The Mining Electrical Engineer.

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• • EDITED BY E. DINSDALE PHILLIPS. • •

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Better Times Pending.

There is a marked tone of optimism pervading recent news and reports concerning the coal industry. Possibly the dual effect of the personal exhilaration enjoyed by the healthy man reacting to the rigours of an arctic winter combined with the effect of the resultant glut of orders for domestic fuel may have induced expressions a little too sanguine. None the less it is most gratifying to observe the tangible facts proving a general and widespread awakening of business. The hard weather brought immediate busy times in the pits, in some cases even to the extent of raising the old outcry of inadequate transport facilities. It is reported that one railway company, owing to congestion of coal traffic and the shortage of wagons, had to impose a temporary stoppage at certain key points: also that many collieries have been unable to fill orders because of wagon shortage. In South Yorkshire and the West Riding the home and export orders have put every colliery on to full time working; the Doncaster district has the whole of its 40,000 miners in full work, and some pits are calling for more men. In Nottingham and Staffordshire the same story is told. In Durham, pits which have been closed down for over three years have resumed working. Whilst this boom can of course be attributed in part to the climatic condition, the nature of the orders shows that it is to a very considerable extent due to a natural revival in the iron and steel trades and in the export demand.

Coincident with this heartening assurance of revival in the ordinary channels of the coal trade there is throughout the country a swelling stream of work actually under way in the building of coking, distillation and carbonisation plants. It is of exceptional interest to note that Ireland is seriously entering the field as a not inconsiderable producer of coal. Reports concerning Dungannon indicate that at least 1500 men will be required there for the brickmaking and colliery works now starting. The coal is equal to the Scotch product now being used locally, and a three-foot seam, as well as another proved seam measuring 4ft. 10in. to 5ft. 6in., will be worked. Over 2,000 acres of coal land have been leased, and the sinking of the first shaft is to be begun at the end of this month.

Manufacturers of mining and electrical plant will therefore be encouraged to put their best foot forward as "salesmen." There is no need here to rub in the excellent advice of the Prince of Wales. It would appear that his timely admonishment is being taken seriously to heart and improvement will follow. In so far as mining electrical plant is concerned the British Industries Fair at Birmingham has this year become exceptionally important. Many of the leading British makers of these special forms of machinery have at last gone to very considerable trouble to exhibit the merits of their products. Which is as it should be, for there is no gainsaying the fact that British mining plant is superior to that of any other country. It is acknowledged that our mining plant makers have been exceptional in regard to sending trained and expert salesmen into the world for business—and that as a result our machinery is found in every mining corner of the globe. What has been done is, however, but a fraction of the trade waiting to be picked up to-day. There is always the great selling point of an undoubted superior quality attaching to this branch of British engineering. It is the inevitable outcome of the expert craftsman being called upon to provide plant, appliances and methods which will economically get coal from difficult and remote places, which will do that under the most rigorous legal regulations as to safety, and under artisan living conditions and working hours which are the most favourable in the world. There is little wonder that, in this branch of engineering at any rate, this country can successfully compete in the world's market. But the business has to be gone out for and got by hard work.

Important Exhibitions.

As said, there are many notable exhibits at Birmingham which particularly appeal to mining electrical engineers. It has not been possible to deal adequately with them in this number, and in deferring particulars to our next issue, exhibitors and readers are assured of receiving that permanent and useful record which is compatible with the importance of the matter.

It is, moreover, necessary to direct early attention to the ambitious move promoted for the industrial welfare of North-East England. A preliminary booklet indicates that the North-East Coast Exhibition is planned on the most ambitious scale. From May to October this year the Town Moor in the centre of Newcastle will be laid out with palatial buildings, gardens, sports' grounds, and all the usual and latest schemes for attracting widespread notice to the arts and industries of the North-East Coast. The Palaces of Engineering alone will yield some 260,000 square feet of floor space; and practically every local electrical and engineering firm of standing will be represented by exceptionally complete and notable working exhibits. Newcastle means coal—and there is sure to be very much of the greatest interest to mining electrical men to be seen in the respective displays staged by the several famous engineering works of the north country.

The A.M.E.E. Annual Convention.

In view of this exceptional attraction is would have been strange had not the Association of Mining Electrical Engineers decided to make Newcastle the scene for this year's convention. The local committee of the Association has happily secured the close collaboration and generous interests of the Exhibition Authorities and of the leading parties connected with the colliery and engineering industries of the district. It will be seen from the preliminary programme given hereunder that a remarkably enjoyable and useful series of events has been organised. We would therefore urge every member to do his best to attend, to show in that way the only proper acknowledgment of the services of the North of England Branch and its friends, and to avail themselves of a unique opportunity brimful of usefulness gained in happiest circumstance.

Association of Mining Electrical Engineers.

Annual Convention, 1929, in Newcastle-upon-Tyne.

Provisional Programme.

Tuesday, July 2nd.—Evening.

Informal Reunion at the Central Station Hotel, Newcastle.

Wednesday, July 3rd.—Morning.

Visit to the Derwenthaugh Coke Works of the Consett Iron Co., Ltd. These works, which are now being started up, are claimed to be the most up-to-date in the country; the electrical equipment has been the subject of special consideration and includes many interesting features. The engine room is of particular interest, containing two 100 K.W. turbo generators of novel design (specially adapted for industrial purposes) and a 1500 K.V.A. induction regulator and transformer equipment for parallel working with the Company's colliery stations over an E.H.P. transmission line: turbine driven exhausters and boosters are employed for transmitting the coke oven gas to Gateshead for use by the Newcastle and Gateshead Gas Company. The works include one of the latest types of pneumatic dry coal cleaning plants with automatic electrical drive.

The Party will kindly be entertained to luncheon by the Consett Iron Co., Ltd. A service of buses will be available to and from Derwenthaugh.

For those not wishing to visit the coke works, a visit to the Roman Wall will be arranged if a sufficient number desire it.

Afternoon.—Visit to Messrs. Reyrolle & Co., Ltd. Works, Hebburn-on-Tyne.

Special reference is to be made to Messrs. Reyrolle's adaptation of switchgear to the stringent requirements of work in coal mines and other places where open sparking might lead to disaster. Flameproof joints, with wide machined flanges, were first designed and developed by this Company nearly twenty years ago; and their provision of boiler-plate switch-tanks, in addition, has made mining switchgear one of the most robust products of the switchgear industry.

Mechanical and electrical interlocking in such types of control gear as those for coal-cutters and conveyors has added still further to the excellent provision for securing the safety of underground workers; and it is one of Messrs. Reyrolle's achievements to have taken a great share in the conversion of colliery switchgear from the haphazard thing it once was to the practically undamageable and well-proportioned product it has come to be. Unceasing attention to the improvement of details, with fundamentally sound principles as a basis, still is, as it has always been, their first care in this as in all other departments of their work.

The Party will be entertained to tea at the works by Messrs. Reyrolle.

Evening.—A Dinner followed by Dancing will take place at the Barras Bridge Assembly Rooms by kind invitation of the Northumberland and Durham Coal Owner's Association to Members and Ladies.

Thursday, July 4th.—Morning.

Visit to Dunston Power Station of the Newcastle upon-Tyne Electric Supply Co., Ltd. This is a modern super-station of 92,000 K.W. capacity including sets each of 15,000 K.W. The plant also comprises a low temperature coal distillation system as supplied to electric generating stations and combining the carbonisation of coal with steam raising and the recovery of by-products from the fuel; an equipment for unloading pneumatically trucks of finely-divided coal, as well as step-up transformers and out-of-door 66 kilo-volt equipment.

A service of buses will be available to and from Dunston.

After the visit the Party will kindly be entertained to luncheon by the Newcastle Electric Supply Co. at the Newcastle Exhibition.

Afternoon. Visit to Seghill Colliery. The whole of the surface equipment of this colliery was recently dismantled, new buildings and headgear were erected and a complete electrification scheme taken in hand, including four A.C. geared electrically operated winding engines, electrically driven haulages, modern screening and washery plant and brickworks. The substation includes 4000 K.V.A. of transformer capacity.

The Party will kindly be entertained to tea at the colliery by Seghill Colliery Co., Ltd., who will also provide tennis and other sports' facilities.

A service of buses will be available to and from Seghill.

Evening. Civic Reception by the Lord Mayor and Sheriff, followed by Dancing at the Old Assembly Rooms.

Friday, July 5th.—Morning.

Association Council Meeting in the Festival Hall in the Exhibition Grounds. Luncheon will be taken at one of the first-class Restaurants at the Exhibition.

Afternoon. Association Annual General Meeting in the Festival Hall in the Exhibition Grounds.

Evening.—The Association Annual Dinner at the Central Station Hotel.

Boiler Repair Risks.

EDWARD INGHAM, A.M.I.Mech.E.

At all collieries where large quantities of steam are used, repairs to one or other of the boilers may be required from time to time. This question of repairs is one which does not always receive the attention its importance demands and, not infrequently, it results that a boiler is in a more unsafe condition afterwards than it was before the repairs were carried out. There are indeed numerous instances on record of boilers which have exploded very shortly after having undergone repairs. These explosions have been mostly caused through the removal of certain strengthening pieces, the functions of which had not been understood by those who have carried out the work.

In one instance, a plain furnace tube of a large cylindrical boiler required renewal on account of its seriously wasted condition. The tube was strengthened by a T-iron hoop, but the repairers, not understanding the function of the hoop, omitted to provide any means of strengthening the new length of tube. Very soon after the boiler was put to work again, the tube collapsed and ruptured, causing the death of a number of men working in the vicinity, and serious injury to many others.

Some boiler repairers evidently do not realise that cross-tubes greatly strengthen a flue tube to resist collapse, for there are several instances where such tubes have been removed without any compensating strength having been provided. In one case, repeated repairs to the furnace and flue tube of a Cornish boiler had resulted in the ultimate removal of the whole of the cross-tubes, which were evidently regarded by the persons concerned as being of little or no practical use. As was only to be expected, the tube eventually collapsed.

In another instance, a defective cross-tube was taken out of one of the furnace and flue tubes of a Lancashire boiler. The works engineer was sufficiently intelligent to realise that the cross-tube afforded a large amount of strength to the main tube, and that its removal necessitated some other means of strengthening. He accordingly fitted a 1in. bolt. This, however, was of very little use, and the tube collapsed soon afterwards. The engineer evidently did not understand that although a 1in. bolt has great strength when used as a tie rod in tension, it offers very little resistance to buckling under compression, especially if the bolt is of any considerable length; in the case mentioned the length would be in the neighbourhood of three feet, so that the strength afforded by the bolt to the main tube would be practically negligible.

There has been an increasing tendency of late years to effect boiler repairs by the aid of welding. Used with discretion, welding may be a valuable means of effecting repairs but, otherwise, it may be responsible for endangering the safety of the boiler. The danger arises principally when the attempt is made to repair parts in tension. There is always an element of uncertainty about a welded joint and, for this reason, parts which are in tension, i.e., parts which are exposed to pulling forces which tend to open up the joint, should not generally be repaired by welding. The practice of making up severely corroded shell plates by welding is one which should be condemned.

There can be no serious objection to this form of repair when applied to defective parts in compression, because the tendency of the pressure is to close the joint; so that even if the welding is not perfectly carried out, there is no great risk of subsequent failure.

A serious fault in boiler repair work is that of cutting out pieces of corroded or defective plate prior to applying a patch, in such a way that sharp corners are left, as at A, B, C and D in Fig. 1. Serious fractures are liable to develop at such corners, and for this reason the hole should be cut to the form shown in Fig. 2, all the corners being rounded to as large a radius as practicable.

It is important to avoid rivetting a patch over a piece of corroded plate. Unless the wasted part be entirely cut out, there will be two thicknesses of plate, and overheating and leakage troubles are then liable to result, especially if the affected part is in a furnace tube, and directly exposed to the heat of the furnace gases.

It occasionally happens that some part of a boiler gives out at a time when the boiler cannot be shut down for the period necessary to effect a permanent repair, and a temporary repair has then to be executed. Not infrequently, these temporary repairs prove unsatisfactory and at times even dangerous. For example, the smoke tubes of loco. type boilers, being thin and liable to considerable erosive action, occasionally perforate and have either to be replaced or plugged up for the time being.

It is not uncommon to find such tubes plugged by plain tapered stoppers which are simply driven in, and which therefore depend entirely for their hold upon the

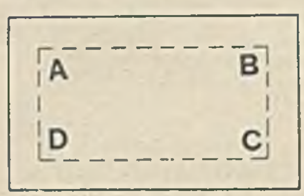

Fig. 1.

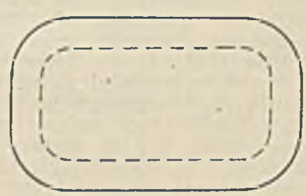

Fig. 2.

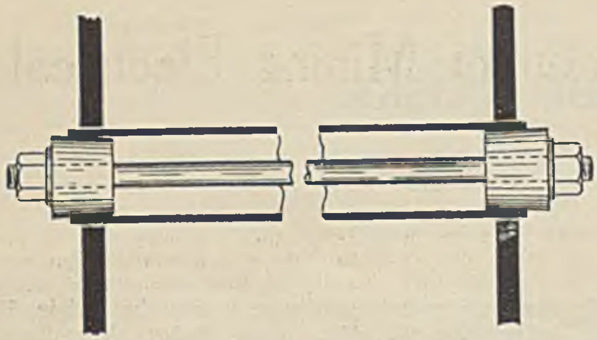

Fig. 3.

friction between stopper and tube. In numerous instances such stoppers have been blown out, the fireman being badly scalded. To avoid this risk, those concerned should make sure that the plugs are positively secured in position by longitudinal bolts passing through the tubes and nutted at each end (see Fig. 3). The bolts should be of ample size, as they are liable to waste and break through the threaded parts if the defective tube is not replaced at an early date.

A similar risk exists if the plugs used for stopping the extension of a fracture are not very carefully fitted. The blowing-out of a small plug may result in the escape of a quantity of steam and hot water sufficient to cause serious injuries to the fireman.

The above remarks show that great risks may arise in connection with boiler repairs if the matter is not given careful consideration. It is strongly advised that all important repairs should be carried out under the supervision of an expert, who has a good knowledge of the strength of boilers, as well as large experience of boiler making.

After repairs have been completed, it is desirable that the boiler should be hydrostatically tested to a pressure a little in excess of the ordinary working pressure.

Careful gauging of parts liable to deformation should be taken just before, during, and after the test. A comparison of the gaugings will enable one to judge if the boiler has suffered any undue deformation during the test, and whether it has received any permanent set. Either of these faults would indicate serious weakness at the part concerned.

Whilst the boiler is under test it should be carefully examined, particularly at the repaired part, for evidences of leakage. Slight leakages which can be staunched by a little light caulking are not usually important, but any pronounced leakage should be regarded with suspicion, and taken as an indication of unsatisfactory work.

The Beginning of The Association of Mining Electrical Engineers.

(With acknowledgments and appreciation we reprint the following abstract from a recent issue of *The Iron and Coal Trades Review*, and would assure our contemporary and those most closely interested that in the article referred to no attempt was made to give any more than a bare outline of the growth of the A.M.E.E. In addition to the kindly reference to Mr. Maurice the *I.C.T.R.* mentions several other names of men who were closely connected with the foundation of the A.M.E.E. It is interesting to note also that another reader sent us a long letter crediting other ardent enthusiasts who so materially helped in putting the A.M.E.E. into being).

This year the Association of Mining Electrical Engineers celebrates its 20th Anniversary. From small beginnings it has grown in membership and influence to a position which entitles it to rank among the important technical institutions of this country. As the Institution of Mining Electrical Engineers—the title it bore at its inauguration—the new body received little encouragement in the early days of its career. By existing technical institutions the new-comer was looked upon as an unnecessary addition to the large number already existing. Exception, too, was taken to the use of the word "Institution" as being likely to cause confusion with the Institution of Electrical Engineers, and so in order to smooth away some of the opposition the "Mining Electricals" consented to adopt the title of Association of Mining Electrical Engineers. The Association was regarded at first by many colliery owners as a trade union rather than as an Association whose sole object was to further the technical interests of its members. A considerable time elapsed before these prejudices were broken down, and the work of the Association came to be recognised as a valuable asset of the mining industry for promoting safety in the use of electricity both above and below ground.

The Association came into being at an opportune moment when colliery proprietors were beginning to recognise the adaptability of electricity to the various operations in connection with mining and were installing large quantities of apparatus. Unfortunately many manufacturers assumed that the gear designed for ordinary industrial use was equally suitable for mining conditions. Consequently many fatal accidents occurred and numerous untoward happenings, especially underground, were rapidly discrediting electricity as a safe medium for use in mines. However, the numerous Papers read before the Association dealing with breakdowns, accidents due to electric shock, the vexed question of earthing, and so on, together with the discussions which followed, did much to stimulate manufacturers in the development of electrical appliances of a more robust character capable of withstanding the onerous conditions of service encountered underground. Moreover, the system of examinations introduced by the Association has done much to raise the standard of technical education of mining electricians, thus ensuring that the apparatus in their charge is properly cared for and maintained.

It is fitting that "The Mining Electrical Engineer" should mark this 20th Anniversary by publishing a brief history of the Association. This appears in the January number; but although the writer pays a valued tribute to *The Iron and Coal Trades Review* for the slight service which it was able to render in connection with the earlier Proceedings of the Association, only bare reference is made to the pioneers, whose enthusiasm and untiring energies successfully launched the Association. The outstanding figure among these was Mr. Wm. Maurice, then Manager of the Hucknall Colliery Company, Limited. At the inaugural meeting of the Association—to use its present style—held on Saturday, April 24th, 1909, at Manchester, Mr. Maurice was elected President, and held that office for the first three critical years of the Association's existence, during which he worked unceasingly to further its interests.

Proceedings of the Association of Mining Electrical Engineers.

SOUTH WALES BRANCH.

A meeting of the South Wales Branch was held in Cardiff on 10th November last. Mr. T. S. Thomas, the President of the Branch, occupied the chair. After the minutes of the previous meeting were read, confirmed and signed the following applications for membership were accepted: Members—Messrs. J. S. Hall, D. Jones and W. Woods; Associate—Mr. W. J. Davies; Students—Messrs. R. H. Campin and E. R. Evans. Also seven new members for the Western Sub-Branch as follows: Messrs. J. I. Howell, A. John, R. D. Morris, D. T. Evans, T. H. Gambold and D. P. Davies.

A Paper was then read by Mr. S. B. Haslam entitled "Modern Methods of Firing Steam Boilers, with Special Reference to Pulverised Fuel." This was profusely illustrated with lantern slides. This paper and discussion proved so interesting and instructive that it was decided to adjourn the discussion until the next meeting, December 8th.

Modern Methods of Steam Raising, with Special Reference to Pulverised Fuel.*

Discussion.

Mr. T. S. THOMAS (Branch President).—Mr. Haslam is to be congratulated on his interesting and informative paper. They had all listened with much appreciation to the able treatment of a complex subject There were two distinct schools claiming equal advantages for the contending systems. Probably the pulverised-coal system with its extreme flexibility in dealing with variations of fuel and load was slightly preferable to the mechanical stoker, but Mr. Haslam's suggestion of a combined system called for much discussion and consideration.

Mr. MacSHEEHY commended the author's method of reviewing the fundamental principles of combustion first, of describing certain pulverised fuel systems next, and thus leading up to the consideration of special systems Such a paper cannot help but bring up the question of pulverised fuel firing versus mechanical stokers. Mr. MacSheehy said he could not see the justification for pulverised coal firing of boilers of under about 80,000lbs. per hour capacity if coal could be got at about 14s. to 18s. per ton. He could quote one case where all the year round on a 40% load factor, 81% efficiency is obtained by mechanical stokers with economisers and air-preheaters. The author had mentioned an efficiency of 83% as a good efficiency on pulverised coal firing: the speaker would rather assume under similar conditions that pulverised fuel boilers with economisers and air-preheaters would give 90% efficiency. That is about 10% saving in the case of pulverised fuel in actual thermal efficiency. With coal at 17s. that would mean the cost of raising a certain amount of steam would be 17s. on stokers and 10% less, that is 15s. 5d., on pulverised fuel—a difference of 1s. 7d. Then there would be the pulverising costs, about 2s. to 3s. per ton, bringing the costs considerably above those on mechanical stokers.

With more expensive coal of course the case gradually changes in favour of pulverised fuel. In the other direction in the case of grades of coal which are not easily fired on mechanical stokers it may pay to purchase this coal at a low rate and pulverise; but is it not an economical fact that if this principle be generally adopted collieries will find themselves with the larger grades of coal on their hands, and that prices of their different grades, small and large will tend to level up and the pulverised fuel users will gradually have to pay more for their coal?

With regard to the application of pulverised fuel to Lancashire boilers it would seem to be fantastical to apply this system to Lancashire boilers: to design a boiler unsuitable for pulverised fuel would be to design a Lancashire boiler. There is a relatively small heating surface at the point of combustion to absorb the heat by radiation which is so much more rapid than conduction and there are beautiful flue arrangements to collect the ash in them which is generally not all deposited in the combustion chamber as one would wish. With the high temperature at the point of combustion it must be really quite a stress on the furnace tubes and unless the water is perfect it would be liable to lead to trouble

There is another point in the early part of the paper. The author refers to the fact that many boilers depend on natural draught and damper regulation. Unfortunately in too many cases they depend only on natural draught without damper regulation. The author implied that even now it is essential to have a certain fairly large percentage of volatile in the coal for pulverised fuel. Certain makers of pulverised fuel plants claim that with sufficiently pre-heated air even semi-anthracitic small can be very satisfactorily dealt with. That would be very useful because it is not very easy to burn this on hand-fired or mechanically-fired boilers. With reference to the percentage of CO_2, ideal combustion is a high temperature near the zone of combustion as high as one can reasonably get it on a hand fired boiler, implying a low proportion of excess air; there is rapid transmission of heat to the water and a steep temperature gradient through the boiler passes and a low stack temperature. If on the other hand too much excess air is supplied, causing a low temperature at the zone of combustion, the temperature might be only a little above that necessary for combustion, transmission of heat is slow, therefore the temperature gradient is shallow, there is low CO_2 and comparatively high stack temperature. That is presuming the setting and brickwork is absolutely tight. If on the other hand fairly good combustion is obtained with a moderate excess of air and the setting is leaky, then there is the liability of getting a low CO_2 percentage at the outlet of the boiler, despite the fact that there is really a good condition at the grate.

Regarding the special case of combined firing, Mr. MacSheehy was rather diffident about saying much without further consideration, but two or three points did occur to him. It is designed principally to deal with a fluctuating load. One would have to consider an alternative system by which the boilers would still have mechanical stokers working at a constant rate, and take up the fluctuations on steam accumulators instead of putting in any special plant. One would imagine the combined system would have a heavier cost than either of the other systems. Can we have some general idea about that? He would qualify his first statement in reference to the use of pulverised fuel in general. There is one case where pulverised fuel is thoroughly justified on any size of boiler and that is at the colliery itself where there is small coal to be got rid of somehow. Particularly with washeries there is small dry coal separated before washing and it is undoubtedly of

*See *The Mining Electrical Engineer*, Jan. 1929, p. 238.

the best quality to pulverise and use in water-tube boilers where some 40% to 50% of the heating surface is exposed to the combustion chamber, including the water screens. Cartage costs are avoided and with an excess of small coal in a suitable district for applying electricity generated by the excess of small coal, arrangements could possibly be made with the local power companies to take the surplus current.

Mr. PATTON.—The author generally has been very fair to the manufacturers, having referred to nearly every system. Perhaps at the beginning of the paper he seemed somewhat brutal as far as the central system is concerned, but there is a decided field for both the unit and the bin and feeder system. Mr. Patton had been interested a while ago to see the prices for a certain installation on the three systems, mechanical stoking, unit pulverised fuel firing and the bin and feeder system. The installation was a large one and the price allotted in the neighbourhood of £100,000. The stoker system was approximately £3,000 below the figure mentioned; the unit system over £4,000 above the £100,000 and the bin and feeder system in between the two at just over the £100,000 figure, showing that on a fairly large plant it is possible to instal a bin and feeder system at a cheaper price than the unit system. In a district such as South Wales, however, where there are a large number of small boiler installations, it is fairly obvious that in the majority of cases the unit system would tend to have priority of claim on capital cost.

It must not be overlooked, however, that it is impossible to lay down a definite rule as to which system is the most economical, for in every case the local conditions must be very carefully studied in order that the plant will be installed which, over a period of time, will show the greatest return of capital expenditure.

The author had mentioned two particular types of pulverisers, the roller mill and the ball mill, and was rather inclined to rule out the roller mill on account of maintenance and reliability. It was interesting to hear that in this country roller mills are pulverising up to 18,000 to 25,000 tons before they require renewals or repairs: that shows a fair amount of reliability for the roller mill.

Here again it should not be overlooked that the type of coal to be pulverised governs the type of mill to be installed. Hard abrasive coals such as anthracite coals will require mills of the ball type. Coals not so abrasive can more economically be pulverised by the roller mill, in that less power is absorbed per ton of pulverised coal for less capital cost.

In connection with his reference to furnaces and method of introducing pulverised fuel, the author had inferred that the accepted method was vertically downwards. This was the method proposed and adopted eighteen months to two years ago. To-day this method has been very largely superseded by firing pulverised coal horizontally through the medium of a turbulent type burner. The old method of firing vertically downwards meant large combustion chambers; for in between each stream of pulverised coal, streams of air were induced, the two streams travelling so comfortably that intermixing was bound to be slow. The present day burner has revolutionised that method. To-day, with the "R" type burner, complete combustion within ten feet from the burner outlet is obtained and this at something like one-fifth of the feeding air pressure required by the old long flame burner. This development shows an enormous advance in the art of pulverised fuel firing because it first of all means a reduction in the size of the furnaces. In the early days we remember the cathedral looking boilers, due to the large combustion chambers required, but to-day, with the new type turbulent burner it is possible to keep down the height required for pulverised fuel fired boiler equipment to the same dimensions required for a modern mechanical stoker equipment.

The statement was made that it has yet to be proved that pulverised fuel could give as high boiler capacity as mechanical stoking. This brought to mind a boiler installation in America where the original boilers were each laid down for an evaporation of 210,000lbs. per hour. The furnaces consisted of a complete refractory wall equipment; the development of the water screens and water walls had not yet taken place. The power station when completed was designed for eight boilers. These were all installed. Very shortly afterwards the demand for power developed considerably and something had to be done to considerably increase the steam output from the completed boiler house. This was done by covering the whole of the refractory walls with water-cooled fin tubes and introducing a water screen at the bottom of each furnace. Radiant superheaters were also introduced. To-day these same boilers are giving a normal evaporation of 400,000lbs. of steam per hour and have given as high as 600,000lbs. per hour from each unit. Could that have been done with mechanical stokers?

It had been thought that the introduction of water cooled walls and water screens was made primarily with a view to obtaining a high evaporation output from the walls and screens themselves. That was not the case. The screens and walls were designed primarily to protect the furnace lining. If an effort was made to approach near to the ratings just mentioned, very serious trouble would be experienced from the slagging of the ash, and the refractory walls would be incapable of withstanding the heat load very long. Actually, in the particular installation referred to, the amount of heat absorbed, or evaporation work done by the boiler proper, increases with the rating on the boiler and the amount of evaporation work done by the water cooled walls and screens decreases; showing that the introduction of these surfaces was not made with a view to obtaining high evaporation from them, but to make it possible to obtain the higher evaporation from the boiler proper.

The loss in the ash was given as 4% from the Lancashire boiler referred to as being pulverised fuel fired Mr. Patton would like to ask the author where this sampling was made: his experience led him to feel that pulverised fuel applied to Lancashire boilers seemed rather like putting the cart before the horse.

He had hoped that the author would make some particular reference to the development in the design of boilers for pulverised fuel firing. There had been great developments in the art of pulverised fuel firing, but boiler design had remained stationary. It is interesting to find in America and in this country, an entirely new British design of boiler appearing. It consists practically of a steel box, the whole of the furnace being enclosed with water heat absorbing surfaces. There is practically no refractory material in the furnace whatever. This steam generator, alongside an absolutely modern stoker fired boiler having 9% more heating surface, is turning out close on 150% more steam. In the one case the mechanical stoker fired boiler is evaporating 60,000 lbs. of steam per hour, but the new steam generator is evaporating 150,000lbs. of steam per hour. The amount of floor space taken by the new steam generator is the same as that taken by the boiler equipped with mechanical stokers.

It may be safely assumed, therefore, that pulverised fuel, operating in conjunction with a boiler designed specially for its use, and having less than half the heating surface of a modern mechanical stoker fired boiler, is capable of giving comfortably the same evaporation.

It is in the design of steam generators that we are going to see something of a very interesting nature in the future use of pulverised fuel. We may be excused for taking pride in the fact that the design of this new steam generator is entirely British: the first one was built in this country and set to work at Taylor Bros. Industrial Works, near Manchester. To any engineers interested in this new boiler Mr. Patten extended a hearty invitation to them to inspect the generator under operating conditions.

Mr. E. K. REGAN said he would like to preface his remarks by referring to the slide showing a locomotive fitted with pulverised fuel equipment, principally because it represented the greatest development which has taken place in the history of pulverised fuel and secondly because he recently had the experience of a 40 mile run on the engine in question. The locomotive is a standard heavy freight type as used on the German State Railways, the tender space occupied by a large cylindrical tank containing the pulverised coal. Coaling is effected by connecting the tender by means of a hose to the fuel system of a central pulverising depot, the operation of pumping in seven or eight tons taking about half an hour. The fuel is fed to the burners by means of two feeder screws extending the full length of the tender tank, a third smaller screw being used for light load periods and during stoppages; the fuel connections between tender and engine are of pipes with flexible joints. The feeder screws are driven through clutches by a small vertical engine of two to three H.P. A portion of the air for combustion is supplied by a steam turbine driven blower which discharges into the fuel pipe from feeder screws, the balance of the air supply being aspirated by the engine exhaust into the fire-box in the usual manner.

Two burners of rectangular cross section are fixed in the fire-box, the discharge of fuel from the burners being in opposition so as to promote a thorough mixing of fuel and air and creating turbulence during combustion. Regulation of the fire and steam output is remarkably simple and is effected by speed regulation of the feeder engine and turbo blower.

Considering that there is no residual body of fire, steaming is very steady, much more so than in ordinary locomotive practice and the flexibility is more pronounced. Higher boiler efficiencies and a consequent economy of fuel up to 20% are claimed for this system, and from experience Mr. Regan said he had no doubt this could be attained.

Slagging in the fire-box appeared to be quite absent and although the bulk of the ash is discharged from the funnel in the form of a very fine powder, it is neither so noticeable nor does it constitute such a nuisance as the smoke and grit discharged from an ordinary locomotive.

The only disadvantage at present is the necessity for connecting up the locomotive external steam supply when lighting up from cold, this being necessary to operate the air and fuel feeders, until steam is available from the locomotive.

Three of these locomotives have recently been delivered to the German State Railways. It may be mentioned in passing that the heat liberation in the furnace is at the rate of 200,000 B.T.U. per cubic foot of firebox volume, whereas with stationary pulverised fuel boilers 20,000 B.T.U. per cubic foot is considered a high figure.

Mr. Regan then said he considered Mr. Haslam had been rather hard on mechanical stokers as regards their inability to deal with sudden increases of load. Provided the draught requirements are sufficient, it was possible to pick up load very quickly by increasing the depth of fire. Provided the fire is originally in good condition the boiler will respond almost instantaneously. Reducing load is rather a different proposition; the speed and draught can be reduced but a large residual fire is on the grate. He would not, however, care to say that stoker firing is as flexible as pulverised fuel firing.

With regard to lower standby losses with pulverised fuel rather exaggerated claims are made. A stoker fired boiler can be banked fairly efficiently. With pulverised fuel it is claimed that to bank a boiler one simply "turns the gas off" as it were and no further fuel is required for the time. The boiler is, however, keeping up pressure on the heat coming from the large masses of brickwork; and on going into service again, this heat must be restored, and until the correct furnace temperature is attained a certain loss occurs.

Regarding the comparisons made between the standard of cleanliness in stoker fired and pulverised fuel fired plants, Mr. Regan said he did not consider that pulverised fuel firing is much cleaner than stoker firing. Most pulverised fuel plants are comparatively new and as regards cleanliness conform more to modern ideas, but this is not entirely due to the system. A very high standard of cleanliness can be established with mechanical stokers, particularly when washed fuel is used. Practically all the dirt which may be found in any modern plant, whether stoker fired or pulverised fuel fired, comes from the same source, i.e., dust carried away by flue gases which finds its way through quite minute crevices, etc., in the fan plant.

Smoke losses and nuisance are generally very much exaggerated; what is not generally appreciated is that even when in the absence of smoke in a stack discharge, a dense volume of gas is being emitted which has undesirable properties. With pulverised fuel firing it is common to find that 20% of the ash in the fuel leaves the stack in the form of a very fine powder, and unless the stack is high this will constitute a nuisance.

In common with a previous speaker, he could not agree that it is accepted that a pulverised fuel flame should be directed downwards; with the older "fish tail" burner that was necessary in order to obtain a long flame path in which to effect complete combustion. The newer type of dispersive burner arranged horizontally will give complete combustion in almost half the distance and in addition obviate the necessity for a brickwork arch.

Slagging of ash has always been a troublesome point but unless the fuel has a low fusion ash, slagging is an indication that operation is bad, or that combustion conditions are out of hand due to the absence of necessary instruments. Most plants of a few years ago were badly equipped in this respect and so experienced trouble with brickwork and slagging. Personally, he had found that with a fuel, the ash of which has a fusion point of 1150 deg. to 1200 deg. C., no difficulty was experienced with slagging when carrying 14% CO_2 constantly.

It was very surprising to find the author stating that pulverised fuel firing is economically limited to soft or bituminous coals: Mr. Regan said he must differ from him on this point very strongly. Makers of plant frequently state that low volatile fuels can be burned efficiently, and back up the statements by quoting results of tests. As, however, these trials have usually been limited to small quantities of fuel, probably a few tons, the statements are not convincing. He could, however, assure the author that a plant has been operating for some months on coal with a volatile content of 11% and, as a trial experiment, has obviously been under close supervision. The results obtained in daily practice prove that this class of fuel can be burned as efficiently as more bituminous fuels, and efficiencies up to 88% boiler and economiser are regularly obtained. He would further suggest that future developments will show that the lower volatile fuels will ultimately prove to be superior to the more bituminous fuels for pulverised fuel firing.

So far as test figures are concerned, with a suitable fuel there is very little margin between a good stoker fired plant and a pulverised fuel plant; but in daily practice the highest efficiency figure is more easily maintained with pulverised fuel firing, provided the plant is equipped with the necessary instruments and full use is made of them. Pulverised fuel firing requires a more scientific system of control—one might describe it as "micrometer control"; but when so operated the results obtained are very regular and high efficiency is maintained.

MAJOR E. IVOR DAVID.—In South Wales there was found great difficulty in creating a reasonable enthusiasm about pulverised fuel because there they were dependent upon selling an expensively produced coal with inherently high burning properties; so that any system introduced to burn low grades of coal would hit South Wales rather hard. But, as engineers, they must try to remove bias when considering the two systems, and not condemn the new system because it threatened to do harm to established business.

Hand firing is condemned very largely because it is overlooked that a good stoker is a highly skilled workman: with hand stoking where efficiencies run to from

70% to 75%, great skill is necessary on the part of the stoker.

In the paper the author referred to chimneys and draught regulation chimneys being out of date. That is true where there is induced draught only, but in modern boilers with forced draught a chimney is preferable because it takes the products of combustion up to a good height and gets them dispersed and away. That is particularly important when burning a low grade fuel.

Coming to the pulverised fuel question, Mr. Haslam gave the impression that a drier was necessary. At the Dunstan Power Station there is a pulverised fuel plant burning coal with 15% moisture quite satisfactorily.

It is a strange thing that when pulverised fuel started engineers seemed to forget all the experience which was available to them. The same thing applied with stone dusting in mines. The colliery went through all the trouble which had been previously encountered by the cement people.

With regard to the percentage of combustible in the ash, 10% is high for a good class stoker.

It was interesting to note that an oil firing installation was removed locally and substituted by a chain stoker installation.

With regard to the ignition of the pulverised fuel, Major David said he did not quite understand where pulverised fuel gets its ignition heat from. It must be heat either reflected or by radiation, and it is found that in burning low volatile coal if the walls are extensively watered there is not enough heat to ignite the coal.

With regard to the question of combustion, it appears as if the fine particles of coal are burnt much easier. Mr. Haslam refers to the fact that ten thousand times the volume of the carbon has to be got adjacent to it in some way. It is a case of letting the dog see the rabbit, only there is only one rabbit and ten thousand dogs. He agreed with the other speakers that the turbulent type of burner has advanced.

Pulverised fuel as an industry has had a bad start in this country. All the sellers of plants were Americans who stated the case exuberantly; but when we got them up against brass tacks and put them up against efficiencies of 86% and 87% they, like the Arab, folded their tents and silently stole away. We could not get them to return into the field for some time, but they are coming back again. A decided reaction in favour of chain grate stokers has set in, but it is only a momentary reaction.

With reference to Lancashire boiler firing, Major David said he had two Lancashire boiler plants burning anthracite coal. There is established in this country an enormous amount of capital in Lancashire boilers which have a life of 25 to 30 years. It would be most costly to have to scrap the existing plants. That explains why people are still trying to burn pulverised fuel on Lancashire boilers. Major David said that to his knowledge this has been done successfully in two instances. The volatile of the coal is over 32%. With regard to the figures given by Mr. Haslam of the relative efficiency it is difficult to see why the pulverised fuel should have a lower efficiency, because everything seems to point to higher efficiency. He would be interested to learn why the pulverised fuel is lower. Mr. Haslam gave the higher efficiency on chain grate stokers on light loads, showing in many cases that boilers are over-run with the rating which we use in this country. Efficiencies up to 90% obtained with stoker fired boilers having air preheaters had been obtained by the speaker.

With reference to the combined plant which Mr. Haslam had suggested, Major David said he had had one in operation for some time, and the results were everything that could be desired. It is an entirely home-made plant; dust is collected on the screens and used during the working shift to boost up the boilers. He was not sure, but he believed it might be possible to devise some arrangement of heat accumulators which would be cheaper, in view of the fact that it would permit of the boilers running at maximum efficiency the whole of the day. The gas firing suggested is a very interesting arrangement and he would like to have more information about it. The handicap is that gas firing is always low in efficiency: it is very difficult to get a higher efficiency than 65%. The scheme is now in operation in the Dunstan installation, where the coal is first treated in a gas producer and the gas is burned under the boiler. The coke produced has a high volatile content of 14% to 15%, and after being crushed is burned on a chain grate stoker under the same boiler. The arrangement comes under Mr. Haslam's combined scheme. The bye-products are extracted from the gases before they are returned to the boiler.

Another interesting point about this installation is that the water wall is not put there solely for evaporation, but for purposes of protection. Evaporation from the boiler part is 260,000lbs. and from the water wall only 15,000lbs., i.e., 6% of the total.

Mr. J. R. JONES said he could not agree with the author that better thermal efficiency is possible with chain grate mechanical stokers on a constant load, but believed that the reverse is the case. As regards furnaces for pulverised fuel, he believed that water cooled walls are essential until more satisfactory refractories are available for the higher temperatures. From experience a few years ago with a boiler fitted with an ordinary refractory lined furnace, it was found that very excellent combustion results could be obtained corresponding to a CO_2 content in the flue gases of 15% to 16%, but under those conditions serious trouble was experienced with the furnace walls. It was actually necessary to admit a considerable amount of excess air to keep the furnace temperature down below the fluxing point of the refractories. It appeared to him that the introduction of water cooled furnaces (although primarily fitted to protect the refractories) should set boiler designers seriously thinking. It seems possible to expose a very much greater heating surface to the radiant heat of the furnace by this means for a given floor space than has been the general practice hitherto.

The author had stated that the class of fuel would affect the maintenance costs of mechanical stoking but not those of pulverised fuel firing. Mr. Jones' experience had been that the maintenance of pulverisers is very materially increased when dealing with high ash coal, depending largely, of course, on the nature of the ash.

He would suggest that the Table giving chimney losses should be extended down to an exit gas temperature of 250 deg. F., as this figure is being approached where boilers are fitted with economisers and air preheaters. He was glad the author has touched upon the combined system of mechanical stokers with pulverised fuel used as an auxiliary or booster, believing there was scope for this method to increase the capacity of existing plant and also where steam demand is very erratic. Makers of booster plant claim that with this method it is possible, where a boiler is evaporating its normal rating with mechanical stokers to increase the rating by 25% in five minutes and 50% in eight minutes, and as it should be equally possible to decrease the rating, which is almost more important, this should be very helpful.

Mr. H. H. CLARE (written communication).—It is correctly stated that at present pulverised fuel plants taken "all in" cannot show a very much greater efficiency or advantage over chain grate plants. Taking most of the articles I have read on the subject, pulverised fuel can give an efficiency of between 83% and 84% over extended periods of normal operation. Chain grate operation can now definitely give from 81% to 82% efficiency over similar periods. But in comparing the two styles two very important conditions do not seem to have attracted their due attention.

In pulverised fuel working two things must definitely be, not merely assumed, but secured, viz., uniform size of dust particles, and a uniform moisture content which must not exceed 2%. Now, if in chain grate working these same two conditions are guaranteed—i.e., size and moisture content—my experience tends to show that the chain grate efficiency would be brought up and made square to that average obtained in pulverised fuel working.

The much vaunted simplification of control does not attract me, and should not be made much of, as all those who have had to tackle the details of high efficiency plants will know that with each advance and addition of automatic sections much more foresight, intuition, diligence and organised effort have to be put into maintenance and inspection if continued efficiency is to be ensured. The advertisement idea of "you twiddle the knob, and we do the rest" does not obtain anywhere.

True, the instant production of an intensely hot flame is a striking performance, but no boiler appreciates this sudden demand upon its activities, and too sudden a change in demand on steam should be studiously avoided as far as possible. Very few power house loads go up in huge and sudden rushes, and in the majority of cases if drastic tactics in the boiler house are indulged in, it generally indicates that the pressure gauge and not the load is being watched, and therefore indicates lack of foresight or suitable preparation.

The suggestion in regard to combined working appears attractive. But is it practical? The air supply through the chain grate is a smooth and gentle stream, whereas the pulverised fuel combustion is turbulent and explosive. Can an arrangement of furnace or flues be made in which these two very different conditions can smoothly unite? At present, I hardly think so.

The scheme is ostensibly for meeting peak loads. Where high peaks are unavoidable, and coming on the top of an otherwise fairly steady load, the addition of one pulverised fuel boiler to the bank of chain grate fired boilers appears to me to be a better proposition Even then the pulverised fuel boiler should not be called upon to meet the whole of a known peak.

The chain grate boilers should be worked up a short time before the expected rise in load to take their share, and the pulverised fuel boiler brought up—also gently —to take the top of the peak only. Gentleness in operation of boilers is essential if maintenance costs are to be kept down and high efficiency obtained over extended periods.

Pulverised fuel has undoubtedly a tremendous future before it. It will widen the scope in heat production, and give increased facilities and conveniencies, in exchange for increased diligence and effort.

Mr. P. J. PLEVIN.—The 40% excess air referred to as a fair average corresponds to about 13% CO_2 for an average semi-bituminous small coal. This seems rather on the high side. Increase in the percentage of CO_2 reduces the weight of flue gases per pound of coal burnt, and raises the temperature of combustion. High furnace temperatures due to this cause, and to excessive air pre-heating, are already reported to result in serious trouble with refractories for furnace linings. Has any value yet been determined for the highest percentage of CO_2 which, for any particular class of coal, is permissible with air pre-heated to a temperature of 700 deg. F., an air temperature which the author, in his next paragraph, indicates is now in use?

With regard to the advantages possessed by the pulverised fuel system in respect of banking, it may interest members to know that it was the daily practice a couple of years ago—and probably is still—at the electricity works of the Wolverhampton Corporation, to shut down the pulverised fuel boilers at noon, and re-start them an hour later, the load during that period being negligible.

Concerning smoke production, while, as the author states, there may be less smoke discharged from a pulverised fuel furnace on a varying load than from a stoker furnace working under the same load conditions, there is more likelihood of an objectionable discharge of grit from the chimney in the case of the pulverised fuel furnace, to prevent which the provision of an effective grit arrester is essential. At the recent Fuel Conference in London, several references were made to a "wet" type of grit arrester, which is stated to be more effective than any other now in use. Can the author give any details of its construction and operation?

The "combined" system advocated by the author in the paragraph headed "Cleanliness" certainly appears to offer advantages when applied to the condition he instances, provided that the existing boilers are fitted with moving grates, and that their furnaces can be readily and inexpensively adapted to accommodate the supplementary burners and to burn the powdered fuel effectively. Where these conditions obtain, the combined system also offers a cheap and ready means whereby the dust collected from the screens may be utilised for steam production at collieries.

Where a new installation is in question, it seems likely that the first cost of a "combined" equipment would be considerably heavier than that of a pulverised fuel equipment only, at similar duties. It would, however, be interesting to know how far the handicap of heavier initial cost would be outweighed by reduction in working cost resulting from the other advantages which the author states are obtainable by the "combined" system.

The bases on which Table I. is computed, e.g., the percentage value of C and H in the coal, the theoretical percentage of CO_2, and the value assumed for the specific heat of flue gas, might also be indicated with advantage.

Mr. IDRIS JONES, proposing a vote of thanks, said Mr. Haslam had no doubt spent considerable time in getting this information together and, from the manner in which the paper had been received as well as from the fact that greater opportunity of discussion was demanded, Mr. Haslam must feel that he has not spent his time in vain.

Mr. W. W. HANNAH said he had very much pleasure in seconding the vote of thanks. Anything which tends towards the better utilisation of coal in these days and which will enable us to compete more successfully with oil and water power is very welcome, and I am sure this paper and the discussion will prove particularly useful from that point of view.

(The Discussion was adjourned until the next meeting, December 8th).

The following meeting took place in Cardiff as a joint meeting of the South Wales Branch with the Colliery Managers' Association on December 8th. The proceedings included the adjourned discussion of Mr. Haslam's paper together with a paper by Mr. H. H. Brcughton on "The Bulk Handling of Coal, Ore and Grain."

Mr. D. Farr Davies, President of the Colliery Managers' Association, was invited to take the chair, and he was supported by Mr. T. S. Thomas, President of the South Wales Branch of the A.M.E.E.

The following applications for membership were accepted: Members—Messrs. F. E. Mills and R. Ll. Thomas; Student—Mr. D. E. C. Leyshon. As members of the Western Sub-Branch: Messrs. S. E. Elliott and A. Ragione.

The adjourned discussion of Mr. Haslam's paper was opened by Mr. Tyce and Major E. Ivor David; a communication from Messrs. Simon-Carves was read by the Secretary; to all of which Mr. Haslam suitably replied.

Mr. Broughton then read his paper, "Bulk Handling of Ore, Coal and Grain," and illustrated it with some very interesting slides of coal and grain handling in the United States and Canada.* Owing to the short time available it was not possible to have a prolonged discussion, and members were invited to send in contributions. A vote of thanks to Mr. Broughton for his able and interesting paper was proposed by Mr. David Evans (Colliery Managers' Association) and seconded by Councillor MacCale. Cordial thanks were also tendered to Mr. Haslam on the proposition of Mr. C. F. Freeborn, seconded by Major David.

(To be continued).

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* This Paper was published in *The Mining Electrical Engineer*, June, 1928, page 478.

STOKE SUB-BRANCH.

Annual Dinner.

The annual dinner and smoking concert of the Stoke Sub-Branch was held on Saturday, Dec. 22nd, 1928, at the Metropole Hotel, Stoke. Many members and friends attended and thoroughly enjoyed a seasonal repart and round of entertainments. The loyal toast having been duly honured, Mr. W. Tyson proposed the "Coal, Iron and Steel Trades." "The Association of Mining Electrical Engineers" was proposed by Mr. G. E. Gittins, to which Mr. J. V. Brittain, Chairman of the Stoke Branch, responded. The "Visitors" was submitted by Mr. E. J. Dryhurst, Mr. Gurney replying. Regrets coupled with good wishes were expressed that Mr. W. E. Swale (an ex-chairman of the Sub-Branch) was leaving the district to take up an appointment with the Manchester Corporation. The best wishes for his success in his new appointment were accorded him. Tribute was paid to the work of the Honorary Secretary for his services in carrying out the multifarious duties for the members' entertainment. Pianoforte solos were contributed by Mr. Turner, and songs by Messrs. Poole, Forster and Aust.

CUMBERLAND SUB-BRANCH.

Ⓟ Detecting Faults in Induction Motor Windings.

E. J. WESTCOTT.

(*Paper read 16th November,* 1928).

The colliery electrical engineer is constantly being asked by the leading lights of this Association to come forward and give papers, but it is not usually possible for him to speak with authority on any particular phase of electrical engineering, as the nature of his employment necessitates his having an all-round knowledge of his profession, and not a specialised knowledge of any particular branch. There are, moreover, other severe handicaps often imposed upon the colliery electrician. In many cases he has to live in isolated villages and consequently is deprived of the benefit of library or literary society where he could obtain technical books or periodicals. Also, in the majority of cases there is no research department available from which to obtain data and in consequence he is left to his own resources.

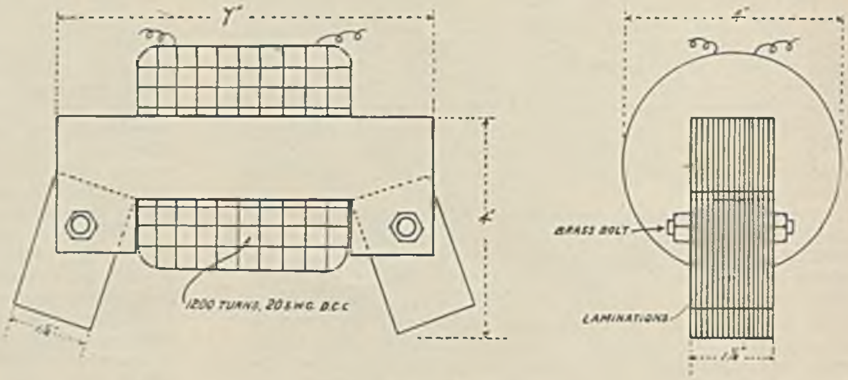


Fig. 2.

But there is a two-fold obligation incumbent upon colliery electrical men; to further their own education and at the same time uphold the aims of this Association by a mutual exchange of ideas upon the various methods in vogue at their respective plants.

It will therefore be appreciated that the author has been put to some difficulty in selecting a subject. He has chosen one dealing with the most common type of colliery apparatus, namely the induction motor, and proposes to submit a few notes on the testing and detection of faults in induction motor windings, which, if not new to all may prove of interest to the majority.

The usual method of testing a motor that has been rewound or repaired, is to measure the resistance of the windings and then connect the machine to a supply for a running-light test; if the ammeters in each phase read approximately alike, then the machine is considered suitable for a load-test. Should the ammeter readings be uneven and the machine show signs of distress then it will be necessary to locate the possible error. Usually in the event of this, the best and quickest method of detection is to have the windings checked by an experienced armature winder who will make the necessary correction. As a rule, the average colliery electrical staff do not rewind their own machines and therefore do not include an experienced winder. In view of this these notes may be of assistance in detecting faults which the colliery electrician will be faced with from time to time.

Of the numerous possible errors which may occur in the connections of stator windings, the following taken in order, are those most likely to occur.

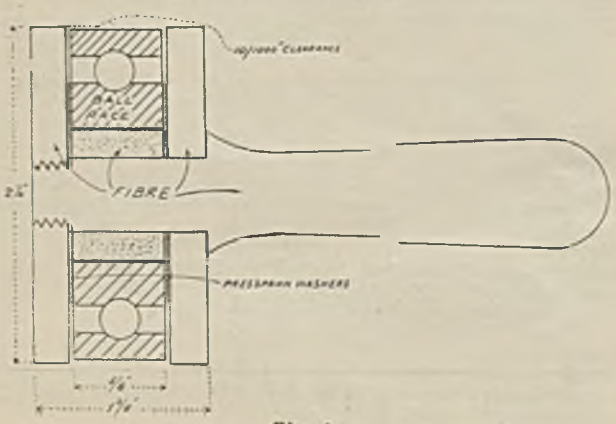


Fig. 1.

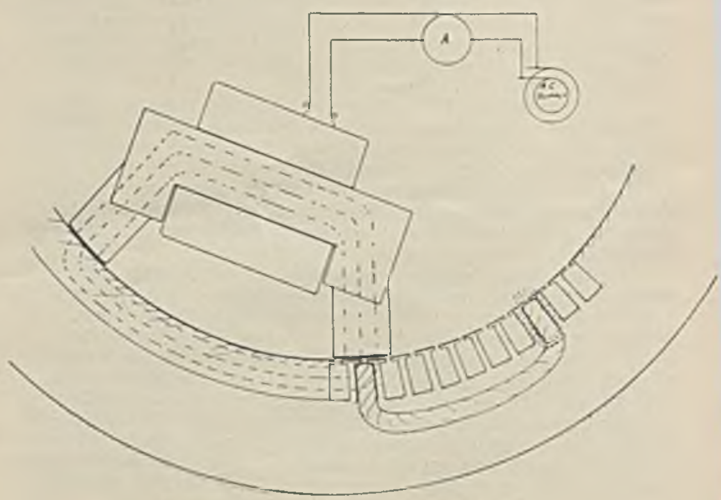
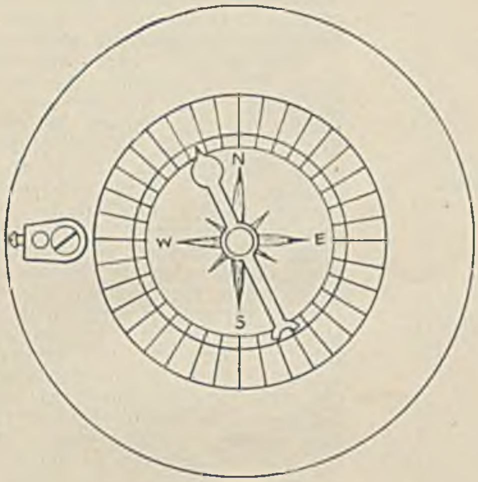


Fig. 3.



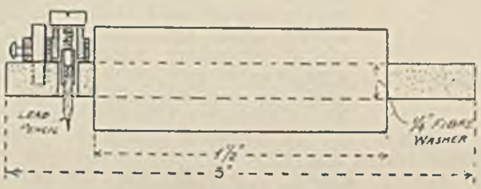


Fig. 4.

(1) Shorts and earths: these are the most common types of faults and generally go together, the latter very often causing a short at the same time.

(2) Open Circuits.

(3) Reversal of part of the windings, which generally takes the form of a single coil, or all the coils of one phase or pole. This is a mistake easily made in the former wound "mush" type of windings, in which the two ends from each coil necessitate a considerable number of connections in the event of an insertion of a few coils, or a re-wind. There are numerous possible wrong connections and their nature and presence can usually be found by means of some of the following methods.

Earths: Open Circuits.

There is no need to attempt to explain how to find an earth or open circuit, as its detection is familiar to all. Certain types of faults can be found by the field form, set up by the stator coils when passing a D.C. or single-phase current through each phase in turn.

In the description of all the following tests a 25 H.P., 550 volt, 50 cycles, three-phase motor was used in obtaining the data and diagrams. The windings consisted of 45 coils, each wound with 12 turns of No. 11 s.w.g., D.C.C. wire, with three coils per pole, 15 coils per phase, and the whole connected in star.

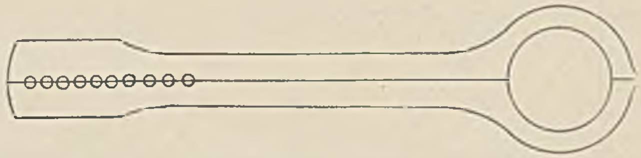


Fig. 6.

Ball-race Test.

A handy device for rapidly checking the stator windings of induction motors, consists of a ball-race fitted up as shown in the diagram, Fig. 1. The centre part of the ball race is held firmly between two fibre or wood washers, which are in turn clamped to a fibre handle. The outer race is left free to rotate by clamping leatheroid distance pieces between the fibre washers. The diameter of the washers is 20/1000" greater than the ball-race, which will leave an air gap of 10/1000" between the outer race and the stator iron when in use. The method of testing is to place the device on the stator iron keeping the handle parallel with the iron core. The windings should then be gradually excited with alternating current until the outer race is revolving at a steady speed under the influence of the revolving field. If the windings are correctly connected the race will continue to revolve while slowly passing the device round the stator iron. When passing a reversed coil the race will stop or tend to reverse, and when over a shorted coil it will stop and vibrate. This is a quick test only taking a few minutes, and is especially justified with large machinery in which the rotor is not available for a running-light test or where considerable time and labour would be involved in dismantling in the event of a fault.

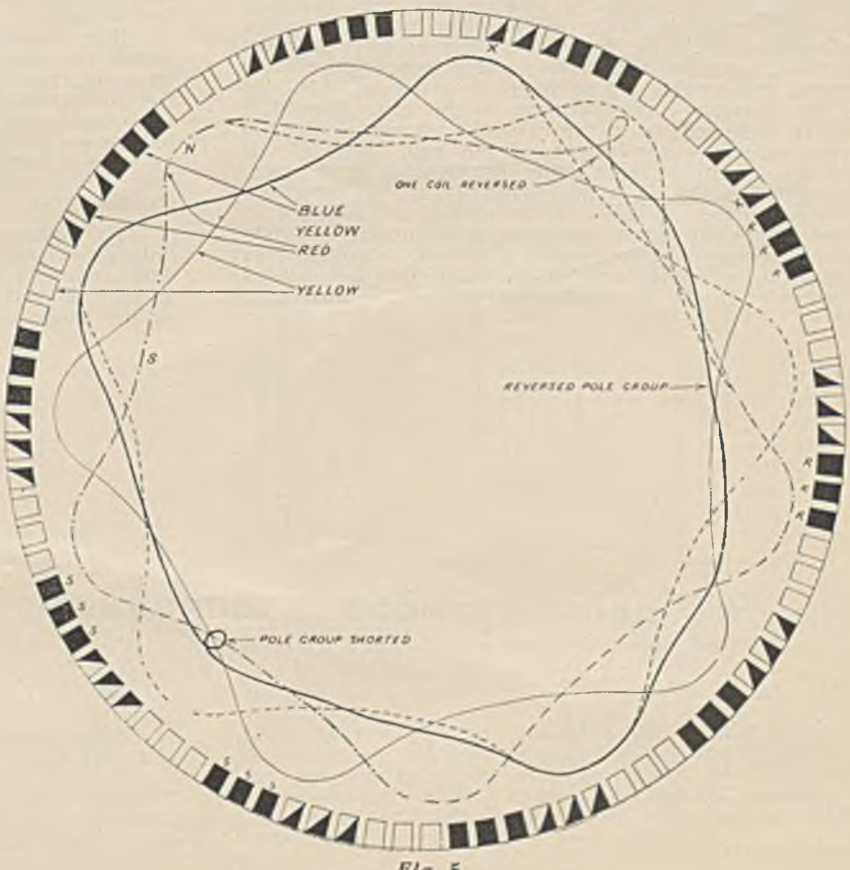


Fig. 5.

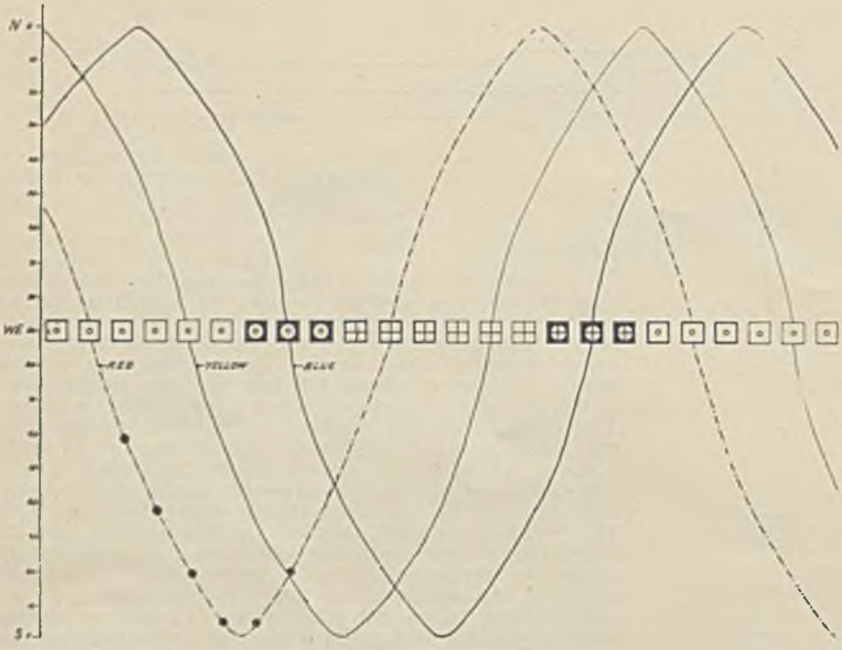


Fig. 7.—Windings Correct.

Search Coil Test for Shorts.

The usual method of detecting short circuited turns or coils is to run the machine light on full voltage or, in the case of totally enclosed machines, to excite the windings with the rotor in position and open circuited. The position of the faulty coil is then found by feeling the windings with the hand, and their presence detected by their excessive temperature. The temperature of a shorted coil reaches a high figure in a few seconds, due to the excessive current flowing in the coil. Should it be well insulated, or in the case of a shorted individual turn situated in the centre of the coil, then it will take a considerable time before its presence is detected. By feeling with the hand, especially where there are a large number of coils, it is seldom its presence is found before the cotton insulation turns brown, and only on rare occasions in the case of a shorted individual turn before the cotton is burnt black, which then necessitates a rewind. In the great majority of cases a short in a repaired or re-wound motor consists of a badly taped joint or a sharp pinnacle of solder piercing the insulation.

The presence of a short can be found before exciting the windings by means of a suitable search coil similar to that shown in diagram, Fig. 2. The coil consists of the primary windings and three sides of the lamination of a small core-type transformer (which incidentally was in this case recovered from the scrap heap. The method of testing is to place the detector on the stator iron as shown in the diagram, Fig. 3, and connect the coil in series with a suitable ammeter to a single-phase supply. With the coil excited, the magnetic circuit is completed via the the stator iron as shown by the dotted lines. By slowly passing the device round the stator iron a shorted coil can be detected as follows:—

By a rise in amperes when over the faulty coil or by the magnetic attraction to a piece of iron placed over the slot surrounding the other side of the coil. The rise in current in the testing coil is due to the defective stator coil acting like a short circuit secondary winding of a current transformer, which rise in current (in the secondary windings of any transformer) will cause a corresponding increase in the primary windings. The current flowing round the side of the shorted coil remote from the testing device, will cause the laminated iron slot surrounding the coil to become magnetised, as shown by the dotted lines in the diagram, hence a piece of iron will be magnetically attracted when lying across the air gap.

If it should be found difficult to drag the search coil round the core due to the strength of the magnetic attraction, then a piece of thin leatheroid placed between the laminations of the search coil and the stator iron will enable the coil to be slowly dragged round by pulling on the leatheroid. This test applies particularly to shorted coils or individual turns.

Compass Test.

The compass test can be used for detecting reversed individual coils or pole groups. A running-light test with ammeters in each phase will seldom detect a reversed coil and it is obvious a resistance test is useless as the ohmic value will be the same whether the coils are reversed or otherwise. The compass test is taken by exciting the windings with a D.C. supply of a suitable value. In the motor under review a current of 6 amperes was passed through each phase in turn, with the negative lead connected to the star point of the windings. By slowly passing a compass round the inner periphery of the stator iron, it will be seen that the needle will steadily revolve, and will reverse when passing from a north to a south pole, and *vice-versa*. When passing over a reversed coil or slot the needle will tend to reverse and when over a reversed pole group will fail to reverse, the direction of the field being the same as in the previous pole. A rough test can be taken by chalking the iron at the points of N. and S. polarity with different coloured chalks. An improved method is either to make an indicator diagram with a compass and pencil, or else plot a curve from the compass readings.

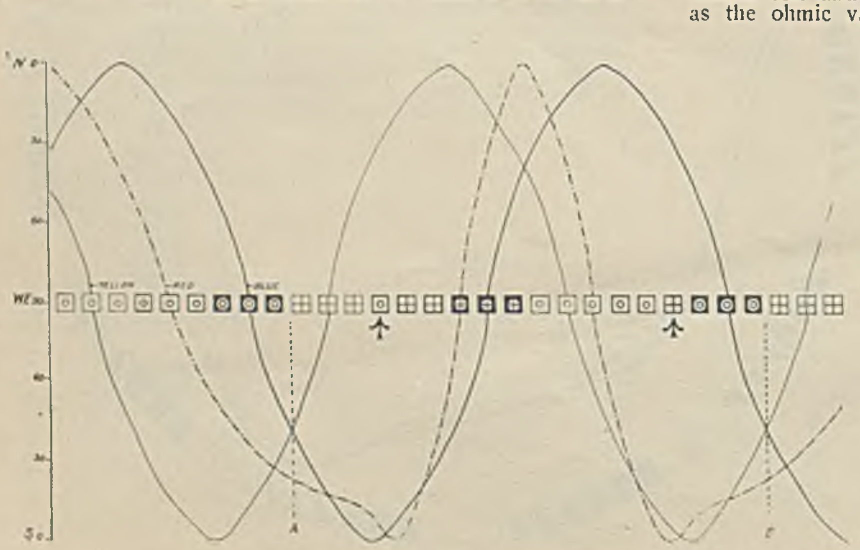


Fig. 8.—One Red Coil Reversed.

Indicator Diagram with Compass.

In order to make an indicator diagram, cut out a circular piece of cardboard or presspahn and to it attach a piece of drawing paper. This should be done so that it fits firmly in the centre of the stator iron. Then fit up a compass as shown in diagram, Fig. 4. The compass should fit securely inside a washer made of wood or fibre, the object of this being to keep the compass at a fixed distance from the iron and to enable it to be revolved freely. The lead of a pencil should be fitted to a hole drilled near the inner circumference of the washer. By fixing upside down the bayonet of a lamp holder to the washer (as shown in the diagram) a steady pressure can be maintained on the lead of the pencil. Having the windings excited with D.C. in turn, as previously explained, the diagram is made by placing the compass on the drawing paper so that the pencil is opposite the arrow on the compass. The diagram is then made by slowly passing the compass round the inside of the core, keeping the pencil opposite the arrow on the compass.

The diagram, Fig. 5, is an actual copy of the field form of a motor in which the windings have been purposely altered to give some idea of the resultant diagrams. Surrounding the diagram is a section of the windings showing the different phases.

Referring to the Red Phase, it will be noticed that the points marked N. (north pole) and S. (south pole) are midway between the red phase windings.

The Yellow Phase windings are correctly connected and it will be seen the diagram is symmetrical. The reversing of one coil as shown opposite the red crosses, will give a curve as shown, the dotted line showing the curve when correctly connected.

By reversing a complete pole group as shown by marks R the magnetic pole is South instead of North, and a similar diagram is obtained with a pole group shorted, marked S. on the diagram.

Curve Plotted from Compass Readings.

An improved method is to take the actual readings of the compass in degrees, when opposite each slot in turn and from the records plot a curve. A device for taking the readings consists of a piece of presspahn shaped like the large hand of a clock as shown in Fig. 6. The compass should be firmly fixed in a hole near the pointer, so that a line drawn from the pivots to the pointer will pass through the point marked S. and the point marked N. on the compass scale. The method of taking the readings is as follows

Fix a narrow piece of wood across the diameter of the stator iron and so attach the indicator by means of a drawing pin that it is pivoted in the centre of the stator core. With the phases excited in turn with D.C. as previously described, a record of the degrees indicated by the pointer of the compass should be taken when opposite each slot. From the records, curves can be plotted and any irregularities will then be quickly detected.

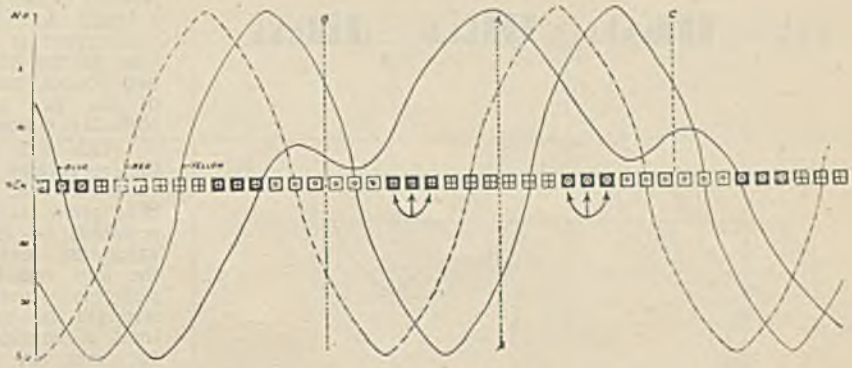


Fig. 9.—One Group in Blue Phase Reversed.

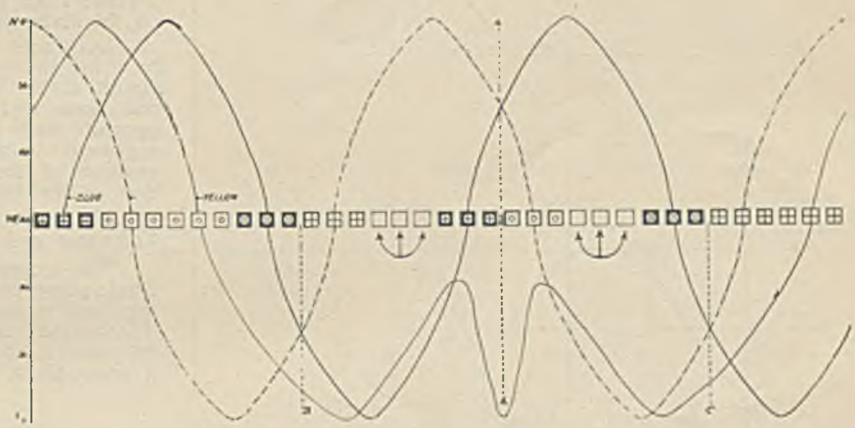


Fig. 10.—One Group in Yellow Phase Shorted.

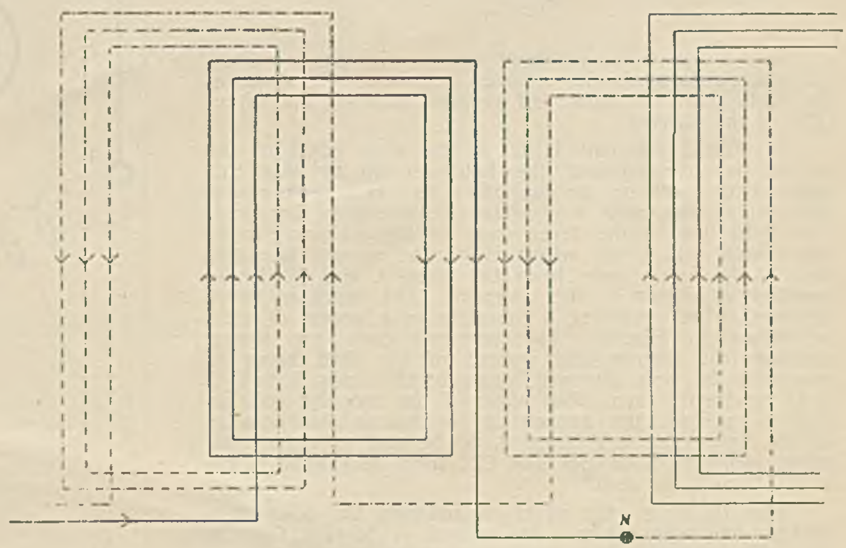


Fig. 11.

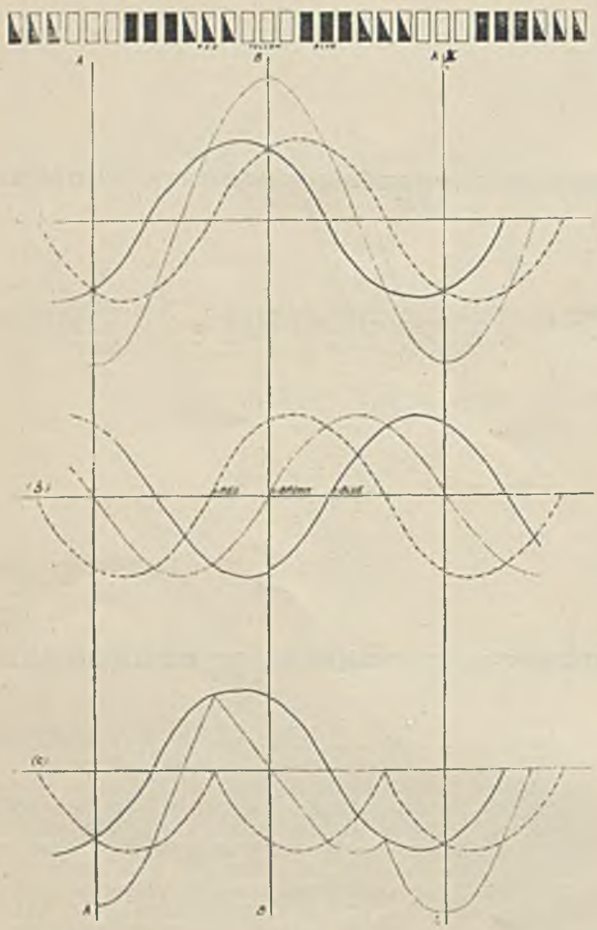


Fig. 12.

Fig. 7 shows the resultant curves with the windings correctly connected, the squares represent the coils in the slots with the dots and crosses showing the direction of the current.

In Fig. 8 the coil lying in the slots opposite the arrows is reversed and the field set up by this coil opposes that set up by the other two coils comprising this pole group, with a resultant weakening of the field. The field due to the three coils of the adjoining coils comprising this phase which is of the correct strength, diverts the South pole from the lines A and B to the position as shown in the diagram. The resultant curve obtained from reversing a complete pole group of coils is shown in Fig. 9. The reversed coils are shown opposite the arrows and instead of the field being of maximum N. pole strength, opposite the lines B and C it is practically zero. The effect of the reversed coils as shown opposite the arrows is to change the polarity of the field (line AA) from S. to N. and to reduce the fields opposite lines BB and CC from maximum North pole strength to zero.

Fig. 10 shows the effect of shorting the coils comprising one pole group. No current is passing through the coils opposite the arrows, the result of which is that the field instead of being North as shown by the line AA is of weak South polarity.

Magnetic Field Form Test.

Mistakes may be located by the form of the magnetic field which is produced by the passing of single phase current through the windings. Diagram, Fig. 11, shows part of the Red and Blue phase connected to the Neutral point of the motor, previously described. With a single A.C. supply connected to Red and Blue phase, the current at any instant, as shown by the arrows, will flow in the same direction in the adjacent coils of the two phases, and the field produced will be the resultant of the two phases, that is when the windings are correctly connected.

This will be seen when referring to Fig. 12 where the rectangles represent the windings. Red and Blue curves in Fig. 12 (a) represent the field due to Red and Blue phase at any instant, the Brown curve showing the resultant of these two curves, which is of maximum value on lines AA and BB which is midway between the Red and Blue windings. In Fig. 12 (b), the Blue phase is assumed to be reversed and it will be seen the strength of the resultant field shown by the Brown lines is considerably reduced, and is of zero value on the lines AA and BB. Fig. 12 (c) shows the effect of reversing one pole group of Red phase. The field form and strength can be obtained by passing a suitable single phase current through any two windings, and plotting a curve from the voltage induced in a testing coil placed on the stator iron.

Diagrams, Figs. 14 to 17, show the results obtained by using the search coil previously explained in the short circuit tests. A suitable voltmeter is connected to the coil leads and readings are taken with the testing coil opposite each slot. In plotting the curves, the ordinates represent volts in the testing coil, and abscissæ the position of the coil. The vertical lines show the position of the field with the windings correctly connected

Voltmeter and Ammeter Tests.

The accuracy of windings can be judged by passing a single-phase current through any two phases of the windings and measuring the current and voltage between the disconnected terminal, and either of those connected to the supply. Fig. 13 represents the motor windings with a single-phase supply connected to Red and Blue phase.

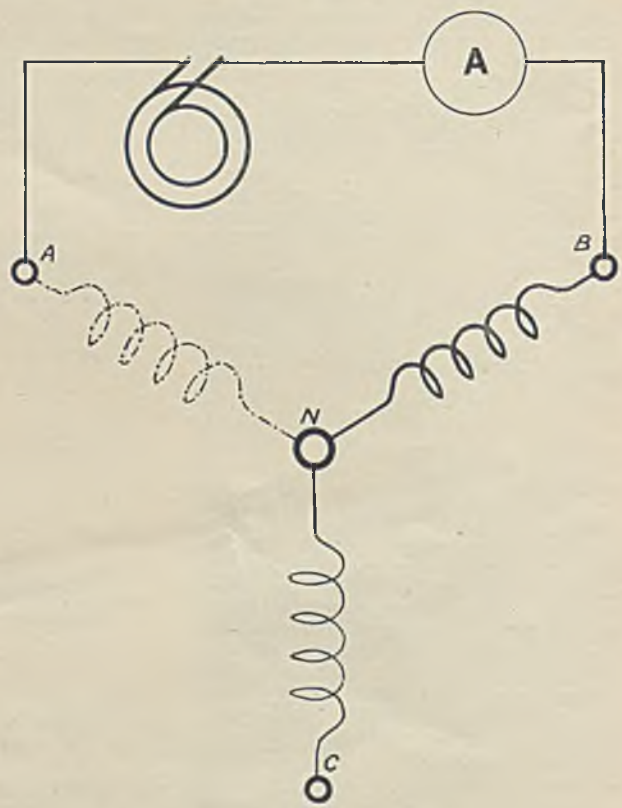


Fig. 13.

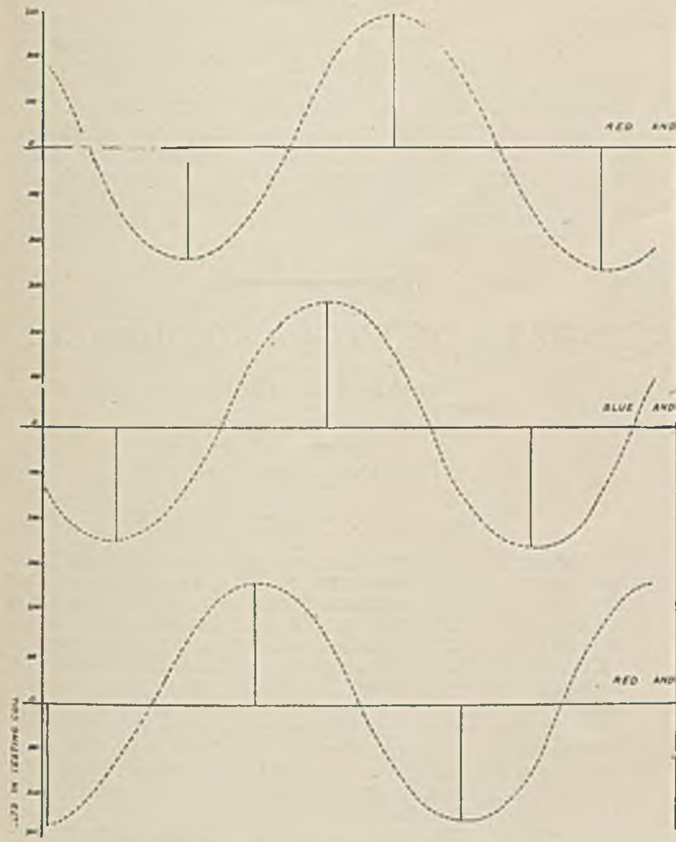


Fig. 14.—*Windings Correct.*

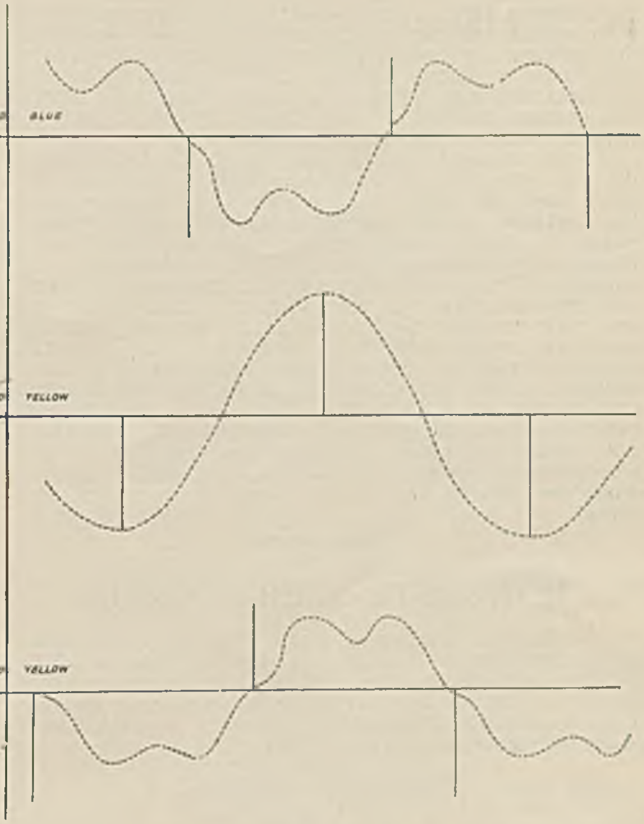


Fig. 15.—*Red Phase Reversed.*

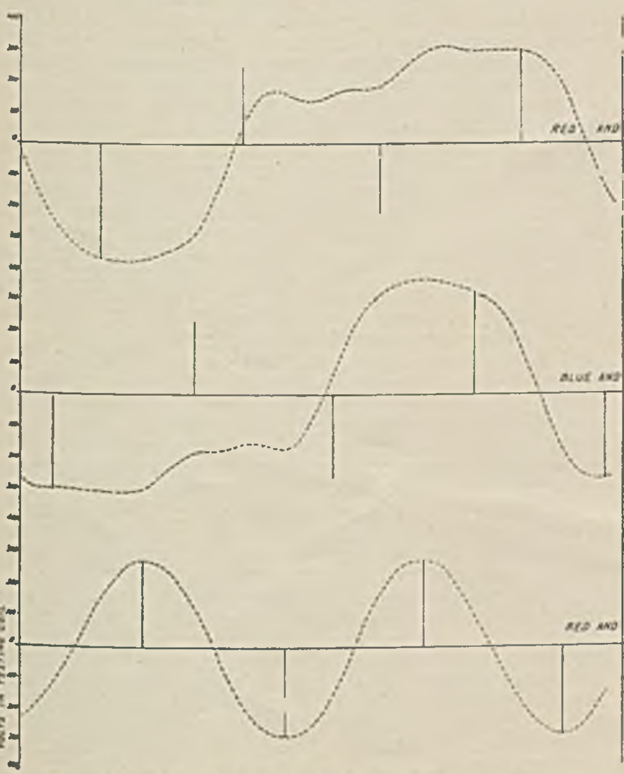


Fig. 16.—*One Blue Pole Group Reversed.*

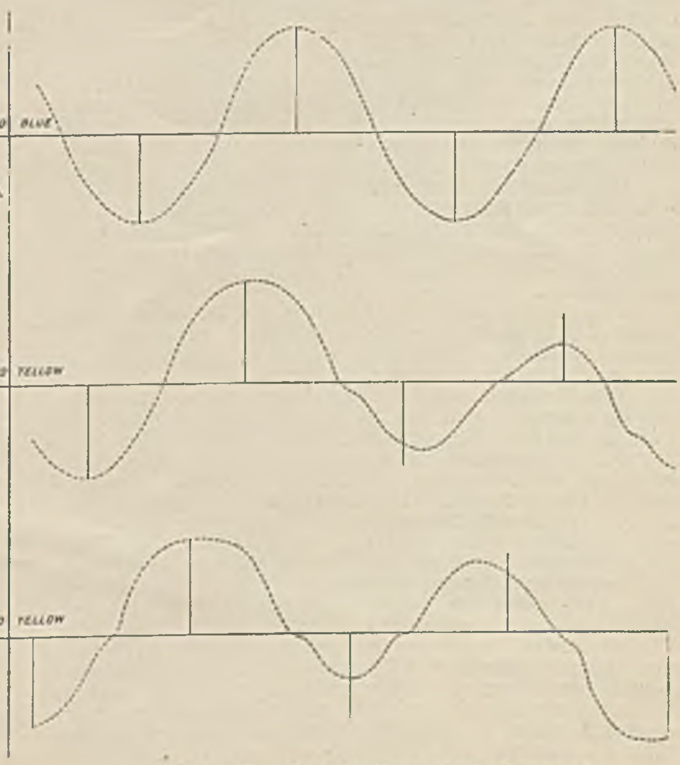


Fig. 17.—*One Yellow Coil Reversed.*

The voltage across A and B will be the supply pressure, and between either A or B and C the voltage measured will be half of the supply pressure, that is assuming the windings are correctly connected. The Yellow phase coils are so placed that no EMF is induced in the windings, the coils acting as a voltmeter lead only, hence the voltage between A and C or between B and C, should be half of the supply pressure.

Reversed coils, pole groups, or phases, by reducing the flux will decrease the impedance, whereas on the other hand, too many coils will increase the impedance. For instance, in the case of complete reversal of Red phase, the flux produced by current in Red and Blue is linked with Yellow phase, and an EMF is induced in this winding. The phase position of the component voltages AN, BN, and CN, will then differ to a considerable extent. The currents and voltages in a reversed pole or single coil would show similar variations, but not to the same extent, as a reversed phase. For instance, a slight difference in the three currents usually signifies an extra coil in one phase. On the other hand, a considerable difference in the currents and voltages denotes a reversed pole group or phase. Finally, some idea as to the correctness or otherwise of the windings, can be obtained from the current and voltage readings, taken as described.

DONCASTER SUB-BRANCH.

At the first meeting of the new session of the Doncaster Sub-Branch, held in Doncaster on Saturday, 27th October last, there were approximately thirty members present. The meeting was to be followed by a smoking concert, and the speaker for the evening was the Chairman, who gave his opening address.

Chairman's Address.

M. WADESON.

Mr. Wadeson stated that the chief industry in England was coal mining, and as this Association dealt chiefly with electricity in mines he proposed to talk more or less on that subject. He believed he was right in saying that electricity was first used in mines about forty-five years ago, and during the intervening period to date the use had increased enormously, but there was still a very large field of service to cover. It would interest members to know that there were still mines where electricity was not used at all.

Mr. Wadeson drew attention to the fact that there was still no lighting at the coal face, and pointed out what a much larger increase in coal output there would be if, say, the coal face could be illuminated by floodlights, and also the benefits the workmen would derive therefrom.

The speaker said the strength of the Association was about 2,000 members, and so it might reasonably be claimed that this Association stood for a great deal in the improvement of the mining industry.

Mr. Wadeson said he particularly wished to speak to the younger members of the Branch, and to give them a word of encouragement in their efforts. He stressed the point of carrying on where the older members had left off and to do their share in the improvement of the industry. He strongly advised them to take part in any of the discussions at the meetings and whenever possible to give a paper. He said that there were often problems that cropped up in their every-day life that would make good ground for discussion at a meeting. Very often the people who gave a very elaborate and "highbrow" paper only knew themselves what the subject matter referred to, and it proved very poor material for discussion. To take part in the discussions would help them in their technical education, and as the question of only certified men taking charge of the electrical plant at collieries might be enforced at any time, he strongly advised them to do all in their power to improve their technical knowledge.

Mr. BLEACH in a few words proposed a vote of thanks to the Chairman for his address that evening, but he was sorry that it was not open for criticism, as he had one or two points he would have liked Mr. Wadeson to explain. He would have to defer that pleasure to a more faouvrable opportunity.

Mr. WILLIAMS, in seconding the vote of thanks, stressed the point to the younger members that some day it might be that only certified men would be allowed to take charge of the electrical plant at collieries, and he urged them to gain all the technical knowledge they could.

NORTH OF ENGLAND BRANCH.

Presidential Address.

Capt. S. WALTON-BROWN, B.Sc.

The Domestic Fire.

(*Meeting held November 10th,* 1928).

Although many methods of utilising coal have been treated before the members of this Association, I feel that one has been neglected and would therefore like to devote a little time to that application—that which is classed in the official returns under the head of "Domestic." Basal metabolism, or heat production by the human body, always continues even in warm air and never falls below a definite minimum value regulated by the active life of the cells of which the body is composed. Muscular work, plentiful food consumption, or warming the cells themselves, increase the rate of heat production, while cooling has the opposite effect. The heat so generated is dissipated from the human body by radiation and convection; if the heat production is great the sweat glands come into operation and the evaporation of perspiration provides a further outlet of heat. In order to maintain the body cells at a temperature suitable for their vital work, especially if sedentary work has to be done, it is necessary to keep the body in a sufficiently heated environment. Although he may not have expressed it in so many words, primitive man early discovered the value of fire for such purposes and the practice has continued.

In the time of the Ancients the open fire was an article of worship and was kept burning in temples as a Sacred Fire; it was also regarded as an agent of destruction, as is designated in the expression "Fire and Sword," and it was an object of endearment when enshrined in that holy of holies in every home, the "Domestic Hearth." The latter is still the main-spring of the comfortable furnishing and other arrangements in our living rooms and the place round which the family gathers for warmth and shelter from the elements.

The earliest forms of fuel were wood or peat burned in piles and they were followed about the twelfth century by the introduction of coal. The last named was at first a luxury but its use extended and, following a period of flat hearths and braziers, it began to be commonly consumed on grates from which those now employed have developed.

Later, gas fires were introduced and lastly came the electric heating of the present day; in both the last named cases the products of coal are employed instead of the raw material.

One rather forms the impression, bearing in mind the considerable improvements which have been effected within recent years in heating by gas and electricity that the open coal fire is, at the moment, in somewhat the same position that gas lighting was placed when electric lighting first threatened it. The prophets mournfully foretold the collapse of the gas industry but the latter faced the situation boldly, produced the incandescent mantle, and other subsequent improvements, and now probably retains as firm a footing as ever. The time seems ripe for some benefactor to come forward with a similarly effective lifebuoy to save the open coal fire from being engulfed.

It might be of advantage to digress for a moment and consider the burning of coal in open grates so that we may form ideas as to the improvements which are required.

When bituminous coal is fed on to a burning fire the subsequent action is practically the same as that occurring during the distillation of coal. There are three distinct periods during combustion:—

(1) The first period involves the heating of the coal by the fire below and tar vapours, coal-gas, and steam are distilled off in proportions which vary with the temperature, the nature of the coal itself, and the moisture content of the coal. The surface of the coal is too cool for the ignition of the combustible gases and these escape as vapours up the chimney. During this period no soot is formed, but the greatest waste of heat takes place in the loss of potential heating energy as vapours and the latent heat used up in their distillation.

(2) After a while, sufficient heat finds its way to the top of the fuel to ignite some of the escaping vapours and a bright illuminating flame is formed above the surface of the fire. These flames radiate a considerable amount of heat and the heat waste is therefore not so great as it was in the first period. It will still be noticed that a large amount of vapour is escaping unburnt owing to some of the hydrocarbons being so diluted with steam as to inhibit their combustion. The flames themselves are lurid at the top and emit particles of carbon.

(3) As time passes, the fire becomes clear with a small flame consisting chiefly of the lambent blue flame of burning carbon monoxide and smokeless combustion is attained. The clear fire radiates out the heat provided by the oxidation of the glowing carbon and now performs its maximum heating capacity.

The radiant efficiency of a coal fire lies between 20% and 24%—for practical purposes it can be taken as 22%—of the total calorific value of the coal and this is a very important point regarding open fire heating. It would be unfair to regard all the balance of potential heat as lost as a certain amount is usefully employed in heating rooms adjacent to the fireback or the chimney. The effect of using small coal instead of lumps is to reduce radiation efficiency by as much as 4%. In the modern barless hearth grate the quantity of air passing through the coal can be controlled, and as a consequence the rate of combustion regulated. The radiated energy from coal fires does not vary very much with the type of grate used: in fact this radiation shows little advantage, if any, in favour of the modern grate and it has been shown that figures obtained from the old-fashioned grates with bars in front are actually higher than those obtained from modern barless grates. Increase or diminution of draught does not alter the value of the radiant efficiency, the only effect being quicker or slower burning.

It is interesting to compare, at this stage, the rather contradictory points in connection with grate design laid down by Harcourt and Teale, two scientists who made a study of the open burning of coal.

Teale says:—"As much firebrick and as little iron as possible. Firebrick retains, stores and accumulates heat. Iron runs away with the heat chiefly in directions in which the heat is least wanted."

"Backs and sides should be of firebrick."

"The back of the fireplace should lean or arch over the fire so as to become heated by the rising flame. The heated back raises the temperature of the gases and helps them to burn, thereby lessening the smoke and sends abundant radiant heat into the room."

"The bottom of the fire, or grating, should be deep. Two points are gained by depth—one that space is allowed for the slanting or arching forward of the firebrick back; the other that there is plenty of room for the fire to 'lie down' away from the direct draught of the chimney. The fire is thereby made horizontal and slow burning instead of vertical and quick burning."

"The slits in the grating should be narrow, not more than ¼in. wide for sitting room grates, and ⅜in. for a kitchen grate. When the slits are larger than this small cinders fall through and are wasted."

"The bars (if any) in front should be narrow, less than ¼in. thick so as not to obstruct much and close together, 1¼in. apart so as to prevent coal and cinder from falling forward, and not more than four in number for an ordinary fire."

"The chamber beneath the fire should be closed in front by a shield or economiser; the effect of which is to stop all currents of air that would pass under the grate and through the fire and so keep the chamber, its floor and walls at a high temperature. By means of a slide in the shield the admission of air through the fire can be effectively regulated."

Harcourt says:—"The face of the fire should be vertical so that the chief radiation should be horizontal. Vertical radiation strikes the ceiling and is wasted."

"The bars should be as light as compatible with strength and wide apart for they do not reach so high a temperature as the glowing fuel behind."

"The fire should be narrow from back to front."

"Air should pass in through the bars at the front and not through the bars underneath, for the most vivid combustion occurs where air and fuel meet."

The design definitions laid down by Teale are by far the most popular for modern grates since they give a more economical burning of the fuel; that is, less coal is needed to start and maintain the fire.

The backs of grates should be in sections so that worn out portions can be replaced without disturbing the grate. To obviate firing of the floor the grate should be set up a little. The provision of a sloping firebrick area in front of the actual grate tends towards cleanliness by preventing ashes reaching the tiled hearth and also increases the firebrick area.

The introduction of an adjustable plate behind the canopy of a grate so as to divide the flue into two sections is advantageous. The plate tilts as the canopy is pushed in or out. When the canopy is back the space between it and the dividing plate is smallest and fuel combustion is at its lowest point. As the canopy is pulled out the plate tilts, making two flue spaces the size of which can be regulated as desired. The products of combustion travel up the rear flue and the room ventilation up the front flue together with any combustible products which may escape the rear flue.

Open fires are largely dependent on radiation for their effect and any obstacle to radiation acts as a screen, hence grates should be recessed as little as possible, be broad in front, narrow behind, and shelve slightly towards the front so that greater radiation from the incandescent coal is presented. The temporary diminution in radiation which accompanies the mending of a fire may be partially avoided by inserting a shovel between the firebrick back of the grate and the residue of fuel in it, and feeding the fresh coal into the gap so formed. At the same time the draught should be momentarily increased. The fresh coal, sandwiched in between the two hot surfaces and fanned by the augmented air current, rapidly ignites, while the incandescent surface of the coked residue is presented to the room and maintains a modified radiation emission pending the burning up of the additional coal. Coal should be added a little at a time and as often as is necessary. It is poor practice to neglect a fire until a few dull embers are left and then to heap on coal and use a "blazer" to induce the maximum draught; during that time much heat is wasted. The fire should be cleaned occasionally so that impeding ash is cleaned away from the coked coal and air allowed to play its part. The ash falls between the grate bars into the pan provided beneath.

The modern barless grate at floor level or slightly raised throws out its heat at an angle to the horizontal and exposes a considerably greater area of radiant heat source than a bar grate. We are all aware that a characteristic attitude of an Englishman is that of back to fire, legs apart, hands behind, and undoubtedly warming that portion of his anatomy which is most needful.

I doubt whether barless grate manufacturers actually acclaim this point in print and single out the adaptability of their grates for this rather selfish purpose, but they may possibly rely on it as that unspoken advantage which makes the sale. It may also be noted that by means of practical testing I have found that neither gas nor electricity equal an open fire for the purpose indicated.

Efficient draught control in grates is essential if practical economy is to be obtained. A means of regulation of the area of the flue and a provision for adjusting the admittance of air under the grates are desiderata. The quantity of air travelling up the chimney is usually far in excess of that required for the combustion of the coal and the greater portion of this air passes directly into the throat of the flue without encountering the burning fuel in the grate. This air serves as ventilating air for the room, but may cause draughts so that it is convenient to have some means of throttling it when desired. The rate at which the fire is burning can be kept constant after throttling the flue by increasing the opening of the lower air inlets. On occasions when a quick burning fire is needed, or when lighting the fire, both air inlets can be kept fully open and the combustion gradually controlled by a judicious adjustment of both inlet and damper.

The ignition temperature of a coal with 36% volatile matter is about 520 deg. C. Fires with such fuel should be lit very easily with a minimum of paper and sticks.

The burning of gas and electricity call for little comment, the latter being merely a matter of turning a switch and the former a tap adjustment and the application of a light. In this respect both have an advantage over coal as coal normally necessitates the ignition of paper and kindling wood, followed by that of the coal itself. Systems of central heating by means of pipes and radiators are continuous in their action but necessitate the maintenance of a stove. Individual radiators can of course be controlled by cocks. Under certain conditions central heating is very economical.

In still air with no radiation 65 deg. F. is a very suitable temperature for long periods of sedentary work. According to Fishenden (to whom I am indebted for this and some other details) in draughts of 2ft., 4ft., and 6ft. per second 69 deg. F., 72 deg. F., and 75 deg. F. are the temperatures required for suitable warmth. The architectural qualities of rooms are therefore of considerable importance from the point of view of coal economy.

A very important asset of the coal fire is the Briton's ingrained liking for fresh air and open windows or doors. This entails a graduated heating of a room such as an open coal fire provides. The occupants when cold can sit near the fire and move gradually back as they are warmed so as to obtain almost any temperature desired.

Gas fires may partially comply with some of these conditions, but the heating range is limited and the ventilation effected is not nearly so good: they are inclined to warm the feet and freeze the brow. Electric heating, whilst it can be made available at any part of the room, does not succeed if there are many room openings in maintaining an adequate temperature and, like central heating, gives better results from the heating point of view with closed doors and windows. The ventilation in both these cases is bad unless extra flues are provided and the room, owing to the air not being so frequently changed as with open fires which often do so five times per hour, becomes uncomfortable. The ventilation is sluggish with other than coal fires, the air following convection currents and becoming vitiated and heavy in time, dependent on the number of occupants.

The dryness of the atmosphere in rooms with heating of types other than the open coal or coke fire is quite pronounced, despite the provision of bowls of water, and in many cases produces sore throats or headaches. During a visit with others to the United States the speaker found the central heating systems there adopted to be so oppressive that, however the clothing was reduced, trips had to be made into the fresh air outside for relief. One reason for the employment of this type of heating in other countries is that the temperature outside the dwelling is, on occasions, much cooler than is normally experienced in Great Britain, and the ventilating air if drawn past a fire and up the chimney would be so cold as to adversely affect the heating of the room. The coal fire provides a means of changing the air in a room so that hygienic conditions are maintained and at the same time the room kept sufficiently warm for comfortable habitation.

Despite the activity of smoke abatement enthusiasts, many of whom are by no means disinterested adherents, one rather hesitates to place the deposition of soot, etc., in the open as of greater importance than the health of the population, whilst occupying the houses. An investigation into the possible connections between the development of gas and electric heating and the incidence of influenza would be of great interest.

There is a saying that "money talks," and the following comparisons in Table I. are of interest.

It would appear that from the cost point of view the open fire has still a great deal in hand and that if other obstacles can be overcome there is no reason why the domestic utilisation of coal should not be stimulated.

The cost figures originally contemplated were intended to represent the average cost of each type of heating over the largest area of Great Britain in which all three are available but have since been considerably modified in favour of gas and electricity. There are areas of course in which coal is the only means possible.

The financial comparison from the point of view of the open fire is even better where coal, as is often the case, can be purchased at a less figure than 25/- per ton.

A domestic fire should maintain the temperature of the room at not less than 65 deg. F. continuously for 14 hours daily.

The domestic problem involved in the carrying of coal and ashes and the labour of grate cleaning with possibly a certain degree of laziness has undoubtedly been mainly responsible for the development of gas and electricity as a source of heat.

Amongst the improvements to open fires to which I would direct the attention of the aforementioned benefactor are:—

(1) A simpler and less troublesome method of ignition as, e.g., petrol or gas pokers.

(2) A contrivance which can be wheeled from room to room fitted with some device on vacuum or other principle to take up ashes, etc.—an automatic brushing device to be also attached.

(3) A reduction in the cleaning required by grates; at the most a wipe with a cloth should suffice.

(4) Moving grates might be tried.

(5) Better air control and more rapid raising and lowering of the radiation.

Possible future improvements in grate design might entail:—

(1) An open grate set in the middle of a room with a flue running beneath the floor promises well in theory, for not only would heat be radiated from all sides and the radiant efficiency greatly increased, but all the gases evolved in period (1) would be completely burnt and provide heat instead of escaping unburnt. Fresh coal would be added to the top of the fire as before and the products of combustion escape downward. It might appear strange at first in building the fire to place the coal at the bottom, then the stick, and finally the shredded newspaper on top. Amongst the disadvantages would be the necessity for some means of draught induction in the initial stages. There would be no cheerful flame struggling upward, valuable space in the room would be taken up and a risk of fumes entering the room. The grate should have mica sides or similar transparent heat-resisting substance so that radiation could proceed.

TABLE I.

Method.	Source of Heat.	B.T.U.'s per 1d.	% Heat entering Room. (Radiation + Convection).	Relative number of B.T.U.'s entering room.	Relative Cost.
OPEN FIRES:—					
Good design	Coal at 25/- per ton 14,000 B.T.U. per lb.	104,500	30	31,350	1.00
Bad design	Ditto.	104,500	20	20,900	1.50
GAS FIRES:—					
Best design	Gas at 8.4d. per therm; or per 200 cu. ft.; or per 100,000 B.T.U.	11,905	75	8,930	3.51
Poor design	Ditto.	11,905	30	3,572	8.77
Electric Heating	Electricity at 2¼d. per unit (3412 B.T.U.)	1,517	100	1,517	20.66

(2) Some means, such as a false bottom to the ordinary rectangular grate so that fresh coal could be introduced at the bottom of the grate.

(3) A rotary grate of cylindrical form with two doors on opposite sides of the curved surface. Fresh coal could be introduced at one door and the grate turned round so that the new fuel would be at the bottom.

(4) The use of pulverised coal in a grate somewhat similar to a gas fire arranged so that the flame impinges against and heats some rounded refractory material which would radiate its heat. If this ever finds favour, and there is no technical theory why it should not, we might have to buy our coal by the gallon instead of the ton.

(5) The conjunction of open fires with water heating at the back of the fire, and the heating of other rooms economically might be further developed. Even now there are some good composite stoves.

(6) A filter capable of being attached to chimneys or other suitable points which would remove the solids from the products of combustion prior to discharge to the atmosphere.

It is of course essential to our well-being as mining electrical engineers that the demand for coal of the highest quality be maintained. "Old King Cole was a merry old soul" but I think even he would find it difficult to maintain a smiling face if he had to shed his gorgeous robes and go about arrayed as a gas fire or an electric stove. If we lose our mantle-pieces where can we put our feet?—not on an electric heater: and where can we put our old envelopes, matches, etc? Fortunately many still cherish their fascination for the leaping flames and drowsy heat, but a new open-type fire of a very up-to-date and labour saving character is urgently required.

A vote of thanks to Captain Walton-Brown for his Address, proposed by S. Tulip, Esq., Past-President of the Branch, was carried with acclamation.

The Branch Presidential Address was followed by a lecture entitled "Surface Lighting at Collieries," given by Mr. E. S. Evans, of the North-East Coast Lighting Service Bureau, and this gave rise to an interesting discussion. In the course of his remarks Mr. Evans said.

Surface Lighting at Collieries.

E. S. EVANS.

In a talk of half-an-hour it would be impossible to deal in great detail with this very involved question, especially in view of the great variation in colliery methods and the types of machinery used. Also, the type of coal, whether it be large or small, dirty or clean, dry or wet, largely influences the method of application and the type of lighting equipment necessary. There is, however, little doubt that the average colliery surface lighting conditions existing at the present time would not be tolerated in any other industry, in spite of the fact that a recent survey showed that approximately 71% of the factories in this country are inadequately lighted.

In the majority of collieries it would appear that the value of good lighting is not sufficiently appreciated. Scientific lighting principles are rarely applied, and it is commonly found that a few lamps of various types, carbon, vacuum, and gas-filled, suspended in odd places, are the hopelessly inadequate and wasteful lighting. The coal industry is prone to retain old lighting methods and traditions, and many of the efforts of research workers are often entirely wasted, owing to the colliery workers involved in the tests regarding them with mistrust and suspicion. It must be admitted that the whole fault is not with the coal industry, but that the electrical industry has been so busy looking after other fields that the subject of colliery lighting has not been given the close consideration it deserves.

(After briefly indicating the principles of good lighting as applied to other industrial processes, the author put forward certain suggestions whereby colliery surface works might be better illuminated).

As artificial lighting is applied to other industries, so can it be to the coal mining industry, especially with regard to surface lighting, and the following recommendations give a rough idea of the method of application to the various processes.

Winding Room.

A reasonably good illumination is required for machinery of about five to eight foot-candles, obtained by the use of B.E.S.A. dispersive reflectors or concentrating reflectors, according to the floor space and mounting height. Indicator dials should have supplementary illumination, obtained by the use of angle type reflectors, concentrating their light on to the dials, etc., but screening the light sources from the eyes of the operator.

Switch and Meter Room.

Good general lighting of about 8 foot-candles is required, owing to the necessity of having good working conditions in the event of emergency work, etc. This can be obtained by the use of dispersive reflectors: while under certain conditions, according to the construction of the switch room, angle type reflectors are entirely satisfactory.

Head of Shaft.

Good lighting is necessary for the intake and outtake, to an intensity of about 5 foot-candles. The method of application is largely determined by the head room available, and whether it be of the open or closed type. Usually dispersive or concentrating type reflectors are suitable, although under certain conditions, angle type reflectors can be used.

Runways.

The lighting for runways to separators, breakers and conveyors is best obtained by the use of well-glass or bulk-head fittings, fitted to the roof or girder work, approximately 10ft. to 18ft. apart, and containing 40-watt obscured lamps.

Inspection and Screening Bands.

This lighting is deserving of particular consideration, and is obtained by two methods, general overhead lighting, or local units. The former method is preferred in American practice. A general intensity of about 10 foot-candles is required. The local unit method which is generally preferred in Great Britain, is obtained by the installation either of a number of small size concentrating units, placed about three to four feet above the screening band, or by trough units, generally about 5ft. long and containing five 60-watt or 100-watt lamps, placed three or four feet high, according to the width of the band. These methods produce a concentrated light on the band with the light source entirely screened from the workers' eyes, and giving a high lighting intensity of anything from 20 to 100 foot-candles.

These methods must of course be supplemented by a certain amount of general overhead lighting for general working conditions other than screening.

In certain collieries the use of "daylight" lamps has proved of great benefit for this class of work, as the light produced is of a good colour matching value, and closely approximates daylight, with the result that the picking is carried out with greater efficiency.

Washing.

The lighting required for this process depends greatly upon the type of machinery used, but generally speaking a good general overhead lighting of 5 foot-candles will be found entirely satisfactory.

Waggon and Truck Loading.

The waggon tunnels below the conveyors are best lighted by means of angle type or dispersive reflectors, which are placed on the roof, well clear of the trucks, to ensure good illumination in the trucks and between the trucks.

Yards and Railway Sidings.

This lighting is generally obtained by the use of outside lanterns or reflectors containing large lamps of 500 watts to 1500 watts, mounted at a considerable height above ground level of anything from 20 feet to 50 feet, which permits an even distribution of light without the necessity of a large number of units.

Floodlights can be used with advantage for these conditions owing to the fact that the lighting can be controlled and directed in any required position.

Whilst these remarks have been directed to the surface lighting, there is little doubt that in the near future it will be possible to use scientifically applied lighting of high intensities in the underground workings, and it is merely a matter of time before completely satisfactory equipment will be designed.

Already a number of Continental mines are using flood lighting for working places, etc., and it is hoped that if satisfactory equipment can be found, the Regulations will be modified to permit the use of this particular form of lighting in this country.

Discussion.

Mr. SIMON.—During Mr. Evans' address he mentioned that it was advisable, although not always at present customary, to have a better lighting of the yards and sidings and so on;: would Mr. Evans enlarge generally on that particular point? There was also the question, which must have occurred to all of them, that in the meeting room with its excellent light, even though the lights were turned down there might well be about 18 foot candles. That was in a clean place, but in a screening plant in a very short time the lights would be very distinctly inferior, due to accumulations of dust. The use of overtype fittings brought the question of cleaning into particular prominence. In conclusion Mr. Simon said he was surprised to learn that the blue lamps absorb 50% of the light, and presumed that the figure must refer to a clear lamp.

Mr. EVANS replied that in the question of yard lighting he purposely did not go into great detail because it depended so much upon the area to be lighted and the surrounding apparatus. Generally speaking lighting is obtained in the open yards from the sides of buildings by means of wall type units, sometimes from a wooden pole construction, as the areas are comparatively small as compared with street lighting. The poles are spaced about 25 to 40 yards apart, using varying sizes of lamps, from 300 watts up to 1500 watts. If it is just a question of yard lighting where trucks are being moved, then a great amount of light is not necessary. Half a foot candle of light in yard lighting is good.

Mr. Simon mentioned the fact that due to the accumulation of dust there was a consequent reduction in the amount of light obtained. Lamp cleaning means a good maintenance system, and in that rests the difficulties. Of course the ideal would be to have plain fittings with only a glazed front to be wiped over. That adds considerably to the cost of every fitting: and the type must be commercially feasible. Excepting where there is very dusty coal the general type of reflecting unit is suitable, owing to the fact that it has an extremely efficient vitreous enamelled surface which can be easily cleaned. The cleaning has to be fairly frequent and in some cases boys are employed for this purpose. In fittings of the local unit type over the picking bands it is quite an easy matter for the men to clean those directly over themselves. With overhead lighting the proposition is formidable and it is undoubtedly one man's work to go round cleaning fittings.

Many people overlook the question of lamp efficiencies—they really believe that by what we call underrunning a lamp they are extending the life of the lamp and using less current for a small reduction in the amount of light. For a 1% drop in voltage there is a 3% drop in the light and a 1½% drop in the current consumption. If we cut it down 10%, making it 216, it has the effect of using 216 volts on 240 volt lamps. Mr. Evans said he recently took a number of readings in the meeting room at 216 volts and the actual readings were 11.5 foot-candles; with the voltage up to full the foot candles rose to 18.4.

Regarding lighting picking bands which are used approximately the whole length of the band: practice varies in collieries as some are rather inclined to work in little groups, but at other collieries they work the whole length of the band. Individual reflectors are sometimes placed at varying distances down the band. The distance depends upon the width of the band and other conditions but, for argument's sake, if a band is about 4 feet wide the reflectors are about 3ft. 6in. high and spaced about 4 feet apart. That would not necessarily be best with every type of band, but the correct arrangement can easily be calculated.

Mr. WARD.—What is the difference in illuminating efficiency in a pearl lamp and an opal lamp? Is there much difference?

Mr. EVANS.—The loss in light output by internal frosting is about 2%—it varies from 1½% to 2%. In the case of the white lamp it varies from about 5% to 9%, that is the white opal or the white street lamp. The last is well compensated by the fact that it gives better diffusion with an open type fitting.

Mr. TULIP said he would like to have some information relating to tunnel lighting where locomotives are in use and the tunnels are without any ventilation.

Mr. EVANS.—Angle type reflectors on the sides of the tunnels and bulk head fittings all the way down the tunnel. For a more wide angle type of diffusion use the bulk head type of fitting, generally about 3in. deep and 10 in. to 12in. face. The light has to be thrown into the tunnel without the drivers or people working in the tunnel seeing the light source. For this use therefore glass covers frosted on the inside are preferable. Overhead lighting by means of bulk head fittings are not suitable. The smoke from the engine absolutely blackens them, and at the same time, if the trucks come to a standstill they practically cut out all light, whereas the light from the sides does light the sides of the truck where light is generally required.

CAPT. WALTON-BROWN proposed the thanks of the meeting to Mr. Evans, and those whom he represented, for the kind manner in which they had been entertained. The attendance of members was good, and the manner in which they had indicated their appreciation of the hospitality likely to be extended was of a most satisfactory character.

Referring to the opinions of Mr. Evans, Capt. Walton-Brown said he felt that before condemning the mining industry for pit lighting, the lecturer should get further information as to what is actually required and then carry out a much better study of the question. He was quite sure that had that been done better facilities would have been available at the colliery than there are to-day.

With regard to underground lighting everybody in the mining industry is most keen to have an efficient lamp, and the Coal Owners were doing everything possible to encourage it. The ideal specification would be about 20 candle power and the weight two to three pounds.

Mr. EVANS.—In acknowledging the vote of thanks Mr. Evans said he quite agreed with Capt. Walton-Brown's criticism: the electrical industry have done quite a lot for the lighting of other industries but seemed to have somewhat neglected the mining industry. To his mind the future of electricity or electric lighting in the mines did not lie so much in the individual hand lamps but in the application of lighting as we know it aboveground and employed underground.

He had been asked how one might overcome the difficulty of men coming from underground to aboveground when they were invariably troubled by the glare of natural light. He believed one doctor had put forward the theory that in his experience no men employed exclusively on night work suffered from astigmatism. Experiments have shown that under greenish hued light the eye becomes very readily adapted. At the bottom of the shaft there were used green tinted lamps and they worked off as the men got further into the tunnels and, in addition, the sides of the tunnels were whitewashed. That, combined with the green tinted lights, prevented the distressing glare for the men coming out to daylight and also made them more readily adaptable to the poor light underground when going from daylight into the pit.

NORTH WESTERN BRANCH.

A meeting of this Branch was held on Friday, November 23rd last, at the Geological and Mining Society, Manchester. Mr. A. M. Bell, the President, was in the chair. The following new members were elected: Associate Member—Mr. H. Oakes; Student Member—Mr. Cyril Smith.

Mr. H. E. Clarke read the following paper.

The Lead Storage Battery in Mining.

H. E. CLARKE, M.A., B.Sc.

Sir Humphry Davy, whose researches into the safe lighting of coal mines are classical, is universally known to have given to the world one of the earliest practical flame safety lamps; but it is perhaps not as widely appreciated that he also suggested electric lighting, on account of the simple way in which the heated filament could be isolated from an explosive gaseous mixture. In his time, however, it was impossible to give practical materialisation to such ideas, not only because reliable portable sources of current were unknown, but also because the technology of bulb making was as yet undreamt of. Davy's work began in 1815, but almost exactly a century had to pass before satisfactory electric safety lamps for miners had seriously come into use in this country. The Secretary of Mines Report for 1925 shows that prior to 1912 the proportion of electric to flame lamps scarcely exceeded 1%, and even at the outbreak of the war the proportion was only a trifle over 10%. In these days when the small capacity lead accumulator is a commonplace in hundreds of thousands of British homes where there are wireless sets, we find it a little hard to understand why the application of such accumulators to miners' safety lamps should have been so long delayed. The accumulator manufacturers themselves do not appear to have sufficiently stressed the importance of the progressive change they had largely in their own power to bring about; they lagged behind lamp design, with the result that even to-day the majority of the lead cells in use are not made by the battery makers pure and simple but by a firm which has taken up the manufacture both of the accumulator and the lamp.

The accumulator in one or other of its types, i.e., acid or alkaline, has so far proved itself the only really suitable portable source of electric current and there is not likely to be any attempt made to popularise a primary cell. Aspirations in the direction of improved illumination are to be praised; but the fundamental principle that the underground worker must not lose lose his light, good or bad, is never to be lost sight of, and the electric lamp with appropriate accumulator continues in this respect to offer a really satisfactory measure of reliability and uniformity. Hence its record of progress since 1912, which has only been retarded by factors affecting the mining industry as a whole.

The year 1912 marked the zenith of the flame lamp and its decline was only temporarily arrested by the boom of 1919-20. On the other hand the number of electric lamps climbed from a paltry 10,700 in 1912 to a formidable 370,100 in 1926, nearly 90,000 having been installed in the period between the end of the war and 1920. The 1926 statistics indicate that approximately 43% of all miners' lamps then in use were electrics and as at that time so now, the vast majority of these are fitted with lead-acid accumulators.

It has been already suggested that the speed of development of the electric filament bulb had an important bearing on the practicability of adopting the accumulator for a miner's electric lamp. Vacuum bulbs for use with 2-volt accumulators could not be made to compare favourably in candle power with the flame of a good oil safety lamp unless consuming about one ampere, and thus a cell with a capacity of something like 10 ampere hours seemed essential. Now a lead accumulator discharging in 10 hours must be well designed if it is to give its output at a reasonably steady voltage, and steady voltage is very desirable in lighting, inasmuch as the temperature of the lamp filament is proportional not to the first power but to the square of the voltage applied. It may, however, be stated that even under ideal conditions, such for example as approximately obtain in Planté batteries with freely separated plates, a ten-hour discharge between 2.0 volts and 1.85 volts will only include five to six hours at unchanging voltage, say 1.95 volts. In order to prolong the period of even one voltage one must so increase the capacity (or size) of the accumulator that it is not exhausted in ten hours. For this reason all modern well designed accumulators for miners' lamps should be well beyond the minimum requirement of the bulb when used for an average shift. The accumulator is not then discharged to the stage where it begins to show a great fall in voltage, though practical considerations for the time being do not allow of the accumulator being designed in such a way as shall make a constant voltage output possible. While it would take more time than can be spared here to enter into this important matter comprehensively it may be useful to indicate one or two of the limiting factors.

In the first place considerations of cost, weight and dimensions set a limit on the capacity which can be entertained. Roughly all three are proportional to the wattage of the accumulator, which is the thing that matters in a lighting proposition. It is questionable whether an avowed increase in the capacity of two-volt types, which can only be achieved by increase in the number or dimensions of the plates, would effect a genuine, measurable reform in lighting, until the candle power of two-volt bulbs per watt has been correspondingly improved. If the increased cost and weight of the accumulator are to run in proportion to the wattage, by which is meant that the difference between a two-volt 20 ampere hour accumulator and a four-volt 10 ampere hour will be inappreciable, the greater economy in consumption per candle power of four-volt over two-volt bulbs obviously suggests that the former line of development is to be preferred. The lamp manufacturers and the accumulator manufacturers have worked along these lines, and four-volt and six-volt lamps designed for gas-filled bulbs are now available to the mining industry; for which it is certainly asked to pay more than for two-volt equipment, but for the sake of an entirely disproportionate advantage in illumination. Time alone will prove how far these suggestions will prove acceptable; present conditions render their adoption most difficult.

The lead accumulator, like every other galvanic battery, has two essentials, viz., positive and negative electrodes immersed in an electrolyte. The electrodes must be prevented from coming into contact with one another, and the electrolyte must not be allowed to get out of the container, not only because it happens to be corrosive, but also because the electrodes must always be covered by it. Practice shows that until a revolutionary improvement has been effected in the method or medium of separation, the necessity for unspillability will impose upon accumulator designers a limitation which manifests itself in a falling voltage on discharge through a lamp bulb. In this respect both theory and practice indicate that the electrolyte should be at least as free as the acknowledged limitations will permit and on this is founded the flat plate type with comparatively close-fitting wood separators, the latter being as porous as possible and only ribbed to the extent necessary for furnishing the safe minimum of dilute sulphuric acid, which operates over a specific gravity range of about 130 points, between 1,280 and 1,150.

When the accumulator is turned upside down the acid not retained by the separators and plates is accommodated in the space between the tops of the plates and the lid of the container, which is furnished with a non-spill vent and filling plug. Within the limits of weight and size at present tolerated, lead cells of this type, which number 200,000 or more in Great Britain alone, give the best average voltage on discharge through standard bulbs, and they have the further advantage of approximating as closely as possible to the proved and tried principles used throughout the lead accumulator industry, and of leaving open the door for still further improvements.

In extending the range to 4-volt and 6-volt types of portable (hand) lamps, the accumulators may simply be multiplied in number without any essential alteration in construction. In this way the charging and management of the cells present no new problems and call for no new equipment. In 4-volt and 6-volt forms the lamps become noteworthy sources of illumination, not only at the face but at all points where stationary lighting cannot be adopted; either because of its lesser convenience or because of a possible infringement of Regulation 78 of the Coal Mines Act of 1911.

A further application for such lamps is on the travelling roads, the lighting being in this way carried in from the brightly illuminated pit-bottom with decreasing intensity to the face, so assisting in accommodation of the hewers' eyesight at the beginning and end of their shift. The advantage of improved illumination on haulage roads wherever stationary lighting is not permissible hardly needs emphasis from the standpoint of safety and the expeditious handling of loads.

The bearing which the rational use of reflectors and the frosting or other similar treatment of the bulb may have on the above argument, has not been forgotten. But all expedients in the way of high beam candle-power on the one hand and uniform scattering on the other, have not satisfied the demand for better and more genial lighting of the working places, as is shown by the demand for still more powerful cap-lamps, which have in the 2-volt form already shown as much as 5 beam candle power.

An important service which may be performed by the lead accumulator in the mine is the supply of energy for visible and audible signals, but it is hardly necessary to enter into this at any length, seeing that the batteries generally used follow the well understood principles of stationary battery construction. They may be of full-Planté, semi-Planté or fully-pasted type and their capacity may be from 30 to 100 ampere hours. This may, perhaps, be an appropriate time to suggest, however, that if there are facilities provided for recharging the signal batteries in eight to ten hours; or, alternatively, arrangements whereby the batteries are "slow-charged" continuously at rates allowing of the drain being made good within 24 hours, Planté batteries could be satisfactorily replaced by less costly types, such as the latest forms of slow-discharge accumulators and also probably of lower capacity than at present.

In connection with gas detection the small accumulater used for lighting has been made to serve as a heater for a metal filament, which may either assist in the burning of the gas mixture, or may simply be used for re-lighting the oil flame lamp for the usual cap inspection.

The design of portable lead accumulators intended for hewers', inspectors' and rescue lanterns must be guided by the most scrupulous regard for safety, ease of maintenance, mechanical robustness and economy in both first and replacement costs. Celluloid has met all requirements as a material for the containers (notwithstanding its inflammable nature) as a consequence of the excellent principles adopted in the construction of the plate terminals and the contacting in the lamps.

The greatest care and not a little ingenuity have also been expended in the arrangement, plant and organisation of charging and repairing rooms where the accumulators are handled shift by shift and passed out in a charged and clean condition, to be returned for recharge before they have been discharged to a voltage at which candle-power has materially fallen. The cells are made so as to be easily dismantled or repaired, or washed out and re-assembled, while spare parts are strictly standardised to ensure uniformity in construction and performance.

In addition the care of the lamps and accumulators is a matter of the deepest concern to their manufacturers, whose trained engineers are placed at the service of the colliery companies for the guidance of lampmen and the securing of the best possible results in safety and economy from the lamp equipments.

It must be said, however, that notwithstanding the best attention on the surface, the electric lamp accumulator could not survive for long the heavy mechanical treatment it gets in the pit were it not very strongly constructed and this strength must be shared by all its parts, notably its plates, separators and box. The active materials of the plates must be of unusual texture and uniformity if they are not to be shaken to bits in a few months, while the separators must do their share in supporting the plates throughout the whole life of the latter. The celluloid box must have immense strength and must not be liable to degeneration through ordinary opening and re-sealing. Preferably re-sealing should be done away with altogether. Finally the cell when filled with sufficient electrolyte must be unspillable, and as stated this has been achieved with complete success.

Discussion.

THE PRESIDENT remarked that they were indebted to Mr. Clarke for the valuable paper he had read to them. As the author had pointed out, the lead storage battery is now in many homes in Great Britain, due largely to the introduction of broadcasting. Those who owned motor cars had also some experience of accumulators. He believed therefore there would be a useful and interesting discussion.

Mr. BOLTON SHAW said he was not quite clear as to why it is that with a 4-volt cell of the same cubical capacity a better candle power is got from the lamps than with a 2-volt cell. The author mentioned that and to some extent explained it, but if he would enlarge on the point it would be interesting. Another point was that one of the lamps displayed appeared to have a different colour of light. Was the glass in that case slightly tinted or was the lamp somewhat ancient?

Mr. CLARKE replied that perhaps the filament of one bulb was not as hot as that of the other.

Mr. BOLTON SHAW.—Is the 2-volt gas-filled lamp not as satisfactory generally as the 4-volt gas-filled lamp?

Mr. CLARKE said that he believed there were no 2-volt gas-filled lamps being used in collieries; all the bulbs were vacuum bulbs and that would have something to do with the brilliance of the light. The greater economy of 4-volt bulbs is due to the fact that whereas in the case of 2-volt (vacuum) bulbs one must have about one ampere per candle power, in the case of the 4-volt one candle power needs about 0.6 ampere. The difference is in the bulb. With regard to the battery, a smaller battery is used simply because the consumption of the bulb is smaller.

Mr. BOLTON SHAW.—But bulk-for-bulk there is an advantage because it is a gas-filled lamp in one case and a vacuum lamp in the other.

Mr. CLARKE.—Yes. The difficulty in regard to lamp construction is in respect of the cooling; getting down to the extreme of the 2-volt or 4-volt bulb, the difficulty is that the filament is so short that it is excessively cooled off by the incoming terminals.

Mr. GURNEY asked what the comparison was, in candle power per watt, between the lamp described by the author and the ordinary domestic lamp. Another point of interest was Mr. Clarke's description of the discharging rate. He understood there was a point somewhere between the full charge and the full discharge where the discharge rate continued at the same voltage for a long time. Was it the practice to charge the lamps only up to that particular rate?

Mr. CLARKE.—The 2-volt cell with a vacuum lamp yields about half a candle power per watt, but in domestic lamps it is about 0.8 candle power per watt, so that there is very much greater efficiency in a gas-filled than in a vacuum lamp, especially with low wattage.

When the accumulator has been taken off the charging frame if immediately put on discharge it starts with a fairly high voltage, somewhere about 2.2, but in a very short time it drops to a trifle over two volts. From that point the fall is very gradual to about 1.9 volt. The flattest part of the curve is at about 1.95 volt at the 10 hour rate of discharge. When it reaches 1.8 the drop in voltage is quite sheer, so that indicates the really effective life of the discharge. In fact experience shows that to use that precipitous part of the discharge damages the accumulator.

(With regard to the discharging of the accumulator Mr. Clarke explained by means of a diagram on the blackboard).

Mr. GURNEY remarked that the accumulator on a motor car had to be of a rather different design on account of the fact that it was subject to rapid discharge all the time. The author had warned them about over-discharging the accumulator, but what about the motor car accumulator? Were there special features in the design to protect that particular type of accumulator from the high discharge rate or discharging beyond the limit described in the paper? Although it had nothing to do with the subject under discussion perhaps the author could give them some information about the cell condition indicators which were advertised for motor car batteries.

Mr. CLARKE.—With regard to the starting battery the reason the cell loses voltage at certain rates of discharge is that the contact between acid of sufficient concentration and the active material cannot be maintained. When a cell discharges the concentration of the acid falls and eventually unless there is effective diffusion of the acid there is only water in contact with the plates and the cell action is stopped. That is the reason the voltage drops. In order to get into the battery the capacity for giving a heavy discharge and maintaining the voltage, it is necessary to keep the acid in contact with the plates as much as possible and that is done by having very thin plates. The thinner the plates the more acid there is in contact with them. In other words the surface per mass is increased. It would be possible to build the active material into a slab like a brick and soak that in acid but, obviously, the deeper lying portions of the active material would never get in contact with the acid and the battery would soon fall in voltage. By cutting the plate material into slices, very thin slices, intimate contact between the acid and the active material is ensured, and that would maintain the discharge.

Mr. GURNEY.—Is it safer to over discharge the battery on a motor car or to under-charge it?

Mr. CLARKE.—It is not common to injure the battery by over-charge on a motor car. The great risk is over-discharging. If a battery is kept on a car and one has to choose between these two abuses, rather overcharge; but take care to top up and there is little risk of doing much harm, but a lot of damage can be done by over-discharging.

With regard to the indicators what Mr. Gurney refers to is an instrument on the dash-board which shows the condition of the battery.

One form of indicator is the specific gravity float or ball made of wax, of which a variety can be obtained for different specific gravities. These waxes are made very heavy, medium density, and very light, and they are ingeniously mixed together in varying proportions cast into balls and tried in a standard solution. Those which do not suit the standard solution are rejected and those that satisfy the requirements are sold. These can be made with wonderful accuracy and are quite useful.

Another form is the glass float, which is not quite so accurate and has the disadvantage of being rather fragile. The use of the specific gravity indicators in the form of floats or balls is prejudiced by one thing. If anyone tampers with the acid the indicators are practically useless. If the accumulator, to begin with, is filled with acid of the correct gravity then the specific gravity float or ball will be useful; but if the acid is changed without having regard to the condition of the charging the indications will be meaningless.

Mr. CROSSELL asked what was the efficiency of the lead accumulators compared with the alkaline form with the steel container that so much was heard about?

Mr. CLARKE.—As regards wattage efficiency the alkaline accumulator does not compare favourably with the lead accumulator. The former requires a very high voltage for charging but it gets up to 3.2 or 3.3 volts and on breaking the charge the voltage immediately takes a sheer drop to about 2.4 or 2.5 volts; that is to say nearly 0.7 of a volt drop on breaking the circuit. That affects the watt hour efficiency enormously.

Another point is that there is much more of a voltage drop in the discharge itself. In the alkaline accumulator, in addition to the sheer drop mentioned, there is more variation between the condition of full charge and discharge than in the lead accumulator. The lead accumulator on an ordinary ten hours' discharge will only drop about 0.2 of a volt between full charge and full discharge, whereas the alkaline accumulator will drop half a volt. One of the problems which face the alkaline accumulator manufacturer is that of getting suitable bulbs for running with their lamps. That has been overcome in some measure, but it used to be a common experience for freshly charged accumulators to blow the bulbs through over-voltage and for the difference in the voltage between the beginning and the end of the shift to be very considerable indeed. The only way to deal with that was to give a capacity to the alkaline accumulators much in excess of the requirements in order to flatten out the discharge curve.

With regard to the general maintainence of accumulators at collieries the lamp men are trained by the firm supplying the apparatus. As far as possible manufacturers endeavour to train the lamp men, who are responsible for managing the lamps, by a course of instruction. These men are taken over the makers' works, are shown the construction of the lamps, and they have explained to them the reasons for doing what they will be asked to do. They are shown why it is necessary to keep the accumulators clean not only from the point of view of safety, but so that there will be no burning out and so on. They also get a training in the repair and maintenance of the lamps. That applies to all the equipment associated with the lamp room such as lamp frames, charging frames and the like. As to the maintenance of the ordinary type of accumulators, it is certain that an accumulator is started out on its life history according to the instructions issued by the manufacturer there is every chance of getting a good, useful and serviceable life from it. The great trouble is that people will not take the trouble to read the instruction labels. The first consideration is that the initial charge should be properly carried out. When the plates are mounted in the cell they are in a general way discharged plates; the process of manufacture results in the negative at any rate being almost completely discharged. After the battery has been given its first charge consider whether it is given a fair show with the discharge imposed upon it. If the manufacturer tells you that it has a 40 ampere hour capacity, all that is needed is to add up the consumption of the bulbs and divide that into the total ampere hours of the battery: that will show the number of hours for which it ought to be run. When those hours are run, even supposing the signals are still quite strong, you have taken out of the battery what the manufacturer has said there is in it; stop then and re-charge.

Another point is, if acid is spilt out of the cell, fill it up with distilled water; adjust the specific gravity when it is fully charged but do not fill it up with acid at any other stage. The only proper time to change the electrolyte at all is when the battery is fully charged. If some of the acid is spilled and it is not known whether the battery is half discharged or what its condition is, do not fill it up with acid, because that would throw the specific gravity completely out. Fill it up with distilled water, run it as long as it will run consistently and when it is charged fill it with the acid of the correct specific gravity. The upkeep is quite simple by following the general principle that the accumulator should never have an acid of a higher specific gravity than 1300 or lower than 1100. The specific gravity should always lie between those two limits.

A trouble that might arise with celluloid is frothing. It is a nasty objection. It gets through the vent plugs and round the terminals. To stop it, pour the acid out, fill the cell with water and charge at a very low rate, say half or quarter the normal rate, until as much acid as possible has been extracted by reaction on the plate.

Another method is to dismantle the battery. Take the plates out, wash the celluloid container, dry it, and paint the inside with amyl acetate. That gives a fresh surface to the celluloid and on re-assembling it will be found that the frothing has ceased. Good celluloid should not froth in cells under three years old.

The acid is one of the most important things in the accumulator which cannot give current unless the acid is there. Absolutely pure acid is essential. It is recommended that those who are not sure of the source of their acid should buy sulphuric acid such as is got from chemical suppliers and as supplied to schools and colleges for analytical purposes. The ordinary commercial sulphuric acid is unsuitable for accumulators. The acid does not deteriorate in service unless the plates have been made from impure materials. Naturally the acid will dissolve out some of those impurities, but now-a-days all responsible manufacturers take great care in the selection of the raw materials. Iron is the commonest impurity which gets into the acid. Mr. Clarke said that as a point of interest it might be mentioned that oxides which went through the laboratory of his firm would be rejected if they contained more than .003 per cent. of iron. Water is one source of introducing impurities. Many people do not appreciate the difference between tap water and distilled water. In Manchester the water is good and soft and it would not do a great amount of damage, but in colliery districts and localities where the water is extremely hard it is dangerous to use tap water for filling up the acid. The reason is this: these impurities are cumulative. The water is evaporated from the cell and the salts dissolved in the water remain in the cell. In the course of time, especially if the water has been brackish or slightly saline, such quantities of chlorides remain in the electrolyte that it attacks the positive material quite appreciably. The water question is an extremely important one in connection with collieries because very frequently the supply is quite unsuitable for even washing out the cells. One of the makers' concerns is constantly to be testing samples of water submitted to see whether they are suitable for washing out the cells, and in many cases the effect is to condemn them.

Mr. HEWITT.—What is the essential difference between a battery for a ten hour rating and one used for a dull emitter valve which may last two or three months?

Mr. CLARKE.—That is a very interesting point. It has already been explained that the starter battery has a thin plate to allow intimate contact between the acid and the plate. The starter battery is particularly suitable for heavy discharges; but for slow discharges it is not necessary to provide for shock discharge rates. The discharge is at a very low rate with the dull emitter and it is not necessary to have ready contact between the acid and the active material. That is the reason why many manufacturers use the block type of plate for dull emitter accumulators. These accumulators are quite satisfactory for their discharge if they are not discharged more rapidly than at the twenty hour rate. Their weakness is in the re-charging. If they will only stand a slow discharge they will only stand a slow re-charge simply because the acid cannot penetrate rapidly to the interior of the plate. The best construction is that provided by the use of the laminode construction of the plates. (Mr. Clarke explained on the blackboard).

Replying to a question as to how to find the correct charging rate with a high tension battery, and how to tell when it was fully charged, Mr. Clarke said that if the electrolyte had been topped up with acid instead of water it was not possible to judge by gravity, but an indication of condition was afforded by the voltage. The voltage on charging is a very good sign supposing the plates are healthy. If a sulphated plate is put on charge there will be a very high voltage to begin with but in time that voltage will fall owing to the removal of the sulphate. If the plate is healthy there will be a continuous rise of voltage up to the condition of full charge. When that voltage reaches its maximum the battery is fully charged.

The same applies to the high tension battery. In both cases the fully charged plates would be gassing freely. The voltage depends on the charging rate so that one should be careful in drawing conclusions form the voltage that the rate of charging is not changed. The voltage of a battery being charged at (say) two amperes may be 2.5 volts; increasing the charging rate to four amperes will lift the volts to 2.55; so the charging rate must be taken into account.

THE PRESIDENT.—Though the discussion has covered many points there was one point not clear After a high tension battery had been in use for three months what would be a fair average charging time to give, assuming the user followed the makers' directions carefully? When a battery had been in use every night for three months it appeared to him that the charge gven must be something between 24 and 36 hours' duration. He may be mistaken, but it would be interesting to have an explanation.

Mr. CLARKE.—Mr. Bell has raised a very interesting point and one that battery charging stations ought to take to heart. It is a very common thing for the charging station merely to give the battery a ten hours' charge forgetting that the battery might have been very heavily drained. It is particularly necessary in the case of high tension batteries, which have been emptied at a very low rate, some even at the 300 hour rate so that everything had been taken out, that they should be given an adequate charge. The more prolonged the discharge the flatter is the voltage curve; the more rapid the discharge the steeper is the voltage curve. The high tension battery is being discharged at a rate which is only 1/300th of its capacity. The voltage curve is dead flat for 150 hours. During all that time the electrolyte works deeper and deeper into the active material. That introduces what is termed the "factor of use." The active material in a plate is not used up in over-discharging; far from it. Only one-third of the total active material is used in a healthy discharge, but when the discharge is prolonged in the way described not one-third but one-half to two-thirds is used and in the most extreme cases well towards the whole of the active material is being sulphated. When the re-charging is under consideration nearly the whole of the active material has to be converted back. It is therefore very necessary after a long discharge such as is common with these slow discharging accumulators, both high tension and low tension but particularly the former, that the charge should be prolonged until the battery is restored to a healthy condition.

Mr. BOLTON SHAW moved a vote of thanks to the author for his very interesting address. He related an experience in connection with miners' oil lamps with a platinum filament for re-lighting. The firm which supplied the lamps and the equipment in the form of batteries for re-lighting and for charging the batteries also supplied the acid. On one occasion he went into the power house and noticed a very pungent smell. He asked the man in attendance what was going on and the reply he got was that they were charging some cells. Then this conversation followed.

He (Mr. Bolton Shaw) said, "They should not smell like this," to which the man answered, "I have put some fresh acid in." It smelled like hydrochloric acid and he asked, "Are you sure you put the right acid in?" "Oh yes," was the reply, "it is what was sent to us and it only came this morning." A carboy of the acid was brought for examination and it was found that hydrochloric acid had been sent in mistake for sulphuric acid. In that connection he would like to ask whether hydrochloric acid was used in any way in the making of the cells.

Mr. GURNEY seconded the vote of thanks which was carried with acclamation.

Mr. CLARKE, responding, said that Mr. Bolton Shaw's story reminded him of an experience he had at the charging station of a bus company. The workman had a number of batteries of different types on charge and one celluloid battery was frothing most violently. He asked the man what he was doing. "Oh," he replied, "I am charging this up." "Yes, but what do you mean by all this froth?" "I am boiling the sulphate out of it." In many quarters a little education was needed in the upkeep of batteries. With regard to lamp rooms at collieries, however, the men in charge now-a-days were of a very much higher grade than they were a few years ago, and he attributed that to the lively interest the men took in their work and also to the efforts made by accumulator manufacturers to give a practical training to those who were engaged in the management of the accumulators.

AYRSHIRE SUB-BRANCH.

The Ayrshire Sub-Branch held a meeting in the Lesser Town Hall, Old Cumnock, on Saturday, December 22nd. As a rule the meetings of the Branch are held alternately in Kilmarnock and Ayr, but at the inaugural meeting of the session it was resolved to hold two in other mining districts of the County, the papers read to be of a practical nature, and to invite coal-cutting operators from the mines in the district to attend. This Cumnock meeting was the first of these and the results were very encouraging, the attendance numbering close on fifty. Mr. T. M. McGlashan, Vice-President, presided, and introduced Mr. Alex. McPhail, who read the following paper.

At the conclusion of the paper a great number of photographs and diagrams of coal-cutting machines, from which lantern slides had been made, were reflected on a screen. Mr. McPhail explained the various points of each and replied to questions that were asked concerning them. In this he was assisted by Mr. Matthew Campbell. The slides were kindly lent for the purpose by Messrs. Mavor & Coulson, Ltd., and the lantern was operated by Mr. James Gaw.

Coal-Cutting by Machinery.

ALEX. McPHAIL.

In coal-cutting, attention to detail is of the utmost importance, and the best results are obtained only by considering the needs of each machine in relation to the conditions under which it has to work, and the particular kind of work it is required to perform. It is obvious that no standard machine equipment, however complete, can contain every accessory that may be required to enable the operator to get the best results under every variety of face conditions that may be encountered.

It is frequently necessary, in order to meet a special condition or to overcome a local difficulty, to contrive some device on the spot. This calls for initiative on the part of the operator, working in co-operation with the colliery engineer or, perhaps more often, with the mechanic under whose direct supervision the coal-cutters are placed.

Much improvement may be wrought in spragging and pulling-prop arrangements, fitting trams for long-wall machines, piping and coupling arrangements for compressed air machines, transport of picks and oil to and from coal-cutters, facilities for turning the machine at the face, type of lamps used, telephonic communication between the mine and fitting stores. Time can be saved in regard to all these matters by eliminating avoidable delays.

The effect of attention to details and to organisation is to increase the cutting time of the machine, and thereby the output. The actual cutting time in a seven hours' shift is so little that every ten minutes saved may represent something like five per cent. increased cutting capacity.

The disc coal-cutter was the fore-runner of existing types of long-wall coal-cutters, and in its original form it was the product of the blacksmith's shop; its special sphere is holing the hardest cuttable materials. In practice economic results are seldom obtained if a set of picks does not last for about 20 lineal yards of cutting.

The disc coal-cutter, although unequalled under the conditions favourable to it, has limitations, especially where the roof is tender, or the coal soft with steps or faults occurring in the seam. Where great power and strength are required the disc machine cannot be equalled and, in addition, it is liable to be subjected to shocks and stresses far more severe than any other type of coal-cutter. Rounder dross is generally got from this machine, because of its bigger bite into the cut, than from any other type of cutter. The motors are powerful and, running at a high speed of rotation, have considerable momentum, or hold a large amount of stored energy. With the best types of disc coal-cutters great power and strength of bearing surfaces and shafting are required, and all these must be subject to limitations of height, width and length.

A few plates of the "Samson" disc coal-cutter were exhibited to show the great strength and build of this machine.

The first "Samson" chain machine to be put to work in November, 1926, is still at work in a Scottish colliery. The output over a period of 21 months has been 35,500 tons, a lineal distance cut of 22,200 yards. Over this period the total cost for oil and spares was 0.224d. per ton. This work was done under adverse conditions for a large portion of its time, because of the troubled ground. Quoting from the "Iron and Coal Trade Review" of 7th September, 1928: "In this connection it is interesting to note that the first 'Samson' machine at Barnsley Main has during a period of 46 weeks regularly cut 470 yards per week, and it will be understood that this includes cutting and flitting. During the period mentioned, the output from the face was 941 tons per week, and the cost for spare parts was 0.09d. per ton. Recently the machine holed out 166 yards in a shift."

It is difficult to make statements which determine the kind of coal-cutters required for various kinds of seams, but in general it can be said that the disc type cannot be applied to such a variety of conditions as the bar or chain type, and it is to the latter two types that much attention is given. The "Universal" bar coal-cutter has characteristics of its own which may be hard to beat. This machine shows an interchangeability to bar or chain type. The machine in respect of haulage gear, motor, and gear-head, is standard and to it either a bar or a chain can be attached. In many instances both bar and chain gear-heads are kept in one seam, and as the conditions require either bar or chain may be used. In such cases the chain "Banjo" would be fitted and the bar "Banjo" laid aside, where a longwall face had been opened out after the heading work had been done. These machines are fitted with either an A.C. or D.C. electric motor or a turbine air motor. They can be adapted to cut any part of the seam from floor to roof and for heading work, or as an arcwall coal-cutter from a longwall coal-cutter by fixing in the under-carriage and reversing the gear box; or from an arc-wall to a longwall by taking out the under-carriage and reversing the gear box. The control handles are all at one end and are easily operated, the oiling being done once a week.

Present-day coal-cutting favours chain machines. For the thicker seams, the larger chain machines: and for the thinner seams the smaller chain machines. Some of these types are doing good work in long-walling in moderately thick seams, and arc-walling in thick seams, while the smaller machine (round about 12in. high) has become a great favourite for thin seams.

Here is a very interesting example of what the 12in. chain machine can do. During the time this 12in. chain machine has been running, it has never lost a cut and the cost for spares for that period has been very low. The management claim it to be the best investment they have ever made. The cutting cost has been reduced 60% and the power consumption has been very much less. The output from this machine is 110 tons daily. It is running on A.C., 25 cycles, electric supply.

The roof and floor are both good, being firm and regular. The average height of the seam is 16in. and the inclination 1 in 8. The cut is 4ft. deep in a hard coal with a rib of splint in the centre of the cutting position. The pick life is about 25 yards, and the time of cutting at present is about 11 hours for 245 yards. In the last quarter's work done by this machine a face of 240 yards was advanced 264 feet, giving an output of roughly 8,500 tons, and a total distance cut of approximately 16,000 yards. This machine has never lost a cut during its two years' service, and the cost for spare parts used during this time amounts to, approximately, 0.16d. per ton.

Cutting in Steep Workings.

In this class of work great care has to be exercised in the using of safety appliances to make sure that everything is properly fixed. The seam is usually cut from bottom to top, and is balanced by what is termed a "Cudy" run down another road parallel with the line of face: a rope is fixed to the coal-cutter at one end and the "Cudy" at the other; the tree at the top, holding the pulleys on which the rope turns, being moved every shift into the face. A second rope is run the whole length of the face with eye hooks at regular intervals on to which the coal-cutter haulage rope is fixed. This system serves best where the roof or pavement may be soft, as the tree at the top can be made secure, and therefore no other trees are required for the coal-cutter haulage.

Bar Machine.—Pick speed in feet per minute, 620 to 880. Revolutions of cutter bar per minute, 325 to 540.

Reciprocating Motion.—One full reciprocation to 10 revolutions of the bar.

Length of reciprocating motion, 1¾in.

The above figures vary between to suit the holing material, and the machine is designed to suit the speeds required and, if three-phase, the speeds vary when working on 25, 40, or 50 periods.

Chain Coal Cutter.—Pick speed in feet per minute, 300 to 470, according to conditions as stated above.

	Periods.	*R.P.M. of Disc.*	*Haulage S.P.M.*	*Motor Speed.*
A.C.	25	26	87	750
A.C.	50	35	116	1000
D.C.	—	24	104	900

Pick speed may vary from 300 to 400 feet per minute as above.

Compressed Air.—Turbine type with bar gear-head, cubic feet of free air per minute 750/800, 45lbs. pressure at face. Machine is 35/40 H.P.

Motors.

Coal-cutter motors are strongly built, the insulation being of the best material, and it is very seldom trouble is got in this direction if proper care be taken. On D.C. machines the greatest trouble is with brushes sparking at commutators caused chiefly by dust. These should be examined at regular intervals and adjusted, because the vibration of the machine is apt to slacken nuts and adjusting screws.

The field coils are well made and very seldom require much attention.

The starting apparatus of D.C. machines gives most trouble, and usually through careless handling of the operator in switching on and off; and more so in changing picks when the switch is switched off at the heaviest load. This causes arcing across the finger tips and barrel connections, burning the points and causing stoppages which may result in the loss of a shift before being repaired. The insulation of the switch may be so badly burned as to cause a "short" between some of the bars and earth, which may mean a whole shift in repairing the machine: most of the trouble is found in this direction. These troubles might be saved if the operator would be more careful in switching off and on quickly; to the first step in switching on, and the last step in switching off. Although quick make and break switches greatly assist in this direction, much can be done by the operator. A.C. machines are all principally of the "squirrel cage" type, and the switch may be "star-delta," which starts up the motor in two steps and usually makes and breaks with quick movements. Switching right on to the mains is becoming very popular in A.C. coal-cutting machine practice, but the "star-delta" switch method is preferable.

When about to start, the machine trailing cable pommels or plug should be inserted into the machine and also into the gate-end box before the power is switched on to it.

A very dangerous practice with operators is switching the power on to the trailing cable when leaving the gate-end box and carrying the machine end pommel or plug by hand, whilst it is electrically "alive." A short circuit may take place when so carrying the plug or when inserting it into the machine, which may result in the loss of the opertator's life and of other lives also. This practice should never be adopted by any operator.

Another dangerous practice is taking the pommel or plug out of the machine "alive," carrying it along the run to the gate-end box, coiling it up at the side of the road and forgetting to switch off, leaving the power still on the trailing cable. This also should never be done by any operator.

It is usual to double up the fuses when the machine is jammed or stalls in the cut, so that the machine can be lifted out by the power. This would perhaps be permissible if the fuses were not left at that and forgotten. The first thing to take place after this neglect is a burnt out armature or stator.

Discussion.

THE CHAIRMAN said he was sure they had all enjoyed listening to Mr. McPhail's clear and instructive paper. He had taken great pains to explain not only the mechanical working of coal-cutting machines, but also the causes of failure and the precautions necessary to be taken to minimise the chance of failure. He had given them much good and sound advice as to what should or should not be done in order to overcome the many incidental troubles which arose in the handling of coal-cutting machines. It was one thing to make a machine and quite another to use it, and the man who used the machine was in a position to give valuable information not only to the electrician but to the manufacturer. Papers such as that, written from the view-point of the user and operator, were instructive to members, and he invited all present to express their views; they ought to give others the benefit of their knowledge and experience. He himself would like Mr. McPhail to say whether in his opinion D.C. or A.C. motors were more suitable for coal-cutting, and why?

Mr. McPHAIL replied that in his opinion the machine with the best advantages, which is cheapest to run, and does the most work, is the D.C. machine. One reason for this is that these machines are usually over-compounded and thus give in effect two machines in one —a shunt machine and a series machine. When the machine is running light the shunt fields keep the motor running, and when a little work has to be done the shunt fields are able to undertake it. As the work increases more current is taken by the armature and that current must pass through the series fields, which give the increased power or torque to the armature for the work required. The D.C. machine, when stalled, will away by its series coils where the A.C. machine would not move. With an A.C. machine there is a definite limit of power, whereas D.C. machines usually have 25% more power than is tabulated on the plates. For these reasons the D.C. machine is considered the best for coal-cutting and the cheapest running machine.

A VISITOR.—A coal-cutting machine operator present asked: Is it possible to have an arrangement on a coal-cutter to prevent the plug from being put in or taken out alive?

Mr. McPHAIL.—There is a type of trailing cable on the market which contains a locking device so that it cannot be switched on at the gate-end box until the plug is inserted in the coal-cutter.

Mr. BANKS.—Would Mr. McPhail say whether, in D.C. applied to coal-cutting, he preferred series, shunt, or compound wound motors?

Mr. McPHAIL said he preferred compound winding because with the series winding alone the machine would run away if it was not cutting coal. In a shunt wound machine the field is at full strength always, whereas in compound machines the series coil provides half the field or more according to the load, the shunt providing the other half. So that a compound wound machine is the best for all-round purposes. It has characteristic advantages of its own which not even any series machine is able to reproduce.

Mr. J. C. MacCALLUM.—Why is it, in A.C. applied to coal-cutting, that squirrel cage motors are adopted in preference to slip-ring motors?

Mr. McPHAIL.—The stator of the coal-cutter for the squirrel cage motor and a slip-ring motor is the same. In the case of a slip-ring motor resistance is required for starting, but with a squirrel cage motor the voltage of the rotor may run from anything from two volts down while the stator may be 500 volts. With slip-rings brushes and starting-gear are required, whereas with a squirrel cage motor only a simple star-delta switch is necessary. Once started up the squirrel-cage and the slip-ring motor practically run the same, but with the squirrel-cage less housing is required.

A VISITOR.—An operator asked Mr. McPhail for hints to prevent the continual burning out of the armature in series machines.

Mr. McPHAIL.—Many preventives are available for this, such as a kicking coil, which is of great service in a series machine. To anyone interested he would be pleased to send details and sketch diagrams.

A VISITOR.—At what inclination can an arc-wall propelled by its own power, work in safety?

Mr. M. CAMPBELL replied that the safe working inclination is about 1 in 7. Some use long batons along the roads and threaded wheels to grip into the batons to prevent slipping. These are put on one side of the rail and bite into the batons when going up hill. One in seven is a reasonable thing. The machine makers provide a special drum for mechanical haulage up or down hill and special provision is made in arc-wall machines for that.

Mr. McGLASHAN said he was pleased to hear Mr. McPhail's remarks about the great care that should be exercised at all times when examining a machine that had unexpectedly stopped. In such cases it was certainly best that the machineman should simply follow the ambulance rule of "making the patient easy until the arrival of the doctor." Mr. McPhail is a great believer in making sure of the earthing. In this respect it is best always to err on the safe side. Safety is the highest aim and should never be lost sight of. His remarks on trailing cables and plugs were also important. Cables and plugs are really the weakest points of the system. They are generally in exposed places and are liable to damage in many ways. Then there is the testing of the earth cores, an important matter in the eyes of the machineman.

Continuing, Mr. McGlashan said he would like to have Mr. McPhail's opinion about what is the best instrument for doing this, and also to know if it was his experience that testing was seen to as regularly as is necessary. Another matter he would like to hear discussed was that of picks. It was surprising what variations of opinion there were among machinemen about the best shapes of picks. The chisel pick, the pointed pick, the duckbill, each has its different purpose, and each man has his own ideas as to which is best and as to how they should be properly balanced.

Mr. McPHAIL.—There are many instruments on the market for testing conductivity. The best and simplest instruments were of the Wheatstone bridge type. It is very important that conductivity should be tested regularly. He remembered a case some years ago where the coal face was 1½ miles from the bottom. The machine being run there was a 25 H.P. machine, and the fuse wire was No. 20 S.W.D., which would carry about 70 amperes. A short circuit took place on the coal cutter and two men were killed. The fuse was not cut out and when the armature was tested the conductivity of the armouring was so high that the voltage would have had to be 1000 before sufficient current could be passed through the resistance to cut out that 20 S.W.D. wire. That showed the necessity for regularly testing the conductivity of all cables and more especially of plug boxes in connection with coal cutting machines. Men's lives are dependent on these things and it is up to the electrician to see that these tests are carried out regularly. It takes very little work or time to do it and he was of opinion that these tests should be made at least once in every three months.

Turning to the question of picks, as far as wheel picks are concerned he preferred the diamond pointed. The correct arrangement is this: put the wide pick down on the ground then put the next pick on top of it, then another on top of that, these two to be intermediates; then put a single pick on top of that. Put the heels of them all straight and look down through the points and see if they are all on the same straight line. Notice the space between them: that is exactly what would be left when cutting the coal. Always work with two intermediates instead of one: a single, an intermediate narrow, and then an intermediate wide altogether.

Mr. CAMPBELL recalled a case where his firm had one of its operators at a certain colliery for a month investigating a difficulty. It was a new disc machine that was concerned and the trouble arose through the picks being out of gauge, so much so that they used a gadget to put in a double fuse. Latterly little blisters came on the leads leading from the coils and the commutator all got pitted, showing that there was a lot of sparking going on. He went into the blacksmiths' shop and got the picks laid down one on top of the other. Instead of the single pick leading, the single pick was lagging behind the intermediate. It was the wide pick that was doing the heavy part of the work: it was taking out a shearing at the floor level. It was also taking a groove out 4½ins. above that. The intermediate was lagging behind these two wide points, and the single was also lagging back. He suggested to the blacksmith taking out the single pick ¼in. before the intermediate, and the intermediate ¼in. out before the wide. After that there was no trouble and the 40-ampere machine was cutting steadily at from 25 to 30 amperes.

On the motion of the Chairman a hearty vote of thanks was given to Mr. McPhail for his paper and his informative replies to questions, and also to Mr. Gaw for his manipulation of the lantern.

Following the meeting the members of the Branch were entertained to tea in a local restaurant by Mr. Dugald Baird, a Past-President.

The Safety of Mining Bells in Parallel.

(*Abstract of the Report on an Investigation at the Mines Department Testing Station, Sheffield, of the Safety of Certified Mine Signalling Bells when Connected in Parallel: by* Captain C. B. Platt, M.B.E., *Superintending Testing Officer, and* R. A. Bailey, Ph.D., *Investigator. Published by H.M. Stationery Office*).

As a result of the Formal Investigation into the cause of the explosion at Senghenydd Colliery in 1913, experimental investigations were carried out by Professor R. V. Wheeler* and Professors R. V. Wheeler and W. M. Thornton jointly,† into the safety of bare wire signalling systems in fiery mines. The reports of these investigations showed that, with the majority of types of bells then in use, the break-flash at bare signalling wires was capable of igniting firedamp, but that it could be made safe by incorporating in the bell one or other of a variety of "safety devices." They laid stress also on the desirability of limiting the amount of current in the circuit. Of the "safety devices" which they suggested the three now commonly employed are: (1) a non-inductive shunt across the magnet coils; (2) a copper sleeve over the core of the magnet; and (3) a closed-circuit winding over the core of the magnet.

Since 1917 numbers of mining type bells fitted with one or other of these safety devices have been officially tested and have been certified as safe for use with any source of current up to the maximum pressure permitted by the Regulations for signalling circuits, namely, 25 volts.

The official test established the fact that with all these types of bells the break-flash at the bare signalling wires has been rendered incapable of igniting firedamp by incorporating a safety device in the bell, but the test was made with one bell only in circuit and the safety of the break-flash is only assured under those conditions.

The certificate of safety was issued subject to that implied limitation, but as it recently became evident that there was some misapprehension on this point, a statement was issued by the Mines Department in July, 1927 (M.D. Circular No. 24), in the course of which it was emphasised that the certificate of safety does not hold good if two or more bells are connected in parallel on a bare wire circuit; for in such conditions the break-flash at the bare signal wires might become dangerous. In any event the margin of safety would be greatly reduced.

The object of the present report is to give an account of further experimental work by which it has been shown that, under certain limiting conditions, certified bells may safely be connected in parallel on a bare wire circuit. Those conditions are defined.

In the simple arrangement of a bare wire signalling system with a single bell, when the bare wires are bridged at any point, a signal is given. When the circuit is broken after giving the signal, a break-flash will occur at the point of contact of the bare wires. This break-flash is due to the interruption of the current flowing round the inductive magnet coils of the bell, and the energy producing it is dependent mainly upon the current passing at the moment the circuit is broken and upon the inductance of the circuit. Part of the induced energy is dissipated in the safety device, a small part is dissipated in eddy currents and hysteresis loss, and the remainder appears at the break-flash. When two or more bells are connected in parallel, the total energy concentrated in the break-flash at the signal wires is the sum of the energy contributed by each bell. This break-flash, which is known to be safe with one certified bell, may therefore become dangerous when two or more certified bells are connected in parallel.

The maintained spark at the trembler of each of the bells is not intensified under these conditions.

The problem for solution is to diminish the energy of the break-flash at the signal wire contacts to less than that which will cause ignition of the most readily ignitable firedamp-air mixture.

There are three methods by which it would seem possible to do this:—

(i) By reducing the battery voltage.

(ii) By increasing the safety factor of the individual bell.

(iii) By limiting the current.

(i) *Reducing the Battery voltage.*

Table I. shows the minimum voltage required to cause ignition when from one to six bells are connected in parallel with no resistance, other than that of the bells, in the circuit.

* Report on Battery Bell Signalling Systems, 1915. By R. V. Wheeler, D.Sc., H.M. Stationery Office, 2d.

† Report on Electric Signalling with Bare Wires, 1916. By R. V. Wheeler, D.Sc., and W. M. Thornton, D.Eng., H.M. Stationery Office, 3d.

TABLE I.

	No. of bells connected in parallel.	Minimum igniting voltage
Bell A, resistance 40 ohms ...	1	28.0
	2	19.5
	3	15.5
	4	13.5
	5	13.0
	6	12.5
Bell B, resistance 25 ohms ...	1	41.5
	2	32.5
	3	26.0
	4	21.5
	5	20.0
	6	18.5
Bell C, resistance 50 ohms ...	1	30.0
	2	21.0
	3	16.0
	4	13.5
	5	12.0
	6	11.0

If this method were adopted, it would be necessary to adjust the battery voltage according to the number of bells in parallel. Furthermore, the voltage at which it would be safe to operate in parallel a given number of bells of one make would not of necessity be safe for operating the same number of bells of another make under the same conditions. For example, with Bell A, a voltage of 19 would be just low enough to afford safety with two bells in parallel, while with four bells in parallel it would be necessary to reduce the voltage to less than 13.5. With Bell B, on the other hand, two in parallel would just be safe at 32 volts, and four in parallel at 21 volts.

In these circumstances, and as it is not an uncommon practice to connect bells of different makes in the same circuit, it will be seen that this method of ensuring safety would be complicated to a degree which would render it, if not impracticable, very unreliable under working conditions.

(ii) *Increasing the Safety Factor of each Bell.*

When a safety device is incorporated in a bell, the safety of the bell is ensured at the expense of its signalling efficiency. With one bell only in circuit the reduction in efficiency need not be a serious matter. But it becomes a very serious matter if the effect of the safety device is increased to the degree necessary to ensure the safety of a circuit containing several bells in parallel.

The simplest, and least costly, method of increasing the safety factor of a certified bell is to incorporate a non-inductive resistance in parallel with the magnet coils. The value was determined, for different makes of bells, of the resistance of the shunt required to ensure the safety of four and six bells, respectively, in parallel. Where the bell was fitted with a shunt as the protective device it was disconnected. The results are shown in Table II.

TABLE II.

IGNITING VOLTAGE, 26 VOLTS.

Type of bell and magnet coil resistance.	Protective device.	Number of bells in parallel.	Shunt resistance required on each bell in order to make the circuit safe. OHMS.
Type C (50 ohms)	Disconnected	4	100
		6	75
Type D (25 ohms)	Short-circuited bare copper wire	4	55
		6	35
Type E (30 ohms)	Disconnected	4	40
		6	30
Type F (50 ohms)	Disconnected	4	95
		6	75

Normally, the resistance of the non-inductive shunt that suffices to ensure safety with a single bell in circuit is from five to ten times that of the magnet coils. Table II. shows, however, that to ensure the safety of a circuit containing several bells in parallel it is necessary to reduce the resistance of the shunt to a figure comparable with the resistance of the magnet coils themselves. This means, of course, that about half the energy supplied to operate the bell would be wasted in the shunt—a serious matter when, as is usually the case, the energy is supplied by batteries of limited capacities.

Other forms of safety device also reduce the signal strength as the safety factor is increased, and there is the added disadvantage that modification would involve reconstruction of the bell.

Another practical objection to increasing the safety factor of the individual bell is that it would involve the withdrawal of all the bells from use for the necessary alterations.

The method next to be discussed, of limiting the current, is not open to this objection.

(iii) *Limiting the Current.*

Experiments were made, with a source of current of negligible internal resistance at 25 volts, to determine the resistance required to reduce the current to the safe limit when different numbers of bells of a given type are operated in parallel. Typical results are given in Table III.

TABLE III.

	No. of bells connected in parallel.	Series resistance in main circuit required, to ensure safety. OHMS.
Bell A, 40 ohms	1	0.0
	2	6.2
	3	8.4
	4	8.5
	5	7.5
	6	6.7
Bell B, 50 ohms	1	0.0
	2	4.5
	3	9.3
	4	10.3
	5	10.0
	6	9.7
Bell C, 25 ohms	1	0.0
	2	0.0
	3	0.0
	4	1.1
	5	1.3
	6	1.5

It will be seen that with Bell A and Bell B the most dangerous circuit—that is to say the circuit requiring the highest added resistance to render it safe—is that in which four bells are included in parallel. As the number of bells in parallel is increased beyond four, the circuit becomes less dangerous and less added resistance is therefore necessary.

This result is one that, with certain qualifications and ignoring the energy contributed to the break-flash direct from the battery, can be deduced mathematically, and the same calculation will show (as the experimental results also show) that, whatever the number of bells connected in parallel, the added resistance necessary to ensure the safety of the circuit need not exceed one quarter of the resistance of the magnet coils of the individual bell.

The results for Bell C are given to illustrate the fact that these generalisations are not true of low resistance bells in which instance an appreciable part of the energy of the break-flash comes direct from the battery. Under such conditions, the added resistance necessary to ensure safety is not at its maximum when the circuit contains four bells in parallel. Nevertheless, an added resistance of one quarter of the resistance of the magnet coils is more than enough to ensure safety. It is necessary to consider how this added resistance can be provided in practice. Any separate resistance inserted in the line would be in danger at some time of being omitted, damaged or short-circuited. The only sure way of including the necessary resistance in the main circuit, and of being certain that it will always remain there and function, seems to be to include it as "internal resistance" of the battery.

Experiments have shown that a type of battery of sufficiently high internal resistance to ensure the safety of nearly all types of certified bells when used in parallel is the porous-pot Leclanché battery, consisting of cells of three-pint size connected in simple series, and provided that not more than one battery of this type is connected in the system. There are one or two types of certified bells which are not safe for use in parallel in definite numbers even with this battery, but they require only slight modification to make them so.

It should be clearly understood that modifications of the ordinary Leclanché cell, having a relatively low internal resistance, such as the "Carsac" and the "Carporous," as well as so-called dry batteries, are not safe for use with certified bells in parallel when operated from bare wire signal circuits.

Relays.

Although the discussion has been confined to certified bells, the characteristics of certified relays were also examined during the course of the investigation.

In most instances it was found that certified relays have a safety factor considerably greater than that of certified bells, particularly in those instances where the relay has a high resistance. Nevertheless, it is advisable that the same precautions as those recommended for bells should be adopted when relays are connected in parallel on a bare wire circuit.

The Resistivity of Aluminium.

A meeting was held at the Laboratoire Central d'Electricité, Paris, on November 16th, to consider proposals for the values of the electrical and other qualities of aluminium for transmission lines for recommendation to the International Electro-technical Commission for adoption. Professor Paul Janet, Director of the Laboratoire Central d'Electricité, presided, and twelve delegates were present, Great Britain being represented by Dr. E. H. Rayner (National Physical Laboratory) and Mr. E. T. Painton (British Aluminium Co.).

The subject has been under consideration for some years, information having been interchanged on a large number of experimental determinations made at the chief national laboratories of the resistivity, density, and other qualities of both hard-drawn and annealed material.

The type of aluminium considered was restricted to hard-drawn material in the form of wire. Annealing usually results in a lowering of resistance of more than 1%. It was decided that it was of first importance to prescribe an upper limit of resistivity with which all commercial supplies of aluminium should comply, as the presence of impurities, if they exceed about 0.5%, is liable to increase the tendency to corrosion; since increase in impurity is accompanied by an inrease of resistivity, a limit to the resistivity permissible serves as a limit to the risk of corrosion. It is also necessary to define "hard-drawn" since resistivity increases with increased strength such as would be obtained by cold working, and in consequence resistivity standards must refer to a well-defined range of tensile strength. Agreement was reached on the following lines:—

The resistivity of commercial hard-drawn aluminium wire at 20 deg. C. is not to exceed 2.873 microhm-centimetres. This is to apply to wire before being stranded into a cable; if the wire is tested after having been stranded, an increase of 1% of the above value is permitted. The wire is required to withstand for one minute a stress of 16 kilograms per square millimetre. The density of aluminium is assumed to be 2.703 at 20 deg. C. The temperature coefficient of linear expansion is 23×10^{-6}. The temperature coefficient of resistance is 0.004.

It was considered desirable to adopt a definite nominal value for the resistance of commercial aluminium, which could be used in designing transmission lines; it would naturally be less than the maximum mentioned above It was thought that this should be the average value of good material as at present manufactured. In order to obtain information on which such a value might be founded, it was decided to postpone a decision on the subject until after March, 1929, and that in the meantime the countries interested should send the necessary information to the Central Office of the International Electrotechnical Commission.

—*The Electrical Review.*

Switchgear for Mining Purposes.*

British manufacturers have not been slow to design and produce apparatus complying with the standard requisite to meet official Rules and Regulations, with the result that British mining switchgear admittedly leads the world in this branch of engineering. This is the more remarkable in that even to-day no properly constituted authority exists in this country charged with the duty of applying the standards and certifying that apparatus complies therewith. Professor Wheeler and the University of Sheffield have, it is true, stepped into the breach, but their position is a precarious one, being self-appointed and non-official. Some people may say it is all the better for being that, but it cannot be denied that to go to great trouble to establish excellent standards of construction and performance, as in the specifications issued by the *British Engineering Standards Association* and in the mining regulations, and then to leave the means of determining whether apparatus complies with the same to chance, is, to say the least, inconsistent.

The first consideration in the design of switchgear for use in coal mines is that it should be mechanically strong enough to withstand the exceptionally rough usage to which it is subjected in such places. If, moreover, the mine be such that "inflammable gas is likely to occur in quantity sufficient to be indicative of danger," i.e., say above ¼%, then the apparatus "shall be constructed . . . and maintained so that in the normal working thereof there shall be no risk of *open sparking.*" In short, the apparatus must be *flameproof.*

For articles of small cubical content (up to, say, half a cubic foot) the desired result may be obtained by making them of very strong metallic construction. The cooling effect of the relatively large mass of metal reduces somewhat the pressure per square inch attained by the exploding gases, and the total pressure exerted on the sides of the containing box is small owing to the restricted area of the same. Directly, however, larger pieces of apparatus have to be built it is no longer possible to rely upon mechanical strength. Economic and weight considerations render this impossible, and a system of venting has to be resorted to. Fortunately it has been found that if exploding gases are forced between two metallic plates for a comparatively short distance, their temperature is reduced to such an extent that they are incapable of igniting even the most inflammable gas mixture. Moreover, the pressure produced by an explosion within a vessel provided with such vents is very materially reduced, thus a cheaper construction is possible. From Statham and Wheeler's researches it has been shown that a spherical vessel having a cubical content of five litres (about 0.17 cubic foot), and fitted with a single flanged joint (round its equator), having [illegible] in. gap and 1½ in. flange, on being

*By C. C. Garrard, Ph.D., M.I.E.E. Abstract from "World Power."

filled with the most explosive mixture of methane and air and exploded, only suffers a pressure rise of about 10 lbs. per square inch, as against about twelve times this figure if no vents were provided at all.

Flameproof switchgear constructed on this principle is provided with wide metallic flanged joints having a definite gap of, say, $\frac{1}{50}$ in. The width of the necessary flange depends upon the size of the gap. There is a definite gap above which any width of flange is useless. For a given width of flange a relationship can be established between total area of vent formed by the gap and the cubic content of the air space within the apparatus. The larger this ratio then the less pressure is produced by an internal explosion.

From experiments mentioned, it was learned that for the smallest sphere (0.035 cubic foot) the ratio is 13.6 square inches of vent per cubic foot content of vessel, and the explosion pressure is 5 lbs., i.e., 4% of the maximum. Further, with the largest sphere (0.282 cubic foot) the ratio is 3.4 square inches of vent per cubic foot content of vessel, and the pressure is reduced to 18 per cent. of the maximum. Within the range of the experiments, therefore, the explosion pressure is very nearly inversely proportional to the ratio of vent to cubic contents. It is doubtful, however, whether this law holds good for larger vessels. The only safe method is to test the matter experimentally with every type of apparatus.

One disadvantage of vented apparatus is that dirt can enter through the vents. To get over this the lids of flameproof apparatus can be arranged to remain closed by their own weight, but to lift slightly when an internal explosion takes place. This lift must naturally be limited, so that the gap formed thereby does not exceed the safe maximum. This method is effective, provided the covers are not too heavy. If they are, then their inertia prevents the quick-enough release of the pressure.

In the foregoing is considered only the effect of the explosion of the gaseous atmosphere inside the switch or other apparatus. With well-designed electrical switchgear, used under conditions within its rating, this gives sufficient guidance as to its flameproof construction. In other words, if the case of the switch, considered as a gas container, will withstand and maintain flame tightness if filled with most explosive gas and exploded; and if, further, the appliance will withstand without destruction a rupturing test equal to its rupturing rating, not made in an explosive atmosphere, it may be reckoned safe under all working conditions. This is especially the case if the explosive test be made with coal gas, which, being more severe in its effects than methane (the gas usually met with in coal mines), provides a certain factor of safety. To guard against all contingencies, the *British Engineering Standards Association* has adopted the following definition:

"A flameproof switch is a totally enclosed switch which will withstand under any conditions of operation within its rating any explosion that may occur within it, and will not ignite any inflammable gases or particles in the surrounding atmosphere."

This definition goes somewhat further than the mining rules, and takes all circumstances into consideration.

The point to bear in mind when applying the foregoing principles is that under working conditions the duty demanded from the appliance must not exceed that for which it is rated. If, for example, an oil switch rated for a breaking capacity of 25,000 K.V.A. be subjected to a short circuit of 50,000 K.V.A., it will be liable to fail; for example, its oil tank may blow off, and danger of an external gas explosion may occur.

The danger of switches in coal mines being subjected to excessive short circuits is increased by the present-day tendency to draw the electric supply for collieries from power companies. The maximum short circuit which can come on an electric network is determined, in the first instance, by the amount of electric generating plant feeding the same. Should this be increased, say, by the amalgamation of several collieries, then the short-circuit values are correspondingly increased, with likelihood of trouble with the switchgear should this be inadequate for the new conditions. This state of affairs actually occurred some few years ago on the joining up of the power systems of a number of collieries in South Wales consequent upon a well-known colliery combine. It was found that switches which had been used for years in the isolated mines failed under the new conditions, and had to be replaced by others of larger capacity. It is particularly necessary that this matter should be closely watched at the present moment, in view of the possibility of collieries becoming connected to the electric grid of transmission lines now being built by the Central Electricity Board. Fortunately there is no great difficulty in dealing with the matter if it be not overlooked, but brought to the attention of any competent electrical engineer. It may be added that the switchgear technical committee of the B.E.A.M.A. have published some calculations of short-circuit values applicable to typical colliery installations: see "World Power," March, 1925.

NEW BOOKS.

"THE BLUE BOOK."—The Electricians' Electrical Trades Directory and Handbook. Ernest Benn, Ltd., Bouverie House, 154 Fleet Street, London, E.C. 4. Price 25s. nett.

As ever, this, the 47th consecutive annual edition, provides the universally accepted directory of the electrical industry. The whole book has been thoroughly revised and brought up-to-date. A new feature is the inclusion of a complete list of electrical contractors for England and Scotland, those who are enrolled on the National Register, and members of the Electrical Contractors' Association of England and for Scotland all being distinctively marked. The increase in the number of the Guide Cards facilitates reference to any section, and in other respects the high standard of production has been fully maintained. By the use of a thinner and stronger paper, the book has been made much handier to use, although in point of fact it contains more matter than ever before, and with its some 1500 pages it must inevitably remain the most imposing volume on the reference shelf.

THE PRACTICAL ELECTRICIANS' POCKET BOOK. Thirty-first Annual Edition: Edited by F. H. Robinson. Odhams Press, Ltd., 93 Long Acre, London, W.C. 2. Price 2s. 6d. nett.

Practical instructions and elementary data concerning applied electricity from the boilers to the switchgear, transmission and overhead line work, transformers, industrial and domestic appliances form the subject headings. The 1929 edition is new from cover to cover. Many of the old contributors and other experts have collaborated to produce a book of reference of great value to every practical man in the industry.

The list of Central Station Voltages has been recast in new form and is up-to-date. The space allocated to the detailed subject index is double that of any previous edition and contains one thousand references. The thirty-first edition of the Pocket Book not only contains more valuable and more up-to-date material than its predecessors but it is an efficient means of quickly extracting whatever may be wanted.

UNDERGROUND CABLE SYSTEMS: G. W. Stubbings, B.Sc. (Lond.), F.Inst.P., A.M.I.E.E. London: Chapman and Hall, Ltd., 11 Henrietta Street, W.C. 2. Price 15s. nett.

This is essentially a practical guide for engineers engaged in the distribution sections of electricity supply. The physical characteristics are dealt with fully, as are the construction and manufacture of cables of all standard types; cable-laying, jointing, testing, repairing; extra-high pressure systems; automatic protective systems; and, finally, the systematic keeping of records and plans. It is a valuable text book for students and can be particularly recommended as a means of bringing the mains' engineer into touch with the latest practice.

ELECTRICITY APPLIED TO MINING: H. Cotton, M.B.E., M.Sc., A.M.I.E.E. London: Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, W.C. 2. Price 35s. nett.

It might be said that this is the first serious attempt to cover in one volume the peculiar conditions of mining-electrical engineering. As it is the book runs to over 600 pages and some 360 illustrations are introduced. The aim of the author is indicated in the following abstract from his preface: he has achieved his object.

"In the past it has been customary to describe the electrical gear required for any particular drive, e.g., a fan or a compressor, without any reference to the peculiar characteristics of the drive. It is felt that such treatment is inadequate, since without a reasonably thorough appreciation of the nature of the driven machine, and the changes of its characteristics with changing conditions of load, it is not possible to choose the most suitable driving motor and control gear. For these reasons the nature of the load, particularly in the case of fan, compressor and pump drives, has been investigated with sufficient completeness to give the responsible electrical engineer all the information he will require.

In certain cases, e.g., the rheostatic control of a fan motor, the current taken by a motor driving a three-throw ram pump, and the speed variations in a Ward-Leonard controlled winder, laboratory experiments have been made with small machines in order to demonstrate certain peculiarities which are not immediately obvious. Speed regulation is of considerable importance with certain drives, and the problem of such regulation, with reference to the nature of the drive, is treated fully."

MATTHEW MURRAY, Pioneer Engineer: Records from 1765 to 1826; Edited by E. Kilburn Scott, A.M.Inst.C.E. Leeds: Edwin Jowett, Ltd., Park St Price: paper 2s. 6d.; cloth 3s 6d. nett.

This book is a part of the Memorial to Matthew Murray; the surplus proceeds of its sales will be devoted to acquiring the several other parts of the perpetual memorial as planned by an influential committee. It is a fascinating collection of general and technical history which reflects great credit upon the care and ability of Mr. Kilburn Scott. Apart from the laudable intention which prompted its production it is wonderfully good value for the money: the 150 pages of letterpress with numerous illustrative plates and diagrams, printed in first-class style might well have carried a higher price, and especially so in view of its object.

NEW CATALOGUES.

SWITCHGEAR & COWANS, Ltd., Old Trafford, Manchester.—The catalogue section No. 27/2 gives a technical description with many illustrations, of the S. & C. out-door type motor operated induction regulator.

BRITISH ALUMINIUM Co., Ltd., Adelaide House, King William St., London, E.C. 4.—An attractive handbook, bound in aluminium cover, tells by means of many photographs of the multifarious uses of aluminium, ranging for example from aeroplanes to typewriters, chemical apparatus to hand lamps, etc.

G. & J. WEIR, Ltd., Cathcart, Glasgow.—A colour-printed catalogue gives dimensions, rating and other general particulars of feed pumps, condenser plants, etc.

ELECTRICAL APPARATUS Co., Ltd., Vauxhall Works, South Lambeth Road, London, S.W. 8.—The motor starter pillars incorporating a patented protective arrangement are fully described in the leaflet A6/A.

CROFTS, Ltd., Bradford.—Leaflets describe power transmission devices in the form of back gears, crown clutches, and belt tension gears.

ALFRED HERBERT, Ltd., Coventry.—No. 2 of the periodical "Atritor News" contains a description of this Company's pulverised fuel installation at the Pooley Hall Colliery, Polesworth. A battery of three water-tube boilers fired by the "Atritor" pulverising system has displaced a number of hand-fired Lancashire boilers. The coal used for pulverising is of low value, the size varying from ¾in. down to dust. The efficiencies obtained under ordinary working conditions are good, and the return on the capital expenditure is excellent. In a paper read by Mr. W. Fenn, the General Manager of the Pooley Hall Colliery before the Midland Branch of the Association of Colliery Managers he stated that the savings effected by the installation were about £5,000 per annum.

THE HAMWORTHY ENGINEERING Co., Ltd., Poole, Dorset.—Leaflet No. 796 gives general specification, dimensions, and ratings of a notable series of heavy oil engines. The range covered is from 4 H.P. to 180 H.P.

CAMBRIDGE INSTRUMENT Co., Ltd., 45 Grosvenor Place, London, S.W. 1.—An attractive postal card directs attention to the Cambridge Pressure Recorders.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2.—A very complete illustrated description of the electrical and mechanical equipment of the South Yorkshire Chemical Works is the subject of the G.E.C. installation leaflet No. 5. The installation includes a conveyor plant for coke preparation which was made at the Company's Fraser and Chalmers Works, Erith.

A handy pocket list gives particulars and prices of the full range of Osram Electric Lamps. Bakelite electrical accessories of every type are described in the Booklet S 4936. Of attractive designs coupled with remarkably low prices are the lighting fittings dealt with in leaflets F 4850/7 8.

ALLEN WEST & Co., Ltd., Brighton.—An attractive multi-coloured printed folder illustrates the important features of this Company's well-known type of liquid starters for hand control and automatic or push button control as for cranes, hoists, main winding gears, etc.

PRIESTMAN BROTHERS, Ltd., 28 Victoria St., London, S.W. 1.—Dredgers and excavating machinery and heavy lifting grabs as installed in various parts of the world are shown in a large illustrated broadsheet.

WALTER McGEE & SONS, Ltd., Albion Works, Paisley.—Together with advice of reduction in prices a descriptive letter and copy of list No. 1110 gives valuable particulars of "Emcol" totally enclosed squirrel cage induction motors.

HANS RENOLD, Ltd., Burnage Works, Didsbury, Manchester.—The new annual pocket price list of standard chain drives is now available.

HEYES & Co., Ltd., Water Heyes Electrical Works, Wigan.—Bulk head fittings having the popular prismatic glass cover are listed in a neat folder.