The Mining Electrical Engineer.

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Educational Points.

Sheer desperation has forced home the lesson that technical proficiency must direct the coal industry. The main fact—pinned down after chasing relevant but accessory themes such as hours of labour, rates of pay, methods of selling, transport and shipping—is that no real, or adequate, gain is possible without a full and general adoption of the latest engineering principles. Applied Science has become the watchword for all who seek to make headway in any industrial effort and in none is it of greater vital consequence than in the coal industry. So it has come that one of the greatest needs of the moment is for more men, many more, who can render those particular services of science-cum-engineering practice in mining. Men with the requisite qualifications are scarce and they are not easily nor quickly made. The combination in an individual of scientific knowledge and practical experience sufficiently complete and extensive as to ensure the economic and competitive efficiency of his work can only be attained by sustained hard educational study and the general cultivation of a natural aptitude.

The education of mining (electrical, mechanical, and power) engineers is being increasingly recognised as an indispensable factor in the scheme of making British mining again fundamentally sound and prosperous. The Departmental Committee appointed to investigate the subject of qualifications of colliery officials has put education well to the front in its deliberations. It would have been strange had that not been so, for it is only too obvious that our national educational code is not in pace with the times. There is happily an encouraging prospect of much early improvement following the work of the Committee. Those who have the disposition to tackle the close study and would persevere in the gaining of knowledge and experience must be provided with the means to that end; and those means must be made as attractive and complete as ingenuity and organisation can devise. An opinion only too frequently heard of late is that the young miner appears to be losing the virtue of ambition and is more prone to reject any suggestion of his continuing or resuming school studies. The natural animal of vigorous youth, the deliberate cultivation of which is so prominent (and in this case popular) a part of education, shrinks from the restraint and drudgery of the school classroom. The acceptance of that fact does not, however, warrant the belief that youth has lost its instinctive urge to do things, to be successful and drive ahead. It is not to say that the will to succeed for the joy to be gained by success has ceased to be an attribute of our young people. Yet it is the fact that very few youths seek to make themselves into proficient mining power engineers. It would appear therefore that there is something seriously wrong or lacking in our present systems and facilities. A writer in *The Colliery Guardian* (from whom we quote elsewhere in this issue) attributes, in part, what he calls "A Slump in Mining Education" to the loss of confidence in the future of the mining industry and the absence of reward gained by those who have gained scholarship awards and certificates.

So it would appear that two of the strongest deterrents are the dreary years at school aggravated by the doubt as to whether the promised reward will materialise. Happily both these objections can be removed by the formation of a practicable and judicious system of education whereby schooling will be interlinked with practical work and by which the successful pupil-apprentice will be assured of a definite industrial qualification with its corresponding and financially compatible staff rating. Nor would this of necessity mean the creation of still another class of privileged official in mines' management. "Officials" are anathema to some level headed mining men who unreservedly deem them irritants and an impediment to coal output. We do not propose to be drawn into that controversy, but it is mentioned so that even the anti-official mind will concede that the defining of what shall constitute a qualified technical power engineer for mines does not in the least involve the question of endowing that engineer with the authority and dignity of an "official" nor of enclosing him in a registered, chartered or any other exclusive circle. The question is—how can the need of the industry for those better engineers be supplied?

In the contemporaneous article to which we have already referred, the subject of mining education was treated particularly from the Surveyors' and Managers' point of view, but many of the writer's suggestions for improvement are equally applicable to mines power engineers. Some of the more important of these are retold in our abstract. They show an appreciation of the difficulty of bringing the lessons of school and mine into that useful and attractive unity by which will be ensured the maximum of personal interest and endeavour as well as the certainty of gaining the most effective educational results.

Into the training of these mines power engineers there enter technical education, works and mines' practice, visits and inspections, lectures by business men, the extension of study into other branches of natural science so as not merely to add colour to the monotony of the regular subjects of study but to cultivate the broad outlook and familiarity with all natural phenomena so necessary to a real education. We hope to return to this subject from time to time and with more detail than can now be. There is, however, the matter of Examinations which calls for urgent mention, for many young engineers will be considering whether and what studies shall be taken up this autumn, and for what Examinations will they enter.

The entrants for the examinations of the Association of Mining Electrical Engineers are comparatively few. Why that should be so when the younger element of mining electrical men are so clamorous that the status of the qualified man should be raised and suitably recognised is rather difficult to explain. We know that some folks are fond of saying that "examinations prove nothing." Usually they really mean that examinations are not all and everything—which is quite true. For the guidance of those who might otherwise be misled by the careless expression we would suggest that they view an examination as an educational contest. The training to get fit is always so much gained over the man who is too lazy to interest himself or to take a spell of hard work for which he is not to be paid at the week-end. To sit for an examination and fail is to have the qualification that studies up to that standard have been done. It is proof of the energy and intention to succeed by voluntary effort. Equally, one failure to the right man with the right way of thinking will not throw him out of training: he will persist and try again. There is a system of handicapping in the examinations' race: the series of A.M.E.E. Examinations are carefully graded to suit the capabilities of elementary, advanced, and honours contestants. In short the young man who has taken up the business of the mining electrical engineer if he will but consider the subject on these lines will be the first to see that his business is one which in its present condition particularly demands for its improvement that he shall give convincing proof of his strong character and business capabilities by taking up the readiest available effective means of doing so—that of training for and entering the A.M.E.E. Examinations.

NEW BOOK.

WINNING AND WORKING by Prof. Ira C. F. Statham, B.Eng., F.G.S., M.I.Min.E., London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C. 2. Price 21s. nett.

This is one of "Mining Certificate Series" being a set of textbooks prepared for candidates for Certificates under the Mines Department and edited by John Roberts, D.I.C., M.I.Min.E., F.G.S. In his preface the author indicates that the winning and working of coal is the most important duty of the Under Manager who, for this reason, while he must be acquainted with many aspects of colliery practice, must perforce have an accurate and extensive knowledge of underground work. In this particular his knowledge should not be inferior to that of the Manager, so that the present volume covers largely the requirements for both First and Second Class candidates. Since mining conditions vary considerably, often in one and the same mine, the Under Manager should possess a wide knowledge of the many and varied methods applicable to different conditions, so that he may be able to decide upon the best method for any given case. It is only by the application of the most suitable methods that the future of British mining will be assured. For this reason the treatment of the several subjects has been made as complete as possible within the limits of space available. In the description of essentially practical operations the use of sketches is invaluable, and generous use of diagrams has been made throughout.

NEW CATALOGUES.

HEYES & Co., Ltd., Water Heyes Electrical Works, Wigan.—The well-known "Wigan" lighting fittings are illustrated, dimensioned, and priced in this very complete catalogue. Particular attention is directed to the mining type fittings.

CROYDON CABLE WORKS, Ltd., Mitcham Road, Croydon.—"Pernax" sheathed, lead-covered cables are listed in the new pocket-size, illustrated Price List. "Pernax" is a speciality of the firm and it is claimed to be a safe protection against electrolysis and corrosion. Full particulars are given of the general properties and other uses of this material.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2.—Church Lighting is the subject of a handsomely illustrated catalogue which shows several views of notable installations and also gives particulars of the individual fittings, etc., employed according to position and circumstance.

SIEMENS Bros., Woolwich, S.E. 18.—This catalogue describes the "Neophone" which is the latest telephone instrument embodying many improvements. A complete description of the principles and performance of the new sets is given.

BRITISH ALUMINIUM Co., Ltd., Adelaide House, King William Street, London, E.C. 4.—An interesting little booklet indicates by means of many and various illustrations the hundred-and-one classes of castings which are today made of aluminium and its alloys.

MAVOR & COULSON, Ltd., 47 Broad Street, Mile End, Glasgow.—New price lists refer respectively to D.C. Motor Starters for general industrial services and those of the flameproof type. The starters range from 7½ to 100 h.p. and 220 to 500 volts.

EVERSHED & VIGNOLES, Ltd., Acton Lane Works, Chiswick, W. 4.—List No. 163 A is a valuable technical consideration of "Earthing" and the use of the "Megger" Earth Tester in connection therewith.

MIDLAND ELECTRIC MANUFACTURING Co., Ltd., Barford Street, Birmingham.—A colour-illustrated folder sets out the particular merits of the new "M.E.M. 8" an all-insulated switch.

Sparking at the Brushes of a Machine.

F. MAWSON.

(This is the fifth of a series of Articles intended more particularly to help Students and Junior Engineers: the preceding Article appeared in the June number).

SPARKING at the brushes may be due to any of the following causes: overload; brushes improperly set; commutator rough or eccentric; high or low commutator bars; brushes making poor contact; dirty brushes or commutator; bent armature shaft; worn bearings; worn commutator; short circuited or reversed armature coil; unsuitable brushes; mechanical vibration; belt slipping; open-circuited armature; weak field; fault connection to earth.

Overload.

In the case of an overload the whole of the armature gets hot. The permissible temperature rise is 40 deg. C. above the temperature of surroundings. The sparking may be reduced, but not stopped, by moving the brushes forward in the direction of rotation, in the case of a dynamo; and backwards in the case of a motor. If the overloaded machine is a motor the speed will be low; and if a dynamo, the voltage will be below the normal.

Brushes Improperly Set.

Brushes may be wrongly set either by reason of incorrect spacing of the brush spindles or brackets, or because the rocker bar has been rotated too far in one direction or the other. The brush spindles should be set geometrically 90 deg. apart for a four pole machine, 60 deg. apart for a six pole machine, etc. In adjusting the brush rocker, it may be moved slightly in both directions until the best position is found.

The correct neutral position is found either by the painted slot method or by the voltmeter method of testing. In the case of the painted slot method, on examining the armature two slot keys will be found to be painted white, and the commutator bars to which the turns in these slots are connected are centre punched at the ends. By setting the painted slots symmetrically with any one pole, the correct position of the brushes for that pole will be at the centre-punched marks mentioned.

In machines with commutation poles the neutral position is usually the correct running position. In motors without commutation poles, the running position is two or three segments behind, and in generators two or three segments in front of the neutral position.

For the voltmeter method of testing: fix a voltmeter, or an ammeter with high resistance in circuit, across the brushes of the armature; separately excite the shunt field with the armature standing still; switch the field current on and off alternately and note the kick in the voltmeter. The brushes should then be moved until this kick is zero or practically zero. If an ammeter with resistance in circuit is used, the resistance may be cut out as the kick diminishes, in order to make the ammeter more sensitive.

Another method of verifying the brush spacing is to place paper tape round the commutator, cutting it to the exact circumference. Divide the paper over into the necessary number of parts, equal in number to the brush arms, and make pencil marks on the paper at the positions found. The paper can then be placed around the commutator again and the brushes set in line at each of those marks.

Commutator Rough or Eccentric.

The commutator is the most easily injured part of a machine, and its faults are liable to develop more quickly than those of any other part. When a commutator is in good condition, it becomes of chocolate colour, has a smooth glazed surface, and causes the carbon brushes to emit a characteristic squeaky noise when the armature is turning slowly.

A commutator may become rough either as a result of misuse or from bad selection of the qualities of the copper and the mica of which it is built. A commutator running out of true may be the result of faulty workmanship and unequal expansion due to heating, or it may be the result of a hard blow. In either case sparking will occur and the commutator must be turned up true, and highly polished before it will operate successfully.

In the case of slight roughness of the commutator, due to temporary overload or other passing abnormal condition, sand-paper may be used to smooth it up again. For persistent roughness more radical treatment must be applied. Narrow scratches right round the commutator indicate that there are particles of hard foreign matter under one or more of the brushes. A wide scratch may be made if one of the brush holders has been set too closely to the commutator or has slipped down to a point where it touches the bars. Unless the brush holder is specially designed to prevent it, the holder itself may bear on the commutator if the brush in it has been allowed to wear down too far.

If a grinder is used to true up a commutator it may be driven from the commutator surface by means of a rubber covered friction pulley and suitable gearing. Usually, in the case of small machines, the simplest method of truing up the commutator is to put the complete armature and shaft in a lathe. A generator may be driven by its engine, running slowly; a motor may be driven by a belt or gear from another small motor. After the commutator has been turned it should be smoothed with sand-paper, burrs between the bars should be carefully removed and vaseline sparingly applied through the pores of a canvas bag.

High or Low Bar.

A high or low commutator bar causes a partial break in the circuit between the brushes and the commutator segments. In either case, each brush or set of brushes sparks when the faulty segment passes under it.

A metallic click, emitted regularly as the commutator revolves, indicates a high bar in the commutator, and in a bad case the brushes will be seen to jump a little when the high bar passes under them. A high bar may be due to its becoming loose, or to the fact that it is of much harder metal than its neighbours and so does not wear at the same rate. If the high bar seems to be firm under a blow from a hammer, it will be safe to take it down with a file while the armature is stopped; but if the hammer test proves the bar to be "floating," that is loose, it is a serious matter, and means that the commutator will probably require to be rebuilt.

In testing a bar or bars with the hammer, a piece of wood should be interposed to take the blow, and care must be taken not to dent the commutator.

In the case of low bars the fault gives very much the same sound as a high bar. This may be due to the commutator having received a severe blow in handling, or that one or more bars are of softer copper than the rest, or it may be due to the burning away of the bar by excessive sparking at one particular point. The only method of getting rid of this defect is to turn down the commutator to the level of the low bar.

If the mica and copper used in the construction of a commutator are not of the proper relative hardness one will wear down faster than the other, leaving the surface of the commutator a succession of ridges. If the mica is too soft it will pit out between the commutator bars, leaving a trough which fills up with carbon dust and partially short-circuits the corresponding armature coils. If the strips of mica are too hard or too thick, the bars will wear in ruts and must be frequently turned down.

Brushes making Poor Contact.

When the brushes make poor contact the trouble may be due to the following defects: the brush may not move freely in the holder; the spring pressing the brushes on the commutator may have lost its nature; the brush lever may rest on the side of the brush holder and not on the brush; the brush may not be fitted to the surface of the commutator; and the holder may be shifted round on the spindle. Each case suggests its own remedy.

Dirty Brushes or Commutator.

Dirty commutators may often result from the use of too soft brushes. The use of oil or grease on the commutator should be avoided as far as possible, as it causes dust and dirt to adhere. Cotton waste should never be used to clean a commutator as particles of the waste are almost certain to lodge under the brushes and thus increase the contact resistance.

Bent Armature Shaft.

A bent armature shaft causes the commutator to run eccentrically, and sparking results from the unequal pressure of the brushes on the commutator as the armature revolves. This will be detected either by the different colour of the commutator at different positions or the difference of the sparking at the brushes.

Worn Bearings.

Excessive wear in the bearings may throw the armature far enough out of centre to distort the field and so cause sparking, due both to improper distribution of the flux in the field and also to incorrect distribution of current between the brush sets, some of which become overloaded.

Worn Commutator.

When a commutator wears down below a certain point, even if in good condition otherwise, it may have a tendency to spark in spite of everything that can be done to prevent it. A possible reason may be because the brushes span a greater number of commutator bars, the bars having become thinner as they wear. On the other hand, trouble may arise on account of the increased distance of the brush spindles from the commutator surface, so that the brush movement is no longer truly radial.

The wearing depth of a commutator is defined as the radial depth by which the commutator may be reduced before it requires renewal by reason of its strength being impaired, or by reason of its becoming unduly heated when working continuously at rated load. The limiting depth is usually shown by a circle turned on the end of the commutator, and it varies from ⅜in. in small machines up to 1¼in. in large commutators. When the end of the commutator is not visible, a hole is sometimes drilled in one of the segments, and from this the wearing depth at any time may be gauged, the bottom of the hole corresponding to the limiting depth.

Short Circuited or Reversed Armature Coil.

A short circuited or reversed armature coil will cause a local current to flow in the armature, with the result that either a dynamo or a motor will require an increased amount of power to run it, even when the machine is unloaded. In bad cases the motor will run with a jerky motion, which is especially noticeable at low speeds and the voltmeter connected to a dynamo will indicate a fluctuating voltage. Such a fault may be due to a short circuit in the coil itself or to contact between two adjacent commutator bars.

Unsuitable Brushes.

Up to a certain point high resistance in a carbon brush is a good feature, but if the resistance is too high, the brush will heat up on account of the high contact resistance, which causes the current to form an arc. The proper pressure to be applied between the brush and the commutator depends on the duty of the machine as well as on the condition of the commutator and on the material of the brush itself. Soft carbon brushes will run well with less pressure than will hard carbon ones; a rough commutator will require greater pressure to be put on the brushes than if it is in good condition. A pressure of 2lbs. to 2½lbs. per square inch of brush surface is a good value to use.

Mechanical Vibration.

Mechanical vibration is easily detected and the remedy is obvious.

Belt Slipping.

A slipping belt will sometimes cause intermittent sparking, because it subjects the machine to unusual variations in speed. A belt that has a stiff or uneven splice may cause sparking by producing mechanical vibration or speed changes as the joint passes over the pulley.

Open Circuited Armature.

Excessive current due to an overload or short circuit may melt one or more of the armature wires out of the soldered joint at the commutator lug, or the insulation of the wire may be burnt through, or a commutator lug may work loose. When this happens definite evidence is given, as the sparking takes place right round the commutator and the mica is eaten away between the bars to which the faulty coil is connected. The commutator becomes dark in colour and pitted. The joint should be made good.

Weak Field.

An abnormally weak field, due to a fault in the field coils, may cause sparking. The starting torque of the motor is decreased, the speed and current increased. In the case of a dynamo the E.M.F. and the ability to excite the field readily are diminished.

Connection to Earth.

If the circuit be earthed at two or more points, the whole or part of the field or armature windings may be cut out and cause the machine to spark. A single earth connection may have little or no effect, but a pair of earth connections forms practically a short circuit and should be dealt with accordingly.

EDUCATIONAL SUGGESTIONS.

"Over and over again it has been said that Great Britain owes its greatness and position in the world of commerce to the extent and quality of its mineral resources. To these may be added the indomitable pluck, skill, resourcefulness, and faith in the future, of those men who developed these resources and built up great and successful industries as a result." It is thus that one who signs himself "A Mining Engineer" introduces in *The Colliery Guardian* a critical and helpful analysis of the methods and materials of mining education. The writer sets forth many reasons why so few take up class studies; there are faults attributed to the characters of the young men, to the quality of the tuition, and to the attitude of the industry as a whole. Most of these criticisms are well known but the following extracts from the writer's suggestions for improvement offer much that is novel.

The Board of Education scheme of mining education is, no doubt, excellent, but the responsible people must not forget that attendance at day and evening technical classes is mostly voluntary; and being so, certain and ample inducements must be held out to bring in the students.

Coal field tours should be reinstituted at the earliest possible moment. The mining student should be given an opportunity of getting out of his coal-dust environment and beyond his necessarily limited horizon to see the methods of other folks in other lands. The benefit is undoubted; the student becomes less insular and bigoted; his outlook is widened, his sympathy is aroused and a friendly feeling towards the foreigner is promoted, whether he be of a neighbouring or of a foreign coalfield. Moreover, technical improvements follow.

There should be a substantial grant to provide book and other prizes for those deserving students who, through force of circumstances, are unable to accept a tour or course scholarship. Practical mining competitions should be re-introduced. The writer is informed that when practical or manual work is to be done there is an improved attendance.

Abolish inquiry into pecuniary circumstances of students. Accord to each the normal value of the particular scholarship; let each be judged by his work alone, whether he be an official or a miner, or the son of a labourer or of a professional man. Refund to students their travelling expenses when class visits are made to collieries and works.

Win over the interest of local mining officials by interviewing them and requesting them to deliver lectures on suitable topics.

The introduction of safety first classes; it is to be inferred that these would be welcomed by the Mines Department and its most important limb, the Mining Dangers Research Board. There is no more praiseworthy object than that which aims at the saving of life and limb, and it would be well if the Miners' Welfare Fund could be drawn upon to finance the establishment. Instead of classes in the strict sense of teacher and taught, a more alluring description would be "The Safety First Debating Society," the periods being devoted to the reading of papers and discussions thereon. The enthusiasm thus created would probably foster a desire for further intensive study.

Extend to the local technical teacher recognition of his importance as a support and feeder for the classes. At the same time make it his personal interest to promote attendance by appointing him to teach junior stages. When this is done there should be insistence on loyal co-operation between the respective courses, and that there is no undue delay in the transference of students from the lower to the senior courses.

All class and exercise books should be provided for the students free of charge. Other appliances, e.g., draughtsman's sets, painting cabinets, slide rules, etc., should be supplied under a system of protracted payments.

Gingering up of local committees. Members of these should be live men (and women) who keep in mind that not the least of their duties is to visit the classes, not merely to check the registers but to afford encouragement to the students and exhort to greater effort.

A greater mining bias should be given to the lower-grade classes. This would make them more popular, with a resulting increased enrolment and improved attendance. In these days of shorter shifts and intensive machine mining there is little opportunity for looking after the boys and training them as formerly, below ground; and this state of things should be countered as much as possible by mining classes. If, by so doing, a few useful young lives can be saved every year, it is surely as important as the training of half-a-dozen mining professors or engineers.

ARMOURCLAD SWITCHGEAR.

The Croydon Corporation have awarded a contract to The English Electric Company for the complete equipment of a new switch house at their new power station. The installation, which is to the designs and specification of Mr. A. C. Crumb, the Borough Electrical Engineer, will be of the most modern type, including electrically-operated compound-filled switchgear of high-rupturing capacity with a special arrangement of duplicate busbars. It will form the main control for the turbo-alternator plant including a new 25,000 k.w. set, and for group feeders to the existing feeder switchgear. The contract, valued at £44,300, is a comprehensive one including reactors, synchronising gear and control boards, telegraphs, telephones, and multi-core cable, earthing equipment, etc.

Proceedings of the Association of Mining Electrical Engineers.

COUNCIL MEETING.

A Council Meeting was held in the forenoon of Friday, July 5th, 1929, at the Festival Hall in the North East Coast Exhibition Grounds, Newcastle-on-Tyne. The following members were present:—

Mr. F. Anslow, President, in the Chair; Mr. A. B. Muirhead, Past President, Advisory Committee; Mr. D. Martin, Past President, Advisory Committee; Mr. G. M. Harvey, Past President, Examinations Committee; Mr. W. T. Anderson, Past President, Certification Committee; Mr. G. Raw, Past President, Certification Committee; Mr. R. Holiday, Past President, Certification Committee; Mr. A. Anderson, Past President, Treasurer; Capt. S. Walton-Brown, Vice-President; Mr. J. W. Gibson, Vice-President, Examinations Committee; Mr. H. J. Fisher, Certification and Examinations Committees; Mr. R. Wilson, Certification Committee; Mr. J. A. B. Horsley, Examinations Committee; Mr. T. H. Williams, Examinations, Certification and Prizes Committees; Mr. F. Beckett, Finance Committee; Mr. S. A. Simon, Papers Committee; Mr. A. C. MacWhirter, Papers Committee; Mr. J. R. Cowie, Prizes Committee; Mr. R. Ainsworth, Publications Committee; Mr. S. H. Morris, Publications Committee; Mr. J. Dawkins, East of Scotland Branch; Mr. J. Walker, Lothians Branch; Mr. J. A. Brown, West of Scotland Branch; Mr. T. T. D. Geesin, West of Scotland Branch; Mr. G. N. Holmes, West of Scotland Branch; Mr. J. R. Laird, West of Scotland Branch; Mr. R. Rogerson, West of Scotland Branch; Mr. A. F. Stevenson, West of Scotland Branch; Mr. J. C. MacCallum, Ayrshire Branch; Mr. E. E. Shatford, North of England Branch; Mr. A. R. Hill, Cumberland Branch; Mr. G. Ward, Cumberland Branch; Mr. G. E. Gittins, North Western Branch; Mr. I. Mackintosh, North Western Branch; Mr. S. J. Roseblade, North Western Branch; Mr. E. R. Hudson, Midland Branch; Mr. F. J. Hopley, Warwickshire and South Staffs. Branch; Mr. W. G. Thompson, Warwickshire and South Staffs. Branch; Mr. H. J. Norton, South Wales Branch; Mr. E. D. C. Owens, South Wales Branch; Mr. J. W. Robinson, London Branch; Mr. C. St. C. Saunders, Secretary.

Letters of apology for absence were received from Messrs. W. M. Thornton, Past President; T. Stretton, Past President and Advisory Committee; A. W. Williams, Advisory Committee; W. G. Gibb, West of Scotland Branch; and W. Bolton Shaw, North Western Branch. Mr. Stretton was unable to be present in consequence of a family bereavement, and a vote of sympathy was unanimously passed to him.

The following notes of the proceedings are abstracted from the minutes.

The Minutes of the Council Meeting held on February 16th, 1929, having been distributed, were confirmed and signed by the Chairman.

Finance.

Reports were submitted with regard to the membership of the Association at March 31st, 1929, Resignations, Deletions and Transfers; the Bank Balances of the General and Publication Accounts on that date; the Receipts and Disbursements and Branch Balances. Statements were submitted setting forth the arrears of subscriptions of members in the Branches. The Auditors' Report was read and a statement was submitted regarding the loss on working in the General Account, which was accounted for by the cost of the List of Members, Special Issue of the Journal, and other items of an unusual nature. The accounts were adopted. A letter was read stating that a further sum of £25 0s. 0d. had been transferred by the London Branch to the General Fund. A vote of thanks was unanimously accorded to the Branch for this action.

Branches of the Association.

The Quarterly Reports of the Branches were available, but were not considered in detail. Mr. Dawkins reported that the East of Scotland Branch was now making satisfactory progress. Mr. Cowie reported that the members in the Kent Coalfield district were desirous of forming a Sub-Branch, and it was resolved that this matter be left to the London Branch to take such action as may seem desirable.

Publication, "The Mining Electrical Engineer."

Mr. Ainsworth reported on behalf of the Committee, but no particular items had arisen to which he required to call attention. A vote of thanks was unanimously passed to the Publications Committee.

Advisory Committee.

Mr. Muirhead reported on behalf of this Committee, but no special items had arisen requiring particular attention.

Scrutineers.

Mr. J. Walker and Mr. J. A. Brown were appointed Scrutineers of the Ballot Papers.

Examinations.

A vote of thanks to the Chief Examiner was unanimously passed for his valuable Report. It was resolved that Prof. Statham be appointed Chief Examiner for the Examinations to be held in 1930.

Mr. Harvey reported that the Examinations Committee had under consideration the Forms of Candidates' Application and Testimonial Forms. The Committee was of the opinion that the following alterations are necessary in this respect.

That all Candidates should have had at least three years' practical experience in the application of Electricity to Mining before being allowed to present themselves for Examination, and that such experience should be set out in full detail by each Candidate, and certified by the Mining Engineer or Colliery Manager, and the Mechanical or Electrical Engineer.

That all Applications and Testimonials from Candidates be forwarded to the Local Branch Secretary at least three months before the Examinations.

That the Local Branch Secretary refer any doubtful testimonials to a Local Committee for enquiries, and if there still be any further doubt, such testimonials to be referred to the Examinations Committee for final decision.

The present regulation that Candidates could obtain a pass upon gaining a requisite number of marks at the Examinations, pending completion of the three years' practical mining experience, was considered subject to misconception, and should be discontinued.

That there be the following four classes of Examinations, each having distinct questions: Honours, First Class, Second Class and Service. The Second Class Papers to be of a more practical nature than the Honours and First Class Examinations.

That a Silver Medal be available for Candidates for Second Class Certificates, obtaining 90% of marks.

That Candidates for Service Certificates must be Members of the Association, not less than 30 years of age, and must have had at least five years experience in the application of Electricity to Mining, to be testified in the manner set forth above.

It was resolved that the Examinations Committee be empowered to re-draft the Regulations as may be requisite. A vote of thanks was unanimously passed to the Examinations Committee.

Prizes for Papers.

Mr. Cowie presented the Report of the Committee on the Papers submitted during the past session, which was adopted, and was to the following effect.

The Committee has given careful consideration to the papers submitted throughout the year, and have found this period very much easier to adjudicate because the markings in the Journals have permitted attention to be given to the papers as and when they have been published, leaving only the final review to take place in the month of May.

The Committee recommend that the Gold Medal be presented to Mr. S. B. Haslam, of the South Wales Branch, for his paper on "Modern Methods of Steam Raising with special reference to Pulverised Fuel," published in the Journal of January, 1929.

Also that a special letter of thanks should be sent to:—

Mr. A. W. Harrison Slade for his Paper on "Coal Screening and Treatment," published in the May Journal, 1928, which was read before the Warwickshire Branch;

Mr. G. E. Armstrong for his Paper on "Mechanical Lay-out of Mining Plant," published in the September Journal, 1928, which was read before the North of England Branch;

Mr. L. B. Childe for his Paper on "Decking Plant," published in the March Journal, 1929, which was read before the London Branch.

The attention of all the Secretaries is again drawn to the ruling at the last Annual Meeting that unless the author is a member of the Association when reading his paper, he is not eligible for consideration for the Gold Medal.

With regard to the Prizes for the Colliery Electricians, who sign the Log Book, etc., it was recommended that:—

The 1st Prize of £8 8s. 0d. be awarded to Mr. E. J. Westcott of the Cumberland Sub-Branch, for his paper on "Detecting Faults in Motor Windings," published in the February Journal, 1929.

The 2nd Prize of £5 5s. 0d. be awarded to Mr. J. N. Gardner of the West of Scotland Branch for his paper on "Electrical Conversions of D.C. Machines," published in the July Journal, 1928.

The 3rd Prize of £3 3s. 0d. be awarded to Mr. J. H. Aust, of the Stoke Sub-Branch, for his paper on "Practice with Dynamo-Electric Machines," published in the March Journal, 1929.

The various Branches were congratulated on the high standard of the papers both for the Gold Medal, and the Special Awards, the final adjudication under this latter category having to be twice considered.

Another point to which attention had been drawn, and which it was understood caused some confusion in the allocation of the Branch Prizes, was the wording of the Committee's instruction as published in the Journal, which states that the papers coming under annual review of the Prizes Committee are those published between one Annual General Meeting of the Association and the next, irrespective of the date upon which any paper may have been read. In actual practice the papers which are reviewed are those published in the Journal from May in one year until April in the next year, inclusive. The reason for this is that the Annual General Meeting usually takes place in June, and the Committee must have the month of May in which to make the final adjudication.

A vote of thanks was unanimously passed to the Prizes for Papers Committee.

Annual Report of the Council, 1928-29.

This was received and adopted. It was resolved that constructive proposals to increase the membership of the Association be considered at the next Council Meeting.

Committees.

The following Committees were appointed:—

Advisory Committee.

Mr. D. Martin, the retiring member, was re-elected. Messrs. A. B. Muirhead, D. Martin, T. Stretton and A. W. Williams. President, Treasurer and two elected Vice-Presidents *ex-officio* members. Convener: Mr. A. B. Muirhead.

Examinations Committee.

Messrs. G. M. Harvey, J. W. Gibson, J. A. B. Horsley, W. M. Thornton, T. J. Nelson, R. Holiday, H. J. Fisher and T. H. Williams. Convener: Mr. G. M. Harvey.

Finance Committee.

Messrs. R. Holiday, A. Anderson, F. Beckett and G. Raw. Convener: Mr. R. Holiday.

Papers Committee.

Messrs. S. A. Simon, J. W. Gibson, G. Henderson, A. C. MacWhirter, S. H. Morris and W. Bolton Shaw. Convener: Mr. S. A. Simon.

Prizes Committee.

Messrs. J. R. Cowie, A. Dixon, Dawson Thomas and T. H. Williams. Convener: Mr. J. R. Cowie.

Publications Committee

Mr. F. Anslow was re-appointed a member of this Committee. Messrs. R. Ainsworth, S. H. Morris, A. W. Williams and F. Anslow. President and Treasurer *ex-officio* members. Convener: Mr. R. Ainsworth.

Certification Committee.

Messrs. G. Raw, W. T. Anderson, H. J. Fisher, G. M. Harvey, R. Holiday, A. B. Muirhead, Dawson Thomas, T. H. Williams, R. Wilson, W. Bolton Shaw and T. H. Elliott. President *ex-officio* member. Convener: Mr. G. Raw.

British Engineering Standards Association Sub-Committees.

Representative: Mr. Theodore Stretton.

Qualifications of Colliery Officials, Departmental Committee.

Mr. Harvey reported upon the evidence to be tendered. This was agreed. Mr. Raw read a letter from the Secretary of the Committee, that in consequence of the absence of the Chairman regular sittings of the Committee had been postponed until September next.

Mines and Quarries Form No. 10.

Mr. Fisher reported upon the suggestions made, and which were at present under consideration.

Next Meeting of the Council.

It was resolved that this Meeting be held on October 19th, 1929, at 9-30 a.m. at the Park Hotel, Preston.

Special Educational Facilities.

A report was presented, and it was resolved that this matter should receive further attention at the next Council Meeting.

British Engineering Standards Association's Committees.

It was reported that no particular items of attention had arisen during the past few months. A letter, however, had been received from the B.E.S. Association drawing attention to the fact that makers of Mining Plugs, etc., have referred to the Specifications as B.E.S.A. Plugs and Sockets, and the Association desires that it would be preferable to refer to the plugs and sockets as "British Standard Plugs," and not B.E.S.A. Plugs and Sockets. It was recommended that the term "British Standard" should be used in all such cases.

ANNUAL GENERAL MEETING.

The Annual General Meeting of the Association was held on Friday, July 5th, 1929, at 2-30 p.m. at the Festival Hall, Exhibition Grounds, Newcastle-on-Tyne.

Mr. Frank Anslow, President, occupied the chair. Letters of apology for absence were received from Messrs. W. M. Thornton, Past President; T. Stretton, Past President and Advisory Committee; A. W. Williams, Advisory Committee; W. G. Gibb, West of Scotland Branch; W. Bolton Shaw, North Western Branch; Llewellyn Foster, Honorary Member; and C. F. Dennis, London Branch.

An Abstract of the Minutes is as follows.

The Minutes of the Annual General Meeting of the Association, held on Friday, June 22nd, 1928, at Buxton, having been distributed, were taken as read and signed by the Chairman.

The Annual Report of the Council (see page 53) and the Report of the Auditors, also the Reports of the several Committees, *viz.*, the Prizes for Papers, Examinations, Publications, and Advisory Committees, were received and adopted. Votes of thanks were duly passed to the respective Committees.

ELECTION OF OFFICERS.

The report of the Scrutineers upon the Ballot Papers for Office Bearers for the Session 1929-1930 was to the following effect:—

President of the Association—Capt. S. Walton-Brown.

Vice-Presidents of the Association—Mr. J. W. Gibson and Major E. Ivor David.

Treasurer of the Association—Mr. Roslyn Holiday.

Capt. S. Walton-Brown then took the Chair.

The President, Capt. S. Walton-Brown, proposed a vote of thanks to the retiring President, Mr. F. Anslow, which was passed unanimously.

A vote of thanks to the retiring Treasurer, Mr. Alexander Anderson, was passed unanimously.

A vote of thanks to all those who made the excellent arrangements and contributed to the enjoyment of members attending the Annual Convention was passed unanimously.

A vote of thanks to the under-mentioned, who extended hospitality and support to the Association during the Annual Convention was passed unanimously:—

The Rt. Hon. The Lord Mayor of Newcastle-upon-Tyne.
The Durham & Northumberland Coal Owners' Associations.
Messrs. A. Reyrolle & Co., Ltd.
Messrs. The Consett Iron Co., Ltd.
Messrs. The Newcastle-upon-Tyne Electric Supply Co., Ltd.
Messrs. Seghill Colliery, Ltd.
Messrs. The Silica Coke Oven & Machinery, Ltd.
Messrs. Babcock & Wilcox Co., Ltd.
Messrs. The Birtley Iron Co., Ltd.
Messrs. W. T. Glover & Co., Ltd.
Messrs. Metropolitan-Vickers Electrical Co., Ltd.

Messrs. Harrison & Sedgwick, Chartered Accountants, St. Mary's Gate, Derby, were appointed Auditors.

The President, Capt. S. Walton-Brown, then delivered his Presidential Address. (See *The Mining Electrical Engineer*, July 1929, page 3).

A vote of thanks to the President for his Address was passed unanimously.

Report of the Council.

The following is an Abstract of the Report of the Council for the year ending 31st March, 1929.

Branches.—The Branches of the Association are as follow: East of Scotland, Lothians, West of Scotland (Sub-Branch: Ayrshire), North of England (Sub-Branch: Cumberland), Yorkshire (Sub-Branch: Doncaster District), North Western (Sub-Branches: North Wales and Stoke), Midland, Warwickshire and South Staffordshire, South Wales (Sub-Branch: Western District), and London.

Meetings of Branches have been held regularly for general business, election of members, reading of Papers, discussions thereon, and other matters affecting mining electrical engineering.

Visits to collieries and works, and demonstrations of improvements in machinery and other apparatus were arranged, and proved of considerable technical and practical value to the members.

Committees.—The following Committees were appointed to deal with the special questions submitted to them: Advisory Committee, Certification Committee, Examinations Committee, Finance Committee, Papers Committee, Publications Committee and Prizes Committee.

The Association has been represented upon the following Committees of the British Engineering Standards Association: Flame-proof Enclosure, Mining Plugs, Mining Switchgear, Bulbs for Miners' Hand Lamps, Ball and Roller Bearings for Electrical Machinery, Face Plate Rotor Starters, Field Rheostats, Underground Lighting Fittings, and other matters.

Sub-Committees of the British Engineering Standards Association. The six representatives of the Association appointed to act in the various districts on the Regional Committees of the British Engineering Standards Association for standardisation of Colliery Requisites and the representatives on the Materials and Mining Electrical Plant Sub-Committees, still represent the Association in that capacity.

Qualifications of Colliery Officials, Departmental Committee. The Certification, Examinations and Advisory Committees jointly considered this reference from the Mines Department, and have submitted a Memorandum to the Departmental Committee, setting forth the Association's views upon the subject.

Mines and Quarries Form No. 10. This subject was referred to the Association by the Mines Department, and a Memorandum with suggested Forms have been submitted.

British Industries Fair, Advisory Committee for the Electrical Section. The President represented the Association on this matter.

Council Meetings & Annual General Meeting.—Council Meetings were held during the year to direct the general business of the Association, and consider other matters of importance.

Meetings of the Advisory and other Committees were held during the Year.

Meetings of Branch Secretaries were also held prior to the Council Meetings to discuss general business.

The Annual Convention of Members was held in Buxton on June 19th, 20th, 21st, 22nd and 23rd, 1928, and the admirable programme arranged by the North Western and Warwickshire & South Staffordshire Branches was participated in by a large number of members and guests.

Examinations.—Examinations were held on April 28th and May 5th, 1928, in seven different centres, and there were 41 candidates.

Honours Examination. There were six candidates, of whom three passed.

Ordinary Examination. There were thirty-five candidates, of whom twelve gained First Class Certificates, and eighteen gained Second Class Certificates.

Prof. Statham of the Mining Department, University of Sheffield, St. George's Square, Sheffield, was the Chief Examiner, and the services rendered by him in undertaking these duties are highly appreciated.

The Superintendents of the Examinations also rendered valuable assistance in conducting the Examinations.

Service Certificates.—An oral examination has been instituted under restrictive conditions for members whose length of experience and service warrant such examination.

Special Educational Facilities for Students of Mining electrical engineering in the various Districts. This subject is receiving careful attention.

Finance.—The finances of the Association have received careful attention, and are in a satisfactory condition, the surplus funds being invested in Government Securities and Bank Deposit.

Libraries.—Branches have made arrangements with other local Technical Societies for the formation of Joint Libraries, and have now available for home study a valuable collection of scientific books.

Membership.—The membership of the Association, although affected by the present difficulties of the mining industry, continues in a satisfactory condition.

Official Journal.—The Association's monthly Journal entitled "The Mining Electrical Engineer," is of great value to the members, and circulates to most parts of the world. It has attained a high position amongst technical journals, and is considered one of the most progressive of publications. Meetings of the Publications Committee have been held frequently.

The financial position is satisfactory, and the Reserve Fund has been invested, and notwithstanding the adverse trade conditions during the past year, it has been possible to maintain the standard of the Journal.

A special issue of the Journal was published in January, 1929, containing Articles of considerable interest to members and non-members, and copies were distributed by the Branches to Mining Electrical Engineers and others who would be likely to support the Association's objects.

A complete List of Members of the Association has been published and was transmitted with the March, 1929, issue of the Journal.

Prizes for Papers.—The Committee presented a Report upon the Session 1927-1928.

A large number of papers of very high merit were submitted, and the discussions arising thereon elicited much practical information.

The Premier Award (Gold Medal) was awarded to Mr. R. Rogerson (West of Scotland Branch).

Prizes were awarded to Mr. R. Wilson (West of Scotland Branch), Mr. J. Comrie (West of Scotland Branch), and Mr. E. E. Pidcock (Midland Branch).

The Council desires to draw the attention of members to the importance of preparing and submitting papers before the commencement of the Session, in order that a complete advance programme may be prepared.

It is also desirable that members, when writing papers, should consult the Branch Secretary regarding the subject matter.

Patrons and Donors.—This class of membership has been maintained, but it is desirable in the interests of the Association that further efforts should be made to enrol many more Colliery Owners and Firms as Patrons and Donors.

President.—Mr. F. Anslow was unanimously elected President of the Association at the Annual Meeting on June 22nd, 1928, and during the year Mr. Anslow has visited most of the Branches of the Association.

Vice-Presidents and Treasurer.—At the same meeting Capt. S. Walton-Brown, B.Sc., and Mr. J. W. Gibson were elected Vice-Presidents, and Mr. A. Anderson elected Treasurer.

Past President.—Mr. G. M. Harvey, the retiring President, was accorded the Association's highest appreciation for the great assistance he rendered during his term of office.

SOUTH WALES BRANCH.

Annual Dinner.

One hundred members and guests attended the Annual Dinner of the South Wales Branch which was held in Cardiff on February 23rd last. The principal guest was Mr. Frank Anslow, the President of the Association. The evening was entirely successful and enjoyable. After the toast of the King quite a number of notable speeches were given: "The Association of Mining Electrical Engineers" was proposed by Captain J. M. Carey, H.M. Mines Inspector, and responded to by the President, Mr. Frank Anslow; "The Mining Industry" was proposed by the Branch President of the South Wales Branch, and responded to by Mr. D. Farr Davies, President of the Colliery Managers' Association, South Wales Branch; "Kindred Associations" was proposed by Mr. Idris Jones and responded to by Prof. Knox, President of the South Wales Institute of Engineers and by Mr. W. J. Bache, Chairman of the Institution of Electrical Engineers, Western Centre. Thereafter Major W. Roberts proposed the toast of "Our Guests," which was replied to by Mr. T. Allan Johnson in his usual inimitable way. After Mr. Dawson Thomas had proposed the vote of thanks to the Chairman, which was supported by Major E. Ivor David to which Mr. T. S. Thomas suitably replied, the evening closed with "Auld Lang Syne" and "Mae Hen wlad fy Nhadau."

CAPT. J. MacCLEOD CAREY, submitting the Toast "The Association of Mining Electrical Engineers," said it was somewhat appropriate that he should be electrified by the presence of so many distinguished people. He would refer in a few words to the members of the Association, with many of whom he was acquainted: their achievements were everywhere to be seen, even the tramcars passing outside were part of them as well as the electric torches which some of them might find useful later in the evening. In South Wales they had wonderful coal, the only coal of its kind in the world, and yet in spite of that they found themselves wallowing in the slough of despond. That should not be and it must not be, they must take a cheerful view and be up and doing. They had the finest product in the world and, if our American friends possessed it, they would set up a Woolworth's stores all over the world: they would advertise it, and he really believed it would be good to take a leaf out of the American book and advertise the virtues of South Wales coal. How many people did, in fact, realise that every class of coal had its distinctive virtues and vices, and how perhaps it was cheaper in the long run to buy a more expensive coal when ton for ton so much more could be got out of it, not only in heat units but in many indirect ways such as safe storage in hot climates, less liability to breakage, less smoke and consequently greater cleanliness in usage?

He was delighted to notice that his old friend Mr. W. M. Llewellyn, of Aberdare, had the courage, perspicacity and good sense to make a bold and timely contribution to the difficulties of the situation. He who knew so much about the mining and disposal of coal said "buy colliery shares."

Mr. FRANK ANSLOW, in reply, said it was very pleasing to receive such a cordial welcome on behalf of the Association, and such a hearty reception of himself personally. He thought the success of the Association had been largely the result of the policy of the founders in having sufficient vision to encourage members of all classes, and in this connection he would like to refer to the Mines Department and the Inspectorate who had rendered service to the Association. They had not only been sympathetic towards the Association, but had helped in a practical way by reading Papers, taking part in discussions, and entertained them to such speeches as they had just heard from Captain Carey. The very best thanks of the Association were due for this practical interest in their work.

There was one serious matter upon which he desired to touch, and which might be considered of a domestic nature, though it was really of first interest to the whole of the coal industry: he referred to the question of educational facilities. They had in the Association attempted to educate the mining electrical engineer and the electrician. They had a system of examinations which had been taken advantage of by many enterprising men, but there was a great gap in the education system of this country which prevented many people who would like to take advantage of these examinations, but who were actually prevented from doing so by the fact that they could not get the required technical education between leaving the elementary school, and taking a technical course.

They all knew of young men who started out full of ambition, and who would like to take the highest degrees possible, but without having the capacity to do so; to start such young men out on a heavy curriculam designed for perhaps a period of five to seven years, was too ambitious for the class of man the Association wished to help. He did not say this with any idea of suggesting that the standard of the Association Examination should be lowered: but, on the contrary, he would deprecate any attempt to do so. Some facility was required whereby those young men could go forward and get the necessary knowledge to pass the examinations without necessarily embarking upon a University course, and he thought that the Educational Authorities should provide some facilities between the Elementary School and the University grades. To his mind the danger at the present time was that there was a tendency to start on too high a grade with the result that many students got discouraged, perhaps the first year, or at the latest the second year, because they could not raise themselves to the high standard set: a standard which after all was necessary only for men wishing to go through a University. He hoped that steps would be taken to bridge the educational gulf if it could possibly be done.

THE CHAIRMAN submitted the toast "Prosperity of the Mining Industry," coupled with the name of Mr. D. Farr Davies. Fortunately the toast was opportune in that it occurred at a time when there appeared signs of a permanent improvement in the industry to which they were so attached. The coal trade had always been confronted more or less with great difficulties, even as far back as the 17th century we read that the mines were becoming waterlogged; man power, horse power and water power were failing to meet the necessary demand and the coal mining world was extremely concerned in finding some method of saving the mines. There were then problems for scientists and engineers, necessity became the mother of invention, the steam engine was invented and that pulled the industry out of the mire and gave it a new lease of life and prosperity. The question to-day frequently asked was, could electricity do for the coal mines what the steam engine had done in the past? It was agreed that no great industry had a right to remain behind the foremost rank of knowledge of its time. As a duty to the Nation it should keep itself abreast of the growth of science and bring into action all those advances which scientists indicated from time to time. It could not be said that our chief coal mines had lapsed in this respect, especially where electricity was concerned, for as far as he was able to gather, there was not a single instance of power applied in and about coal mines that had not been successfully attempted by electrical means. Moreover, the modern electrical plant installed in collieries operated with an efficiency second to none in the country.

Of recent years the trouble had not been with waterlogged mines but with a steady contraction of markets for British coal brought about by many adverse factors. Oil had been and was still a serious rival; its use had militated against the coal industry, but it would appear that its threatened supremacy was being challenged by coal in the form of pulverised fuel. This was one source of recovery which might possibly lead to prosperity of the mining industry.

Then there was "salesmanship" as referred to by The Prince of Wales. There was no doubt that a huge responsibility rested with the salesmen. They were usually a keen and active body of men, and he had no doubt that given peace and goodwill, markets free from reparation coal, and an end to the restriction of long term contracts arising from industrial strike, the salesmen would acquit themselves as efficiently as the British engineers. It was really a pleasure to all of them during the last few weeks to read of collieries opening up again: they need not take a gloomy view of the future of the mining industry for he personally realised that when he drank to the prosperity of the mining industry he did so with the sure and certain conviction that prosperity was coming.

Mr. D. FARR DAVIES, in reply, said he was glad to notice the spurt in the mining industry; it looked a little healthier but was not yet convalescent. The coal trade had been very sick and it had had a wonderful lot of advice; everyone thought he could run a coal mine. The coal trade certainly was not declining for the lack of advice, but it was sick from over-production and the spurt in the coal trade to-day was due to the increase in the world necessity for coal. Their President had said there was no lack of technical facilities, technical abilities, nor was there any hesitation in the introduction of electricity to the mines. They looked to the mining electrical engineers to assist in the prosperity of the coal trade, and with their assistance and the assistance of every technical engineer, which they were always ready to receive, he was certain the coal trade would see in the near future more prosperity than it had seen during the last four years.

Continuing, Mr. Farr Davies said he was there as the President this year of the South Wales Colliery Managers' Association. They had had during the year joint meetings of his Association and the Association of Mining Electrical Engineers and he hoped they would have many more. The prosperity of the coal trade depended on the good feeling between the engineers of every branch, and he believed if they had a joint Annual Dinner of the Colliery Managers' and that Association it would be a very good thing indeed. Let them face the future with courage and determination that they as engineers would leave no stone unturned to make the future of the coal trade as prosperous as it had ever been in the past.

Mr. IDRIS JONES, giving the toast "Kindred Associations," said the South Wales Branch of Mining Electrical Engineers always welcomed the members of all kindred associations to their meetings. The progress of the Association had been due not only to their own efforts but also, and largely, to the assistance and the kindly guidance they had received from the various kindred associations. They were all delighted to see so many representatives there that evening, and it was his privilege and pleasure to have to couple with the toast the names of Prof. Knox, who was the President of the South Wales Institute of Engineers and who had been a father to practically all the Institutes in South Wales; and Mr. Bache, Chairman of the Western Centre of the Institution of Electrical Engineers, to which Institution so many of their members also belonged.

PROF. GEORGE KNOX, replying to the toast, said the President had touched on one very serious subject which had engaged the attention of a great many people, not only in South Wales but all over Great Britain—the question of educational facilities for the electrical engineer. Unfortunately in this country we had always looked upon that type of education as being quite voluntary. It was the only type of education which was not compulsory in this country. No doubt that arose from the early inception of technical education in the Mechanics' Institutes, where workmen went in the evening to get what benefit they could from the lecturers, many of whom were actually working mechanics at the time. The lecturers had learnt something of the technique of their craft and wished to transmit it to others. The whole of our system of technical education had grown up in that haphazard way. When they spoke of higher or further education, apart from adult education, they were always more or less concerned with the type of education essential for the professions. Only a short time ago a Committee was appointed to enquire into the question of the relationship between education and industry. The Government were asked to appoint a Royal Commission to inquire into the matter, but they said it was too big a subject and preferred to appoint three or four Committees instead. They all knew what that usually meant, but in this case one of the Committees not only issued an excellent report, but the report was made public as soon as it was prepared and in that was laid down a very good scheme which, if put into operation, would get over many of the difficulties to which the President had referred.

A great deal had been done and was being done with regard to that side of the education problem, but there was still a great deal more to do. It rested as much with Associations such as theirs as with the Education Authorities, because the latter as a rule did not know what their requirements were. A huge body like the County Council consisted of men who were elected for all manner of purposes. They appointed from amongst their number an Education Committee. That Committee consisted of all kinds of people, no doubt interested in Education, but they had no idea what were the special needs of the electrical engineer, and unless they were told what those needs were they were not likely to know how to meet them. It was for the Association as much as anybody else to render the necessary assistance.

Mr. D. Farr Davies had said that the present condition in the coal trade was due to over-production; that was, he thought, only partially true. We were not producing in Europe as much coal to-day as in 1913, and yet we were producing too much for the market, due to the fact that in the interval we had had a trade revolution in internal combustion engines. There had been an enormous growth in the use of new types of fuel, especially of crude oil. When they realised that in 1927 150,000,000 tons of oil was produced and supplied all over the world, which was practically equivalent to three times that quantity of coal (450,000,000 tons). As the output of coal for the whole of Europe last year was 545,000,000 tons, they would realise what they were up against. It was not a question of the increasing production of coal, but that we had something which was taking the place of coal. We had to face that fact and therefore try to utilise our coal by making it a more mobile product so that we could compete against the other forms of fuel such as oil.

Mr. W. J. BACHE, also replying to the toast, said in connection with the mining industry he believed that the assistance of all the kindred institutes of engineers was required. It was a vast, complicated and many-sided industry, and the coal trade would be wise to seek the co-operation of all engineers, whether they be electrical, civil, or mechanical. Co-operation, he would remind them, worked both ways, and as far as his own Institution was concerned they had to acknowledge a debt to the mining industry, who had spared to them their Branch President and other colliery engineers, who were now engaged in the supply side of the industry.

The assistance they could render was illustrated by a conversation he had recently with a member of the Electricity Board. He (Mr. Bache) suggested to him that if the Board had not already sent their representative to South Wales they should do so in order to study the electrical transmission methods adopted by the colliery engineers and profit by their experience and learn by their mistakes. The gentleman was surprised to learn of the large amount of this work which had been done in South Wales, and he certainly thought that the very valuable experience which had been gained by the mining industry would be of great assistance and help to the National Scheme in the near future.

MAJ. W. ROBERTS, in proposing "The Visitors," referred to the many distinguished people representing Industries, Institutions and Professions, and accorded them a very hearty welcome. Several of them had already spoken, and he would now call upon Mr. T. Allan Johnson, whose name he coupled with the toast, to reply on behalf of the guests.

Mr. T. ALLAN JOHNSON having replied: Mr. DAWSON THOMAS proposed the health of the Chairman, the Branch President (Mr. T. S. Thomas).

MAJOR IVOR DAVID supported the vote of thanks to the Branch President, and referred to the certification of various grades of colliery officials. The Mines Department had asked for assistance in this matter and that assistance, he said, would be given by their Association. It was for the members of the Association to back it up with all the power they could, and with all the new members they could, so as to be able to say that all the best men in the industry were members of their Association. Their certificate carried with it a standard of competency, and if they could say that then when electrical jobs were going, and the colliery managers had to select from numerous applicants, they would know that the applicant who was a member of their Association would be qualified to fill the job.

Mr. T. S. THOMAS, in his reply, paid a tribute to the valuable work which had been done during the year of office by the Hon. Secretary, Mr. H. J. Norton, and the Hon. Treasurer, Mr. A. C. MacWhirter. He also thanked the artistes, the Press, and others who had contributed to the success of the Branch and to the evening's entertainment.

SOUTH WALES BRANCH.

A general meeting of this Branch was held in Cardiff on March 23rd last. Mr. T. S. Thomas took the chair, and the following new members were elected: Members—Messrs. Alfred Bundy, of Ton Pentre; Archibald Luther Goldie Davies, of Aberdare; Alfred Charles Evans, of Blaenavon; Ernest David Patten, of Cwmtillery; and Edgar Jefferies, of Crumlin. Associates—Messrs. Idris Arthur, of Pontllanfraith, and Idris Walker of Llanhilleth. Also, to the Western Sub-Branch, Mr. William Henry Robins, of Ammanford (Member), and Mr. Ogwin Samuel, of Seven Sisters (Associate).

A paper was read by Mr. C. L. James entitled "Power Factor—its Cause and Effect." It was illustrated with lantern slides, and an interesting discussion was opened by the Chairman who was followed by Messrs. Idris Jones, W. E. Richardson, R. H. Morgan, J. B. J. Higham, D. J. Thomas, C. F. Freeborn and Jos. Jones, to all of whom Mr. James suitably replied.

A hearty vote of thanks, proposed by Mr. W. W. Hannah and seconded by Mr. Dawson Thomas, was accorded to the author for a very able paper.

Power Factor—Its Cause and Effect.*

Discussion.

Mr. IDRIS JONES congratulated Mr. James on putting together such a very clear and concise paper. He was particularly pleased to note that Mr. James was a student who had been brought up in the collieries. He hoped that the criticism in discussion would be constructive and of the helpful character which would encourage other student members.

The power-factor horse had been flogged quite a good deal during the last few years; he did not propose to go into the formulæ, believing that members were concerned chiefly, as mining engineers, with the means of dealing in practice with this question of low power factor. He would therefore try to show what was being done with regard to improving low power factor on some of the large colliery installations. It is generally acknowledged that there is no particular method to meet all conditions: of the many different methods, such as static condensers, synchronous motors, etc., no one particular method would meet every condition of power factor improvement. Each has its own field of usefulness.

With regard to the different types of power factor correction, Mr. Idris Jones said he was in the fortunate position of having had some experience of every one of the types in use at the present time. At the collieries with which he was connected there were quite a lot of synchronous motors used for driving compressors, and motor generators varying from 200 H.P. to 1000 H.P.

* See *The Mining Electrical Engineer*, June 1929, p. 399

Those motors are higher in efficiency than the ordinary motor or auto-synchronous motor. In small generating plants they have disadvantages; they require a greater starting current to get them up to speed. With regard to synchronous machines, the question of over-excitation serves a very good purpose for troubled conditions. He recalled a particular case during the gale of about twelve months ago when South Wales experienced trouble with overhead lines which were affected by salt spray. After the gale it was impossible to keep the lines in at 33,000 volts. It meant that collieries 13 miles away were without power for hours at a stretch until the insulators affected by salt had been cleaned down with fresh water, and that meant a lot of work.

Fortunately, at the other end of the line there was a lot of synchronous plant and thus they were able to put a reduced pressure on the lines, utilising the synchronous plant to boost up the voltage at the receiving substation. By doing that they were able to work some of the small winders and to keep the pits from being flooded out. That instance shows an advantage of synchronous machines under very bad conditions and what could be done not only from the point of view of power factor correction but to overcome extreme difficulties.

A somewhat similar case was where one of the lines was being supplied and an open circuit occurred on one particular phase. There was a synchronous machine of 1,500 H.P. driving a motor generator set and they were able to get two of the collieries going with a single phase supply simply by having this motor generator set coupled in, the synchronous motor supplying the third phase.

With regard to static condensers, they had about three of these in use. Back in 1920 they were working 4000 yards in-bye and struck a large supply of water, which meant providing some means of improving the power factor or duplicating the cable. The cables were not overloaded, but owing to the distance they could not get the output from the machines. It was a question either of putting in 4000 yards of cable or a static condenser; the cost of the latter was about 25% of that of the cable, and it served the purpose quite well. A few figures of this installation were: 3000-volt job; 220 K.V.A.; distance in-bye 4,000 yards. The supply volts at sub-station was 3000 volts, but with the condenser in circuit it was 3058 volts, or a boost of 58 volts. With one pump on and the condenser off there was a voltage drop of 920: with the condenser in (and one pump) the voltage was 3010: with both pumps working and the condenser in the circuit the voltage was maintained at 2950 volts. This gives an idea of the advantage of installing a static condenser right at the point of using the power. That condenser was afterwards taken out and re-connected for 550 volts on the supply at another substation.

The synchronous motor is of course practically a fixed machine which cannot conveniently be shifted about. Another instance of a static condenser was at a substation where there were two 300 K.V.A. transformers. In this case the power factor was 0.6 and a static condenser of 110 K.V.A. costing £330 was installed; the result was that one transformer could be cut out and kept as a spare for all time: that meant a saving of £50 per annum, which, it would be agreed, was a very good return on the money spent.

Continuing, Mr. Idris Jones said he would like to mention a point which Mr. James had not touched upon. They had heard a lot of talk recently, especially in regard to large systems, about circuit breakers clearing under fault conditions. One of the causes of trouble in this respect was power factor. There was no doubt, said Mr. Jones, that circuit breakers do actually clear very much larger K.V.A. under a high power factor than under a low power factor. The rupturing capacity was limited to a certain extent by the power factor of the circuit.

With regard to the case where they were using a phase advancer, he did not think they were likely to put in any more of them. They gave practically a fixed power factor regulation from 0.75 to almost full unity whereas with a synchronous machine the power factor could be adjusted to any value as desired.

Mr. W. E. RICHARDSON said the paper had been in the nature of a revelation to him in more ways than one: he had held the impression that colliery engineers were very wasteful and did not care how much coal they burnt or how much steam or "juice" they wasted: Mr. James had altered that opinion. He had been interested in the remarks of Mr. Idris Jones, who mentioned the use of the synchronous machine to "boost" up the local voltage in the event of a breakdown on one phase of the supply. He could remember a power station where the shift engineers considered it good practice (in the case of where they had several generators running in parallel) on taking one off load to reduce the load on the outcoming generator and trip the switch with the same power factor as the machines still on load. Whereas the proper method was to adjust the power factor on the outcoming generator to unity and, with the load off, to trip the switch, under which conditions little or no current would be broken by the switch contacts.

Mr. R. H. MORGAN said Mr. James had presented an excellent paper, all that could be desired excepting perhaps for a tendency in a few places to be not sufficiently definite in statement. Regarding the first sentence under the heading "Inductive Circuit," sight should not be lost of the fact that in direct current the effects of induction are present on the opening and closing of the circuit or when the magnitude of the current is varied or its direction reversed. The total voltage had been treated as being composed of two components. There is actually one voltage in a circuit and one current, but either can be treated as being composite. Mr. Morgan considered it would have been as well to have dealt with the current in that way. Both methods were mathematically correct and gave, of course, the same result, for power is only represented by the voltage and current coincident in phase. Mr. James had considered the effects of self-induction overcome by an "idle" voltage component, and Mr. Morgan suggested that the current carrying capacity viewpoint, which had been stressed, would be more clearly demonstrated by considering an "idle" current component, as the magnetising current necessary for the production of the magnetic field from which arises the self-induction.

He also considered that the introduction of tables giving, say, the ratio of "wattless" or "idle" current to "power" current and to "apparent" current, and to the heating losses at various power factors, would be an asset.

The low power factor resulting from the low load running of induction motors was difficult to deal with because of the need for standardisation which does not lend itself to adopting a precisely rated motor for each individual duty. The reactance of a transformer has an appreciable effect upon the regulation at low power factor. A low reactance transformer gives close regulation but good regulation is overshadowed by safety requirements obtained by higher reactance, and yet at loads of low power factor and with a higher reactance, the regulation becomes of serious consequence. It would be seen, therefore, that the maintenance of high power factor is imperative on modern high capacity installations.

The statement under "The Static Condenser" that a leading current is as detrimental as a lagging current should be qualified, for a leading current has a beneficial effect upon the system's resultant power factor. As the example given aims at reducing the current flowing to a minimum it may be well to mention that as far as the static condenser itself is concerned it costs as much to improve the power factor from about 0.95 to unity as it does from about 0.7 to 0.9 as the cost of a condenser is approximately proportional to its K.V.A. capacity.

Mr. J. B. J. HIGHAM.—This question of power factor is a difficult one to deal with, and it is evident that Mr. James has cleared up the ground for himself and many others. The following statement, made by an electrical engineer, is an illustration that many are in complete ignorance of the real meaning of power factor and its cause and effect: "It is not fair to victimise a consumer by an additional charge, or higher price per unit, because his power factor is below, say 0.7, when the power company cannot supply him with energy at a higher power factor." The man who uses the current is responsible for his power factor and not the supply company.

Mr. Morgan had objected to the statement that the leading current taken by a synchronous machine circuit would not relieve the cables connected to asynchronous machines or other circuits, but would only affect the power factor of the whole system. Mr. James was, however, quite correct. In most cases a synchronous machine cannot be placed, say, next to an induction motor, in order to improve the power factor and hence relieve all cables, switches, etc., connecting the induction motor to the system. A static condenser could be put right on the terminals of an induction motor; the motor circuit was relieved and the power factor of the system was improved at the same time.

Again, Mr. James was perfectly correct in treating an applied E.M.F. as consisting of two components in quadrature; in fact he, Mr. Higham, would say that method was fundamentally correct.

There was just one point Mr. Higham said he would like to query: in the section headed "Effect of Power Factor on Transmission," he took it that Mr. James' calculation was arithmetically correct up to the point "Impedance drop $= \sqrt{(800)^2 + (400)^2} = 895$ volts." That was the drop on one line of 10 ohms resistance and 5 ohms (apparent resistance) reactance. The actual drop for a three-phase case would be $\sqrt{3} \times 895 = 1550$ volts.

With regard to the calculation given on condensers it would have been interesting had the author worked out the two cases, i.e., for the Star and Delta connection of condensers.

Mr. D. J. THOMAS.—Consider the question of power factor from another point of view, viz., from the point of view of the people who take bulk supplies. When putting in a condenser or other apparatus it must be proved on economical grounds—the saving in comparison to the capital expended. In one case the author showed a reduction in cost of £167. That in itself was alright, but the point is, what would it cost to save that £167? Looking at some recent figures of cost of condensers he, Mr. Thomas, would estimate a cost of about £200, so that the outlay would be saved in under 18 months.

In connection with this, another example would further illustrate that condensers do pay to put in if the consumers' charges are on a maximum demand K.V.A. basis. A colliery maximum demand is 72 K.V.A. and the average P.F. is 0.66. The charge is £6 per K.V.A. per annum and the cost of a condenser to improve the P.F. to 0.95 is about £240. The reduction in maximum demand K.V.A. is about 50, and thus a saving on one year of about £300 is effected by putting in a condenser costing £240.

What perhaps is not usually considered is that it pays to put in a static condenser for small motors. A case the speaker recently had to deal with was an engineering shop having four 7½ H.P. motors. The average P.F. was 0.7 on three-quarter load, and to bring this to 0.95 meant a saving to the consumer of £64 per annum and the cost of the condenser was about £50. These cases only bring out clearly what an important part power factor plays in the cost if the consumer is paying on the maximum demand K.V.A. basis.

Regarding one of the illustrations shown, on which an isolating switch was depicted between the condenser and the motor: a dangerous condition might arise if the condenser by some chance got isolated from the motor and in a charged condition. It would appear that the safest plan would be to connect the condenser to the starter so that the charge would be dissipated through the windings of the motor.

The breakdowns of static condensers can now be minimised by the introduction of the unit system method whereby the condenser is built in sections and these sections fused. In this case a breakdown of one unit does not put the whole out of commission, and simply means that with the section out the remainder of the condenser still remains in circuit and the nett result is only to reduce the amount of leading K.V.A. supplied to the system.

The author raised the question of whether it is better to raise the power factor to unity or less. The attached curve clearly showed that for unity the capacity of the condenser required would be raised disproportionately to the effect produced, and hence on economical grounds of capital expended versus money saved it generally followed that 0.95 is the figure assumed to be the one best suited. It should, however, be remembered that the saving per annum after the condenser is paid for is greater when the resultant power factor is unity than 0.95.

Mr. C. F. FREEBORN.—Mr. Idris Jones mentioned the rupturing capacity of switches on a low power factor; the influence of power factor is very noticeable in the case of air break reversing switches controlling large winder motors when, although the switch appears easily to open an overload of 100% with very little arcing, the rupture of the magnetising current only causes a decided flash.

On the subject of power factor correction generally, the economical side is the deciding factor; the extent to which correction should be applied should be governed by the conditions of supply, and whereas in one instance it may be worth while carrying the correction as far as unity power factor as, for instance, where a bonus is payable above 0.9 lagging; in another instance the capital expenditure involved is not justified beyond 0.85 lagging. Again, the case of a large colliery undertaking generating and transmitting its own power is quite different from that of a small consumer; the large company will study economical transmission and suitable load distribution among its various units of generating plant, employing synchronous machinery practically exclusively as its means of power factor correction; the small consumer will scheme only to reduce his monthly current bill in the cheapest way and will make his choice between such methods as phase advancers and condensers, having regard to his load factor, and the terms under which he purchases current.

In general, for the smaller consumer, the methods have fairly well defined scopes: for small individual motor drives of 15 H.P. to 20 H.P., a condenser connected permanently across the motor windings meets the case; above that size, and up to about 100 H.P., a phase advancer makes the best proposition, making a cheaper combination than a synchronous induction motor as a rule, and capable of application in most cases to an existing slip-ring motor, where the load factor of same is suitable. An interesting feature of the phase advancer is that it actually improves the overload performance of the motor to which it is applied, but as it imposes a slightly heavier duty than normal on the rotor, the latter must not be too near the heating limit in the first place.

From 100 H.P. upwards, the synchronous induction, or salient pole synchronous, motor becomes the best method, and in some cases synchronous condensers are employed, because the static condenser becomes relatively expensive in the larger capacities at high voltages.

Mr. Idris Jones mentioned the apparently curious case of synchronous machinery maintaining a local three-phase supply while operating on a single phase main supply, but this principle is employed in traction work in America; the high tension single phase current is taken from an overhead line and brought to a rotating converter in the locomotive which generates three-phase power in precisely this manner; the three-phase power is then used for the traction motors in the ordinary way.

In conclusion Mr. Freeborn said he must certainly congratulate Mr. James on his paper, and expressed a wish that the other student members would follow his good example.

LONDON BRANCH.

Electrical Instruments and Meters for Bulk Supply and General Measurements.

C. L. LIPMAN.

(Paper read 20th February, 1929).

Summary.

The paper gives a general survey of modern Indicating and Recording Instruments and Integrating Meters for various purposes. Some particulars are given regarding recent improvements in induction type instruments and in phase-meters. Special meters are described for the purpose of special tariffs; together with methods used for obtaining summated consumption and demands. Finally a few remarks are made regarding instrument transformers.

The rapid growth of electricity supply in "bulk" has brought to the fore the question of its proper measurement and control. The problems of correct measurement and registration of the fundamental electrical quantities have occupied the thoughts of power engineers and instrument makers for a long time with the result that this branch of electrical engineering is now in a state of high development.

The object of this paper is to describe some recent improvements in electrical instruments and meters for bulk supply and general measurements, and it is hoped that it may tend towards a better understanding of good metering practice.

Indicating Instruments.

For the measurement of electric current and pressure, moving-iron and induction type ammeters and voltmeters are recommended.

Considerable advances have recently been made in the design and construction of induction-type instruments with the result that they can now be supplied with an inherent accuracy higher than B.E.S.A. first grade.

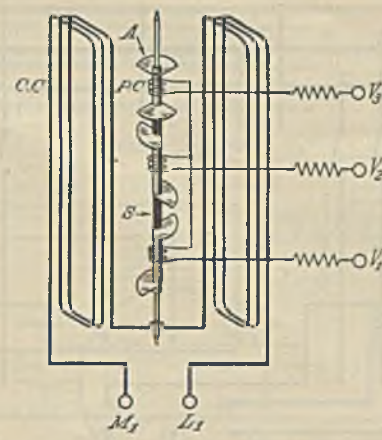
The following technical particulars relate to a new induction ammeter manufactured under the author's patents and wound for 5 amps 50 cycles.

By way of comparison similar data are given for the ordinary shaded-pole type of induction ammeter.

	Nalder-Lipman improved induction ammeter.	Ordinary shaded pole induction ammeter.
(a) Change of reading for a rise or fall of 1 deg. C. in temperature	0.015%	0.4%
(b) Change of reading for a change of 20% up or down in frequency	0.4%	12%
(c) Change of reading after being left in circuit for 2 hours	0.5%	3%
(d) Weight of moving parts	9 gms.	30 gms.
(e) Volt ampere consumption for full scale deflection ...	4	10

The new induction voltmeter and wattmeter possess similar advantages as regards accuracy and construction.

Wherever power factor regulation is attempted, a direct reading power-factor meter is necessary, as it is out of the question to calculate the power factor from the readings of wattmeters, ammeters and voltmeters. The improvement of power factor of an A.C. system is a question of great importance, as a low power factor is extremely undesirable for several reasons. In the first place, the cost of the supply mains is largely increased if, for a given kilowatt load, the power factor is low, and the losses in the mains are likewise increased. The alternators can give a larger output at a high power factor, while at the same time the inherent regulation of the machines is better, the variation of the voltage with changes in the load being much less



3 phase Balanced Load Power Factor Meter: Lipman type

Fig. 1.

at a high power factor than when the power factor is low.

Satisfactory direct reading power-factor meters are of the moving iron type working on the "alternating field" (as opposed to the "rotating field") principle. The distinguishing feature of these phase meters is that owing to their special construction no resultant rotating field is set up, and consequently no "rotational drag torque" upon the moving iron system is produced, and the disadvantages and errors arising from that torque are eliminated.

For important polyphase circuits unbalanced load pattern instruments and meters should be specified.

Whilst most of the leading switchgear manufacturers have adopted this policy, the author is aware of instances where by reason of economy balanced load power factor meters are being coupled together with unbalanced load wattmeters. The method of using a single-element meter assumes equality of current, pressure and phase angle on the three phases, a condition which is very rarely obtained on polyphase power circuits.

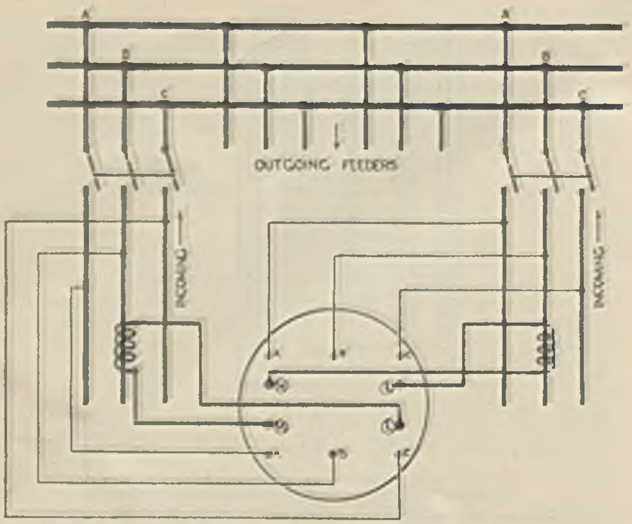
A form of three-phase balanced load power factor meter which has gained considerable popularity during the last few years is illustrated in Fig. 1 and consists of one current coil CC and three pressure coils PC. The readings of this meter are unaffected by variations of the load current, pressure, frequency, temperature or wave form within the limits met with in ordinary practice. It enables a saving in the number of current transformers to be effected, and is less disturbed by slight unbalanced loads than would be the case with a balanced-load pattern power factor meter having one pressure and three current coils.

An interesting application of this type of meter for the measurement of power factor of two incoming feeders is shown in Fig. 2.

Recording Instruments.

Considerable developments have also taken place in chart recording or "graphic" instruments. In addition to recording ammeters, voltmeters and wattmeters, the details of which are well known, power factor indicators and frequency meters have been introduced. Combination instruments are also obtainable for such purposes as feeder logs, etc., multiple pen recorders for telephone work, and revolution recorders or speed indicators, which generally consist of a magnetogenerator and a recording voltmeter.

Recorders have been specially adapted for fitting to electric trains, and a special system of cradle mounting has been devised which protects the instruments from the effects of excessive vibration.



POWER FACTOR MEASUREMENTS OF TWO INCOMING FEEDERS.
NALDER - LIPMAN PATENT.

Fig. 2.

These recorders give valuable information, and tend to promote the efficient and economical running of the trains.

With regard to the method of marking the chart, the original method was to fix a pen at the end of the pointer arm. The disadvantage of this method lies in the fact that errors due to the variation of the amount of ink in the pen can never be wholly eliminated. Various methods of getting over this difficulty have been adopted by different makers, amongst which the following serve as examples.

A tapping mechanism by which the chart is inked at regular intervals. The inking device consists of a short length of fine tube fixed to the end of the pen arm, one end of which moves in a trough, at the back of which is an inking pad; the other end taps on the chart at regular intervals, generally a quarter or half minute, and is depressed on to it by a bar actuated by an electro-magnet, thus (simultaneously) causing the ink to flow in the tube from the pad and making a dot on the chart. If the time intervals are sufficiently short, the record differs little from a continuous line.

The advantage of this method of inking is that the pen is not continuously in contact with the chart, and thus "pen to paper friction" is eliminated. This ensures accuracy, and is particularly valuable in the case of instruments wherein the forces are necessarily small, as in recording frequency meters and power factor indicators. Fig. 3 illustrates a recording frequency meter embodying these features and Fig. 4 gives typical ranges obtainable. A typical chart of a recording power factor meter is illustrated in Fig. 5.

Another type of recording instrument which also gets over the error due to variation of ink in the pen was originally introduced by the Esterline Company of Indianapolis, and has since been further developed in this country by various instrument makers.

In this type the pen arm consists of a fine tube which is normally full of ink, one end moving in a vessel containing the ink and the other end over the chart; the error due to variation of the amount of ink is thus eliminated.

With regard to charts, there has been little alteration in these in the last few years.

Generally speaking, the hour, or time, lines are curved. Some time ago a recording instrument was patented by Murday, which gives rectangular co-ordinates.

Integrating Meters.

Generally speaking, an integrating meter may be derived from the corresponding indicating pattern of meter by substituting for the spring control and pointer and eddy current brake and a counting train respectively. Practically all modern A.C. integrating meters operate on the induction principle, and are capable of giving a high degree of accuracy under working conditions. The most important integrating meter is the energy meter upon the K.W.-hour readings of which is based the fundamental Board of Trade unit tariff for electricity supplied. For the meter to read correctly, the speed of rotation of the rotor must be proportional to the power in the circuit in which the meter is connected.

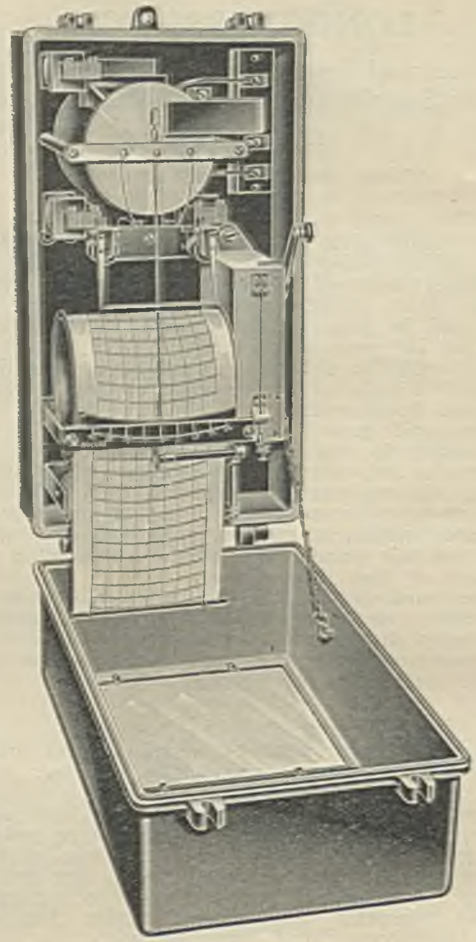


Fig. 3.

Numerous forms of construction of energy meters have been devised, the principal differences in construction being confined chiefly to:—

1.—The arrangement of the operating electro-magnets.

2.—The methods of obtaining the correct phase difference between the fluxes of the series and shunt windings; and

3.—The method of compensating for friction.

Wattless component or reactive meters are similar to watt-hour meters; the only difference consists in the phase relation between the magnetic fluxes. In the wattless component meter the flux from the coil energised at the full pressure lags to such an extent that there is a phase displacement of 180 deg. between this field and the applied pressure producing it. For the purpose of registration of total kilovolt-ampere hours several methods have been devised, most of which are, however, of an approximate nature. The torque of the induction type A.C. meter changes with the power factor accord-

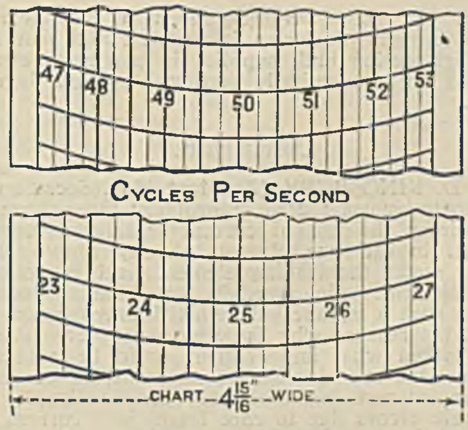


Fig. 4.

ing to a sine function. As a result, the torque is practically constant in the neighbourhood of the power factor at which it is a maximum.

The instrument registers the K.V.A. hours with a relatively small error, irrespective of the power factor. By suitable choice of the displacement between the active shunt flux and the impressed voltage, the maximum value of the torque can be arranged to occur approximately in the middle of the power factor range for which the instrument is designed. These meters are, therefore, only suitable for a fixed range of power factor.

Another method of arriving at the total K.V.A. hours is by the employment of two meters, one of which is a standard energy meter and the other a wattless component meter. The total K.V.A. hours is the vectorial sum of the two component readings taken over a given time interval.

A more recent development of K.V.A. hour meter is the "trivector" meter, in which an integration of K.V.A. hours is obtained by a mechanical combination of an energy meter with a reactive meter, and is suitable for use over a wide range of power factor and voltage. In another interesting construction of K.V.A. hour meter the revolutions of these two meter rotors are transmitted to a suspended sphere, which rotates at a speed and in a direction representing

$$\sqrt{(WH)^2 + (RVAH)^2}$$

A floating gear is arranged to take the drive off this sphere at the point where the peripheral speed is greatest and this drive is transmitted to the maximum demand indicator mechanism which records the maximum demand in intervals of 15 or 30 minutes, both in K.W. and K.V.A.

Special Meters.

The type of meter adopted for the metering of bulk supplies depends largely on the tariff which is selected

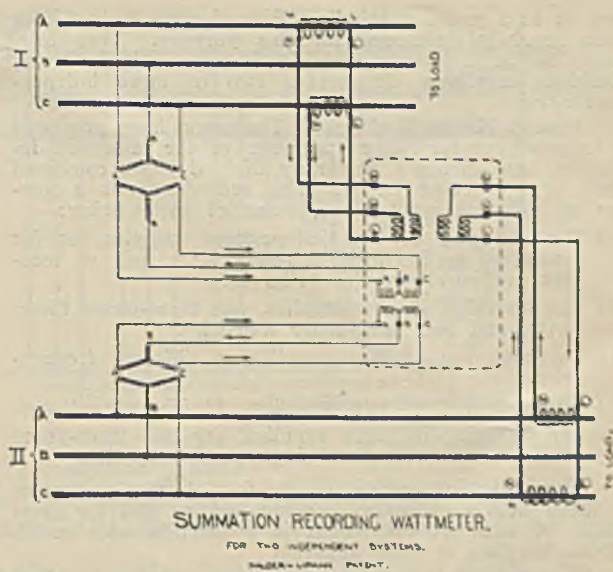


Fig. 6.

for the supply. The usual form of tariff for a supply of this nature is one which includes a term proportional to the maximum demand on the system. Taking kilowatt maximum demand as the first example, the usual induction meter is used together with a Merz-type maximum demand indicator. The maximum demand is averaged over a certain definite period, which is controlled by a contactor. This contactor may be either self-contained with the meter, or separate.

As an alternative an averaging recorder is available. When the maximum demand is required to be in K.V.A. a separate K.V.A. and maximum demand indicator must be employed, or as an alternative the trivector type of meter can be used. The latter incorporates both kilowatt and K.V.A. records.

A further alternative tariff is based on the average power factor or on the minimum power factor, as the case may be, given by the consumer. For the former tariff a reactive component meter or recording power factor meter is used in conjunction with the kilowatt hour meter, and for the latter a minimum power factor indicator is used in conjunction with the K.W. hour meter. In connection with large supplies chart recording maximum demand meters of the "Printometer" or "Maxigraph" pattern are particularly recommended. Besides integrating the total energy consumed, they record the units consumed during successive periods, so as to demonstrate exactly the load conditions during each individual period of maximum demand. In connection with an interchange supply two simple watthour meters with ratchet devices can be used, one recording incoming and the other outgoing power.

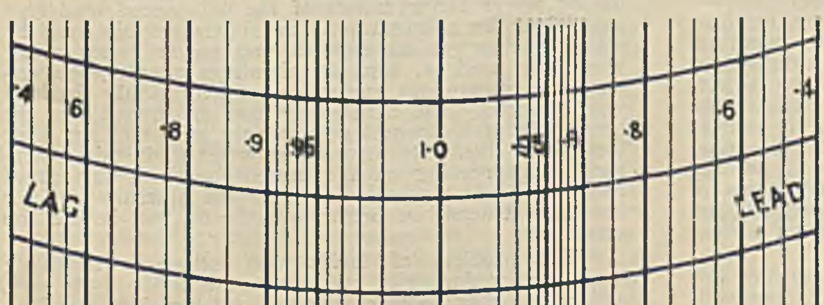


Fig. 5.

Summation Metering.

A type of suppply often met with in connection with bulk supplies is that where two or more feeders are used, and the load from each of these feeders has to be summated in order that a true maximum demand may be obtained. If the several circuits are supplied from a common voltage, then the secondaries of the current transformers are often connected in parallel to the current coils of the meter, the latter of course being wound suitable for the sum of the secondary currents. A better solution of this problem is to use meters compounded on to a common spindle. Four-element meters have been specially developed for this purpose. They integrate the total energy and simultaneously indicate the combined maximum demand in two or more independent circuits.

Messrs. Nalder Brothers & Thompson have produced a four-element recording wattmeter of the improved induction type giving a uniformly divided chart combined with large working forces. This recorder finds a number of different applications, some of them being:—

(a) The metering of two independent supplies, as for example, sectionalised bus-bars, or a pair of feeders not paralleled (see Fig. 6).

(b) The metering of two supplies, one three-phase three-wire, and one three-phase four-wire.

(c) The metering of two supplies at different frequencies.

(d) The metering of two supplies at different voltages.

(e) The metering of three supplies, say one three-phase and two independent single-phase supplies.

The indicating pattern of the four-element wattmeter is fitted with a maximum demand pointer and the great utility of such an instrument in connection with multi-feeder supplies is quite apparent.

Where more than two polyphase circuits are involved special summation equipment becomes necessary.

In America such summation is carried out by the "impulse" method, but in the present author's opinion a more accurate, simple and technically sound method is to convert the A.C. quantities to correspondingly proportional direct current voltages or currents and then add up the latter by means of ordinary D.C. meters.

Instrument Transformers.

Switchboard instruments and meters are, as a rule, working in conjunction with instrument transformers. The chief point in connection with an equipment of this nature is the type of current transformer employed. Considerable errors can be introduced to the metering equipment as a whole, if this point is not carefully looked into. Generally speaking, for best results the nominal volt-ampere rating of the transformer should be as high as possible consistent with the requirements and the secondary burden as low as possible. Precision current transformers are now available having nickel-iron cores. The greatest difficulty arises when "bar" type or "bushing" type current transformers are employed with limited primary ampere turns.

Some time ago the author had been considering the problem of straight-through metering on extra-high tension systems with primary currents as low as 10 amperes, in conjunction with Messrs. Nalder Brothers and Thompson, Ltd., and Messrs. A. Reyrolle and Co., and we concluded our investigations with the development of a new series of highly efficient low volt-ampere consumption instruments, including ammeters, wattmeters, power factor meters, and protective relays, the current windings of which were made suitable for a secondary current of 0.5 ampere instead of the usual 5 amperes. This recommendation has now been approved by the Central Electricity Board for the British Grid.

The advantages arising from 0.5 ampere as full-load secondary current instead of 5 amperes are manifold. The 0.5 ampere metering improves the performance of the bushing transformer, permitting a finer turn adjustment; it reduces the secondary burden; it reduces the losses in the long run of connecting leads; it enables accurate measurements to be carried out in the usual manner on extra high tension systems; and it has led to the development of a new and improved series of instruments, requiring very low power consumption and giving exceptionally high working forces, control springs of normal strength being employed.

In order to keep the size and weight of the low ampere-turns bushing transformeers within reasonable limits, it is further recommended to make the magnetic core of such transformers of metal laminations.

From the above considerations it is clear that "straight-through" metering in general, and that metering of high-tension bulk supplies in particular can now be carried out economically and with a high degree of accuracy.

Discussion.

Mr. D. KINGSBURY (Assistant Hon. Secretary), referring to instruments used in ordinary three-phase work and requiring the use of current transformers, said it was usual to call one element of, say, a two element watt-hour meter the leading element, and the other the lagging element. He asked if Mr. Lipman could explain, in such a manner that his hearers could never forget it, the reasons why these elements were so named. He also asked what improvement could be expected to result from the use of mumetal cores instead of ordinary stalloy in current transformers. Extraordinarily small phase angle errors due to core losses in a current transformer produced very large errors in results when the power factor of the circuit in which the transformer was being used fell.

Mr. J. A. B. HORSLEY was impressed by the wonderful diversity in the types of instruments now available for the purpose of metering, and with the ingenuity that evidently had been expended in overcoming the various sources of error. With ordinary work-a-day switchboard instruments an accuracy beyond what was possible a few years ago is now shown to be attainable.

With regard to recording instruments, Mr. Horsley expressed the view that for colliery purposes very much more use should be made of chart recording instruments. The author of the paper had not referred specifically to recording leakage indicators but, obviously, the principles described were equally applicable to that form of instrument. Generally there was some form of leakage indicator in use at a colliery, but it was of very little practical value. The real value of a leakage indicator is only realised when it permits continuous observation to be kept upon the state of the insulation, and that could be obtained only by means of a graphic type of instrument. He was aware, of course, that the leakage reading might be wholly misleading unless the insulation of the system as a whole was maintained. Apart from that the instrument might be shunted by complex faults on the system, but he did consider that chart recorders might be used at collieries particularly with great advantage.

Mr. C. S. BUYERS, referring to the author's statement that in the shaded pole induction ammeter (was that the ordinary moving iron instrument?) the change of reading for a rise or fall of 1 deg. C. in temperature was 0.4%, asked if that meant that if there were a rise in temperature to the extent of 20 deg. C. would the change of reading be 8%? He also pointed to the author's statement that the change of reading after the instrument had been left in circuit for two hours was 3%, and said that an ammeter was as a rule left in circuit practically continuously. He had no idea that there were likely to be errors of 8% and 3% respectively in certain types of A.C. ammeters working under ordinary conditions. The author's remarks with regard to the use of power factor meters of the unbalanced load type as against the balanced type had interested him, and he asked whether an unbalanced load power factor meter should be used in, say, the circuit of a rotary converter or a synchronous motor where theoretically the load was balanced. The unbalanced load instrument was the more difficult to connect up correctly as it had six leads instead of five. He also asked whether, if this instrument were reading on the bottom quadrant instead of the top, it was preferable to alter the pressure leads or the current leads in order to make it read in the top quadrant.

The problem of tariffs was extremely involved; nearly every Authority had a separate tariff of its own, especially where power factor was taken into consideration and a K.V.A. maximum demand meter was installed.

With regard to the use of recording meters which the author appeared to favour to some extent, he asked whether the duty of altering the charts fell upon the Supply Authorities or the consumer.

Dealing with the problem of summation metering, he said that some consumers had both an A.C. and D.C. supply. He did not know if a charge were made on the maximum demand of both systems added together, but would be interested to learn if it was possible to have a summation meter which would give the true maximum demand of the two different systems.

He asked if the new type of ammeter referred to by the author was of B.E.S.A. first grade accuracy.

The paper was presented at a most opportune time and if some of the diagrams shown by Mr. Lipman on the screen were published, it would be very valuable for reference.

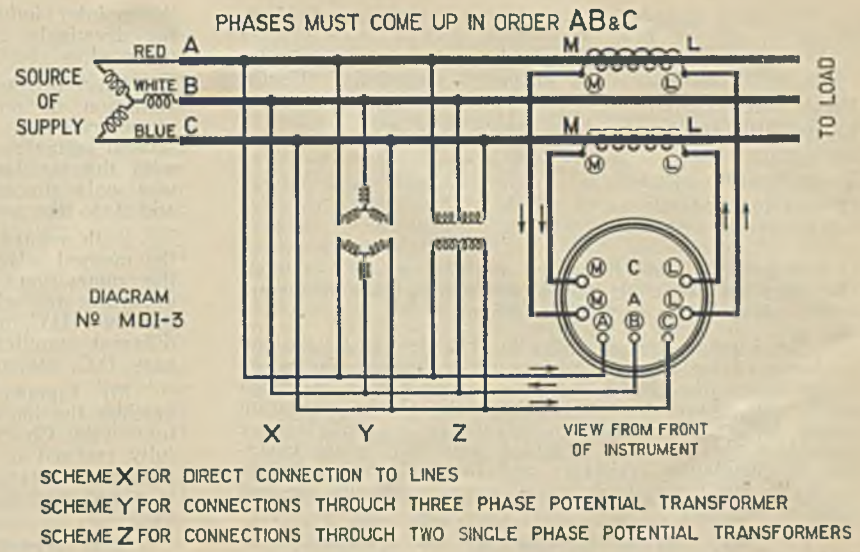


Fig. 7.

THE CHAIRMAN said that in the past he had avoided the installation of a power factor meter wherever possible, but in view of the improvements effected, as indicated by the paper, the position appeared to be more hopeful, and he hoped to follow up that matter. Emphasising the importance of using good clocks, he said that unless good clocks were used, there were cases when the advantage of the increased accuracy of the instruments themselves were lost. With regard to the use of a second meter as check, he said that if it gave a reading differing from that of the other meter, it was difficult to determine which of the two meters was giving the more correct reading without test. Some people held the view that if more than one meter was used for a given purpose, not less than three should be used, as giving a better average. The cost of meters was a material point in the case of small undertakings and unless this was tackled, the continental tendency might spread, i.e., the quoting of a price of so much a month for a supply, such as water heating, thus cutting out the use of meters; they had found that if the meter cost together with its maintenance and depreciation charges were avoided, a sufficiently low rate could be charged to attract the business.

Mr. C. L. LIPMAN (in reply).—The point raised by Mr. Kingsbury regarding the "leading" and "lagging" elements of a polyphase watt-hour meter will be of interest to those concerned with the installation and working of polyphase meters on a three-phase circuit.

If the sequence in which the respective voltages of a three-phase circuit attain their maxima is Red, White, Blue, Red, White, Blue, etc., then the Red phase E.M.F. is leading and the Blue phase E.M.F. is lagging in time-phase relative to the White phase E.M.F.

It is seen therefore that the meaning of "leading" and "lagging" is not absolute but relative. For instance, it is equally correct to say that the White phase E.M.F. is leading and the Red phase E.M.F. is lagging relative to the Blue phase E.M.F.

If the above is clearly understood there should be no difficulty (provided the phase rotation is known) in connecting up power factor meters, e.g., that illustrated in Fig. 1 of the paper, correctly to existing current and potential transformers on a three phase system. Supposing, for example, the two ends of the current coil are connected to the secondary terminals M_2 L_2 of a current transformer in the White phase instead of to M_1 L_1 of the Red phase as shown in Fig. 1, then in order that the meter may read correctly all that is necessary to do is to re-name the pressure terminals V_1 V_2 V_3 to V_2 V_3 V_1 (i.e., White, Blue, Red) respectively.

On account of the necessity of maintaining a standard phase relationship between the voltages in each element of a polyphase watt-hour meter, the British Engineering Standards Association (Specification No. 37/1919) recommended that the upper element of such a meter (see Fig. 7) should be connected in what is usually designated the "leading phase." As will be explained presently, this term "leading phase" actually refers to the element having its current coil connected in the Blue phase, and should not be confused with the earlier definition given above that the Blue E.M.F. is lagging relatively to the White E.M.F.

Referring to Fig. 8, which is the vector diagram for a balanced three-phase circuit, it will be observed that with the phase rotation taken as counter-clockwise the element which carries the current in the blue phase is energised by a voltage which, at unity power factor, lags this current. The current in the blue phase element thus leads on the meter voltage, hence the name "leading element."

Similarly, it appears from the vector diagram that the current in the red phase element lags the voltage on this element, hence the name "lagging element."

When the load is non-inductive the phase displacement between the current and voltage vectors in each element is 30 degrees in each case.

With regard to the other question asked by Mr. Kingsbury, the improved performance of a current transformer resulting from the use of mumetal instead of ordinary stalloy cores can be judged from the following figures relating to a "precision" mumetal transformer wound for 1200 ampere-turns at rated current.

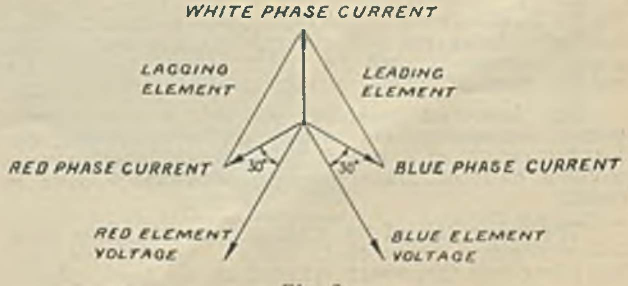


Fig. 8.

	V.A. output	*% ratio variation*	*Phase displacement in minutes (lead)*
From rated current	7½	.05	3
to one-fifth rated	15	.05	5
current	40	.05	8
From one-fifth rated	7½	.06	4
current to one-tenth	15	.06	7
rated current	40	.06	11

It will be noted that the phase angle errors are so small that they do not affect the accuracy of watt-hour meters under all possible service conditions.

Mr. Lipman agreed with Mr. Horsley as to the importance of installing chart recording leakage indicators in collieries, this being the only effective way in which continuous observation upon the state of the insulation could be kept. A further advantage is that leakage recorders are generally provided with two scales enabling the insulation resistance and the leakage current to earth to be determined simultaneously at any desired time of the day.

For Mr. Buyers' information, the induction type instruments form a class of their own and are quite distinct from the moving iron type of instrument. In the past the moving iron type of ammeter was capable of giving a higher degree of accuracy than the shaded pole induction type of instrument, the latter having been used mainly on account of its long circular scale and robust construction.

The shaded pole type of induction ammeter is affected to the extent of 0.4% per 1 deg. C., and if there were a rise or fall in temperature of 20 degrees C. the change of reading would be + or — 8%. However, first grade induction ammeters are now available (as described in the paper) the temperature co-efficient of which is only 0.015% per 1 deg. C., causing an error of only 0.3% for a rise or fall of 20 degrees C. in temperature.

Induction type instruments are also subject to "self-heating" errors, which fortunately can be allowed for in the calibration. Generally speaking, an induction ammeter of the shaded pole type gives steady readings only after it has been in circuit for about 45 minutes to two hours, after which time the readings do not alter appreciably due to this cause.

As stated above, this error (about 3%) can be entirely eliminated in calibration. In the improved type of induction ammeter the self-heating error is only about one-half of 1%, meaning that reliable readings can be taken after the instrument has been in circuit for five or ten minutes.

In connection with this matter it may be appropriate to quote the following passage from paragraph 32 of B.E.S.A. Specification No. 89, 1929.

Methods of Testing for Accuracy.

(*b*) When an instrument is liable to vary in its indications according to the time during which it has been in circuit, the following procedure shall be followed when testing it:—

(i) A sub-standard instrument may be tested at any time after being put into circuit: but first and second-grade instruments shall be tested after being run for not less than 30 minutes at rated current and/or voltage.

For important polyphase circuits unbalanced load pattern instruments and meters are recommended, but for the circuit of a rotary converter or a synchronous motor a balanced load power factor meter is quite in order.

The upper half of the scale of a power factor meter indicates power delivered to motors, rotaries, etc., and the lower half the power returned to the lines. Should the pointer indicate in the reverse sense, the leads at the terminals of each current transformer must be reversed.

Most of the difficulties experienced during the installation of power factor meters are due to wrong phase rotation. Mr. Lipman said he was aware of several instances where the colour scheme does not agree with the standard sequence of phase rotation and that was only discovered when a power factor meter was added to the switchboard equipment.

With regard to the problem of summation metering the method advocated in the paper is quite suitable for the summation of A.C. and D.C. supplies. The A.C. quantities are primarily converted to correspondingly proportional D.C. quantities and then the summation of the different supplies is effected in the usual way by ordinary D.C. meters.

Mr. Lipman entirely agreed with the Chairman regarding the importance of using good clocks in conjunction with Chart Recording Apparatus. That point is fully realised by instrument makers and considerable improvements have recently been introduced into the design and manufacture of that particular piece of mechanism.

With regard to the cost of meters this is now so low in comparison with the service they give that further reductions are hardly possible.

NORTH OF ENGLAND BRANCH.

The North of England Branch held its fifth ordinary meeting for the session on Saturday, 23rd March, at Durham, when Major John English read a paper on "Dry Cleaning of Coal," which was followed by a most interesting discussion. Mr. H. J. Fisher occupied the chair, in the unavoidable absence of the Branch President.

Pneumatic Cleaning of Coal.

MAJOR JOHN ENGLISH.

The old fashioned method of dealing with coal when it came out of the pit was to tip the tub over an ordinary kickup on to a bar screen. Of the round coal which did not go through the bars, much of it shot straight into the wagon; the remainder was shovelled in by two men at the bottom of the bar screen. If these men saw a piece of stone they picked it out and threw it on one side. The small which went through the bar screen went straight into another wagon, and was sold as small; or it went into a big tub which, when full, was hauled up an incline plane on rails to the top of what was called the bees-wing. There it was tipped and further screened into nuts and duff, but no further cleaning was done, and probably in those days none was necessary.

This method was superseded by the coal being tipped on to a bar screen; the round being shot on to a moving belt alongside which were stationed boys who picked out the stone as the coal passed by them. The screening was very imperfect as can be imagined, consequently some improvement was called for, and the bar screen was superseded by the jigging screen, which separated the small from the round more perfectly, but still it was only the round coal which was dealt with so far as cleaning was concerned, the small passing into the wagon just as it came out of the pit.

In some cases where a colliery was supplying unscreened coal, the separation of round from small still took place on the jigger. Where it was desired to make unscreened coal, the small and round were mixed again, the separation only being made so that the round could be cleaned more thoroughly.

As time went on, and with the advent of coal-cutters, it was discovered that the ash content in the coal became higher and higher. This fact called for inquiries as to the cause, and as to where the ash was coming from. It was found that a large percentage of the ash was in the small.

There can be no doubt that coal cutting has tended to increase the amount of stone in the small. However expert the man responsible for cutting the coal may be, there are times when the coal-cutter jib gets into the bottom stone, with the result that the curvings contain a certain amount of stone. Moreover, if the thill of the seam is at all soft, the weight of the coal-cutter as it is dragged along the face has the effect of breaking up the floor, which makes it difficult to fill the coal without a fair percentage of small dirt in it.

It was found to be impossible to pick out stones from small coal under an inch in size, and therefore there was no means of cleaning this small coal until mining engineers turned their attention to washing it with water.

The application of water to coal for the purpose of removing the dirt was satisfactory for some kinds of coal, but most unsuitable for gas coal, as the buyer objected to buying gas coal with perhaps ten per cent. or more of moisture in it.

At the time when this question of cleaning small coal became acute, the Americans introduced the spiral separator, which is simply a spiral chute down which the uncleaned coal gravitates. There is no moving part about the apparatus, the separation being effected by the centrifugal force causing the coal to travel out and fall over the edge of the chute sooner than the stone on account of the difference in the specific gravity. This method is understood to be quite effective within certain ranges and with certain coal of a certain shape.

Following on this the Americans introduced a method of cleaning coal by what might be described as washing it with air. This method and the plant, which the author has to do with, will be described in some detail.

The original plant of the author was the first of its kind outside the United States. It was in effect the pioneer example of the system and, as is invariably the case, conveyed very many lessons as to what not to do. From its very inception it was plainly on the right lines, as the anticipated results were secured.

The term "washing by air" clearly distinguishes the process. It is common knowledge that in all wet washers the underlying principle is that coal being lighter than stone will float on troubled water while the stone sinks. This is precisely what takes place in air washing. Where the difference in the specific gravity between the coal and stone to be separated is great, the operation is comparatively easy, but where the dross is near in weight to that of the coal, the process becomes more difficult, and in some cases impossible.

The plant under the author's charge comprises four pneumatic dry separators of the S.J. type. Each table deals with a specific size as follows: No. 1, 2in. to $1\frac{1}{2}$in.; No. 2, $1\frac{1}{2}$in. to 1in.; No. 3, 1in. to $\frac{5}{8}$in.; No. 4, $\frac{5}{8}$in. to $\frac{1}{4}$in. All below $\frac{1}{4}$in. size will be cleaned on the latest type of table which will be described later. The S.J. tables in general design are similar, differing only in detail to accommodate the size of coal each has to deal with.

Two factors are brought into use to effect the ultimate separation. Firstly, a current of air is employed to lift or dissemble the whole product. Secondly, a quick short jigging motion is used to deal with the stone. The work done by these two factors will be clearly understood from the following description of the tables.

Each table is formed with a deck, the frame of which is of timber, shaped as shown in Fig. 1. Stretched on top of this deck is a steel woven wire mesh of 16's gauge wire with 64 meshes to the square inch for the smaller sizes down to 16 for the larger sizes. Fixed on top of the mesh are light steel L-shaped tapered riffles running parallel with the laths shown in the timber frame, Fig. 1, Section 8—8. These riffles vary in size and pitch according to size of coal to be treated; for $\frac{5}{8}$in. to $\frac{1}{4}$in. size, they would be 1in. high tapering to 0; for 2in. to $1\frac{1}{2}$in. size, they would be 2in. high tapering again to 0. All riffles finish approximately 6in. from the right hand or the refuse side of the table, making a clear track for stone as it is separated.

Situated on the underside of the wire mesh on the deck, and running the whole length and width of the stone track, is a thin perforated plate 18's gauge with $\frac{1}{16}$in. holes for the smaller sizes, and larger holes for the larger sizes as required. This is to dampen the air pressure under the stone track, and so prevent the stones being thrown back among the coals.

Air baffling is again effected by means of U section perforated steel baffles placed alongside the laths on the timber framework and immediately behind the riffles as shown in Section 1—1 in Fig. 1. These again dampen the air pressure, and so prevent stones being lifted over the top of the riffles once they have settled.

Each table deck is fitted on the underside with a set of steel vanes marked 2 on the slide as shown on view looking in direction of arrow. These act as separator directors, their function being described later. The whole of this deck is fixed to a wind box formed of light sheet steel as shown in Fig. 2, and is fitted with a steel mesh having $\frac{5}{16}$in. to $\frac{1}{2}$in. holes, depending on the size of coal the table is designed for, situated about 9ins. above the air inlet. Curved steel directional vanes marked 3 are fitted as shown on slide; their purpose will be dealt with later.

The wind box is connected to the fan by means of a strong canvas tube about 2ft. diameter and 2ft. long. The fan is of Sirocco volumetric type single inlet, 30in. diameter, direct coupled to a 30 or 40 H.P. totally enclosed motor running at 780 r.p.m.

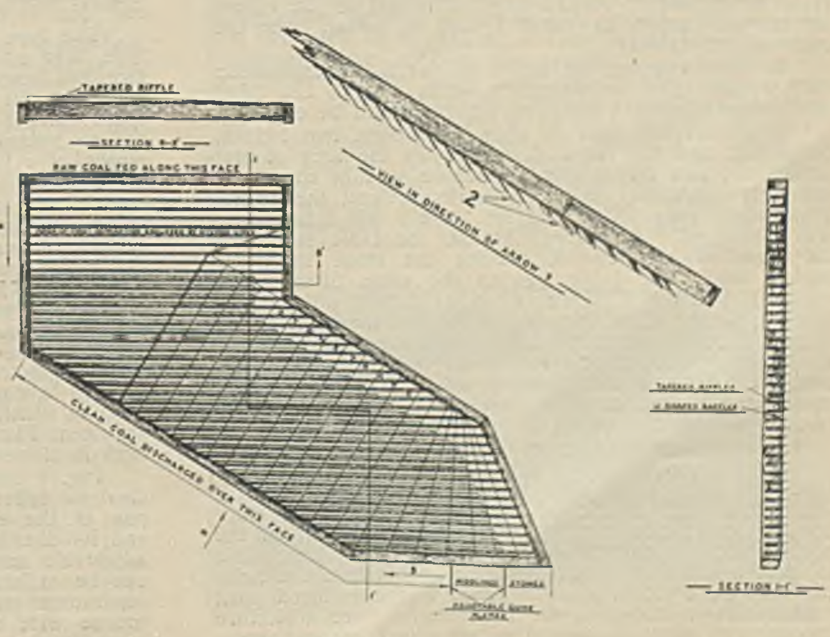


Fig. 1.—S.J. Type Deck.

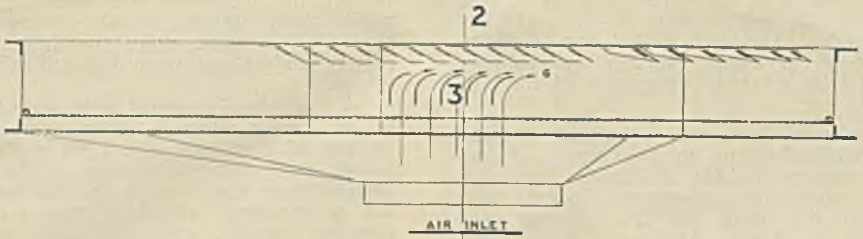
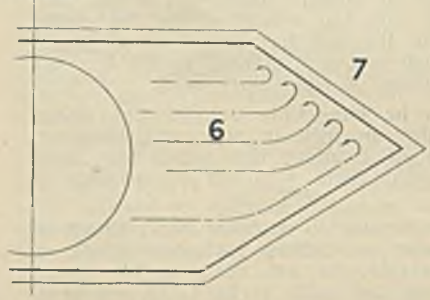


Fig. 2.—S.J. Type Windbox.



Each wind box and table deck, as a unit, is fixed to an under-carriage formed with eccentric sheaves, straps and rods set to run at a speed of 340 r.p.m., with a throw of $\frac{3}{16}$in. on the eccentrics, making a total travel of $\frac{3}{8}$in. While the speed of 340 r.p.m. is mentioned, this being taken as normal, it may be varied as required 15 r.p.m. either way.

We may now deal with the two factors mentioned previously to effect the ultimate separation.

Factor No. 1—Air. Air ranging from 9000 to 16,000 cubic feet per minute is employed according to the size of coal to be treated to dissemble and lift the product. Referring to Fig. 1, the raw product is fed on to the top face by means of a mechanically operated adjustable shovel feed arrangement. The table deck is set to slope from this top face as shown in direction of arrow 4. This inclination is about 6 deg. While the table is set to slope in the direction of arrow 4, it is also sloping at an angle of 3 deg. to 4 deg. in direction of arrow 5. Though definite figures are here given to these angles it is important to point out that they are ruling factors in the proper operation of the table, and are capable of variation by means of adjustable rocker beams forming part of the under-carriage.

Up to this point we have only got the coal in flotation due to a vertical stream of air. Refer now to the vanes marked 3 in Fig. 2. These change the direction of part of the air current, causing it to flow as indicated by arrows 6 shown in section on the slide. This current is baffled by the end plate 7 of the wind box and, returning, is directed and separated by vanes marked 2. Shown in Fig. 1 is an area of first separation. While some clean coal is passed out from this area, the remainder coming forward is met by the return air current caused by vanes 3, and is passed over the edge of the table.

In the foregoing the action of the air is explained; but, without the assistance of factor No. 2, i.e., "the quick short jigging action," no results would be obtained.

It is necessary now to show how these two factors, combined, give the required result. In the area of first separation, and throughout the whole area of the table, stone is constantly being deposited behind the riffles. This would only lodge and lie there if air action only was employed. As already stated, the table slopes in the direction of arrow 5, making the stone track the higher side. The table jigs in the same direction as arrow 5, and has a lifting or radial motion obtained by being set on adjustable toggle plates working at an angle of approximately 50 deg. The stone lodged behind the riffles is not entirely free from flotation, due to air pressure, and this fact coupled with the jigging action causes it to travel along behind the riffles to the stone track.

Attention must be given at this point to a description of the method by which the various products are taken from the table after separation has been effected. The major part of the table area is occupied by pure coal, which is discharged over the side and part of the bottom edge as shown in Fig. 1. As it is impossible to have a definite line of demarcation between the clean coal and pure stone, another product is introduced, viz., "middlings"; these, as the term implies, are a mixture of coal and stone in approximately equal proportions.

While the clean coal is discharged as shown, fingers or adjustable guide plates are fixed situated on the bottom edge of the table deck, which precipitate the middlings down a chute on to a conveyor for re-circulating and re-cleaning, while the stone is discharged into tubs or conveyor by chutes, and thus sent to the waste heap.

In the foregoing it has been explained how coals from 2in. down to $\frac{1}{4}$in. size are cleaned on four S.J. tables.

After the introduction of the S.J. table it was found that a table of greater capacity was needed. The Wye table was then evolved. This is only two S.J. tables put together. When the English firm who have the sole rights of manufacture of this American patent in England and the Continent commenced seriously the manufacture of these tables, they very soon evolved the Vee table, which is the latest thing of its kind. This Vee table is much more simple, has much better means of adjustment, and has a much greater capacity than any type which had been made before. It is this table which it is intended to introduce for the cleaning of the small coal $\frac{1}{4}$in. to 0, and which will now be described.

The type Vee separator differs essentially from the type Wye as regards the shape of its "deck" or surface, but beneath this the essential parts have been modified in detail only, and the separator is still reciprocated by means of eccentrics acting through toggles, whilst the air pressure below the bed of coal is maintained by means of a fan situated below the separator.

Fig. 3 shows the air chest which is mounted upon the mechanism and upon which the deck shown in Fig. 4 is in turn mounted. The illustration Fig. 5 shows the adjustable louvres which are situated immediately above the outlet from the fan, and which are used to distribute the air pressure. It will be seen that these can be operated in sections by means of control bars, the ends of which are shown at the extreme left-hand end of the photograph. The three back sections are shown open on the photograph, and the six forward sections are seen to be closed. This, however, is merely for the purpose of illustration. Round the outside of the air chest are seen, Fig. 3, the projections by means of which the deck is clamped securely down to this air chest.

Fig. 4 shows the standard Vee deck in plan view. Coal is delivered to the deck from the mild-steel feed pan at the extreme left hand side of the illustration, and its distribution on to the deck is controlled by two adjustable gates so that the necessary thickness of bed can be maintained across the width of the deck. The separating surface itself consists of a heavy phosphor bronze wire cloth which supports the bed of coal and is at the same time pervious to the air. The combined

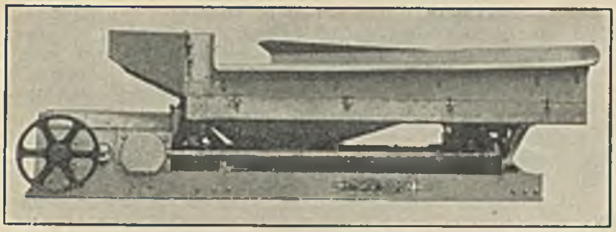


Fig. 3.—Side View of Table.

action of the air pressure and the jigging motion of the separator has the same effect as in the S.J. table and causes stratification to take place, the coal being on the top and the stone underneath.

Having stratified the raw coal into clean coal lying above a bed of refuse, it still remains to concentrate these products so that they can be collected in a state of purity. This is effected by moving the upper layer outwards and the lower layer inwards, whilst both are being propelled forwards by the motion of the separator.

In other words the V in the centre of the illustration is acting as a plough and pushing off the upper layer of clean coal as the cross section of the deck decreases. The refuse, on the other hand, is progressively deflected away from the clean coal spillage by means of the inclined riffles, and is moved forward along the sides of the V until it approaches the curved ends of the deck. Here, the last particles of the upper layer of coal having been squeezed off, the refuse crops out in a pure state and is banked up against the curved end of the banking bar from whence it is finally discharged.

In setting a machine to work, the inclination of the separating surface, the height of the tailing riffle, the speed of running and the pressure of the air are so adjusted as to maintain a fluid bed of coal over the entire deck. The operator soon learns to distinguish the correct position of the bed either by throwing a handful of refuse on to its surface and observing how quickly it sinks or, alternatively, by putting his hand into the bed of coal.

The Vee separator has proved itself to be much more elastic in operation than previous forms of separators, and by means of the independently adjustable end of the tailing riffle at the shale end of the separator, coals containing only a small percentage of refuse can now be separated so as to give a much better refuse product than was previously possible.

Also, due to the absence of any sudden constriction on the deck, coals containing a very high percentage of refuse can be treated more successfully at higher capacities than could be obtained formerly. This, perhaps, is not so important when considering English coals, but the treatment of raw coal containing as much as 50% of refuse is of considerable importance in France and Belgium.

This separator has given very good results in the treatment of unsized coal, and it is claimed to be capable of effecting a separation which is practically perfect over a size range of 8 : 1. From the author's experience, however, he would not advise such a size range if the best results are desired. He has found that the closer the sizing of the coal to be treated, the better will be the ultimate ash content in the finished product, providing the table is kept up to full capacity. In other words, if a table has not its full thickness of bed, the results will not be so good, and moreover, if it has to be constantly stopped for want of coal and started again when sufficient coal has accumulated, the results will not be so good.

There is on the market now a larger machine of heavier construction known as the "Super Vee." It has been found to facilitate the cleaning of small coal, ¼in. to 0, but to do so it is essential to separate the dust from the coal before it goes on to the table. To achieve this an aspirator is introduced between the bottom of the supply hopper and the feeder on to the table. This is a vertical rectangular box fitted with steel louvres

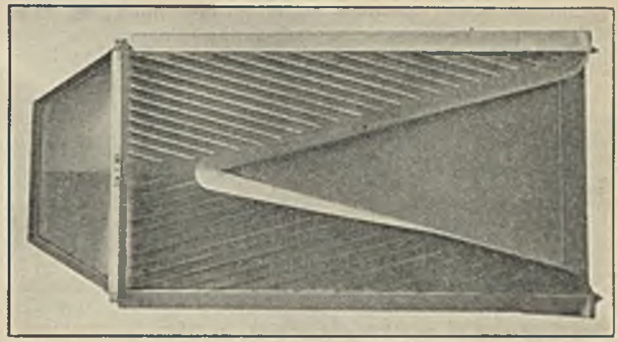


Fig. 4.—Deck for V Table.

over which the coal is fed. As the coal passes down over the louvres in a thin stream air suction is applied, which takes out the fine dust, and passes it into the main air duct of the extractor, so enabling the remaining product to be efficiently cleaned.

Dust.

Wet washing has its attendant evil of Slurry—troublesome and wasteful.

Pneumatic cleaning has its equivalent evil—Dust.

From every machine, no matter how efficient the grading of the coal may be, in every air current, dust will be found which, if not collected, makes the whole plant inefficient and unpleasant to work in. It is essential that some form of dust extracting plant should be installed, not only for the sake of efficiency and comfort, but in order to collect the dust and make use of it in some way, as it is a combustible matter, and therefore valuable. The amount made varies very much with different kinds of coal. Probably in coals of the County of Durham the amount of dust is from 3% to 6% of the coal dealt with. The problem of what to do with this dust is a serious one. The best possible thing to do with it is to blow it direct to the boilers, where it can be utilised to raise steam. Even this, simple as it seems, is not found to be so in practice.

Before describing any other table, it is advisable to indicate briefly how the sizing of our coal is done. There are many ways of sizing coal, any of which will do for a cleaning plant providing the efficiency is good. In the author's case all coal direct from the pits passes to the rotary tipplers in the screening plant, from whence it is delivered on to jigging screens having 2in. diameter perforated plates. Above 2in. in size it is passed on to steel plate picking belts, where the dross is taken out by boys. The 2in. size and below is delivered on to steel plate conveyors, which in turn deposit the coal into a continuous bucket elevator where it is lifted to a height of 63ft. above the ground level. The elevator is fitted at the head with a breeches chute, each leg of which discharges into a rotary screen. These screens are 5ft. diameter by 33ft. long, each divided into three sections, viz.: first 17ft. fitted with ¾in. wire mesh;

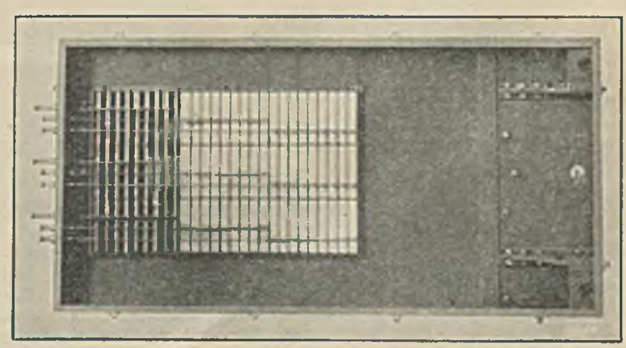


Fig. 5.—Adjustable Louvres on underside of V Table.

second 8ft. fitted with 1in. wire mesh; third 8ft. fitted with 1½in. wire mesh; the remaining 2in. passing over the end. These give the necessary sizes for tables 1, 2 and 3.

All the ½in. to 0in. size passes into a steel hopper made to deliver on to an inclined scraper conveyor, which discharges into a third rotary screen, 5ft. diameter by 22ft. long, fitted along its whole length with ¼in. wire mesh. This extracts ¼in. to 0in. size, delivering into a hopper, which in turn will discharge on to a Vee table or into a truck as required. The ½in. and ¼in. size passes on to the S.J. table No. 4, which completes the feeding of all four tables.

As the coal is graded in the rotary screens for the various tables it is delivered into steel plate hoppers, each capable of holding a supply of coal to regularise the feed and maintain the bed on the tables, which is essential for good cleaning. From experience it appears necessary to have a hopper above each table of such a capacity as to keep the table supplied with coal for at least half an hour, and preferably for twice this period.

All coal from the tables is delivered by chutes on to a common clean coal conveyor, where it is met in a common chute by the larger hand picked sizes from the screening plant, which discharges the whole into wagons.

Whilst all coal may be delivered on to a common belt, provision has been made to keep any size separate and to deliver it into truck if necessary.

COST.

	£	s.	d.
Labour per fortnight	44	6	0
Oil and grease	0	11	0
Electricity	60	2	8
	£104	19	8

Assuming pit output to be averaged at 18,000 tons per fortnight, 75 per cent. of which passes through the pneumatic cleaner = 13,500 tons, then the cost works out at 1.86d. per ton.

Results of Dry Cleaning.

Samples are taken all through the day from the delivery chute of each table at the point where the coal is being delivered on to the clean coal belt. This large sample is all analysed by the float and sink test; the solution used is 1.5 specific gravity.

The following is the average result of analyses from each table:—

No. 1 Table, 2in. to 1½in.	0.91%	stone in the coal.
No. 2 Table, 1½in. to 1in.	2.14%	„ „
No. 3 Table, 1in. to ½in.	2.30%	„ „
No 4 Table, ½in. to ¼in.	2.76%	„ „

The dross also is analysed daily in order to check what amount of coal is going into it, and this is found to average about 0.8% to 1% of coal in the stone. This has come to be considered as an unavoidable loss. It has been found in analyses of coal taken at the ship that the percentage of sulphur is less now than it used to be, showing that the tables are getting rid of the pyrites.

THE STATIC DRY WASHER.

The patentees claim that with this plant separation is effected not by blowing air through a bed of coal as is done in the case of the tables just described, but by balancing the air pressure put against the bed of coal. That is to say, the air pressure on a given area must be such as to equal just the weight of the bed of coal on the same area.

At this critical pressure the bed becomes alive; it, so to speak, floats, and the stone particles of all sizes owing to the specific gravity sink gradually to the bottom of the bed and there become stratified. If the pressure is allowed to fall below the critical pressure the bed of coal becomes inert; on the other hand, if the pressure is raised above the critical pressure, the surface tension breaks down, and the air rushes through wherever it can find a weak place in the bed, and there forms a blow hole.

For successful operation it is necessary to have unsized small coal from 2¼in. to 0in., so that the larger particles can be surrounded and embedded in the small or duff coal to make the bed as air tight as possible.

The principle feature of this table is its capability of cleaning unsized coal, consequently, no screens or sizing machinery is required. By eliminating the screens, the building necessary to house the plant would be of comparatively moderate height.

It was found by experiment that a fluctuating pressure if employed in the correct periodicity, amplitude and phase gave a quicker and better stratification, and the quantity of air escaping through the bed was less than under a condition of constant pressure.

In this apparatus the unsized coal 2in. to 0in. is put into a 20 to 30 tons hopper, on the bottom of which is fitted a rotary feed, the speed of which can be varied by a variable speed gear. The coal is by this means put on to one end of the table in any quantity required to suit the circumstances, within certain limits.

The table is simply a trough about 18ft. long, the bottom of which is formed of 1/16in. perforated plate through which the air pulsates. The coal is fed on to the table at such a rate as to maintain a bed of about 6ins. thick over the whole width of the trough, which is about 2ft. wide. A skimmer with a plough attachment is fixed about 6 feet from the end to skim off the top layer of clean coal.

The coal passes down a slight slope in the base of the table into the second compartment, which is narrowed down to maintain the bed at the same thickness as in the first compartment. Here better stratification takes place, and by the time the coal has passed through this compartment, the coal and stone is thoroughly stratified. Another skimmer is fixed lower down the table, which skims the remainder of the clean coal off, allowing what is left to pass down a small slope in the base of the table into the third compartment, at the end of which a third skimmer is fixed to take off the middlings, allowing the pure stone to pass over the end of the table.

There is rather an ingenious adjustable chute at the stone end by which the stone can be choked back or allowed to come freely at will. This serves a very useful purpose in preventing any stray pieces of coal from going away with the stone, and forcing them into the middlings. The middlings are re-elevated and re-circulated. The table is set with a slight inclination forward, and is oscillated by an eccentric in order to maintain the bed at a uniform thickness. The table stands above the air box, and is joined to it by an airtight flexible material.

Considerable care and thought has been exercised in designing this air box, as the shape is a very material factor in the proper working of the table. The air is delivered by a fan at a suitable pressure, and is passed through a pulsator in order to give it the fluctuating pressure which, as described, is necessary to get the best results.

Dust.

As the air pressure through the coal is so very slight, there is not the tendency to blow the dust into the air to any great extent, so by fixing a canvas canopy of ample proportions over the table, it is found that all but the very flocculent dust falls back on the table. The whole plant as described is worked by one motor as will be seen from Fig. 6. The author has not a table of this kind working, and consequently cannot give figures regarding costs, but in a paper read by Mr. George Raw, the following figures are given:—

COST.

	Pence per ton of Raw Coal.
Interest on Capital at 5%	.371
Depreciation at 15%	1.110
Maintenance	.413
Attendants	.838
Electric Power	.510
	3.242

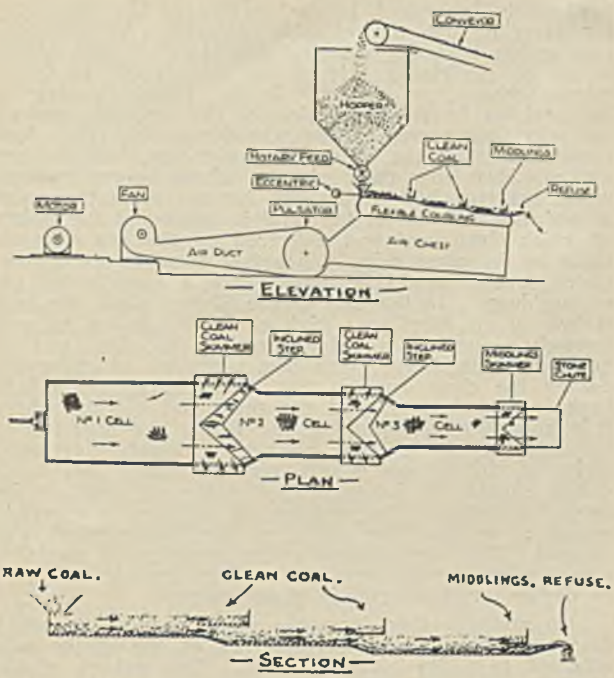


Fig. 6.—The Static Dry Washer.

THE LOCKWOOD PROCESS.

This is a comparatively simple method of separating coal and stone. The method seems to be that the mixture of coal and stone is thrown against a wall, and the coal rebounds further than the stone, thus separating the one from the other.

The tables are constructed of wood, and are about 2ft. wide by about 6ft. long by about 3ins. deep. Each table has a slight slope in the direction in which the coal travels. On the floor of the table are nailed small slats of wood, which stretch from the middle of the table to the right edge when looking from the bottom of the table (marked AA on the plan, Fig. 7). These slats are about ¼in. thick on the middle of the table, tapering down to nothing.

Each table is jigged at a speed of about 240 times a minute at right angles to the flow of the coal, as shown by the arrow on the plan, by an eccentric with 1¼in. throw. This causes the mass to be thrown against the right hand edge of the table. When this is done, the coal rebounds further than the stone, and thus the separation is effected.

The stone and very small coal clings to the right side of the table, and passes out at the part shown in the diagram, where there is a gauze fixed through which the very small coal with its impurities passes, from whence it is carried to a second series of tables, where it is again put through the same process on a similar table. The clean coal passes away by the left corner as shown on the plan.

A small quantity of air at a pressure of 3lbs. per square inch is passed into a tube which is let into the side wall of the table. This tube has a thin saw cut along its entire length, through which the air gently blows on the coal; the idea being to blow the coal back on the middle of the table, and keep the separation when once it has been effected. The tables are built in batteries of six, all being driven by the eccentric marked X.

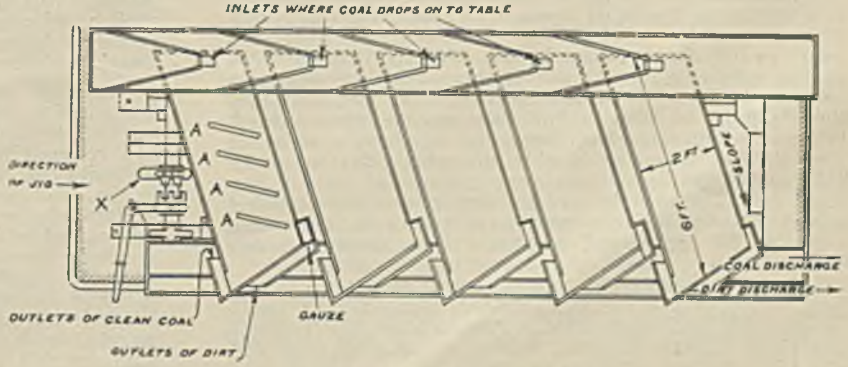


Fig. 7.—The Lockwood Process.

The very fine coal and stone which passes through the gauze on the first set of tables is carried to a further set of tables of a similar design, but which have no air to assist the separation. They have, however, two or three small hammers which tap at the side of the table with each vibration, and thus help to keep the stone and coal separated.

The power required is very small indeed, as the tables are so light and well balanced, and the load of coal is small. The cost of making and erecting a plant of this kind, without including the house to put it in, should be a very moderate one. The capacity of each table is not to be compared to either of the other systems which have been described; consequently, to deal with a similar quantity, a large number of tables would be required, and the house to cover them would necessarily occupy much more ground. The principle feature about the process is the absence of dust, consequently no dust extracting plant would be necessary for a plant of this kind.

Discussion.

Mr. H. J. FISHER expressed the pleasure and great interest with which they had listened to Major English. In closely following the different processes of coal cleaning described by the lecturer, he had certainly increased his knowledge of a subject of which he could hardly claim to know a great deal. There were, however, many present at the meeting better able to discuss the matter.

Mr. G. WARWICK said that the percentage of coal in the stone, given by Major English as 0.8% or 1%, seemed to be a very small figure. Presumably, added to that there would be a quantity of material comprising pieces of stone, shale or other non-combustible matter adhering closely to them, and that additional proportion together with the pure stone and dross would make up the quantity removed from the raw coal, and would represent the loss of vend. He would like to know what is the amount of the loss of vend. Though he was speaking as a buyer, he still wondered how much the collieries were losing in that way, because he could not see that the improvement in coal by washing or dry cleaning entirely accounted for the very great difference in price between the cleaned article and the uncleaned article. There must also be a very heavy loss of vend, quite apart from market considerations, to account for the difference.

Mr. BULMER congratulated the author on his excellent paper and his clearly expressed detail and lucid description. Would Major English say what prompted him to go in for dry cleaning in the first place because in his, Mr. Bulmer's, opinion, dry cleaning remains still the less efficient cleaning process when compared with the best of the wet cleaning processes. That is very important; but on the other hand there is the question of coal which is being cleaned for carbonising industries. Coke oven people are agreed that if the coal is washed, however much ash may be taken out of it, there is an increased expenditure of fuel in the coke oven, which amounts to about 6 B.T.U. per pound of coal carbonised, for every 1% of moisture present. That would seem to suggest a very great advantage in favour of dry cleaning.

Loss of vend in cleaning coal had been mentioned: obviously a very important matter indeed. Although the cost of cleaning coal might range in dry cleaning processes between 2d. up to perhaps 6d. a ton of coal, the loss of vend might be represented by anything from 10d. to 2/- a ton. The reason for this is that certain coals are very easily cleaned, while others are not.

Major English had mentioned in the paper the fact of middlings being in the coal. In the case of his process, of course, that described as middlings is not what is called true middlings; it was very often a mixture of stone and poor coal, separated essentially for the smooth operation in the process of cleaning. On the other hand, there were some coals which had a large percentage of true middlings, and those have a high specific gravity compared with the clean coal, and are intermediate in specific gravity between the shale and the good coal; therefore they must be dealt with separately and, in the case of coal which has a high percentage of true middlings, then it was probable the producer of clean coal would make three groups, namely, clean, middlings, and shale. The middlings product might have a very high ash content but it might be used in the colliery boilers or at some place close by.

Mr. Bulmer then referred to some interesting data from an American source in regard to boiler coal. In that article it was described how they tested various coals on boilers, coals with various ashes varying from 4% to 21%, and the amount of coal required per boiler horse-power in the case of 4% ash was 3lbs., and in the case of the 21% ash, was 5.4lbs. They had gone on also to estimate the efficiency of the boiler plant and found, in the case of 4% ash, the efficiency was 77.7%, and in the case of 21% ash, it was 53.1%. Here was, said Mr. Bulmer, a specific instance in which clean boiler fuel has a very strong case, and he believed there would be more cleaning of coal in this country if the consumers would pay more for that coal. That may represent anything from 1s. 6d. to 3s. a ton to reduce the ash 4% to 5%.

In regard to the carbonising industries, there is the question of moisture in coal, but there is a growing demand for coke for domestic purposes, and he was interested to read in a paper some time ago the statement that 1% of radiant heat was sacrificed for every 1% increase in ash. People were being asked to burn smokeless fuel in order to prevent pollution of the atmosphere, but it would be much better if manufacturers of coke could put on the market an ashless fuel. That, he thought, would be more appreciated by the ordinary householder than a smokeless fuel; and then again it afforded an avenue in which coal cleaning would find a use.

Furthermore, in the manufacture of pig iron, there is a saving in the blast furnace of something like ½-cwt. of coke per ton of iron for each reduction of 1% of ash; in all these things it was obvious that to clean coal was the right thing. The question therefore becomes: is the coal worth cleaning from the coal producer's point of view? And this may be answered: it is only worth cleaning, from the producer's point of view, if the consumer is able to pay a little more for that coal. That may be a very commercial way of putting the case, but it has a bearing on the technical aspect as well. Those who were trying to clean coal ought to be encouraged perhaps a little more than they had been.

Mr. S. A. SIMON said Mr. Bulmer had given his views regarding the commercial and metallurgical aspect of the advantage of cleaning coal, but a point that had not been touched upon so far, and which was of first importance to the Association, was the electrical side, particularly in regard to the driving of the apparatus for carrying out the cleaning process. As electrical people they naturally assumed that most of these plants would be electrically driven, and they would be interested, perhaps not so much in the actual cleaning of the coal, as in the application of the electrical motors and electrical power to the whole process. They had seen pictures of the Wye and Vee tables, but did not get any idea from those pictures of the stages through which the coal had to pass on its way from the point at which it left the pit tub until it arrived at the points at which clean coal was delivered on the one side, or shale on the other side. When they came to see a complete plant it would be found quite a complicated set of machinery. In the case of the Birtley plant, the coal is first of all lifted to a high elevation; it has to pass through a number of sizing screens; the fans and so on have to be driven; and then a number of conveyors convey the clean coal in one direction, the middlings back to the elevator, and the shale and dirt to where it is going to be deposited, and finally the dust has to be dealt with. All this connotes a highly developed series of drives, and it was very important that those drives should be interconnected with one another for proper operation. The motors had to start in a certain sequence, so that the safety of the whole plant was secured. This necessitated rather complicated electrical arrangements which certainly required considerable skill in design, erection, and in maintenance.

In addition there was the dust question, to which Major English had already referred as one of the evils attached to a dry cleaning plant. The makers of the plant to which Mr. Simon was referring had evolved an extremely ingenious system of control by means of which the individual items were started in proper sequence and intervals. Should a "key" motor stop, all antecedent motors would stop to prevent piling up of coal. This control apparatus was of the contactor type, and one of the difficulties to be contended with is in regard to the proper housing of the apparatus and the prevention of the possibility of coal dust explosion. With the amount of coal dust prevailing on a plant of this sort, it was undoubtedly a great danger which must have very serious consideration. The motors and lighting fittings presented no great difficulty for mining electrical engineers. It was already known what precautions had to be taken with these, and dependable flameproof machinery had been evolved. The point that does want particular attention, however, in the layout of a cleaning plant was the proper housing of the control equipment, which must be so separated from the rest of the cleaning plant that there could be no danger of a dangerous mixture of coal dust and air having access to it.

Continuing, Mr. Simon said he would like to ask Major English what was the effect of atmospheric humidity on the various dry coal cleaning systems. For example, he had been told that on a foggy morning the spiral cleaner worked very well, but when the sun shone it began to give trouble, so that it was necessary to provide artificial humidifiers to get the plant to work properly. It would be interesting to learn whether any similar adjustment for the humidity of the air was necessary in connection with the Wye and Vee and other cleaning plants.

Another point—possibly of minor importance—was the question of the correct sizing of the coal before it reached the tables. In the plant to which Mr. Simon had referred there were four different tables, two dealing with smallest size of coal, up to ⅛in., one for ⅛in. to ½in., and one for ½in. to 1½in. The question was as to the relative capacity of the tables to deal with the full output of the plant. It must be necessary to have a certain amount of margin on each table so as to deal with the varying proportion of the different sizes, and it would be interesting to know what the manufacturers in their layouts of such a plant usually allowed for margin so that the plant could be capable of dealing with the full output which may be required in a given time.

In the paper, Major English mentioned that the cost works out at 1.8d. per ton. It was not quite clear whether that 1.8d. refers to the ton of coal dealt with by the cleaning—which is 75% of the total output—or whether it referred to the total output of the pit.

Mr. W. L. TULIP.—Having noticed that in the plant described by Major English the screens were of the rotary type; whereas, in later plants of similar design, the "Hum-mer" screen had been adopted, Mr. Tulip asked whether the latter type had been introduced because of a higher efficiency, or merely because of its economy in space.

Mr. H. BICKERTON.—Would the author state whether he had had any experience with wet coal on his plant; for example, coal coming from one district in the pit which was very wet. Did that coal choke the gauzes, or what was its effect? Also, what method did Major English adopt to overcome that difficulty, if it ever presented itself?

CAPTAIN S. WALTON-BROWN said the members were very fortunate in having Major English contribute this paper to the Branch. Major English was the first mining engineer in Great Britain to treat coal by pneumatic cleaning, and the step must have necessitated a considerable amount of courage on his part. If a new departure by a mining engineer failed to come up to expectations there were always plenty of people to comment on its subsequent obsequies to the effect that "they knew it would never work." Where, however, success was realised, and as a result most useful development work accomplished, the same people frequently walked in and took advantage of the knowledge gained without even according proper thanks to the pioneer who had done so much for their benefit.

Major English must therefore now feel much gratified at the extension of the process of dry-cleaning which had taken place within recent years and he, Captain Walton-Brown, and all present would not withhold their compliments to Major English for his foresight and thank him for "blazing the trail."

Captain Walton-Brown said it was quite impossible to lay down any standard methods of cleaning for all coals and all conditions. Such experience as he had had led him to conclude that not only did the raw product of each undertaking present a special problem, but the different seams and different sizes of coal in each seam were but further extensions of the same problem. Over and above the producers' problem was superimposed that of the consumer, and it was obvious that the requirements of the latter must be given the utmost consideration and a balance struck and methods adopted which would give the most satisfactory results to both parties.

The different systems, dry and wet, presented various advantages and also various disadvantages, but unfortunately it would hardly seem possible to combine all the advantages in one of them. The position was that if one good factor were desired another bad factor had to be swallowed; it was necessary to select either the plant which gave the highest overall efficiency in the particular case under notice, or else design a special composite plant. Where outputs would justify the expenditure involved, he thought the latter method presented the best prospects of success, and valuable information should accrue from experiments on those composite lines which were at present being made.

Captain Walton-Brown said he had the feeling that in dry-cleaning there was an element of chance regarding the disposal of middle products, and it would be interesting if Major English could express any general opinions he may have formed as to:

(1) Whether middle products should be simply recirculated until they disappear either into clean coal or the stone; or

(2) Whether the coal middlings product should be made to a definite ash content, a definite stone product rejected, and a middlings/stone product crushed prior to recirculation.

He, the speaker, would like to add to a dry-cleaning plant some definite middle product which could be easily observed and to ascertain in what proportion and in what time it was absorbed either into the coal or into the stone, and to see how results varied in different tests. Does the recirculation tend to alter the bulk of the middle product by drying it and so "in the opinion of the machine" improve it and put it into the clean coal although its actual analysis will be unchanged?

He would be indebted to Major English if he could extend his contribution to cover the treatment of the smaller sizes and give some idea of the results he would expect to get on a Super-Vee Table with a raw product $\frac{1}{16}$in. to 1/64in. containing say 20% ash. He, the speaker, was particularly interested in this problem and would be grateful for any information as to the possibilities of approaching an improvement to 10%. What were the limitations imposed by adherent moisture at these sizes, and what effect was caused by variations in the proportions of large, medium, and small components of the $\frac{1}{16}$in. and 1/64in. range?

MAJOR ENGLISH (in reply).—Some member asked what there was peculiar about the stone chute on the Raw table. The end of the chute is hinged, and underneath the hinged end and attached to it is a right and left hand screw by which it can be raised or lowered. If it is lowered, the stone comes away freely and is apt to bring middlings with it. If it is raised, the stone is choked back, thus forcing the middlings into the proper chute. To those who ask "Where is coal cleaning to end?" the old answer is "Where?" Competition is so keen now-a-days that it behoves the mining engineer to put his product on the market as clean as possible to get the best price for it. He may find it very difficult to get 3d. per ton off his cost underground, whereas by cleaning the coal carefully he may increase the selling price by 6d. or even more. The time may be not far distant when the buyer will insist on a guaranteed ash content.

Mechanical cleaning of coal has brought to one's mind new ideas. The hewer or the filler underground is working with a lamp of half candle-power. He is a highly paid man, and he is asked to keep his coal clean and he has given to him a lamp of half candle-power to do it with. If the coal is brought to the surface, it is cleaned by boys who have a small wage, or mechanically, and it is done in day-light. If one could only get the men that fill the coal to fill it away reasonably clean, the proper place to clean it is undoubtedly on the face at a less cost. When that day will arrive, one cannot say. With the hewers and fillers as one knows them, it is a difficult question, but the matter has been put before them, and possibly as time goes on they, the hewers and fillers, may see the wisdom of it.

Mr. Warwick asked a question about the stone in the coal. The figure given in the paper of 0.8% to 1% is the amount of float in a 1.5 solution. There may be other particles which consist of part stone and part coal, but if they sink they are counted as dross. Fortunately, at the collieries which the author represents there is very little of this intergrown coal. The greatest cost is undoubtedly the loss of vend.

Mr. Bulmer asked what induced the colliery company which the author represents to go in for dry cleaning. The answer is: stern necessity. When it was discovered that the complaints for excess of ash were caused by the small coal, attention was directed to some method of cleaning it, and it was decided to adopt the spiral separator method; consequently the contract was placed for a number of spiral separators with the necessary screens and house complete. The author's attention was called to a paper giving particulars of the latest method of dry cleaning adopted in America on the Sutton Steel and Steel Table. It was realised at once that this method would be superior for our coal to the spiral separators, and it was consequently adopted and the spiral separator scheme abandoned.

Mr. Bulmer also stated that this dry cleaning was less efficient than wet washing. The author cannot argue about that because he has had no experience of wet washing, but he considers it very doubtful. Major English said they were satisfied with the results they were getting, but in any case wet washing for gas coal was out of the question.

Regarding the loss of vend, if one wanted to make the coal very pure and very clean, it could be done by taking out all the middlings, but the loss of vend would then be a very serious matter indeed. So at the present time—whatever may happen in the future—one is inclined to hit the happy medium. One knows—at least the Sales Department know—what percentage of ash at the ship the buyer would be satisfied with, and an endeavour was made to give it to him.

Some collieries were taking a lot of middlings out and using them in the boilers. This possibly may be the right thing to do in that case, but where no boilers existed and all the work was done electrically, it was obviously impossible to adopt that system.

He agreed with Mr. Simon: the electrical apparatus had developed into a complicated set of machinery. There was usually an elevator delivering into a hopper; the hopper delivering on to screens; the screens to further hoppers, and the hoppers to the cleaning tables, and so on. It was essential that this machinery should start up in proper sequence, or the elevator might be delivering on to a stationery belt with disastrous results.

All these troubles had been gone through, and out of them had evolved the latest type of contactor gear, which ensured that the motors were started up in their proper order. These elaborate electrical gears had naturally made the first cost of a plant much higher.

Regarding the dust and the danger from it, the Government was aware of this, and so were the owners of the dry cleaning plants. It was advisable to treat the screen-house as if it were a dry and dusty mine, and to comply with the law as if the house were underground. The workmen should be searched; no naked lights should be used, and all the electrical apparatus should be totally enclosed.

Regarding the effect of humidity. There was no doubt the humidity of the air played an important part in the proper working of spiral separators. It seemed to have the effect of altering the co-efficient of friction between the coal or stone and the iron plate along which it slides, which tended to prevent proper separation. With the air cleaning plant it was not found that atmospheric conditions materially affected their efficiency.

The sizing of wet coal was not easy to accomplish. With almost any kind of screen, the wet coal clogs up the mesh and at once decreases the efficiency of the screen. Possibly the plant may have to be stopped for the purpose of cleaning the mesh. At some collieries the wet coal was not put over the dry cleaning plant at all, but was tipped on a separate tippler and dealt with in other ways. It was found to be an advantage to have ample hopper accommodation everywhere about a plant in order to deal with peak outputs.

Mr. Simon asked the question as to whether the cost figures given were worked out on the total output or the total tons dealt with. The cost given in the paper was the cost per ton of coal dealt with by the air cleaning plant.

Mr. Tulip was anxious to know the reason for adopting the rotary screen. Screens have been used for sizing coal possibly since the dark ages. Any screen which was efficient and which had the capacity required would do to size the coal. There seems to be very little doubt that the Hummer screen was one over which could be put the greatest quantity of coal in a given time with the greatest efficiency, but they were also very expensive. The rotary screens mentioned in the paper were adopted because it was thought possible to get all the coal required through them, and the screens were much less costly. They had not been found to be particularly successful so far as efficiency was concerned, but were so from the mechanical point of view. The repair and upkeep had been very heavy.

Some member asked a question about dust and the best way to deal with it. When dry cleaning was first started nothing was known as to the quantity of dust to be expected, and little was known as to how to collect it. It was found to be a very difficult question, and even now it is found to be almost an impossibility to extract 100% of the dust.

The dust to be extracted consists not only of the very fine flocculent dust found on the roof and sides of old haulage roads in the old days, but also particles of quite a different nature. When the dust was examined under a magnifying glass, there was found what appeared to be large pieces of lump coal. The eroding effect of such pieces travelling with speed would play all sorts of havoc with the dust extracting apparatus. The method first adopted was to suck the dust away by a fan, and blow it into a series of canvas bags, where the air passed through the bags and left the dust inside. It was found that the bags could not stand the wear and tear; moreover, with some coal some kind of chemical action was set up in the cloth or canvas, which quickly rotted away.

At some collieries where the dust was sucked through the fan the eroding effect of the dust was such that the fan runners had to be renewed very frequently.

The latest method and the one which has been adopted on the Consett plant was not to draw the dust through the fan, but to put the fan in such a position that the whole dust extracting plant was under suction.

The question of Captain S. Walton-Brown as to whether middle products should be simply recirculated until they disappear either into the clean coal or the stone was really answered by himself when he said the requirements of the customer must receive the utmost consideration, and a balance struck and methods adopted which gave the most satisfactory results to both parties.

As a matter of fact, there was no plant in this country where a middle product was made with a definite ash content, although it was done on the Continent. At some English collieries the middle product was taken out and used as boiler fuel or in some other way. The re-circulation of the middle product did not tend to alter the bulk of the middle product and improve it so that it passed into the clean coal.

The re-circulation of the middlings had the advantage of averaging the amount of stone in the coal, so that the fingers on the table which deflected the coal into the various chutes need not be altered, or in other words, it kept the amount of stone more or less constant.

The crushing of the middlings before re-treatment did not do any good in most coals, as unfortunately the middle product remained still a middle product however small it might be crushed.

For the treatment of smaller sizes, say $\frac{1}{16}$in. to 1/64in., a super Vee table was not used. The ordinary Vee table was used, and on such a table the size range could be ⅛in. to 1/64in. When such coal was being treated it was essential that an aspirator must be used to take out the dust before the coal passed on to the table.

Assuming the bulk sample of small coal to contain 20% of ash, and provided it did not contain more than 50% of very fine coal, there should be no difficulty in reducing the ash content to 10%; that applied to Northumberland smalls. When treating coal of that size, that is, ⅛in. to 1/64in., it must be dry, as 3% of moisture made it very difficult to get good results.

MIDLAND BRANCH.

The Case for the Internal Combustion Engine in the Colliery Plant.

WILLIAM MORLEY.

(The following Paper was read before the Branch in April of last year. Exceptional circumstances have delayed its publication; it will be generally agreed, however, that the subject is one of considerable interest and moreover one which is sure to receive greater attention as carbonisation processes come into more general use).

In the course of an account of the performance of the Low Temperature Carbonisation Plant at Karnap Colliery in Germany, the following statements appealed to the author as being highly suggestive and significant:—

"Incidentally, it may be stated that a very large number of different qualities of coal have been put through this retort at Karnap Colliery, and many rich English bitumenous coals are found to give up to 26 galls. of low temperature tar per ton, of which up to 60% (15.6 galls.) is suitable for Diesel engine operation"; and "The yield of good quality gas is from 2,700 cu ft. per ton of coal carbonised."

Statements of this kind may be taken as a signpost pointing in a very definite direction and showing on what lines future development of the coal industry is practically certain to take place. Having this in mind, it is easy to visualise the colliery of the future as a different affair from what it is to-day.

Steam plant will have very little place on the up-to-date colliery—the colliery of the future will be all-electric as is the present-day all-electric colliery, but with this distinction, the electric current to the colliery of the future will be supplied from a central station where the generators will be driven by internal combustion engines using the fuel oil and the gas distilled from coal as a product of low temperature carbonisation.

The great cry and aim to-day is for greater efficiency, cheaper power, and reduction in the cost of production. We have only to look round at the improvements and refinements of operation which are being introduced into the power plant to achieve these ends, to realise the importance attached to these questions, and to note the feverish haste with which scientists are trying to solve them. The present-day refinements for the improvement of efficiencies are all very well and laudable, and it is a pity it is not more commonly the case than the exception to find these refinements, as, for instance, the scientifically controlled boiler house, introduced into the colliery plant. There is, however, a limit up to which these refinements remain financially sound, and that limit is passed when the financial advantages gained by their introduction are counterbalanced by the cost of their introduction and their maintenance. High thermal efficiencies may be obtained in the steam plant but the cost of this may be such that the plant is not commercially satisfactory when considered in terms of money. Efficiency and economy are not necessarily synonymous terms for, after all, the real criterion of commercial efficiency is the over-all cost per unit of electricity delivered from the station to the mains.

In any case, so long as the present-day method of burning coal obtains, any refinement of operation introduced can only be expected to improve the over-all efficiency by a very small amount.

It is an established fact that to burn coal in its raw state is very wasteful and that it is not the way to realise its full potentialities. Some go so far as to say that the time will come when it will be a criminal offence to burn raw coal in the open grate. Be that as it may, those who look at it from a health point of view are all in agreement that the sooner there is less smoke pollution of the atmosphere the better.

How then must coal be burnt to realise to the full its possibilities and value? The answer is "Low temperature carbonisation." This is the process of reducing bitumenous coals to a hard, smokeless, free-burning fuel and rendering the volatile constituents of the coal readily available to be turned into valuable commodities. During the process the greater part of the volatile matter is driven off, leaving just sufficient of the heavier volatiles (about 10% to 15%) in the residual fuel, i.e., in the smokeless fuel, to make it sufficiently free burning and suitable for all ordinary purposes. This, then, will be the standard fire-fuel of the future for steam raising as well as for house use. The products which constitute the volatiles are gas, oils, tar and ammonia, the preparation of which will greatly increase the commercial value of the coal produced and bring prosperity to those collieries which adopted these modern systems.

The colliery of the future then will be something more than a place where coal is mined; it will be a coal mine, chemical works, oil refinery and electricity supply undertaking rolled into one. Before that can be achieved, however, certain difficulties will have to be overcome, one of which is the disposal of the gas which is evolved in the carbonisation process.

The quantity of gas evolved per ton of coal carbonised varies between 2700 cu. ft. to 5000 cu. ft. according to the quality of the coal and the particular process in use. The disposal of this gas would present no difficulties if it were available near to a large town, as arrangements could be made with the local gas authority to take delivery of large quantities of gas at a comparatively cheap rate. Generally, however, coal mines are situated rather distant from large towns, so that the disposal of this gas becomes a real problem. It is here, then, that the internal combustion engine will come into its own at the colliery: coal mining is the only industry, using power, into which the internal combustion engine has not been generally introduced. In every case where this type of engine has been tried it has shown itself to be as reliable as steam plant, and certainly more economical in operation. The reason it has not been adopted for colliery power is due to the great amount of low grade coal that has been available for boiler firing purposes: it is more economical to burn this stuff at a lower thermal efficiency under boilers than to purchase fuel to run a highly efficient internal combustion engine plant.

In the future this will be changed. We all know that there is a great amount of coal left in the stalls in the form of slack. The slack will be just as valuable for carbonisation purposes as the large coal, and instead of the slack remaining in the pit it will all be loaded into the tubs and sent out with the lumps, which will automatically increase the coal tonnage output and reduce the cost of production.

Up to comparatively recently it has not been the practice to build internal combustion engines of very great horse power. This has put very definite restrictions on the use of this type of prime mover for large power stations. During the last two or three years, however, rapid strides have been made in this direction due to the impetus given to the industry by the demand for large marine internal combustion engines. At the present time there are gas engines of 5000 H.P. running regularly in this country driving alternators in parallel with steam turbo-alternators, and there are Diesel engines of 10,000 H.P. in British ships doing work more economically and just as reliably as steam engines. This type of prime mover is already a serious competitor of the medium sized steam unit, as evinced by the recent installation of a 15,000 H.P. Diesel engine unit at Hamburg Electricity Works. The author firmly believes the next few years will see as great an advance in the design and development of the internal combustion engine as have the last few years. The old proverb says "Necessity is the mother of invention"; that proverb will apply in this case.

Of course, the gas could be used for raising steam by burning it under gas-fired boilers, but this would be a roundabout way of achieving that which could be done more efficiently by using the gas direct in gas engines, and the same applies to the use of fuel oil.

There are definite advantages accruing from the use of internal combustion engines, the chief of which are: very high brake thermal efficiencies, lower operating costs, no standby losses, and reduced wages bill due to the smaller staff required. Every pound of fuel fired under the boiler or consumed in the internal combustion engine has a definite heating value as represented in the number of heat units it contains. Every unit of electricity taken from the generator is also represented as containing a definite number of heat units. One heat unit (B.T.U.) is equal to the amount of heat that would have to be imparted to 1lb. of water to raise its temperature from 60 deg. F. to 61 deg. F. Now for any given plant working under given conditions, to generate one unit of electricity a definite quantity of fuel must be consumed. The amount of fuel consumed per unit of current generated varies with the different plants. In considering the commercial efficiency of a plant—i.e., that efficiency which shows how much mechanical or electrical power is obtained in return for the money spent on the whole installation—the cost of fuel per unit of electricity generated is, no doubt, the most important item, and in drawing comparisons of costs between a steam plant and an internal combustion engine plant it plays a very important part.

The brake thermal efficiency of any plant indicates the proportion of the total heat supplied in the fuel which is converted and made available as useful power at the engine shaft. The best results so far obtained with any steam plant shows an over-all thermal efficiency of 21.83%. This, however, is an exceptional case and, for general practice, it is a very well managed steam plant that shows a continued efficiency of 12.5%. Further, we have it on very good authority that the average thermal efficiency of colliery plants is round about 5%. Against this the gas engine shows an efficiency of about 24%, while the Diesel engine has a brake thermal efficiency of 34%. In considering thermal efficiencies it is well to remember that the high thermal efficiency of the internal combustion engine is an innate characteristic. So long as the engine receives proper maintenance it cannot help but maintain its high efficiency. On the other hand, to achieve high thermal efficiencies in the steam plant it is necessary to introduce expensive apparatus which requires close attention on the part of the staff to get the most out of the plant.

At the present time it is not possible to purchase fuel oil suitable for Diesel engines at less than £5 per ton, owing to practically all the oil having to be purchased from abroad. When fuel oil is produced in this country in sufficient quantities to influence the market the price will no doubt come down. In spite of the high price of oil fuel, the Diesel engine will run indefinitely generating current at just over one farthing per K.W.H. on fuel basis only. The fuel consumption of the Diesel plant is round about 0.5384lb. of fuel per K.W.H. on full load. With oil at £5 per ton this works out at 0.2984 pence per K.W.H., or just over a farthing. In spite of the cheapness of coal used at collieries at the present time, it is to be doubted whether there are many plants that can generate electric current so cheaply.

In considering steam prime movers it is necessary to take into consideration the boiler plant and auxiliaries—the boilers and auxiliaries are a necessary adjunct to the prime mover. The internal combustion engine is self-contained in so far that it only needs to be supplied with fuel. Further, when the steam prime mover has been shut down a constant loss is taking place owing to the necessity of maintaining the steam pressure in the boilers by banking or firing up at more or less longer periods. When the internal combustion engine is shut down the fuel expenditure ceases automatically until the engine is started up again. The fuel charges start and stop with the starting and stopping of the engine.

A great deal has been said about the load factor It is a fortunate station that has a load factor of 40% or 50%. With the internal combustion engine station it is nothing unusual to maintain a load factor of from 70% to 80%. In practice it is usual to split up the capacity of the station into several units so graded in power that just sufficient units can be started up or shut down to accommodate whatever load is demanded. In this way the load factor is kept as near unity as possible and the fuel costs kept at a minimum.

In considering the cost of attendance, the internal combustion engine plant requires at the most only two-thirds the number of attendants. In the steam plant there is the boiler room staff as well as the engine-room staff to consider. It is not proposed to submit figures of comparative operating costs of the different types of power stations, as such figures could not be considered as representative of the case in point. It is only the application of the internal combustion engine to the colliery of the future that is dealt with in this paper. Coal which is now considered to be unfit for sale and whose only use is to burn it under the colliery boilers will then be worth so much a ton to the coal carbonising plant, and there will be such a supply of cheap gas and fuel oil that the present-day prices of these fuels will not be comparable. The figures for the Diesel engine operating costs were only quoted to emphasise the fact that in spite of the high cost of fuel oil electric current can be generated by internal combustion engines at a fraction over a farthing per unit.

In selecting a site for a large power station so that it can operate at the highest point of economy several important considerations have to be dealt with, chief of which are availability and total over-all cost of fuel supplies, cooling water supply and the distance of the power station from its consumers. In the future, when the National electricity scheme has become an accomplished fact, some of these considerations will not be so important as now. At the very high voltages proposed the localisation of the power station with respect to its consumers will not bear the same importance as hitherto, as the station can be linked up at almost any geographical point in the scheme to supply its quota of current. If, therefore, the difficulty of the supply of cooling water can be overcome it will be agreed that the best situation for a power station is as near to its source of fuel supply as possible.

Having regard to the high thermal efficiency of the Diesel and gas engines and the great quantities of gas and fuel oil which will be available when low temperature carbonisation plants are established at the collieries in this country, large power stations will be a feature of the carbonisation plant and large internal combustion engines will be used, if not solely, then very largely in those power stations. By generating in this way what we might call the Nation's current at the collieries with this type of plant, it is no exaggeration to state that the cost of electricity could be brought to an absolute minimum.

Discussion.

Mr. R. WILSON, Branch President, said he considered the paper was one to evoke a really good discussion. It was quite original in character: he did not recollect having heard of one of this description read before the Association. He would like to make a few remarks based upon his own experience. Some years ago whilst employed at a power station in the north, they decided to instal large gas engines somewhat on the lines advocated by Mr. Morley. The principle of the scheme was that they would put down a gas producer plant (incidentally, they used coal from the Notts. coalfield), sell the bye-products such as sulphate of ammonia and tar, and practically get the gas for nothing. They tried using the gas with Lancashire boilers, which was fairly successful, but when they came to run the engines it was quite a different matter, for it was found that whilst the fuel costs were remarkably low, the maintenance costs were correspondingly high. Eventually (after Mr. Wilson left that station) they scrapped the whole of the gas plant and installed steam turbines, which turned out to be a success. He, personally, had not yet too much confidence in the use of very large gas engines.

At Staveley they had large gas engines, but even there he did not think they had yet had sufficient experience to form an opinion as to whether the scheme justified the expense, because the capital expenditure was fairly heavy. So far as the Diesel engine was concerned, that he thought was another matter, and he quite agreed with Mr. Morley's remarks and the opinions expressed with regard to the efficiency of the Diesel engine.

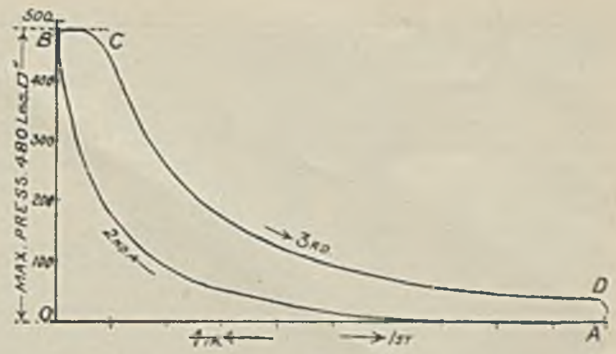
Mr. H. COTTON said he had enjoyed Mr. Morley's paper; it was one of the best they had had, and the author had given them a good deal to think about as a prophet. The state of the coal industry at present certainly required that very stringent economy must be practised, not only in material but in the abstraction of heat. Mr. Morley's paper was rather a plea for economy in heat. Owing to the length of the base of the Rankin diagram there was a great deal of rejection of heat to the condenser. The base of the Karno diagram was very much shorter. The economy of heat with steam plant necessitated a good deal of auxiliary plant, and it might easily happen that it was not justified from a financial point of view.

Owing to the nature of things there was no rejection of heat to the condenser with internal combustion engines, and the thermal efficiency was very much higher than with steam plant. It seemed a much sounder proposition to use coal in a modern coke oven plant and use the by-products for the purpose of producing power. The difficulty seemed to be answering the question: how was one going to utilise all the gas and tar products? After all, if the coal produced were to be utilised in this manner there would be a great amount of gas, probably far too much to be used. There was a very large concern in Germany from which large quantities of gas were distributed to neighbouring towns and villages. That offered one possibility of utilising the gas products. Another difficulty was with regard to the modern requirements of power stations; as we knew from the details of the Electricity Scheme. The idea was to have a small number of very large stations linked together, and these power stations might have a capacity of anything like 100,000 to 200,000 K.W. With steam, capacities like this are very difficult to deal with. These very large sizes are necessary if super power stations are to be worked with any degree of economy. The proper way was not to have a power station with about fifty comparatively small units; what was wanted was five or six units, then there would be sufficient to meet the variation in demand from time to time. He did not know how the internal combustion engine would meet this condition. At Staveley they had about 6,000 H.P. The point was that with internal combustion engines the largest at present made were only what might be called medium power machines, and with very large outputs a rather unweildy number of units would be required.

With regard to the operation of internal combustion engines Mr. Cotton said there was the old question of a number of these working in parallel. The theory of the parallel operation of alternators had been worked out and it was possible to design machines which would operate quite successfully in parallel, but it was necessary that all the engines should have identical indicator diagrams. In the case of reciprocating engines, when the valves had been set then the indicator diagrams would remain the same for very long periods, but with the internal combustion engine, an examination of the diagrams showed that they varied with the wearing of the valves. If modifications of this kind took place it meant that the time would arrive when the alternators would no longer work in parallel, even though they had done so in the beginning. It would be necessary to equip all the engines with indicating appliances and to indicate all the engines at regular intervals as a routine test, and adjustments could be carried out only by skilled men. The maintenance of a large internal combustion engine plant would be rather more expensive than that of steam plant. Another difficulty with very large plants, if equipped with internal combustion engines, was that owing to the fact that they run only at moderate speeds they would require a large floor space, and the cost per unit would be seriously increased. The overhead charges might very often be far more important than the legitimate running expenses.

Mr. MORLEY said with regard to Mr. Cotton's remarks about indicating the engines to make them run in parallel, from his own experience he had found Diesel engines equally as good as steam for driving alternators in parallel and had known them to run quite a long time without the attention they should have had, and they had kept the alternators in parallel without any difficulty or sign of trouble of any kind. There was no doubt the Diesel engine had proved itself good enough to compare with the steam engine, except in the limitation of size. If the coal for steam plant were not too cheap, then the Diesel plant was more economical than steam plant.

It was quite true with respect to indicator diagrams. In time it was found that the shape of the diagram had changed, due of course to the reduction in time of opening, and wear of the valves, etc. Fig. 1 is a good example of a full load diagram of a four-stroke cycle



O to A—Stroke No. 1: *Suction Stroke.*
A „ B— „ No. 2: *Compression Stroke.*
B „ D— „ No. 3: *Expansion or Working Stroke.*
D „ O— „ No. 4: *Exhaust Stroke.*
B „ C—*Fuel Admission Period.*

Fig. 1.

Fig. 2.

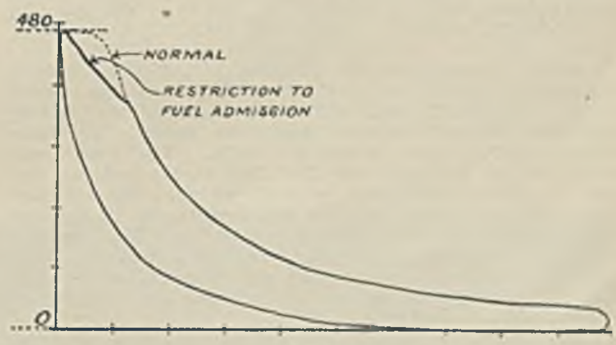


Fig. 3.

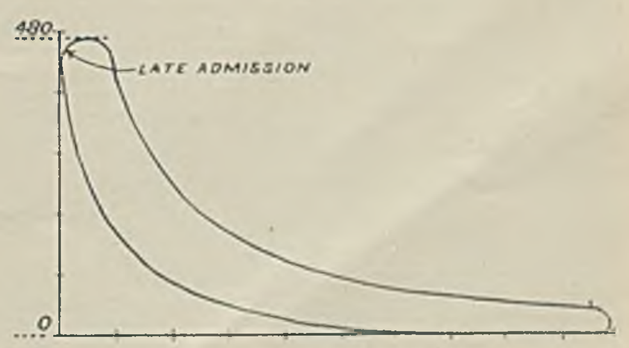


Fig. 4.

Diesel engine in good condition. Figs. 2, 3 and 4 would illustrate the changes that took place under different conditions which demanded adjustment. Fig. 2 showed a reduction in maximum compression pressure in the cylinder which might be due either to wear in the cylinder, big end bearings, restriction in the air induction manifold or burnt or leaky valves. Fig. 3 showed no diminution in maximum pressure. The change there was caused by a restriction of some kind due to the oil as it was being injected into the cylinder. Fig. 4 showed the correct maximum pressure, but a late admission. Such a condition could be brought about by wear in the fuel valve or an excessive clearance in its operating gear.

One thing that was noticed and was very striking, however much the diagram might alter within reasonable limits, there was very little difference in the running of the Diesel so far as parallelling alternators was concerned. He had known engines to be running when one line had been practically out of commission but the engine had kept up to speed, and it was only through indicating that it had been found out. The engine might have laboured a little, but nothing seriously to be noticed.

The maintenance costs were a little high to begin with, but were not now so high as previously; if the purchaser of a Diesel plant would see that he had a good man in the station and pay him a good wage he would find that his maintenance costs were very little more than the equivalent power in steam. With regard to skilled attendants, it was necessary to have one person who knew what he was about, but from his own experience he did not think it was necessary to have a station of skilled Diesel engineers. The cost of employing a Diesel engineer, as time went on, would be no more than the cost of a steam engineer. With regard to space, power for power, it was generally recognised that it required smaller space for Diesel plant than for steam.

Mr. COTTON said he was referring rather to gas plant than to Diesel.

Mr. MORLEY agreed, but said with the modern gas engine there was very little more space required than for steam. It was an interesting fact that the original Diesel engine built in England in 1897 was still running at Stockport, where it might be seen at the makers' works.

At the request of Mr. Wilson, Mr. Morley gave a description of the principle of working of the Diesel engine, particularly with regard to the ignition; stating that the Diesel engines work on either the four-stroke cycle or the two-stroke cycle. The four-stroke cycle was as follows: on the first stroke nothing but pure air from atmosphere was drawn into the cylinder. On the second stroke this air was compressed to between 475lbs. per sq. in. and 500lbs. per sq. in. The very act of compressing the air to this pressure automatically increased the temperature of the air to round about 1000 deg. F., which was far above the ignition temperature of all ordinary fuel oils.

At the commencement of the third stroke, fuel oil was injected direct into the cylinder in a finely atomised state. The very fact of the air having attained the high temperature at the end of the second stroke was sufficient to cause the fuel to burn (not explode) as it entered the cylinder, and the gases expand during the whole of the third stroke, doing their work on the piston. The fourth stroke was taken up in ejecting the waste gases to the exhaust. As only pure air is compressed in the cylinder during the second stroke, it will be appreciated that the dangers from pre-ignition are avoided.

Mr. R. WILSON, referring to Mr. Cotton's remarks, stated that one has to bear in mind the fact that where the costs of large generating plant are concerned and there are large reciprocating sets they have to run at low speeds compared with a turbine, and a slow-speed generator always costs more than a high speed generator.

He would like to ask Mr. Morley if he understood him correctly in his remarks on load factor—"owing to a large number of smaller units one would get a high load factor." He did not quite see how that would affect the economy of the station at all. It was the practice in most central stations to run a number of sets as required to carry the load, and he did not see how that could be used in favour of the oil engine; he thought the effect in oil or steam would be the same. Mr. Morley mentioned Barton Power Station load factor—he thought 53%; that was the factor which was not based upon the actual plant capacity of the station, but upon the maximum load observed and the percentage of time that that load was observed. He did not think Mr. Morley could maintain that running the Barton load on oil would be better than running on steam.

Mr. MORLEY, in reply, said that it was Diesel practice to split up the capacity of the station into several units, so graded that sufficient units could be started up or shut down to take the load demanded. For efficient working a 1000 K.W. station would be split up into a 500, a 250 and probably two 150 sets. One never got 100% load factor. The time of peak load varied with different stations. He had been at stations where the peak load was obtained between 4-30 and 7 p.m. All the units would be running.

The characteristic of the peak curve was that it gradually came down, and when one was used to the station one could anticipate to five minutes what the load was going to be. The peak load comes on with quite a bang. It was a fact that a Diesel set could be started up from stone cold and put on full load within one minute.

In speaking of load factor he should have made it quite clear that he had in mind the immediate load factor of the units in actual operation and the conservation of fuel by fully loading up one set before starting up an additional set. Quite an appreciable saving in fuel costs could be affected in this way in a well managed Diesel station. When a Diesel set was running fully loaded, full load overall thermal efficiency was being obtained with that set irrespective of the size of the unit.

The same advantages of fuel conservation did not obtain with steam plant for this reason: when a Diesel unit is shut down there are no stand-by fuel consumption losses, whereas in anticipating the steam plant load sufficient boiler capacity to carry the maximum peak load must be under steam, the whole of the 24 hours, and although a good percentage of the boiler plant is not required for, say, an eight-hour period of the 24 hours, a very active fuel consumption is taking place during this period to keep the boilers not required on the range ready to put on the range. In the steam plant it is not unusual for the coal consumption during the banking period to be 40% of the full load consumption.

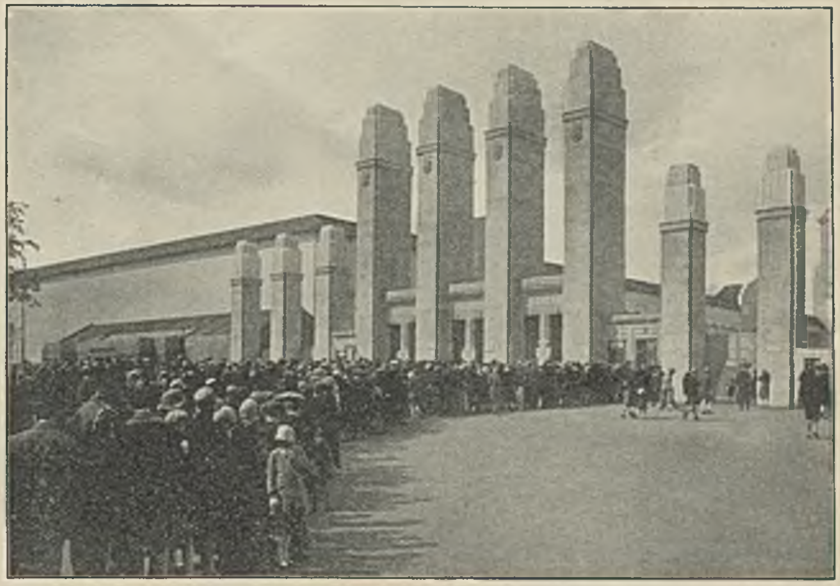
Mr. R. WILSON, in closing the discussion, said the theory of low temperature carbonisation was coming to the fore, and he believed the Government had made a grant towards experiments being carried out in Yorkshire. Everyone should make themselves thoroughly conversant with what there was to be known about it. He would like to propose their best thanks to Mr. Morley for his paper.

Mr. H. COTTON, in seconding the resolution, said it was very creditable of Mr. Morley having come forward at practically the last minute and to have given them such a valuable paper.

Coal Drills and Face Lighting.

The advertisement of Messrs. Siemens—Schuckert (Great Britain) Ltd., in our last issue set forth the particular merits of the Electric Coal Face Lighting System and carried an illustration of another speciality of the firm—The Electric Coal Drilling Machine. By one of those inexplicable lapses the wrong block was used. Correctly partnered with the proper letterpress the Coal Face Lighting illustration is given in this issue. Whilst an error is always to be regretted, in this case one might plead in mitigation that the effect was a dual advertisement set out in an arresting manner.

The North-East Coast Exhibition.



The Main Entrance to the Exhibition.

Those who attended the recent Annual Convention of the Association of Mining Electrical Engineers will retain pleasant memories of the North-East Coast Exhibition at Newcastle-upon-Tyne. They will be interested to know that the success of that great commercial adventure continues unabated and that it is amply justifying the unwavering optimism of its promoters. Great crowds of visitors continue to throng its palaces and pavilions: at the time of writing the three-million mark is within sight and this is at the period about midway between the opening and closing dates of the Exhibition.

Exhibitors in the heavy engineering section report actual business and also many very valuable enquiries which are likely to result in further business. The Palace of Engineering being representative of the heavy industries of the north-east coast it is not expected that many immediate sales of such items as Diesel engines or Giant Reflector Telescopes can be arranged, but the genuineness of the many enquiries, both from home and abroad, are considered extremely satisfactory.

In the Palace of Industries where the lesser industries of the district are represented, a very considerable amount of actual trade is being done.

The Empire Marketing Board, whose very ornate pavilion is one of the special features of the Exhibition, houses periodic exhibits from the Dominions and Colonies and in every case their trade representatives have reported that they are more than satisfied with results.

A number of important conferences have been held in the beautiful Festival Hall including the Advertising Convention; the Transport and General Workers Union Conference; the Conference of the North-East Coast Institution of Engineers and Shipbuilders; the Baltic and International Maritime Conference; the Electrical Contractors' Association, and the Electrical Association for Women.

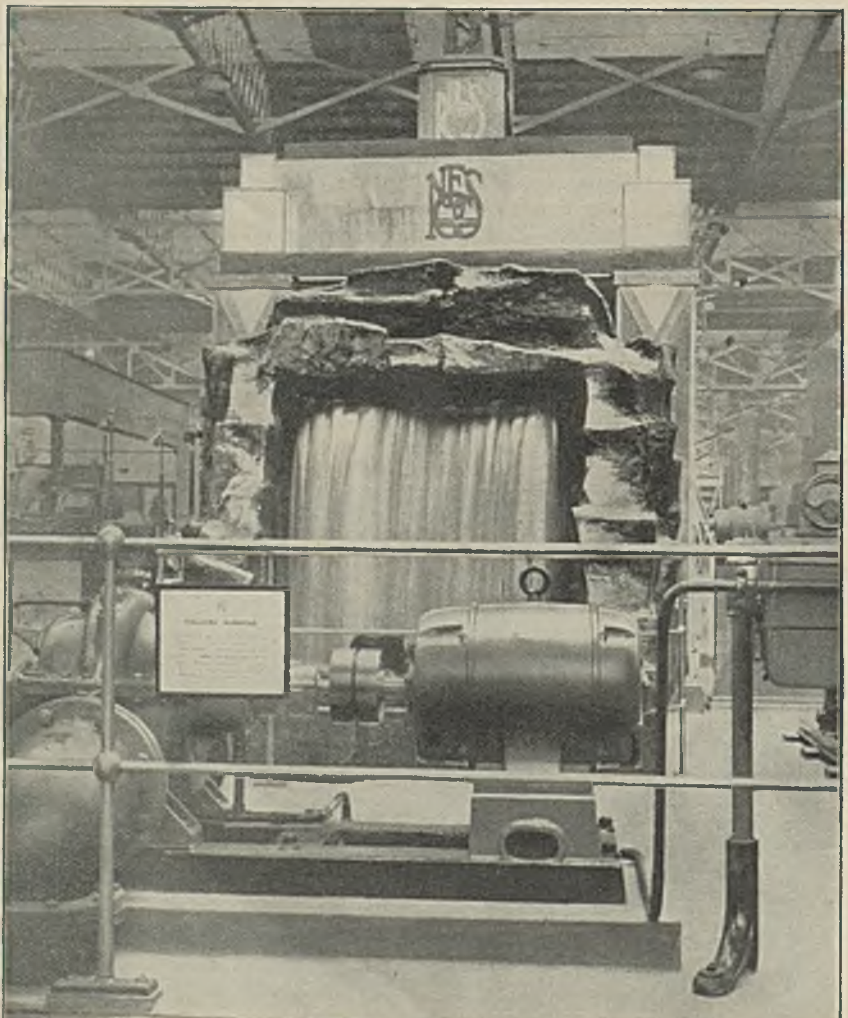
Since the opening many important visitors have been to see the Exhibition including the Sultan of Zanzibar, the King of Spain, the Marquess and Marchioness Yorisada Tokugawa of Japan, High Commissioners from the Dominions and Colonies, Cabinet Ministers and others.

The Palace of Arts, which contains what is acknowledged to be one of the finest loan collections of pictures ever shown in a provincial city, is naturally attracting a very large amount of attention and has brought to the Exhibition many art connoisseurs and art dealers of world-wide reputation.

Many things have conspired to make the North-East Coast Exhibition the success it is, not the least of these being the favourable weather which has enabled the large crowds to enjoy to the full extent the delightful situation in which the Exhibition stands. Had it been held in 1928 as was originally intended a different story might have had to be told, because there is a marked difference between the summer of last year and this. The Exhibition's best advertisement is the fact that it is a really good show, and almost everyone of its thousands of visitors goes away satisfied with what he or she has seen and becomes at once a valuable publicity agent.

The Palace of Arts.

General View showing Palace of Engineering on the left.



The Exhibit of the Newcastle-upon-Tyne Electric Supply Co., Ltd.

In these notes it is necessary to confine the descriptive details to a few of the more prominent exhibits which claim the particular interest of mining and electrical power men. Shipyards, iron and steel works, engineering works and chemical works are, with collieries and other mines, the great labour centres of this heavily industrial corner of England. It follows therefore as a matter of course, that the engineering value of the Exhibition is supreme in the universal range of its attractions, and that it is only possible here to select a small number of typically distinctive items from the extensive collection of machinery and plant.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY Co., Ltd.

In equipping the Mining Section of this popularly attractive Stand in the Palace of Engineering, the N.E.S. Co. had to bear in mind firstly, the display of mining plant of up-to-date design; and, secondly, to draw attention by these means to the power supply activities of the Company in regard to colliery load. For example, in the "waterfall" of which an illustration is given here, the motor driven centrifugal pump and its incidentals show the latest practice in pumping gear: it also indicates very effectively the very large quantity of water which has to be raised from the colliery workings in Northumberland and Durham in the course of a year by a high aggregate horse power of motors installed for that purpose, and directly connected to the Electric Supply Company's distribution system. The cardinal power requirements at collieries are pumping, ventilating, winding, hauling, and those connected with the operation of coal cutters, conveyors and other coal face machinery; therefore, an example of each of these types of plant is to be found on the Stand. Not the least interesting feature of the exhibit is a recently developed example of electrically-actuated Shaft Signalling Gear.

An electrically-operated endless rope haulage engine serves to impress the fact that the N.E.S. Co. and its Associated Companies supply electric power to approximately 66,000 H.P. of coal haulage equipment, installed below ground, which transports from the coal workings to the pit shafts more than 33 million tons of coal per annum. A portable sub-station shows the method adopted underground for the control of electrically-operated machinery installed at the coal face, such as a group of motors working coal cutters, conveyors, gate end loaders, etc. The Supply Company provides electric power for working approximately 17,000 H.P. of such machinery. This includes a large number of coal cutters, by the use of which over five million tons of coal are obtained per annum.

Similarly, a model of a double inlet mine ventilating fan with reversing doors for changing the direction of the air current in case of fire or other emergency, carries the lesson of electric supply for the working of approximately 22,000 H.P. of mine ventilating fans which are extracting more than 1,000 tons weight of air per minute from colliery workings.

The Exhibit of A. Reyrolle & Co., Ltd.

Then again, a model of an electrically-operated colliery winding engine exhibits the fact of over 25,000 H.P. of electric motors installed for operating winding engines and fed from the Supply mains. These electric winders vary in size up to 700 H.P., the largest being capable of hoisting 190 tons of coal per hour from a depth of 1,350 feet at a maximum speed of 44ft. per second. Another mining service is the supply of electric power to 30,000 H.P. of air compressors installed at collieries which supply over 2,000 million cubic feet of compressed high pressure air per annum.

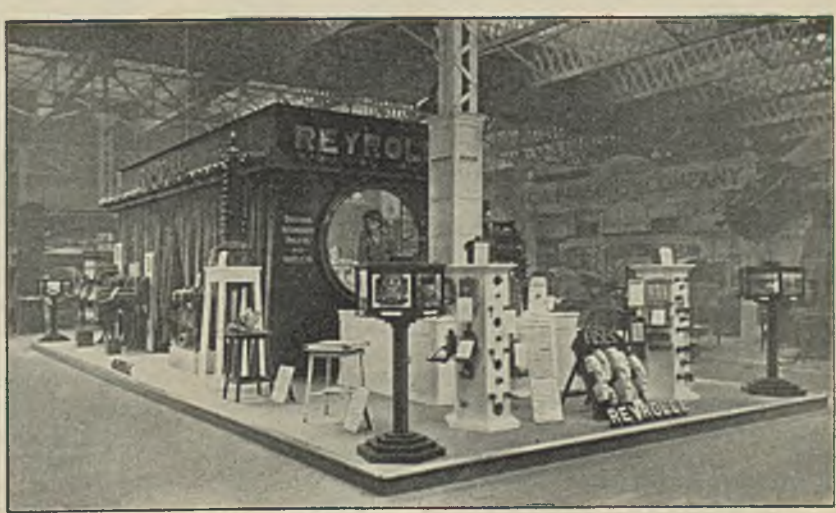
The waterfall display already referred to denotes that the Newcastle-upon-Tyne Electric Supply Co., Ltd. and its Associated Companies supply electric power to more than 50,000 H.P. of pumping equipment, which raises approximately 125 million tons of water annually to the surface from colliery workings in the Northumberland and Durham coalfields.

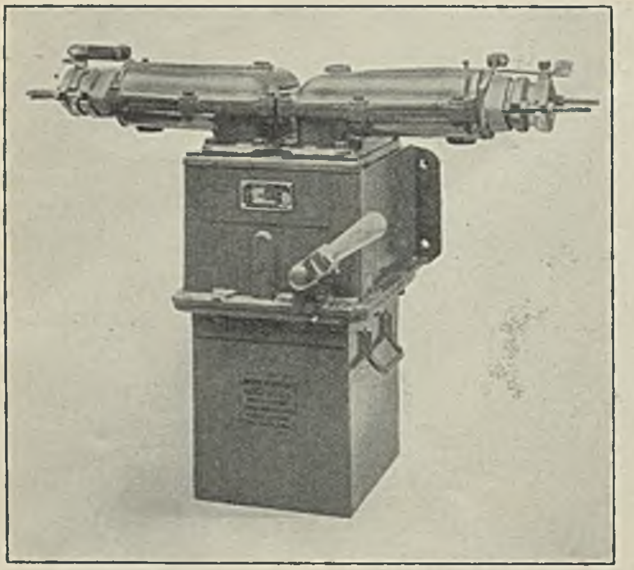
A. REYROLLE & Co., Ltd.

Messrs. Reyrolle supply all parts of the world, from their works at Hebburn-on-Tyne, with metal-clad switchgear of every size and type up to the largest. Incidentally, they have supplied the whole of the main high-tension and low-tension switchgear required in the Exhibition. This includes switches for controlling the supply to such buildings as the Palace of Industry, the Palace of Arts, and the Empire Marketing Board Pavilion. Their switchgear also controls the electricity required for all the illuminations in the gardens, for the fountain, and for the Amusement Park. The model of the world at one end of the Stand symbolises their widespread activity, and draws attention to the places in U.S.A., Holland, Denmark, Australia, Germany, and France, where "Reyrolle" designs are now being manufactured under licence.

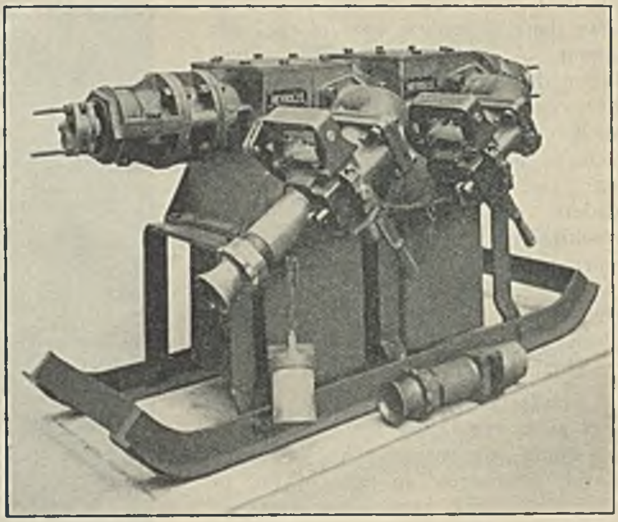
A cinema demonstration on the Stand is proving to be one of the most attractive "side-shows" of the Exhibition. Besides showing details of the manufacture and construction of switchgear a series of films show the up-to-date electric home with Reyrolle apparatus in day-by-day use.

Messrs. Reyrolle invite visitors to inspect samples of their very large switchgear and also domestic electric appliances at their works which are not far from the Exhibition. They show on the Stand selected examples of smaller varieties, such as mining switchgear, industrial switchgear, and plugs and sockets. These exhibits, though small in size, are peculiarly vital parts of suc-


The Exhibit of A. Reyrolle & Co., Ltd.



660 *Volt,* 100 *Amp., Three-phase, Flame-proof Circuit Breaker with detachable Dividing Boxes.*



Two-panel "Mothergate" Switchboard with 100 *Amp. Plugs for Trailing Cables.*

cessful electrical equipment, since they constitute the essentials of safety of life and plant.

Metal-clad switchgear, in earthed enclosures, and adequate protective systems for isolating faulty sections of an installation, are included in Messrs. Reyrolle's achievements and exemplified in their exhibits.

At one end of the Stand a large globe illustrates the penetration of Reyrolle's sales into nearly all the civilised parts of the world, and on each side of the model of the globe there are shown examples of leading switchgear products, together with a specimen bushing from the large "grid" order for 132,000-volt switchgear for the Central Electricity Board. The other end of the Stand is divided into four sections, illustrating the Company's activities in (1) Research, (2) Design, (3) Workmanship, and (4) Home Equipment.

The section on Research includes an analysis of materials used in the making of bakelised paper condenser-type insulators, as well as completed sections of bushings and insulators. The characteristics of good and bad porcelain are illustrated by means of micro-photographic slides, and hard rubber and moulded insulation are shown in the form of details of raw materials and sections of finished articles.

A model, one-sixteenth of full size, of the 500,000 volt testing transformer used in Reyrolle's Laboratory, and photographs of the laboratory itself, are also exhibited. The samples of materials that have been tested up to the breakdown point, and the curves showing performances of materials and circuit-breakers, will be of considerable interest to the expert and of some educational value to the student.

Design is illustrated by means of sections of components. A scale model of a standard metal-clad draw-out switchgear unit can be dissected to show the internal arrangement of parts. Specimen drawings and photostats give a good impression of the importance attached to accuracy and initiative in drawing-office work.

The Workmanship section is prepared by the several foremen in turn. Thus, the first set shows the complete assembly of a switch-handle mechanism and a set of separated components. Visitors who appreciate what a good fit means in workmanship are invited to handle these parts for themselves.

The Home Equipment section includes requisites which are mainly of types illustrating the use of the dimensions laid down for the 5-ampere rating of British Standard Specification No. 196—1927 as applied to outlet and inlet Plugs and Sockets for all household applications of electrical apparatus.

Ring Main Isolating Switches.

Messrs. Reyrolle are showing one of their ring main isolating switches fitted with a switch-fuse so that a connection can be easily and economically teed off a ring main to a small consumer. The isolating switches are of the oil-immersed quick-make and quick-break type, and are suitable for pressures up to 11,000 volts. Separate switches are provided for each cable of the ring main, and each of these can be placed in any of three positions, namely "on," "off," and "earth," a definite stop being provided so that it is impossible to move the switch accidentally from "on" to "earth." On changing over to the "earth" position, the cable concerned, having been earthed in this way, is safe to handle; and at the same time an interlock is released which makes it possible to remove a cover over a testing socket. A plug connector can then be inserted, and the cable tested after the switch has been moved to the "off" position. The interlocking is such that the switch cannot be thrown over to the "on" position if the cover is open. If it happens that when a cable is being tested it is made alive from the other end, no serious damage results because the testing plugs supplied are provided with a small air-gap to discharge any excess pressure. The switch-fuse for protecting the consumer's property is itself oil-immersed. The fuse elements are supported from a steel lid, and this is made to swing clear of all live parts when replacements are necessary, or when it is required to inspect the fuse. The whole equipment is very solidly constructed, and, since it is proof against flooding, it can be safely installed in underground manholes, or in other places where flooding is likely to occur.

(*To be Continued.*)