will be appreciated that no branch of the employees has been called upon to advance so far and so quickly in technical knowledge and ability to discharge their duty as have those connected with the electrical branch. The difference in worth between the skilled technical employee, and the ordinary manual worker will stand the test of careful thought. The electrical engineer and the ordinary electrician have kept up-to-date by devoting much of their spare time to education: included in which has been active membership of this Association.

With regard to the Association, its object is entirely educational, and there is not the slightest taint of anything otherwise. The speaker so strongly believes in the excellent work that the Association does, and the benefits that accrue to the collieries from it, that he would strongly appeal to the employers that it ought to be possible for members to attend meetings at least four times a year in mid-week without pecuniary loss, instead of the existing arrangement of always involving the members in the sacrifice of their Saturday half-holiday.

In closing his Address, Mr. Watson Smith said he had no apology to offer for daring to have said so much about the status of mining electrical men. He wished to say in unmistakeable language that the promptings and intentions of his address from beginning to end were for the advancement and benefit of the industry to which most of them were proud to belong. His membership of the Association was for the same reason.

NORTH WESTERN BRANCH.

Mr. S. J. Roseblade, Branch President, presided at the meeting of the North Western Branch, held at the Wigan Mining and Technical College on Thursday, December 10th last. Mr. Edmund Read, 1 Grange Villa, Haydock, was elected a member. Mr. Colin McLuckie, of the Mining Laboratories of the College, gave the following lecture.

Firedamp and the Detection of Firedamp in Mines.

COLIN McLUCKIE.

The term "firedamp" was used to designate the inflammable gas mixture given off naturally from the strata. A number of experiments had been made in the College, in connection with different seams in the Lancashire coalfield, with a view to ascertaining the rate at which coal would give off this gas. One simple experiment was to place three pounds of coal in a jar, the gas being allowed to collect and then drawn off at intervals. A sample from the Arley seam gave off approximately 300 c.c. of firedamp in ten days, and a sample from the Crombouke seam gave off four times as much. Resolved to simple figures this shewed that the gas yield from the Arley per 48 hours per ton of coal was 2.2 cubic feet, and from the Crombouke 8.8 cubic feet. The seam in the first case was at a depth of 240 yards and in the second case 715 yards. It would be seen that the amount of gas met with depended, first of all, on the nature of the coal, some coals giving off more gas than others. The rate of advance at the coal face was also a factor. The faster the rate of advance, more coal and breaks were exposed in a given time and consequently the greater the rate of gas emission.

In some seams in Lancashire as much as 300 cubic feet of firedamp was given off per minute, necessitating, as one could easily imagine, a great amount of dilution with air. Although air was blown into the pit for the purpose of dilution, the gas collected in pockets and in various corners, particularly where there had been a fall of ground. (Mr. McLuckie indicated by means of charts the positions of gas pockets in various seams).

In one case there had been a fall of roof which had been timbered and covered up in the usual way, and in a hole in the cover was found an atmosphere containing about 40 per cent. of gas. In another instance there was a break in the roof, and two feet up inside the break 8½ per cent. of firedamp was discovered at a height at which a man would probably be drilling for shot firing. In a third case 36 per cent. was found in a hole in the face of a ripping. While the general body of air might contain a low percentage of gas, high percentages were frequently present in breaks in the roof and cavities, where tests could not be readily carried out with the ordinary flame safety lamp.

Firedamp is a mixture of gases consisting chiefly of methane with traces of nitrogen, carbon dioxide, and in some cases other hydro-carbons and sulphuretted hydrogen. The presence of sulphuretted hydrogen and some of the hydro-carbons gives the gas an odour by which it can be detected by the sense of smell. Under certain circumstances, however, firedamp is odourless, and in most British mines it very seldom contains any inflammable gas other than methane. As a rule it is odourless and tasteless, and for the purpose of detection, where it is present in dangerous quantities the ordinary flame safety lamp is used.

Firedamp has well-defined limits of inflammability. It begins to be explosive at, roughly 6 per cent., and at a concentration of 10 per cent. the maximum explosive pressure is developed and also the maximum rate at which the flame will travel. Rising from 10 per cent. the severity of pressure and velocity decreases until, in the region of 15 per cent., the mixture is non-explosive.

The Coal Mines Act specifies definite maximum percentages of imflammable gas in mine air under certain conditions, ranging from ½ per cent. to 2½ per cent. If the gas present is less than 2 per cent. it is difficult to see the cap on the testing lamp. As an accurate determination of methane in air cannot be made by means of the flame safety lamp it is frequently necessary for samples to be taken and sent for analysis. When the conditions are such that the person responsible for mining ventilation has occasion to collect samples for analysis the individual naturally desires to know the result immediately. The time that would elapse between collecting the samples and obtaining the result might vary from a few hours to several days. That time interval is too great and to help the persons responsible for ventilation in the mine, a portable methane meter has been designed: the apparatus is safe under all conditions, easy to operate, and indicates the gas content without the necessity for calculations.

Experimental work was carried out in the College and the actual instrument ultimately devised is shewn in the sectional diagram, Fig. 1. It consists of a metallic vessel divided into two equal volumes. The lower part of the vessel is the combustion chamber, and the upper part is a compensating chamber to eliminate errors due to temperature and pressure. In the combustion chamber is a platinum wire which is heated by a current from a two-volt accumulator and which will burn-off any gas present in the sample under test. A U-tube containing a coloured liquid is connected to the two chambers, and acts as a water gauge to measure any difference in pressure between the two compartments.

The sample to be tested is first freed from coal dust by means of a filter attached to a small rubber pump. The pump is squeezed twelve to fourteen times in order to transfer the mine air into the apparatus. When the sample is being transferred into the apparatus, all passages connected to the two chambers are opened by adjusting the cocks; in the actual apparatus, however, there is a multiple-way cock that controls the openings. When the sample has been transferred to the apparatus all passages are closed; in order to ensure that the air blown into the apparatus is at the same temperature as the metallic vessel, the apparatus is allowed to stand for two minutes. At the end of two minutes all passages are opened to the atmosphere for a few seconds in order to allow the air pressure in the two chambers to balance at atmospheric pressure. When a balance of temperature and pressure has been produced, all the passages are closed and the electric current is switched on for two minutes. During the two minutes' burning, the glowing wire will cause the methane molecules present in the combustion chamber to combine with the oxygen and to produce carbon dioxide and steam. The latter will condense and produce a drop in pressure proportional to the amount of methane present.

At the end of two minutes' burning, the current is switched off, and the apparatus is then allowed to cool for a further two minutes. The idea of allowing two minutes' cooling after combustion is to enable the heat generated by the glowing wire to spread into the compensating chamber and thus heat the air in the top chamber to the same temperature as the air in the bottom chamber. After two minutes' cooling, the U-tube is communicated to the chambers by turning the cock. Any difference in pressure between the two chambers will be indicated by the liquid levels in the U-tube. If the liquid should rise towards the combustion chamber, this will indicate that a certain amount of inflammable gas has been burned. A scale is provided on the U-tube to enable the amount of inflammable gas present to be measured direct without any calculation.

The combustion chamber, switch, accumulator, etc. are contained in an aluminium casing. The box is approximately 12 inches high and 4 inches square, the total weight of the apparatus when fully charged being 8¾ lbs. A multiple-way cock is used to admit the air into the combustion chamber, to close all passages during the combustion period, and to make communication to the two chambers and the U-tube when measuring the amount of inflammable gas in the air. A handle is provided on the cock, which is rotated into three positions during a test, namely positions 1, 2, and 3. When the cock is in No. 1 position, all passages are open to the atmosphere, and when in this position the sample to be tested can be transferred to the apparatus by means of a pump, or from an inflated bladder. When the cock is in No. 2 position all passages are closed. In this position combustion is made by pulling out the switch handle. When the switch is pulled out, the platinum wire can be seen glowing through the inspection window contained in the combustion chamber. After the combustion period of two minutes, the cock handle is rotated into No. 3 position and the amount of firedamp present is then measured on the scale. By rotating the cock into No. 1 position the apparatus is then ready for further tests.

The position of the switch is such that when the handle of the cock is in No. 1 position, the current cannot possibly be switched on. This precaution is a safeguard against having at any time the glowing platinum wire communicating to the mine atmosphere. Attached to the handle of the cock is a spring plunger that enables the operator when in the mine to fix the position of the cock by touch, sight, and hearing.

Gas Surveys.

For the guidance of colliery officials responsible for the ventilation of mines, gas surveys conducted at frequent intervals, say once a month, have been useful in the following respects : (*a*) The detection of air leakages; (*b*) the detection of increased quantities of gas being given off, necessitating increased quantities of air being circulated; (*c*) the distribution of the air in the various districts in order to get the best results; (*d*) to ascertain if a safe standard of ventilation is being maintained in the various districts. In some pits where large quantities of firedamp are given off, an effort is made to circulate sufficient air in order to keep the methane proportion less than one per cent. in the general body of the air.

The method adopted is as follows: Sampling or testing places are fixed for each district and on the day on which the test has to be made samples of the air are taken at the various sampling stations, and the methane percentage determined. Figure 2 shews a longwall district where the coal is machine-mined.

The sampling places are: (A) 50 yards from the first working place; (B) the first working place in which the air enters: (C) halfway along the face: (D) the last working place; (E) 50 yards from the last working face; (F) 100 yards from the last working face.

The results are recorded as in Table I.

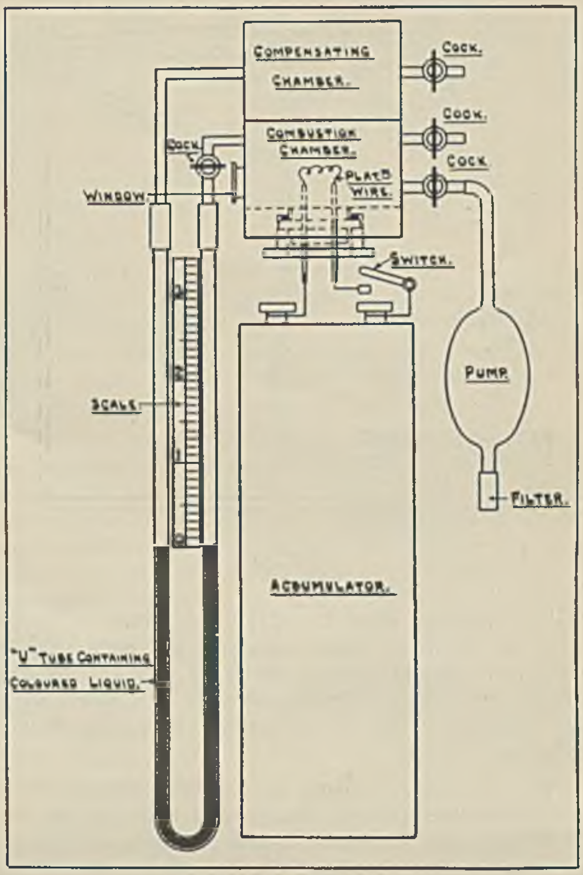


Fig. 1.

TABLE I.

Pit: A. *District*: King Coal No. 1.

Sampling Station.	% CH_4 1*st March.*	% CH_4 1*st April.*	% CH_4 1*st May.*
A	0.15	0.15	0.15
B	0.2	0.25	0.2
C	0.4	0.45	0.4
D	0.6	0.7	0.65
E	0.55	0.6	0.6
F	0.4	0.5	0.45

From the tabulated values the colliery manager may see at a glance whether the standard of ventilation at the coal face is being maintained. If the results are consistent from one month to another it indicates that the ventilation is good. Should the percentage of methane get high at sampling station D, then it would indicate either that there was a decrease in the quantity of air passing or that an increased quantity of methane was being given off. The quantity of air entering the district, of course, would be measured once a month by means of the anemometer. From the results it is also shewn that there is a gradual decrease in the quantity of methane in the return airway, this being due to air leakage, that is air passing through the packs and broken ground. The greater the rate of decrease the greater is the leakage. Air leakage across air-door and air-crossings can be readily ascertained from the methane content in the air. Take the case of an air-crossing. If the methane is ascertained before the air passes over the air-crossing and after the air passes over the crossing, a reduction in the methane percentage will indicate leakage. Leakage of air at the air-locks on the surface can be readily ascertained in the same manner.

The methane percentage in the air in the upcast shaft at one particular colliery was 0.4, and the percentage of methane ascertained at the ear of the fan was 0.3. The leakage of air at the air-doors on the surface and at the fan drift was thus shewn to be considerable.

These surveys are exceedingly useful where electrical gear is in use underground, because the maximum percentage of inflammable gas permissible in the air is $1\frac{1}{4}$ (C.M.A.)

Figure 3 shews a plan of a longwall district where the coal is got by hand. The values shewn on the plan indicate the percentage of methane in the general body of the air. In the intake the percentage of CH_4 is 0.05, and in the first working place in which the air enters the CH_4 percentage is 0.1. As the air travels to the left-hand side of the district a small fault or step F is encountered, which causes a sudden step up in the percentage of CH_4 in the general body of the air. In

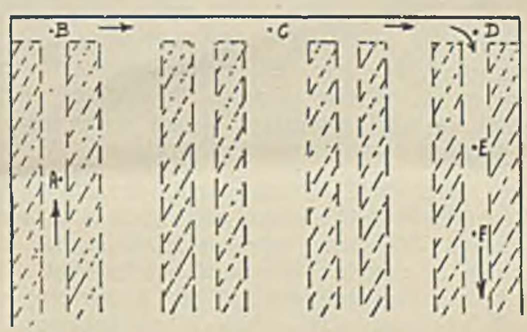


Fig. 2.

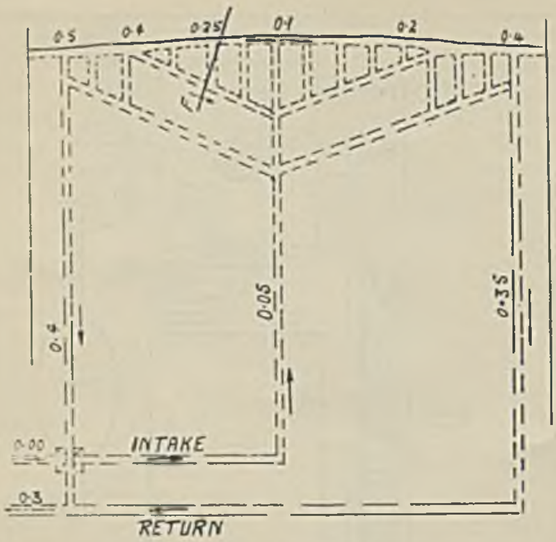


Fig. 3.

the last working place the CH_4 percentage is 0.5, that is on the left-hand side, while on the right-hand side of the face the CH_4 percentage is 0.4. As the air passes through the return airway there is a decrease in the CH_4 percentage due to air-leakage from the intake to the return.

This gas survey shews in a simple manner the distribution of the CH_4 in the general body of the air in the district, and if compared with previous surveys made in the same district will enable the officials to determine whether or not the ventilation is being maintained at the required standard. Of course it is only in mines containing CH_4 where such surveys can be conducted.

(Mr. McLuckie then described experiments which had been made with a detector which depended for its action upon diffusion. He also explained an apparatus upon which he is now engaged, where, by means of the ordinary safety lamp the presence of gas in certain quantities is indicated by the lighting up of a red electric bulb).

Discussion.

Mr. S. J. ROSEBLADE, President, assured Mr. McLuckie that he had delivered a lecture which the members greatly appreciated—and particularly so by reason of the experiments. They had all been given a much clearer understanding of the properties of firedamp. Mr. McLuckie was to be heartily congratulated on his excellent work is solving one of the most difficult problems with which mining men had to contend.

Mr. Roseblade would like to ask the lecturer a question. Under the Mines Regulation Act, when the admixture of gas was 1½ per cent. the electric service in the mine had to be turned off, when it reached 2½ per cent. the men had to be withdrawn, and when it reached 5 per cent. the atmosphere was to be regarded as an explosive mixture. It would be interesting to know in what percentage of gas a man could continue to do a normal amount of work.

Mr. McLUCKIE.—A man would be able to breathe in a mixture of firedamp and air. There is 21 per cent. oxygen and 79 per cent. nitrogen in the air we breathe. According to experiments carried out by Prof. Haldane we can replace the nitrogen and have 21 per cent. oxygen and 79 per cent. CH_4 which is non-poisonous. The CH_4 is similar to nitrogen as far as the physiological properties are concerned. If 5 per cent. of firedamp is added to the air, what is going to happen? It could be assumed there is 1 of oxygen to 4 of nitrogen in the air. That is, as 20 to 80. If 5 volumes of firedamp is added to the air, one volume of oxygen and 4 volumes of nitrogen will be displaced. So, every 5 per cent. of firedamp added to the air reduces the oxygen by 1 per cent. A man can work in an atmosphere weakened down to as low as 15 per cent. oxygen, at which stage he begins to get uncomfortable. With only 10 per cent. of oxygen in the air he begins to be very distressed in his breathing, and he loses consciousness with 7 per cent. of oxygen in the air.

In reply to another question Mr. McLuckie stated that a man could work in an explosive atmosphere. He was also asked what percentage of gas would put out the flame of a safety lamp and replied that with about 5 per cent. the flame passed up inside the gauze. When there was no oxygen to support the burning of the flame, of course it went out.

Continuing Mr. McLuckie said he did not think any high-tension spark was not strong enough to ignite firedamp. Friction sparks from picks were sufficient for the purpose. Any source of heat higher than 700°C. and of sufficient duration would ignite the gas. The Detector he had described had been tested by the Mines Department for accuracy and was regarded as satisfactory. It was not made for large percentages but would meet conditions within the range specified in the Act: mixtures of the order of 1½ per cent. and so on.

Mr. A. M. BELL asked Mr. McLuckie whether he suggested it was possible to ignite gas with sparks from coalcutter picks: he had thought the flame temperature of such sparks could not ignite the gas.

Mr. McLUCKIE replied that in Scotland the gas was repeatedly ignited: the occurrence depended on the nature of the holing, or on the nature of the rock; a soft material would, of course, not yield a spark equal to that obtained from a hard sandstone floor. There was always a risk in the case of the latter.

Mr. BELL mentioned that a recent inquiry it was suggested that the explosion was due to a broken bulb is an electric lamp.

Mr. McLUCKIE replied that he did not think that was likely.

The PRESIDENT referred to the diagram of crevices where gas could accumulate and said it seemed to him there was a great danger in shot firing, unless there was some method available for ascertaining when gas was present.

Mr. McLUCKIE mentioned that the gas he had used in the experiments was collected by means of a tube four feet long.

Mr. WHITTAKER remarked that in connection with coal face lighting there seemed to be a divergence of views on the question of the voltage. One school of thought was in favour of fairly high voltage, whilst another school of thought supported the adoption of a lower voltage. For voltages even as low as 12 and 15 volts rather a thick filament was necessary. If a lamp of that description was broken would its filament be so thick as to retain its heat for sufficient time to cause an explosion, if firedamp were present?

Mr. McLUCKIE replied that with a heavy filament there was a greater danger of retaining enough heat to ignite gas than with a thin one.

Asked what length of time it took to fire gas, Mr. McLuckie said there was an interval of time before the molecules got sufficiently hot to cause them to combine with the oxygen. Therefore the question of time factor came in.

Mr. HEYES stated that Prof. Wheeler was experimenting with a lamp which had a sort of contact arrangement inside the bulb. There was a difference of pressure between the atmosphere outside the bulb and that inside, and when the lamp was broken the difference in pressure would act upon the circuit. Professor Wheeler claimed that the time taken for the gas mixture to fire was so long that the filament would be cold before ignition could happen.

Mr. BOLTON SHAW suggested that in the case of the fracture of a lamp where the blow was not sufficiently severe to shatter the filament but only to break its continuity, the bits might continue to vibrate, and if the ends touched one another quite moderate sparks might be caused.

Mr. McLUCKIE.—After a colliery accident everything is damaged, even flame lamps and electric gear, and it was generally difficult to say what was the immediate cause of an explosion.

Mr. BOLTON SHAW remarked that he referred to a blow such as that from an ordinary pick which might smash the bulb of a lamp but might not shatter the filament, with the result that loose ends would be flipping about and those were liable to cause sparking.

Mr. BELL proposed a vote of thanks to Mr. McLuckie for having enabled them to spend a very interesting and entertaining evening. It was seldom they had the opportunity of seeing demonstrations of gas detection by an expert. To his mind the great risk from the electrical man's point of view would appear to be shock, and from the mining point of view the ignition of gas. It was, however, very important that an efficient gas-testing apparatus should be available, and it had been proved to them that evening that such a device had been provided. They were very much indebted to Mr. McLuckie for the great pains he had taken to demonstrate to them by means of actual experiments the advantages of a reliable gas testing apparatus.

Mr. WILLIAMSON seconded the vote of thanks and complimented Mr. McLuckie on the good work he had done and was continuing to do in the field of mines gas detection.

Mr. McLUCKIE responding, said it had been a great pleasure to give his demonstration. The fact that no lives were lost last year through electricity in mines spoke volumes for the care which had been displayed by the electrical engineers in looking after the plant under their care.

LONDON BRANCH.

Starting and Speed Control of Squirrel-cage Motors.

Discussion.

Mr. M. G. R. ELLIOTT pointed out that some inductors had one element and some had two, and he asked if it meant that two elements were in two phases and that the third phase was left connected to the line. Mr. Walton having replied that that was so, Mr. Elliott said that, therefore, there was not a true balanced control.

Mr. WALTON replied that the two phases were used only for starting purposes: for regulating purposes three phases were used.

Mr. ELLIOTT said he would be interested to know what the effect was with regard to the modern type of motor. The modern motor was very largely dependent on its speed for the necessary ventilation. He realised that the current was falling when reducing speed on the Barbour controller, but he would like to know if that fall in current was sufficient to compensate for the reduced ventilation. Had the motor to be built much larger than the normal size for the particular duty it had to perform?

Mr. WALTON said it depended entirely on the duty; for haulages, where one wanted speed reduction for a comparatively short time, and at a reduced load, the motor had not to be made bigger. On the other hand, if one wanted a big reduction against constant torque, then the motor would have to be larger.

Mr. H. H. SPENCER emphasised the question of the importance of the size of the motor. It was obvious, as was set out in the paper, that if the stator voltage was reduced, the rotor current must increase if the motor had to develop the same torque. Therefore, it would seem that if the motor was not specially designed and 50% speed reduction against constant torque was required, for example, the machine would overheat, not only in the rotor, but in the complete machine itself. It appeared to him that it was preferable to provide for that dissipation of heat in a separate resistance external to the motor rather than in the motor itself. That would not apply, however, in the case of a centrifugal pump or fan load where the torque fell rapidly with the speed.

The Barbour inductor, from the description and illustrations, appeared to consist of a fixed stator and a rotor with an air gap and he asked what effect the use of such an inductor had on the power factor of the motor.

The question really boiled down to one of cost and, presumably, applied to large units of 100 h.p. or more, as there was not much difficulty nowadays in getting motors of 50 h.p. or even 100 h.p. connected to supplies with the standard auto-transformer starter; it would appear that the costs of this apparatus in comparison with that of the Barbour inductor plus the special motor would be the deciding factor in many cases. He asked for comparative costs if possible on a percentage basis of the two systems.

Mr. WALTON replying to the question concerning speed reduction, said he had considered three instances in which it was most commonly required, namely, pumps, fans and haulages. In pumps and fans the torque fell very definitely as the speed was reduced, so that undue heating did not arise. It depended entirely on the motor, but in a number of cases, even down to small machines, it was found quite a reasonable and economical proceeding. If any appreciable speed reduction against full load torque was required, the motor would have to be larger, there was no question about that, but such cases were much more rare than those in which the torque varied as the speed was reduced. The inductor had an air gap in it and took magnetising current, the same sort of magnetising current that a good motor would take, but not as much, because when it was running at full speed the inductor was not in circuit, so that there were no losses in it and it did not affect the power factor. As soon as it was put in, the current applied to the motor was reduced, cutting down the magnetising current; and, on the whole, a squirrel-cage motor with power factor inductor was comparable with a slipring machine with resistance control.

With regard to the comparison of costs of this machine and the ordinary auto-transformers, Mr. Walton said his Company had recently obtained an order in which this machine worked out to be the cheaper.

It was not always true that there was no difficulty in getting quite big motors with auto-transformers on to a line. One had often to put an 85% tap, sometimes even higher than that, on a transformer starter and so it was almost a waste of money to install an auto-transformer at all. There was a very big current rush and also a high initial torque, which might be alright for the motor but not at all good for the mechanical parts of the driven machine; with the inductor a low initial torque could be obtained and the motor brought up to speed very slowly.

Mr. A. E. DREW suggested that the question concerning power factor was answered by Fig. 5, in which was shewn the line k.w. when a condenser was used. He gathered that the condenser was proportioned so as to give a power factor as near unity as possible. It was interesting to know that the curves for motor volts, line amps. and line k.w. followed each other very closely. Mr. Drew asked if any provision was made in the starters for dealing with reverse phase.

Mr. WALTON replied that there was no provision for reverse phase.

Mr. J. A. B. HORSLEY (H.M. Electrical Inspector of Mines and Past President of the Branch) said it appeared from the paper that in this apparatus the whole of the energy was transformed at starting, or during speed control in running in the Barbour inductor. That inductor, although as Mr. Walton had pointed out, it could be built for 3300 volts, relied upon dry insulation. Immersion in oil, which was regarded as necessary in the case of an ordinary transformer, partly as insulation and partly to dissipate heat, was apparently not necessary in this inductor and he asked for further information so that he could understand better how that came about. One appreciated, of course, that in a motor it was not necessary to immerse the windings in oil either for the purpose of insulation or for dissipation of heat, but the inductor appeared to approximate much more nearly to a transformer.

Mr. Horsley also asked what were the comparative efficiencies of an inductor such as that described in the paper, either for starting or for speed control, and the ordinary methods employed: e.g., the auto-transformer for starting and the metallic resistance for speed control. It would appear that when the inductor was used for speed control, the losses were transferred to the motor itself, and he did not understand that matter fully. In the case of rheostatic control, obviously the losses were concentrated in the rheostat, but assuming that full load torque was required at, say, half speed, did that necessitate, when the Barbour inductor was used, that the motor should be larger than the motor required with rheostatic control?

Mr. Horsley also asked how the bulk of the apparatus required for Mr. Walton's method of starting and speed control compared with the bulk of the apparatus used with the ordinary methods. The point was perhaps of no very great moment in colliery practice, for generally there was ample room where there were large pumps and large haulages, such as Mr. Walton contemplated applying his apparatus to. On the other hand, Mr. Horsley could not appreciate why it was so advantageous, as Mr. Walton had suggested, to house everything in one common container. In one case illustrated there was an electrical interlock between the circuit breaker component and the inductor component, but in another illustration the whole assembly was in one case. He suggested that in the case of a 250 h.p. haulage motor, the assembly would be very bulky if the components were in one container, and it might be more convenient, from the point of view of handling in the colliery, to have them separate.

Mr. WALTON replied that the inductor was sometimes oil-immersed but was more often air-cooled. The only losses it had to get rid of were its own losses. It was made air-cooled mostly because his Company were great believers in keeping oil out of the gear, and they had not experienced any difficulty either in regard to insulation or in dissipating the heat as the result of the absence of oil. It was true that if the transformer windings were not immersed in oil it was necessary to impregnate them or to avoid the effect of damp upon them in other ways.

It was a little difficult to answer the question as to the relative efficiency of the inductor and the auto-transformer or rheostat for starting purposes: the inductor was an auto-transformer. On the whole, its losses were less during the starting period because instead of having to give surplus torque at starting, it was only necessary to give the exact torque required and to run the machine up to speed with that torque only.

As to the general losses, to give 50 per cent. speed reduction against full load torque, would create very big losses in the rotor circuit of the motor, and the motor would have to be designed to deal with them. The losses which normally occurred in the rheostat connected to a rotor circuit would be concentrated in the rotor in this case. It must be remembered that the rotor of the motor was not like the stator which had lots of cotton or other fibrous insulation in its make-up; the rotor had practically no insulation and was able to withstand a great deal of heat. The losses at these speed reductions did not take place in the inductor: they were all in the machine. On fan loads that did not mean great overheating in the machine. On constant torque jobs it did mean that the machine had to be very carefully considered.

Dealing with the relative bulks of this apparatus and standard gear, Mr. Walton said that like for like his apparatus was less bulky because there was not the necessity of providing for the dissipation of any rheostatic losses. The reason for housing everything in one case was that it ensured that nobody would have access to any parts which normally would be alive, without first having made them dead. The more the equipment was split into separate parts the more difficult it was to ensure that. There was a limit, of course, at which it became impossible to put everything into one case and that limit was about 300 h.p.

Mr. J. A. B. HORSLEY asked whether, inasmuch as the inductor was for all practical purposes a transformer, Mr. Walton would suggest that there would be any advantage in using, say 3300 volts as the primary voltage and, perhaps, 500 volts for the motor winding voltage.

Mr. WALTON suggested in reply that it would be more economical, if one wanted to do it, to put in an orthodox transformer first to step down to the 500 volts.

Mr. HORSLEY said the method appeared to offer attractions also from the point of view of effective protection against sustained overload of the motor, which was only approximated to by the use of retarding devices to prevent the immediate operation of overload trips at starting and acceleration, but it was only at best an approximation.

Mr. WALTON replied that that was quite correct. One of the most difficult jobs was to secure effective protection for a motor that was switched straight on to the line.

Mr. HORSLEY.—Or even from an auto-transformer?

Mr. WALTON.—Yes.

Mr. HORSLEY.—Or star-delta?

Mr. WALTON.—Well, it gets better as the scale is descended.

YORKSHIRE BRANCH.

The Protection of Machines and Personnel at the Coal Face.*

Discussion.

Mr. MANN (author of the paper) in opening the discussion said he had put together quite a considerable sheaf of notes but, unfortunately, he had them with him when he attended the meeting at the Sheffield Exhibition and someone in the Hall took possession of them. Consequently, he had not had much time to renew the information. The lost notes included some particulars regarding the number of switches and fuses in use, underground, in Scotland as against those in England: though unable now to quote definite figures he could say that the deaths due to accidents in places where switches and fuses were used were much higher than in places where automatic protection was used.

Respecting the method of earth plate testing for conductivity resistance, it was suggested when the paper was read that two volts was the specified voltage, but the former figure of four volts passing a current of two amperes was correct; that was the figure taken from the Ministry of Transport regulations. Mr. Mann thought that the people who suggested two volts had in mind the question of testing by the conductivity testing set. There had apparently been a little confusion in following the remarks in the paper.

Mr. MAWSON.—Mr. Mann in his notes under the heading of Connected Chambers had stated that with inter-communicating chambers, an explosion in one chamber caused pressure piling and turbulence in the second. The Safety in Mines Research Board have recently published a pamphlet upon this subject of turbulence, and the whole idea is that any explosion in the second chamber is much more rapid. There are some very good illustrations in the paper and, no doubt, if members were sufficiently interested it would be possible to borrow lantern slides from the Safety in Mines Research Board.

Mr. WILLIAMS asked whether Mr. Mann could give any further information respecting apparatus used in connection with the Ringrose Gas Detector. Also, had he any knowledge as to the working of remote control gear in damp situations?

Mr. MANN.—In the particular case dealt with the gas detector was placed in the main gate and, as would be gathered from the remarks in the paper, the writer maintained that the proper place for the detector itself was actually where the machine was at work. That was particularly the case when dealing with coalcutters. In the case mentioned the detector was fitted in the gate and it naturally followed that the maximum amount of gas did not collect there; the switch did not actually operate, except when gas was brought into the vicinity of the detector.

* See *The Mining Electrical Engineer*, July 1931, page 38.

Mr. WILLIAMS asked what percentage of gas was required to work the detector?

Mr. MANN replied that he had not made a laboratory test of the actual percentage of gas required, but believed that with 1¼% of gas it could be made to work: he had never known of conditions arising which brought the apparatus into operation on its own initiative.

Mr. WILLIAMS.—What was the time lag between the introduction of the gas and the operation of the switch?

Mr. MANN would not care to lay down any hard and fast figures, but thought it was a matter of some seconds. Mr. Ringrose himself was to read a paper at the next meeting of the Branch, and therefore Mr. Williams would be able to enquire of the inventor with regard to the technicalities of the instrument.

As to the use of remote control gear in damp workings, Mr. Mann said he had had no experience of this: he did not, however, see any objection. With reference to the use of earth circuit protection, he believed all would heartily agree as to its merits under wet face conditions.

Mr. HIGGENS referred to a point which created a good deal of discussion when the paper was read, namely, the question of air-break versus oil-break switchgear. Mr. Mann had said that he had installed air-break gate-end switches. He had also mentioned that by means of a "grid" the arc was split up into various parts. Mr. Higgens would like to have some further details, and to know whether Mr. Mann still found the air-break switches satisfactory.

Mr. MANN in reply, said he was afraid some had misunderstood him at the reading of the paper: they seemed to have the impression that he was against the use of oil-break gear. He wished to emphasise that that was not at all his opinion but, according to personal experience, the use of air-break gear at and near the face was, he considered, the best method to adopt. For one thing, as pointed out in the paper, the possibilities of the switch being tipped at an angle may constitute a danger if oil-immersed gear is being used. Furthermore, the use of the air-break gear eliminated the production of the explosive gases such as were mentioned, mainly hydrogen and acetylene.

Referring to the method of cutting down the arc: the idea was that, upon the breaking of the contacts, the arc was split up into a number of paths, to pass through a series of separately insulated copper sheets, which cooled the arc and so quenched it in the minimum time.

From the point of view of arc wear upon the contacts the effect of prolonged arcing had been reduced to a minimum. With regard to a particular switch which had now had a considerable amount of use, Mr. Mann said it had worked very satisfactorily along with other air-break gear in the vicinity.

Mr. COWAN.—In an oil-break circuit breaker, when load current is broken under oil, gases are produced due to "cracking" of the oil and a large percentage (about 60%) of these gases is hydrogen. Venting devices which prove effective against a methane-air explosion have been shewn to be ineffective in cooling the flame resulting from a hydrogen-air explosion. For this reason, vents should not be employed in oil-break gear designed for use in situations in which firedamp is a hazard, and the structure should be designed to withstand, unvented, the pressure of an internal explosion. This consideration does not, of course, apply to air-break gear, which may account for the popularity of the latter for use at the coal face, referred to by Mr. Mann.

The generation of the hydrogen takes place below the oil level. The danger of ignition of the accumulated gas arises only when the oil level is low.

Mr. WILLIAMS wondered there was not some misapprehension: he would venture to say that many of the oil-break switches would be quite safe even if the oil were absent, and they should be safe whether filled with oil or not. Oil afforded second safeguard. For a damp situation, oil had the merit of keeping all parts of the gear well lubricated, so that it would work freely when required. With some types of air-break gear, he was inclined to think that when the call came for the overload to operate it would be found to be rusted up.

Mr. MANN said that though he, fortunately, had reasonably dry machine faces, he had experienced a good deal of humidity in the air: even with the use of oil-immersed switchgear, which Mr. Williams appeared to think would be free of dirt or rust trouble by automatic lubrication of the working parts, Mr. Mann had not found that to be so in practice. In the type he had in mind, the oil tank was entirely separate from the tripping mechanism.

The whole of the trouble of that kind was overcome simply by having the push rods, etc., made of gunmetal instead of mild steel. With the use of simple precautions in air-break gear, Mr. Mann did not think there was any possibility of that trouble, provided proper maintenance was given. No matter whether oil-immersed gear or air-break gear was used, it still required adequate maintenance, and surely, it was the duty of the men to see that the devices were properly cleaned, greased and attended to. He thought it would be generally admitted that oil-immersed gear required more maintenance by reason of the fact that the working parts were usually more obscure. Also, his experience with some classes of oil-immersed gear switches had been that the tank actually became the base portion, and the switch had to be slung up by a hook before it could be properly examined.

Mr. HIGGENS.—Mr. Mann had mentioned, in the case of a particular breaker, that the arc was spilt up into a number of paths. Mr. Higgens said he had some doubts as to whether cooling was really the cause of the advantages gained. There might be a more important principle involved. As to oil-immersed gear was it not rather like a method of putting a fire out with petrol? Provided there was a sufficient head of petrol, or oil, over it the arc could not exist. It seemed to Mr. Higgens that there might be a similarity between the action of the arc-quenching grid and the grid of a thermionic valve. If a valve grid became negatively charged or biassed as regards the filament or cathode, the effect was to reduce the electron emission from the filament thus reducing the value of the current flowing from plate to filament. May not the insulated arc-quenching grid accumulate electrons (negative charges) to a sufficient degree immediately the arc commences to pass through it to prevent the emission of further electrons from the cathode when the current has fallen to zero at the end of the first half cycle? Much research work on these lines had been carried out by one or two of the mercury arc rectifier manufacturers with most interesting results. The principle involved might well be a most important one in connection with future developments of air-break switchgear.

Mr. WOODYATT asked Mr. Mann whether he had any information respecting the burning of the contacts with this arc-quenching device and what was the difference noted respecting the wear of contacts in different types of apparatus?

Mr. MANN replied that the use of air-break switchgear with the type of grid mentioned had, unfortunately for the discussion, not been paralleled by switchgear of similar capacity of any other type, for which a test had been taken. Previous to the installation of this arrangement, they had used the ordinary air-break gear without the use of a quencher.

Mr. WOODYATT asked what class of switch of this type he had used.

Mr. MANN.—Only the gate-end switch up to the present.

Mr. LUNDON said it was important not to overlook the fact that the type of man who sometimes had to deal with the apparatus was absolutely untrained and had no respect for mechanism of any kind. In his case they had experienced considerable trouble with the amount of oil in the dash-pots. The first time they moved an oil-break gate-end switch it was turned upside down. As yet, and probably for many years, the switchgear must be fool-proof, even with respect to the oil, and no oil should be used unless the gear was installed in an absolutely firm position.

Of course, the advantages over the old-fashioned switch and fuse box were tremendous; Mr. Lundon often thought how very lucky was the way in which the switch and fuse box were used: to touch it with a finger usually resulted in a "tickling" shock.

Mr. ROGERS asked whether Mr. Mann had had any experience with extensive d.c. systems. With very long runs switches had failed to clear due to the pressure rise on the d.c. system. The only way was to introduce twin cables, but when the length was upwards of 2000 yards that involved very considerable expense. Regarding a.c. switchgear, of course no trouble of that nature should be experienced.

Mr. Rogers said his experience of the arc-quenching device described had shewn it to be very successful. Could Mr. Mann give any information as to its use with high voltages?

Mr. MANN said he had not attempted to use arc-quenching gear in connection with H.T.: he would much rather stick to the oil-immersed gear for 3000 and higher voltages.

With reference to the continual moving of oil-immersed gear, he had had considerable trouble on that account in the past, and that was one of the main reasons for his adoption of air-break coal face switchgear. Although there may be examinations twice a day, there was still risk of trouble due to the switch being tipped. This brought him back to the suggestion that oil-immersed switchgear with the oil removed was quite as reliable in breaking as air-break gear. He could not agree with that view, because of the smaller clearances allowed in oil-immersed gear. He remembered an occasion when, inspecting a particular type of switchgear which had been installed at one of the Exhibitions by a firm of coal face machinery experts, the representative was so keen in shewing what the switchgear could do that he operated it without the presence of the oil. The result was immediate and extensive damage to the switch.

Mr. Mann said he was happy in the knowledge that he had got away from d.c. coalcutting. When, in the past, he had experienced pressure rises on breaking with single core cables he had found a better job for the long cable lengths and replaced them by twin cables.

Mr. Mann here mentioned that the discussion tended to revolve around the design of air-break and oil-immersed gear: whereas the object of the paper was to induce discussion on ways and means of obtaining greater safety to machines and personnel at the coal face. He must, however, again emphasise that it was the abnormal conditions at the face which led him to consider the use of air-break gear there. Whilst he fully realised that there was a field for both types of gear, he thought air-break gear was to be preferred.

Turning to the subject of cables, Mr. Mann said that prior to his experience of earth shields on the trailing cables he had had considerable experience with unprotected cables. One great difficulty and danger which arose with the latter was the projection of fine wires from the haulage ropes, which very often broke off into the trailing cables and penetrated the live cores.

The main objection raised against the protected trailing cable was its weight, but, as pointed out in the paper, the weight came out very favourably and was actually in favour of the armoured trailing cable. With regard to the maintenance of the cables, he must give credit to the manager at the colliery who insisted on the careful use of trailing cables generally. Mr. Mann had not found the repairing of spirally wound cables so difficult as some people would make out. The particular cables he had mentioned had been in use for three years and they had given no trouble.

Mr. STAFFORD said he had found, by experience of coalcutting, that the best safeguard was to bring the machines out periodically (say, every three months) and the trailing cables much more frequently. They were brought into the shops, dismantled, overhauled and examined as often as possible, and as soon as one was taken back another was brought out.

Mr. WOODYATT.—Did Mr. Mann have any trouble due to broken conductors?

Mr. MANN.—All the cores of the trailing cables were of the same size and no trouble was experienced owing to the conductors breaking. In the old type, the pilot cable was carried in the centre and so carried undue stress, but in the cable now used the centre core was the earth core, which was in contact with the earth shield of the main core.

Mr. LUNDON said he had all-rope haulages, but was more or less free from the difficulty of fragments of wire penetrating the trailing cables.

Mr. COWAN.—Nevertheless, the reports of the Electrical Inspector of Mines for past years contain many instances. Although damage of that kind was not observable to the naked eye, it could be traced by a suitable test.

Mr. MANN agreed with the last speaker, and said that though modern trailing cable withstood pressures and indentures much better than earlier types did, he frequently had occasion to extract wires which had penetrated from the haulage rope.

NORTH OF ENGLAND BRANCH.

Alternating Current Motors for Collieries.

A. T. ROBERTSON.

(*Paper read 5th December, 1931*).

To mining electrical engineers the subject of this paper should be of general interest, and particularly so in the North Eeast Coast area affected by the change of frequency. In many cases the change will mean an entire replacement of all motors and though the changeover will involve a considerable disturbance of ordinary routine the collieries will gain with the installation of modern electric plant.

The Supply Companies, as Authorised Undertakers acting on behalf of the Central Electricity Board, are responsible for carrying out the changeover, and they are taking a very broad view with due regard to the future general benefit of industry. Where new plant is required, before power at the new frequency is available, they contribute a proper allowance towards its purchase cost, provided it is designed for 40/50 cycle working, and instead of merely replacing all existing 40 cycle plant, like for like, they permit considerable reorganisation of their consumers' installations subject to necessary and fair financial adjustments within the limits of the drive-for-drive changeover estimate. By this means colliery engineers are given a good opportunity to make improvements in drives and lay-outs and to choose the best type of motor to suit particular requirements. A close consideration of the various types of motors that are now available, will, therefore, be useful.

For colliery services, primarily, the right motor is one that will comply with the Mining Regulations and will give safe and reliable operation under the severe conditions imposed: it must also be of such a type that, as a motor, it will give the best and most efficient operation. Induction motors are ideal for most duties, but synchronous motors and commutator motors must be considered for applications where their special characteristics enable them to give a performance superior to that of the induction type. Generally speaking, it will be right to buy the simplest type of motor that will do the job, because such a motor has fewer parts to go wrong, and therefore ensures a lower maintenance cost.

Of all motors yet devised, the squirrel-cage induction motor is the simplest, the most robust, and the lowest in first cost; and a ventilated motor of this type, started by switching direct on to the supply, should be looked upon fundamentally as the right machine to install, unless it can be shewn that better performance will be given by a motor of a more elaborate type. For instance, a more complete enclosure than that of a normally ventilated motor is often advisable, because by preventing the accumulation of dirt in the windings the risk of breakdown is reduced. For heavy starting duties it is better to use a slipring motor than a squirrel-cage motor with some form of variable gear and clutch between it and its drive. A synchronous motor may be required, because, for example, the improvement in power-factor may save the cost of additional cable. A commutator motor may be chosen because it provides the best means of obtaining efficient speed variation.

It is well to remember that the development of new types of motors and accessories is likely to mean a change from what had come to be regarded as correct practice. For example, the saving in maintenance cost effected by the use of a totally-enclosed motor might not have been warranted in the past for a particular duty, but the lower cost of a self-cooled totally-enclosed motor may now make the position just the reverse.

Detailed consideration of the behaviour of the various types of motors and their limitations will help to determine which should be used for any given duty.

Squirrel-cage Induction Motors.

Squirrel-cage induction motors give practically constant speed with varying loads at 3000, 1500, 1000, 750, 600, and other lower r.p.m. on a 50 cycle supply, or at more than one of these speeds if specially made for the purpose, although this usually increases considerably both the size and the cost. Formerly, before power supply plant was as large as it is now, the most serious objection to the use of squirrel-cage motors was that the starting current taken when they were switched direct on to the line was sufficient to affect the supply voltage; and star-delta, series-parallel or auto-transformer starters were required to limit the current during starting. Such starters reduce both the current and the starting torque in proportion to the square of the voltage applied to the windings, that is, to one-third of the full-voltage value with a star-delta starter and to the square of the tapping-ratio with an auto-transformer starter, e.g. to 9/16 of the full voltage value on a 0.75 tapping. This restriction has limited the application of squirrel-cage motors in the past, but now quite large motors are switched direct on to the full voltage of the line, and the starting torque obtained is sufficient for all but exceptionally heavy duties. The motors are not subjected to any undue strain by being started in this way.

Table I. shews average test results obtained from a large number of motors, and indicates that there is no need to worry about starting torque for any normal motor of well-balanced design, if it is permissible to start it direct on. Motors of the Boucherot type, with double squirrel-cage windings, give about the same starting torques as are shewn in the table; any slight reduction in their starting current that may be possible is counterbalanced by a reduction in their power-factor when running, and by the extra cost of their construction, which it is difficult to make as robust as that of a single winding.

A star-delta starter is cheap, and has few parts that can go wrong; and hence, if the starting conditions are such that one-third of the direct-on starting torque of the motor will be enough to get it away, the small additional cost of a star-delta starter is warranted, especially on a large motor, by the reduction in starting current also to one-third. Star-delta starters are suitable for motors driving centrifugal pumps, fans, motor-generators, and belts with fast and loose pulleys.

An auto-transformer starter, in comparison with a star-delta starter, is not cheap, and, because it contains a short-rated transformer, is far more apt to give trouble. With a 0.58 tapping, an auto-transformer starter gives the same starting torque and starting current as a star-delta starter, and so should never be used in preference to a star-delta starter when such a tapping is known to be required. Its advantage over the star-delta starter is that the tapping can be varied to meet the required starting conditions, within the range of the motor, with the minimum starting current. On tappings below 0.58 the reduction in starting current is rarely worth while, and if a tapping above 0.58 is necessary the inferior starting characteristics of the squirrel-cage motor compared with those of a slipring motor with a rotor starter usually make the latter worth the slight additional cost.

TABLE I.

STARTING TORQUES AND CURRENTS OF SQUIRREL-CAGE MOTORS.

No. of Poles.	Torque (Times Full-Load Torque). Direct Switching.	Star-Delta Starting.	Auto-Transformer Starting (75 per cent. tapping).	Current (Times Full-Load Current). Direct Switching.	Star-Delta Starting.	Auto-Transformer Starting 75 per cent. tapping).
2	3.0	1.00	1.70	6.0	2.0	3.4
4	2.4	.80	1.30	5.0	1.7	2.8
6	2.0	.67	1.10	4.7	1.6	2.6
8	1.7	.57	.95	4.4	1.5	2.5
10	1.5	.50	.85	4.2	1.4	2.4
12	1.4	.47	.80	4.0	1.3	2.3

Many engineers do not believe that the use of an auto-transformer starter can ever be justified, although it does seem to have a limited field for some starting duties when the power supply conditions are restrictive.

The limitations imposed by the use of a squirrel-cage motor are (1) that less than the maximum torque of the motor is available when starting, and (2) that the drive must be a constant speed one.

Slipring Induction Motors.

A wound rotor induction motor, with sliprings, overcomes the starting torque limitation because the external rotor resistance can be so adjusted that the motor will develop its maximum torque when starting. Speed control can also be obtained by varying the external resistance, provided there is load on the motor (without load the speed will rise to the synchronous speed, whatever the value of the external resistance may be); but this speed control is an inefficient, unfortunately, as series speed control of a direct current motor, the loss in the resistance being proportional to the speed reduction, so that at half speed there is as much power wasted in the resistance as is developed by the motor. Slipring motors should therefore be used where the starting conditions are severe, or where the duty requires speed control for a given load as it does in haulages, winders, large compressors, ram pumps, and other similar drives.

Induction motors would be used for every drive if they did not work with a lagging power factor, and if they were capable of efficient speed variation. It is to overcome these inherent limitations that other types have been developed.

Lagging Power Factor.

The magnetising current for an induction motor is obtained from the supply, and the greater the number of poles, the greater the number of times the flux has to be forced across the air gap. This increases the magnetising current, and results in a lower power factor. Induction motors can be fitted with special devices, such as the commutator winding on the no-lag motor, or a Kapp vibrator, to provide self-magnetisation, but these have only a limited application. Synchronous motors require direct current excitation of the rotor, and this is usually provided by a small generator on the motor shaft. They can be arranged to run at unity power factor, or, by increasing the field strength, at a leading power factor, to improve the power factor of the system as a whole.

The development of the self-synchronising type has provided a motor that does not require the services of an expert attendant for starting and synchronising, as was once necessary. There are two types of self-synchronising motors—one with a salient pole rotor for light starting and the other with a cylindrical rotor for heavy starting. Both are started in exactly the same way as an induction motor, and when the rotor winding is connected to the exciter the motor automatically pulls into step as soon as it reaches its full load speed as an induction motor. The salient-pole rotor type is similar in construction to the conventional slow speed alternator, with an exciting winding on the rotor, and a separate squirrel-cage starting winding mounted in the pole faces. Such a motor is started either by being switched direct on to the supply or by means of a star-delta or auto-transformer starter, the method adopted depending upon the conditions of load and supply; and it is subject to exactly the same limitations of starting characteristics as a squirrel-cage induction motor. The cylindrical rotor type, with a two-phase or three-phase rotor winding

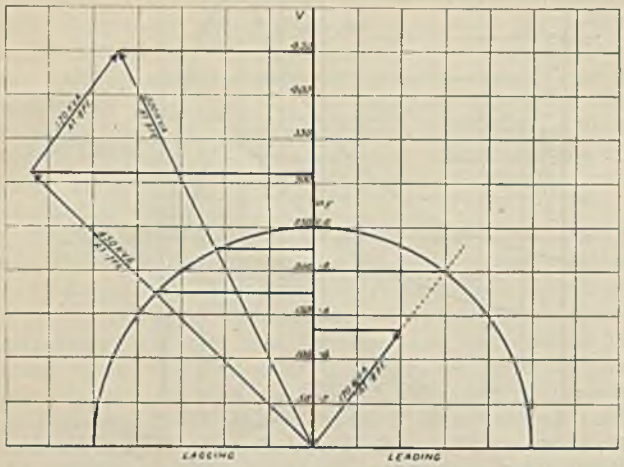


Fig. 1.—Power Factor Improvement.

EXAMPLE:

Assuming: 1. *Additional* 160 *h.p. drive is wanted.*
2. *Existing Load* = 450*k.v.a. at* 0.7 *lagging power factor* = 315 *k.w.*

Determine: *Capacity of Synchronous Motor to improve the Power factor to* 0.9 *lagging.*

160 *h.p. drive requires, say,* 180 *h.p. or* 135 *k.w. input.*

Total Ultimate Load = 135 + 315 = 450 *k.w.*
= 500 *k.v.a. at* 0.9 *lagging power factor.*

From Diagram: *Required Motor Capacity* =
170 *k.v.a. at* 0.8 *leading power factor.*

connected to an external resistance for starting, is like a slipring induction motor, and has corresponding starting characteristics.

Fig. 1 shews how the amount of power factor improvement obtained by the use of a synchronous motor can be determined by taking the vector sum of the existing and the added motor k.v.a. Full advantage should be taken of the facts that a synchronous motor designed to work at about 0.8 power factor, leading, is usually no larger or more costly than one at unity power factor, and that the large amount of leading k.v.a. necessary to improve the power factor above 0.9 is rarely worth the expense. Synchronous motors are used to their best advantage when applied to drives such as those of large, slow speed compressors, pumps and fans, that would put a heavy magnetising load continuously on the generator, transformer, and cables, if induction motors were used.

Efficient Speed Variation.

Efficient speed variation can be obtained by using an alternating current commutator motor. The shunt type, working on the Schrage principle, is a complicated machine not really suitable for colliery work; but the series type is quite simple in construction and enables large speed ranges to be efficiently obtained. It may therefore be used in preference to a slipring induction motor with rotor regulation when the saving in power more than compensates for the increase in first cost.

Fig. 2 shews a large series type commutator motor, and Fig. 3 a smaller one of standard design. These motors consist of a stator similar to that of an induction motor and a rotor similar to a direct current motor armature. The rotor winding is connected in series with the stator across the supply, but in order to limit the voltage on the commutator to less than about 100

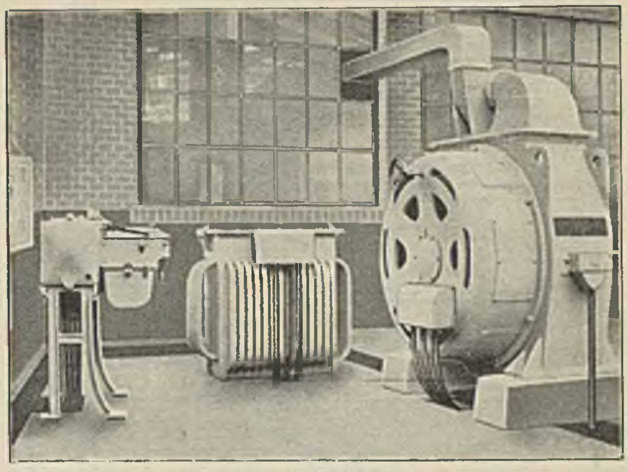


Fig. 2.

volts, and so obtain sparkless commutation, a transformer is usually connected between the stator and the rotor.

No starting gear is required, because the motor can be switched direct on to the line, with the brushes in the starting position, when it takes only a small current, and full control of the speed is obtained by movement of the brushes. Reversal of rotation is obtained by changing-over two stator leads and racking the brushes backwards. For short period reversals, merely racking the brushes back beyond the starting position, without changing the leads is all that is necessary.

In view of the low voltage on the commutator, and the simple construction of the motor, reliable operation without heavy maintenance costs can be assured, and the additional first cost, as compared with that of a slipring induction motor, is to some extent offset because no control gear is required.

Fig. 4 shews a comparison between the power inputs to an induction motor and to a commutator motor for a constant torque, variable speed drive; and Fig. 5 shews the corresponding currents.

Series type alternating current commutator motors have characteristics similar to those of direct current series wound motors with speed limiting shunt windings, and are useful for drivinig fans, compressors, pumps, and the like, in which the loads cannot be detached, or where the motor is always under control; but for drives such as those of machine tools, requiring an adjustable

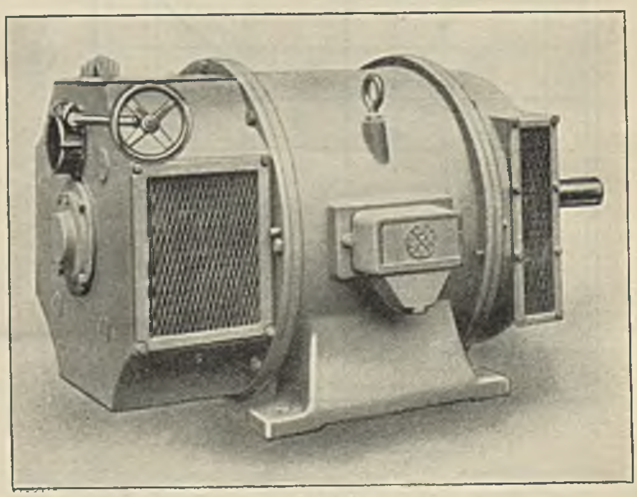


Fig. 3.

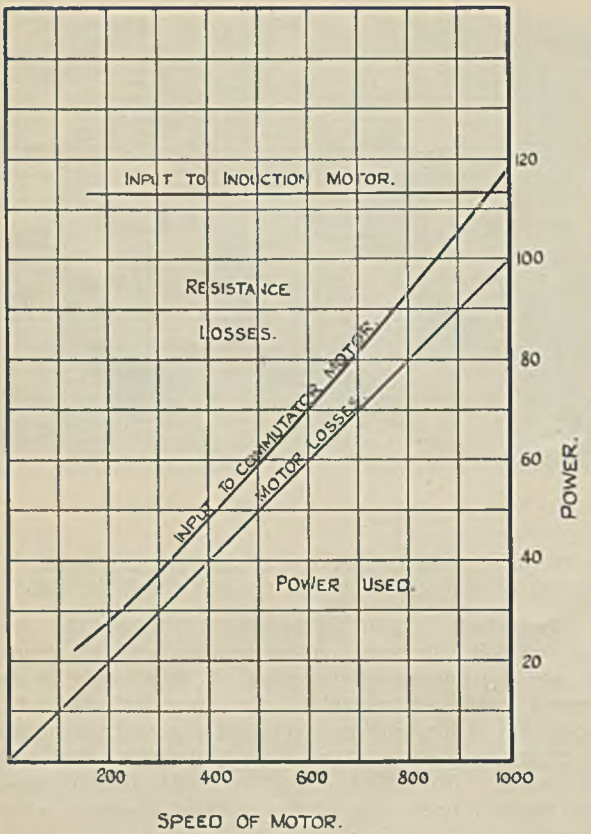


Fig. 4.—Power Speed Curves for Induction Motors and Commutator Motors with Constant Torque.

speed that does not vary with changes in the load, shunt type commutator motors would be necessary.

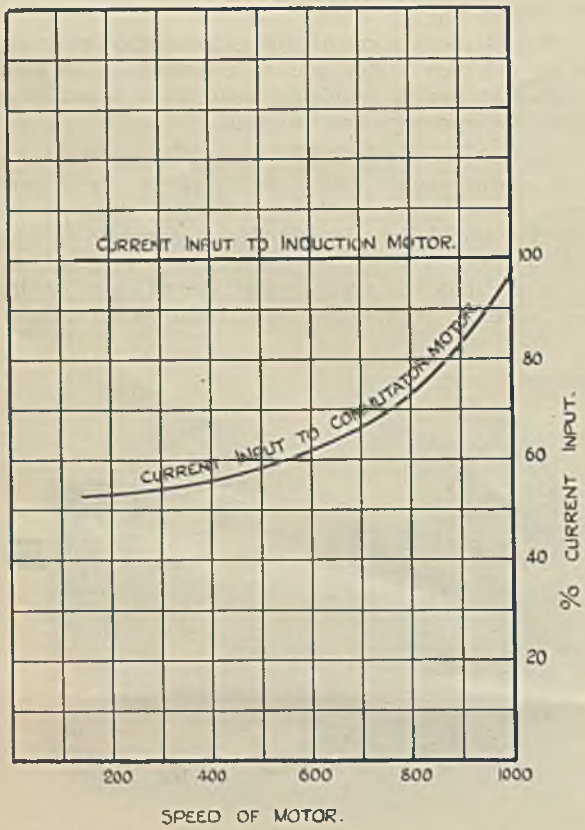


Fig. 5.—Current Speed Curves for Induction Motors and Commutator Motors with Constant Torque.

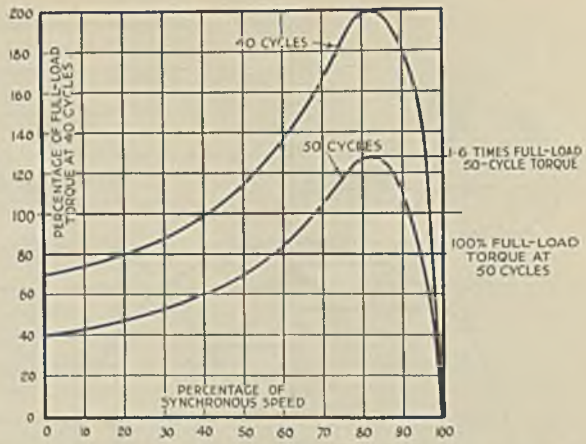


Fig.6.—Speed Torque Curves of 40 cycle. 150 h.p. Haulage Motor when working at 50 cycles with the voltage unchanged.

The first cost of synchronous motors and commutator motors is more than that of induction motors; but it is surprising how often the saving in other directions more than compensates for the additional capital outlay they involve. They have only a strictly limited application to mining, not because they cannot be constructed to meet the conditions, but rather because their special features are not frequently required; for duties that do need the special features, however, their reliable performance can be depended upon.

Change of Frequency.

A 40 cycle motor, when connected to a 50 cycle supply, will run about 25 per cent. faster, and it is sometimes asked why the motor need be changed if the drive can be arranged to accommodate the higher speed. The reason is that at 50 cycles the motor is likely to have insufficient overload capacity. Fig. 6 shews the speed torque curves of a 40 cycle motor working at 40 cycles, and of the same motor working at 50 cycles with the voltage unchanged.

There are two separate and independent limits to the output of an induction motor, namely, temperature rise and overload capacity; and if secondary considerations are neglected it can be said that:

Temperature rise is determined by the losses, which are proportional to the ratio h.p./r.p.m.; and

Overload capacity (the ratio of maximum torque to full load torque) is determined by the flux, which is proportional to the ratio volts/cycles.

By increasing the frequency of the supply to a motor from 40 to 50 cycles, and the supply voltage in the same proportion, say from 440 to 550 volts, the horse-power may also be increased in the same proportion without material change in the temperature rise, the overload capacity, or the other characteristics of the motor. It is not proposed to make any such alteration to the supply voltage, however, and therefore, although a motor is capable of an even greater output at 50 cycles than at 40 for the same temperature rise, its output is limited by its overload capacity to something less than before. The flux is reduced by one-fifth, and unless the horse-power output is also reduced by one-fifth, the motor will not have the same overload capacity as it had at 40 cycles. For example: a 40 h.p., 800 r.p.m. motor designed for 440 volts and 40 cycles is quite good at 50 periods and 1000 r.p.m. for 50 h.p. at 550 volts, but only for 32 h.p. at 440 volts; and this is why existing motors have to be exchanged even when it is possible to alter the drives to accommodate the higher 50 cycle speeds.

Most of the new motors will be wound with more poles than those they replace, so as to leave the speeds more or less the same. Identical synchronous speeds can only be obtained when the replaced motors have a number of poles that can be increased exactly in the ratio 40 to 50 (for instance, 8 poles increased to 10 is exactly correct); but generally one additional pair of poles gives a new speed sufficiently near the old for practical purposes.

Fig. 7 shews power factor curves for a 40 cycle motor and those for a corresponding 50 cycle motor; motors with 8 and 10 poles respectively have been chosen in order to get a fair comparison. More poles mean more magnetising current from the line, and care should be taken when changing over to make the speed of the new motors as high as possible, and not to specify unnecessarily large powers. Fig. 8 shews the 40 cycle and the corresponding 50 cycle power factors likely to be obtained if this is not attended to.

To save the cost and trouble of replacing practically new motors installed after the decision to change the frequency, and in some instances in order to make the changeover with the least inconvenience to the user, special types of motors have been devised to work satisfactorily at either 40 or 50 cycles. These are known as dual-frequency, inter-frequency, and delta-parallel-star motors. A dual-frequency motor is one that runs at substantially the same speed at either frequency. Inter-frequency and delta-parallel-star motors have a constant number of poles and are designed to work at different speeds at the two frequencies; they are useful where the drive can be easily changed to suit the difference in speed.

Dual-frequency motors are not so useful for the North-East Coast changeover from 40 to 50 cycles as for Glasgow, Birmingham, and South Wales, where the change is from 25 to 50 cycles, because there, the number of poles for 50 cycles being twice the number required for the same speed at 25 cycles, a simple reconnection of the windings is possible. In this area the motors must usually have one pair of poles more for 50 cycles than for 40, and no such simple reconnection is possible; but by using a basket-winding, with two coil sides per slot, it is possible to alter all the end-winding connections, and so the number of poles, when the frequency is changed. This can be done relatively quickly, and without disturbing the winding itself; but it is only possible on a motor large enough for the number of slots per pole per phase to be at least as many as half the number of pole-pairs. Dual-frequency motors are useful for driving large machines for important duty, such as winders, and, since these require slipring motors with wound rotors, both stator and rotor windings must be capable of reconnection.

Inter-frequency motors are excellent from the user's point of view; they are normal motors, but are of larger size than the output required at either frequency alone would necessitate. They can only be used, however, as has been indicated, where the drives can be arranged to accommodate the inevitable change in speed. The reason for the increased size as compared with standard 40 cycle or 50 cycle motors can perhaps best be understood by an example. As has been previously explained, a motor that will give 40 h.p. at 40 cycles will do 40 h.p. comfortably as regards temperature rise at 50 cycles with the voltage unchanged, but will be short of overload capacity. To obtain the additional overload capacity at 50 cycles, the flux must be increased in the proportion of $\sqrt{(50/40)}$, i.e., by about 12 per cent. The greater flux requires approximately a 12 per cent. increase in the core-size to carry it, and so on the average an

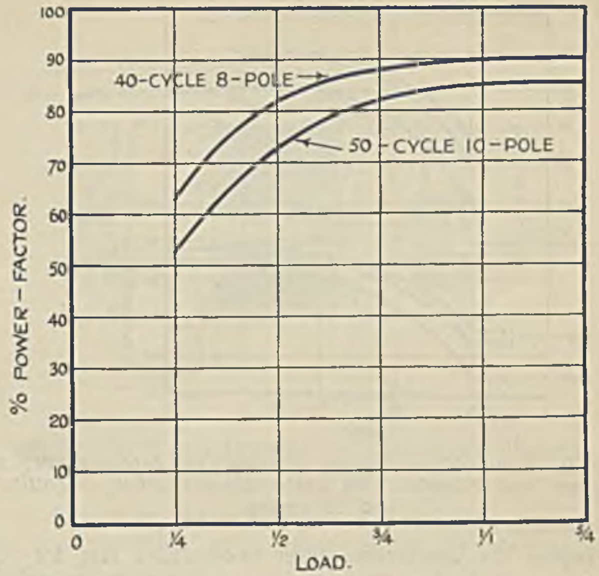


Fig. 7.—Power Factor/Load Curves of 40 cycle and 50 cycle, 60 h.p. 600 r.p.m. Motors.

inter-frequency motor is about 12 per cent. larger than a 40 cycle motor of the same horse-power and 40 cycle speed; when run at 50 cycles, with unchanged horse-power, it is doing only 40/50 of the output its frame-size could give if it had been wound for maximum output at 50 cycles only, and hence it is about 35 to 40 per cent. (1.12 times 50/40) larger than a 50 cycle motor of the same horse-power and 50 cycle speed.

Fig. 9 shews a comparison between an inter-frequency motor working at 50 cycles and a standard 50 cycle motor, and illustrates how much it is to the user's interest to install this type of induction motor whenever possible.

Delta-parallel-star motors are connected delta for use at 40 cycles, and reconnected two parallel-star for 50 cycles. They are useful for application where, owing to the change in speed or to the temporary nature of the 40 cycle supply, the frame-size may be determined by the 50 cycle output. The output of a 50 cycle motor is reduced by one fifth when it is working at 40 cycles, and, provided there is a corresponding reduction in the voltage, the characteristics of the motor will remain substantially the same at the lower output and speed.

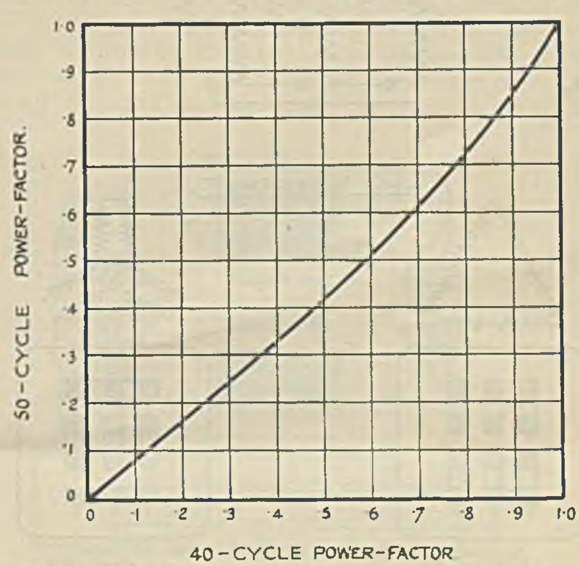


Fig. 8.—Possible Effect of Change of Frequency on the Power Factor of a Supply to Induction Motors.

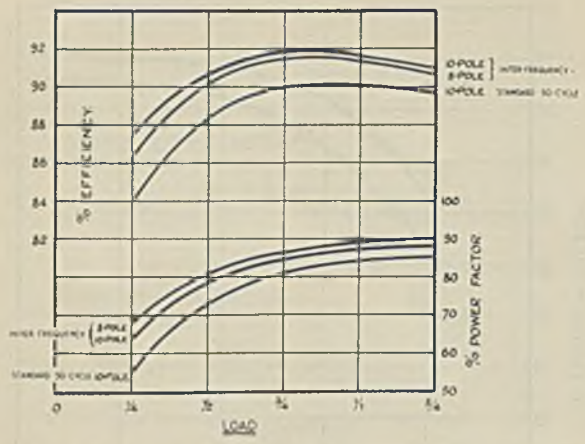


Fig. 9.—Load Characteristic Curves of Inter-Frequency Motors and Standard 50 cycle Motors when operating at 50 cycles.

Changing the connections from two-parallel star for 50 cycles to delta for 40 cycles is equivalent to reducing the voltage to $(440/2)\sqrt{3} = 380$ volts instead of to the strictly correct $440(40/50) = 352$ volts; and hence the flux at 40 cycles is about 8 per cent. greater than is necessary to give the required overload capacity. There is no objection to this, provided due allowance has been made for the additional flux in settling the size of the core. The larger core gives an advantage at 50 cycles over the standard 50 cycle motor, because it slightly reduces the core loss and the magnetising current, and so leads to an increase in efficiency and power factor. Fig. 10 shews a link-box that enables the reconnection to be made in a few moments without in any way interfering with the supply leads or with the terminal box.

These various types of special motors have been devised, largely at the request of the Supply Authorities, in order to simplify the changeover as much as possible. Each type has its own clearly defined applications, and, though more costly, they give a better performance at 50 cycles than standard motors.

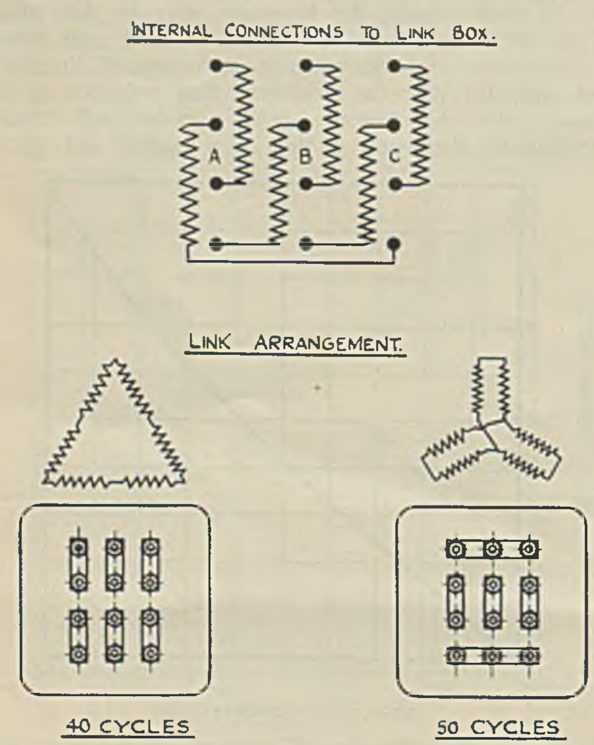


Fig. 10.—Connections of Delta-Parallel-Star Motors.

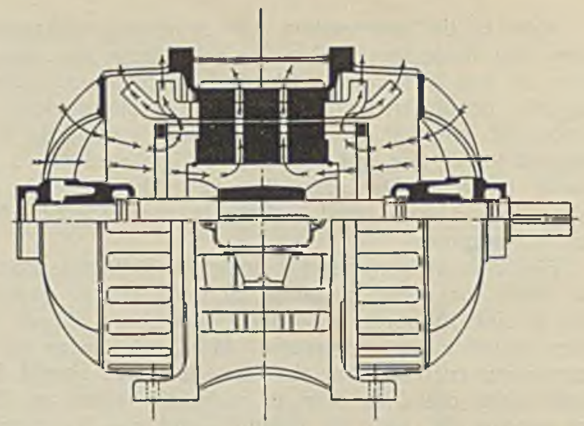


Fig. 11.—Sectional Drawing of Ribbed Frame Protected Enclosed Motor.

DETAILS OF CONSTRUCTION.

The construction of motors, and of induction motors in particular, is probably of more vital concern to the colliery engineer than the consideration so far given to the available types.

Enclosure.

It is interesting to note the gradual development that has taken place, particularly during the last few years, in the style of enclosure. This development is more or less common to all makes of motors, and is the result of an endeavour on the part of manufacturers, without increasing the cost, to provide more reliable machines by giving increased protection against dust and damage, and at the same time to improve the cooling in order to prevent the possibility of high temperatures at any point.

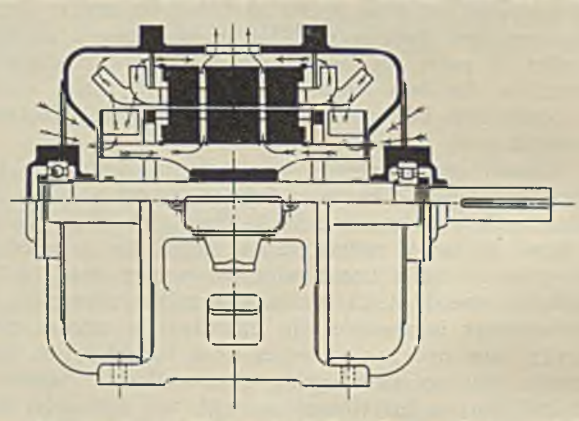


Fig. 12.—Sectional Drawing of Box Frame Protected Enclosed Motor.

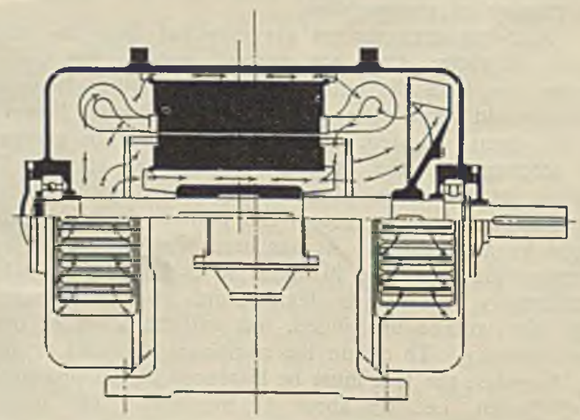


Fig. 13.—Sectional Drawing of Solid Frame Protected Enclosed Motor.

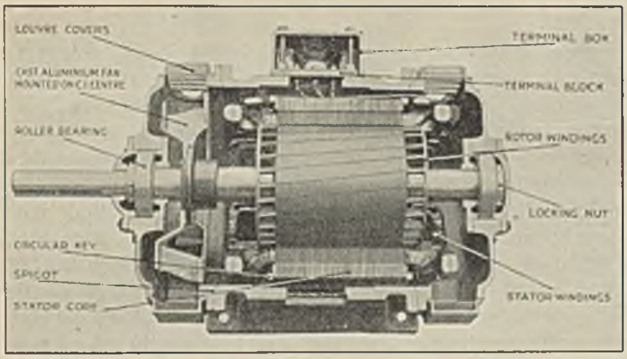


Fig. 14.

Fig. 11 shews a protected enclosure, of a type in use some years ago, which consisted of open-backed stator frames with exposed laminations, the natural ventilation being obtained through holes round the bearings and round the periphery of the end-brackets. The objections to this form of enclosure were (1) its insufficient protection of the stator end windings against dust and damage because they were immediately inside the openings in the end-brackets, (2) the risk of mechanical damage to the exposed laminations and of excessive temperature rise owing to a reduction in the radiating effect of the laminations when they become lagged with dirt, and (3) indifferent cooling because ventilation was obtained only from disturbance of air by the revolving rotor.

These objections were overcome subsequently by what is now generally known as the box-type stator frame. Fig. 12 shews how this frame encloses the laminations; end-brackets without holes in the periphery may be used without interfering with free ventilation from both ends of the motor through the end windings and finally out of holes in the box stator. Small diameter fans fitted at each end of the rotor to ensure adequate cooling came into general use at about the time of the introduction of this type of frame.

Fig. 13 shews an enclosure now becoming fashionable. A fan of larger diameter than the rotor is fitted at one end of the motor to draw the ventilating air in at one end-bracket and expel it at the other. This arrangement gives the designer better control of the ventilation, and enables a solid casting or a fabricated frame to be used, enclosing the stator laminations. Fig. 14 shews a section of a motor with this type of enclosure, which may be considered the most up-to-date.

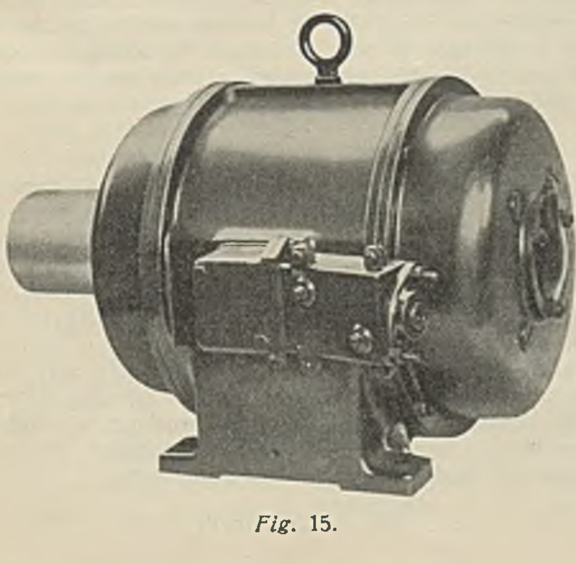


Fig. 15.

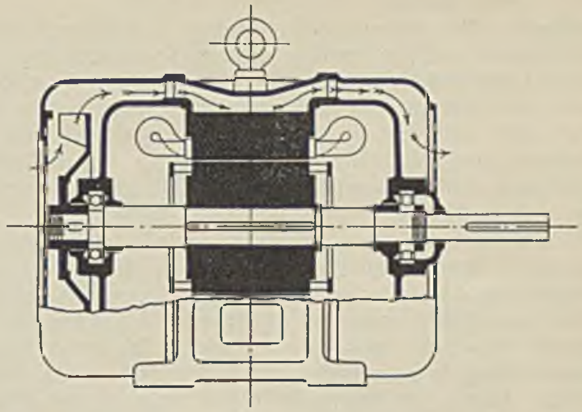


Fig. 16.—*Sectional Drawing of Fan-cooled Totally-Enclosed Motor.*

It is difficult to see how it can be materially improved for the protection of a motor cooled by air passing through the windings.

Totally enclosed motors depending for cooling upon the natural radiation from their cases are large and expensive, except for small powers. Fig. 15 shews the general appearance of a small-power motor of this kind. Pipe-veltilated motors have a very limited field of use in collieries, being applicable chiefly to surface duties where there may be a chance of leading in clean cooling air. Fig. 16 shews the ventilating arrangements of a type of motor developed to overcome the two difficulties just referred to. It is a totally-enclosed, self-cooled motor, which has its windings and working parts fully enclosed, but is cooled by a draught of air directed over the outside of the enclosure. In price and size, such machines are intermediate between protected or pipe-ventilated motors and natural radiation totally-enclosed motors.

Fig. 17 shews another form of total enclosure suitable for large frames. This is the external-radiator-cooled type, in which the internal air of the motor is circulated through a separate radiator where it is cooled before being returned to the motor. A radiator consisting simply of a bank of plain tubes expanded into a pair of sheet-steel plates needs very little attention, because the high velocity draught prevents the dust from settling on the smooth radiating surface of the tubes. An occasional clean-out is quickly done if the bank is designed for easy withdrawal. It is often convenient to arrange the radiator in the bedplate of the motor, so that one fan, driven by the motor, circulates internal air, and another blows external air over the

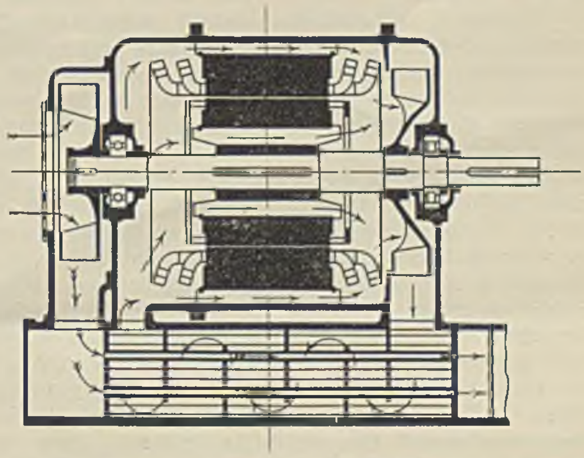


Fig. 17.—*Sectional Drawing of Radiator-cooled Totally-Enclosed Motor.*

radiator. This arrangement is preferable, because it makes the motor and its cooling gear self-contained, and no special interlocks are necessary to ensure that the cooling fans are always working when the motor is in use. For dirty positions, it will generally be found that the reduced cost of maintenance outweighs the additional first cost of these special types of totally-enclosed motors as compared with that of protected motors.

The output of a naturally cooled totally-enclosed motor is approximately proportional to the surface area of its frame, i.e., to the square of its dimensions, because it is upon this area that it depends for radiating its losses; and the weight of a motor is approximately proportional to its volume, i.e. to the cube of its dimensions. Hence, the larger the power required, the greater is the ratio of weight to horse-power (roughly, four times the horse-power needs a motor of eight times the weight), which means that large totally-enclosed motors must be of the self-cooled or radiator cooled type unless they are to be prohibitive in size and cost.

End-Bracket Location.

The importance of end-bracket location for obtaining concentric air gaps cannot be over-estimated, particularly in motors of the induction type, which have short air gaps to limit the magnetising current as much as possible and so to obtain good power-factors on load. Merely to bolt the end-brackets to the frame, and to depend upon the friction between the surfaces to retain the brackets in position, is obviously unreliable. At one time, some makers fitted adjustable screws to the brackets, bearing upon machined faces on the stator frame; but this method of location has now been discarded, mainly because it was a skilled fitter's job to reassemble the brackets, but also because the bearing surfaces between the ends of the screws and the machined faces were too small to be reliable.

Dowel-pins, inserted in holes drilled and reamered out while the brackets are held in the correct position, are probably the ideal means of ensuring a perfectly uniform air gap; the original fitting at the maker's works must be done by a skilled workman, but subsequent correct reassembly is assured. Dowel-pinning brackets, however, though good engineering, has practical objections against it: brackets are not interchangeable, and spares have to be drilled, reamered, and fitted with pins on site. Spigots are now favoured by most engineers as the best practical means of locating end-brackets, because correct reassembly and interchangeability are ensured; but unfortunately they cannot be considered ideal, because there is no adjustment to allow for the correction of machining tolerances, which may be all in the same direction and may thus throw the rotor slightly out of centre.

To obtain substantially uniform gaps without adjustment of bracket location, parts must be machined to exceedingly fine limits, and it is essential that the following pairs of operations should each be done without changing the machine tool setting: (1) machining the stator bore and spigot, (2) machining the end-bracket bearing bore and faucet, (3) machining the rotor spider bore and outside diameter, and (4) grinding the shaft at the bearings and core support; and special care must be taken to ensure that the outsides and insides of the core-plates are concentric. There is not so much objection to grinding the rotor core as there is to grinding the stator bore, on account of the low speed at which it is cut by flux. Some makers do grind the rotor, and so save the cost of the extremely fine machining tolerances otherwise required. Both spigot and faucet should be continuous round the whole circumference, since otherwise it is easy for the short bearing surfaces to be filed or damaged in such a way as to spoil the accurate location.

Bearings.

For induction motors, which must have relatively small air gaps, sleeve bearings are not really suitable on account of their tendency to wear, except for large motors in which the air gaps are no longer small compared with the working clearance of the bearings; they are sometimes necessary, however, when a motor has to be solidly coupled to a driven machine fitted with sleeve bearings. Ball or roller bearings have now been brought to such a state of perfection that they can be relied upon to give good service, even on exceptionally bad drives, provided they are kept free from extraneous grit and moisture. For the great majority of drives, where end location of the motor shaft is required against a moderate end thrust, a good arrangement is to provide a roller bearing at the driving end, where the journal load is greater, and a ball bearing at the other end. If the ball bearing is of the same size as the roller bearing it is capable of withstanding a continuous end thrust in addition to the journal load. This arrangement has the advantage of simplicity in the fitting of both bearings; the housings and caps are the same at both ends, and the outside races of both bearings can be securely located endwise without throwing any internal end strain on the motor parts because of unequal expansion when the motor warms up.

Lubrication.

The temperature of motor bearings is apt to be higher than that of bearings working away from the heat of a motor, and so the grease should have a high liquefying point. The main object of the grease is to prevent dirt and moisture from getting into the bearings; and the best way to ensure freedom from bearing trouble is to open up the bearings every twelve months or so, clean out the old grease, and completely fill the housing with new grease, which should be free from moisture and grit, and chemically inert to the metals of the bearings. A small quantity of grease inserted occasionally through a bearing plug to make up for any wastage will help to ensure long service. Grease nipples make this a quick and simple operation.

Shafts.

Motor shafts must be of ample diameter between the bearings for stiffness. The use of special alloy high-tensile tempered steel gives increased durability as well as strength to the shaft extension. When the dimensions of a motor allow it, the rotor core should be built on a spider to which both the core and the shaft are keyed. This makes it a comparatively simple matter to replace the shaft; but it is also possible to do so even if the core is built direct on the shaft, provided it is suitably constructed and care is taken not to damage or disturb it while it is removed from the shaft.

Insulation of Windings.

Flexible mica protected against mechanical damage is the best insulation for the slots, and should be used on all motors. The use by some makers of fibrous materials, such as presspahn, is to be deprecated. Impregnated cotton forms a suitable insulation between the turns of the winding, except that (1) it should be reinforced with empire tape on the end turns of a high-voltage winding where switching surges may give rise to a high voltage between turns; and (2) asbestos covered wires should be used in motors working at higher temperatures than, say, 180 deg. F. Asbestos is very hygroscopic, and needs to be well impregnated.

(*To be continued*).

MIDLAND BRANCH.

Visit to the Research Station, Buxton.

On Sunday, August 31st, 1931, a visit was paid by the Midland Branch of the Association, jointly with members of the North Western Branch, to the Research Station at Harpur Hill, Buxton, under the control of the Safety in Mines Research Board. The party consisted of a total of 75, and assembled in the Lecture Hall, where Dr. A. F. Beadle, the Director of the Station, briefly indicated the lines on which research was being carried out.

The party were then conducted to the gallery used for experimental explosions, and after inspecting this reassembled at the "View point," from which they witnessed a most violent and awe-inspiring explosion

After this the visitors were divided into groups, each under the charge of a most efficient guide, and inspected the various testing departments where details of the work in hand were fully explained. Members were particularly interested in the Test House devoted to the testing of electrical apparatus for "flame-proofness," and considerable interest was also shewn in the work being carried out on gob fires and explosives.

The party was then entertained to an excellent lunch, and in the afternoon a lecture on "Underground Lighting" was given by Dr. Wheeler. The lecture was followed by discussion, at the conclusion of which Mr. C. D. Wilkinson, President of the Midand Branch, proposed a vote of thanks to Dr. Wheeler and also to the Director of the Station, Dr. Beadle; this was seconded by Mr. Roseblade, President of the North Western Branch.

WEST OF SCOTLAND BRANCH.

Lighting in Mines.

Discussion.

A meeting of the West of Scotland Branch was held in Glasgow on 11th November last. Mr. Arthur Dixon, President of the Branch, presided, and there was a good attendance of members.

Mr. ARTHUR DIXON, President, introduced the discussion on pit lighting which, he said, was a subject of important topical interest: the old order seemed to be giving way to the new and personally he was finding the position a little confusing. He, therefore, hoped that the pending discussion would tend to clear the position. The business of the meeting was twofold: first a general discussion and, secondly, the consideration of the amendments put forward by the Committee of the Association detailed to deal with this matter, and make recommendations. The Committee wished to have definite recommendations from the Branch.

Mr. Stevenson had kindly offered to start the discussion.

Mr. STEVENSON.—Some time ago the Branch listened to a lecture on "Industrial Lighting", the occasion being a joint meeting with the Colliery Managers' Association. In the lecture figures were given as to the increases of output and diminution of accidents due to increasing an illumination already of a comparatively high standard. An increase from 8 candle feet to 12 candle feet resulted in an increase of output of something like 15 to 20 per cent. Of course, the intensity of illumination at the coal face is only something like 0.001 of a candle foot. Mr. Stevenson believed that the figures thus given kindled live enthusiasm amongst the mine managers, but it faded with the realisation that such good things were not for them: that the regulations and costs were prohibitive.

The task was, therefore, to overcome those two great difficulties: it was now necessary to shew that adequate lighting at the coalface and in-bye could be provided without any increase of danger but, on the contrary to shew that adequate and proper lighting would actually be a most effective means of securing increased safety, for better lighting would inevitably lessen the risks and danger of falls. After that it was necessary to shew that the increased costs of the better lighting were more than recoverable by reason of the increased output due to more efficient working and fewer accidents and stoppages.

Nystagmus costs the coal industry large sums each year; it was entirely due to poor lighting. There was also another item which could fairly be placed on the credit side: the gloom in which the miner works affects not only his eyes but also his mind. One might almost say that the very word "miner" is synonymous with depression and discontent. The mechanic would be ill to deal with if he worked in a shop where the only illumination was a lamp of about one C.P. over each machine.

Turning to the practical side, Mr. Stevenson said that much could be done already under the existing regulations and by special permission.

Even in places where electric power is barred one can use an air turbine lamp. It is rather interesting to see that the safety, as far as the lamp is concerned, is secured by part of the exhaust from the turbine going round the lamp. (Mr. Stevenson here exhibited a sectioned example.) These turbine lamps are also being fitted to compressed air coal cutters.

It is also permissible to use high candle power battery lamps. (Specimen exhibited.) As many of these as desired may be used along the face. This fact was of particular interest as shewing that practice is at last getting away from the fetish of the hand lamp with its limitation of about 5 lbs. in weight, and candle power. Once the principle that the source of illumination is not to be carried to the face by the miner but taken some other way is generally accepted, a big step forward will be made.

Mr. Stevenson said that he looked upon the turbine lamp and the big battery lamp as purely temporary expedients. There must be lamps strung out along the face supplied through a transformer and safety switch gear at the gate-end; the whole, lanterns, cables and switchgear, being moved forward with the conveyor and the coalcutter as the face advances. Since the length of the cable, per unit of the system, is very short and it is necessary always to transform down, the lowest practicable lighting pressure should be used. He would suggest 12 volts. The cable would be of the tough rubber-sheathed type and would include an earth wire in the ordinary way. Experience had shewn that earth sheaths consisting of small wires were not wholly satisfactory, so for protection he would favour the heavy tough rubber sheathing of not less than 150 mils. in thickness. Even though the cables would only be bent not oftener than once in 24 hours, when the whole equipment was being flitted forward, still the use of an armoured cable under such circumstances would be very cumbersome.

Mr. Stevenson considered that the whole unit, cables, lanterns and the plug which goes into the gate-end box, should be assembled at the surface or in some gas-free part of the pit ; and it should be grouped together in such a way that it would be impossible for the men at the face to remove any part. He did not favour the idea of the lanterns being plugged into the cables ; the elements would all be pulled apart as the gear was flitted forward: he held that it would be better to have the whole thing fitted into an indivisible unit.

Mr. ROGERSON.—The Report of the findings of the Committee of the Association appointed to deal with the proposals of the Mines Department for Pit Lighting suggests that in our discussions special consideration should be given to the following questions :—

Safety Lamps.

(a) Weight of Lamp.
(b) Effect on Nystagmus Cases.
(c) Accidents generally.
(d) Increased Output and Clean Coal.
(e) Suggestions for forms of well-glass and anti-glare devices.

(a) *Weight of Lamp.*

The chief objection to the use of cap electric lamps is the weight of the battery (about 5½ lbs.) slung on the back. The weight of a hand lamp, either oil or electric, has not the same inconvenience, as it is mostly whilst travelling between the pit-bottom and the working face, or *vice-versa,* that the hand lamp has to be carried. It is usually hung on a prop while the miner is at work. Nevertheless, any increase in weight beyond the present weight of electric hand lamps (about 6½ lbs.) would constitute an undesirable burden on the worker. At the present stage in the evolution of portable electric lamps, no gain can be achieved in candle-power capacity without adding to the weight of the existing equipment.

(b) *Effect on Nystagmus Cases.*

A comparison is given in Table I. of the percentage number of cases of Nystagmus reported in the Scottish coalfields during the years 1927-1930, and a percentage comparison of the various types of lamps used.

It will be observed that the percentage incidence rate for electric cap lamps and oil and acetylene open lights is very low compared with that for hand electric and oil safety lamps. Also, that the incidence rate for electric hand lamps is not far removed from that of oil safety lamps. This would indicate that the installation of electric hand lamps is not in any way contributing towards diminution in the cases of nystagmus reported. In view of these figures it is disappointing to observe that in 1929 almost 80 per cent. of the total electric lamps installed were of the hand type. Mr. Rogerson said that, in his opinion, it mattered little what increase in candle power may be ultimately enforced by the Mines Department, so long as hand electric lamps were allowed to be installed for general use. Any increase in candle power would only tend to aggravate the incidence rate, due, especially, to the increased element of glare. A practical illustration of this disability is to walk along a haulage road close behind someone carrying an electric hand lamp. Unless the light from the hand lamp is shielded, it is a most unpleasant experience and obviously one which is detrimental to the eyesight.

The preference, in most cases, for hand lamps as against cap lamps is due to the inconvenience of the battery slung on the back of the user during working hours. To most people who have had experience in the use of cap lamps, this inconvenience is more apparent than real and is readily forgotten after the cap lamp has been used for a few days.

In the American Coalfields, where nystagmus is practically unknown, the mines are worked with closed lights ; head lamps are chiefly used and flood lighting in the workings is in general use. In Scotland 65 per cent. of underground workmen use open lights or cap lamps, while in the remainder of Great Britain the proportion is not more than 10 per cent. Notwithstanding these figures, the incidence rate for nystagmus is much higher for Scotland than for the whole of Great Britain or South Wales and Monmouthshire. This is perhaps due, or at least partly due, to the large percentage of hand lamps in use in Scotland.

(c) *Accidents Generally.*

The diminution in accident rate in mines due to improved lighting cannot be calculated mathematically, but there is no gainsaying that a large reduction would occur. Perhaps the best way to visualise what improvement is likely to take place is to imagine an engineering works being worked in utter blackness except for the aid of a small 2 volt lamp which, if of the hand type, would require to be laid on the floor or hung up before the user could make any attempt to perform a little work. With such means of illumination factory inspectors would be kept much more busy than mines inspectors investigating accidents. On the other hand, what would the efficient lighting of some works mean to the miner in the gloom and darkness of underground works?

(d) *Increased Output and Cleaner Coal.*

There is no doubt that better lighting would increase man-shift output and, especially in seams where dirt bands exist in the coal seam, cleaner coal would be produced. It must be borne in mind that in many seams containing dirt bands, the dirt is almost indistinguishable from coal. In the poor illumination of present-day mining it is not to be wondered at that 10 per cent. to 15 per cent. of pit output is dirt. It has also to be remembered that it costs the colliery company the same amount per ton for this dirt as it does for the actual coal raised.

(e) *Well-glass and Anti-glare Devices.*

Much experimental work has been done with different types of electric lamp glasses, but in the present stage of the low candle power capacity of these lamps any type other than the clear glass interposes an obstruction, which prevents light radiation and diminshes the illumination or radiating power of the lamp, even if the interior candle power remains the same. Consider the case of a room in daylight with clear glass in the windows and the substitution of frosted glass panes, the lighting is greatly reduced: to go further and colour or darken the glass, means still further to diminish the light radiation. So it is with safety lamp glasses. To interpose a coloured glass, is to diminish light emission, and when it is realised that less than 5 per

TABLE I.

Types of Lamps	Total No. of Cases Reported	Yearly Mean No. of Lamps Used	Mean Yearly Incidence of Cases per 100 Lamps in Use
Electric Hand Lamps ...	37.26% ...	15.59% ...	0.95
Oil Safety Lamps ...	54.28% ...	18.75% ...	1.15
Electric Cap Lamps ...	4.27% ...	7.12% ...	0.19
Oil Open Lamps ...	1.61% ...	18.18% ...	0.035
Acetylene Open Lamps ...	2.58% ...	38.36% ...	0.025

cent. of light is reflected from the black surroundings underground, any changes or modifications which entail further reductions at the light source must be destroying what is presumably the aim of this discussion, namely, to improve the present standard of lighting. Mr. Rogerson said he would very much have liked to enter further into this question, but on this occasion he felt he would be taking up too much of the time of the meeting.

Desired Amount of Illumination.

In regard to the question as to sufficient illumination: it is known that the retina is the portion of the eye which receives the image; all objects looked at are reflected on the retina. In good light, one sees the object looked at with the macula. In bad light, one cannot see with the macula and another portion of the retina, called the periphery, has to be used. A practical demonstration of this is as follows:—

When one goes underground, or into a cinema, one is nearly blind for a period; then the sight returns. What really happens is that one is changing over from the macular to the peripheral vision. All tradesmen working under ordinary light conditions use the macula for observing and following their work, but it is not so with the underground worker using a lamp of one candle-power or less. That meagre light is not good enough for macular vision and the miner's eyes must necessarily use the periphery of the retina which with constant use, or abuse, ultimately fails and in many of these cases the workers develop nystagmus.

Thus the question which arises is as to what amount of illumination is necessary to ensure macular, or central, vision. The border line between peripheral and macular vision is given by physiologists as corresponding to a field of brightness of about 0.0073 milli-lambert. With out entering into any mathematical calculations it appears that lights less than 3.5 to 4 candle-power are incapable of giving sufficient illumination to ensure the employment of the worker's central or macular vision. It does not appear therefore as if the new proposals, so far as portable safety lamps are concerned, are likely to assist materially in diminishing nystagmus.

Other Means of Direct Lighting.

In concluding his remarks, Mr. Rogerson said that more progress could be anticipated in the proposals to revoke Sections 32 (1) (i) of the C.M.A. and also to revoke General Regulations 78 and 132 (IV), as these rules had, so far, prevented any system of direct lighting at the coal face in safety lamp workings from being adopted. Let it be understood that over 80 per cent. of nystagmus cases occur at the coal face and over 50 per cent. of the fatal accidents in mines also occur at the working face.

There is no doubting the ability of manufacturers to supply suitable flame-proof lighting equipment, and there is even less doubt as to the average energetic colliery engineer being able to maintain it in a safe and satisfactory condition. Mr. Rogerson indicated that the number of electricity accidents fully confirmed this point. It should be borne in mind, however, that with a direct lighting system at the coal face the miner must necessarily require the use of a portable safety lamp to travel to and from his work. Mr. Rogerson referred to the device designed by Professor Thornton and mentioned by him (Mr. Rogerson) in a paper read before this Branch in 1925. A double-filament lamp was designed whereby the workman could use a self-contained battery while travelling in the workings and, when at work at the coal face, switch his other filament on the lamp on to a lighting supply at the working face. That was quite an ingenious and feasible proposition, but restrictions in the regulations had so far prevented any progress being made. Professor Thornton also found from experiments that an electric spark from a low voltage high-frequency current would not ignite an inflammable mixture of gas, unless an excessively large amount of current was passing in the circuit at the time. Should the regulations be revoked, that point would also again receive very careful consideration.

Mr. JAMES R. LAIRD said that on looking over the past journals (*The Mining Electrical Engineer*) he found there had been several important articles on underground lighting from as far back as 1926. Before referring more particularly to them, he would like to give a few personal notes on the problems introduced.

The problem of coal face lighting has been in existence ever since coal came to be mined or won in the seam leaving a floor and roof with the coal removed. With present-day knowledge the coal face can be lighted by large capacity battery lamps or by suitable lamp fittings clamped to a flexible armoured cable supplied with a suitable a.c. voltage and frequency which will not ignite gas, say, 12 volts at 150 cycles. If we know definitely that such lighting is required, it is only a matter of cost to carry it out with the most suitable material and means at our disposal. The lighting installation will require careful supervision which would limit its economic use to a fair thickness of coal seam. Where the supply is d.c. a motor alternator would have to be installed. Compressed air motors had been suggested as a suitable means for driving the lighting alternator. If he, Mr. Laird, were to be asked to light a coal face he would arrange for a suitable a.c. supply which would terminate in gate-end switches with suitable plugs. The lamps would be fixed in cast steel or other suitable housings with thick glass windows, to be on the floor or pavement and have a wide angle outlook to shine over the floor, face, and roof and the beam of light to project along the face to right and left having a lamp say every 10 to 20 yards, depending on the height of the seam. The lamps would be grouped in batches of, say, four lamps, securely fixed mechanically to the flexible armoured cable. Covers would be provided to protect the glasses from breakages and scratching, etc. while being removed to the next site.

The cost would be the only factor which would determine whether the face could be lighted economically or not. A suitable lamp fitting would cost say 20s. each, the length of cable and plug say £6, so that each unit of four lamps would cost £10, and it would last at least six months. The cost of carrying forward the supply is well known in coalcutting and the lighting supply would advance at the same rate. In the light of present knowledge Mr. Laird said he could not see any royal high road successfully to accomplish coal face lighting except by means of a straightforward robust and well supervised system such as he had described.

Mr. Laird then referred to the paper read in 1926 by Mr. Williams at a joint meeting of the Yorkshire Branch and the Colliery Managers. Mr. Williams put the cost of lighting at 1d. to 1½d. per ton, and members who would look up *The Mining Electrical Engineer* for January 1926, would find that paper very interesting reading.

The PRESIDENT mentioned that the general part of the discussion might now give way to the consideration of the amendments put forward by the Committee of the Association. They were particularly fortunate in having Mr. Muirhead present at the meeting. He was there in a treble capacity, first as an old Branch President, secondly an old President of the Association, and thirdly, what was most important to them on this particular occasion, as the Convener of the Committee which had issued the leaflet of amendments. He had therefore much pleasure in inviting Mr. Muirhead to give them the benefit of his views.

Mr. A. B. MUIRHEAD.—The history of the case goes back some distance further than the appointment of the Committee. It is a considerable time since the Home Office made it known to the mining world generally that they were prepared to make it easy for colliery owners to extend the system of lighting, not only to the main roads but to the faces, and that they were prepared to grant exemptions allowing the present regulations to be cancelled, in cases where suitable fittings for either purpose were brought before their notice. Furthur, it so happens that another Committee in which Mr. Anslow and he (Mr. Muirhead) were particularly interested, took up the subject of fittings for main road work. The problem was that the standard well-glass fitting as specified by the B.E.S.A. would not take a 60 watt gas-filled lamp without over-heating and the reason for designing the fitting which was under consideration was to get sufficient area to dissipate the heat. Since then much practical work has been done in various districts in attempting to design a fitting which would meet the requirements, which would keep down the temperature of the lamp cap and which at the same time would not be too clumsy or expensive. Following that, the question of face lighting arose. It is known, as intimated already, that the Mines Department are particularly anxious to help in the matter in adopting a better system of face lighting and that if a suitable range of fittings could be got out which would enable the face lighting to be supplied from the power circuit they would be all the better pleased. The first thing was to consider voltages of 100 or 110 but, partly as a result of some information which Mr. Anslow and he had received, they made up their minds that a 12 volt motor-car lamp was the most robust type of lamp that was manufactured. In comparing notes with Mr. Horsley (H.M. Electrical Inspector of Mines) he, after some consideration of the subject, agreed that the 12 volt lamp might be adopted if it could be shewn that it was possible to transmit the power along the face without an undue drop in voltage. From some information which they had received they were able to assure themselves that the 12 volt motor-car lamp would withstand a voltage of 14 and that the voltage could be allowed to drop to 10½ without either affecting the lamp or unduly affecting the candle-power. Thus a great deal of work had been done which would be available for the use of the Association before very long, in designing a range of fittings that would enable a lamp of the same type as the present accumulator lamp to be used but with the strong lantern or casing which had already been advocated by Mr. Laird.

Mr. Muirhead was pleased to say that this Branch of the Association could be complimented on having made some remarkably good contributions on this subject already. They had got together a considerable amount of valuable information which would be laid before the Committee and which would in due course reach the Mines Department.

Reverting to the point about the connecting cable, some of them had come to the conclusion that if a standard section of four-core trailing cable were adopted with the lamps connected alternatively between each phase and the earth wire and the fittings spaced at least eight yards apart, it would be reasonable to have a circuit of nine lamps on each side of the gate road where the transformer would be placed. They were therefore working on the assumption that it would be found possible to design a range of lamps and fittings with a small transformer which would enable the lighting to be carried out in that manner. Mr. Muirhead had no doubt that the various members of the West of Scotland Branch in common with the members of certain of the other branches who were looking into the subject would be able to place before the Committee such detailed information as would enable them to probe to the uttermost those various points which were enumerated on the document which has been circulated. What he had said about the main road fitting and the particular type of face fitting had not yet reached the Committee but it would do so in due course. If anything he had said so far would help the members present to add to the discussion or to ask questions likely to throw more light on the problem, he would gladly give them all the help he could.

Mr. FRANK ANSLOW said Mr. Muirhead had put the position very clearly, and there was little he need add. He would, however, like to make comment in regard to the question of voltage. Mr. Laird had mentioned that 50 volts at 150 periods per second had been demonstrated to be safe, and he, Mr. Anslow, would admit that at one time he was in favour of this higher voltage as giving a bigger range of distribution. Latterly, however, he had come to change his views in favour of the 12 volt motor-car type of lamp, as being more robust and probably sufficiently adequate to give the desired range of distribution; he would therefore suggest that it might help to simplify the discussion if they were to concentrate their ideas on the probabilities of adopting 12 volts as against the higher voltages. Apparently 12 volts, even with its limitations, was quite enough to give a range that would cover a sufficient distance on each side of the gate-end box and, if that that was that case, it should be satisfactory.

Mr. FRANK BECKETT said he rather gathered from Mr. Muirhead's remarks that the B.E.S.A. Committee were concentrating upon the design of a fitting for mines lighting. It seemed to him that they were making a mistake in starting off from the old well-glass fittings for industrial use as a basis; that they should consider the problem from the mining point of view. What was wanted for mines, if possible, was concealed lighting. The source of light should be shielded from the eyes of the men walking on the roadway. For example, consider the ordinary retail shop lighting: in the old days the lamp starkly glared in the face of the window gazer who could see little else but the lamp, but in the up-to-date lighting the source of the light was entirely hidden from view. The same principle should be followed in mines lighting in the road lighting and in the face lighting. Modern methods should be such that the source of light was concealed and the illumination directed on to the point where it was required for useful purpose.

Mr. MUIRHEAD said Mr. Beckett had correctly described the requirements. The B.E.S.A. Committee directed their efforts towards getting a fitting which would give efficient light and not be too glaring.

Mr. HOWATT referred to the remark passed that after reaching a certain candle-power the lighting did not so much tend to cause nystagmus. There was a fitting now available fitted with prismatic glass which obviated a great deal of the glare of the lamp. It was, of course, worked at about 100 volts and 60 watts.

Mr. ROGERSON asked Mr. Muirhead whether he could give them any idea of the effect of the voltage being brought from 12 to 10½ in the motor-car lamp; would not the fall in candle-power be something in the region of 40 per cent?

Mr. Rogerson then referred to the remarks by Mr. Beckett, who advocated the modern system of light reflection underground. It appeared to Mr. Rogerson that the suggestion was impracticable at the present time because light reflection underground was very much below 5 per cent., and to throw the light against the roof so that it could be reflected and diffused on to the road over 90 per cent. of the initial volume of light would be dissipated and lost.

Mr. BECKETT replied that he had apparently been misunderstood; he was not advocating indirect lighting at all, but that the lamp bulb itself should be recessed into the fitting so that the man could not actually see the lamp until he was very close to it. If there was a bulkhead fitting in the wall, which would shine up and down the road until the man was three yards away he would not actually see the lamp and glare would thus be avoided.

The PRESIDENT, referring to the circular issued by the Association Committee, said he noticed that the figure of candle-power put forward and recommended as minimum by the Mines Department had been increased from 1.3 to 2.25.

Mr. MUIRHEAD said that had been done because of information given to the Committee that the higher value lamps could now be obtained, and it was desirable to allow industry the benefit of the progress which had been made.

Mr. RUTHERFORD gave particulars of a lighting equipment mentioned by Mr. McCallum. The 440 volt supply was transformed down to 25 volts by means of a 0.06 k.v.a. single-phase double-wound transformer coupled across two phases and controlled only on the 440 volt side by means of a flame-proof double-pole switch and fuse, a socket to take a plug only being fitted on the 25 volt side. The lamps used were 15 watt gas-filled obscured type. The face cable was arranged with a coupling between every four fittings, which was found desirable so as to advance the equipment with the least trouble and labour through the face timbers. Specially guarded fittings were arranged for plugging into junctions which were fitted on the cable; the junctions were spaced 12 feet apart, this spacing being adopted after considerable experiment. It was found that with a 15 watt lamp 12 ft. was the maximum distance to give the miner sufficient light to see the back of his working place, which might be 5 or 6 feet from the front of the coal, at the beginning of the shift. It should, of course, be borne in mind that the lamp would be another 5 feet or so back from this coal front, so that the maximum distance to the coal before the lamp was moved forward would be say 10 to 11 feet from the lamp.

The class of cable used along the face was concentric 7/0.036 cab tyre sheathed, this being the strongest cable for this class of work. It was sufficient in area for a 70 yard face employing lamps of 25 volts, 15 watts, spaced 12 ft. apart.

Mr. Rutherford agreed that 12 volt lamps would be better than 25 volt lamps because they had a stronger filament and were more standard, but to employ that voltage meant a much larger area of cable to eliminate the effect of the drop in volts.

Considerable trouble was experienced due to breakage of lamps, and that was one of the important factors against the system. It was also found that wherever a face lighting equipment was installed the management anticipated a higher production per collier. Whilst this particular face lighting equipment was intended only for collieries where naked lights were allowed, the fitting used was tested in the Company's gas testing plant by disconnecting the fitting and letting it drop when the current was on, but it failed to ignite an explosive gas mixture.

The PRESIDENT referred to the question of white-washing: it seemed to him that perhaps along main roads there was some possibility of that, even mixing lime with the stone dust: that would certainly help Mr. Rogerson's five per cent. figure, but he could not see that the principle could be applied at the face.

Mr. ROGERSON replied that the only trouble was the cost of white-washing. Another very important point included in the Mines Department proposals was the use of white stone-dust, entirely white, and that in itself would certainly increase the reflective capacity of the various lamps in use.

Mr. ANSLOW referred to Mr. Rutherford's remarks and speaking from memory, said he believed that a 12 volt lamp would take 36 watts, which was somewhat higher than the 15 watts mentioned by Mr. Rutherford. With regard to the cables, Mr. Rutherford had mentioned the use of concentric cables but, with three-phase current available, four cores would be used, namely, one for each phase and one for neutral, which would result in much less drop in voltage over given distances from the gate-end box.

Mr. RUTHERFORD.—It makes the cable very heavy at the face and it is very necessary to keep weight down, because when there is a 100 yard face there is a considerable amount to shift.

Mr. STEVENSON drew the attention of members to two lamps which had been lent for exhibition. One of these was a battery lamp of a small size, intended to be charged at the surface and taken down to the working face once every 24 hours or so depending on the size of the storage battery. This type was available at weights up to about 17 lbs. The Home Office had passed them, and it was merely a matter of cost as to whether they were a success in any particular pit or not.

The other exhibit was a turbine-driven compressed air electric lamp which has been cut in section to shew the two-stage turbine and the generator. The lamp has a governor which could be set to allow for the variations in the air pressure due to varying loads on the main. The usual setting was for 40 lbs. so that even if the main pressure rose to 80 lbs. the pressure in the turbine would still be 40 lbs. The well-glass was ventilated by a by-pass from the exhaust so that there was no possibility of external gases entering the lamp, so that even if the lamp bulb broke or burst there was no risk of fire. The lamp looked expensive and Mr. Stevenson said he was afraid that most of the Scottish collieries at the present moment would not be likely to pay about £17 each for this type of lamp. An opal lamp is used instead of the clear lamp: the lamp being a 40 watt lamp in the type shewn. Some users of this form of lamp complain about its noise, a sort of vacuum sweeper whine but, said Mr. Stevenson, his experience of collieries was that there was plenty of noise going on in any case.

Mr. MUIRHEAD said that a member of the Committee had reported about a lamp of this type as used in

Wales: the lamp provided an excellent light, almost as good as flood lighting but, to him, the main objection was that it was noisy. He viewed the noise trouble from a different angle to Mr. Stevenson's. He said it was of importance that men working the coalcutters, the men working at the face, should not be disturbed by any external noises as it prevented them under certain conditions from taking due care either of the machinery they were in charge of or of themselves. That was the only criticism, and Mr. Muirhead agreed with it.

Mr. STEVENSON.—With regard to the use of couplings, and the remarks of Mr. Rutherford, Mr. Stevenson said he did not see any objection at all to the use of couplings in an unfiery face, but thought they would be exceedingly dangerous in a safety lamp place, because although a plug on the gate-end box could be made inoperative as long as the switch was on, he did not see how that could be done with the coupling away from the boxes.

Mr. RUTHERFORD.—As a matter of fact the coupling was arranged as a long sleeve coupling and the positive broke in the chamber long before the earth connection broke; there was no trouble there, but he realised the defects of the system for fiery mine service.

The PRESIDENT said it seemed to him that so far as control was concerned there must be one switch controlling one cable. At the face, with a cable going to each side, each with seven or eight lamps, he supposed the only practicable way would be to have a flameproof switch just at the start of each cable. There could not be any individual control.

Mr. MUIRHEAD.—No. One of the points the Committee would like information about was the very one that Mr. Dixon had raised. That was, whether a circuit breaker on the primary side of the transformer would meet the case, and whether it was necessary to have a circuit breaker and switches on the 12 volt side. The Committee had, so far, no definite views on the subject.

Mr. STEVENSON.—Transformers are now about the most reliable bit of electrical apparatus and it would be as well to have the control on the 440 side on account of the smaller fittings required.

Mr. MUIRHEAD said that was a valuable point of view because of its effect on the cost. It would not be necessary to use a high overload setting on the circuit breaker protecting the transformer, therefore it could be finely set.

Mr. RUTHERFORD.—As a matter of fact only a very small fuse was necessary on the high tension side.

Mr. LAIRD said he considered that if trips were provided, to have any form of control on the low tension side would only be doubling the gear and was quite unnecessary.

Mr. BECKETT.—If there were a single switch on the high tension side and three sets of lamps on the low tension side and a short circuit occurred the whole place would be thrown into darkness; it seemed to him better to have three single switches.

Mr. STEVENSON said he believed the proposition to be to have a 0.3 k.w. transformer or a 0.6 k.w. transformer at each gate-end, with nine lamps one way and nine lamps the other.

The PRESIDENT referred to the case of the 0.3 k.w. transformer: it might be for six or eight lamps with the high tension trips set accordingly. If only one lamp was coupled in and got broken, would it not be possible to pass sufficient current to cause an explosion without the protective gear operating?

The subject worked round the old question of putting in protective means where cable sections were reduced. To protect the small cable there would have to be some protective device at the junction: if the normal full load of the transformer could be thrown into a fault in one lamp it would introduce a source of danger.

Mr. BURT gave particulars of a cap lamp installation. The costs of which worked out at a little less than the equivalent of 1¼d. per ton: including upkeep, maintaining stock, current used and rent of cabin.

Regarding face lighting, Mr. Burt said he had tried a system a few years ago in an open light-seam. The lights were placed 15 feet apart along the conveyor face. In that method of lighting there is always some time or other when the miner's body obscures the light from the actual point at which he is working. He is not working along the face, he is either going up or down on the end of the cut coal and the light is either in front or behind him. Mr. Burt's opinion was that there is nothing better than the head light for this class of work. In Lanarkshire, where there is practically nothing left but thin seams to work, there in no tendency to adopt any face lighting system even in safety lamp pits, as it would mean an extra cost per ton.

Mr. Burt recorded an incident in which an accident happened at a very busy junction in a safety lamp mine. As a result and to prevent recurrence a few lights were fixed round about the junction. It was a great benefit to the workers. But their use was a contravention of the C.M.R.A. and so they had to be removed. Mr. Burt would ask Mr. Muirhead, while working on the Committee, to try and get this Rule altered so as to allow colliery managers to install lights at busy centres and so help to reduce accidents.

Mr. MUIRHEAD mentioned that in his earlier remarks he began by saying that the Mines Department had indicated that if a suitable range of fittings were produced they would do all they could to promote their use underground by granting exemption where the present regulations prohibited the use of such lamps. He would like to add, now that Mr. Burt had raised the point, that, he understood, there were at least four things which would be insisted upon: one, that the fittings should be of a type not easily tampered with. (That was one reason why the fuses mentioned by Mr. Crawford should not be used if possible). The second essential was that the glasses must be fitted in such a way that they have no tendency to become loose in their frames. The third point was that it would be preferable, when glasses had to be renewed that the new part should be the glass with frame complete and so obviate any attempt to take the glass out of its frame in the pit. The fourth condition was that the glass must be capable of withstanding a reasonable pressure if an ignition of gas inside the fitting should happen to occur.

Continuing, Mr. Muirhead said that the discussion had mainly centred round face lighting and it had been indicated by more than one speaker that perhaps it would be a long time before face lighting was introduced in Scotland. He would be sorry if that impression got abroad, as he did not think Scotland was in any way behind any other district in Great Britain. Scottish mining engineers were to the fore in trying out every likely method of increasing the safety of the mines or facilitating the work of the men. It might be that they are devoting too much time to face lighting, whereas a general lighting installation could be applied first of all to greater advantage in the side roads or gate roads. The roads leading up to the face might be better lit than now and that would be one step, and it could be gradually developed towards the working face. He would say that in the case of a system being applied to gate or side roads, it would not be so necessary to adopt cables of the trailing type, single wire armoured cables would suffice.

The PRESIDENT closed the discussion by moving that the notes of the discussion be remitted to the Technical Sub-Committee of the Branch who having heard all that had been said and with the many points fresh in memory could draft a special report: that report to be sent out as requested in the circular of the Association Headquarters.

Mr. BECKETT having seconded the motion, it was duly agreed.

CORRESPONDENCE.

"EARTHING."

The Editor.

Having recently to refer to *The Mining Electrical Engineer,* 1930-31, Vol. II, I have appreciated the importance of "Earthing" in mining engineering by the frequency of the references to the subject. The following two extracts dealing with research on the subject are taken from papers contained in the volume quoted above: (i) on page 57, "while the importance of such points as are here mentioned cannot be over-estimated, comparatively little practical research appears to have been undertaken in this matter"; and (ii) on page 359, "little has been done to make generally known the results of research in this important matter." In view of these statements I should like to draw your attention to a paper by the writer, entitled "An Investigation of Earthing Resistances," Journal of the Institution of Electrical Engineers, 1930, Vol. 68, pp. 736-750, and discussion pp. 1363-1367.

The second extract has been taken from a paper by Mr. J. Vaughan Harries, entitled "Earthing of Electrical Apparatus," in which he has stressed the importance of earth connections of large contact area in order, presumably, that the connections might be efficient or, in other words, have low earthing resistances. It may be shewn by theory, and it is borne out in practice, that contact area is not a factor which directly affects earthing resistance; in fact it is possible to obtain lower resistances with smaller contact surfaces under certain conditions as described below. The theoretical formula for calculating the earthing resistance of an earth connection (electrode) is

$$R = \frac{\rho}{2\pi C}$$

where ρ is the resistivity of the soil in which the electrode is buried, and C is the electrostatic capacity in space of the electrode with its image above the ground.

The resistance being directly proportional to the soil resistivity, it is important that the latter be low. In this respect the soil should be fairly free from bodies of high resistivity such as sand, stones, or coal; it should permanently be fairly wet and above the freezing point as soil resistivity increases rapidly with drying or with freezing. The electrode itself being a metal conductor of relatively large sectional area and small length, has very little resistance. The resistance of the contact of the electrode with the soil is also of little account, except possibly where an appreciable amount of direct current electrolysis has occurred, or where the electrode surfaces have semi-insulating films such as paint, grease, or scale. The earthing resistance is, therefore, in general, almost entirely due to the soil surrounding the electrode, and gives a voltage gradient in the soil when a current flows.

The earthing resistance is also inversely proportional to the electrostatic capacity in space of the electrode with its image above the ground. To obtain a small resistance the capacity should, therefore, be large. Interpreted practically this means that lower resistances are obtainable by means of a number of small electrodes dispersed in the ground and connected together than by means of similar amounts of metal less widely dispersed. Thus a given amount of metal and contact area gives lower resistances as two or more driven pipes spaced apart than as one large pipe, as a long narrow strip laid straight than as a rectangular or square plate, and as two strips spaced apart or one long strip than as a wide strip. The extent of the dispersion of metal would, of course, be limited in practice to reasonable values as regards the costs of installation, the ground area used, or the dimensions of the individual electrode, the last being with respect to adequate mechanical strength and durability in the presence of possible corrosion. The dispersion is, therefore, made large but actually there is little to be gained in spacing electrodes of ordinary sizes at greater distances apart than about 20 feet and 5 feet may be used where the ground area is restricted. Coke being a material of low resistivity as compared with natural soils, its effect in decreasing the earthing resistance of an electrode is practically the same as that of increasing the size of the electrode itself to the limits of the coke. The extent of the decrease is, however, small in relation to the increase in the contact area and in the amount of material used because of the compactness and small capacity of the whole.

The foregoing remarks apply to electrodes having inextensive areas of contact with the soil, such electrodes being driven pipes, buried trips, plates and the like. Pipe systems, conductor rails, etc. which are dispersed over neighbourhoods have extensive areas of contact with soil. The earthing resistances given by inextensive electrodes range from, say, 5 ohms to hundreds of ohms, the lower values being generally obtainable by several electrodes dispersed and connected together; values lower than the 5 ohms are obtainable by using still more electrodes, the ultimate value of resistance obtained being generally limited only by the permissible installation costs. The earthing resistances given by extensive electrodes are largely contained in the metal of the electrodes and not in the soil, and values of the order of a fraction of an ohm with them are common. Therefore extensive electrodes, with the possible exception of gas pipes, should be used wherever suitable and convenient and very low resistances are required, and a water pipe of ample size to deal safely with the possible fault currents is generally accepted to be the best example.

P. J. HIGGS.

The National Physical Laboratory,
26th January, 1932.

Personal.

Mr. Thomas T. D. Geesin whose new address is Commercial Chambers, 132 Renfrew Street, Glasgow, C. 2, Telephone No. Douglas 5780, advises that he has now been appointed Scottish Representative for Messrs. John Spencer, Ltd., Wednesbury, the well-known and old established tube manufacturers.

Mr. Thomas Ormiston Callender, the son of Sir Thomas Octavius Callender, Deputy Chairman and Managing Director of Callender's Cable & Construction Co. Ltd., has also been appointed a Director of the Company.

Manufacturers' Specialities.

A.C. Frame-Cooled Motors.

The difficulty of making totally-enclosed motors of medium to large outputs in frames of reasonable dimensions arises from the fact that all the losses in the machine have to be dissipated by heat radiation from the shell, and the minimum frame size for a given output is thus settled by the external cooling surface necessary to dissipate the losses at that output. To meet the demand for a totally-enclosed a.c. motor, reasonable in size and cost, and at the same time completely enclosed from any form of dust, the frame-cooled motor has been developed.

The Witton frame-cooled motor of the General Electric Co. Ltd. is built on the usual lines so far as the core and windings are concerned, but with a shell of special construction designed to give efficient cooling. The shell consists of a double wall casting, the annular space between the two walls being divided into sections by ribs to form ventilating ducts.

The inside of the inner wall is bored out to hold the stator stampings. In the centre of the shell the greater part of the back of the stampings is exposed to the air flowing in the shell ducts.

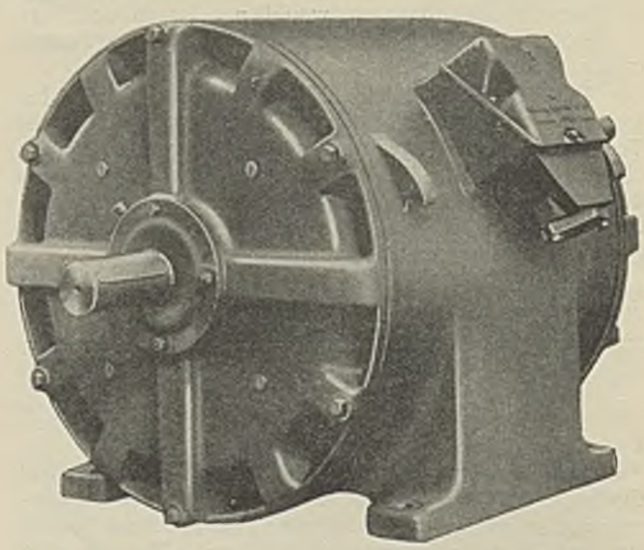
The ducts are arranged to form two entirely separate circuits for air flow, adjacent ducts being in different circuits. The internal air circuit is formed by (a) a set of alternate ducts, (b) the axial ducts in the rotor core, or alternatively holes in the hub, and (c) the space at each end between the brackets and end winding. Air is blown round this internal circuit by a fan fitted at the driving end of the machine: it scours the exposed surfaces of the stator and rotor end windings from which it absorbs the heat. During its passage through the stator internal ducts, this air scours the ribs, which are kept cool by the air in the adjoining vent duct which is in the external circuit. Thus the air in the internal duct gives up its heat before again circulating round the machine.

The external circuit consists of the external ducts through which cool air is forced by a second fan; this air scours the back of the core and the walls of the ducts, from which it absorbs heat, and is then exhausted through holes in the end-bracket. By keeping the core cool, a temperature gradient is maintained between the slot portion of the stator coil and the core, resulting in a flow of heat from the winding which is thus maintained at permissible temperatures.

This ventilation scheme in two circuits provides for cooling all parts of the motor, and there is, moreover, no possibility of air remaining stationary in any part of the machine: on the contrary, it is continually in motion in a definite path carrying heat from the centre of the machine to the outside.

The fans are fitted on the rotor in such a way as to leave both the bearings accessible from the outside, making the dismantling and re-assembly of the machines a simple matter. The exhaust openings for the external air are arranged with a clear opening as seen in the illustration, and thus the external ducts can be cleaned out with a flue brush when necessary, without disturbing any part of the motor. The sliprings are in totally-enclosed covers outside the bearing.

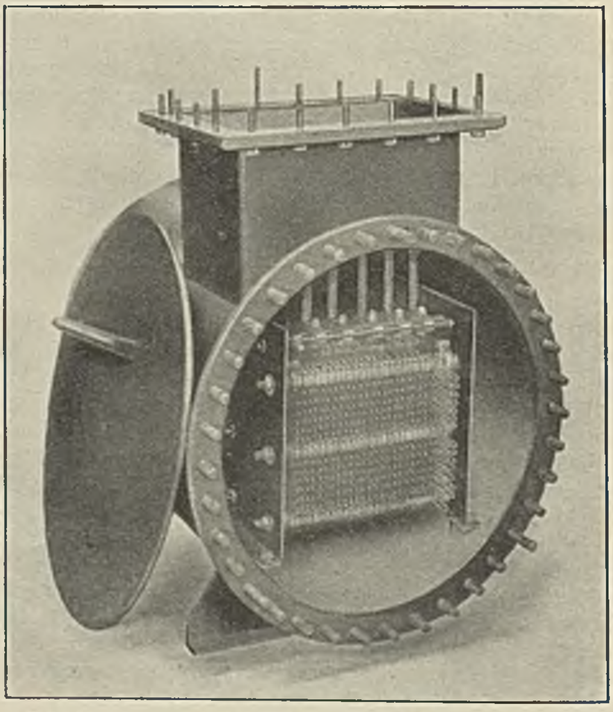
Motors are rated in accordance with B.S.S. 168/1926, and the temperature rise will not exceed 50 deg. C. after a continuous run on rated full load for six hours. They are capable of maintaining 50% overload in torque for one minute, or 100% overload in torque for 15 seconds.



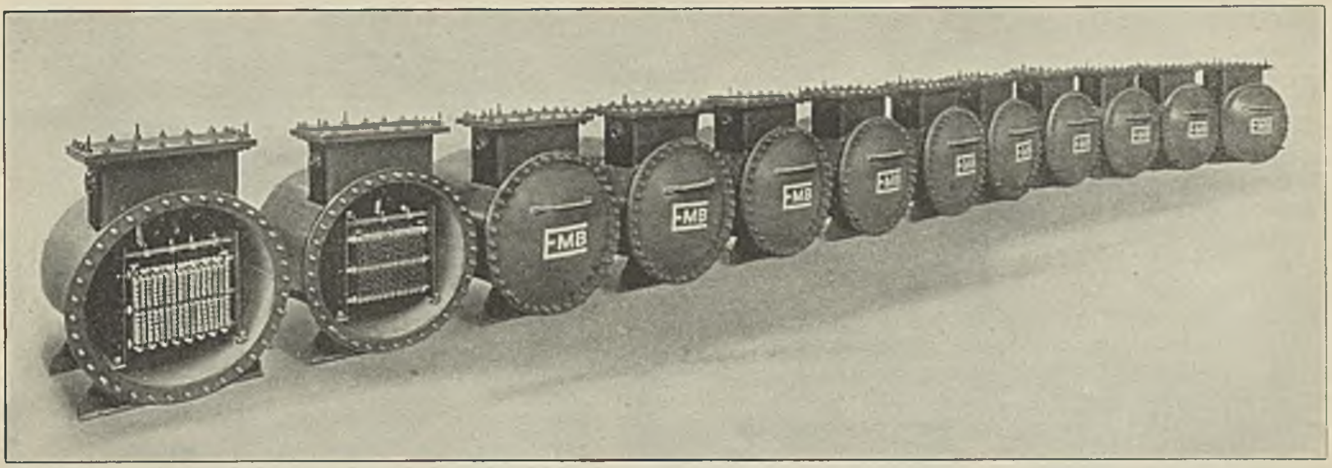
"Witton" Frame-cooled Squirrel-cage Motor shewing the extended duct outlets of the bearing bracket.

A New Flame-proof Resistance.

The transference of the Official Testing Authority for flame-proof enclosures for electrical equipment, from Sheffield University to the Mines Department, and the inauguration of the new testing station at Harpur Hill, Buxton, signifies the official intention regarding the type of electrical apparatus which will in future be approved



E.M.B. Flame-proof Resistance with Cover open.



A Group of E.M.B. Flame-proof Resistances.

for use in coal mines. It would appear that all designs for which Sheffield Certificates are now held will have to be re-approved and, in many cases, samples will have to be re-tested at the Mines' Department Testing Station, Buxton, before new certificates are issued. Colliery Managers would therefore be well advised to request Official Certificates of Flame-proof Enclosure for any future equipment ordered, and thereby obviate the possibility of costly modifications at a later date.

One of the first manufacturers to bring their designs into line with the new requirements is The Electro-Mechanical Brake Co. Ltd. of West Bromwich, who have sent us the illustrations, reproduced here, of a group of their latest type of Flame-proof Resistances which have been designed in collaboration with the Mines Department, and for the Flame-proof enclosure of which a certificate has recently been issued.

The unit itself is the standard 'EMB' Unbreakable, Jointless and Rustless Grid Type Resistance, the general design of which was patented by the Company some twenty years ago. The grids are mounted on mica insulated steel bars carried on mild steel end frames suitably arranged for mounting inside the cylindrical portion of the case. The rectangular terminal compartment is welded on to the cylindrical portion and connections between the two parts are made by means of flame-proof terminals of moulded insulating material fitted in holes drilled in the main case.

In this resistance unit no vent or ring relief device is fitted, the case being made strong enough to withstand an internal explosion, without any definite relief beyond that provided by the rough machining on the flanges of the covers. Actually the greatest internal pressure recorded in the official tests was only 93 lbs. per sq. in. as compared with the manufacturers' pressure test of 150 lbs. per sq. in. We understand that this type of Resistance case is being made in two standard sizes to cover all normal requirements.

Metro-Vick Progress in 1931.

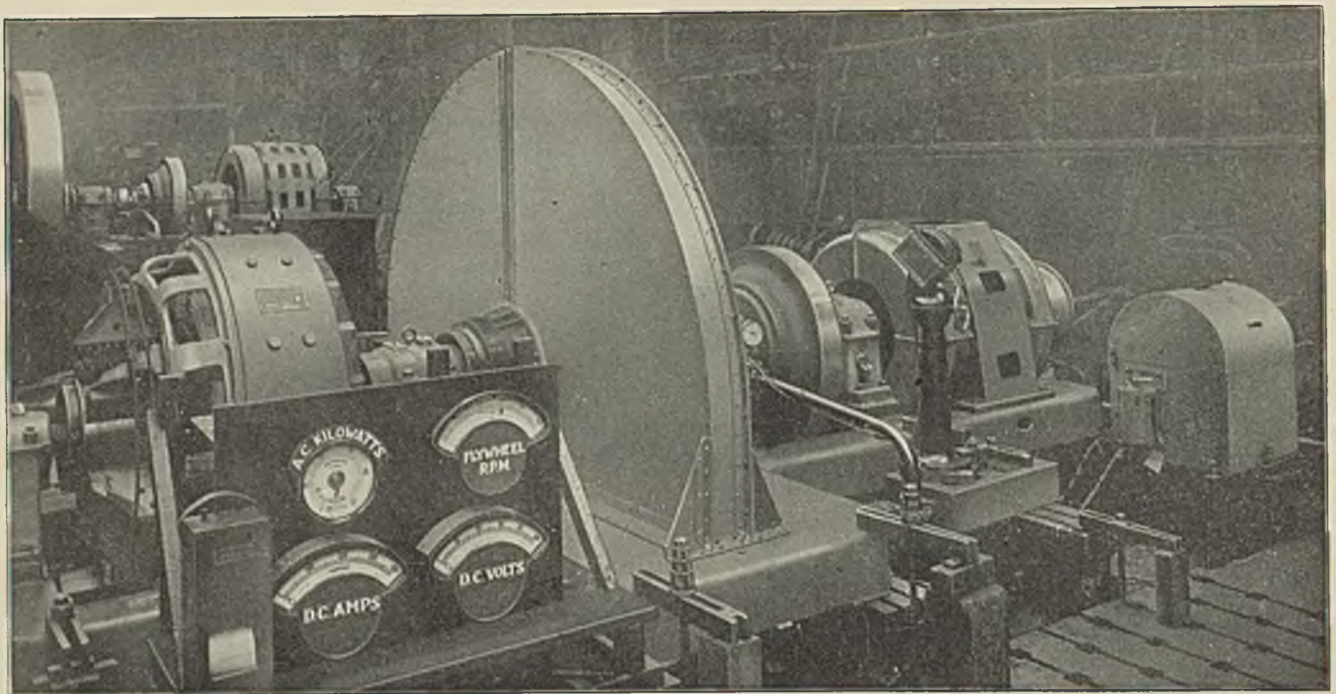
In general, though the financial situation throughout the world was very unsettled during the past year the actual tonnage of the orders shipped from the works of the Metropolitan-Vickers Electrical Co. Ltd., was nearly equal to that of 1930. Some of the largest turbo-generator sets ever sent out by the firm were shipped last year and the same may be said of high voltage switchgear and transformers. Developments of great importance have taken place in the field of automatic and supervisory control and the Company's research department were very active in all fields.

Of notable interest to mining men was the ever-growing list of Ward-Leonard equipments supplied and on order. One order is for a third equipment for the North Broken Hill Mining Company, New South Wales, Australia, and there are several orders from South Africa, one of which is for a Motor Generator equipment for a winder which comprises a 5000 h.p. induction motor capable of exerting a pull-out torque of four times normal full load. This motor drives two d.c. generators each rated at 2000 k.w. The speed of the set is 375 r.p.m. Orders for a large number of small a.c. motor winders have come in from abroad, one of which includes fourteen such equipments.

A considerable number of orders are also going through the Works in connection with the change of frequency carried out on the North East Coast.

During the year no less than nine large Ward-Leonard winder equipments went through the Test Department. Each of these equipments was supplied with the M.V. new hydraulic slip regulator which was in every case tested with its equipment under conditions as near as possible to those obtaining on the site. The slip regulator consists of a hydraulic coupling between the motor and the flywheel. An impeller wheel is mounted on the motor shaft and a runner wheel mounted on the flywheel shaft; both being enclosed in a casing in which a supply of oil provides the working medium. By varying the amount of oil in the coupling the slip can be regulated to any desired value from practically zero to nearly 100 per cent. In the past it has been impossible to use a synchronous motor in cases where a flywheel was used for load equalisation as the power given out or taken in by the flywheel necessarily depended on a variation in speed of the motor. By the use of the slip regulator it is possible to use a synchronous motor and get the advantages of power factor control together with those of load equalisation.

The illustration shews two of the synchronous motor generator flywheel equipments as erected in the Test Department. The one in the foreground is for the Zinc Corporation, Broken Hill, New South Wales, which is running at its full synchronous speed of 800 r.p.m. The set in the background is one of three equipments ordered by the North Broken Hill Company, New South Wales. The hydraulic slip regulators are clearly shewn in the photograph. The first hydraulic slip regulator to be installed in this country was recently put into commission at Messrs. Barber Walker's Watnall Colliery.



Two M.-V. Synchronous Motor Generators, with Hydraulic Slip Regulators.

The first installation of the new brake governor recently developed by the Company was put into commission in April of last year, and has given every satisfaction. Nine similar governors are now being fitted on equipments in Africa and Australia, and will shortly be in regular service.

A complete description of this braking system was published in a recent issue of this journal, but it may briefly be repeated that the system is such that the amount of braking effort is applied as a function of the speed change of the cages; compensation being made automatically for all variations of load, speed of travel and other conditions. It will be seen therefore that any given position of the brake lever will give a definite rate of retardation under all conditions and any desired rate of retardation can be obtained without shock. The retardation under emergency conditions is capable of accurate setting, a rapid rate can be set for positions where the cages are approaching the end of the travel and a relatively slow rate if they are in intermediate positions. The system thus ensures any required stoppage in a reasonably short distance, while at the same time eliminating the risk of a sudden stoppage which may be the cause of grave danger.

The control gear supplied in connection with the Broken Hill Winding equipment is interesting from the point of view that for the six Ward-Leonard sets automatic equipments are provided, which control the sets alternatively either by a master controller on the driver's platform, or by push-buttons from various working levels below ground.

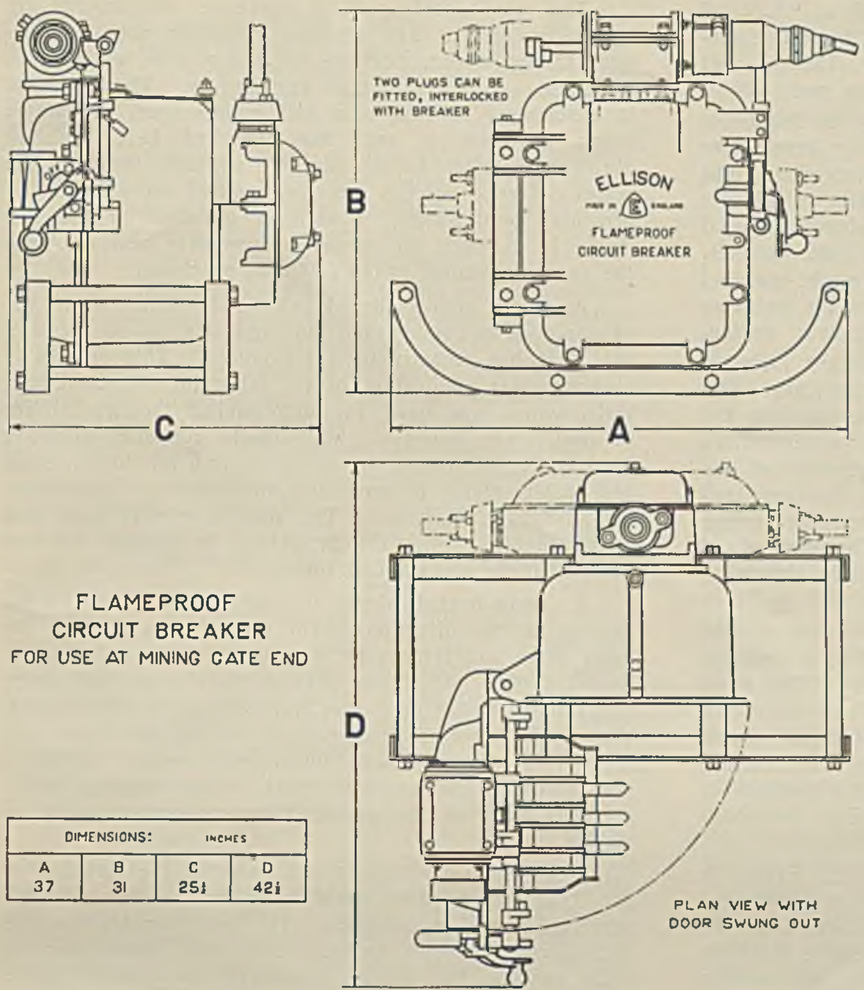
A full automatic blast furnace equipment comprising a 130 h.p. skip-hoist motor was another interesting plant started up last year. The equipment comprises automatic control and sequence of the hoist motor, small and large bell operating gear and revolving distributor gear, raising and lowering of the test sounding rods, each operation being sequence-controlled so as to reduce delays to a minimum and to ensure even distribution of the material in the furnace. The plant was for the Workington I. & S. Company, and supplied through John Milburn & Company, and the Workington Bridge and Boiler Company, who are supplying the mechanical portion of the furnace. Distributor gear was also fitted on a Ward-Leonard hoist for Lloyds Ironstone Company at Corby, and one is being fitted to a steam-driven hoist for the Staveley Company through Head Wrightson & Company.

During the year the Metropolitan-Vickers Company successfully tried out a new form of multiple operator electric welding generator. It is anticipated that this type of machine will have a considerable sale in the ship-yards and other industries where it is impossible to take the machine to the job. This machine is not quite so efficient as the single operator set, but it is superior in that respect to the type of multiple operator machine usually offered. The Company has now in operation a number of automatic welding equipments for both straight seam welding and circular seam welding, and the speeds obtained have been such as to enable a mass of work to be dealt with which would have been impossible with the ordinary hand-welding methods without a very considerable increase in the number of welders employed. A further important development undertaken is that of the atomic hydrogen welding equipment. Several equipments have been sold, and the Company anticipate that this will be a very successful line of business.

British Industries Fair: Birmingham.

GEORGE ELLISON Ltd.

Circuit breakers are the special interest of George Ellison Ltd., and a number of varying types are shewn from the 15 amp. "Bantam" oil breaker up to a 1500 amp. drawout unit with busbars complete for medium pressures; air-break gate-end breakers for mines and places where flame-proof switchgear is necessary; and high tension cubicle and truck types of units. An exhibit of particular interest is the new switch-fuse for overhead power lines which can be operated and re-fused



FLAMEPROOF CIRCUIT BREAKER FOR USE AT MINING GATE END

DIMENSIONS: INCHES			
A	B	C	D
37	31	25½	42½

by a man standing on the ground, by means of a patented operating gear which opens the switch and lowers or raises the fuses at the turn of a handle. Non-drawout, as well as drawout switchgear is to be seen together with cable accessories, limit switches, drum-type controllers, brake solenoids and control units for slipring and squirrel-cage induction motors.

Two types of flame-proof enclosures have hitherto been accepted as adequate for switchgear in mines, if certified that they have passed the accepted flame-proof tests, but doubts have arisen to shake the sense of security which they are supposed to give. The welded steel case with a flame-proof vent would be excellent if the vent itself were maintained clean in service, but the human element cannot always be relied upon and the vent may become choked with coal dust. The cast-iron case with wide machined flanges, made with a slight gap between the flanges, would also be quite safe if the gap were kept clean. Therefore, with either type, there is a risk that at a crisis the gap may fail to relieve pressure quickly enough and a fracture of the case allow flame to issue. Assurance of safety can only be certain if the enclosure is made so strongly as to be able to resist any explosive pressure that may be generated inside the case, without reliance upon vent or gap.

Both the above types of certified flame-proof breakers are made by George Ellison Ltd., and over 1500 of them have been installed during the last few years. No failures have been experienced and these breakers have given altogether satisfactory service, but to meet the wishes of mining engineers, who are responsible for maintenance and safety of life, an improved design* has been developed to embody the newer ideas regarding flame-proof enclosures, isolation for inspection, cabling facilities and interlocks.

The new "Ellison" Gate-end Circuit Breaker, which is shewn for the first time at the Fair, is contained in an explosion-proof cast-iron case with hinged door, mounted on skids. General particulars of its form and dimensions are shewn in the illustration. The joint between the case and the door, is made with wide smooth machined flanges which bolt together without a gap. No relief vent is provided as the case is strong enough to withstand the internal pressure which would be generated by the ignition of an explosive mixture within it. A magnetic blowout air-break circuit breaker is mounted on the inside of the door, to engage with switch contacts at the back of the case when the door is closed and to swing out with the door, completely isolated, for inspection. Connected to the fixed contacts at the back, and bolted to the rear of the case, is a detachable end fitting for the feeder armoured cable. This fitting is the Ellison patent "cable end" which is the same as the half of a link coupling and can be used for extending the cable run by simply bolting up another length of cable with corresponding end fittings, when the gate-end breaker is moved forward to a new working position.

On the top of the breaker case, in front, a plug socket is mounted to take one or two reversible or non-reversible trailing cable plugs for connection to coal-cutters, haulages or loaders. Mechanical interlocks are arranged for the trailing cables and electrical interlocks can be arranged. Bonding and earthing connections are thorough. The complete breaker unit is compact, very strong, and fulfils the requirements of the most exacting mining services.

GENERAL ELECTRIC Co. Ltd.

The General Electric Co. Ltd. has taken up an island site in a very prominent position in the electrical section. The main exhibit consists of a demonstration of Osram Lamp manufacture with some of the latest machinery as employed at the Osram Works. Arranged at the four corners of the Stand are examples of Witton fractional horse-power motors, Magnet cleaners, floor polishers, and heat storage cookers; Osram ultra-violet lamps are also shewn. Showboards display Magnet conduit wiring systems, bells, telephones, and electric lighting accessories, household appliances, electric fires, reflectors, and electric light fittings and glassware. Cleon Signs ornament the four corners, and the whole Stand is illuminated by cinema type floodlights.

Considerable interest attaches to the typical 132,000 volt outdoor substation (as supplied by the G.E.C. to the Central Electricity Board) erected in the open-air on the south side of the main building of the Fair.

This outdoor substation represents part of an "L.N.E." type of substation, and comprises a 132,000 volt, three-phase oil circuit breaker, and a set of 132,000 volt rotary isolating links mounted on concrete pedestals.

The oil circuit breakers have a capacity of 300 amps. at 132,000 volts and are provided with four breaks per phase. The three breakers forming a three-phase unit are simultaneously operated by a system of levers mechanically connected to a powerful solenoid housed in a weatherproof steel case at the side of the breaker. Means are provided whereby each breaker can be operated manually, although in normal circumstances the breakers would be remote controlled from the power station.

The breakers are connected to the rotary isolating links, which are opened or closed mechanically. An interesting feature in the design of these links is the chopping action imparted to the blade, as it enters or leaves the fixed contact, by the off-centering of the moving post. The connections from the links are led to one side of a typical transmission tower, representing one circuit of a double circuit line. The method of anchoring and insulating the cables is clearly shewn by the exhibit.

The Fraser & Chalmers Engineering Works of The General Electric Co. Ltd., are represented by a separate exhibit in the mining section of the Fair. The plant shewn includes examples of conveying and screening plant, and rolling mills. Most of the machines are shewn in operation, being driven by Witton squirrel-cage motors with direct-to-line contactor starters; and advantage is taken of the opportunity to exhibit G.E.C. industrial lighting fittings.

The conveying plant includes two 16 ft. Fraser & Chalmers-Redler conveyors which form an economical solution to the problem of conveying powdered, granular, and small lumpy substances. The conveying is done on a chain which consists of suitably-shaped links between which some of the material collects to form a belt on which the remainder is conveyed in a quiescent mass. The conveyor is totally enclosed and is therefore dust-less and weather-proof; over small spans it is self-supporting, and it can be extended very cheaply. The speed is slow, so that the wear and tear are negligible. Capacities up to 200 tons per hour have been obtained; the power consumption is low, both the conveyors shewn being driven by a single one h.p. motor.

Round two sides of the stand runs a Webb Conveyor a type that has only recently been introduced to this country for the circulation of raw material and work in production in factories. It works on a well-known principle, the efficiency of which has been improved by the use of modern developments such as drop-forged links and ball-bearings, employing an endless articulated chain suspended by ball-bearing trolleys from an overhead runway. Various floors can be traversed regardless of turns or vertical lifts, and the material can be brought low down within easy reach of the operators, or high overhead where head room is required. The machine is very flexible, and can be adapted to any condition. The example shewn is driven by a ⅓ h.p. motor.

The Sherwen screen as shewn incorporates a new principle in vibrating mechanism. The moving frame is mounted on spring slats of hickory or ash and given 2400-3000 vibrations per minute by two solenoids controlled by a make and break mechanism. The amplitude and rate of vibration and the screen angle can be adjusted during operation. There are no bearings, pulleys, belts or shafting, and the power consumption is very small. The same principle has been successfully applied to concentrating tables for coal, sand, slimes, etc.

The more usual types of conveyors and screens are exemplified by a 20 ft. portable conveyor and a single-deck Gyrex screen, both of the Robin type, and driven by 3 h.p. and 5 h.p. motors respectively. The conveyor is economical in first cost and maintenance, the frame being self-cleaning and the troughed belt enabling abrasive material to be handled without wear on the edges. Gyrex screens can be applied to almost any screening proposition; a uniform gyration of the live frame is obtained by means of eccentric bearings, and the capacities range up to 600 tons per hour.

A model coal-washer is shewn to demonstrate the principle of a patent sand flotation process of washing coal that has recently been introduced. This process is a commercial application of the laboratory float-and-sink tests, which are used for determining the washability of coal. The expensive high-density chemical solutions used in the laboratory are replaced by a mixture of sand and water, which is kept in a fluid state by mechanical and hydraulic agitation. The density of the sand and water mixture, which can be varied, is arranged so that the coal floats and the dirt sinks.

A steam-heated dryer is also shewn, the steam flowing in two directions. The steam flows through the inner drum and returns by way of the outer jacket. The dryer is used for drying certain coals, ores, and other material where the maximum temperature must be limited. Very little power is required to operate the dryer and it is very economical in steam consumption, about 85 per cent. of the available heat being utilised. It is specially adapted for drying adherent material such as sludge, etc.

A Bliss cluster rolling mill, one of the smallest of the type made, will draw attention to these highly perfected precision machines. The use of roller bearings with large diameter backing rolls and small working rolls enables the rolling pressures and reductions to be increased, the power consumption remaining low. Fewer passes are required, resulting in increased output, and sheets up to 50 ins. wide can be cold rolled with the advantages of ductility, even gauge, and high finish. A mill for rolling 48 ins. steel plates has been recently installed at Messrs. Baldwins Ltd., Wildon Ironworks.

GENT & Co. Ltd.

For many years past the exhibit staged by Messrs. Gent has been one of the most attractive in the electrical section of the Fair. This year's display is no less fascinating as typical of the skill of the British craftsman who, as it were, bridges the gap between the engineer fitter and the instrument maker. Of particular interest to mining men are the bells, signals, telephones, alarms, remote control, recorder and indicator systems—all specifically designed for miners' services. In this range of "Tangent" specialities are included: flame-proof mining bells, relays of improved pattern, passed by H.M. Mines Department for bare wire signalling for single or parallel operating: flame-proof mining pushes and pulls, also keys with improved operating handle arranged to prevent fatigue of the operator during continual use; a new pattern of flame-proof two-way mining pull, see illustration, for use underground where bare wire signalling is not desirable; flame-proof mining telephones, magneto and battery call, and ironclad switchboards.

Particular mention can also be made of the electrically operated liquid level indicating and recording apparatus, also alarms, consisting of a water-tight ironclad transmitter, suitable for fixing in the open over reservoirs, tanks, etc., which operates contacts at every inch rise or fall of the water or liquid, over any distance. This apparatus is suitable for single line working and the indicator or recorder is fitted with metal rectifiers and relays.

There are motor syrens in sizes ranging from 1/10th to 8 h.p., suitable for public fire alarms, and for sound signals in mines and factories: similarly there are automatic motor syrens, of a new and improved coding pattern for docks, harbours, lighthouses, etc.

Other labour-saving systems for extensive industrial concerns and large public institutions are staff locators (lamp signals) for calling members of staff immediately in case of trunk or other urgent calls: telephones, including the "Parsons-Sloper" Intercommunication telephones, "Electromatic" central battery interphones, push-button call "Regent" telephones, and switchboards.

Included in the assembly of bells devised for every class of service is a notable range of iron cased weather-proof bells, suitable for circuits from battery, d.c. and a.c. mains up to 250 volts. The a.c. bells are provided with laminated cores.

Other "power" classes of apparatus are the relays for controlling power or motor circuits at a distance, with two-way operations suitable for operating contactors for starting and stopping motor alarms or other devices of that character: an exhibit is made of a main switch, relay-operated from a distance, double or triple pole, for 500 volts up to 50 amperes.

Of more general interest are the numerous examples of time recording, indicating and transmitting apparatus and furnishings. Typical items include:— New frequency "Electro-matic" clocks of various designs suitable for a.c. 50 period supplies, where frequency is controlled. New frequency "Pul-Syn-Etic" transmitter operated from frequency controlled mains and suitable for driving from a local battery, any number of ordinary impulse clocks. A frequency meter transmitter with two clock dials, one shewing Greenwich Time with hour, minute and second hands, the other clock dial showing frequency-Time with hour, minute and second hands. A time transmitter controlling the clock on the Stand, also clocks in the Exhibition operated by sealed high tension battery, trickle charged from the a.c. mains, and so not affected by any stoppage of the mains current. A sub-transmitter fitted with relay "Reflex" pendulum control operated from a prime transmitter for use in buildings which are separate from the main building and where overhead wires are used, so that if the wires are carried away, the time transmitters continue to operate. An electric turret clock consisting of three three-foot dials with exposed hands operated by a "Waiting-Train" movement, and which is controlled by the time transmitter on the Stand. A bell, made by Taylor's of Loughborough, weighing about one cwt., counts the hours, the hammer being operated by a motor driven striking apparatus through an hourly contact maker operated by the time transmitter. Electric impulse marine type time transmitter fitted with advance or retard apparatus for use on ships, together with marine clocks.

BRITISH THOMSON-HOUSTON Co. Ltd.

Various novel devices are in operation on the Mazda Lamp Stand of the British Thomson-Houston Co. Ltd.; two of these are operated by standard B.T.H. photo-electric relays, and a third controlled by a thyratron. The purpose of a photo-electric cell is to obtain an electric current from light energy in order to actuate an electrical instrument, such as a loud-speaker for use with talking films, or a relay for the operation of signalling, lighting, and other control devices. Further applications of an industrial nature are the sorting and counting of articles, smoke and fog detection, elevator control, traffic control, railway signal control, the control of artificial illumination according to the variations in daylight intensity, fire alarms, and testing the quality of dyes, papers, oils, etc.

The B.T.H. Mazda photo-electric cell, which is of the thin film caesium type, consists of an anode and cathode, sealed in a glass bulb which is filled with an inert gas. The cathode consists of a copper base, coated by a special process with a film of activated material of molecular thickness, which is capable of emitting electrons under the action of light. This electron emission is amplified by the ionisation of the inert gas and attracted by the anode.

One of the devices shewn to demonstrate the practical use of a photo-electric cell, is that in which a lighted match is applied to the bulb of a lamp and the lamp lights. The apparatus for this demonstration consists of an ordinary incandescent filament lamp standing near to a photo-electric relay unit. The lamp is so placed that the light from the match falls on to a photo-electric cell which operates in the grid circuit of a thermionic valve. Illumination falling on the cell produces a photo-electric current which is amplified by the valve to a value sufficient to operate a relay which in turn closes its contacts to energise a small contactor. The contacts of the latter are in the lamp circuit, and since the light rays from the lamp also fall on the cell, the lamp continues alight until it is removed from the proximity of the cell.

Another interesting device in which a photo-electric cell is used is an invisible ray burglar alarm, which operates when a beam of invisible rays is interrupted. These rays, obtained from a small electric lamp shielded by a special filter, impinge on a photo-electric cell. This cell is also arranged in a thermionic valve amplifier circuit, the essential difference between the circuit used in this exhibit and that described above lies in the arrangement of the relay and contactor circuits. In the present case the contactor is energised to operate an electric electric bell and lamp when the invisible rays are cut off from the cell. The circuit can be arranged so that a warning is given only when the beam is being cut off, or so that once the beam is interrupted a continuous alarm is given until the apparatus is reset.

Also of very considerable interest is that in which a thyratron is used. The thyratron is a hot cathode mercury vapour valve with grid control. In the demonstration it is arranged so that an alteration in the value of the capacity associated with the thyratron grid alters the grid voltage, which allows an arc to flow through the thyratron. The arc current is made to operate a contactor controlling the floodlight. The great sensitivity of the thyratron is shewn by the fact that it is sufficient to bring one's hand near to the concealed metal plate and so to alter the capacity as to switch on the spot-light.

VLASTO, CLARK and WATSON.

A notable display of control gears of the automatic contactor type represents the latest practice of this Company who have for so many years specialised in this class of work. Of particular interest is the flame-proof three-phase vertical air-break controller of a type which has passed the Sheffield University test. This form of gear has been extensively adopted in various mines. It consists essentially of a strong cast-iron case with hinged door, complete with terminals in a separate flame-proof compartment in the controller so that there is no dependence on the sealing of the trifurcating boxes in order to render them flame-proof. These terminals are very easily accessible for wiring up. On the back of the controller there is mounted a flame-proof three-pole contactor type circuit breaker with three overload relays with time lags electrically interlocked with the controller and interconnected so as to form a complete unit.

W. H. ALLEN, SONS & Co., Ltd.

The most prominent exhibit on this stand is the six cylinder Airless Injection Diesel Engine direct coupled to a d.c. generator. The engine is of the vertical single acting four-stroke type, being one of the standard range made with from two to eight cylinders. The fuel is injected into the cylinder near the top dead-centre position. The absence of fuel from the cylinder during the greater part of the compression stroke enables a high compression to be used without danger of pre-ignition. The efficiency of the engine is high, both in the fuel and lubricating oil consumptions, the former not exceeding 0.39 lbs. per b.h.p. and the latter 0.005 lbs. per b.h.p. per hour at full load. Special attention has been given to the question of silent running, silencers are fitted on both the air supply and exhaust end. The camshaft is operated by roller chain. The engine is fitted with trunk pistons, and the bedplate and cylinder trunk casting form a totally-enclosed oiltight crankpit of very rigid design. Inspection doors of ample proportion are provided to give free access to the main bearings and all internal working parts. Forced lubrication is applied to the main bearings, connecting rod bearings, pistons and the camshaft drive.

Cylinders are fitted with separate liners; the cylinder covers contain the fuel injector, starting valve, air inlet valve and exhaust valve, all of which are fitted in a vertical position. The covers are fitted with safety valves, set to lift at a predetermined pressure. All valves are fitted in loose boxes so that they can easily be removed for cleaning. The exhaust valve box is water-cooled.

The fuel supply is maintained by a separate pump to each cylinder; no distributors are used. The fuel injector is of the spring loaded type and is water-cooled, being provided with a gunmetal casing. Pressure on the spring, against which the fuel has to work before raising the injector valve, is capable of adjustment. The injector nozzle is of high carbon steel and is provided with a series of holes through which the fuel is fored, thus ensuring efficient atomisation. The governor regulates automatically the consumption of fuel oil at different loads and is fitted with adjusting gear to enable the number of revolutions to be varied whilst running. The governing of the engine meets all usual industrial requirements and is particularly suitable for driving electric generators, where excedingly sensitive governing and parallel operation are required. The flywheel is of ample proportion to secure steady running and it is provided at the edge of its rim with a toothed rack for engagement with the pawls of the turbine gear supplied.

Another important exhibit on the stand is a small single stage impulse type d.c. Turbo-Generator. This machine, which is suitable for use as a pilot set in conjunction with a large Turbo-Generator, has an output of 50 k.w. The reduction gear incorporated is of the single helical type with the pinion made integral with the shaft and the turbine rotor is mounted on a shaft extension.

The speed governor is of the centrifugal type, driven by a vertical shaft at the turbine steam end through a worm and wheel, and operating the throttle valve through an oil relay. The overspeed trip-ring and oil pump are also driven by the governor shaft. Special materials are employed throughout to ensure long operating life and absolute reliability: for example, the moving blades are machined from solid low carbon stainless steel bar, specimens of which are to be seen on the stand. The pinion shaft is made of special oil hardened and heat treated nickel steel. A hand valve is provided to enable the turbine to operate economically with either back pressure or vacuum exhaust. The main conditions applying to this 50 k.w. Turbo-Generator are: Steam pressure, 225 lbs. per square inch gauge; superheat, 150 deg. F.; exhaust, 25 lbs. gauge, or condensing; overload capacity, 10 per cent.

Examples of newly developed "Conqueror" pumps shewn by Messrs. Allen, include a modern washery pump of improved design, a new small pump of high efficiency, and a novel and interesting design of small unchokeable sewage pump.

The improved washery pump is a development of the original sands pump which was manufactured by the Company over a quarter of a century ago to replace the tailing wheels used in gold mines and other mines. It has remarkable capacity for resisting the wear occasioned by the pumping of grit-laden water, a duty which has to be performed continuously in colliery washing plant. So arduous is this work that the ordinary type of centrifugal pump is quickly attacked and the rate of wear is so rapid that the efficiency of the pump falls progressively and the necessity for frequent renewals involves high maintenance charges. The outer casing of this washery pump is made of close grained grey cast-iron and the impeller and liners of a special mixture of chilled cast-iron which is unmachineable and offers high resistance to the wear set up by grit-laden water.

In spite of the inherent toughness of cast steel it is rarely possible to obtain a steel casting without blowholes and other defects, and experience has shewn that where such defects exist the part is quickly attacked and honeycombed. Another disadvantage of steel castings is that replacements are difficult to obtain in some situations.

An important feature of the washery pump is the relatively low running speed which considerably affects remarkable influence upon the life of the parts and therefore directly upon the maintenance charges.

The impeller is of the single suction type overhung from a massive shaft and this arrangement requires but one gland in the pump casing. The shaft is supported in two heavy pedestal bearings of the ring lubricated type and the housing of one bearing carries a heavy double-thrust ball-bearing capable of taking up the thrust due to out-of-balance effects that may occur owing to unequal wear. To prevent spray water from the gland impinging upon the bearings an ingenious thrower is fitted to the shaft. The construction of the gland itself is a special feature as this is a point where in most designs heavy wear occurs. The grit is prevented from entering into the gland by a high pressure water supply.

The "Conqueror-Unalow" pump shewn is one of a range of the smaller centrifugal pumps of moderate cost but embodying all those features which have made the larger "Conqueror" pumps so popular. This type of pump is made with branches of from 2 ins. to 6 ins. and by rigid standardisation of parts, the manufacturers are enabled to offer the various sizes of pumps at favourable prices. The various sizes in the range give high efficiencies: the four-inch pump, for example, gives an efficiency under favourable circumstances of 82 per cent. Being of the single suction, single impeller type it is suitable for pumping against lifts ranging from 15 ft. to 65 ft. The normal output for the complete range is based on 1450 r.p.m., which suits the 50 cycles a.c. supply; the speeds may also be varied within wide range.

The suction of the pump is a side suction and the standard position for the discharge branch is vertical and off-centre. In addition to the usual inside bearing, the impeller shaft is supported in a double purpose ball-bearing situated external to the pump casing. The impeller is provided with balancing holes so that no hydraulic end-thrust is transmitted to the motor shaft in the case of a direct drive. A special thrower is fitted to the shaft to prevent any gland leakage water finding its way into the ball-bearings. The pump casings are made of close grained grey cast-iron, whilst the impellers are made of gunmetal, and the shafts of steel.

Another pump shewn here for the first time is an entirely new design of unchokeable sewage pump designed to deal with solid materials and capable of passing solid spheres up to the diameter of the pump branch.

The impeller is of the single bladed type made of chilled cast-iron and overhung from a substantial shaft supported in ball-bearings, one of these bearings being a combined journal and thrust bearing. The outer casing is of close grained grey cast-iron and the cover which forms the outer shroud of the impeller is adjustable for wear.

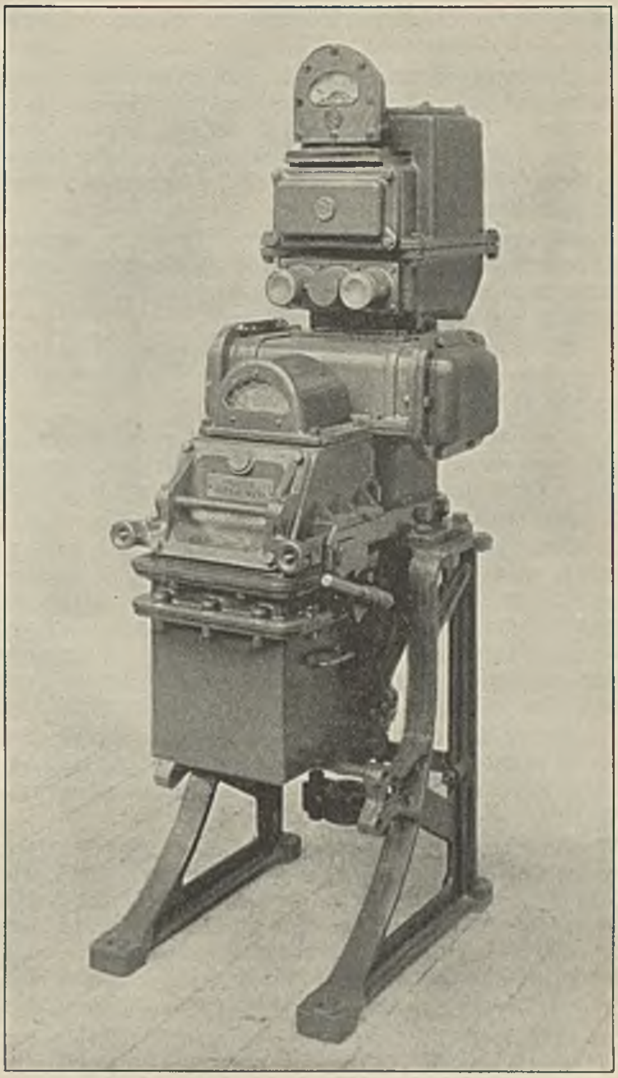
The pump passes with ease those materials which have proved so difficult to pump in the past, rags, waste, straw, shavings are all readily pumped without the characteristic difficulty of "balling" which causes so much trouble in many other designs of pumps.

Usually, unchokeable pumps have relatively low efficiency, the efficiency for a three-inch pump being from 40 per cent. to 50 per cent. In this new pump the special single bladed impeller permits the relatively high efficiency of 65 per cent. to be obtained under reasonable conditions.

M. & C. SWITCHGEAR, Ltd.

This Company exhibits a comprehensive range of switchgear and control gear suitable for almost every industry. The examples of oil type circuit breaker gear shew many noteworthy features: they are completely metal-clad, everything including trip coils being oil-immersed within enclosures which are strong and at the same time attractive in outline. The calibration tubes and time lags being under oil, there is no danger of rusting and consequent failure of the breaker to trip. The heavy renewable contacts are of improved design. The specimens shewn include the regular industrial pattern and also the flame-proof pattern.

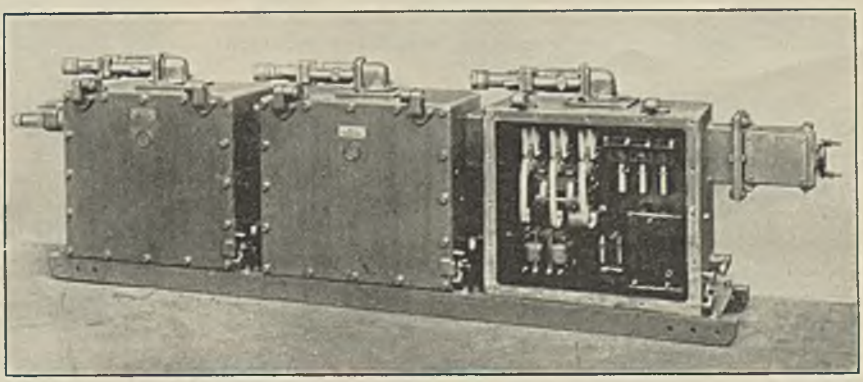
Oil-break gear on view includes a four-panel, industrial draw-out board, low tension; a three-panel flame-proof, draw-out board, low tension; and a flame-proof, draw-out pillar, 100 amps., 3300 volts, which is a typical example of M. & C. S. high voltage gear.



M. & C. S. Flame-proof Switch; 100 *amp.*, 3300 *volts.*

There are also two industrial non-draw-out oil circuit breakers, floor mounted, one 60 amps., and one 100 amps. The former is of the single-break pattern, specially designed to meet the demand for a cheaper oil circuit breaker which is built on the same sound mechanical lines as larger oil switches: they make ideal straight-on starters for squirrel-cage motors.

The M. & C. S. air-break switchgear of the ironclad type is built up on the unit system. Two boards are shewn: a two-panel, 100 amp. and 60 amp. flame-proof



M. & C. S. Three-unit Remote Control Flame-proof Gate-end Switchgear for One Coalcutter and Two Conveyors.

board; and a two-panel 200 amp. and 60 amp. industrial board.

The rotor starter pillar exhibited incorporates a rotor starter and an oil-break circuit breaker. The case is of cast-iron. The contacts are at the top, under clean oil and free of the sludge which collects at the bottom of tanks. The interior is accessible for inspection without disconnecting cables.

The push-button starter shewn has been designed for small squirrel-cage motors, and comprises a contactor with thermal relays, the start and stop pushes being incorporated in the enclosure.

Flame-proof, weather-proof and totally-enclosed d.c. starters are shewn for various power ranging from 7½ h.p. to 55 h.p.

The display of M. & C. S. gate-end switches and circuit breakers is very comprehensive and mining men will find a great deal to interest them in the exhibits, many of which will probably be quite new to them.

The type A1, 100 amp., flame-proof air-break gate-end switch, skid mounted, is the standard for this class of switch. It is strong, simple and reliable. A less expensive form is the type A140, 100 amp. flame-proof air-break gate-end switch, skid mounted: this is a cheaper type of switch than the A1, but it complies with all applicable rules and no essential has been omitted.

The 60 amp., non-flame-proof air-break switch plug box is suitable for use in certain collieries, quarries and other places in connection with portable machinery of all kinds.

The flame-proof gate-end oil circuit breaker, skid mounted, comprising an oil circuit breaker fitted with B.S. plug, exhibits a special feature in the great facility with which the whole of the interior mechanism may be removed, and replaced by a spare, if necessary, without disturbing the gate-end box or cables in any way.

The 60 amp. flame-proof gate-end oil circuit breaker has been specially designed for the control of conveyors and other machines of similar duty.

The flame-proof air-break remote control gate-end circuit breaker acts in conjunction with a series isolating and reversing switch with an auxiliary control switch fitted in the machine, all circuit closing and opening takes place automatically at the gate-end circuit breaker. This circuit breaker, while providing the fullest protection is mechanically robust in details, as for example, the important operating relay. M. & C. Switchgear Ltd. have done much pioneer work in the introduction of this method of control for mining machinery.

The new flame-proof contactor type gate-end box comprises a three-pole contactor and overload relay enclosed in a welded steel plate case, in the cover of which is incorporated a push button, start and stop. A B.S. plug and socket and an armouring gland are mounted on the external terminal chamber.

Flame-proof controllers shewn include those of the air-break and oil-break types specially designed for arduous mining services. There is also a comprehensive display of mining electrical accessories such as junction boxes, lighting fittings, etc.

G. A. HARVEY & Co. (London) Ltd.

The extensions to this Company's works which this time last year were in course of erection, are now completed and afford greatly both the steel furniture and Industrial plant departments increased facilities for manufacturing under modern ideal conditions. The extensive range of perforated metals shewn on this stand are of particular interest, including the very many patterns needed for all kinds of sifting, sorting, filtering and grading such diverse materials as coal, stone, grain, food products, chemicals, etc. The catalogue issued by the Company reaches encyclopædic dimensions, and illustrates convincingly the range of work done. Slots 1½ ins. by ⅜ in. wide through ⅞ in. thick steel, to round holes 0.015 in. diameter prove that the technical difficulties presented are regularly overcome by experience gained during a period of nearly sixty years.

From perforated metals, one is attracted to woven wire cloths. This material is produced by Messrs. Harvey in all metals and gauges and its industrial uses vary to a similar extent to those of perforations.

In the form of ornamental metal-work, perforated metal is seen at its best; radiator covers, grilles, ventilating panels and pipe guards all in bigger demand than ever before for hotels, mansions, offices, luxury liners, etc.

Considerable progress has recently been made in this country in the canning industry, and the Harvey horizontal processing retort exhibited will prove of interest to those connected with this growing industry. This firm specialise in all kinds of plant needed in food manufacture and produce vertical processing retorts, vacuum drying, evaporating and distilling plants, sterilisers, jacketed pens, exhausters, cooling tanks, vacuum sealing tanks and can and bottle crates.

Amongst the array of sheet metal work on this stand, of outstanding interest is the Harvey 100% British steel equipment for offices and works. Such items as filing cabinets, cupboards, shelving, storage bins and racks fabricated in steel are now becoming more used by progressive executives everywhere. Steel equipment is fire resisting, hygienic, proof against vermin and can be dismantled and re-erected at any time, anywhere without depreciation. Mild steel gutters, ventilators, and gilled tubes are other items of interest on this stand worthy of attention by buyers everywhere.

MIDLAND ELECTRIC INSTALLATION Co. Ltd.

As specialists in the repair of electrical machinery the exhibit of this Company consists in the main of a demonstration of re-winding electric motor armatures, rotors, stators, etc. and coil winding. Flash testing of commutators is also being shewn.

The Company exhibit examples of their "Mepic" shop window and car heaters also of the testing transformers and split transformer ammeters of which they are the makers.

The Company has adopted the slogan "Wolverhampton's Hospital for Electric Motors" and it is perhaps natural but none the less interesting that the exhibit is planned to represent a hospital with the demonstrators dressed as doctors and nurses, and that actual operations are seen in progress on "patients" which are in for "cure."

DARWINS LIMITED.

It is a claim of this Company that they were the first in the world commercially to produce cast magnets and they exhibit a whole range of cast magnets as well as magnets made from rolled bar. Some 250 different magnets are shown amongst which are magnets for practically every purpose for which a permanent magnet has ever been used. The range of magnets suitable for use in moving coil loud-speakers is particularly extensive: it is a branch in which Darwins Ltd. have long long been the pioneers, the majority of new designs originating from their Research Department. The exhibit of magnets for moving coil loud-speakers comprises cast four-claw magnets and enclosed pot magnets, and also units built up from straight bar Cobalt steel magnets, utilising laminated top and bottom mild steel plates. Efficient dust-caps are fitted to all magnets and guard the under-side of the gap.

A magnetic separation fitted with permanent magnets and suitable for use in many classes of machinery is shown. The magnets fitted in these separators, as well as all the other permanent magnets on this exhibit, are correctly designed in accordance with the properties of the steel from which they are made, and every magnet is fully tested before leaving the factory. One method of test is being demonstrated as a feature of the exhibit.

Samples of a special Cobalt-iron alloy which has a saturation value from 10% to 15% higher than that of pure iron, are shown. The preparation of this metal on a commercial scale has only been rendered possible by the advent of the high-frequency induction furnace. The magnetic properties of this metal render it of great value in parts of electro-magnetic apparatus where extreme magnetic densities are required.

An exhibit of heat-resisting alloys comprises case-hardening boxes, burner parts, electric furnace parts, pyrometer tubes, valve seats, pettets, etc. Pettets are metal supports used to hold utensils that are being enamelled and they have to work at a bright red heat and are subject to repeated and rapid heating and cooling. One pettet which is being exhibited and which is intended for use in a continuous furnace is made up of 23 parts, and is a remarkable example of high grade workmanship.

Darwins Limited manufacture several different types of stainless steel, besides the ordinary austenitic variety containing approximately 18% chromium and 8% nickel. They are exhibiting castings (finished and unfinished) of valves, shop fittings, pump parts, etc.

The non-distorting tool steel exhibits comprise bars and tools of Cobalt-fastwork and Neor. Both these steels can be supplied in the form of casting of which numerous examples are shown. Darwins' most recent development in cheap steels is N. 1932, one of the strongest chisel steels on the market. It maintains so keen a cutting edge and is so strong that it can easily be driven through a 2 ins. bar of steel.

A. REYROLLE & Co. Ltd.

This year Messrs. Reyrolle are showing apparatus widely representative of all their manufactures. Horizontal draw-out switchgear for power-station and sub-station indoor service is exemplified by a four-panel board of Type C 3 switchgear rated at 7000 volts, 400 amperes, and a single panel of Type 2B 4, duplicate busbar switchgear rated at 11,000 volts, 1600 amperes. On the Type C 3 switchboard one of the circuit breakers has a glass-fronted tank to reveal the arrangement of the contacts inside. Trucks for removing the circuit breaker and for lowering the tanks form part of each equipment. Of particular interest is an enlarged reproduction of an oscillogram obtained during the testing of a Class C circuit breaker at the makers' works.

Outdoor sub-station switchgear is represented by non-draw-out, Type UWY, automatic switchgear mounted on framework, and a TOI (tee-off isolating) unit for insertion in a ring-main with a switch-fuse tee-off for a consumer. Both units have been designed with a view to promoting economy in outdoor sub-station layout.

Flame-proof apparatus for mines is a special feature of the exhibit. It includes an oil-break gate-end switch combined with a small lighting transformer. The transformer winding is assembled in the same tank as the switch mechanism, and protection is afforded by the use of series over-current trips, and by fuses, all of which are incorporated in the combined unit. It is designed to comply with both British and Continental Regulations for flame-proof enclosure. Flame-proof plugs and sockets for currents up to 100 amperes at 660 volts are exhibited, and an application of one of this type is shewn in its use on a coal drilling machine.

Another switching unit of flame-proof construction, and of particular use in mines, is a reversing switch with fuses in the same containing enclosure; this was developed specially for use in conjunction with shot hole and rock drills because of the jamming that often occurs. A detachable gland is provided for the incoming cable, and a plug interlocked with the switch handle is fitted for the outgoing cable to the drill. The exhibit includes 200 ampere and a 60 ampere detachable cable sealing boxes, generally known as "flit-plugs." They have their particular application in the extending of cables at the coal face, and their use is recommended by H. M. Electrical Inspector for Mines.

In addition to switchgear of all kinds, Messrs. Reyrolle manufacture apparatus for water heating, oil heating, and steam raising, and an electrode water heater and steam raiser forms a very interesting part of their exhibit. The design is suitable for voltages up to 11,000 volts, and for loadings up to 2000 k.w. Load control is effected by raising or lowering movable shields over the electrodes, this having the effect of lengthening or shortening the path of the current between them. The equipment includes the usual inlet and outlet valves, a safety-valve, a water level gauge and guard, and a motor driven pump for circulating the water over the electrodes.

A domestic thermal storage water heating cylinder is also shewn, and another interesting exhibit for this kind of service is a self-contained wash-basin and storage water heater. The water heater is contained in the stone-ware pedestal of the wash-basin, and in size and appearance the combined unit is not materially different from the ordinary wash-basin. Its chief advantage lies in the fact that only a cold water supply and a source of electricity are required for a constant supply of hot water, and long expansion pipes are unnecessary.

Examples of immersion heaters for water heating and for oil heating are shewn both as separate units, and in banks of a number of units with busbars and cable sealing and dividing boxes.

As specialists in the design and application of automatic protective schemes, Messrs. Reyrolle shew a number of relays of the kind used in modern systems. They also shew complete control boards for controlling 66,000 volt switchgear: the control panels are of dust-tight sheet steel cubicle construction, and have slate fronts with mimic diagrams and automatic indicators mounted on them.

A range of air-break switchgear for factory and general industrial use, and cooker switches and plugs and sockets for domestic use, form other exhibits. A range of heavy-duty cartridge fuses is shewn: these are suitable for fitting into standard holders, and are therefore particularly serviceable when extensions to generating plant have exceeded the safe limits of open-type fuses.

Another interesting exhibit is an outdoor pole mounting distribution box, many of which have been supplied for controlling flood-lighting circuits in outdoor sub-stations. Each equipment consists of a steel box containing six fuses and three "swugs" (switch-plugs of the protected type) arranged for controlling three 250 volt, 15 ampere circuits.

A selection is shewn of cable sealing bells and cable sealing and dividing boxes, which Messrs. Reyrolle manufacture, for both high and low voltages. Various designs are available for both pole-mounting and for transformer mounting, as well as for all kinds of indoor and outdoor service.

It should also be mentioned that Messrs. Reyrolle have supplied the switchgear for the electric restaurant of the Fair, which comprises two three-pole switch and fuse combinations, one for 100 amperes, and the other for 60 amperes, five 60 ampere, two-pole switch and fuse combinations, and five 30 ampere two-pole switch and fuse combinations, all of the 660 volt type.

J. H. HOLMES & Co. Ltd.

Messrs. J. H. Holmes & Company are associated with Messrs. A. Reyrolle & Company Limited, and exhibit on the same stand. The Holmes exhibit includes two induction motors for general use, a flame-proof motor, a totally-enclosed fan-cooled motor, a variable-speed commutator motor, and a conveyor motor, all of which are for alternating current. A direct current motor is also shewn.

One of the two general-purpose induction motors is cut away to illustrate the soundness of its construction. The totally-enclosed fan-cooled motor is built on the twin-case principle, there being an annular space between the inner and outer cases through which cooling air is driven by a fan mounted on the end of the motor shaft.

The flame-proof motor has a strongly ribbed frame and wide metal-to-metal flanges, which very effectively prevent the passage of flame. A flame-proof starting switch is fitted to the motor, and its enclosing case forms part of the case of the motor.

The a.c. commutator motor, which is of the series characteristic type, is one of a range specially designed to give efficient speed control. Messrs. Holmes also manufacture commutator motors with shunt characteristics. Speed regulation is effected by moving the brushes round the commutator. Manual control of the brush position by means of a handwheel can be provided, or remote control by means of a small motor. The a.c. commutator motors are suitable for many kinds of service, such as for driving fans, pumps, turn-tables, winches, and the like: they can be designed to give under suitable conditions speed ranges as high as 12½ to 1.

The a.c. conveyor motor merits special mention. It has been designed for use at the coal face, and has a plain cylindrical exterior, so that it can be rolled a long the roadway at the coal face with a minimum of effort. Each motor is provided with a special cradle for supporting it when in use.

The direct current motor is typical of the standard range of d.c. motors and generators manufactured by Messrs. Holmes. The particular machine shewn is shunt-wound, and has an output of 15 h.p. when running at 1200 r.p.m. on a 480 volt supply.

In addition to these motors, Messrs. Holmes also shew an electric arc-welding equipment, consisting of a specially designed welding generator, which can be coupled to an a.c. or d.c. driving motor or to a petrol engine. The whole equipment is mounted on a rigid fabricated bed-plate, which can be supported on wheels if required. The control gear and resistances are fitted above the generator, and are so arranged that good ventilation is secured at all times. The particular set shewn is a single operator equipment, of 200 ampere capacity, suitable for working from a 400 volt, three-phase, 50 cycle supply.

Other exhibits include unit type air-break metal-clad switchboards, designed for floor or wall mounting and providing a simple and inexpensive means of control for general industrial purposes. The units are made for current ratings ranging from 30 amperes to 350 amperes at 660 volts, and include busbar chambers, fuse-boxes, switches, circuit breakers, and cable sealing and dividing boxes for armoured cables. The particular switchboard shewn is arranged for floor mounting, and has one incoming circuit of 200 ampere capacity, and four outgoing circuits, two of 30 ampere capacity, and two of 60 amperes capacity.

Messrs. Holmes have been manufacturing automatic electric traffic control apparatus for some time, and have supplied a number of equipments for various places. They are exhibiting examples of the equipment, and it is important that this all-British product should be made known as widely as possible in view of the increasing use of automatic traffic control all over the country.

(*To be continued*).

Association Visits to B.I. Fair, Birmingham.

The schedule of official visits to the British Industries Fair, Birmingham, includes the following of electrical and allied interests.

Tuesday, February 23rd.

Electrical Association for Women.

Wednesday, February 24th.

Institution of Electrical Engineers—South Midland Centre.
Incorporated Municipal Electrical Association (Mid. Sec.).
Electrical Contractors Association, Inc.
Electrical Contractors Association of Scotland.
Association of Consulting Engineers, Inc.
Association of Supervising Electrical Engineers.
Illuminating Engineering Society.
Municipal Tramways & Transport Association.
Tramways & Light Railways Association.

Friday, February 26th.

Association of Mining Electrical Engineers.

Saturday, February 27th.

Electrical Power Engineers' Association.
Students Section—South Midland Centre—I.E.E.

Wednesday, March 2nd.

Institution of Electrical Engineers—Council.
Incorporated Municipal Electrical Association—Council.
British Electrical Development Association, Inc.
Incorporated Association of Electric Power Companies.
Provincial Electric Supply Association.
Electrical Wholesalers Federation Ltd.
Electrical Merchants & Manufacturers Association.
London Electricity Supply Association.
British Electrical and Allied Manufacturers' Association.
B.E.D.A. Dinner in the evening.

Thursday, March 3rd.

Electrical Wholesalers Federation Ltd.