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EDITED BY E. DINSDALE PHILLIPS

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The A.M.E.E. Comes of Age.

Twenty-one years ago a small group of men, animated with the impatience of those who pioneer reforms, met together for the purpose of devising some way by which electrical engineering as applied to mining purposes could be recognised and fostered as befitted its specialised character. It matters not whether the germ of the movement had its origin in the fire of indignation that the mining electrician was held as of no account, or whether it was bred in the obvious need for a cohesive organisation amongst electrical mining men: the outcome of that meeting was the birth of the Association of Mining Electrical Engineers.

The work done by the A.M.E.E., its progression to its present eminence, and the still greater field of usefulness in which it continues so successfully to apply itself—these, to say the least, constitute monumental reasons for honest pride in those who reared the A.M.E.E. in its precarious infancy. For the young movement had to withstand rough buffetings and wear down much powerful opposition and prejudice. Above all, and to the still greater credit of its first sponsors, as the A.M.E.E. won through to security and success it gained the support and friendship of erstwhile antagonists. Such has ever been the course of beneficient reformation in the steps of progress.

Let us then, on the eve of celebrating the twenty-first birthday of the Association, be permitted to outline in a few words how and for what reasons it has attained its high reputation. It has been a forceful help in developing the use of electricity in mines; a leading policy being to make electricity in mining as widespread, as safe, and as economically perfect as possible. The Association provides simple and pleasant, yet powerful and effective, means for making competent mining electrical engineers; and, coincidently, for ensuring those engineers due recognition and fair valuation for their essential highly specialised services. The pursuit of these main endeavours has entailed a vast amount of work in many directions. Very early in its history the A.M.E.E. learned that it could not possibly achieve any real tangible success in the industrial sense, and could only be of very restricted technical value, unless it opened its doors widely to all actively connected with and closely interested in mining electrical work, industrial, technical and scientific. This meant that the Association had to plan and organise its working so that all those who followed the several branches of electrical engineering in mines, from workman to professor, should derive some benefit from active membership. Mine owners and managers, mines inspectors, scientific professors and lecturers, consultants and specialists, engineering manufacturers and designers, practical working mining men, apprentices and students—all these have, as members, put their efforts and influence actively into directing the affairs of the Association: they realise the value to themselves of co-operation in this common good endeavour.

Yet even in this its twenty-first year the work of the A.M.E.E. is but in the beginning. There is much more to be done. With the advance of economic and international industrial interests, and the quickened scientific and socialistic trend of this modern age, the field for useful and productive work of this kind is vastly extended. The world offers wider, broader and more extensive scope for the efforts of the A.M.E.E. than was the case twenty-one years ago.

The Practical Outcome of Scientific Research.

If there be still any who retain the old-fashioned doubts as to the commercial value of the research laboratory let them read the latest record of the Safety in Mines Research Board and thereby gain conversion. The eighth annual

> **A. M. E. E.**
> **21 YEARS OLD.**
>
> This Year The Association of Mining Electrical Engineers attains its Majority.
>
> **THE OCTOBER NUMBER OF THIS JOURNAL**
>
> will signify and commemorate, by historical record and report, the progressive development of the Association to its present state of sturdy maturity.
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> *N.B.—The Editor will be pleased to receive any interesting notes or reminiscences concerning the early days of the A.M.E.E.*

report of the Safety in Mines Research Board, containing also a report by the Health Advisory Committee (H.M. Stationery Office, price one shilling), is full of extremely valuable information. It can fitly be described as an exception in the "blue-book" class in that it provides no end of instructional and controversial material to be read with real interest and discussed fervently in every grade and circle of mining men. How often, for example, have men argued as to the danger of frictional electric sparks and the sparks struck by the pick? Here it is clearly shewn that the static discharge sparks—as produced by air jets, streams of coal dust, etc.—are quite harmless and will not fire mine gas. On the other hand there might be danger from the sparks of the pick: the shower of brilliant sparks from the pick point is harmless, but the dull yellow glow and small sparks produced by the pick striking a slanting blow on hard rock are dangerous. Particularly is there danger in the hand-wielded short rapid pick strokes making sparks of this description. The obvious lesson is indicated: a man ripping a roof should not strike blows in rapid succession on the same spot of hard rock.

Tests and experiments with flame-proof electrical gear have probably been the most frequent of all the numerous items tackled in mining electrical research. The great accumulation of the reports and results of these investigations will be condensed and summarised in a "paper" in course of publication. It is noted that the past year's records shew an increasing tendency to rely on strong enclosing cases with flange protection: but it is also indicated that the chief source of danger with fuses, etc., in robust flanged cases is not the possible fracture of the case. The serious danger is likely to be caused by particles of metal projected from the blown fuse and shorting or earthing the insulation.

Experiments of this type may be made without any high degree of scientific application; but the research scientist in making these tests noticed much more than would a non-scientific man: it was found, for instance, that the duration of the arc on opening the circuit was shorter with an explosive mixture in the casing than it was with clean air. An obvious deduction is that some kind of gas, non-explosive, might be usefully introduced into flame-proof gear to reduce the risks of dangerous arcing. It is further suggested that some solid material or chemical substance might be found suitable for packing into fuse boxes, and which would liberate the desired gas at the moment an arc starts. New experiments towards gaining this end are now being made.

Electrical men will be interested to learn that miners' electric lamps have evidently so shewn up a fault of flame lamps that some research work is being done to "improve" the out-of-date species. A lamp to throw nearly twice the usual amount of light forward, instead of only distributing a wasteful small light all round, has been found in practice to be preferable for general working and consequently experiments on the design of internal reflectors for flame safety lamps are being made.

For some time now mining electrical men have girded against the restrictions preventing the use of electric lighting for general illumination at the coal face. The research officials, realising the dual nature of their duty—to ensure safety and to assist development, are earnestly attacking this important problem. Good progress is reported in regard to a new type of electric cable designed for safety in this service. The face lighting cable has a system of pilot wires embedded in the insulation and surrounding the conductor core: the pilot wires carry a small current, too small to ignite firedamp but sufficient to actuate an automatic cut-out should the main conductor be exposed. Laboratory tests have been successful on this cable, and it is now to be put, under scientific observation, to trial use and experiment underground.

These brief references are but merely to mention a few of the large number of subjects dealt with by the safety in mines research board; but they will, we hope, serve to kindle such lively interest as will prompt the enquiring mining man to invest the modest shilling and gain full information of the great work which these scientists are doing for the good of the mining industry.

NEW BOOKS.

H.M. STATIONERY OFFICE.

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

MINES DEPARTMENT.—EIGHTH ANNUAL REPORT OF THE SAFETY IN MINES RESEARCH BOARD, including a Report of matters dealt with by the Health Advisory Committee, 1929. Price 1s. nett.

Divided into three parts and with six appendices this Report runs to 64 pages. The General Section reviews the conditions of the research stations, finance, staff, publication of results, visits of miners to stations, and the research work of other countries.

The second part gives the essential features of the several particular researches and experiments engaged in: whilst the third part covers eight particular phases of the work done by the Health Advisory Committee.

The appendices include progress reports on researches at Sheffield and Buxton; the Universities of Birmingham, Leeds and Manchester; the Imperial College of Science and Technology: the co-operation with the United States Bureau of Mines: schedule of grants made to other research organisations and individuals: list of reports on researches published during 1929.

MINES DEPARTMENT.—THE OPENING AND RELIGHTING OF SAFETY LAMPS BELOW-GROUND. M.D. Circular No. 44.

This circular reminds mine owners and managers that the practice of unlocking safety lamps at the appointed lamp stations in any mine or part of a mine in which safety lamps are required by law to be used, will be prohibited as from 1st January, 1931.

Proceedings of the Association of Mining Electrical Engineers.

LONDON BRANCH.

Notes on The Maintenance of Flame-proof Enclosures for Electrical Apparatus.*

Discussion.

Mr. H. M. MORGANS (Past Branch President) confessed that he hoped he would not have to instal electrical plant in underground situations where there might exist explosive gas mixtures, because, although he appreciated that the efforts made to render plant flame-proof were very fine and had been largely successful, there was still considerable risk involved in the use of electrical plant in such situations. With regard to vents, he expressed a preference for open packs of plates rather than hooded packs, because in the case of the latter there was a chance that dirt would accumulate unnoticed under the hoods.

Mr. W. F. BISHOP (Past Branch President), referring to cables, said he did not think they could be called flame-proof enclosures, or that the ideas put forward in the paper could be applied to them but, arising out of the speaker's references to maintenance, he emphasised the necessity for greater attention to the maintenance of cables, particularly of trailing cables. He had seen some horrible examples of the improper use and repair of trailing cables. Only within the last few weeks he had seen samples of trailing cables which had been repaired by someone who, though presumably an authorised person, could not have had the faintest idea of what an electrical cable was, or how it should be used; it was quite clear from the reports of H.M. Inspector that a good proportion of accidents were due to trailing cables, and Mr. Bishop believed that many, or most of them, could be avoided if the cables were used and maintained with greater care. During the last few years many new designs of trailing cables had been tried out, most of them having been introduced with a view to avoiding shock, but we had not yet achieved the perfect cable, and probably never should. At the moment the authorities were attempting to standardise various types, which was a step in the right direction.

Mr. ARTHUR E. DREW said that apparently Mr. Rainford had himself experienced difficulty in regard to nomenclature, for he had mentioned that the use of pressure relief devices on apparatus at or near the coal face was not to be recommended, whereas presumably that statement was meant to apply to venting devices. Mr. Drew did not know what alternative there was to pressure relief devices, unless one made a "Bomb-proof" enclosure and confined the explosion inside it. It was stated in the paper that the maximum clearance allowed was 20 mils., and it would be interesting also to know the width of flange that was recommended as a minimum.

Commenting on a statement in the paper that the designer, as the result of experience gained from research work had an advantage over the user, Mr. Drew urged that the advantage lay with the user. A designer might produce apparatus which was quite ideal theoretically, but its design might give rise to all sorts of difficulties when the apparatus was placed in its working position; and, in consequence, prove a failure because it was never properly looked after as the man responsible hated it. Collaboration between designer and user was necessary, and in this connection the Association might help a great deal, for it provided opportunities for the constructive criticism of designs; it would be most helpful for designers to have the views of users so that they could appreciate the difficulties that occurred in practice. The Sheffield University authorities had made most helpful suggestions to designers, but he did not know how far the Association of Mining Electrical Engineers was collaborating with the University authorities in connection with the testing of apparatus. The work of the University had a very great influence on the electrical equipment in the mining industry, and the Association should be in close contact so that it could protect the interests of its members in matters concerning the design of the apparatus. This point might well be brought to the attention of those responsible for the management of the Association.

Mr. E. E. PICKETT, commenting upon the author's references to the dangers arising as the result of users of flame-proof apparatus omitting to replace bolts, and so on, said that in many cases the blame rested with the manufacturers, who often placed bolt holes in most awkward positions quite unnecessary; and, where flanges had to be bolted together by, say, six bolts, five of the bolts would be of one size and the remaining one of another size, which meant that a man in charge of such apparatus had to carry a large number of spanners. In one case he had tried for two days to get a bolt in, but had found it impossible. He had started with a $\frac{3}{8}$ in. bolt, and had reduced the head and finally cut a groove in the head and had tried to screw it into the hole by means of a screwdriver, but had been unsuccessful, and finally he had filled up the bolt hole with a lump of clay. The mine in which the apparatus was used, however, was not a dangerous one; it was one in which the use of blowlamps was permitted.

It was very important that proper attention should be paid to details in order that the users should not be discouraged. Only a few weeks ago he had seen a motor on which were used $\frac{5}{8}$ ins. bolts with the heads reduced to 9/16 ins., and he was informed that the reason for that was to effect economy. In the works at which the motor was used there were about forty fitters, but not one of them possessed a spanner which would fit the bolt heads and a spanner had to be made specially. There was plenty of room on the casing to enable full size bolt heads to be used, but apparently the makers had reduced the size and had thereby introduced difficulty because thereby they could get about two extra bolts to the cwt. That was the sort of thing that got the colliery electrician into trouble.

Mr. J. R. COWIE (Branch Hon. Secretary) emphasised that the problems dealt with in the paper had in-

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*See *The Mining Electrical Engineer*, June 1930, p. 468

volved an enormous amount of testing work, covering a period of five or six years. The work had commenced with what the author had referred to casually as a bomb, but it should be appreciated that bombs had been used having all kinds of capacities, all kinds of gaps, all kinds of flanges and all kinds of fabricated relief devices. That had been the first stage, and the work had progressed through subsequent stages, including the actual testing of manufacturers' apparatus, as the result of which very many hints were given to the manufacturers as to the means by which they might improve their products. He was not giving away secrets when he said that the results given in the paper would be amplified by the results of a further set of tests which would shortly be published by the U.S. Bureau of Mines.

Mr. Rainford had pointed out in the paper that in certain situations air-break apparatus might have advantages over oil-immersed apparatus. Mr. Cowie believed that what the author meant was, that if one were using a venting device one could use coarser vents in the air-break apparatus than in the oil-immersed apparatus, for the reason that the speed of propagation of a hydrogen flame was greater and more intense than that of a methane air mixture. That was quite right but, unfortunately, in the case of an air-break apparatus one was limited as to voltage, one was limited as to current, which was quite small—some people said the limit was 200 amps., and others said 350 amps. and 660 volts—and there was limitation as to rupture capacity. There would be a lot of information on that matter in the Bureau of Mines report.

Some years ago a very careful analysis was made, as the result of which it was ascertained that the average rupturing capacity required underground was quite low. With the advent of the big central power stations, and as the result of the grouping of collieries and the extended use of electrical apparatus underground, there had arisen the necessity for higher rupturing capacity switchgear, however. In general the high rupturing capacity switchgear for underground work was of the order of about 30,000 k.v.a., and in some instances it would be necessary to go to higher capacities. That could be done only by very careful design of what was known as the unvented enclosure, plus a very specially designed venting device. He believed he was right in saying that not more than one or two pieces of apparatus of that particular nature, of very high rupturing capacity had yet passed the Sheffield test. Thus Mr. Rainford's paper pointed a road to the manufacturers, and it impressed upon the colliery electricians the very great care which must be exercised to maintain the apparatus properly. In a few quiet sentences Mr. Rainford had emphasised points of vital importance from everybody's point of view, and the paper would be considered very carefully and would give rise to extensive discussion among those concerned when it was published in *The Mining Electrical Engineer*.

Mr. J. R. WALTON (Branch Vice-President), referring to the statement in the paper that the use of vented apparatus at the coal face was not to be recommended, said that on most of the comparatively small switches used at the coal face there was a certain amount of pressure release at the flanges; the cases were not hermetically sealed. Therefore, he asked what was the dividing line between vented and unvented flame-proof devices. As to the author's statement that the use of a compound to make an enclosure flame-proof was not permissible where the compound had to be applied *in situ*, Mr. Walton said he believed the Testing Authority prohibited the use of compound even if it were applied by the manufacturers before the apparatus was installed. He asked for guidance on this matter.

Mr. A. C. SPARKS, Branch President, said that he felt strongly on the point brought out by the author as to the necessity for proper collaboration between those concerned with research, manufacture, and the use of various pieces of apparatus. There was a large measure of co-operation between those associated with research and manufacture, and the manufacturers had very largely studied requirements of users. After all this, however, a number of points were naturally brought to light by the actual use of plant but owing to the long channel through which the information had to pass before it reached the manufacturer, the co-operation of the actual user appeared the most difficult.

Further, owing to the growth of manufacturers, even when attempts were made to assist, by passing on comments that appeared helpful, it was not always certain that they reached the parties most interested or that such points or suggestions were received in the spirit in which they were intended.

His firm tried to point out to manufacturers suggestions or modifications, however small, which were brought out in actual operation with a view to their adoption—if considered desirable—in future similar apparatus. Certain of the smaller firms appeared to appreciate this endeavour, and he felt that if this practice were extended it would prove one helpful means of collaboration between manufacturer and user, to the benefit of both. Possibly manufacturers through their agents, who were in touch with the actual users, could develop the suggestion box principle with advantage.

Mr. J. W. WILKINSON (Branch Hon. Treasurer) endorsed Mr. Cowie's remark as to the great value of the paper, inasmuch as it was based on an enormous amount of research. Discussing the plate type of vent, he said it seemed extremely difficult to prevent interference with it by persons who were not necessarily ignorant but extraordinarily curious. It must be very difficult to render it impossible to replace the plate type of vent in any but the original condition, and he asked whether the flanged type of vent had proved distinctly more favourable than the plate type. With regard to bottomed bolt holes, he asked whether there was a possibility of the metal at the bottom of a hole being blown out if the user omitted to insert the bolt, or whether there was always a sufficient thickness of metal to prevent that blowing out. As to the danger of the mis-use of electric apparatus in the collieries, he referred to an instance in which a man was dragging a coalcutter along and had tried to drag his gate-end box after it. In another case he had seen a man of overwhelmingly curiosity attempting to open a plate vent by means of a pick in order to see what was inside.

Mr. H. RAINFORD, in reply, mentioned that several contributors to the discussion referred to the advantages and disadvantages of pressure relief devices and he could therefore deal with several points under this heading. The type of apparatus used in the vicinity of the coal face is usually strong enough to withstand an internal explosion without any definite provision for release of pressure and, as stated in the paper, the use of pressure relief devices on coal face units is of less importance than with larger units in other locations. Relief devices which are external to the enclosures are, of course, liable to damage both by accident or misuse, but if the men thoroughly understand the object of the devices there should be little danger of this happening.

Mr. Wilkinson asked whether release at flanged joints had not proved more favourable than with the plate type of vent. Except for the largest units, release of pressure at a flanged joint between say, a casing and its cover, is certainly preferable. With small casings a definite gap need not be provided since a rough-machined flanged joint will allow a certain amount of pressure release.

This introduces the point raised by Mr. Walton, who asked about the dividing line between vented and unvented casings. In practice it is not possible to use a flame-proof enclosure hermetically sealed, and an unvented casing must be taken as one in which there is no definite arrangement for release of pressure. Even with smooth-machined joints and close-fitting bearings some release of pressure takes place but such a casing can be considered as an unvented casing.

Mr. Morgans expressed a view that there was still a big risk involved in the use of electrical plant where firedamp is a hazard. The risk must not be overlooked even with a type of apparatus which has been proved safe under test conditions but, if such apparatus is properly maintained and if the men know why they are using this particular type of apparatus, then the use of electrical gear is certainly justified.

Mr. Rainford said he must agree with Mr. Bishop that trailing cables are a grave source of danger. In fact, they can be regarded as the most dangerous part of the electrical equipment, because they are so liable to damage. Research is being carried out with a view to evolving a type of cable which could be damaged without a consequent risk of open-sparking. Although the details of maintenance, as outlined in the paper, do not refer to cables, the general principle must apply and greater attention should be paid to the proper use and correct repair of cables.

Mr. Drew referred to the width of flanges at joints. The minimum permissible width of flange is one inch but for large casings the flanges should be wider to afford greater rigidity and also more space for large bolts. Experiments have indicated that a wider flange, does not necessarily provide a larger factor of safety and the maximum permissible width of gap must be 0.02 ins. for the wider flange as for a one-inch flange.

Mr. Pickett had given some very interesting points from the practical side; it was reassuring to learn that the bolt hole sealed by a lump of clay was in a unit used in a naked light pit. If a user could give the designers hints with regard to the apparatus he wanted to use, he should do so as far as possible. If bolts and fittings were put in inaccessible places it was up to the user, to some extent, to point out the difficulties to the manufacturers. He did not, however, know how far the user could influence the manufacturers to make apparatus as the former wanted it. It had been said by some users that the manufacturers' attitude was that the users must have what they (the makers) were prepared to supply. How far that could be overcome he was not prepared to say, but it should be overcome and the user should be able to criticise designs and to collaborate with the manufacturers to ensure the production of the most suitable apparatus. That would redound to the benefit of both the designer and the user.

With regard to Mr. Walton's question in connection with sealing with compound. The specifications require that reliance shall not be placed upon the addition of molten insulating compound during installation for rendering the completed equipment flame-proof. The insertion of compound at the makers' works, in parts where it was unlikely to be disturbed, complied with the specification, Mr. Rainford held the opinion that sealing by compound for the purpose of rendering an enclosure flame-proof should be entirely eliminated.

The report referred to by Mr. Cowie should give valuable information and it could also be mentioned that a summarising report on flame-proof electrical apparatus would shortly be published by the Safety in Mines Research Board. That report would also be of great assistance to both the designer and the user.

In connection with the question of air-break versus oil-immersed gear, one would have to write a separate paper to deal adequately with the problems. The danger from the explosive gases evolved by arcing under oil is a real one, particularly with apparatus used in the vicinity of the coal face. In apparatus such as controllers where contact is made and broken more frequently than in main switchgear, there were possibilities of the gases evolved from the oil forming highly explosive mixtures above the oil and this question was being studied very fully.

The President's remarks concerning co-operation form a fitting conclusion to the discussion. Such co-operation coupled with the better education of the colliery workers could only make for greater safety in the use of mining electrical apparatus.

WARWICKSHIRE & SOUTH STAFFS. BRANCH.

Modern Power Station Practice.

T. E. BOOTHBY.

(*Paper read 12th December*, 1929.)

The object of this paper is to give a brief resumé of the considerations which have led up to the building of large power stations, and the economic and engineering reasons for the diversity of the layouts which are found in some of the latest examples of engineering interpretation. In order to fully appreciate the present condition of the electric supply industry, perhaps a short historical review will not be out of place.

The electric supply industry in the years just preceding and following the war can be likened to a growing boy, all arms and legs, with an unsettled mind and, to a large extent, without discipline. This condition was not altogether due to the neglect of its progenitors, since it is undoubtedly a fact that too early legislation created many difficulties and anomalies; yet in spite of all these drawbacks the field of activity in the application of electricity in the service of man was recognised by legislators to be so vast, and the results of its use so necessary to the well-being of human life, that whatever anomalies now exist in the new legislation, and there are many, the nation can be assured that the service offered to them will be of the best.

At the time of passing the 1926 Act there were in this country several hundred stations separately and actively engaged in the generation of electricity, and into each of the plants that were laid down there was interwoven the individuality of every engineer who at different periods was responsible for the design and subsequent operation of these undertakings. As a natural consequence we find even to-day a variety of plants and systems in operation, to describe which might induce serious mental indigestion, but there is no doubt that the early legislation which fostered the parochial spirit was responsible to a very large extent for such a state of affairs. In recent times Advisory Joint Committees have done a great deal to break down this spirit, and to-day municipal and company undertakings work in perfect harmony.

As a direct result of such conditions changes in design and operation were carried out by certain undertakings who had the vision to anticipate the 1926 Act, and who made definite progress in the direction of lower production costs coupled with greater facility of service. The installation of larger and more efficient steam raising and generating plant, coupled with the unification of large areas previously supplied by a number of small power stations, has undoubtedly played a large part in the reduction of costs, even when against such savings are set the cost of the various interconnections and their transformers.

An example of such progress can be illustrated by the activities in recent years of the S.W. & S. Power Company, who since the opening of their Stourport Station have closed down many of the smaller stations which operated under their control. The effect of such interconnections has also brought into the ambit of electric supply many of the intervening districts which previously had no supply available; in many cases there was no supply of gas either.

Owing to the rapid development of the electrical supply industry, and the constant demand for large blocks of cheap power, and in order to establish ideal thermal conditions, it has become necessary for the supply engineer to co-operate very closely with the designers of boilers and generating plant, and also the metallurgist.

Referring to the compilation of station results issued by the Electricity Commissoners, it will be noticed that the thermal efficiency of stations operating to-day varies between 4% and 21%. Endeavours are now being made to obtain useful work from that percentage of B.T.U's. represented by the difference between 21% and 100%, at the same time coupling with this endeavour reasonable continuity of service.

The pursuit of these ideals has led the engineer to explore the use of higher initial steam pressures and temperatures. As a result there are now plants in daily commercial use operating at over 1000 lbs. pressure and 800 degs. F. temperature. In this country, however, the standard adopted appears to range between 250 lbs. and 375 lbs. per square inch, though the North Tees and Leeds Stations at 450 lbs. and the new Bradford plant at 1100 lbs. are examples of attempts at higher pressures.

The general opinion amongst prominent engineers would suggest that 600 lbs. and 750 degs. F. temperature will for a while be the most economic standard to adopt on a new station, having regard to the limits imposed on designers by the steel manufacturer.

In considering the design of modern power stations, the first question to arise is what is the ideal site for a power station? The author would reply—100 acres of good land with rock foundation, suitably levelled by nature, situated on the banks of a wide clean river, just below a waterfall or weir with such convenient fall that the river would gravitate to the lower channel via the main condensers. Not far distant from the site would be coal pits from which could be obtained fuel giving about 14,000 B.T.U's. per lb., with little or no ash, and levels so arranged by nature that fuel could be dropped from the pit heads straight into the boiler house bunkers. Nor is that all, for the site would be in the centre of the area it had to supply. Thus main feeders would be of equal length, and the loads on those feeders would always be equal with 100% load factor and unity power factor.

It is in an endeavour to approach this ideal that the ingenuity of the engineer is brought into play, and the more difficult the site and conditions the more thought and brilliance is brought to bear upon the respective problems: thus it is by reason of the diversity of conditions that power stations differ so much in fundamental features of design.

When a site has been chosen, and the ultimate capacity of the power station agreed, the question arises as to choice of plant. In dealing with this problem the boiler house and turbine room need to be considered both separately and as a whole, together with the methods to be embodied for coal and ash handling. In any case coal handling can only be arranged to suit each individual site, and no hard and fast rule can be applied: but in whatever manner coal is delivered to the site adequate provision should be made for weighing and checking all fuel into the works or on stock.

In connection with steam raising plant opinion is divided as to whether pulverised fuel or stoker firing is best. In this connection there is the view that pulverised fuel does undoubtedly give higher thermal efficiency, but also the doubt whether it is commercially more efficient than stoker firing when the higher capital costs and increased maintenance charges are taken into account; yet there is no doubt that in some instances the case for pulverised fuel can be proved. The author's personal view is that a combination of powdered fuel and stoker firing should prove highly efficient, since it is possible in this case for the operating engineers to operate their stoker-fired boilers on a base output, and carry the peaky sections of their load on the more flexible pulverised fuel plant (Fig. 1).

We are, however, bound to consider the use of pulverised fuel when dealing with an installation of boilers having an evaporative capacity of 150,000 lbs. and over.

In drawing up the boiler specification it has become common practice with designing engineers to include the following equipments:—

Steam and air flow meters, which usually incorporate a flue gas temperature recorder.

Recording or indicating thermometers, which shew the final temperature of the steam; the inlet and outlet gas temperature on the economiser; the inlet and outlet water temperature on the economiser.

CO_2 indicator and recorder.

Feed water meters and coal weighers.

Incorporated in the design of the modern powdered fuel boiler, there are usually either water cooled or air cooled walls, air heaters, and sometimes a small economiser, and it is undoubtedly a fact that the incorporation of such devices has done a great deal to increase the efficiency of the powdered fuel plant.

Proceeding along the same lines the stoker maker is now incorporating into a greatly improved stoker design water cooled walls, water cooled arches and air heaters, but whilst with stoker-fired boilers it does not at present seem possible to obtain such high ratings per square foot of heating surface, thermal efficiencies of 86% are being obtained at a much lower capital cost. Consequently, under certain conditions, stoker-firing is commercially more efficient.

It has been mentioned that whilst the boiler house and turbine room should be considered separately they must also be considered as a whole; this means that the surfaces of air heater and economiser must be designed to suit the feed heating conditions laid down, and the turbine must be so arranged that feed heaters can be supplied by steam bled from different stages of the turbine after a certain amount of the heat energy has been expended.

The diagram, Fig. 2, illustrates the three stage bled steam feed heating system incorporated on the new plant at the Stourport power station. Hams Hall is arranged on similar lines, and the new Ironbridge station is also similar.

The introduction of feed heaters at these points improves the efficiency of the turbine, since the passage of a reduced quantity of steam through the lower stages of the turbine reduces the leaving losses on the turbine blades. It also permits a reduction of the surface of the condenser, and at the same time reduces the quantity of circulating water required. It will thus be evident that since the condenser extracts a certain amount of heat which is discharged with the cooling water, either over the cooling towers or into the river, certain heat units have been put into the feed water which otherwise would have been wasted.

The turbo-alternator proper is not a difficult proposition, and the design of it need not worry the man who is laying down the plant, since most of the leading

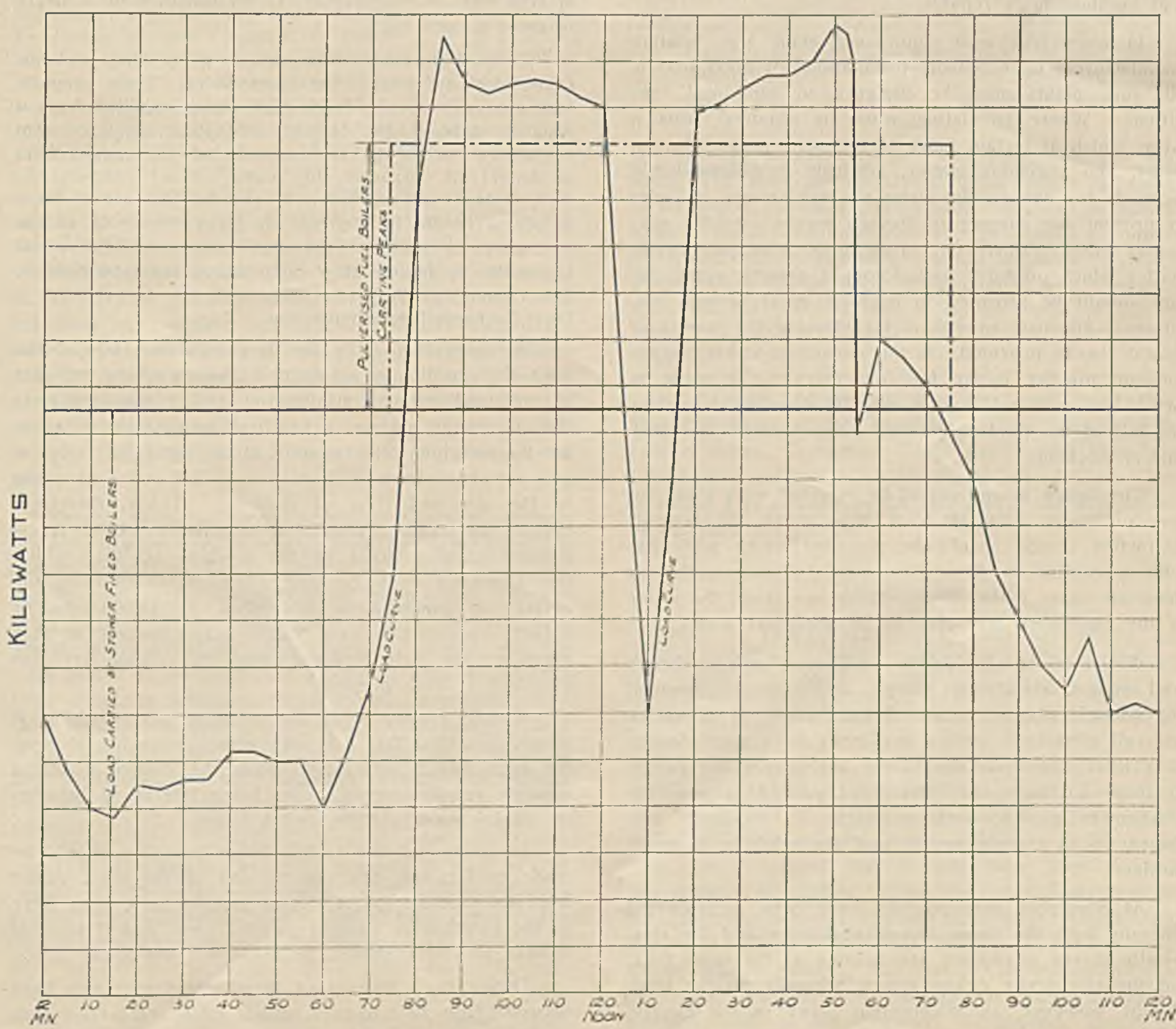

Fig. 1.—Graph shewing the Peak Load taken by Pulverised Fuel Boilers.

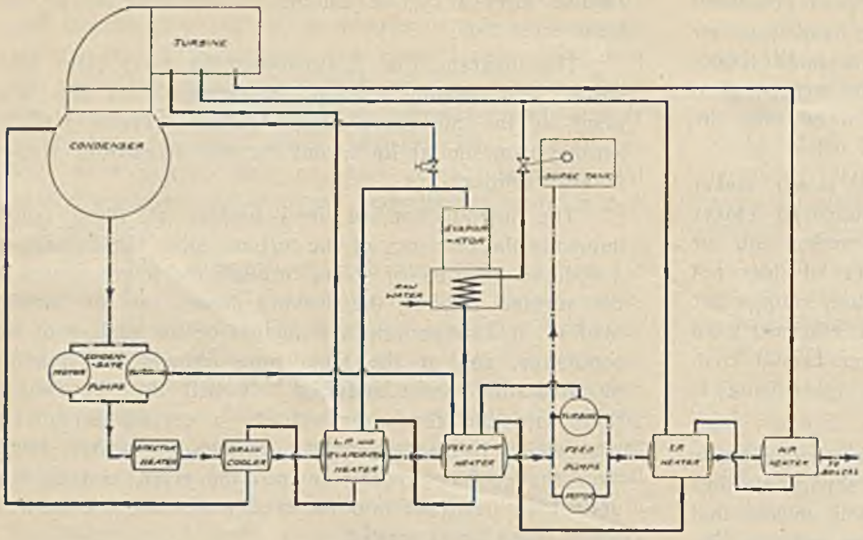

Fig. 2.—Diagram of Feed Heating.

manufacturers can provide a plant of any capacity which will be thoroughly reliable.

In connection with condensing plant also, leading manufacturers offer reliable installations of good design, but such plants must be designed to suit local conditions. Where circulating water is obtained from a river, which at certain times of the year contains leaves, twigs, and vegetable matter, adequate provision should be made for passing the water through screens in order to prevent the passage of foreign matter into the condenser tubes. Where circulating water contains organic matter which produces bacteriological growth, extra surface should be provided to maintain good vacuum conditions. Adequate provisions for cleaning the condenser should also be provided. In this connection it has become common practice to-day for condensers to be made in two halves, each half with a separate door which enables one-half of the condenser to be cleaned whilst the other half is working.

Circulating pumps should be specified with a margin for continuous duty at least 10% above the normal. Extraction pumps should be provided which will deal with a continuous 25% over normal requirements, as there are times when, due to faulty operation, the water in the condenser may rise to an abnormal level.

Whilst electrically driven auxiliaries, such as boiler feed pumps, circulating pumps, and extraction pumps, are undoubtedly the most efficient, a station operating with all electrically driven auxiliaries is in some danger of a total shut-down should for any reason the supply to those auxiliaries be interrupted, and it is now the practice to provide such auxiliaries in duplicate, one driven by an electric motor, and the other by a small turbine.

At Stourport arrangements have been incorporated whereby both the steam driven auxiliaries and the electrically driven auxiliaries are running at the same time, but the electrically driven pumps normally do the load. Should, however, an interruption occur in the electric supply which would cause a failure, a pressure-operated relay comes into action, and automatically opens up the throttles controlling the circulating pump turbine, the extraction pump turbine and the feed pump turbine. This is an entirely new departure, and will, no doubt, be incorporated in other power stations.

The incorporation of the closed type air filter in the alternator has become common practice since it was found that the use of the wet air filter was responsible to a large extent for the breakdown of the windings.

In all high duty boilers the question of pure feed water is of paramount importance. In some large stations are installed chemical water softeners arranged to deliver to the boilers pure water with a slight alkalinity, but the author is of the opinion that unless such an installation is operated with extreme care there is the danger of getting scale on the boiler tubes, and in the modern boiler working at high rates of evaporation of 1/64 inch of scale is likely to cause a burst tube.

At the Stourport station, and in many other stations, evaporators are used for make-up water. These evaporators generally are fed with bled steam supplied from a suitable stage in the turbine, and it is supposed that chemically pure water is obtained, but here again there is danger of corrosion, by reason of air entering the feed system, and in order to prevent this action there is placed in the feed circuit on the suction side of the feed pump a machine known as a deaerator, in which the water is boiled at a temperature corresponding to the vacuum in the condenser, and the air content is thus discharged to atmosphere.

In connection with the large stations now being built the question of generating and switching voltages has received serious consideration, and it was very clear that it would not be a practical proposition to carry out the switching of large units at the generated voltages, i.e., anywhere from 5500 volts to 11,000 volts according to the size and class of machine. It has, therefore, become the standard practice to incorporate step-up transformers coupled solid to the machine so that whilst the alternator may be generating at 11,000 volts the voltage is immediately stepped-up to 33,000 volts or higher, and switched on to the main busbars at that pressure; the main feeders leaving the station are also switched at that pressure.

Whilst dealing with the question of switching it should be noted that it is now common practice to keep the main switch house away from the station proper, a separate remote control, room being interposed between the engine room and the switch house.

In laying out the switch house provision should be made to facilitate the running out of the main cables from the machine to the step-up transformers, from there to the switches in straight parallel lines, and if possible similar provision should be made for out-going cables.

Owing to a number of disastrous fires which have occurred from time to time both in small and large power stations it has now become common practice to instal all transformers out of doors, and provide special means for dealing with bursts or fires should such occur. In the Stourport switch house provision is made for the running off from the switch cubicles of any oil which may accumulate by reason of leaks or even a burst.

Before leaving the question of plant the question of the internal or house supply to the station might be considered. Generally the auxiliaries are driven by either three-phase a.c. or variable speed d.c. motors, but in each case whilst either may receive a supply from the main busbars via a bank of transformers and the rotary converter, a separate steam driven unit is always desirable for use in the event of a total interruption of supply.

The above references deal as briefly as possible with the general factors affecting design, and it would be impossible at reasonable length to discuss the merits of various layouts. It is, therefore, proposed to consider the operation of the system and explain the economies which are being effected by reason of group control of power stations, particularly where the most efficient plant is running on base load conditions, whilst the others in order of efficiency merit perform their quota of duty according to the peak demands (Fig. 3).

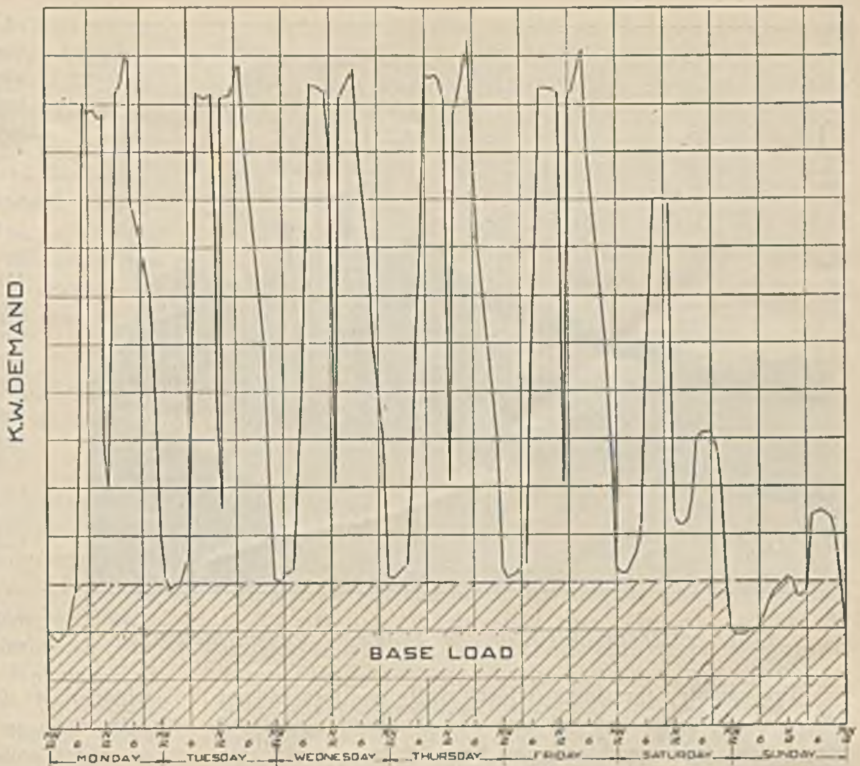

Fig. 3.—Load Curve.

Every station which will either give or receive a supply from the Grid must make adequate provision for switching and handling the large blocks of power which it is proposed they will handle. In this connection power station engineers will be called upon to make provision for complete automatic and remote control not only of their switches but also of their turbo-alternators and their large boilers. Such automatic control so far as either stoker or pulverised fuel fired boilers are concerned is an easy matter, and it is quite possible to-day to get complete flexibility over the whole range of boiler loads.

In regard to the turbo-alternators it is now common practice, if necessary, to control from the switchboard all operations with regard to speed variation and the actual tripping out of the steam side of the machine. At the other extreme it is possible for the turbine attendant whilst tripping out his own machine to trip out the main switch at the same time. Coupled with these operations there is included the automatic operation of a field suppression switch, which not only breaks the field of the alternator, but immediately suppresses it, and it is by a combination of these automatic devices that damage to plant can be prevented in the event of the sudden removal of large blocks of power.

This Association being so intimate a part of the mining industry, this paper cannot very well avoid mentioning the relationship which should exist between the electric supply industry and the coal industry, particularly with regard to the supply of a clean fuel. In particular, reference is to be made to the popular agitation respecting the emission of dust, grit, and sulphur. With regard to the former the elimination of this nuisance lies definitely in the hands of the mine owner and the engineer. The mine owner has it in his power to supply to the power station a much cleaner fuel than is received to-day. Fuels containing from 15% to 20% of ash can be so treated that the ash content would fall from 5% to 8%. There would still be a certain amount of ash to contend with, but the problem then is in the hands of the engineer, to provide suitable grit catching and washing facilities.

With regard to the sulphur content, experiments have been proceeding at the Grove Road power station of the London Power Company. These experiments have been sufficiently successful to enable the House of Lords Committee to give consent to the building of the first section of the Battersea station.

Discussion.

Mr. W. HOLLAND said he was particularly impressed with the remarks on boilers and boiler houses, since the average Black Country colliery boiler house was a monument of inefficiency and a standing example of how not to generate steam. Many engineers seemed to lack the courage of their convictions, but that charge could not be laid at Mr. Boothby's door. Two years ago he decided to install water cooled arch and side walls, and this was by way of being a bold experiment, since nothing had at that time been done in this country on similar lines. The plant had its teething troubles, but Mr. Holland was sure Mr. Boothby would be the first to admit that the experiment was an unqualified success, and that for a trifling increase in capital cost he had entirely eliminated brickwork troubles, one of the bugbears of modern generating stations.

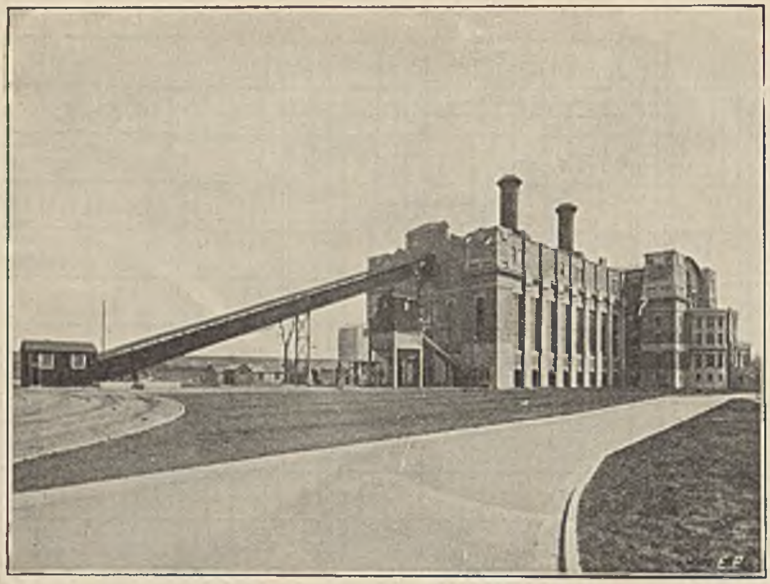

Fig. 4.—General View of the Stourport Power Station.

Presumably, the thing which really matters is not efficiency, as such, but the cost per thousand pounds of steam, and this could only be brought to a reasonable figure by the bold policy of scrapping plant fifteen or more years old, and installing in its place modern boilers and stokers; or steam generators, designed to burn efficiently slack having little or no value in the open market.

A large colliery in Staffordshire recently installed a stoker similar to that in use at Stourport, with the result that they are now burning inferior grades of fuel and releasing for the market a good quality coal, thereby showing a saving sufficiently big to pay for the new stoker in twenty months. Mr. Holland's experience of collieries was that such a saving was not unusual, and was easily possible in almost every plant. With regard to pulverised coal he agreed that in general the ideal arrangement was a battery of stoker-fired boilers to take the base load and two or more pulverised coal-fired steam generators to deal with sudden fog or other peak loads.

The emission of dust and sulphur had now been reduced to a point where it no longer constituted a public nuisance. The installation by colliery propietors of dry cleaning plant appeared definitely to eliminate any possible trouble from dust emission, whilst the washing of flue gas had obviated the formation of sulphuric acid. Further, the capital cost of a direct fired steam generator was no longer in excess of that of a stoker-fired boiler of equal evaporative capacity—on the contrary, it was usually lower.

Mr. G. M. HARVEY.—After listening to many papers on pulverised fuel versus stoker firing, the authors of which were all, quite obviously, sitting on the fence, it was refreshing to hear the definite statements of opinion of Mr. Boothby. The plea for increased coal-washing at the collieries reminded Mr. Harvey that at Cadeby Main Colliery the "fines"—about $\frac{1}{16}$ in.—which are taken out of the coal before it enters the washery, contain 25 per cent. of ash and about 4 per cent. moisture. The removal of the fines reduced the ash in the washed coal to below 2 per cent., while the fines, after pulverising, were used to fire three boilers, each of 30,000 lbs. per hour normal output.

Power Station Engineers seemed to be sharply divided into two camps—the "Gadgeteers" and the "Antigadgeteers"—and he was sorry that he missed the first part of Mr. Boothby's paper, as he wanted to learn more about Padiham where, he understood, the bests results in the country were being obtained with old-fashioned boilers and without pulverised fuel, air preheating, forced or induced draught, high pressure, high superheat, stage bleeding, interstage reheating or any of the multitude of fancy "gadgets" dear to the hearts of some station engineers. It makes one wonder whether there is not, even to-day, a certain virtue in simplicity.

Mr. Harvey had been much impressed with the layout of the Stourport Station when he was fortunate enough to visit it, but he would like to ask Mr. Boothby whether it was really necessary to generate at 5500 volts, step up to 33,000 volts, up to 66,000 volts, down to 11,000 volts and down to 440 volts. He supposed there would be another step to 132,000 volts when the link with the Grid was completed.

Mr. Boothby's conception held that the ideal site was a riverside one. Liverpool, some years ago, considered three alternatives for adding to their power plant, viz.: erecting a new station at a colliery ten or fifteen miles from the city; erecting a new riverside station; and extending the existing cooling-tower station at Lister Drive. The first was turned down owing to the cost of transmission, and the second owing to the cost of civil engineering work necessary to cope with the tidal variation of something over 30 feet. However, they are now putting down a new station at Clarence Dock, and it would be interesting if Mr. Boothby could say how they were meeting the tidal difficulty.

Mr. Harvey said he had been told that, if low temperature carbonisation became commercially practicable, it would be possible to generate from waste gas and coke so cheaply that the correct site for the large stations would certainly be at the collieries. Would Mr. Boothby give his views on this matter?

Mr. HARRISON-SLADE.—Although the controversy still continues as to the respective merits of pulverised fuel and mechanical stoker firing as the sole method of firing, one point does emerge clearly, namely, that each method has marked advantages peculiar to itself and to secure these, boilers must be arranged for both systems of firing so that the stokers take the base load and the pulverised fuel plant looks after the peak loads.

As regards the use of low grade fuel Mr. Harvey hit the nail on the head in suggesting that collieries should do more in the preparation of coal before marketing, by removing the fine coal into which generally the bulk of the ash is segregated. Support was lent to this suggestion by Mr. Boothby's assertion that power station engineers were prepared to pay a fair price for well-cleaned coal. The removal of all the fines at the colliery leaves the latter with the problem of how best to dispose of it and he, Mr. Harrison-Slade would suggest there was no better way than to generate steam with it. Mr. Boothby, without reference to the type of fuel had said that in his opinion pulverised fuel firing gave higher efficiency than solid fuel firing and when it came to using low grade fines, no one who had experience of the matter would dispute the advantage which pulverised fuel firing possesses as regards its ability for meeting rapidly fluctuating loads and maintaining overloads at high efficiency.

The removal and utilisation of fines in this way at the colliery incidentally simplified the washing of the coal and improved the washed product.

Mr. T. E. BOOTHBY, in reply, and referring to the remarks by Mr. Holland on the question of the bold policy of scrapping plant 15 or more years old, said that may sound very well in theory, but there were economic factors other than the actual cost of steam, and it might be that in some classes of manufacture the fuel costs formed an exceedingly small percentage of the total production costs. In such instances the natural economic process would be to spend the money where it would be of the most beneficial use.

Nevertheless, so far as collieries and power stations were concerned, he was in full agreement with Mr. Holland's suggestion.

With regard to Mr. Harvey's remarks on the subject of clean fuel, Mr. Boothby said he was of opinion that industrial users generally and the electric supply industry in particular should make a definite demand for clean fuel. Users should decide on the class of fuel most suited to their requirements, and see that they get it. To his mind it was a crime to use national transport resources for the conveyance of dirt which was bound to reduce the efficiency of industrial plants. It might be stated without fear of serious contradiction that most fuels could be successfully cleaned at a small cost by one of the wet or dry cleaning processes now in use. As a large user of smalls he favoured dry cleaning for the reason that one was then reasonably certain about the moisture content.

In the adoption of gadgets there was always a happy mean. In this connection Mr. Harvey should not lose sight of the fact that the power engineer and every other engineer who used fuel must, if worth his job, study the economics of production, and endeavour always to obtain the maximum heat output from the fuel used. For that reason he was forced into the adoption of any devices which could be of proved assistance in the establishment of better thermal conditions, but in connection with any such improvements commercial efficiency must always be kept in mind.

Padiham was quoted as an example of simplicity and efficiency. Mr. Boothby had not the time available to give a description of the factors which contribute so much to its efficiency, but the operating conditions were exceptional, and not to be found in any other instance. Given the same conditions of load and plant capacity he had no hesitation in stating that as good if not better results could be obtained on any other plant. Nevertheless, Padiham did set them thinking, and they took off their hats with due respect.

With regard to the voltages in use at Stourport, he must say that this was but a passing phase due to rapid growth, legislation, and other factors over which the engineers had no control. Shortly there would be three voltages only, i.e., 33,000 volts, 66,000 volts, and later the Grid voltage of 132,000 volts. All switching operations were carried out at 33,000 volts, so they might therefore ignore the generator voltage since the step-up transformers being solidly coupled to the alternator stators could be considered an integral part of the alternator windings. In any case it would have been an expensive and unweildy process to carry out the switching of large blocks of current at either 5500 volts or 11,000 volts.

Mr. Harvey had mentioned the Clarence Dock Station at Liverpool. Mr. Boothby was sorry he could not provide details of that scheme, but would assure Mr. Harvey that tidal extremes do not worry the civil engineer, always providing the owners of the scheme were prepared to pay for the civil work. There were several instances of river and seaside stations where the tidal difficulty had been successfully overcome, and in this connection he would mention the Portishead Station of the Bristol Corporation, where four circulating water ducts had been cut beneath the foreshore of the Severn Estuary. In this instance any one of these tunnels could be made into an inlet or outlet tunnel at the discretion of the engineer, thus any accumulation of mud or sand in an inlet tunnel would be washed out when the flow was reversed and the tunnel changed from inlet to outlet. Figs. 5 and 6 are a contour line sketch and section of these tunnels, respectively.

Mr. Boothby said he agreed that the adoption of low temperature carbonisation on a national scale would be bound to have some effect on the electric supply industry, and from the point of view of convenience the natural site for a power station of a limited capacity was at the pithead. One must not lose sight of the necessity for the large quantities of water required for condensing purposes, and also the economic factors effecting the collection and marketing of the by-products, to say nothing of the cost of transmission, bearing in mind that industrial centres were tending to gravitate away from the mining areas, the exception of course being the iron and steel industries. Personally he cared not where the generating station was situated so long as it was possible to get most closely to the ideal conditions he had described.

He was pleased to note that Mr. Slade was generally in agreement with his views, particularly with regard to the suggestions on the preparation of fuel before marketing, and the disposal of the dirty fines under the colliery boilers. Mr. Boothby was certain that any colliery undertaking that laid out its plant to burn its own refuse would not only have available a greater quantity of marketable fuel, for which there was always a demand, but would have the benefit of the higher selling price.

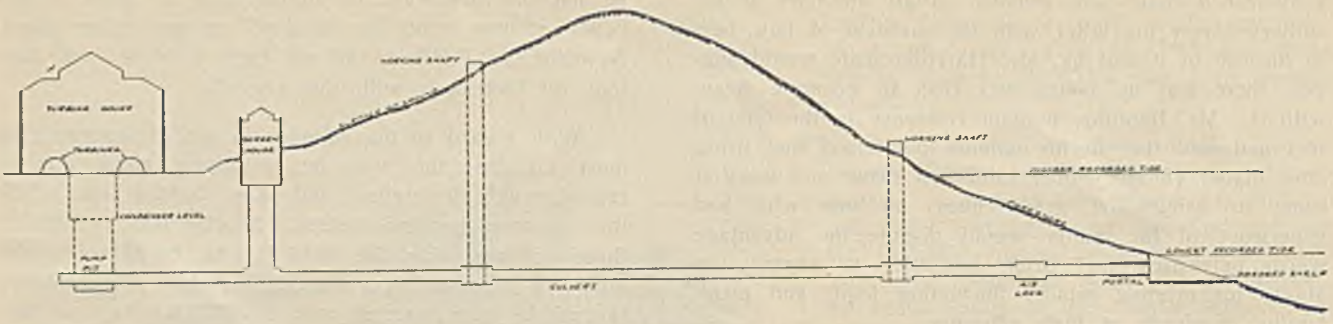

Fig. 5.—Contour of Culverts.

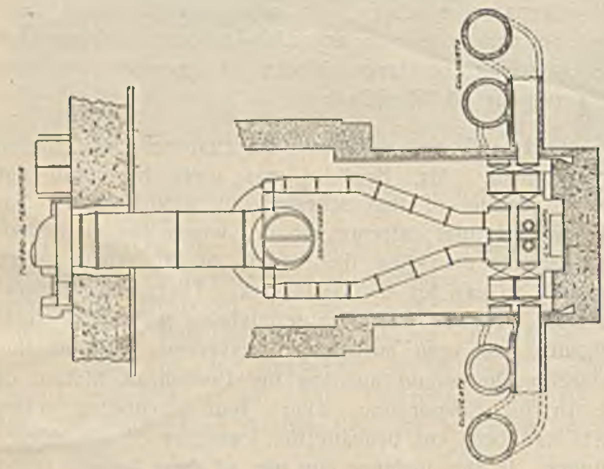

Fig. 6.—Section of Culverts.

Frankly, he did not think it correct practice to pulverise low grade fine at the ordinary power station. It was not cheap, because the wear and tear of pulverising plant, and the continued nuisance of grit and dust, must go a long way towards the cancellation of the savings which might accrue by reason of increased thermal efficiency. He believed that on the point of extreme flexibility alone were the exponents of pulverised fuel able to prove their case.

MIDLAND BRANCH.

Ⓟ A Novel Method of Installing a Shaft Cable.

H. W. RANDALL.

(*Paper read 26th March,* 1930)

These notes describe briefly a method of installing a shaft cable which the author ventures to think is unique. Many and varied are the methods used to instal shaft cables, the actual method employed having to be adapted in detail to suit the conditions which prevail in each particular case. Probably the two most popular methods are :—

(1) Lowering the cable by means of a winch;

(2) Lowering the cable with the aid of a locomotive engine.

In some cases where the shaft size permits, the drums of cable are taken to the shaft bottom and the cable drawn upwards.

Before proceeding with the description of the installation, it will be useful to give a few particulars regarding the shaft at the Brookhill Colliery. The shaft is 404 yards deep with four landings, viz.:

Waterloo landing.
Hard Coal landing.
Low Main landing.
Silkstone landing.

The cables were to be installed from the surface to the Waterloo inset, and from the Waterloo to the Hard Coal.

The Waterloo cable length was 155 yds. and weighed 1 ton 16 cwts.

The second length of cable was 168 yds., weighing 1 ton, 19 cwts.

The cable was three-core, D.W.A., bitumen served, with 0.1 sq. inch cores, and insulated for 3000 volts working pressure.

The surface arrangements were as follows. The cable drums were run on to the pit bank, and the 155 yds. length was mounted in pedestals on girders which were placed lean-to to the head gear. The drum when mounted was fitted with substantial plank brakes to each drum flange.

A 2 feet diameter wheel was mounted in the headgear, on the cross timbers used for the pit top drop chairs; the wheel was set in alignment with the winder drum and the shaft side as shewn in the sketch, Fig. 1.

While the electrical staff was mounting the cable drum, the blacksmiths were winding an old winding rope on to the winding drum on the top of the rope used for ordinary winding purposes. This rope was $1\frac{1}{2}$ ins. diameter. The rope was then passed over the pulley in the headgear and lowered to the surface landing. The cable end was now lowered to the surface, the first four yards of the cable being fastened to the rope by spun yarn to facilitate drawing the end in at the Waterloo Inset. The cable end was passed through a sleeve on the chair side.

At five yards the first clamp was fixed. The clamps were made to grip the rope and the cable as shewn in Fig. 2; they were 9 ins. by 6 ins., secured by $\frac{5}{8}$ ins. bolts. The clamps were attached to the rope and cable at eight yard intervals. In this manner the cable was lowered by the winding engine to the Waterloo inset. When the cable end reached the inset, enough length was drawn inside to make a "three-way" box and to form a bite in the cable to drain the water from the cable in the event of any running down it from the shaft side. The cable lowering rope was then clamped in the headgear, similar to the clamping arrangement of a conductor, thus leaving the winding drum free to revolve.

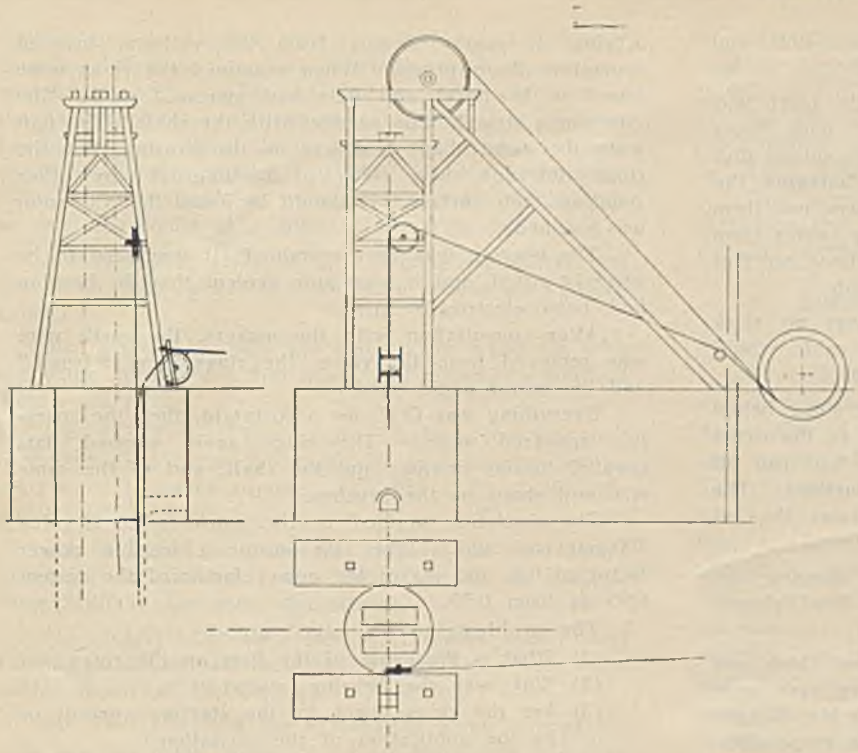

Fig. 1.

The next job was fastening the cable to the shaft side. This was done with long wooden clamps. These were 4 feet long by 6ins. by 6 ins. hollowed out to fit the cable with sufficient nip on the cable to make a sound job. These clamps were fitted with eight bolts. ⅝ in. diameter. The bolts also passed through strong plates back and front with two long plates 4 ft. 6 ins. long. These long plates had long eye bolts fitted to them 1 ft. 6 ins. long by ¾ in. diameter. The long bolts were passed through eye bolts 1¾ ins. diameter, let in the shaft side at regular intervals, for suspending purposes. The clamps were attached at intervals of fifteen yards, and the long screws were so arranged as either to lower or lift the cable in the case of its elongation.

The total time taken to lower and secure this length was four hours. The second length was lowered in and secured next day.

The staff was arranged as follows :—

No. of men with cable drum	4
„ „ attaching lowering clamps	2
„ „ on signals—2: 1 at bank, 1 at inset	
„ „ at Waterloo inset	3
„ „ on cage	1

And the winder with 4 labourers.

Three men were employed in securing the cable to the shaft side but these were drawn from the above number of men. The week following its installation the cable was jointed, tested, and put in commission. The joint at the Waterloo inset was made in a three-link joint box and filled with compound to the link connectors.

Both cables were installed in the west side of the shaft.

Discussion.

Mr. R. WILSON complimented Mr. Randall on his paper, and said there was perhaps a little more information which would be of interest. His own experience with these jobs was that the determining factor as to the method to be employed of installing shaft cables was the size of the shaft, and he would like to know the size of this particular shaft. Mr. Randall had mentioned a method of installing cable whereby the whole length of cable was lowered into the pit bottom; then a rope fastened on one end and the cable hoisted up. That was a method he personally would not recommend only under very exceptional circumstances. One of the great points to be observed in installing shaft cables was that the cable must not be strained in any way. Another method which he thought worthy of consideration whenever possible was that where the drum was mounted on the cage itself. Where there was room on the cage and in the shaft this was the method he, personally, very much favoured.

Mr. RANDALL stated that the shaft was 16 ft. diameter, but it would not allow the drum to go on the cage. They had a cable drum to take cable into the pit in 150 yards' lengths, and had the greatest difficulty in getting that on the cage. They could not use the surface locomotive, as the lines on the surface ran parallel with the shaft wind.

A SPEAKER asked what was the method of using the eyebolts. Were they just stalked and let into the shaft sides ?

Mr. RANDALL replied that they were put in one foot deep. There were two bolts per clamp, the clamps

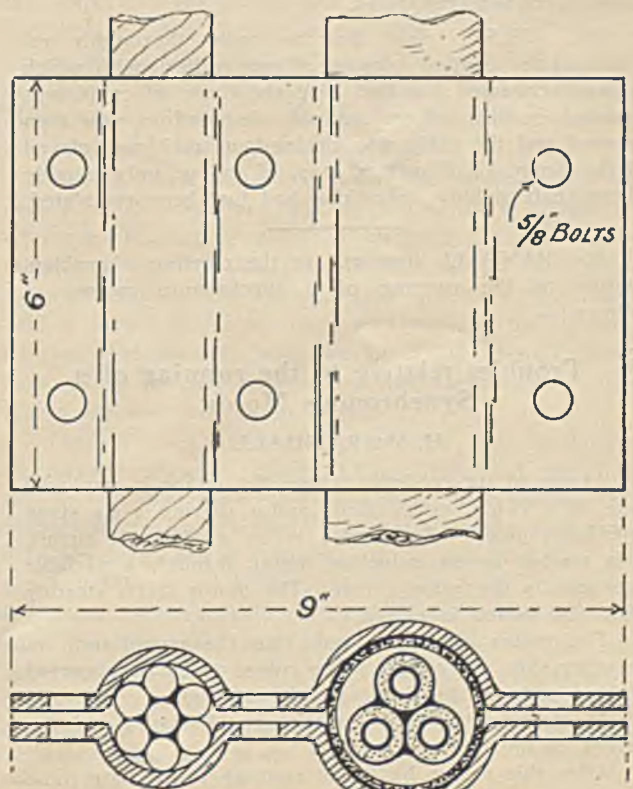

Fig. 2.

were 45 ft. apart. The job was done in May, 1928, and there had been no signs of lengthening.

Mr. HUDSON thought clamps 15 yards apart was rather close, and that it would be better with fewer points of suspension. Also, with iron clamps, unless they were a perfect fit, there was a risk of damaging the cable by compression. Personally, he always put them down lashed with spunyarn. In suspending cables from the shaft side he preferred to put a big hook so that the cable could stand clear of the shaft side.

Mr. PEACH thought that as there was no slack between each cleat it was likely that the cable would take its own complete weight from the top.

Mr. HUDSON said he had had a drum slung below the cage, and this could be done so long as the drum would go between the conductors, and he had run off lengths of 440 yards successfully by this method. The chief point was to have sufficient height at the pit top to get the drum under.

Mr. WRIGHT said, with regard to slinging the cleats by eyebolts, he still regarded the fixed clamps as making the most satisfactory job.

Mr. WILSON said personally he did not think one could lay down hard and fast rules. Every case must be considered on its own. He agreed with Mr. Wright that it should be made as satisfactory a job as possible. He was not much in favour of adjustable cleats, but it was nearly impossible to make provision against every contingency in every shaft.

Mr. H. MORRIS said he had had very little experience in the actual installation of shaft cables, but the point so far as he could see it was to get the cable attached to the rope in such a manner that there was no strain on any part of the cable. He did not like the idea of taking the cable down and hoisting it up. as he thought it would put a strain on the cable. He agreed with Mr. Wilson that one could not lay down hard and fast rules.

Mr. WILSON said that he could thoroughly recommend the method adopted at one colliery with which he was connected; in that case the drum of cable was mounted on the sinkers scaffold, the scaffold was then lowered and the cable was clamped up as it was played off the drum. This method was, of course, only suitable where shaft sinking operations had just been completed.

Mr. RANDALL then put to the meeting a problem relative to the running of a synchronous motor, as follows :—

Ⓟ Troubles relative to the running of a Synchronous Motor.

H. W. RANDALL.

At one of the collieries where the author is employed there is a 95 h.p. synchronous motor driving a six stage centrifugal pump. The motor is on a 1100 volt circuit. It is started as an induction motor through a variable resistance in the rotor circuit. The motor starts steadily when the switch is closed.

The motor drives on one side the pump and, on the other side, the exciter. The rotor, which is supported by two pedestal bearings, weighs 14½ cwts.

At starting the rotor voltage is 1100 volts and the current 39 amps.

After this motor had been running for a short time excessive sparking was noted on the rings. The driver went to investigate and noticed what appeared to be a ring of sparks issuing from the pedestal bearing nearest to the sliprings. When examined the rings were found to be burnt and flats had appeared on all the rings in a straight line parallel with the shaft. The flats were the same shape and size as the brushes, but the rings did not shew signs of burning at any other point on their surface. It should be noted that the rotor was earthed.

The bearing was next examined: it was seen to be severely pitted, and it was quite evident that the bearing had been electrically alive.

After consultation with the makers, the earth wire was removed from the rotor, the rings were "trued" and the motor again tried.

Everything was O.K. for a fortnight, then the sparking appeared again. The rings again shewed flats parallel to one another and the shaft, and of the same size and shape as the brushes.

The excitation applied to the rotor is at 10 volts, 100 amperes, which gives the motor a leading power factor of 0.8. and makes the power factor of the system 0.95 as from 0.55.

The problems to be solved are:—

(1) What is the cause of the flats on the rings?
(2) Why was the bearing seared?
(3) Are the rings burnt by the starting current or by the application of the excitation?
(4) Has the weight of the pump, motor, and exciter any bearing on the trouble?

Discussion.

Mr. WILSON asked in what way was the excitation current brought into the motor. He understood there were three sliprings on the rotor, one ring only being earthed. Was that ring the third point in another winding, or where was it connected?

Mr. RANDALL said the star point was earthed. When the motor had got up to a certain speed the excitation was applied.

There were four brushes on each ring, and the flats appeared all at the same place, the size of one brush.

Mr. NORTHCOTT said they appeared to have been running with a leaky foot valve.

Mr. RANDALL said there was no trouble in the exciter itself.

A SPEAKER asked how often was the machine started up.

Mr. RANDALL. Probably several times in a week.

Mr. NORTHCOTT said it was rather remarkable that it shewed only the size of one brush when there were four brushes on each ring.

Mr. WILSON said no doubt a good many of those present had had experiences in the early days with turbines and would remember the trouble there was with bearings due to currents circulating through the shaft and round through the bed and back through the turbine itself. It is the practice to-day to insulate at least one of the bearings, and thus there is an open circuit between the bed and the shaft and bearings. This arrangement was made to prevent the particular action which has been observed in this case. The pitting on this machine was due to circulating current, but that did not explain the ring trouble. He would first like to criticise the makers of that machine for arranging the rotor windings in that manner. They had conductors of which one third were carrying twice as much as the other two thirds, which produced an unbalanced condition. Some of the leading makers of this type of machine had definitely abandoned that arrangement of windings. It was a very contentious point. The fact that sparking occurred at the same point on all the rings shewed that it must be due to a common cause, and it did appear to shew mechanical out-of-balance. If this trouble reappeared, it would be advisable to try and arrange for the brushes on one ring to be of a different size from the others.

A SPEAKER asked if Mr. Wilson suggested that the three flats were due to some mechanical out-of-balance.

Mr. RANDALL said the rings were trued up with a machine tool in the first place, and afterwards finished with a diamond.

Mr. NORTHCOTT suggested that as the flats had happened once since the machine was disconnected, it must be a transient trouble. It could not be a trouble which was inherent.

Mr. WILSON said the fact that it had been found necessary to disconnect the earth seemed to indicate some fault in the same department.

Mr. RANDALL said the synchronous motor was running practically all the time, as they had a very poor power factor at the colliery.

Mr. BROWN said the explanation given seemed the only one he could think of. If it had been a bigger machine he thought one bearing would have been insulated.

Mr. HUDSON said if it happened again would it be possible to stagger the brushes? Would three brushes carry the current?

Mr. RANDALL said the brushes themselves were parallel and were 1¼ ins. wide, nearly square.

A SPEAKER asked what was the alternative method method of connection.

Mr. WILSON said one arrangement was to put the three windings in series; then it would be possible to put in Delta windings. If there should be an electrical out-of-balance it was quite possible to get a resultant mechanical out-of-balance.

Mr. Wilson said he had great pleasure in proposing that their best thanks be given to Mr. Randall, and he hoped that if this trouble arose again he would be good enough to come along and let them know about it.

Mr. NORTHCOTT, in seconding the vote, said they were all indebted to Mr. Randall for his efforts that evening.

SOUTH WALES BRANCH.

At the Meeting held on 12th February last, Mr. W. W. Hannah in the Chair, the following were accepted for membership:—
Members: Messrs. George Dotchon, Charles H. Gow, George W. Robinson, William E. Lewis, and Oliver E. Thomas; Associate: Mr. Frederick J. Burman.

Mr. W. A. Hutchings read his Paper entitled "Safety and Efficiency in Mines" which was suitably illustrated with lantern slides. The paper produced a very animated discussion, which was opened by the Chairman and continued by Messrs. J. Jones, R. H. Morgan, S. B. Haslam, J. F. Smith, B. J. Burkle, W. D. Woolley, S. J. Lewis, Idris Jones, J. H. Bates, J. B. J. Higham, and S. Dwyer. The Secretary also read communicated criticisms and comments from Capt. T. E. Richards, Secretary of the South Wales Branch of the Colliery Managers' Association, and Mr. E. D. C. Owens.

The Colliery Managers' Association had been particularly invited to hear the paper, and many availed themselves of the opportunity. Owing to the length of time taken by the unfinished discussion, it was decided that it should be adjourned until the next meeting on March 15th.

The meeting closed with a very hearty vote of thanks to the author, proposed by Mr. Theodore Stretton and seconded by Mr. C. F. Freeborn.

Safety and Efficiency in Mines.

W. A. HUTCHINGS.

As a fitting introduction to this subject, the author would like to take the opportunity of thanking the Association of Mining Electrical Engineers for the valuable papers which have been read at its meetings from time to time, and also for its journal; *The Mining Electrical Engineer* has done, and is still doing a great deal to further the cause of safety and efficiency in and about mines. There is no text book that gives such full information about the application of electricity in the mine, as does this journal. The author finds it very valuable and most instructive, as it deals with every branch of electricity, its troubles and the many problems and difficulties which confront the engineer at the collieries. It would be well if, perhaps a little more general and practical appreciation were shewn for the help this Association is giving to make men more efficient in carrying out their work. It will be agreed that the day is far gone for the men who are only practical; they must also be technically equipped to meet the requirements of their responsibility in the mine.

A word of appreciation is also due to H.M. Electrical Inspector of Mines for the Yearly Report giving in detail the cause of accidents. It would be to the advantage of every electrician to be in possession of this Report, as he would find it most valuable, making him "think twice before acting once."

In considering this subject of Safety and Efficiency in Mines, the main factors entering are: Adequate Maintenance, Systematic Inspection, Effective Supervision, and, not least, Common Sense.

Having been connected with the collieries for a period of 25 years, and still with a Colliery Company, who are the largest users of electricity in the mines throughout South Wales, the author from experience, has formed definitely the opinion that providing the right gear is installed and the right men engaged to maintain it, also, that the men who operate it are given instructions as to its care and proper use, then, there is no reason for any fear as to its safety.

Colliery companies have spent large sums of money on flame-proof gear, safety devices, etc., but one has still to ask: Why are we not using them more extensively? Manufacturers have brought the material side to a very high standard; but it is greatly to be regretted that we are not able to mark this improvement with regard to the human element side. This does not mean that we have not any good men at the collieries, or that we have not had good men at the collieries; the greatest trouble is to retain them. This contention is based upon the Reports of Accidents: the cause of most of these accidents being due to the following:—

(a) Improper Use.
(b) Unwarranted Interference or Gross Negligence.
(c) Lack of Common Sense.

Colliery electricians are being constantly asked by this Association to give papers, but it is not usually possible for them to speak with authority on one particular subject, as the very nature of their employment necessitates them having an all round knowledge of every branch of electrical power and mining work.

Safety of the mine is of vital importance to every one. If safeguarding is dependent upon the foresight of the engineers, before the management appoints any man to operate electric machines the electrician should be consulted, so that he could instruct the man in his duties, and satisfy himself as to the competency and reliability of the man.

Every man should examine his machine externally before starting his shift for the following:—

(a) Missing and loose nuts and bolts.
(b) Loose earth tapes.
(c) Oil in bearings, etc.

and he should keep his machine as clean as possible. Should he find any parts out of order he should report to the electrician or management before attempting to start up. This close inspection of general details does not require any technical knowledge or entail any expense, but it certainly adds to the safety of the man himself as well as the safety of the mine. The time has come when men who operate machinery in the mine should be educated to their sense of responsibility: nor does this imply that the electrician is thereby relieved in any degree of his great responsibility.

The initial provision of satisfactory plant does not suffice: adequate maintenance is very necessary in all cases, and this duty falls upon the electrician for the upkeep of the electrical installation. However good and robust the plant might be, systematic inspection and effective supervision by the electrician are absolutely essential. In the Coal Mines Act, Part II. Memorandum of Regulations, Section A, are very clearly stated the duties of the employees who operate any part of electrical plant, and also the duties of the electrician. It is for us to see that those duties are carried out effectively and we ask for the co-operation of the management in dealing with this matter.

Every man entering the mine is given a lamp, and he is held responsible for its care and safety, the same rule should be applied to electrical machinery. Safety is best attained by ourselves; this not only applies to electrical plant, but it covers every part of the mine.

Having regard to the financial condition of the coal industry to-day, electricity should be used more extensively as a proved means of reducing the cost of production.

ACCIDENTS.

H.M. Electrical Inspector's Report for the Year ending 1928 states that the total horse power of electrical equipment increased from 1,481,932 in 1924 to 1,722,332 in 1928. During the latter year there were fifteen accidents involving the loss of nineteen lives, attributable to the use of electricity in collieries. From the details given in this Report, it is evident that these accidents were due in many cases to the fallible human element, lack of supervision, wrong men sent to carry out necessary repairs, also, for the want in some cases, of common sense. A number of accidents were in connection with coalcutters. Here it is suggested that trailing cables should be protected with armour, plugs should be electrically interlocked with the gate-end switch, all nuts and bolts should have spring washers, and the men put to work the coal-cutting machines should have definite instructions from the electrician, with regard to the safety and care of the gear. It is most important that the men who operate these machines should examine them externally for missing, as well as loose, nuts and bolts, etc. They should see that the trailing cables are placed in safe positions, and if any parts are found to be defective or missing, current must not be switched on until all is correct and put in good order. Also, periodical inspection by the electrician should be made whether any complaints have been referred to him or not.

Recently comments have been made in the Press with regard to the safe use of electricity in the mines, indicating that the lives of miners hang by the thread of a nut and bolt, and calling for drastic measures to be taken. This extreme criticism does not apply to the mining industry only, but may just as truly be said of every other power-using industry. What must be done is to see that these nuts and bolts are well secured. The Miners' Safety Lamp is only secured with a lead lock and the safety and care of that depends on the man using it.

BREAKDOWNS.

The effective maintenance of electrical machinery is a tax upon the most skilful and wide-awake electrician. The best method to prevent breakdowns, is to go and meet them, not wait for them to come. It must be admitted that whilst there is still plenty of scope for improvement in design, there is still more for progress in the standard of maintenance.

The attention of manufacturers is particularly needed in the design of mining type electrical gear with regard to quality and quantity of insulation: weakness of insulation is the chief cause of breakdowns and if the manufacturers would pay particular attention to improvements in this respect it would be very much appreciated.

All electrical gear should be overhauled, as often as possible; also tests taken each time and a record of them kept.

EARTHED NEUTRAL.

Much has been said for and against the earthing of the neutral. The author is entirely in favour of doing so. An earthed neutral does protect the plant from serious damage, and with it the insulation of the whole system must be kept in good condition. It may be argued that if the insulation is in good condition there is no need to earth the neutral; the author cannot agree, as the earthed neutral will find what a 1,000 volt Megger will not.

In one case a 3,300 volt, 100 h.p. haulage motor switched having tripped, the motor tested with the Megger gave the reading "Infinity." The switch was closed three times, and a test was taken each time with the same results. It was then decided to change the motor, which was brought up from the pit. After careully examining the windings, it was found that one phase had gone partially to earth. Had this motor been allowed to work, it would have broken down dead to earth, possibly may have caused other breakdowns, and imposed heavy surging on the system. The defective motor was repaired in a few hours; had it been left in service the total failure would have meant completely rewinding the motor.

In another case with the neutral earthed on a 550 volt system, a fault of one phase to earth developed in a controller. The switch did not trip in this case, and upon examination it was found that the trip coil in the switch was defective. This example goes to prove how very necessary it is to overhaul and test these tripping devices periodically.

The best method of earthing the neutral of a colliery plant with its own turbo alternators, and having one or more systems, that is, 3300 volts and 6600 volts is to earth from the main busbars through a reactance and limit resistance to earth. With regard to the protection of the generators, the core balance system of protection is the best method.

EARTH PLATES.

This is a subject of great technical importance; the only effective method of obtaining a good earth is to rely upon a surface system placed in carefully chosen surroundings. Local earth-plates underground have often been known to fail and they are not sufficiently reliable for the purpose of providing a sure means of safety. The general practice is to put the plates as near as possible to the power house, this, in the author's opinion, is a mistake, having regard to the mass of ground taken away for the foundations of the building and the power plant. Then, again, it is sometimes necessary to water these plates and that is likely to interfere with the building and foundations. The plates should preferably be at least fifty yards away from the power house.

There should be three plates sunk six to seven feet, bedded in crushed coke and laid vertically with a layer of broken coke six inches thick immediately surrounding them. With regard to the distance between the plates, this is a matter for discussion, and a definite rule laid down. Generally the plates are placed 20 to 30 feet apart, but the author fails to see how with that distance one can normally expect to pass a current of two amperes with a pressure of four volts between the plates, as per the Board of Trade regulations. It might be possible by using some artificial preparation in the ground.

The connection of the plates should be brought to a common insulated earth-bar in the power house, placed in a visible position and readily accessible. If copper earth-plates are used, they should be dug up and examined every three years.

While the importance of such points as are here mentioned cannot be over-estimated, comparatively little practical research appears to have been undertaken in this matter.

UNDERGROUND SWITCHGEAR.

The author has come to the conclusion that all switchgear used in the mine should be of the drawout mining type, explosion proof construction. This class of gear gives definite proof that men are safe to work on any apparatus as the action is very positive.

During the year 1927 a circular was sent from H.M. Inspector, in which it was pointed out that every year there are a number of mine accidents, some fatal, by electric shock from apparatus on cables whilst under examination test or repair. It is not sufficient to remove the residual charge by earthing the conductors momentarily; the conductors should, therefore, be kept at earth potential until the work in hand is finished.

The principle advocated is that the circuit shall be earthed through the circuit breakers so that if by any mischance the circuit should become alive then the breaker would trip.

Where switchgear of the draw-out type is installed, detachable extension contact pieces are plugged on and thus lengthen the terminals of the breaker after the withdrawal of the switch from the pedestal base. An earthing clip is attached to the terminals of the breaker which is then pushed back until the circuit contacts engage with the base. The circuit is then put direct to earth by switching on. This does away with the primitive method of flashing with a piece of wire to find out if the circuit is dead; a hapazard method which may itself be considered dangerous.

The author has often wondered whether it would be of advantage to fix the handles of the switch on the left hand side, so as to prevent the man standing directly in front of the switch, as there is a possibility of closing the switch against a dead short. This is a matter of opinion perhaps worthy of discussion.

There is another important matter to which should be called the attention of the manufacturer of this type of switchgear. After drawing the switch from the base, there are three live connections exposed. There are times when it is necessary to test from this base to the out-going cables or other apparatus. It should be made impossible to place the testing wires on the live contacts. Accidental contact with live parts must be made impossible.

The insulation must be able to withstand excessive pressure which is liable to arise under abnormal conditions. The sectional area of conductors must be such as to carry any maximum overload to which they are liable.

Automatic protection which will isolate a faulty section without interference with a healthy section, should always be included. Overload protection alone, even when it is applied intelligently, cannot be relied upon to prevent an outbreak of fire resulting from damaged cable. Leakage protection, however, which can be given any desired degree of sensitivity is undoubtedly an assurance against fire, for it may be anticipated reasonably that a leakage to the metallic sheath of the cable will precede or accompany the short circuit between the working conductors, so that the circuit will be isolated at an early stage of the development of the fault.

EXPLOSION PROOF APPARATUS.

Explosion proof appparatus will withstand without injury any explosion that may occur in practice within it, under the conditions of operation within the rating of the apparatus enclosed by it, and will prevent the transmission of flame such as will ignite any inflammable mixture which may be present in the surrounding atmosphere.

With regard to the damage which would result from a destructive short circuit within the enclosure, special attention to details of design and manufacture is necessary.

In addition to protection of the circuit supplying the apparatus, it should be such as to ensure as far as possible that the highest recognised overload for the apparatus shall not be exceeded, having regard to the amount of destructive energy available at the apparatus, calculated from the size of the generating plant and the impedance of the circuit between it and the apparatus.

SHAFT CABLES.

Consider the case of a colliery using electrical power for a number of large motors, haulages, pumps, etc. With a lay-out of this kind, it would be necessary to have duplicate feeders, 3,300 volts, paper insulated, vulcanised bitumen sheathed, with a copper sheath for earthing, double wire armoured; the copper sheath and also the armouring of the cables to be connected to the surface earth plates. No earth plates should be used underground. These cables should be connected on each side of a section switch on the main switchboard in the power house. The other end of the cables would be connected in a similar manner at the pit bottom sub-station, with a section switch between them. This switch would normally be kept open, and so would divide the outgoing circuits into two. With this method, should a fault develop on one side and the switches fail to operate, the generator would then be feeding the fault through one cable only. In some cases it may be necessary to have more than two feeders and similar arrangements should be made. The author would suggest the placing of reactances in each shaft cable, as a means of protecting the plant from any surge which may develop.

UNDERGROUND CABLES.

The author's experience has always been to use paper insulated vulcanised bitumen sheathed, double-wire armoured cables for haulages and pumps in the mine, and he is happily able to say that he has never had a cable of this class break down through faulty manufacture. When a breakdown has occurred it has been caused through falls, or journeys breaking away.

At the same time it is to be noted that cables for use in the mines should be of a better class than for other industries as they have to work under abnormal conditions, and are liable to be man-handled very often.

No cable should be less than .04 in. in size, for reasons of mechanical strength. Also, there should be some methed of marking the cables, that is, to distinguish at a glance high tension from low tension. For instance, a cable of .06 h.t. and .06 l.t., are very little different in regard to appearances; this is very misleading and liable to cause serious trouble.

All cables should be suspended where possible, but in cases where the gradients are steep, it is safer to lay the cable on the side in steel troughing. With this method, the author has prevented considerable losses by damage. Cables should not be buried as very often they are, being out of sight, forgotten till trouble comes.

Special care should be given when jointing is carried out on cables underground, and all connections should be thoroughly taped and filled with compound. The two armourings should be clamped to each side of the joint-box, there should also be a copper bonding over the box so as to ensure a very definite earthing arrangement.

In taking an earth-return test of cables, every bonding over the joint-box should be tested: taking a test from end to end is not satisfactory, the cables are often suspended on steel rings, and with these resting against the earth, the end-to-end test would be very misleading.

EARTH CONTINUITY TESTS.

The usual process of taking these tests is from the power house to the farthest point underground: perhaps including about 2500 yards of cables.

The switch is withdrawn from the base, three extension pieces are placed on to the out-going side of the switch contacts, these are then shorted to earth by closing the switch. We now proceed to the farthest point to make the test of one conductor of the cable and earth, at the same time, making sure that all fuses are withdrawn from potential transformers which may be in the circuit.

We now proceed back to the pit bottom, taking a test of the bonding over each joint-box. To take this test, we take the copper tape or wire off one clamp, and test from clamp to clamp; this gives us the assurance that the clamps are in good contact with the armouring of the cable.

Having used the Ducter for some time, the author has found it very serviceable. It enables these tests to be made much more rapidly than with the Bridge Megger, as the Ducter gives a direct reading and there are no calculations necessary; nor with the Ducter is any fastening of the testing leads under nuts and bolts needed, and again, it is lighter to carry. It may be suggested that the capacity of the battery might be smaller as this would lessen the weight, a feature which would be much appreciated, having regard to the long distances over which the instrument has to be carried underground.

INSULATION TESTS.

It is fairly certain that most electricians engaged in maintenance of cables will agree that, even under existing circumstances, the time spent on systematic and periodical testing is time well spent and is, in fact, an assurance against breakdowns. However, having no doubts that the tests are well worth doing, one is often up against the fact that it is almost impossible to get a cable shut down to permit of making the test, as this is usually carried out from the conductor to earth or between phases. As a rule, therefore, these tests are done by night, or on Sundays. Every part of the electrical euipment depends for its stability and proper performance on the maintenance of the insulation which forms an integral part of its structure.

Since all insulating materials are liable to deterioration and become more or less unstable, it is of vital importance to know in connection with a particular appliance whether its insulating material is retaining its dielectric strength.

Apart from more or less obscure sources of possible decay, all insulating material is affected by moisture and the changes in temperature which occur in service. If such materials once start to decay, the deterioration of the insulating qualities will be progressing and advance with increasing rapidity as time goes on.

Insulation is usually the most vital element in any electrical circuit, and the consequencies of its failure are ordinarily most disastrous and costly of all.

Consider the case of insulation testing with a system including 3300 volt cable, 2000 yards long, .06 paper insulated, double-wire armoured, with nine straight through joint-boxes. The switch feeding this cable was a draw-out mining type, 200 amp. capacity with the overload trips set at 60 amps. (insulated neutral). This switch tripped and a test was taken with a 1000 volt Megger, reading "Infinity" to earth and between phases. The switch was closed a number of times and a test taken each time it tripped, but with the same results. Finally, the switch refused to stay closed and it was then that, with the Megger, a dead short was located between the phases.

The indication therefore was that a partial short had developed between the phases which the 1000 volt Megger would not read. This was a very serious defect and calls for some discussion as to whether there is not some other method of localising these high resistance or incipient faults without having to keep the circuit in use until total breakdown ensues.

UNDERGROUND MOTORS.

Efficient and frequent inspection is a prime necessity: probably 65% of the money spent for repairs on motors is due to dirt in one form or another and attention to the following points will prevent a large proportion of the expense. Motor-houses must be constructed of fire-proof material and a nominal addition to the cost would render cleanliness much easier. No matter how carefully these points are attended to, some dirt will accumulate on the motor windings, and this should be blown out at regular intervals by a suitable blower or compressed air jet.

Most motor bearings are of the type known as self-oiling rings. Under normal working conditions such bearings only require attention at intervals, when the oil should be drawn off and replaced with new; the displaced oil can be filtered and used again on other less important machinery.

Haulage and pump attendants, with the best intentions, but from lack of experience, often add oil at intervals each day, with the result that such surplus usually runs over into the motor windings and mixed with the dust has a very destructive effect on the insulating material.

Ball bearings overcome a great deal of trouble, require less attention, have greater efficiency, and eliminate the risk of the rotor fouling the stator.

The air gap of all motors should be checked by feelers at least once in every three months at four points of the circumference and the results recorded in a book. This prevents undetected wear of bearings, and avoids the rotor dropping down to touch the stator with serious results.

It is a good plan to bring motors up to the surface at intervals so that they can be thoroughly overhauled, cleaned, any defects in the insulation repaired, and to revarnish the windings. A spare duplicate motor can be put into temporary service and the overhaul carried out in the repair shop.

The attention of the manufacturers is particularly directed to the insulation of motor windings; especial care should be taken with the insulation where phases cross each other as this has shown itself frequently as a very weak spot. Having regard to the condition of the mine with stone dusting all motors should be thoroughly taped and well varnished. Every nut and bolt on slipring casings and covers should have spring washers, as they are subject to vibration. Star points of the motors should be brought out for testing and connecting on either side if necessary.

HAULAGE CONTROLLERS.

Having had twenty years' experience with a large number of liquid controllers for haulage work in the mine, the author favours their use as providing perfectly smooth control with even acceleration of the motor from creeping to full speed. The sudden jerks liable to occur with metallic resistance controllers are eliminated. The value of this in service is very great, for the load can be handled without the risk of trams being jerked off the rails and with less risk of breaking haulage ropes or couplings. The strain on the ropes is reduced to a minimum.

A point which is not properly apppreciated, in connection with liquid controllers is that the strength of the electrolyte, normally a one per cent. solution, can be adjusted on site to suit the conditions of service. Thus, supposing the motor is rather on the large side for the duty required, then a smaller torque will be necessary for starting: the electrolyte can be weakened so as to increase the resistance and limit the starting current.

It is essential that apparatus installed in a fiery mine shall operate without open sparking, the liquid controller completely meets this requirement as the electrodes are submerged in all positions.

Any stop on a haulage plane from whatsoever cause it may arise, is extremely serious. The type of controller used must, therefore, virtually speaking, be proof against unreliable working and need for adjustment. The liquid controller fulfils this condition to a remarkable degree, because owing to its simple construction there is practically nothing to go wrong.

The maintenance cost of a liquid controller is extremely low, and low maintenance cost together with extreme reliability far more than compensate for the somewhat higher first cost involved.

For underground haulages where there is no natural supply of cooling water there has been, up to the present, objections to liquid controllers on account of the difficulty experienced in conveying to and carrying away of the circulating cooling water.

It has been proved after much experimental work that by the use of storage tanks and an efficient system of thermo syphon circulation of cooling water, that this objection can be satisfactorily overcome. Where this system of cooling is installed, it is recommended that the tanks be mounted as high as possible above the liquid controller. The bottom of the cooling tanks should never be less than three feet above the electrolyte in the controller, this ensures that the necessary head is obtained to provide the current rating required. When determining the size of the storage tanks to instal, say for 100 h.p. to 150 h.p. haulages, three tanks, 36 inches in diameter, and 46 inches deep (about 150 gallons capacity each) will be a reasonable basis to work from.

In cases where the continuous dissipating capacity required is not known, it can safely be assumed that it is 33⅓% of the normal h.p. of the motor. The author has had for a considerable time a number of haulages working with this system of thermo syphon, and they have given every satisfaction.

There is now on the market a liquid controller suitable for working a 50 h.p. haulage. With this controller there is no circulating water, the dissipation depends on its own body of water, which has a dissipation of 15 h.p. continuously: fresh water will have to be added when necessary. The floor space occupied by this controller is 4 ft. 9 ins × 2 ft. 3 ins., while the overall height is 4 ft. 3 ins. This controller offers great advantages when compared with air cooled grid resistances for working inbye haulages. It is to be hoped that the time is not far distant, when we shall have these smaller haulages controlled with friction clutches and gears.

In connection with the liquid type controller, one has to consider the reversing switch. This is probably the hardest working switch on the colliery, and it should be operated by contactor gear. This reversing switch should be overhauled and tested at least once a month, and the oil changed every three months. The line switch should be of the draw-out type; the ammeter, or instrument which indicates the rate at which the power is being used, should be fixed in front of the attendant, so that when looking at the working parts of his plant the instrument is directly in his line of sight. When so arranged, a sudden overload due to trams coming off the road can be observed instantly, and the haulage stopped long before a signal can be transmitted. Frequently the ammeter is placed on a switch panel outside the attendant's view, and it is then of little use.

INBYE HAULAGES.

When it is necessary to instal one or more 100 h.p. and 40 h.p. haulages in the same district, say from 2000 to 3000 yards from the main sub-station at the pit bottom, the author would suggest that one 3300 volt cable should be taken to a convenient inbye sub-station and from there to feed the 100 h.p. haulages, one or two as the case may be, at 3300 volts.

A 150kva step-down transformer, 3300 volts to 550 volts, with two or three tappings, should be installed to feed the smaller haulages, as these smaller haulages may be some distance away from the transformer. This provision of extra tappings on the transformers overcomes voltage drop and avoids the extra cost of heavy capacity cables. There are suitable transformers on the market, to meet these requirements and which conform with the regulations of the Coal Mines Act in every respect. They are of very small dimensions and are taken inbye on their own wheels. The author has had a number of these transformers in use for a considerable time and they have given every satisfaction. The temperature indicators of these transformers should be electrically connected up to a tripping device of the switch, allowing a good margin for temperature rise, and they should be tested as often as possible.

SHAFT SIGNALLING.

Since the introduction of the luminous and visible signalling system for mine shafts, which has proved very satisfactory, there have been fewer accidents. However, there is one point which is well worth considering, and that is with regard to the Home Office Regulation of the code of rings for the "Raise" and "Stop." One is given when the engine is stationary, which means "Raise," and one is given when the engine is moving which means "Stop." It has been known, that after giving an action signal "One" the on-setter, owing to a sudden emergency has given a "Stop" signal before the engineman has moved the engine. The engineman may take this signal as right away, when it should be "Stop" or "Not Move." There is here a very dangerous risk . The author maintains that when a signal "One" is given by either the banksman or the on-setter to the engineman, it should mean "Stop" every time. The "Right Away" signal should be "Two." This matter calls for further consideration and discussion.

IN GENERAL.

The engineering advantages obtained by the use of electricity are fully recognised, and fortunately the accidents from electrical causes have been very few in proportion to accidents from other causes. At the same time, the extension of the immense field for electricity depends very largely upon the freedom from fatal accidents. The author, before concluding these notes, would like to impress upon every mining electrician (himself included) the endeavour to carry out the Regulations of the Coal Mines Act to the uttermost, and if possible, go further, still striving to ensure safety in mines. It is very often remarked that the electrician is a necessary evil. It is fair and necessary that all concerned should recognise him as a man who occupies a vital position in regard to the safety of the mine as well as one of the main factors working for the economical output of coal.

WEST OF SCOTLAND BRANCH.

Gear Drives.*

Discussion.

Mr. G. N. HOLMES (Branch President) opened the discussion with an acknowledgment of their obligation to Dr. Merritt for his lecture. When they came to notice the accuracy of every detail concerned in the manufacture of gears, and looked back a matter of 20 or 30 years they realised what gear making was at that time and how great had been the developments in design.

Mr. FRANK BECKETT said he quite agreed with Dr. Merritt that the principal factor governing the load-carrying capacity of double helical gearing was not the strength to resist breaking but the resistance to pitting and abrasion as determined by the surface stresses.

Dr. Merritt had said: "increasing the spiral angle increases the normal tooth reaction for a given tangential load, and at the some time increases the relative radius of curvature and decreases the total length of line of contact." Looking at Table I this statement seemed to require slight modification, as the length of line of contact was shown to increase from 22½ degrees to 30 degrees spiral angle, and to decrease again from 30 degrees to 45 degrees, the pressure angle in each case being 20 degrees. At the same time the load per inch of line of contact was practically the same for both 22½ degrees and 30 degrees spiral angle. This seemed to point to the spiral angle of 30 degrees being near the critical angle, and superior to greater or less angles. In view also of the fact that with the 30 degrees angle there were more teeth in engagement, he, Mr. Beckett, was rather curious to learn why the

*See *The Mining Electrical Engineer*, June 1930, p. 446.

author's firm selected 22½ degrees as the standard spiral angle. Another well known firm adopted the 30 degrees spiral angle. Referring to the Shorter process of surface hardening, Mr. Beckett presumed that the fitting necessary for hardening double helical teeth would be much more elaborate than for straight teeth.

Mr. Beckett quite agreed that it is the counsel of perfection that every gear should be totally enclosed, continuously lubricated, and protected from dust and abrasive matter. It was, however, a little difficult at times to convince mining men of this. Some of the old school preferred, so they said, to have their troubles before them. They did not appear to appreciate the fact that if they would properly enclose their gears some of their troubles would disappear entirely.

The higher running temperature due to gears dipping too deeply into the oil could not be too strongly stressed. Dr. Merritt's advice on the method of securing economy in lubrication was very pertinent and worthy of careful consideration.

The paper generally contained much matter of interest to the colliery engineer and manager, and would repay careful study. There was no doubt that the pioneer research work carried out by such men as Dr. Merritt had been of very great benefit to the engineering industry in this country, and through it to the mining and other industries.

Mr. A. McK. LEES asked if Dr. Merritt could say whether there were any relative advantages in the patent wheel exhibited and which he believed was called a hypoid, over say a spiral, or perhaps a spiral as well as a hypoid over say a straight tooth wheel?

Mr. JAMES LAIRD said that, like Mr. Beckett, he had very much appreciated the paper. He quite understood the necessity for accuracy in gears by decimals to the extent of the 200th part of an inch, but in the pit they had to accept the gear as supplied and make the best of it. In regard to oil temperature, Dr. Merritt had said that the final temperature was not 140 degrees Fahrenheit. How far would it be safe to go before the oil started to carbonise? Putting limits of tolerance on mal-alignment, Mr. Laird asked how far it would be possible to mal-align with safety. Had chromium plating ever been tried as a method of case hardening wheels or for worm hardening? Would the chromium plating destroy the accuracy of the tooth face in any way? Dr. Merritt had not said anything about laminated gears: those gears were working very successfully in collieries.

Mr. D. C. GEMMELL said he had enjoyed Dr. Merrit's paper very much and that it contained a great deal that was interesting and instructive to colliery managers. A few years ago many colliery engineers had little faith in direct gearing for pump and haulage drives, belts being preferred: that was now changed. Speaking of belting, when Dr. Merritt was showing the film of the very modern shops he, Mr. Gemmell wondered why there was so much belting shown, and it occurred to him that the elimination of the belt might have been carried out a little more at home.

In no department of mining had there been more progress in the application of gearing than in the coalcutting machine. One only requires to compare the coalcutter of to-day with that of 20 years ago to realise this. The modern coalcutter is one of the finest gear reduction cases that is produced.

Dr. Merritt had just touched slightly upon one matter which Mr. Gemmell would like him to explain further. It concerned the old controversy, as to which direction should double helical gear be run to obtain the best results; that is, whether the apex should lead or follow. Dr. Merritt hinted that it did not much matter but it might be interesting if he would give us the why and wherefore for his opinion.

Mr. A. B. SMITH, in expressing his appreciation of the paper, which was of outstanding interest to engineers, said it was rare to get the opportunity of listening to a paper covering this highly specialised subject in such a practical manner. Dr. Merritt had laid stress on the necessity for seeing that the lubrication of modern gears was given careful attention, and Mr. Smith would be glad to know whether the author had found it necessary to differentiate between a speed reducing and a speed increasing double helical or spur gear when selecting the correct body of oil for lubrication purposes. Although, at a given load and speed, the pressure on the teeth surfaces is the same for either speed reduction or increasing gears, Mr. Smith had found that the speed increasing gear was more likely to shew a tendency to slight vibration, owing presumably to the longer leverage through which the power was transmitted through the driver to the driven in a speed increasing gear; and this vibration could be absorbed and smoother running obtained by the use of a slightly heavier bodied oil than would be used for a speed reduction gear of the same power and speed.

Another point on which he would be glad to have Dr. Merrit's experience was in connection with spraying nozzles used on steam turbine and similar gearing. He understood that above certain speeds in feet per minute, a generous flow of oil to the engaging side of the teeth imposed a heavy load on the gear, and where it was found necessary to attain normal running temperatures had it been found preferable to apply only sufficient oil to cushion the teeth on the engaging side and to fit a generous spraying nozzle for cooling purposes to the disengaging side of the teeth?

Mr. R. ROGERSON asked whether Dr. Merritt could give any reference to experience of fan driving underground by spur gearing: and whether he could give information as to the safe minimum and maximum diameter of solid rawhide pinions for colliery work.

Dr. MERRITT, in replying to the discussion, said: The choice of spiral angle referred to by Mr. Beckett was probably a matter of personal preference of the designer, who would be guided by the dimensions of the cutter and the possible difficulty of clearing the chip in a continuous-tooth double helical gear. The same angle is used in hobbed double helical gears because it gives the narrowest gap. The figures given in the table for the load carrying capacity of 30 degree gears are higher than those of 22½, the reason being that the tooth proportion chosen are those of turbine gears, in which the teeth are deeper than usual. If ordinary industrial proportions were used there would be no difference in load carrying capacity between 22½ and 30 degrees.

In surface hardening double helical gears by the "Shorter" process, the gear is tilted so that the tooth to be hardened lies with the greater part of its volume under water and with the face to be hardened just above the surface. The flame is then traversed across the tooth in the same way as for spur gears and the result is very satisfactory.

Mr. Beckett has stressed the value of totally enclosing all gears, and this is a point which cannot be emphasised too much or too often. The extra cost of a totally enclosed housing is more than compensated for by the longer life and lower maintenance cost of both the gears and bearings.

Mr. Lees raised the question of the hypoid gear. This is intermediate between a bevel gear and a worm gear and consequently does not possess the full advantages of either. There is rarely any need to use this form of gear, which is expensive, awkward to mount and adjust and, what is very important, it is unfamiliar to the engineer in charge.

Mr. Laird asked about the final temperature of the oil. I am not in a position to say what is the maximum temperature to which oil may be safely subjected, but an outlet temperature up to 160 degrees F seems to be quite satisfactory and oil stands up to this temperature without giving any trouble. Mr. Laird also asks how far gears can be mal-aligned. The answer is that they should not be mal-aligned at all. Whilst it is not possible to achieve perfection, the tooth contact of gears when finally mounted should be tested and any lack of uniformity in tooth load should be corrected by adjusting the bearings.

The question of the advantage of chromium plating of gears is a doubtful one: although the surface is very hard it is very thin, and the material below the surface layers would not stand any higher loading than can ordinarily be applied without failing.

Laminated gears tend to give quiter running because of the breaking of the solid mass of the gear rim, but in my own opinion they are to be looked to chiefly as an expedient for overcoming imperfections in design or manufacture.

Mr. Gemmell's reference to the drives in the work shops was rather like a hit below the belt. The drives from the motors to the line shafts are by reduction gears, but beyond that point individual motor drive is hardly possible with the bulk of machines employed.

I am sorry I omitted to refer to coalcutters in the paper. These machines require great skill in design and gears of a very high standard of quality, in order to transmit considerable power with high ratios of reduction in a small space.

In reply to Mr. Gemmel's question about the direction in which a helical gear should run I would say that there is no difference. There is certainly no advantage in running a gear in one direction, such as with apex leading, although this statement has been frequently made and repeated. Properly made a double helical gear will run equally well in either direction. There is no object in using a triple helical gear. The reason why these have been used was based on the mistaken idea that the apex must lead. Sometimes when the apex is trailing and the gear dips too deeply in oil a curious oil noise results but it does not give rise to any trouble of any kind.

In reply to Mr. Aubrey Smith, I can agree with his observations on the somewhat greater difficulty of making increasing gears run smoothly as compared with reducing gears. There is, as Mr. Smith says, no substantial difference in the conditions of tooth engagement, but there may be an appreciable difference in the frictional conditions of the bearing, particularly if the diameter of the bearing is large in comparison with the diameter of the pinion. It has not been the author's practice to specify a heavier grade of oil for increasing than for reducing gears, but the suggestion is a valuable one.

With regard to the second point raised by Mr. Smith, the practice is to concentrate all the cooling oil on the ingoing sides of the teeth. There is an appreciable churning loss due to the presence of oil between the teeth, but in my opinion the greater part of this churning loss is made up of the loss due to the change in momentum of the oil as it strikes the teeth, and would be more or less constant regardless of the point on the periphery of the gears at which it was directed. In the case of gears running at 10,000 ft. per minute the impact loss is equivalent to a pressure of 350 lbs. per square inch in the oil delivery pipe.

With regard to the last speaker's question about spur reduction gears for fan drives I would say that every gear should be so arranged that it is as far as possible removed from the effects of subsidence of the floor or movement of other parts in which it is connected. This is done by making the gear unit entirely rigid and self-contained and isolating it by flexible couplings.

With regard to raw-hide pinions, they are now largely superseded by compressed fabrics treated with bakelite which gives a much more reliable material, free from the effects of oil, water and temperature.

CUMBERLAND SUB-BRANCH.

Coal Cleaning.

W. H. HOLMES.

(Paper read 8th November, 1929)

In the early days of coal mining it was common practice to leave the finer sizes underground and to load out only the large coal, or, alternatively, the fines were brought to bank and partly or entirely discarded on to the refuse heap. The obvious reason for this was that the market was strictly limited; the size and ash contents of these smalls rendered them unsuitable for domestic purposes, and the industrial demand was only small. With the rapid development in the iron and steel industry during the last century, increasing quantities of coke were required and the market for smalls began to expand, but it was still closed to a number of coals owing to their high ash content, and such fuels had either to be disposed of for steam raising or discarded as before.

It was natural then that those interested in the engineering side of the mining industry should look about for some means whereby the impurities in many small coals could be reduced to such an extent as to provide suitable raw material for bee hive coke ovens, and it was equally natural that they should turn to the type of apparatus that had been used for many years to effect similar results in the concentration of minerals.

The first coal washing machinery was, therefore, developed from such primitive apparatus as was then in common use for ore dressing, and coal washing is supposed to have been the first method as practised in France or Belgium. Those conversant with the Continental, and particularly with French coals, will not be surprised at this, because such coals are generally associated with a much larger quantity of "free" refuse than are the coals in this country. Coal washing, therefore, was an economic necessity so far as France and Belgium were concerned, but in this country the practice was slow in developing because, in many cases, clean seams were available and dirty seams were left unworked.

The earliest forms of coal washing machinery were mostly trough washers, often running to considerable length, and fitted with movable dams. These troughs were kept in operation until they were full of refuse, then the raw coal feed was stopped, the dams were removed and the dirt was sluiced out. Later, the simple "jig" came into prominence and was followed by many mechanical and technical developments, such as the differential motion of the piston and the use of felspar in the wash-boxes treating the finer sizes.

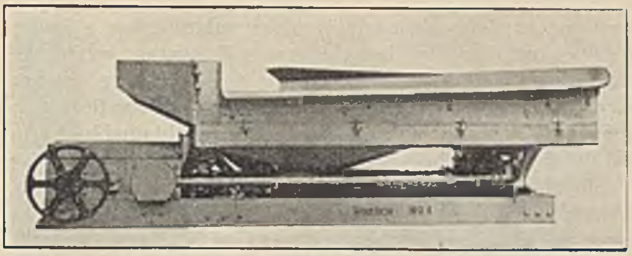

Fig. 1.

Subsequent developments in coal washing have been along similar lines, and to-day practically the whole of the coal that is wet-washed in Europe is treated in either a jig washery, of which type the "Baum" is a modern example, or in the trough type of washer, which has developed into the modern Rheolaveur. Modern examples of these two types of washery attain a very high standard of performance, but they are incapable of removing the dirt from the coal without introducing another inert material, namely, water. It will be appreciated that water is used only as a means to an end, and if the end can be achieved by some other means with a similar efficiency and economy in operation, then the opportunity is afforded of removing one form of inert material, i.e. dirt, from the coal without substituting for it another deleterious material in the form of water.

The relative merits or demerits of ash and moisture will be discussed later. The removal of dirt from coal by pneumatic rather than hydraulic means, will first be described. Just in the same way as the machine for the wet washing of coal was developed from earlier apparatus used in ore dressing, so was the first machinery to be brought into use for pneumatic separation. In this case, however, the earliest type of pneumatic concentrator was not developed from the trough, but from the jig.

It is placed on record in technical works that the first air jigs functioned fairly satisfactorily, but their capacity was very small, and it is from the wet concentrating table that the modern pneumatic separator has developed. So far as the author is aware the first installation for the pneumatic separation of dirt from coal was put to work in Brilliant, New Mexico, U.S.A., in 1919. That plant is still in operation and its component separators contain the essentials for effecting successful separation, namely, they consist of a pervious surface on to which the raw coal is fed and where it is acted on by an air pressure and a jigging motion. Once these factors are regulated it is possible to render the bed of coal quite mobile, so that it behaves almost like a liquid, and the heavy particles of dirt or pyrites sink through the mass of coal particles and, reaching the bottom, are collected as a separate product.

It is quite true that Stephenson's Rocket was propelled by means of steam and pulled trucks along rails, but it would hardly meet present-day conditions on our railways. The railway tractor has been so developed over a period of 100 years as to be altered out of all recognition, retaining, however, its fundamental features. Just in the same way the apparatus employed in the pneumatic separation of dirt from coal has also been vastly altered and for the same reason, namely, that if the coal industry was to have any use for this process, it must be developed and improved to meet the needs of the industry. The advances that have been made, not in the last century, but in the last decade, have raised pneumatic separation from the level of a makeshift, to be used in arid or frost-bound localities, to

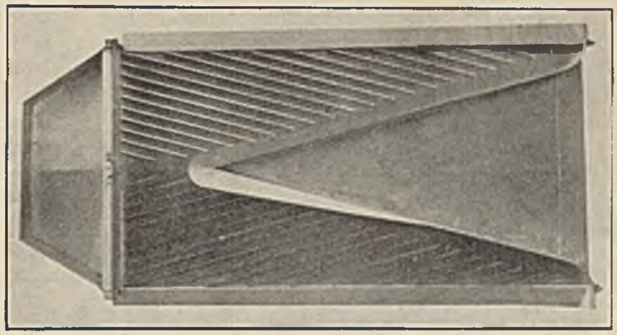

Fig. 2.

that of a process which compels the attention of the world's mining industry.

There would seem to be no place in such a brief paper for a description of the various stages through which the modern pneumatic separator has been developed but rather to describe it briefly as it exists to-day. The illustration, Fig. 1, shews the side elevation of a standard "VEE" Pneumatic Separator. A reciprocating motion is imparted to the separator by means of a pair of eccentrics having a throw of $\frac{3}{8}$ in. running at a speed of about 400 revs. per minute. This motion is transmitted to the table through a pair of inclined toggle plates, so that the machine moves both forward and upward on the forward stroke and downward and backward on the return stroke. Below the centre of the separator the fan is connected to the air chest supplying the necessary air pressure to the deck. The second illustration, Fig. 2, shews the separator surface in plan. The raw coal is fed from the feed pan on the left and is traversed forward by the combined action of the air pressure and and the jigging motion of the separator. As the mass of coal passes forward it moves as a fluid and the heavy particles sink through the mass on to the pervious deck. Here they are trapped in the inclined riffle and moved away from the spillage edge of the machine over which the clean coal is deilvered. There are thus three actions going on simultaneously.

(1) The heavy particles sink vertically downwards;
(2) These same particles having reached the pervious surface of the deck are deflected inwardly; and
(3) The upper stratum, freed of heavy particles, consists of clean coal and is spilled progressively by the narrowing of the deck over each of its outer edges.

The heavy particles of refuse having been concentrated towards the V shaped banking bar, move along it and are discharged at the extremities of the V.

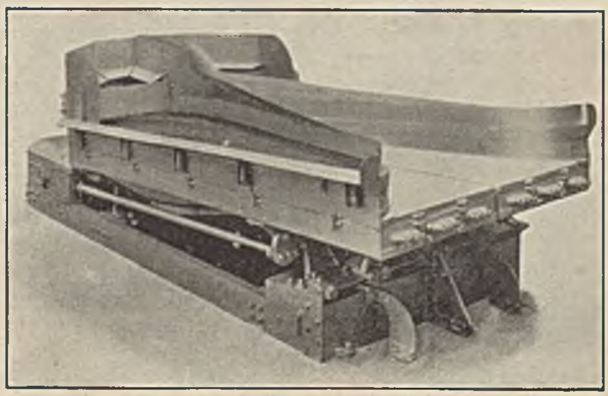

Fig. 3.

It is always surprising to those who are not familiar with the working of these separators to see how rapidly a handful of refuse thrown on to the fluid bed of clean coal disappears. It sinks almost as quickly as if it had been thrown into water.

As in all phases of engineering, there was a demand in the dry cleaning of coal for a machine having a higher capacity, and to this end the Super "VEE" was developed. This consists essentially of two half decks, each with its own air chest mounted upon a single running gear. Details of this construction will be seen in the illustration, Fig. 3.

It is general in practice to take three products from the separator, viz., clean coal, middlings, and refuse. This middling product consists of a mixture of clean coal, intergrown material, and refuse, and amounts usually to about 10% of the output of the separator. It is returned to the raw coal feed, recirculated over the separator, and divided up into its components according to their density. It has been found by experiment that very little difference is made to the purity of the coal and refuse by circulating this product. It is also found that it does not accumulate and, further, it affords an insurance against fluctuation in the stone content of the raw coal.

A pneumatic separator plant is very like a washery. Indeed it may almost be said that two-thirds of the designs and first costs of the component parts of either type of plant are practically identical. In each case the raw coal must be lifted to the head of the plant, either some storage mast be provided, or means devised whereby a reasonably steady feed is given to the cleaning machinery and, finally, the separated products must be taken out of the building for delivery to points where they are loaded up into wagons or otherwise disposed of. The differences are that pneumatic separators are installed in place of wash boxes or troughs; circulating water pumps are replaced by fans; and the necessary plant for the collection of slurry and the clarification of the wash water are replaced by a cyclone and bag filter for the collection of the dust and the cleaning of the air.

Having described briefly the means by which coal is cleaned pneumatically, the questions naturally arise:

(1) How efficient is this process?
(2) What is the largest, and what is the smallest size of coal that it will treat?
(3) What is the highest moisture content that can be handled?
(4) What is the biggest range of sizes that can be treated on one separator?
(5) What is its first cost per ton per hour, and how does it compare with a wet washery as regards operating costs?

There is no answer to any of these questions in a general way, because every coal cleaning plant must be treated on its own merits, no two coals are alike, and operating conditions differ from one pit to another. It will be better then if these questions are treated one by one as well as they can be treated in a general way, and instances given from specific cases to support the statements made.

So far as the efficiency of pneumatic separation is concerned, it is generally true that 2" to 0 slack can be dry cleaned down to an ash content that compares very favourably with good washery operation—but this can rarely be done dry in one size. In wet washing one has the density of the wash water which fills the voids between the particles of coal acting favourably, whereas in pneumatic separation an artificial fluid has to be made from the particles themselves, which mixture has a lower density than would be the case if water were the separating medium. It follows then that a rather narrower range of sizes must be treated pneumatically in order that results comparable to those obtainable by a wet washery can be procured.

In the early days of the process it was considered necessary with the apparatus then available to make as many as six sizes in the treatment of a 2" to 0 slack, but modern practice tends towards the use of two, or possibly three, sizes and equally good results are obtained.

A recent plant consisting of two Super "Vee" separators and installed for the treatment of 75 tons per hour of 2" to 0 slack in two sizes—2" to ¼" and ¼" to 0—gave the following average results over a week's working:

2"—¼"	Raw Coal Ash	15.7%
	Clean do.	5.2%
	Coal in stone	1.5%
Fines	Raw Coal Ash	23.3%
	Clean do.	11.4%
	Coal in stone	3%

The fixed ash in this coal is 4.1%. The comparatively high ash in the cleaned coal being due to high ash dust.

In a similar plant using similar sizes, the larger sizes averaged 6.8% over a week's running, and the fines 7%, the raw coal containing 13% of ash. In this case the fixed ash was 4.7%.

It will be seen that excellent results can be obtained with only a small amount of preliminary sizing, and it is of interest to note that for a size range of 2" to ¼" in the case of the first plant cited, the ash content of the cleaned coal is only 1% above the fixed ash. In the latter instance it has been found possible from figures taken in loading out cargoes of coal to dry clean the smalls to a lower ash content than that of the hand-picked round coal. This, of course, is due to the fact that the fixed ash content falls in the smaller sizes.

Generally speaking the upper economic limit of size, so far as pneumatic separation is concerned, is about 2½", and whilst there is no definite lower limit, it is assumed for commercial purposes to be $\frac{1}{64}$", or approximately 1 m.m. Below this size all processes which depend on the difference in density between the coal and the stone either fail completely or function at such low capacities as to be of doubtful utility. Material below this size must be either treated by froth flotation or used as it is.

No definite figure can be given so far as the "free" moisture content of the coal is concerned, because this depends in its turn upon how much fire clay there is in the associated refuse, and upon how much fine dust there is present in the coal. So far as the treatment of coal above ⅛" is concerned, moisture is of little or no importance. It is only when the particles of coal and dirt are so small as to adhere to each other so strongly that they cannot be shaken apart by the motion of the table, that the process fails.

The longest range of sizes that can be treated in one operation is again indefinite. In some foreign coals this is quite narrow, probably only 2, or 3, to 1, because there is little difference in density between coal and refuse; but a study of the operation of plants in this country treating reasonably free-cleaning coals 1" to 0, without preliminary sizing, shews that almost perfect results are obtained down to ¼", a large percentage of stone between ¼" and $\frac{1}{16}$" is removed, but below this figure the improvement is confined to the removal of a small percentage of particles of heavy pyrites.

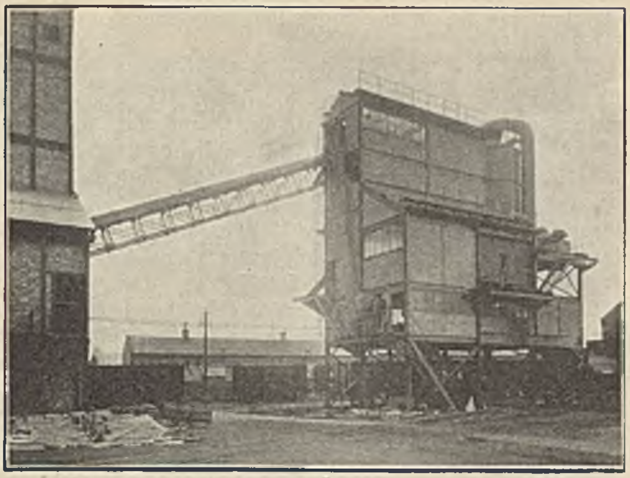

Fig. 4.

A paper read before a Technical Society does not appeal to the writer as being the ideal place to discuss the question of first and operating costs in detail, however important they may be. As generalisations, such figures are apt to be misleading, and, if given in detail, they tend to associate the reading of technical papers with salesmanship. Sufficient to say that such figures compare very favourably with those for washeries.

A clearer conception of this process in commercial operation may be obtained by describing very briefly three plants, the first being a small and simple installation for the treatment of Unsized Coal, the second being a larger and more elaborate plant for the preparation of a Low Ash Coking Slack, and the third embodying a new development of the process.

The first plant is illustrated in Fig. 4. Northumberland Steam Smalls 1″ to 0 are taken from the colliery screening plant by means of a belt conveyer to the head of the plant where they are discharged into a 10 ton storage bunker. This discharges on to a Super "Vee" Pneumatic separator which is enclosed in the dust hood. The clean coal and shale are discharged into wagons from this plant, whilst the dust-laden air is drawn off into a dust filter seen at the right hand side of the plant, the elevator returning middlings to the raw feed is seen on the left-hand side of the plant in the illustration, Fig. 4.

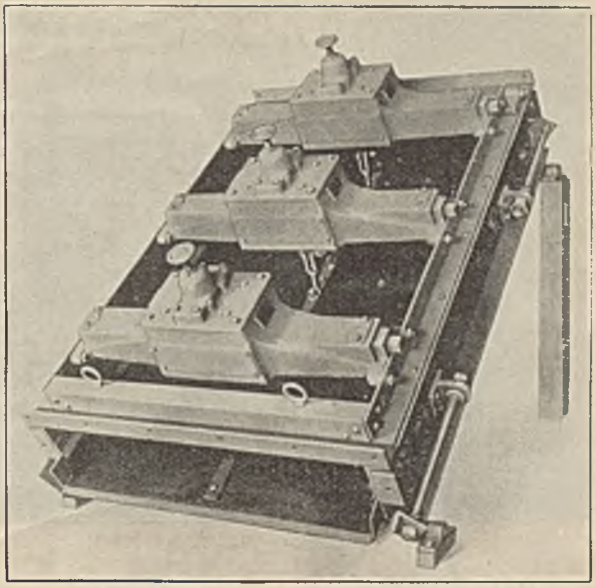

Fig. 5.

The second plant described was installed for the cleaning of Durham Coking Slack to permit the manufacture of an 8% ash coke. This plant has a capacity of 100 tons of coal per hour, and is equipped with four Standard "Vee" Separators. Here the raw coal taken to the head of the pant is passed over two Hummer Vibrating Screens separating at ⅛″. The oversize consisting of coal 1½ ins. to ⅛ in. is passed over a further screen fitted with a ½″ mesh. All three products, 1½″ to ½″, ½″ to ⅛″, and ⅛″ to 0 are fed to their respective separators, one being installed to deal with each of the two larger sizes, and two being installed to deal with the fines. This latter point is necessary because of the high percentage of fines in this coal. The type of vibrating screen employed is shewn in Fig. 5. This type of screen is installed almost universally in pneumatic separator plants, first because of its high capacity per square foot of screen cloth, and secondly because only the screen cloth is vibrated, thereby eliminating vibration from the upper part of the building. In consequence this screen can be installed at heights where the operation of a jigging screen, with its heavy unbalanced parts, would be very objectionable indeed.

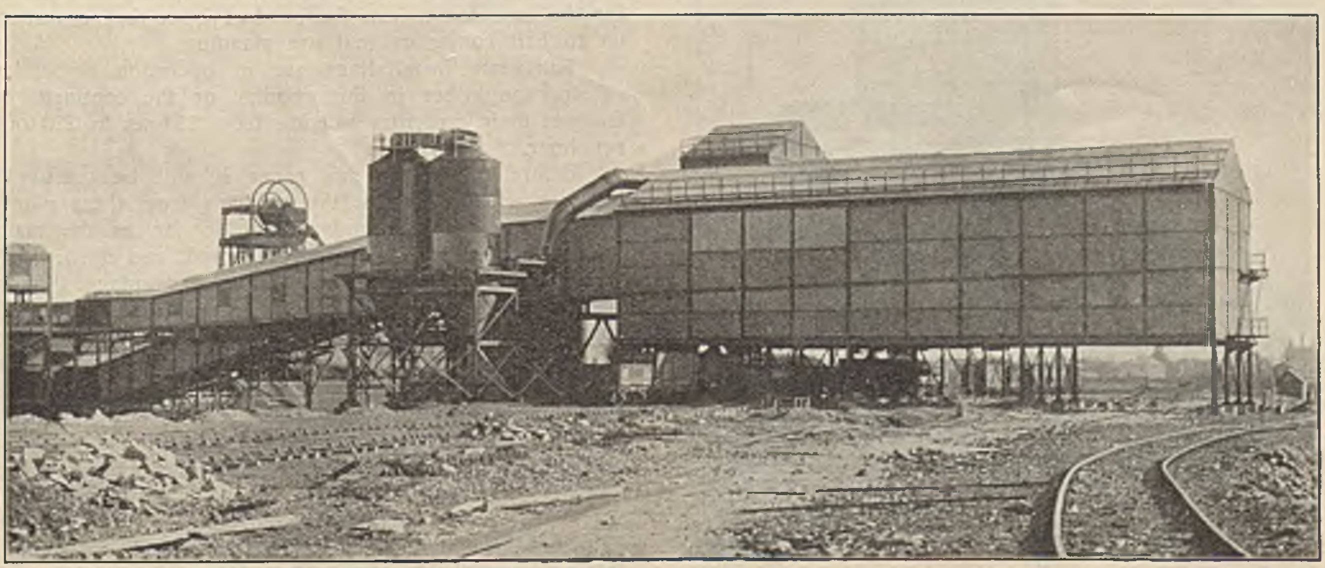

Fig. 6.

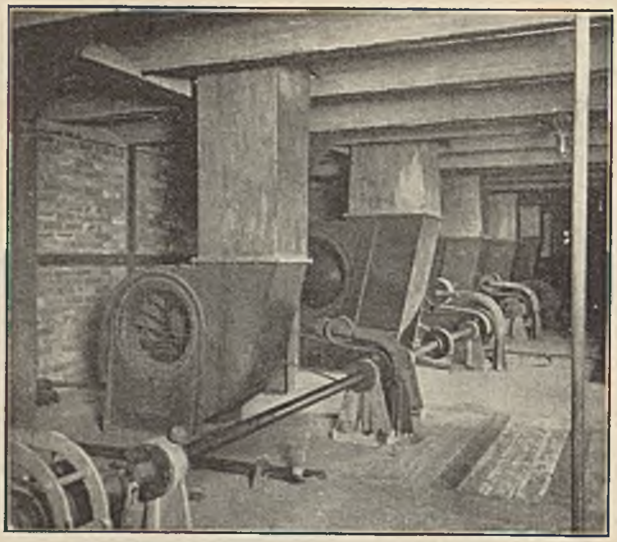

Fig. 7.

The third type of plant (shewn in Fig. 6) has recently been put to work in County Durham, and in this case the opportunity was afforded of building the cleaning plant and the screening plant together. The full tubs are run through the tipplers, and the smalls below 2" are screened out and elevated to a raw coal bunker which feeds the pneumatic separator plant. Here, the whole of the coal 2" to 0 is treated on a primary Super "Vee" Pneumatic Separator where practically the whole of the visible stone is removed and the partially cleaned coal is passed on to two Arms Horizontal Vibrating Screens. Here the cleaned large coal is removed, whilst the partially cleaned fines are passed on to a second pneumatic separator where the smallest shale is removed. The whole of the cleaned smalls are re-mixed and are fed on to a channel passing down the centre of the picking belts. By this means the hand-picked large and the cleaned smalls are delivered into wagons together, in the correct proportions, and are shipped for export as Gas Coal. This modification of the process offers many advantages, and will probably in the future become standard practice where more than one stage of cleaning is required.

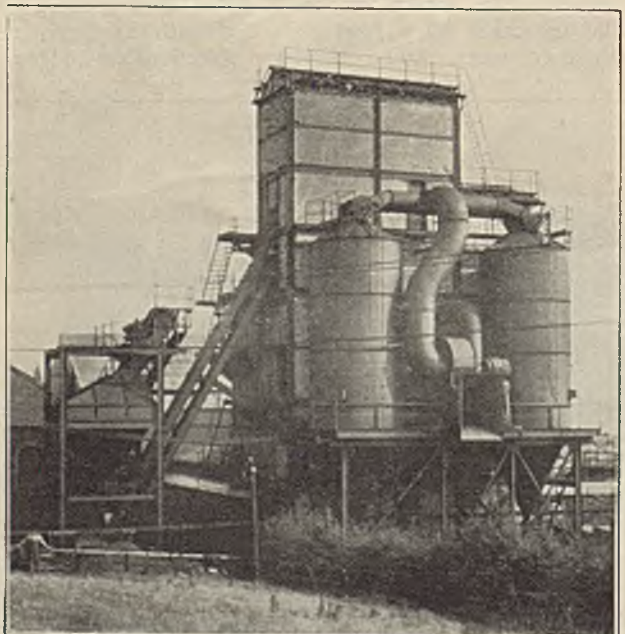

Fig. 8.

Two points in the design of pneumatic separator plant remain to be discussed, the first is the air system in connection with this type of plant, and the second is a note regarding the electrical equipment.

Free air is drawn into the fans underneath the separators and is discharged into the air chests and through a bed of coal with the necessary pressure (ranging from 3" to 5" water gauge) for this purpose. A typical fan floor is seen in Fig. 7. The separators are completely enclosed in mild steel hoods and their outlets connected to a suction range leading to a Waring Dust Filter. This filter consists of a mild steel cyclone wherein the heavier dust particles are deposited, and upon which is placed a bag filter into which the vortex from the cyclone passes upwards, carrying with it the finest dust particles which cannot be separated in the cyclone. These are collected on the inside of the filter bags and the dust-free air is sucked out from the top of the casing by means of an exhauster fan. Two of these filters with reversing valves and fan are shewn in Fig. 8. The problem of handling large quantities of coal dust and air has been solved by this means, and in the plant illustrated there is very much less dust than is to be found in the average colliery screen house. Generally speaking, it takes about 20,000 c.f. of free air to treat one ton of coal, and from this about 1 cwt. of dust has to be separated.

So far as the electrical equipment is concerned, the motors must, of course, comply with the Mines Regulations and are of types familiar to all mining engineers. One most interesting feature, however, in the electrical installation, which has been made standard throughout the whole of the plants with which the writer has been associated, lies in the centralised control and automatic contactor gear. A push button panel is provided on the separator floor comprising a main "start" and a main "stop" button, and individual stops for each unit. A typical contactor panel is illustrated in Fig. 9. On pressing the main start button the contactor clock is set in operation and operates one unit of switch gear after another at predetermined time intervals, the sequence being so arranged that the conveyors handling the finished products are the first to start up, whilst the elevator or conveyer bringing the raw feed into the plant is the last unit to function. The plant is therefore made practically fool-proof and it is virtually impossible for the operator to run the product from the separators on to belt conveyors that are standing.

Thirty-one installations are in operation or under construction either in this country or the continent of Europe, their capacities ranging from 25 tons to 250 tons per hour.

Before concluding this paper it will be useful to consider whether or not the products from these plants possess any particular advantages so far as the main fuel consuming industries are concerned, and if so, what these advantages are. There is one advantage that is common to all these industries, namely, the saving in freight on small coal, because, prior to the introduction of pneumatic separation it was inevitable that either ash or moisture must be transported along with the pure coal substance. It does not lie within the province of this paper to discuss whether such an advantage is shared between the producer and the consumer, or whether the benefit is confined to either party; but it will surely be agreed that it is economically unsound for either of them to waste money on transporting something that is worse than useless to somewhere where it is not wanted.

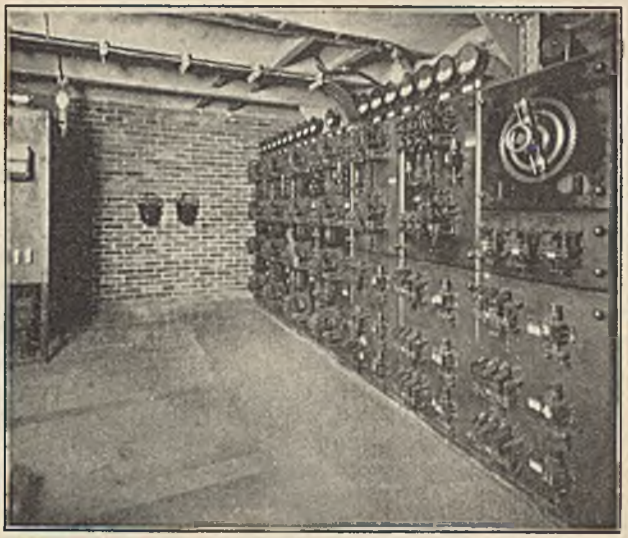

Fig. 9.

So far as steam raising is concerned, it will readily be conceded that water associated with boiler fuel is not only lacking in calorific value, but is actually a consumer of a portion of the available heat in the fuel. Moisture has one use and one use only in this connection, and that is in enabling duff or fine slacks to be fired on certain types of chain grate stoker.

In the burning of pulverised fuel, dry cleaned coal as a raw material offers considerable advantages because damp coal cannot be pulverised to the required degree of fineness without preliminary drying, whilst, on the other hand, fuels that contain high percentages of dirt, especially pyrites, are a prime source of high costs in the working of pulverised fuel installations. A comparatively small proportion of pyrites will not only send up pulverising costs considerably, but it has been proved to be the most fertile source of erosion of refractory materials in the installation.

Comparatively few years ago it was thought that anything that would burn could be used as pulverised fuel. Experience taught us otherwise.

In several pneumatic separator plants the dust from the collectors, a large proportion of which is already below 200 mesh, has been pulverised and fired under water-tube boilers.

The next industry to consider is the first one that was affected by the introduction of this process, that is to say, the gas industry. Here, a large tonnage of small coals, especially in Durham, have been made available for this market by pneumatic separation. Originally their ash contents were so high as to render them unsuitable for this purpose, whilst had they been washed with water, their moisture contents would have been equally high and equally objectionable. In a modern gas works continuity and uniformity of operation are absolutely essential, and it is only by the provision of a raw material having a reasonably low and uniform content of ash and moisture that this end can be attained. Moisture has not only a detrimental effect on the output from the retorts, but also on the retorts themselves; and, further, having been evaporated from the retorts, it has again to be dealt with in the working up of the residuals.

In the other branch of the Carbonisation Industry, namely, the manufacture of metallurgical coke, the question of throughput is perhaps the most important.

In the mining of coal, and in the manufacture of coke, pig iron, or steel, it is equally true that overhead charges are lost on every ton of product that is not won or made; assuming, of course, that a market can be found for it; and when it is borne in mind that each 1% of unnecessary moisture put into a coke oven increases the carbonisation period by approximately ¾ hour it will be seen that this is a very important matter indeed. Also, as is the case in the gas industry, moisture has a detrimental effect upon the oven structure, and its influence is felt also in the by-product plant. In an installation recently put to work in Germany, only the coal below 10 m.m. is dry cleaned and mixed with the larger washed coal. Yet a saving of approximately 9d. per ton of coke has resulted.

Pneumatic separation will, in the near future, offer another advantage to the coke manufacturer in that each 1% of moisture reduces the yield of surplus gas by approximately 125 c.f. per ton treated. At the moment, when so much coke oven gas is bled to waste, this is not a vital matter, but there are indications that surplus oven gas will require to be utilised more profitably, and the 125 c.f. of gas referred to above will probably have a market value of nearly one penny.

The objection may be raised that many coals will not make a satisfactory coke unless they are fed to the oven in the form of wet compressed charges. The answer to this is that there are actually very few caking coals which cannot be converted into a satisfactory coke without resorting to compressed charges.

WESTERN DISTRICT SUB-BRANCH.

Discussion of Report of H.M. Electrical Inspector of Mines for Year 1928.

(*Meeting held 29th March,* 1930).

Mr. J. A. B. HORSLEY (H.M. Electrical Inspector of Mines) provided the following notes with which the discussion was opened. In Mr. Horsley's unavoidable absence, the notes were read by Mr. W. M. Thomas.

1.—*Use of Electrical Power.*

Table 1 shews decrease in the number of mines using electricity of 162 but an increase in total h.p. of 240,400.

It also indicates a progressive falling off in the annual increment, viz.:—from 117,000 in 1924 to 38,000 h.p. in 1928.

This might suggest that the use of electricity in Coal Mines is approaching saturation but from knowledge of the actual opportunities for the use of electricity I do not believe that to be the case.

The economic state of the industry is more probably the explanation. Apart from financial stringency, what is there to retard a great expansion in the use of electrical power?

2.—*Conditions limiting the use of Electricity at Mines.*

Consider first the use of electricity at bank.

There is an almost untouched field in the major applications of electric power to Winding and to Ventilation.

Here there is no question of danger to life but only considerations of reliability and comparative cost.

Let us take reliability first.

The electrical motor with its associated switchgear, given skilled supervision, is not wanting in this respect.

There is an element of unreliability, however, in the transmission lines owing to the occasional intervention of natural forces outside the control of the engineer but that has not prevented the development of electrical transmission over considerable areas, nor has it deterred both collieries and other industries from relying upon such transmission. Of course where continuity of supply is of paramount importance, duplication of lines is essential with an ample reserve of power for feeding the lines.

As to cost, the major difficulty in which the electrical engineer finds himself is in pitting ascertained costs, or reasonable calculations against assertions which are not founded upon a cost sheet. However, the merging of small collieries in groups is pointing the way to the elimination of the isolated steam plant.

Below ground the reliability and superior economy of electrical power are to-day unchallenged but another consideration enters.

It is safety.

Under this heading there are three risks to consider, viz. : shock, fire, and explosion.

Table 3 shews that of the number of fatal accidents in the last 10 years, 78% were due to shock, less than 1% to fires, and 14½% to explosion of firedamp. The relative smallness of this last figure, although it appears to be a tribute to the safety of electricity is really due to its exclusion from dangerous places.

3.—*Flame-proof enclosure*.

Much has been done in recent years to regularise the position in this country in regard to what is known to-day as "flame-proof enclosure".

For example, there is a B.S. Specification No. 229 defining the term flame-proof enclosure and in which tests have been prescribed to prove compliance with that definition. At the same time arrangements were made with Sheffield University to carry out type tests and Certificates were given by the Mining Department of Sheffield University in favour of apparatus that had successfully passed their tests.

The Mines Department of the Board of Trade has now decided to undertake such testing and to give official certificates for apparatus that passes their tests and also satisfies their requirements in details of design.

4.—*Maintenance*.

It is one thing, however, to procure apparatus that is initially safe but it is quite another thing to keep it safe under working conditions.

In this respect colliery practice is woefully lacking, as may be seen by perusing the accounts of accidents in which firedamp was ignited by "open-sparking". Until it is realised by colliery management that a special organisation is necessary to provide for and to enforce adequate maintenance, little progress can be expected in this direction.

Nevertheless, the future of electricity at the coal face in gaseous seams is bound up with this question of adequate maintenance.

5.—*Use Electricity at the Coal Face*.

Table 11 shews that the percentage of mineral got by machine mining in Great Britain was 25.2% for the year 1928, while Table 12 shews that 11.42% of the mineral got was conveyed by machinery. Table 11 shews that 65.9% of the machine-cut mineral is credited to electricity while Table 12 shews that 43% of the number of conveyors in use were electrically driven.

6.—*Electrical Accidents*.

As to accidents from electrical shock, Tables 3 and 6 indicate a position that might be considered satisfactory, were it not that nearly every one of these accidents might have been avoided.

This characteristic of avoidability is, however, really the hopeful feature in these accidents for it is a measure of the improvement that can be expected when adequate maintenance becomes the rule rather than the exception.

I would direct your attention in particular to the review of accidents with trailing cables and plugs in Table 9.

Such accidents are not inevitable but with the increasing use of electricity at the coal face these accidents will increase, to the prejudice of electricity, unless it is realised that they are generally preventable and that it is possible to prevent them by better designs and by a properly organised system of examination and testing.

It is not sufficient to provide the electrician with a roll of sticky tape and a Megger and expect him to keep the trailing cables safe in his spare time.

7.—*Trailing Cables*.

Too much is expected of the trailing cable.

It is not designed to serve as a roller for the transit of sections of a conveyor, nor as a stell prop.

Flexible cables should never be pulled out from a simple coil, for that results in twisting the cores with inevitable injury.

The surplus length should be flaked in a figure of 8 so that, when the end of the cable is drawn out, each alternate half twist is reversed.

There is no need to use unarmoured flexible cables for conveyors and loaders. The armoured flexible cable is giving satisfactory service.

8.—*Precautions before working upon high pressure circuits*.

With the linking up of groups of collieries, involving transmission at high pressure, the importance of Reg. 131 (g) is coming to the front. M.D. Cir. 23, which was sent to all collieries in 1927 drew attention to this Regulation.

Two things are necessary for the avoidance of serious risks. These are, first, the provision of means to enable the circuit to be put to earth, before the conductors are handled and, second, the establishment and enforcement of a rigid routine. Structural provision in the switchgear to enable the circuit to be put to earth without danger to the operator, should be regarded as an essential requirement.

Table 4 shews that during the ten years 1919-1928, 22 electricians lost their lives, out of 90 persons killed. In the majority of these cases the electrician was attempting work upon, or close to, live conductors.

This prompts me to suggest that use should be made of a live conductor indicator, such as a small Neon tube. A detector of this type, suitable for the pocket is procurable and although it should not be relied upon entirely it would have prevented some of these fatal accidents.

9.—*Earthing of apparatus and automatic isolation of faulty circuits*.

I will conclude with a reference to the subject of earthing. It is essential that all metallic parts other than the conductors shall be properly earthed but such earthing is not in itself an assurance that a dangerous, or even a fatal shock, cannot be received from the earthed apparatus.

Such earthing is, under colliery conditions, only a means to an end.

If the insulation gives way, in the winding of a motor for example, it generally results that a leakage current flows in the earthing conductor until the circuit is made dead by the automatic cut-out, if any, provided for that purpose.

Under such conditions, there is, therefore, a potential gradient over the earthing conductor and anyone touching the motor frame will receive a shock, the severity of the shock depending upon the potential gradient.

If the installation is only protected by overload devices it is obvious that unless the fault current exceeds the working current the overload device will not operate.

Where leakage protection is used, however, the faulty circuit will be isolated when the fault current reaches, say, 10% of the working current. There is, therefore, a much greater probability that the faulty circuit will be isolated promptly so that the chances of a serious accident are substantially reduced.

There is evidence that tends to shew that the duration of the shock determines, to some extent, its consequences. If the victim is not held fast, he is more likely to escape death or serious injury.

Mr. HANNAH said that he looked upon Mr. Horsley's report as an annual nightmare. One read it through and immediately visualised each type of accident as so easily occurring at the collieries with which one was connected. Mr. Horsley divided the accidents into two groups, "Electrical Shock" and "Ignition of Firedamp". Mr. Hannah's experience during the last year or two was that there was little opportunity of igniting firedamp.

Applications to instal electrical apparatus inbye were being very strictly scrutinised by H.M. Inspectors of Mines and, having regard to the recent explosion in the neighbourhood, perhaps rightly so. It was, however, a great pity that they should see electricity being driven back from the coal face instead of advancing towards it, and from that point of view Mr. Hannah got back to his favourite subject—the colliery managers. He thought the colliery manager was to blame for this state of affairs. The mining electrical engineer had too little scope and too few opportunities of exercising his own judgment. If he might say so, the engineers were a rather inferior lot of men too prone to accept the crude conditions which existed and very often unworthy of the plant entrusted to their care. The manager, through lack of understanding, did not set a high enough value on the electrical staff and consequently this side of the industry did not attract the very best type of man. He hoped, however, that the stringency exercised by the Inspectors would not be pressed too far. When evidence is produced that the requirements of the C.M.A. and the Electrical Regulations are being properly met at a particular colliery then as much latitude as possible should be allowed that concern.

All the other items in the report could be commented on. One in particular, the rupture of switchgear at Windsor Colliery was interesting, and they owed a great debt to their former President, Major Ivor David, for getting down to earth on this subject and shewing how the conditions obtaining at any point of a system could be easily calculated and provision made accordingly.

The whole nature of Mr. Horsley's report shewed that it was intended to be of assistance to the mining electrical engineer and he regarded it as being an effort to promote the use of electricity in mines rather than to restrict it in any way.

Mr. S. T. RICHARDS (Chairman) said there was no doubt that Mr. Horsley was out to assist the mining electrical engineer, by giving him a freer hand. As Mr. Horsley said, a good deal of responsibility rests with the colliery management. One thing that is striking in the report is the emphasis that Mr. Horsley puts upon adequate maintenance. Owing to the state of some collieries in the last few years, it had become impossible to give the plant adequate maintenance unless some other means were found to assist the electrician. Mr. Richards thought the colliery management should assist the electrical staff more in this respect. Taking the question of accidents due to trailing cables, Mr. Horsley had said these should be examined once a day and brought to bank once a week, but in many collieries it was impossible to do this. True, the electrician examines cables at every opportunity, but it is pretty nigh impossible to give them a thorough examination in the mine; even on bank it takes a long time to examine trailing cables for faults. Mr. Richards gave an instance where a cable had been closely examined from end to end and thought safe; then a final examination was made and a very minute crack was discovered, and found to go right through the core. A casual examination of a trailing cable is by no means satisfactory. Mr. Horsley had suggested in his report a system for discovering and locating weak spots in trailing cables, and Mr. Richards read the recommendation in question. Mr. Horsley cited two instances of electrical shock, where, after very minute examination, it was discovered that the fault was caused by the puncture of the trailing cable by the detonator wire after shot firing. That accidental damage introduced again the question as to what type of cab tyre cable should be employed for coal cutters.

Mr. Horsley had drawn attention to the plugs, and Mr. Richards pointed out that there is a standard plug on the market that will no doubt, when put into service, minimise accidents due to plug trouble.

Re the application of flexible armoured cables for conveyor work, Mr. Richards said that at the collieries with which he was connected, in every case they employed flexible armoured cable, and experienced no trouble in so doing.

As to costs, he said far more progress would be made in the application of electricity in coal mines if, when schemes were put forward, accurate estimates of costs were made on both sides.

Re safety, he thought what was required was the education of the men operating electrical machinery.

With regard to the specification for flame-proof enclosure, the Mining Dept. of the Sheffield University issued a certificate for a type test. He thought that, seeing such serious accidents occurred in the use of switchgear, it was quite possible for a switch conforming to an approved type to be not absolutely flame-proof. There should be a certificate for each switch; each switch should be tested individually.

Referring to testing of the installation, Mr. Richards said he had tried to keep a system of weekly testing and endeavoured to keep schedules in regard to each colliery shewing the records of any failure of insulation or weakness in sulation.

Mr. Richards then referred to the new Memorandum issued by Mr. Horsley, and read to the meeting the suggestions made therein.

Re M.D. Circular 23, he would like to have the views of members as to this, as there were several situations where the application of this circular is very difficult.

He referred to an Editorial article in the current (March, 1930) "Mining Electrical Engineer" dealing with the General Regulations, with special reference to the new Memorandum issued by Mr. Horsley on the electrical rules, and thought it should be well studied by every member.

Mr. C. E. YATES—Mr. Horsley's report for 1928 was, as usual, both interesting and instructive, although they must all regret that Mr. Horsley was not able to be present to answer any questions which they might wish to ask him.

After reading the figures given in Table 1 of the report, and hearing Mr. Horsley's comments upon the falling-off in the annual increment, he thought it would be interesting to compare figures of horse power in use in South Wales and Monmouthshire for the years 1923-1928. These figures, as given in previous Reports, shewed a steady annual increase in the h.p. of motors in use, but a steady decline in the annual increment, which in 1924 was 28 (in thousands of h.p.) against 6 in 1928. An investigation of the table for h.p. in use for the various duties above and below ground in South Wales and Monmouthshire for the past six years gives some interesting figures. He had tabulated these, and quoted them to the meeting.

Again considering South Wales and Monmouthshire alone, there was only one fatal accident in that district during 1928, which represented 6.6% of the total fatal accidents for the year. As the h.p. in use in the district was about 25% of the total for the whole country, he thought that they had some cause for self-congratulation. For the area covered by the Western District Sub-Branch of the Association there was a clean bill of health for the year under review, a record which he trusted would be maintained in future reports.

Mr. TANNER said that the report contained much that is useful. There was a time when they were all afraid of the Inspectors, but he felt that in Mr. Horsley they had a friendly helper. The keynote of Mr. Horsley's previous papers before the Association had been—"Is it a good engineering job?" Prompted by this attitude, there was great benefit to be derived from Mr. Horsley's Reports.

As to the increased use of electricity in mines, they could do their share towards removing the retarding forces. There should be single control of the engineering department of the mine. Electricity is applied to mechanical purposes in mining work, and mechanical and electrical engineering could not be separated. Another thing that retarded the expansion of electricity in mines was that of the design of apparatus.

With regard to adequate room for apparatus, colliery managements were blamed, but the colliery electrical men were not free from blame, because it was their duty to see that there was adequate room for apparatus. Simplification of design was needed for the expansion of electrical power. The need was for plant—strong, accessible, and without too many separate parts.

The Regulations should be made more flexible and more trust placed in the man on the job. Having the right man in the right place, there would be no need for such stringent regulations. To secure the right men for the job, a certain definite standard was needed, such as a Government Certificate. They, as a branch, should endeavour to obtain information as to the qualifications of electricians, and whether any man meeting with an accident held the Certificate of the Association.

Mr. Tanner then referred to the folly of aiming at a low weekly cost instead of spreading the expenditure over a longer period; in the latter case repairs and renewals, etc., would shew up to better advantage.

With regard to choice of gear, he said the people who buy, or have to pay for, gear, depend on advice, but do not always get the best advice. Consultants were often out of touch with conditions underground, and apt to put forward suggestions based on efficiency of gear. It did not necessarily follow that it was the best for the colliery.

The number of accidents due to shock would be reduced if they had more room to work in. He had seen really good gear put underground in a sub-station which was hanging with fungus, and damp.

With regard to flame-proof motors, it was all very well to have certificates of tests, but if a machine failed, it was usually the windings which had gone. He thought they were carrying this flame-proof business a little too far. If they had started from the other end they could improve matters greatly.

Mr. Tanner concluded with a reference to the efficient ventilation of machine rooms, which would greatly improve the safety of electrical machinery.

Mr. COPE.—When reading through the report, it was necessary to understand the underlying ideas of the Inspector. Obviously he was not satisfied with manufacturers. He was going into the question of design, and it was expected that permitted electrical apparatus would be defined. Mr. Horsley was going to take up the question of Reg. 131 g very seriously. It was evidently a very big subject, especially with old gear. Again, Mr. Horsley appeared to shew a particular liking for braiding on coalcutter cables. Mr. Cope said he thought at first that the braiding would be a very good precaution, and he had put in a high tension cable paper, bitumen and and double wire armouring; but he had been very disappointed with this braiding, and after about three months of use the whole thing was scrapped.

Mr. Cope then referred to the lengths of trailing cables, and thought they should be limited to some definite length. He found that 70 yards was a reasonable length. It meant a little extra capital cost in the multiplication of gate-end switches, but the lengths of cable could easily be taken from one gate-end box to another. This limitation would cut down a lot of the accidents which had been reported.

Mr. E. D. C. OWENS said that Mr. Horsley was extremely interested in the Association, being a member of the Council, and working all the time in the interests of the members.

With regard to the question of mechanical interlocks, Mr. Owens thought there should be an electrical interlock in each case. On page 7 of the Report, Mr. Horsley had referred to defects in design and to misapplication. Mr. Owens considered there were more defects due to misapplication than to design.

The question of the flame-proof enclosure was interesting; he wondered whether there would be a B.O.T. certificate, and whether the Mines Department would instruct manufacturers how to construct their apparatus. As to the question of costs, he thought that if managements were prepared to pay a good price they would get the best article.

Major ROBERTS said they were indebted to Mr. Horsley for his introduction to the discussion and he expressed appreciation of the cordial relations existing between the Inspectors and the Mines Management. The two publications issued by the Electrical Inspector of Mines were most useful, as they not only give particulars of the accidents but contain the collective wisdom of the department in shewing how accidents can be avoided.

Major Roberts was inclined to take up a more optimistic view of Table 1. In 1928, three hundred and twenty-two collieries went out of production, but only sixty-one of these were electrically equipped, and the net result was that at the end of the year 58% of the collieries in production were electrically equipped as against 53½% for the previous year. Table 2 shewed the increase in horse power for the preceding year with every district shewing an increase.

Referring to the Table 4, Mr. Roberts thought it deplorable that nearly 25% of those who sustained fatal accidents were people who should have been qualified and should not have taken the risk involved.

Table 6 gave statistics over ten years of horse power and accidents, and the increase of horse power and the decrease of accidents indicated that the risk of death was now only one-third of what it was.

A complaint was made in the Report that Mines Department Circular No. 23, dealing with earthing, was sent out, but that the circular seemed to have received little attention. Major Roberts believed this indicated that though the circular was despatched it was not in every case received by the right man, and he strongly advocated that the instructions of the Mines Department should be sent not only to the Managers but to the Engineers as well.

The Report dealt with the danger of explosion from a low level of oil, and in this connection Major Roberts suggested that a way out of the difficulty would be to use air-break apparatus and do away with oil entirely.

Table 14 offered hope and encouragement to electrical manufacturers as it shewed that only one-fifth of the metalliferous mines in this country have electrical equipment.

Mr. W. M. THOMAS said that plants to-day are certainly worked more nearly to saturation point than they were years ago. Economic conditions and the depressed state of the industry accounted for this. He thought they ought to be glad that colliery managements were pushing electricity back from the coal face.

In Table 3 of the Report, the total of accidents for the year seemed the greatest during the last decade. If they had figures relative to tonnage, it might have a different aspect. They could all agree on one point, he thought, that there was a preponderance of accidents due to electrical shock and to the ignition of firedamp. Of the four fatal accidents given in Table 4, three of them were to electricians. In the general analysis of accidents given by Mr. Horsley, he thought they could say that a number of them were due to carelessness, and that those in the coal face were due to operating coal-cutters and conveyors at the same time without taking the necessary precautions. There was a lack of effective appreciation and ignorance of Regulation 131 g.

Mr. HIDER thought that the discussion had been most valuable but was rather disappointed in Mr. Horsley's notes as they did not appear to be conclusive. Mr. Horsley had suggested that saturation point had been reached in the use of electricity underground in collieries, but it would appear that the data upon which he formed this opinion was not quite complete, inasmuch as apparently it was not co-related to output.

He (the speaker) had not had the opportunity of reading the Report and his remarks were based on the notes read by Mr. Thomas. There were many factors tending to reduce the output of coal in this country, i.e., the development of water power on the continent and the Diesel engine for marine and land purposes. It therefore appeared to be necessary to relate electricity used underground with output. It was certainly startling to hear Mr. Horsley speak of saturation point even for underground, as he believed the Electricity Act of 1926 assumed that power stations will get increased loads from the collieries.

The fatal accidents referred to by Mr. Horsley emphasised the fact that the colliery engineer had a tremendous responsibility. It appeared that the status of the colliery engineer required some modification as clearly it was essential to have really first-class men in supreme control. The use of electricity underground was, of course, a question of economics only. The debit side of such economic problems must include the fact that fatal accidents occurred with rather alarming frequency. To eliminate the danger it was therefore necessary that such electrical installation should be under the control of highly qualified engineers and the equipment used must be of the very highest class.

After all there was no real reason why these accidents should occur, but one had to face the fact that to make such accidents impossible, would tend to increase the cost of production, and the complete solution might be that electricity was not the cheapest form of power to use underground.

Mr. EDMUNDS said that people who handle electrical apparatus, other than the electrician, should have some idea of the danger, or some knowledge of what the apparatus is doing. If people understood the danger they would undoubtedly take more care in the work they are doing.

In the case of transmission lines, he thought there might be more precautions taken. There should be some means of being positive that a circuit is dead, for instance. He instanced a case of putting a crystal wireless set in a sub-station for testing purposes.

With regard to trailing cables, he referred to a case of armouring trailing cables, and the possibility of putting in two insulated armourings, with an electrical circuit attached to armouring A and in circuit with armouring B.

A vote of thanks to Mr. Horsley for his notes, and to Mr. W. M. Thomas for his able reading of them, was proposed by Mr. T. J. Reece, and seconded by Mr. Hezekiah Thomas.

Mr. J. A. B. HORSLEY (a reply to the discussion: communicated).—The object of describing, in the Annual Report of the Electrical Inspector, a number of the accidents that have occurred is not to pillory those immediately concerned, but to afford to others the opportunity of visualising possible similar accidents, in the plant under their charge, in the hope that they may be inspired to take suitable precautions, in anticipation.

From Mr. Hannah's opening remarks I am glad to learn that in his case the first step to the prevention of accidents, namely a realisation of the circumstances under which similar accidents may occur, is taken when he reads this Report, and I only wish that he had proceeded to tell the meeting what had been his next step, for then I could have rejoiced that my object had been achieved.

Mr. Hannah's remarks appear to suggest that the use of electricity inbye is checked by the action of H.M. Inspectors of Mines, but I would remind him that the only general power of objection is that conferred upon the Inspector by the terms of Section 60 (1) of the Coal Mines Act, 1911, which reads as follows, "Electricity shall not be used in any part of a mine where, on account of the risk of explosion of gas or coal dust, the use of electricity would be dangerous to life . ."

Even that power of objection is qualified by the right of the owner to appeal to an independent Arbitrator, against the Inspector's objection. As that power of objection is based, in effect, upon the inadequacy of the ventilation and/or, upon the condition as to coal dust in the district in which it is proposed to introduce, or to continue to use, electricity, the remedy lies in the hands of the owner of the mine. Section 60 (1) not only confers a power of objection upon the Inspector, but, by implication, it lays a duty upon him, to object to the use of electricity in those cases where his observation of the conditions as to ventilation, coupled with his knowledge of the seam, warn him that the possibility of a dangerous accumulation of firedamp must be postulated.

In short, Section 60 (1) forbids the use of electricity where firedamp is an actual and continuing hazard, whereas General Regulation 132 provides for those cases where this risk is merely contingent, or hypothetical.

Mr. Richards spoke of the difficulty of properly maintaining the plant with inadequate means. I do not despair that the time will come when the owners will provide all the means necessary and will insist upon the highest standard of upkeep in all collieries, and that for the business reason that it pays to do so.

Neglect of cable insulation, for example, for lack of men and testing appliances, not to mention skill and special knowledge, is expensive parsimony, for the deterioration, when moisture enters the cable, is not confined to the point of damage.

Maintenance should be regarded as a dual insurance, viz.: against loss of capital and against interruption of service.

As to trailing cables, a simple device for locating incisions and punctures in the sheath is described on page 33 of my Report for 1928.

I have received particulars of two testing appliances based upon this principle, one of which was designed by Mr. Imeson, an electrician at Isabella Colliery, in Northumberland, and the other by a firm of electrical contractors in Dunfermline.

Mr. Richards referred to the type tests to prove flame-proof enclosure that have been undertaken since 1922 by the Mining Department of Sheffield University, first under the direction of Professor Douglas Hay, and subsequently under that of Professor I. C. F. Statham, and he suggests that every article should be so tested lest the bulk should not equal the sample; but a study of the accounts of accidents in this category will shew him that explosions have not resulted from defects of that nature, but from gross faults of maintenance.

If there is a reasonable margin of safety in the design, small departures from standard are of no practical consequence, although any departure, outside the limits of engineering tolerances, would, doubtless, invalidate the certificate.

It is open, however, to the purchaser's engineer to ask for copies of the drawings of the certified design from the manufacturer, for comparison with the apparatus supplied.

Mr. Yates congratulated the South Wales area upon its freedom from electrical accidents but, while the total h.p. of motors installed in South Wales is substantial, the relative use of electricity away from the pit bottom is negligible as compared, for example, with the Scottish Division, and it is with small and scattered items of plant inbye, and particularly at the coal face, that the opportunities for accident are more likely to occur.

The risk of accident with 10 motors each of 25 h.p. in use with trailing cables at the coal face is much more than 10 times as great as the risk with one 250 h.p. haulage, or pump motor near the pit bottom. Appendix A to the Report, shews that for South Wales with Monmouth, there was a total of 4301 h.p. of motors in portable and semi-portable machinery compared with 24,120 h.p. in Northumberland and Durham, and with 49,768 h.p. in Scotland.

Perhaps, however, Mr. Yates was subtly felicitating the members of the Branch upon their peaceful lot which, so to speak, kept them at the base and out of the firing line.

Mr. Tanner appears to be dissatisfied with the design of some of the electrical plant that has come under his observation, but commercial design is necessarily a compromise between that which the manufacturer would like to turn out and that which the user will pay for. He demands simplicity. Now a walking stick is a simple structure, but if one wants to keep off the rain, or to angle for fish, one must reconcile onself to the use of apparatus comprising a multiplicity of separate parts which, when properly assembled and skilfully applied, achieve objects unobtainable by the use of the simple staff.

Mr. Cope anticipates the day when all electrical equipment will be of permitted types, but the electrician will then be a dull dog.

That would be Bureaucracy in Excelsis, but it would not stop accidents.

Table 7, on page 19 of the Report, shews that 178 accidents, out of a total of 256 in the last five years, were attributable to faults of maintenance, misuse, or negligence.

Possibly he contemplates permitted types of operatives also. I am afraid that the liability to spontaneous variation from the certified design would defeat the object in view, in the living structure.

Perhaps, however, he means that flame-proof enclosures will all be of a type that has been officially certified after official test. If that is what he has in mind, I have already indicated that the Mines Department is preparing to undertake such official tests although, unless and until the Regulations are amended, it will not be legally necessary to confine the choice of plant to such certified apparatus.

The Mines Department does not propose to instruct manufacturers in their own business, but I have no doubt that manufacturers will continue to welcome the laying down of broad principles for their general guidance, leaving the application and all details in their own capable hands.

Major Roberts deduces, from Table 1, that the collieries that lacked electrical equipment went to the wall first. Doubtless those still in production will take the warning.

He suggests that air-break switchgear should supplant oil-immersed switchgear, but that is hardly a practicable proposal at present. There is of course air-break contactor gear operating large motors at high pressure but its place is not as yet in the mine,—not even at the bottom of the downcast shaft.

Mr. Thomas rejoices that electricity is retreating from the coal face and in that he appears to be seconding the vote of self-congratulation proposed by Mr. Yates. I do not agree, however, that electricity is, like Mark Twain's Redskin "being druv nearer and nearer to the settin' sun". My information is to the contrary and I should be sorry to think that Mining Engineers were throwing up the sponge just as we are about to offer them official certificates of safety.

Mr. Hider has got my remarks inverted—I believe that saturation is still far off, in the use of electricity in mining, and I am only astonished at the continuance in use of plant for power production and utilisation which should have been written off and replaced by electrical equipment long ago. As by far the greater number of accidents in mines is due to falls of ground and rope and horse haulage systems, I cannot agree that the economics of acidents are in the least likely to decree the supersession of electricity by any other form of power that is as yet available.

The following table, extracted from information published in the Report of H.M. Chief Inspector of Mines, shews the number of separate fatal accidents under various headings in coal mines for the year 1928.

Classification.	Number of separate fatal accidents.
Explosions of firedamp or coal dust not due to electricity	11
Falls of ground	484
Shaft accidents	27
Underground haulage	228
Miscellaneous underground	89
Miscellaneous on surface	93
Electric shock above and below ground	12
Electric ignition of firedamp	4
Total above and below ground	948

In reply to Mr. Edmunds, there is only one way to ensure that a circuit is dead and that is to put all the conductors to earth. No other precaution is necessary where that is done. Voltage indicators are, in cases, a useful auxiliary, but they are not infallible. If you cut off a man's head he is dead; 'if you give him poison he may throw it off and recover'.

The discussion appears to have been well sustained and I regret my inability to attend the meeting.

Junior Electrical Inspector of Mines.

Mr. James Cowan, electrical engineer to Messrs. M. Cockburn & Company, Ironfounders, Falkirk, has been appointed Junior Electrical Inspector of Mines with His Majesty's Home Office. There were three new appointments to be made and about 1500 applicants. Mr. Cowan started his career on the practical side with The Fife Coal Company. His principal training ground was with the Carron Company at their Letham and Carronhall Collieries under Mr. J. R. Laird..

On the technical side he was educated at the Fife School of Mining, Cowdenbeath, under Dr. Parker. This year he was one of the two who successfully passed the Honours Examination of the Association of Mining Electrical Engineers. Mr. Cowan is well known in Falkirk as a teacher of Electrical Engineering, he having directed all the electrical classes under the Education Authority of that city for five years.

It is generally conceded by those who know him best that Mr. Cowan has risen to this position of Junior Electrical Inspector of Mines to His Majesty's Government, by sheer ability, perseverance, and indomitable pluck. His headquarters are to be at Sheffield. Mr. Cowan is a native of Kelty, Fife.

A.M.E.E., NORTH WALES SUB-BRANCH: CORRECTION.

In the List of Branch Officials included in the "Supplement" issued last month, the name of Mr. W. Potts was inadvertantly given as Chairman of the North Wales Sub-Branch for the Session 1929/1930. The Chairman of that Branch during the Session was Mr. W. Waite.

A 120 Ton Rolling Mill Motor Equipment.

Messrs. Brown Bayleys Steel Works Ltd., whose works are situated in Sheffield, have placed an order with the English Electric Co. Ltd., for the whole of the electrical plant required to drive their existing 27 inch reversing mill. The mill is at present driven by a steam engine and it was necessary to reduce the cost of power required for rolling. Many alternative schemes were examined and equipments inspected both in this country and on the Continent and, after a detailed consideration of the problem, it was decided that the electric drive employing energy supplied by the Sheffield Corporation Electricity Supply Department, would be the most economical. The mill rolls alloy and high carbon steel ingots, 23 cwts. in weight, down to billets and small sections. When the change-over is effected the mill will be directly driven by a single direct current motor having a present maximum output of 6000 b.h.p., the machine being so designed that at a later date, this output may be increased to 12,000 b.h.p. by the addition of further generating plant, as described later.

The motor will be of the forced-ventilated type and will be supplied with clean air by means of a fan and filter. The complete motor will weigh approximately 120 tons, 50 tons of which represents the rotating portion, while the shaft end will be 24 ins. in diameter. A flexible coupling of the Wellman-Bibby type is to be interposed between the motor and the pinions on the mill.

In order that it may be quickly and economically varied in speed to suit the rolling operations, the mill motor requires to be supplied with variable-voltage direct current, whereas the Corporation supply is 11,000 volts alternating current. The equipment will therefore include a converting set, consisting of an 11,000 volts, 2000 h.p. motor driving a large direct current generator, interposed between the supply mains and the mill motor.

It should further be noted that as the load on the mill motor is exceedingly variable, the converting set will be provided with a cast steel high speed flywheel weighing 21 tons and having a rim speed of approximately 240 miles per hour, the object of the flywheel being to prevent imposing excessive peak loads on the Corporation mains.

Speed variation of the mill motor will be effected by control of the field systems of the motor and generator of the convertor set, separate exciters being installed for the field supply. Hence the main circuits, which carry very heavy currents, will always remain closed and the control gear, which has to deal with small currents only, can be made very simple and convenient for direct handling by the mill driver; the whole of the control both in regard to direction of rotation and the motor speed, being carried out by a single lever which the driver operates. The speed of the mill may be altered from 70 r.p.m. in one direction, to 70 r.p.m. in the opposite direction almost as quickly as the driver can move the lever. With the addition of a further generator to the converting set at a later date, the maximum speed of the mill motor will be raised to 110 r.p.m. and it will then give 12,000 h.p.

It is only in the case of the largest installations that this particular form of control is used, and the equipment in question will be the twenty-second of a similar type supplied by the English Electric Co. for this country and abroad. Fifteen of these equipments are employed in the steel industry, and the remainder in mills dealing with other metals.

Hydro-Electric Lead Mining.*

ONE of the few remaining lead mines which are still worked in this country is that of the Greenside Mining Company near the village of Glenridding in Westmorland. This mine has been worked continuously for over a hundred years and is believed to have been the first metalliferous mine to adopt the use of electricity underground. In the opinion of the owners the use of electricity has been an important contributory cause of the mine's success throughout the many vicissitudes which the industry has suffered, and which have caused many mines to close down.

The electrical equipment of the Greenside mine has recently been reorganised and extended, and now constitutes an excellent example of up-to-date methods applied to very old workings.

As early as 1891, a complete system of electrical operation was adopted, with a hydro-electric power plant consisting of a 100 h.p. Vortex turbine and a belt driven 100 kw. 500 volt d.c. generator. The energy was transmitted to the underground workings and used for hoisting, haulage, for driving air compressors, and for pumping. Reliability of the pumping equipment has always been of the utmost importance, as the lower levels of the mine are 2160 feet from the outcrop and 180 feet below the surface of Ullswater, near the south-west end of which the mine is situated. Fig. 1 gives a general view of the mine. The ridge behind it is a northern spur of Helvellyn. To the right of the mine head is seen the stream which is used for power generation.

* Reprint in abstract from *The Metropolitan-Vickers Gazette*.

In 1898 the d.c. generating plant was increased by the addition of a single-jet Gilkes Pelton Wheel of 100 h.p. direct coupled to a 100 k.w. generator, but in 1911 the system was changed to a.c. operation, the two d.c. generating sets being replaced by a 250 h.p. double-runner twin-jet Gilkes Pelton Wheel direct coupled to a 200 k.w., 2200 volt, three-phase, 50 cycle Metrovick alternator. This plant is still at work in the old No. 1 power station: it was supplemented in 1924 by a shaft governor controlled "Turgo" impulse wheel, direct connected to an alternator of 110 k.w. capacity.

The satisfactory performance of this unit led the management to adopt the same type of wheel and governor for their latest power station, which has been completed in the last few months. The new hydraulic plant, like the existing equipment, has therefore, been supplied by Messrs. Gilbert Gilkes and Gordon Ltd., by whom the design has been developed. At the same time the electric plant has been completely re-organised and considerably extended, the work being carried out by the Metropolitan-Vickers Electrical Company Ltd.

The object of this recent power development has been to make the most efficient use of the water power available to provide for the growing demand of the mine for electric energy. The tail water of the old pelton plant, and the water used for ore dressing and other purposes, is now collected behind a small dam and diverted into a head-race canal, 4500 feet long to the forebay of the new station. A pipeline, 21 in. bore and 1530 ft. long, conducts the water to the power house where it supplies two "Turgo" impulse wheels, direct connected to alternators of 110 k.w. and 250 k.w. capacity respectively. The smaller of these machines is the

Fig. 1.—The Greenside lead mine under the northern spur of Helvellyn.

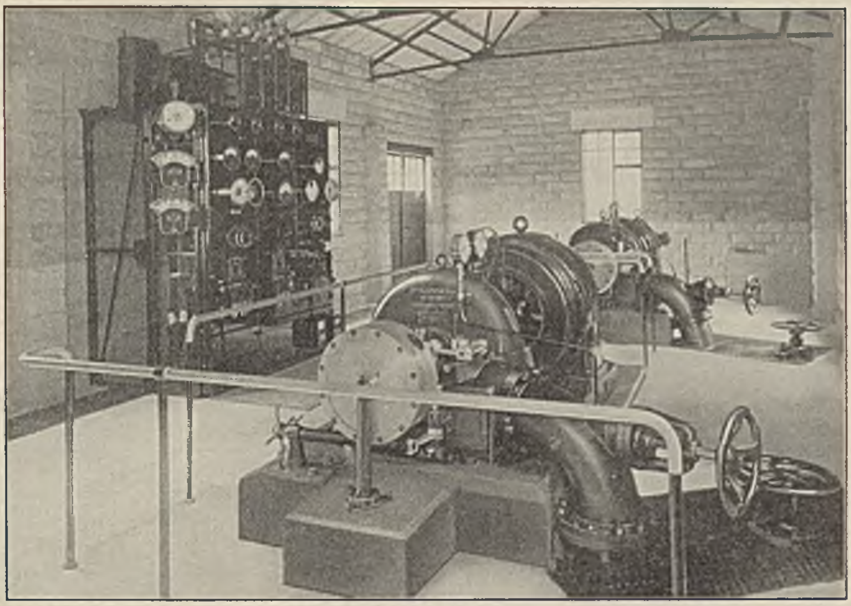

Fig. 2.—Interior of the New Power House.

"Turgo" wheel referred to above, moved from its old site to the present station. The larger was ordered last year, and erected some months ago. Fig. 2 shews the interior of the new power house with the two sets in service.

The technical data of the two units are of considerable interest to hydro-electric engineers, and are given in Table I.

TABLE I.

Elec. output of Alternator.	*B.H.P. of Waterwheel.*	*Speed r.p.m.*	*Working head in feet.*	*Date of manufacture.*
110 k.w.	170 b.h.p.	750	430	1924
250 k.w.	370 b.h.p.	1000	430	1928

The most striking point to note is the high specific speed of the later set. The makers of the "Turgo" wheel state that for these hydraulic conditions a speed of 1000 r.p.m. would not have been attainable with a pelton wheel without a duplication of runners or jets, whereas with the "Turgo" wheel adopted only one runner with a single jet is used. It is claimed that very marked economies both on the hydraulic and electrical sides have thus been effected over what would have been possible with an older fashioned pelton wheel, and also that on account of its special characteristics the "Turgo" wheel is becoming a serious competitor of the pelton wheel in the high head field of water-power development. The buckets of the "Turgo" wheel are shrouded at their outer periphery, and the water is thus guided accurately in its passage through the wheel, and the windage loss is very low.

The speed control of these units presents another interesting feature of this installation. A powerful centrifugal pendulum is mounted on the waterwheel shaft, and its sleeve is directly connected to a deflector by links and levers without any servo-motor or relay. The deflector is interposed between the jet and the runner at reduced loads, and there is only allowed to act on the runner that portion of the jet which is necessary to carry the load. Thus, if the load on the generator is light, practically all the jet is deflected; whereas if full load is required the deflector is moved clear of the jet which then impinges directly on the runner. The absence of relays enables quicker governing action to be obtained than is possible with a servo-motor type oil pressure governor. With the whole load suddenly thrown off, the momentary rise of speed is less than 2 per cent., a remarkable result, considering that no flywheel is used on either set; nor was any flywheel effect provided in the rotors of the alternators in excess of that which was necessary for their ordinary electrical and mechanical design.

The makers state that upwards of 150 "Turgo" plant have been installed and are at work. The design is fully protected by patents, and it is satisfactory to

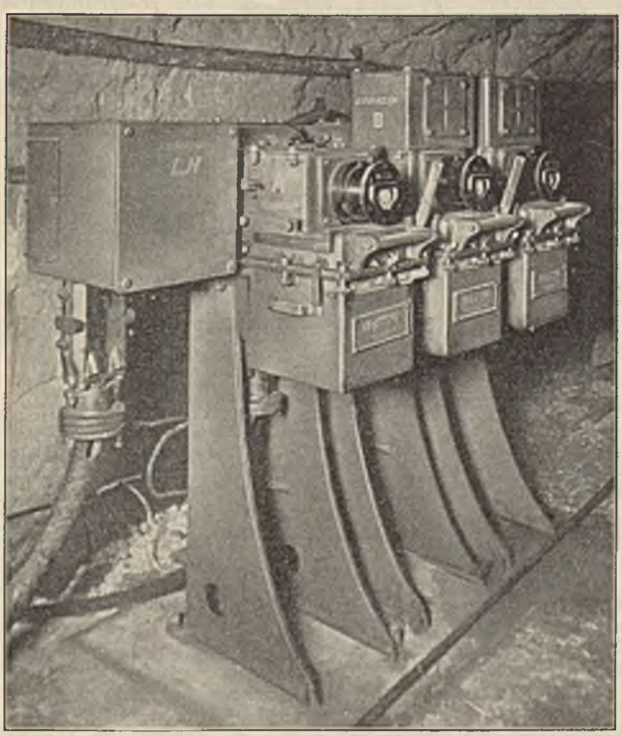

Fig. 3.—The Metrovick High Tension Distribution Board underground.

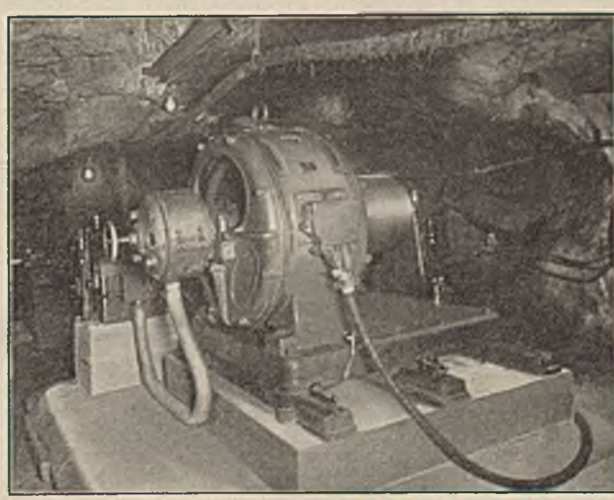

Fig. 4.—Metrovick 120 h.p. 2000 volt induction motor; driving air compressor.

note that in a field, where some regard the Continent as being pre-eminent, this recent and very successful design has been entirely developed by a British firm, and its own British engineers.

The new power station and the older No. 1 power station are arranged so that they may be operated in parallel, the synchronising equipment previously used for the two sets in No. 1 power station being now installed in the new power station for this purpose. Alternatively, either station may feed the system at times of light load. The supply from the new station to a point of junction with the No. 1 station supply line at the drift mouth of the Lucy Level a distance of about 2000 yards, is by means of a new overhead line mounted on wooden poles. The supply to the underground workings is thence taken along the drift to a high tension distribution board 1560 yards in-bye. Fig. 3 shews the distribution board, consisting of three Metrovick draw-out type pillars, two pillars controlling lines to motors driving compressors, and one pillar controlling a line to the electric winders and the pumps.

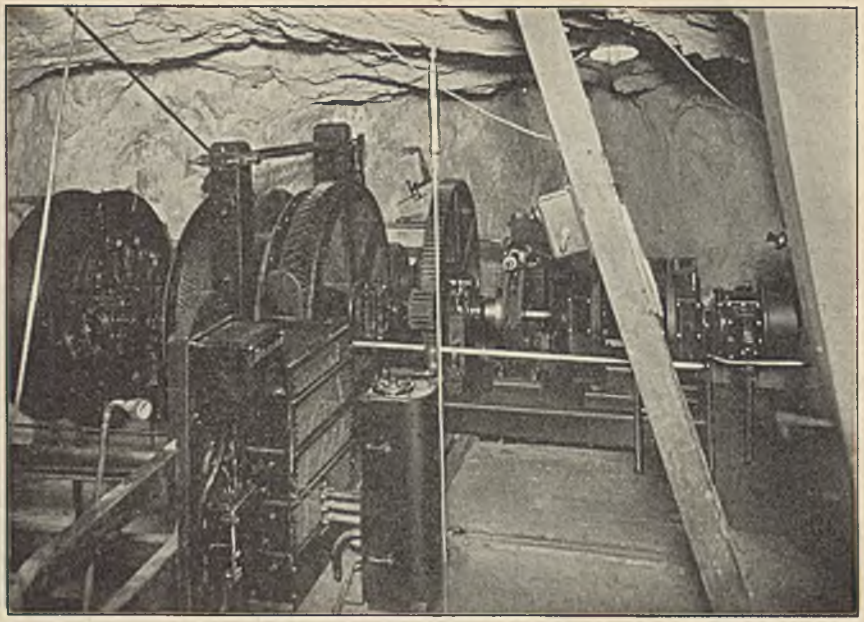

Fig. 5.—Underground winder with Metrovick induction motor and double-helical gear drive.

The ore is brought up from the workings by two electric winders. "Murray's winder" lifts the ore from the lowest workings, 360 ft. above sea-level, to a point 720 ft. above sea level. "Smith's winder" then lifts it from this level a further 540 ft. to the Lucy Level, where it is taken up the drift by an electric locomotive. Fig. 5 shews the lower winder, which has a 65 h.p. Metrovick induction motor driving the drum through double reduction gearing with a shock absorbing coupling. The upper winder is similar in arrangement but has a 50 h.p. motor. The mechanical equipment of both winders is the original equipment used with the d.c. motor drives which have now been superseded. Each induction motor is operated on a 650 volt supply, provided by a transformer installed beside it, and is controlled by means of a switch pillar of the same type as those shewn in Fig. 3, together with a Metrovick cam-operated contactor type controller with resistances, connected in the rotor circuit. The equipment includes protective gear giving complete safeguard against such contingencies as overspeed, overwind, over acceleration or delayed retardation.

The pumps are driven by squirrel cage motors operated with auto-transformer starters on a 650 volt supply from transformers beside them. At the 90-fathom level a new installation has been made consisting of a Mackley turbine pump driven at 1450 r.p.m. by a direct-coupled 55 h.p. motor. At the 150-fathom level a new 20 h.p., 720 r.p.m. motor has been installed for an existing reciprocating pump, with belt drive giving the required speed of 225 r.p.m. on the pump pinion shaft.

Two electrically driven air-compressors operate at the in-bye end of the Lucy Level drift. One of these is a Sentinel compressor driven by an existing 110 h.p. 440 volt motor. The other, a Walker compressor, has been equipped with a new 120 h.p. 2000 volt motor with a liquid-type starter. Fig. 4 shews the new compressor motor equipment.

Advantage has been taken of the re-organisation of the equipment to provide electric drive for the workshops which are about 100 yards from the drift mouth. For the blacksmith's shop a 35 h.p., 720 r.p.m. squirrel cage motor has been installed with an auto-transformer starter and belt drive to shafting, and for the joiner's shop a 20 h.p., 720 r.p.m. motor of the same type and similarly arranged. The supply for these machines is tapped off the 2200 volt overhead line and transformed down to 440 volts. Provision has also been made for electric lighting, both at the mine head and in the mine, the supply for this purpose being given at 110 volts by a number of small transformers installed at convenient places on the system.

Personal: Mr. T. R. Stretton.

Mr. Theodore Reginald Stretton, son of Mr. Theodore Stretton, Past President of the Association of Mining Electrical Engineers, of Messrs. Haslam and Stretton, Cardiff, has been awarded the Duddell Scholarship founded by the Institution of Electrical Engineers as a memorial to the late Mr. William Duddell, C.B.E., F.R.S., a former president of the institution. This is a scholarship in electrical engineering tenable for three years, open to candidates whose parents or near relatives are members of the institution. Another condition is that candidates must be under 19 years of age and must have passed the matriculation examination of a British University. The significance of the success of Mr. Stretton, junior, will be appreciated when it is realised that there are about 12,000 members of the Institution of Electrical Engineers, any of whose relatives were entitled to enter the competition.

The G.E.C. Journal.

The second number of the "G.E.C. Journal" is even more attractive than the initial issue of this new technical periodical. The editorial offices are at the Witton Works, in direct touch with manufacture and it is the stated policy to endeavour to provide literature of a high technical standard embracing all phases of the Company's activities, and to publish authoritative information concerning new developments in the theory, design, manufacture and application of British electrical apparatus.