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EDITED BY E. DINSDALE PHILLIPS.

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The "Conventional" Holiday.

Now is the time come when engineers, and most other people, set about planning for summer change and holidays. Some would hold that no real holiday is possible without, for the time, dismissing every thought of business: "rest" is their magic word. Others lean more towards the term "recuperation" and reckon nothing of the outings and excursions which do not combine business with pleasure; they seek physical and mental plus financial stimulation. The temperament of the individual and the common limitations imposed by his particular class of work and conditions of employment will mainly influence the ultimate decision. Few engineers, however, are so placed that they can relegate business entirely out of mind for days on end; fortunate are those who therefore have the opportunity to indulge in the business-cum-pleasure style of vacation. Perhaps it is for this reason that the annual conventions of technical associations and societies have become so popular; for, as a rule, they are extremely well organised to yield the maximum interest and benefit to those who take part.

So it would have been rather singular if the Association of Mining Electrical Engineers had selected any other place than the North East Coast for their Summer Convention this year. The great Exhibition in Newcastle will, as a matter of course, be "well worth seeing." The city will be *en fete* all through from May to October. Durham and Northumberland are never mentioned without the immediate mental association of coal and engineering, electric power, shipping, railways—all great national industries which had their beginnings and have grown to immense proportions 'twixt Tyne and Tees.

The programme of the A.M.E.E. Convention, which will be held during the first week of July with Newcastle as headquarters, shows how well the North of England Branch of the Association has risen to the occasion. Before the time of the meeting we hope to be able to publish articles descriptive of the several works which will be covered in the round of official visits, so that those who attend will be the better enabled to acquire in a short time a more complete insight into the merits of the plants and industries seen. At this writing we may, however, give a brief outline of the Dunston Power Station and of the Seghill Collieries as indicative of their exceptional value to those who would always be conversant with the most successful and modern in electrical engineering and mining.

The Dunston Power Station, situated on the River Tyne about three miles to the west of Newcastle, is one of the three principal interconnected generating stations operated by the Newcastle-upon-Tyne Electric Supply Co., Ltd., and its Associated Companies. It has been selected for the intended visit on account of its interesting features in connection with the generation of electrical energy on the most modern lines, and more especially for the method of transforming this energy to extra high tension for transmission. The other two principal stations are "Carville," also on the River Tyne, and "North Tees" on the River Tees. The aggregate capacity of generating plant in these three stations is 285,000 kilowatts. The Dunston super-power station has a capacity of 92,000 kilowatts. It generates three-phase current at 6,000 volts and that is stepped up by means of outdoor transformers to 66,000 volts for transmission to distribution centres in Northumberland and Durham. The area of the supply covers 4,150 square miles; there are 36 power stations running in parallel with the system and the yearly output from these stations is approximately one thousand million units. The route length of the 66,000 volt lines is 60 miles and the distributing mains total something like 1550 miles. One hundred and eighty collieries draw their electric power from the system.

Of these collieries one of the most interesting from the electrical point of view is the Seghill Colliery which is to be visited during the meeting. This colliery is situated about eight miles from Newcastle. It is of exceptional interest as being a case where a colliery group, over 100 years old, to meet the trend of the times has been modernised by an entire reorganisation of the plant. Steam has been abolished entirely and the entire plant is now electrified. The continuous ratings of the four electrically operated winding engines are 420 b.h.p., 420 b.h.p., 300 b.h.p. and 130 b.h.p. respectively, with an aggregate acceleration peak corresponding approximately to 2500 b.h.p. Coal is drawn from different levels, three shafts being downcast and one upcast, and the winding capacity is about 4,000 tons from depths which vary between 300 feet and 900 feet.

Complete high tension and medium tension electric ring mains have been provided. The cables are of the paper insulated, lead covered, armoured type, arranged on racks in a specially prepared and drained tunnel approximately 6ft. high by 5ft. wide, affording a clear passage way throughout from the main switch house to the several points at which the surface load requirements are distributed, and also a means of rapidly approaching and repairing any fault. Compressed air and water pipes, etc., are also accommodated in this duct.

A brickworks forms an independent section to utilise material surplus from underground, which would otherwise have to be dumped on the neighbouring land. The brickmaking plant is operated by means of a 100 H.P. slip-ring motor, and an interesting provision is a small electrically operated fan which supplies a cold air douche in any chamber required and so contributes to the comfort of the workers in warm weather.

Particular interest also attaches to the Seghill Collieries welfare scheme which owes so much to the generosity of General Sir. J. F. Laycock, K.C.M.G., D.S.O., the principal owner. Five football grounds, dressing and club rooms, cricket ground, tennis courts, bowling green, colliery institute, etc., are provided, and it is pleasing to note the success and happy results of the extensive facilities.

Book Early for Newcastle.

It is desirable to remind members of the Association that the Exhibition will inevitably impose a great peak load upon the hotels in Newcastle and district. Those who propose to attend the Annual Convention, during the first week in July, will realise the importance of losing no time in settling where to stay. The Committee of the North of England Branch, who are organising the Convention, as a first step definitely booked a large number of single and double rooms at the leading hotels and which they hold at the disposal of members. Those rooms will be allotted to intending visitors in priority of request, and it is recommended that prompt application be sent to Mr. S. Burns, Carliol House, Newcastle-on-Tyne. Casual short-notice attempts to book hotel accommodation are practically sure to be unavailing or at the best unsatisfactory and more expensive. Nor, in this connection, should it be overlooked that the Committee are pledged to take up the rooms they have reserved. For all of which reasons it is strongly urged that enquiries for hotel accommodation should be sent direct to Mr. Burns.

In regard to this matter of expense it is most gratifying to take this early opportunity of acknowledging the generosity of the Civic and Industrial Friends of the Association. As will be seen by reference to the Programme published under "A.M.E.E. Notices" in this issue, those who attend will be almost overwhelmed with the lavish hospitality of the men of the North Country. So, whilst we may feel very reluctant even to mention money in the same breath as this happy anticipation, it is none the less assured that the A.M.E.E. visitor's pocket need not be strained despite the general conditions of super-normal congestion and the more or less inflated expenses which are inseparable from any Great Exhibition.

This is but to give a meagre outline of the good things which await those who avail themselves of the exceptional opportunity presented by this year's A.M.E.E. Convention. The programme opens on Tuesday, July 2nd, with a general re-union and reception by the President of the Association, at which it is hoped a record in the way of attendance will form the best acknowledgment of the generous efforts of the local committee and their friends.

Pulverised Fuel for Ships.

At a recent meeting of the Institution of Naval Architects, Engineer-Admiral W. Scott Hill said no one had yet been courageous enough to venture on the ideal coal-fired steamship embodying all the known economies resulting from high-pressure steam, most recent turbine practice, the best auxiliaries, and the best method of coal consumption, though all these steps had been taken in individual cases. There were not, as yet, any results for a pulverised fuel ship, but Admiral Hill was able to announce that in the "Stuartstar" the owners, the Blue Star Line, were satisfied that an economy of 15 per cent. in coal consumption had been achieved in the boilers converted to pulverised coal firing. He added that the owners had received such satisfactory reports by wireless that the remaining double-ended boiler was to be converted. After the next voyage of the "Stuartstar" a complete and authoritative report would be available.

Changes of Address.

Mr. W. Bolton Shaw, M.Sc., M.I.E.E., M.I.Min.E., who has carried on his consulting practice at 25 Market Street, Manchester, for the last eighteen years, has removed to 1 New Brown Street, where he will continue in practice.

As from April 6th the address of the Greenwich Cable Works, Ltd., will be Mitcham Road, Croydon (telephone, Thornton Heath 2882). The new works at this address have been entirely modernised, fitted with the most up-to-date machinery for cable making, and have full rail facilities, with ample provision for future extensions.

The Sterling Varnish Company having acquired property and land for the further accommodation of their rapidly extending business are, in future, to be addressed at the new works, Fraser Rd., Trafford Park, Manchester.

New Machines and Apparatus.

F. MAWSON.

(*This is the second of a series of Articles intended more particularly to help Students and Junior Engineers*).

(*Continued from page* 284).

WHEN a new machine or other piece of electrical apparatus is received, and especially where the object is too heavy to handle by hand, great care should be taken in unloading and unpacking. At any time or in whatever position the piece may be, no weight should be allowed to rest on the windings. Under no circumstances should any of the weight of an armature or rotor be supported by any sling or prop or other device in contact with the commutator or slip rings. Field magnets and machine frames are usually made with lifting eyes and wherever possible these should be used. If this is not convenient then the slings or lifting tackle should be passed round the casting, being careful to see that the lifting rope does not press on any wires, terminals, etc.

Every machine of 25 horse-power or more should be provided with a substantial foundation, which should if possible be independent of the floor and wall of the building in which it has to be installed, so as to avoid communicating to them the vibration incidental to the running of the machine. Where there are several machines to be installed, the whole floor space should be concreted, and either capped with a layer of cement or covered with a wooden floor. Where a single machine is to be installed, it is sufficient to limit the foundation to a little more than its floor area. Concrete and solid brickwork make the best foundation, but where these are impracticable, as in the case of an underground haulage, a substantial frame made of steel joists can be used. No rule can be given in regard to the depth of foundation to cover all cases, as this is dependent on the nature of the subsoil, and this varies very considerably. In one section, bed rock will be found a few feet from the surface, while at another it may be necessary to drive piles to support the foundations of the heavier machines. No unprotected woodwork or other combustible matter should be allowed anywhere near the machine. The foundation is built up of rough concrete capped with cement and brought to a level surface.

When making the foundations square wooden cases are embedded in the concrete so as to form the holes for the foundation bolts. In some cases thin cast iron pipes are used, but they should be eased or taken out just before the cement has set.

The holding down, or foundation, bolts can be either in the form of straight bolts with large square cast-iron washers, or they may be of the rag bolt type. In the former case, to prevent the bolts from turning, they should be made with square necks which fit into square recesses in the washers. For very large machines the lower ends of the bolts should be accessible and secured by means of cotters which bear against the large cast iron washers.

For a motor or belt driven generator means should be provided for tightening or slackening the belt. This may be accomplished by mounting the machine on a sliding base plate or on slide rails fitted with a long screw adjustment.

Small machines, as a rule, are sent out by the manufacturers complete and ready to run, so there is nothing to do but to put them in place, fix a pulley and line them up. Large machines cannot be sent out conveniently or with safety in an assembled condition, and some are in fact much too large to go by rail or road in one piece. The work of re-assembling and erecting should not be undertaken by anyone who is not familiar with such work; no attempt should be made to assemble the parts of a heavy machine without proper rigging devices adapted to the work. The majority of collieries are equipped with cranes for this purpose.

In lining up a fairly large machine, the most common method is to have the surface of the foundation left at ¼in. to ½in. below the finished level. The bedplate of the machine is then raised to the correct height and levelled by means of small steel wedges. The shaft of the machine should be level and in line with or parallel to the driving mechanism or driven shaft. While in this position, the holes round the foundation bolts and the whole of the space under the bedplate is filled in with liquid cement, or grouting as it is usually termed. Shallow dams of clay or sand must be made round the bedplate to retain the grouting until it is set. While doing this the machine should be carefully covered, especially the bearings, as cement dust is extremely detrimental to bearings of all descriptions.

Before starting up the machine, ample time should be allowed for the cement to set. The machine should be thoroughly cleaned and the dust blown off the coils by means of an air blast or bellows.

Where parts of the machine have been exposed and are damp, the insulation resistance will be low, and arrangements should be made for "drying out." This may be done before the machine is erected by placing it in a warm, dry position for some days. If this cannot be done, then the machine must be dried out in position, and to do this arrangements should be made to pass the full normal current at low voltage through the windings for several hours; care should be taken to insert a voltmeter and ammeter in the drying circuit so that a definite check can be kept on the amperage and an indication given should any electrical fault appear. The object of circulating the full load amperes is, of course, to heat up the windings and thus gradually drive out the moisture. It is also very important before starting the initial run to look very carefully over all the electrical connections to see that they are in accordance with the wiring diagram supplied by the manufacturers.

A generator is, of course, started by means of its engine or turbine; a motor is started by the current from the line. In either case care must be taken that there are no tools or implements in the generator or near the belt, where they can be shaken off on to the rotating parts of the machine or be drawn into it by the field magnets.

The machine should be run at about half speed for an hour or more, to allow any tight or badly fitted bearings to be detected, if such exist, and to see that the oil rings do not stick, or the ball and roller bearings (if fitted) are functioning properly. If all the parts of the machine seem to be in good working order, the speed may be run up to normal, and the machine excited; but, except in the case of small machines, no load should be put on for several hours.

Wherever possible, it is usual to drive direct by means of a coupling; this should in all cases be slightly flexible. Where driving belts are used they should preferably be endless, that is, they should have a cemented joint instead of the usual laced joint. Where large belts are used a means should be provided for removing the static or frictional electricity that sometimes accumulates on them; a usual method consists of a metal comb, connected to the frame of the machine and so fixed that the belt will run near the teeth, the charge is thus drawn off through the comb to earth. An occasional application of glycerine or castor oil to a leather belt serves to keep the belt moist and prevents the formation of static charges.

Before bringing any machine into operation, the whole of the framework and switchgear should be suitably earthed. The best method is to use a single bare soft copper strip or wire of suitable size secured by copper clips to the respective parts and to the earthing system. The idea of the uncovered strip is that any break in it can be easily detected, as often there is a tendency to neglect the inspection of this essential feature. In the majority of modern machines, especially the larger ones, the cable box is so made that the earth connection is secured at the armouring gland to the cable armour, a lug or set screw being provided for that specific purpose.

(*To be continued*).

Flame-proof Switchgear.

At the resumed discussion by the Midland Institute of Mining Engineers of Prof. I. C. F. Statham's paper on Flame-proof Electrical Apparatus, two interesting contributions were those of Prof. Douglas Hay and Mr. E. P. Austin, respectively.

Prof. Hay referred to the matter of possible dangers that might arise with oil-break switchgear if the oil level was not properly maintained, from the production of hydrogen and other gases from the oil-making switch which was flame-proof with methane and not flame-proof with the other gases. He had had the opportunity of discussing the matter with manufacturers of switchgear, and found it was quite practicable to use air-break gear in situations at or near the face where switchgear with a comparatively low rupturing capacity was required. In such a situation the switchgear was a considerable distance from the point of generation, and the resistance of the connecting feeder was high, so that a rupturing capacity of the order of 5,000 K.V.A. was sufficient, and consequently the necessary clearance could be obtained with a switch of comparatively small dimensions and reasonable cost. On the other hand, at situations nearer the point of generation it might be necessary to provide for a rupturing capacity of 40,000 to 50,000 K.V.A., and in such situations air-break switchgear would be too bulky and too costly. They might expect, therefore, that, as far as the present state of knowledge went, it would be necessary to use oil-break gear for feeder switches at or near the pit-bottom. They had examples of air-break gear for heavy duty on the surface for large hauling or winding engines where contactor air-break gear could be used; but in those cases there was plenty of room to put in a bulky switchgear and provide the necessary large clearance. Between those two extremes, however, it seemed that they would still have to use oil-break gear.

Mr. Austin, in regard to the point that vented flanges were the simplest and most effective means of venting the casing of an air-break switch, stated that he had been experimenting with boxes, of the dimensions of about 2ft. by 8in. by 5in., with hydraulic pressure, the flanges being 1½in., and grooved in a planing machine, with the idea of seeing at what point the pressure would be relieved, and what distortion, if any, in the box took place. He found that the box was slightly distorted at about 70lb. per sq. inch, but when the pressure was relieved the box resumed its normal shape. He considered that the construction of a box should be that the mechanism be mounted on a separate back plate, which should be suitably fixed in the casing so that any distortion which might occur in the case, due to an explosion, would not prevent the operation of the switch, which would perhaps happen if the mechanism were fixed to the sides of the case. In regard to the question of air-break versus oil-break, it was essential to use oil-break switches in pit bottom and in-bye sub-stations where inflammable gas was not likely to occur, for such switches would be called upon to rupture high K.V.A. capacities; but for smaller switches near the coal face, then the oil should be excluded. He had recently been using switches for loader and conveyor gear which were air-break, and occupied small space and were fully equipped with all the necessary protective devices. They had been devised to do away with fuses, which should never be used near the face. He considered that air-break switches, fitted with magnetic blow-out coils, were capable of rupturing in high K.V.A. capacities, and there was no doubt there would be an increasing use of such gear in the near future. In regard to costs it could hardly be expected that an air-break switch would be cheaper than an oil-break switch, because in the air-break switch allowance had to be made for more clearance, and the parts would be rather larger for their work.

A Great Magneto Test.

A particularly notable long distance record was recently established by a 348 c.c. Dunelt Majestic motor cycle on the Montlhéry track, Paris. The motor cycle was one selected by the A.C.U. from a stock of similar machines (each fitted with a B.T.H. magneto) at the manufacturer's works, and subsequently was driven day and night under A.C.U. observation for between 23 and 24 days, a distance of 25,000 miles being covered. During the run the B.T.H. magneto made over fifty million sparks.

North East Coast Exhibition Notes.

THE Newcastle Town Moor is now the scene of great activity for here, on May 15th of this year, the great North East Coast Exhibition will be opened by His Royal Highness the Prince of Wales. This Exhibition, which covers a site of more than 100 acres and has cost a quarter of a million pounds to erect, will be the largest of its kind ever held in the provinces.

The two main buildings consist of a Palace of Engineering and a Palace of Industries, the former occupying a space of 100,000 square feet and the latter 160,000 square feet, and these buildings will contain the Stands of four hundred exhibitors.

In the Palace of Engineering will be seen excellent examples of the machinery produced by the engineering works situated in the North East Coast area, and a considerable portion of the space in this building will be devoted not only to the latest developments in electrical apparatus but also to up-to-date electrical appliances as used in the great coal mining industry. The exteriors of both of these Palaces will be beautifully illuminated at night by means of electric flood lighting and numerous coloured lamps.

Another fine building is the Festival Hall, situated near the Bandstand and illuminated fountain in the Grand Court. It is in this Hall that the Annual Meeting of the Association of Mining Electrical Engineers will be held. Numerous other conferences also are to be convened during the period of the Exhibition.

A handsome building, known as The Palace of Arts, is reached by a bridge over a large artificial lake on which boating will be available.

In addition to the practical side of the Exhibition there will be offered much of great interest to the general visitor, and the spacious grounds now being laid out will be well worth a visit. A handsome Stadium, which will accommodate 30,000 spectators, is being constructed and here will take place numerous sporting events. In addition there is an Amusement Park in which will be the most up-to-date ideas for the amusement of visitors to the Exhibition.

Of the many firms who will have Stands in the Palace of Engineering the following, selected from the preliminary list, will serve to indicate that mining electrical interests will be exceptionally well covered.

George Angus & Co., Ltd.
Ashmore, Benson, Pease & Co., Ltd.
Babcock & Wilcox, Ltd.
Bever, Dorling & Co., Ltd.
Birtley Iron Co., Ltd.
Bolckow, Vaughan & Co., Ltd.
British Electrical Repairs, Ltd.
Cambridge Instrument Co., Ltd.
Cargo Fleet Iron Co., Ltd.
Clarke, Chapman & Co., Ltd.
Consett Iron Co., Ltd.
Dorman, Long & Co., Ltd.
Head, Wrightson & Co., Ltd.
J. H. Holmes & Co., Ltd.
R. Hood, Haggie & Sons, Ltd.
International Channelling Machines, Ltd.
Imperial Chemical Industries, Ltd.
E. N. Mackley & Co., Ltd.
Michell Bearings, Ltd.
Newcastle-on-Tyne Electric Supply Co., Ltd.
C. A. Parsons, Ltd.
Pease & Partners, Ltd.
Redpath, Brown & Co., Ltd.
A. Reyrolle & Co., Ltd.
Robson & Coleman.
South Durham Steel & Iron Co., Ltd.
Stewarts & Lloyds, Ltd.
Sunderland Forge & Engineering Co., Ltd.
Vickers-Armstrongs, Ltd.
G. & J. Weir, Ltd.
Yorkshire Copper Works, Ltd.
Yorkshire Electric Detonator Co., Ltd.

A General View of the Exhibition. *Photo: Newcastle North Mail.*

The International Engineering Exhibition, Barcelona.

A special invitation is extended to British firms to become exhibitors at the Engineering International Exhibition to be held in Barcelona from May to December this year. It is stated that this exhibition is to be the most important international one held since the War. Detailed arrangements are being undertaken by the township of Barcelona, which is defraying the expenses, amounting to about £5,000,000. The exhibition has received the patronage of the King of Spain, and the Spanish Government is actively co-operating.

A strong British Committee has been formed, including Sir Philip Cunliffe-Lister, President of the Board of Trade, Viscount Rothermere, Lord Kylsant, Lord Waring, Lord Riddell, Lord Melchett, Sir Charles Wakefield, Sir Arthur Balfour, Sir Auckland Geddes, Sir William P. Burton, Sir John F. Beale and Mr. John Walter.

All the leading nations will be represented by exhibits. One section is to be given over entirely to the display of the products of British firms. The Spanish nation hope that the exhibition will be the means of extending British commercial interests in Spain. In the opinion of Spanish business men, it is not sufficiently recognised in Great Britain how big a market there is in Spain for British exports, and what efforts other countries, notably France and Germany, are making to capture the field.

Spain is undertaking an ambitious programme of progressive modernisation, and with the help of her Government is developing her railways, irrigation, hydraulic and electrical power, harbours and docks. In the construction of her arterial roads for motor traffic she is spending alone many millions of pounds sterling.

Many leading British firms, through the British Section Office of the Barcelona Exhibition, 42 Pall Mall, London, have booked space, and arrangements are being made, in addition, with the British Chamber of Commerce for Spain, and the Spanish office of the Federation of British Industries, to put exhibitors in touch with reliable established firms likely to be interested in taking up their agencies.

An additional inducement to British exhibitors is the opportunity that the exhibition will afford them for opening up trade with the South American Republics. Thousands of traders will be attending the Spanish-American exhibition to be opened earlier at Seville, and will go on from there to Barcelona.

The British Section is to be housed in the International Pavilion, near the Stadium and the French and Italian buildings—one of the finest and most accessible sites in the Exhibition grounds.

NEW CATALOGUES.

W. T. HENLEY'S TELEGRAPH WORKS Co., Ltd., Holborn Viaduct, London, E.C. 1.—*Correction*: In referring last month to certain new Henley catalogues an unfortunate printer's error attached the name "Vienna" to the well known VICMA brand of Henley Tough Rubber Sheathed Wires and Cables. "Vicma" and "Vinazo" are proudly British to the core; the printer slipped right off the track!

Messrs. Henley have issued a Nett Price Trade Catalogue, in handy pocket form, covering all the more commonly used sizes and varieties of Insulated Conductors; Rubber Insulated and Tough Rubber Sheathed in C.M.A. and Nonazo; Henley Wiring System in Nonazo. Conductor carrying capacities, dimensions and particulars of respective coverings and sheathings make the list extremely useful and complete.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs. —Demand Indicators, illustrated folder No. PF 51, and Rust-proof Rubber Insulated Wires and Cables, are subjects of new editions.

Pole Line Materials in which the B.I. Co. are well-known as specialists, are fully dealt with in the illustrated catalogue No. P 246.

A Bell Wire price list and a full List of the Company's manufactures at the Prescot and Helsby Works, respectively, are also recent B.I. publications.

BRITISH THOMSON-HOUSTON Co., Ltd., Rugby.—A 36-page Descriptive List No. 2420-C is in effect a valuable technical book dealing with the theoretical principles and practical construction of Rotary Converters.

The Descriptive List No. 5281 gives the constructional and operating features of a range of Auto-Transformer Starter Equipments for large induction motors, synchronous motors and condensers.

Particulars are published of a new type of Induction motor. Known as the "K" type, these machines are standardised in a range from 1 H.P. to 25 H.P., 400/440 volts, three-phase, 50 periods. They comply in all respects with B.S.S. 168, have high efficiency and power factor, give maximum starting and overload torque, and take low starting current. Ball and roller bearings are fitted. The rotor has aluminium bars and end rings cast in one piece by a special process and is practically indestructible under service conditions. The core is ground on the periphery to ensure true running. The stator windings are specially dried and impregnated under vacuum.

B.T.H. Steam Turbines are fully described in the new catalogue No. 1105A, which is exceptionally replete with details, running to over 50 pages of matter.

The B.T.H. Descriptive List No. 3305 is concerned with Metal-clad Vertical Plugging Switchgear.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2.—A leaflet schedules the price increases of rubber insulated Wires, Cables and Flexible Cords which came into effect on February 12th.

Leaflets Nos. S 4951 and S 4976 deal respectively with Interlocked Switch Plugs and Watertight Switches. A new type of Home Office Fuses grouped in teak cases are described in the Leaflet No. S 4999.

W. T. GLOVER & Co., Ltd., Trafford Park, Manchester. —This Company also issues a sheet showing the Cables, etc., price increases.

BROOKHIRST SWITCHGEAR, Ltd., Northgate Works, Chester.—The Control of Synchronous Motors and the problem of Power Factor Correction is the subject of a useful booklet which is mainly confined to descriptions of self-contained P.F. control equipments.

BRUCE PEEBLES & Co., Ltd., Edinburgh.—The leaflet No. 170 contains much useful information on the design and installation of Pole-Type Transformers. Weights, dimensions, ratings, etc., of a large range are given.

The "Girl" Calendar.

Welcome and attractive as ever is the fifteenth of the series of "Girl" Calendars which the Metropolitan-Vickers Electrical Company have just issued to carry the days forward until the Spring of next year.

Proceedings of the Association of Mining Electrical Engineers.

SOUTH WALES BRANCH.

Modern Methods of Steam Raising, with particular reference to Pulverised Fuel*

Discussion.

(*Continued from page* 257).

Mr. W. H. TYCE.—It is interesting to note with special reference to Mr. Haslam's remarks relating to the possibilities of a combined system using pulverised fuel and mechanical stokers, that successful plants of this kind have been in operation for some time. A combined system has been developed by Messrs. Alfred Herbert, makers of the "Atritor" unit pulveriser. Although primarily intended for boosting, the results obtained with this application have proved effective and a direct saving has been gained. The installation obviates the need for keeping a stand-by boiler banked down to meet the heavy peak loads to be encountered. Two typical results from this plant are as follows:—

(1) Increase in evaporation in one test from 31,900 lbs. to 43,000lbs. per hour in 2½ minutes, and in another test from 44,000lbs. to 57,200lbs. per hour in three minutes.

(2) Equally rapid decrease in evaporation, which in both tests returned to normal in about five minutes.

(3) The final steam and flue gas temperatures were not appreciably effected, while the pressure and CO_2 percentage in the flue gases were increased.

In this case the machine was installed in the basement and the pulverised fuel supply pipe split into two, one pipe going to each side of the furnace where it feeds a burner at right angles to the mechanical stoker.

The extreme rapidity with which the plant responds to violent load fluctuations is interesting; it should be noted, however, that this plant is only intended for short runs, the boosting period rarely exceeds thirty minutes owing to the risk of damage to the furnace or boiler if the plant was run for a longer period. This plant has been successfully operating for over two years; there are two plants in successful operation in this country, and a third plant is in course of installation.

Another combined system has been developed by the Riley Stoker Corporation in America, where the pulverised fuel plant is being used in a combustion chamber primarily designed for this combined system, with the result that the pulverised fuel can be used for longer periods without risk of damage. Here again the full benefit is felt of the great flexibility to be obtained by using pulverised fuel.

Mr. Tyce supplemented his remarks by forwarding to the Branch Secretary the following report of tests:—

Rotterdam Electricity Works: The "Boosting" of Stoker Fired Boilers by Pulverised Coal.

One No. 10 Atritor has been installed to fire two boilers. Up to the present one boiler only has been fitted and the data refers thereto.

Boiler.

Type: Babcock & Wilcox C.T.M.

Heating surface of	boiler	523 sq. m.	= 5630 sq. ft.
" "	superheater	171 sq. m.	= 1840 sq. ft.
" "	economiser	360 sq. m.	= 3870 sq. ft.

Normal working pressure	=	14 kg. per sq. cm. = 198.8lbs. per sq. inch.
Normal steam temperature	=	375 deg. C.
Normal steam production	=	17 tonnes per hour = 37,500lbs. per hour.
Maximum " "	=	22 tonnes per hour = 48,500lbs. per hour.

Stoker.

Two underfeed chain grates with forced and induced draught.

Grate area per boiler (total) = 21 sq. m. = 226 sq. ft.

Coal.

Name	Westfaalsche	Emma
Character	Non-coking	Coking
Moisture	3%	3%
Ash	6%	7%
Volatile matter	25%	23%
Calorific value	13,500 B.T.U.'s per lb.	13,500 B.T.U.'s per lb.

(Details of Boiler Tests are tabulated overleaf).

Messrs. SIMON CARVES (written contribution).—We have been extremely interested in Mr. Haslam's paper and note his preference for a combination of stokers and pulverised fuel. The author rightly says that whereas with mechanical stokers high CO_2 (14% or 15%) can be obtained under test conditions, "it is well-nigh impossible to do so under the varying load obtaining in a boiler house." In our opinion this is the crux of the whole matter, but the author elsewhere quotes efficiencies of 83% for pulverised fuel and 83% to 87% for mechanical stokers and leaves it to be inferred that such figures are average performance. In effect the efficiency of either type of boiler can be increased under modern conditions to well over 90% of the gross calorific value, on a short eight-hour test.

In practice such high efficiencies as a rule are not commercially economical, since they are attained by installing a large amount of economiser and, or, air heater surface, so as to reduce the exit temperature of the gases to a very low figure. The higher the percentage of CO^2 (provided no combustible gases are present) the smaller the heating surface necessary to reduce waste gases from any given initial temperature to any given final temperature.

The author admits that with a pulverised fuel boiler CO^2 of 14% to 15% can be maintained day in and day out, which is impossible with mechanical stokers. He further admits that as regards combustible in the ash the pulverised fuel boiler has a marked advantage, that its flexibility is far greater, and that banking losses are smaller.

We cannot see any advantage claimed for the mechanical stoker except the remarkable statement that "there is a wider choice of fuels available for mechanical stokers than for pulverised fuel firing." We agree that although theoretically there is no class of coal which cannot be burnt in pulverised form, various local conditions render some not commercially economical. For example metallurgical coke can be pulverised, but is so abrasive as to increase maintenance charges beyond an economic limit; while the cost of drying washery slurry would prove prohibitive in most cases.

The author's submission that only soft coals can be used economically for pulverising is one to which we cannot for a moment agree, since one of our installations has been at work in South Wales for nearly five

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

TEST ON BOILER No. 23, SATURDAY, 13TH NOVEMBER, 1926.

TIME.	STEAM.			ECONOMISER.		FLUE GASES.			REMARKS.
	Output tonnes/hr.	*Pressure kg/sq. cm.*	*Temp. °C.*	*Water Inlet °C.*	*Water. Outlet °C.*	*After Boiler °C.*	*After Econr. °C.*	CO_2 %	
10.00	12	13.5	352	58	158	342	223	8	Smoke white.
11.30	14	13.8	346	58	150	342	222	10½	" "
11.43	16	13.6	340	56	148	345	222	—	" "
11.57	14½	—	—	—	—	—	—	—	Atritor started.
12.05	20	14.6	337	—	146	360	228	11¼	Smoke grey.
12.10	21½	14.6	330	—	147	364	230	11½	" "
12.15	20½	14.5	327	59	142	366	228	11½	Smoke lt. grey
12.25	21	14.5	332	66	133	366	226	11½	" "
12.35	21	14.5	332	63	130	370	226	11½	" "
12.50	14½	—	336	—	132	371	227	—	Atritor stopped 12.46

Flame Temperature.

Right hand and left hand door.	11-30	12-05	12-25	12-50
Right hand side	1200° C.	1400° C.	1420° C.	1440° C.
Left hand side	1180° C.	1400° C.	1420° C.	1420° C.
Centre	1465° C.	1500° C.	1520° C.	1520° C.

Coal used was Westfaalsche (Westphalian).
Throughout test thickness of fire bed was 60 m/m. Stoker speed 5.
Draught Conditions.—At damper — 25 m/m.; over fire bed — 2 m/m.; under grate + 50 m/m.
Atritor started up at 11-57 a.m. Steam production 14½ tons per hour (metric).
2½ minutes after starting up steam production was 19½ tons per hour (metric).
5 " " " " 20½ tons per hour.
Steam production throughout test was 20½ to 21½ tons per hour.

TEST OF BOILER No. 23, WEDNESDAY, 17TH NOVEMBER, 1926.

TIME.	STEAM.			ECONOMISER.		FLUE GASES.			REMARKS.
	Output tonnes/hr.	*Pressure kg/sq. cm.*	*Temp. °C.*	*Water Inlet °C.*	*Water Outlet °C.*	*After Boiler °C.*	*After Econr. °C.*	CO_2 %	
9.50	19.5	14.7	360	59	148	383	244	11.4	Smoke white
9.55	20	14.8	359	58	150	386	246	11.8	" "
10.02	20	—	—	—	—	—	—	—	Atritor started.
10.05	25.8	15.9	353	57	151	396	250	12.3	Smoke dk. grey
10.10	25	15.9	347	57	146	399	252	13.2	" "
10.15	26	15.6	347	57	141	396	251	13.5	" "
10.20	26	15.5	348	57	139	402	250	13.2	" "
10.25	26	15.4	349	58	137	400	251	13.2	" "
10.30	25.8	15.3	350	58	134	403	252	13.9	" "
10.33	26	—	—	—	—	—	—	—	Atritor stopped
10.35	23.2	15.2	350	57	136	398	251	14.1	
10.40	20.1	14.8	359	58	133	388	247	12.8	Stokers retar'd.
10.45	19.5	14.8	361	58	136	384	244	11.9	
10.50	15.8	14.2	346	58	133	360	238	12	
10.55	14.2	14	346	58	132	356	227	11.2	

Flame Temperatures.

Right and left hand door.	9-50	10-15
Right hand side	1320° C.	1480° C.
Left hand side	1320° C.	1480° C.
Centre	1530° C.	1580° C.

Coal used was Emma.
Throughout test thickness of fire bed was 80 m/m. Stoker speed 5/6.
Draught Conditions.—At damper — 37 m/m.; over fire — 2½ m/m.; under grate + 56 m/m.

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years on Aberpergwm anthracite duff, showing a saving over previous practice of 5d. per thousand pounds of steam generated; while a new installation is shortly to be started at an anthracite colliery where this class of fuel will be used entirely. Analyses of this coal have given 4.9% and 6.4% volatiles with 13.4% and 16.8% of ash respectively.

Maintenance costs with anthracite are undoubtedly higher than with soft bituminous coals, but we have not yet on any of our plants encountered pulveriser maintenance costs as high as 3d. per ton; the usual figure is well under 2d.

It still remains to be demonstrated over a long period that satisfactory results can be obtained from firing anthracite duff on mechanical stokers. Even if this, and other claims as to the capability of mechanical stokers for burning different coals, is substantiated it will remain true that a plant installed to burn one type of fuel would give very bad results should the class of fuel be changed; whereas with pulverised fuel it is possible to burn widely differing coals one after another, with only minor adjustments to the air controls and without any loss in efficiency whatever.

To sum up, we would suggest that the higher CO_2 which can be admittedly maintained day in and day out, the lower quantity of combustible in the ash, the flexibility and ease of control, and the wide range of fuels available, all combine to make pulverised fuel firing a more efficient system in all cases, unless there are some special local conditions.

MAJOR E. IVOR DAVID.—There is an experimental station in South Wales operating at the present moment on the direct gasification method Mr. Haslam spoke of. It is a plain fired boiler with no intermediate connections at all. It is operating on anthracite shale, but it is much too early in the day to make any comments as to its success or otherwise. Up to the present it may be said that it is reasonably successful. By next year we may be able to say more about it. Every single system Mr. Haslam has suggested is in operation in South Wales. Here again it can be claimed that this district has been the pioneer for the country as it was in respect to high pressure steam and one or two other important developments.

Mr. S. B. HASLAM (in reply).—Having suitably thanked the members for their kind reception and the various manufacturers who had lent lantern slides and for their general help, Mr. Haslam said that whilst many articles and papers on pulverised fuel have been written most if not all deal with one type of plant only and are more concerned with the results of that plant than with the general ideas of burning fuel in a powdered or pulverised form.

Before trying to answer the various points raised in the discussion he thought it well to call attention to the various points of view which had been put forward. Precept and practice intermingled with the views of manufacturers should make the discussion of considerable value.

He was glad to hear Mr. MacSheehy, in opening the discussion, sound a note of alarm by pointing out that pulverised fuel firing is not suitable for every class and size of boiler. He agreed with Mr. MacSheehy—they had all seen new ideas put to a lot of harm and their development retarded tremendously by ill-advised and ill-considered applications.

There is no doubt that excessive use of pulverised fuel plants will tend to level up the prices of small and large coal, and those who are basing their running costs on the prices they pay to-day for a product which has a very limited market, or no market at all, may in a few years' time find that their figures will require considerable revision.

A point also to take into mind is the fact that when putting down a new plant, and burning pulverised fuel, manufacturers are too apt to take all the resultant economies to their own credit—overlooking the fact that in most cases very considerable economies could be made on the existing plant by the installation of instruments and such like general modernisation.

Mr. MacSheehy had pointed out a mis-statement in the paper as regards the result of too much excess air in the CO_2. The paragraph is certainly not worded as well as it might be, but circumstances have operated to prevent close revision and the correction is accepted.

Several speakers joined issue in regard to the statement that coals used as pulverised fuel must have a fair percentage of volatile matter, but Mr. Haslam said he would point out that in all cases he had used the word economically and the same remarks apply to mechanically fired boilers. It is of course apparent that where only hard coal is available the remarks do not apply, but the contention is that it will be cheaper in the end (taking maintenance charges into consideration) to procure and burn a soft coal, provided always that a market can be found for the hard coal produced. Of course, the ideal system is to generate at the source of the most suitable coals and transmit electrically.

Mr. Patton confirmed the remarks relative to the unit or central systems, and Mr. Haslam therefore felt more than ever convinced that except in exceedingly large plants the central system should not be seriously considered.

Mr. Patton's figures regarding the life of roller mills are interesting but he, Mr. Haslam, still maintained that an average would come out in favour of the bar mill and believed that experience gained in cement works more than ever confirmed his view. The possibility of extraneous matter in the coal such as bolts and nuts, rivet heads, etc., cannot be lost sight of.

He noted that Mr. Patton referred to the vertical method of introducing the fuel as almost antiquated; if so it will be a big advance as it will mean a considerable reduction of costs owing to the smaller combustion chamber required, but it would appear that a horizontal feed is only possible by the use of the modern type of turbulent burner. In the paper attention was directed to the great need of turbulence, but he would submit that there is still a risk in depending too much on the burner—which after all is bound to lose in efficiency in course of time.

With regret he had to agree with Mr. Patton that they are ahead of us in America though perhaps not as much as they would have us believe. This, he thought, was due to the fact that until recently we had, or thought we had, too much of that good thing, coal.

Now that this country had made a start he felt sure we would soon overtake our American cousins. With regard to the losses on Lancashire boilers due to ash, Mr. Patton mentioned 4%, but it should be noted that included in this figure in the paper were radiation losses unaccounted for, and that would account for at least half the figure in question.

He was very grateful to Mr. Regan for his description of the loco. slide, and it is very interesting indeed to learn that Mr. Regan had a long run on the engine, and to note the very excellent results which are being obtained. Mr. Regan had suggested that Mr. Haslam was rather hard on the mechanical stoker. That was not so: he, Mr. Haslam, was a very great believer in the mechanical stoker and, except in the case of the combined system, would be very loath to instal pulverised fuel plant in preference to mechanical stoking; but he did consider that pulverised fuel plant has certain advantages, even if only in the matters of raising steam quickly and handling fluctuating loads with the maximum economy. Certainly it is most difficult on a mechanical stoker plant to deal with a load falling away from the peak position.

He really could not see how Mr. Regan's claims as regards cleanliness could be substantiated, though he agreed with him that a great deal might be done with existing mechanically fired plant to improve the conditions as regards cleanliness.

The question of control has been raised by one or two speakers and there is certainly a feeling that this can be overdone. He could not altogether agree, though naturally it does require a greater amount of intelligence to get the best results out of a plant which is dependent to a large extent on records and instruments. It would seem to be quite unanswerable that the more the human elements can be removed the better the results will be, provided of course as Mr. Clare had said, that the proper amount of intelligence is brought to bear in learning the lesson given by the instruments and acting on the same.

Mr. Regan was one of the speakers who took up the question of the type of coal to be burnt with pulverised fuel plants, and he had taken this matter up very strongly. Mr. Haslam said he did not wish it to be inferred that he had suggested at any time that efficiencies could never be obtained with a hard coal, but he did think that at the present time and on all the information available at the present moment, the evidence is strongly in favour of the fact that hard coals are not so suitable for pulverised fuel firing as softer or more bituminous coal.

It must not be forgotten that the introduction of the turbulent burner as against the fish tail type is largely responsible for the increasing use of lower volatile coal, but it is still to be proved that the turbulent burner will maintain its efficiency indefinitely; and it must not be togotten that the use of this burner and the hard fuel, while economical as regards steam raising efficiency, may become uneconomical if the maintenance costs become too high.

Major David has of course put his finger on a point which undoubtedly operates against pulverised fuel firing in South Wales. It is not likely that the same enthusiasm can be raised in a district which is dependent on selling an expensively produced coal with high burning properties, when the system to be introduced will largely remove the extra value of that coal.

Mr. Haslam did not wish it to be inferred that his remarks regarding chimneys and draught regulation were meant to suggest that chimneys were out of date. Where used in conjunction with forced draught there is no doubt that a chimney has many advantages and uses; his remarks chiefly referred to those cases where the fact of there being a chimney creating a certain draught was considered sufficient for all purposes and the fact of controlling that draught was overlooked altogether.

With regard to the necessity of the drier he agreed that in some cases this drier is not necessary, and had mentioned that fact in the paper, but none the less he did not think that it would be at all safe to dispense with the drying on all occasions and with every type of burner.

Major David had referred to the fact that he has a combined plant actually in operation under his control, and asked for figures regarding this type of plant. Whilst Mr. Haslam agreed that such figures would be of great interest, he was afraid he had none available which could be taken as in any way reliable, but he had been assured that an efficiency approximating to 89% had been obtained on one of these plants in this country; possibly Major David would be able to give them some figures regarding his plant.

With regard to the pre-gasification installation on the Lancashire boilers, the following figures are available.

Record of Tests on Lancashire Boiler Fired with Pulverised Fuel by Pre-gasification System, conducted under working conditions.

Lancashire Boiler, 9ft. diameter, 24ft. long.
No Superheater or Economiser.
Total Heating Surface, 920 sq. feet.
Natural draught.
Fuel used—"Barnesley Bed" fine slack (waste from screens).

	DATE.	
	28*th July*, 1927	25*th Apr.*, 1928
Duration of test	6.66 hours	5 hours
Total coal fired per hour	854lb.	1243.2lb.
Total water evaporated	44,115lb.	44,620lb.
Evaporation per hour	6,630lb.	8,924lb.
Average gauge pressure	110.2lb. sq. in.	116lb. sq. in.
Evaporation per lb. of coal as fired (actual)	7.76lb.	7.18lb.
Average feed temperature ...	170 degs. F.	160 degs. F.
Evaporation per lb. of coal as fired (from and at)	8.42lb.	7.86lb.
Evaporation per sq. foot of heating surface per hour (from and at)	7.8lb.	9.7lb.
Average CO_2 content in flue gases	13.9%	14.2%
Nett calorific value of coal as fired per lb.	11,010 B.Th.U.	11,293 B.Th.U.
Percentage of ash in the fuel	11.83%	16.2%
Rating of boiler output in per cent. of designed output (hand firing, 7500 lb. hr.) ..	95%	119%
Power for pulverising	17 k.w.h. ton	17 k.w.h. ton
Nett over-all thermal efficiency of boiler	73.7%	76%

N.B.—In previous tests on the same boiler under identical conditions, but when hand-fired and fitted with steam-jet furnaces, the highest boiler efficiency obtained was 50%, using "washed singles."

In connection with these tests it will be noted that the initial plant was most inefficient and there is no doubt that an efficient plant with a superheater or an economiser would give very excellent results with this system.

Various questions have been asked as regards the cost of the combined system, but this obviously will not be very much more than for an ordinary travelling grate stoker. Figures given to him, Mr. Haslam, seemed to show that, taking as a standard a 100,000lb. boiler unit, the cost of the complete firing equipment on the combined system would be between 11% and 12% of the total cost, or say £4,000 out of the total of £36,000. In all probability the actual cost of a similar plant equipped with pulverised fuel firing would be from 10% to 12% higher than that figure, whereas with mechanical stokers the cost would be very much the same.

Judging from their contribution Messrs. Simon-Carves seemed to think that he, Mr. Haslam, was rather running down pulverised fuel and advocating mechanical stokers; such was certainly not at all the case: he had not the slightest interest in either one or the other, in fact all the claims which are made for pulverised fuel plants in this criticism were put forward in the paper as advantages for that plant.

Mr. Haslam said, however, that in Simon-Carves contribution certain points which might have the effect of reducing the high claims they make were omitted; for example, the cost of drying. It appeared to Mr. Haslam that if it was going to be necessary to have an expensive drying plant and a wastage of heat to dry the coal that would introduce a severe handicap. That was why he was very interested to hear Major David say that he is connected with a plant where the coal is supplied direct to the burner without a drier even though the coal contained approximately 15% of moisture. That appeared to be a great step forward, as the sooner the drier can be dispensed with the better for efficiency.

When comparing these various figures of efficiency it is not always clear whether the power that is taken for the pulveriser plant and the drier is debited to the efficiency of the boiler. Of course it should be. In the case of mechanical stokers the steam generated in the boiler is generally used so that it is taken into account, but in the case of pulveriser plant a large amount of electrical power is used and when taking tests that figure was apparently often ignored.

Messrs. Simon-Carves questioned the efficiencies given in the paper and quoted some very high figures. Of course they qualified this statement afterwards by stating that it was on test and further, that a high efficiency obtained on test is not always economical. Mr. Haslam maintained that his own figures were fairly reasonable and represented normal running of the plant in question. Possibly it was because he had given a higher efficiency for a stoker plant than a pulverised fuel plant that Simon-Carves had questioned the figures at all.

Messrs. Simon-Carves also take up strongly the question of the fuel, but Mr. Haslam did not see any need to depart from the attitude he had previously taken up and the replies made to previous speakers. Certainly it was not correct to say that satisfactory results have not been obtained from firing anthracite duff on mechanical stokers: a very short journey from the colliery where Simon-Carves are putting up their pulverised fuel plant would show them a mechanical stoker which had been working for many years with perfect success and good efficiency on firing anthracite duff. Also the statement they made that a mechanical stoker plant installed to burn one type of coal would give very bad results should the class of fuel be changed appeared to be extraordinary; most engineers who have any experience of the operation of mechanical stokers would find it just as easy to accommodate their conditions to the new fuel as in the case of a pulverised fuel plant. He was especially glad to note the last line of Messrs. Simon-Carves communication as this appeared to sum up the whole matter. It is almost impossible to lay down any hard and fast rules as local conditions must come in, but it can be put down broadly that there are very few fuels which can be burnt on pulverised fuel plants which cannot be burnt on chain grate stoker installations.

Mr. C. F. FREEBORN, proposing a vote of thanks to Mr. Haslam, referred to his paper as one which contained a tremendous fund of information and which would be a valuable asset to the Proceedings.

MAJOR E. IVOR DAVID seconded the vote of thanks, which was warmly carried.

WEST OF SCOTLAND BRANCH.

(*Meeting held 16th January*, 1929).

Ⓟ Electrical Equipment and Its Operation in Mining Work.

JAMES COWAN.

The deciding factors in the choice of the system to be employed in a colliery are chiefly dependent upon local conditions. The systems in general use in collier-are three-phase alternating current (insulated and earthed neutral), and direct current (two wire and concentric). If a new mine is being planned, and it is decided to instal electrical power plant, A.C. three-phase is invariably chosen. For this reason, if for no other, this paper will deal principally with alternating current work.

The A.C. system has many advantages over D.C. systems. Its maintenance costs are lower, its reliability is higher, and it is much easier to manufacture flameproof A.C. motors and gear. Perhaps its chief advantage, however, over D.C., especially where conditions of a fiery nature may be encountered, lies in the fact that with the same current it requires a much higher A.C. pressure before ignition could be possible.

Should it be intended that the colliery will have extensive workings the distribution of energy will form a very important point. Energy sent for a long distance underground must of necessity have a high pressure so that the cable sizes may be kept down and the voltage drop kept at a minimum.

One large colliery company transmits energy at 3300 volts three-phase, along the main haulage ways to a point at the entrance to the various sections, where the energy is then transformed down to 500 volts suitable for haulers, coal-cutters, etc. In the transforming sub-stations, the H.T. switchgear and L.T. switchgear are respectively standardised. Both types of gear, although supplied by different manufacturers, are equipped with isolators for each individual switch. A leakage indicator on the L.T. side is of much assistance in anticipating and localising faults. The transformers are fitted with wheels on the under-carriage of the tanks, of the same gauge as the colliery tram road. The utility of the three single-phase transformers in this case is obvious for large transformers, replacements being possible on site.

Due to developments in a section it is sometimes necessary to have a L.T. sub-station inbye, and the installation is so arranged that the station possesses a main switch controlling the bank of switches, and the cable for each section is supplied from a separate switch. While this method may increase the initial cost of gear, considerable savings are effected in maintenance.

In a modern A.C. colliery lay-out such as this where new machinery has been installed, the motors driving the respective units have been carefully selected so that they may operate at or near full load as far as may be possible.

When dealing with a colliery which has been in operation for a number of years, however, it is frequently found that there are motors working at 50% to 75% of their full load output, and since the power factor of an induction motor of fairly high speed may vary from 0.015 to 0.85 from no-load to full load, the result obtained where a large number of motors are in operation can be imagined.

The Disadvantages of Low Power Factor.

This effect is more easily seen as motor after motor is added to the system, for the low power factor tends to become still lower. A system possessing low power factor conditions is uneconomical, because the necessary current to supply the load demand is greater than would be required under unity power factor conditions. It means cables of increased cross-sectional area and the equipment in general requires to be larger to deal with the greater currents.

Fig. 1 gives a representation of this. If OI represents the current, to a certain scale, taken by the system at unity power factor, then OI_2 represents the current to the same scale taken by the same system if the power factor is reduced to 0.7.

Suppose OI = 300 amps.,

Then OI_2 = 300/0.7 = 428.57 amps.

So that if the power factor of the system is 0.7 the cables, switchgear, etc., must be of sufficient dimensions to deal with the greater current. The heat experienced in the cables and apparatus varies as the square of the current flowing.

What is the cause of a low power factor? This question is frequently asked. To consider this it would be necessary to go back to fundamentals.

It is known that a current flowing in a winding produces a magnetic field, and that the magnitude and direction of the field depends on the magnitude and direction of the current. An A.C. current will therefore produce a rapidly changing field. With every variation in the value of the current, there is a change in the number of magnetic lines passing through the winding. These magnetic lines cut the conductors of the winding, producing an E.M.F. which is sometimes termed the "Back" or "Counter" E.M.F. due to self-induction.

The characteristic of this E.M.F. is that it opposes at every instant the current which produces it. For instance, if a current is started in a winding, this E.M.F. opposes it, and tends to keep it from growing in value, and if the current ceases to flow, the E.M.F. tends to maintain the correct flow.

The value of this E.M.F. = $2\pi fLI$

where f = the frequency of supply in cycles per second.

L = the co-efficient of self-induction in henries

I = the current in amperes.

Now, the value L is greater for apparatus containing coils or windings, more especially those with iron in their construction, as compared with straight conductors.

An E.M.F. to supply a circuit containing iron cored coils, such as brake magnets, must be of such a value that it will overcome resistance and inductive reactance. A brake magnet coil, although essentially an inductive piece of apparatus, possesses a winding having resistance. The supply E..M.F. therefore must consist of two components, termed respectively a resistance component Er, and an inductive component Ex.

These components are at 90 deg. to each other as shown in Fig. 2, and the required supply E.M.F. is as represented by E. The following case is given to illustrate this.

The resistance component of the supply pressure is 45 volts, and the inductive component is 60 volts. Obtain the supply pressure:

$$E^2 = Er^2 + Ex^2 \qquad \therefore E = \sqrt{Er^2 + Ex^2}$$

$$\therefore E = \sqrt{45^2 + 60^2}$$

$\therefore E = \sqrt{5625}$

$\therefore E = 75$ volts.

The power factor in this case

$$= \text{Cos}\frac{ER}{E} = \frac{45}{75} = 0.6$$

Now, the current (which is always in phase with Er) lags behind E by the angle θ. The cosine of this angle has been termed the power factor of the system. So that the larger the angle θ the lower the power factor, and the angle in this case is caused by the presence of the inductive reactance, due to the use of iron cored windings.

It will be fairly obvious, then, that if the power factor has to be improved in this particular case Ex must be decreased (Fig. 3) or Er increased (Fig. 4). In both cases is the angle θ less, and the power factor better. The only way in which the value of Ex can apparently be cut down is to oppose its evil effects by another reactive component, namely, a capacity reactive component, Ek (Fig. 5). The second method of improving the power factor, that of increasing Er, has not much to commend it since the presence of a resistance represents a large loss (I^2R), although the insertion of a resistance in the rotor circuit of an induction motor is the means whereby a fairly good starting torque is attained.

Stated briefly, the inductive effect in a circuit causes the current to lag behind the supply E.M.F., while the capacity effect causes the current to lead the supply pressure. So that by carefully adjusting the reactive values of the circuit it is possible to obtain good conditions.

Transformers and induction motors are two of the principal causes of low power factor in mines.

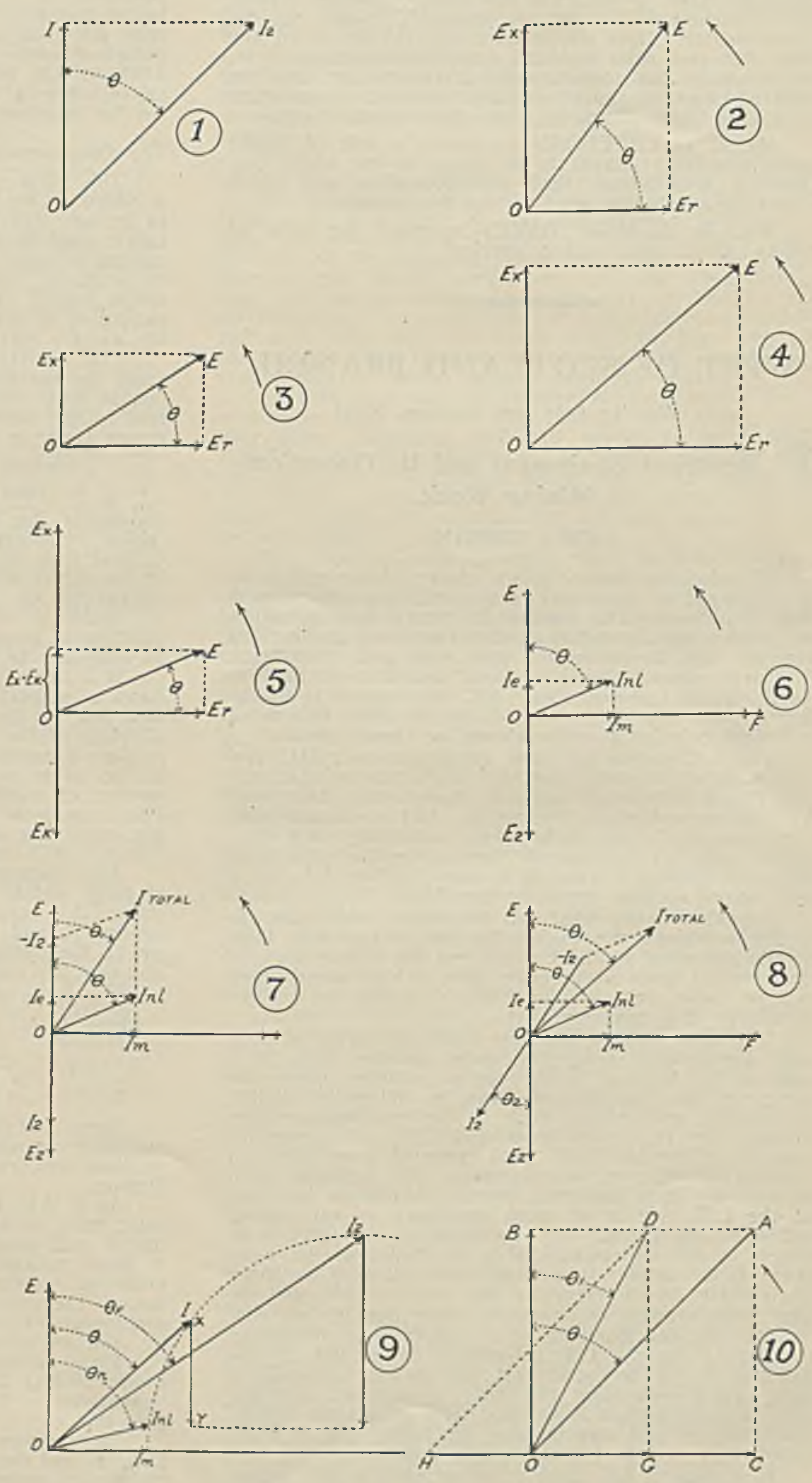
A transformer may be installed with the idea of its supplying ultimately a fairly large area, but until this time arrives the transformer may be working at only 0.5 to 0.75 of full load, and if the theory of the transformer is slightly considered, it will be observed that this may assist the furtherance of low power factor. A transformer with no-load on the secondary side still absorbs power from the supply on the primary side. This primary power is therefore all spent on magnetising the transformer core. The magnetising current is represented by OInl (Fig. 6).

The vectors are given of course as single phase in construction, as three phases are too complicated to be shown clearly.

OE = the applied pressure.

O Ie = the energy or useful component of the current.

O Im = the magnetising or useless component of the current.



Figs. 1—10.

The power factor of the transformer at no-load is shown by the cosine of the angle θ. The power factor is very low, since the angle is large. The current drawn from the supply, to a scale = O In1, and is the current as read by an ammeter. The current usefully employed is represented to the same scale by O Ie.

When a lighting load is placed on the secondary winding the angle θ is decreased, and the power factor is raised (Fig. 7).

OI_2 = the secondary load current,

$O\text{-}I_2$ = the primary current necessary to balance the secondary current.

The lighting load is of course the best type of load from a power factor point of view. When a load such as induction motors is placed on the secondary side the angle θ is larger and the power factor lower than it is for a similar lighting load (Fig. 8).

Where a colliery has extensive surface plant it may have a fairly high winter-time lighting load, and on many occasions one finds the transformer operating 24 hours per day. The remedy, of course, is to have a transformer of low K.V.A., and therefore low no-load losses and a transformer of the required K.V.A. for the maximum loads with suitable change-over switching arrangements.

The Induction Motor.

The characteristics of the induction motor are similar to the transformer, its power factor at no load being very low (Fig. 9). The vector diagram is not to scale.

In Im = no-load losses,
O I = current at maximum P.F. value,
OI_2 = current taken at full load,
θ = angle at maximum power factor,
θn = angle at no-load,
θf = angle at full load.

It will be observed that the maximum power factor does not occur when the motor is developing its full load output, but at a slightly less load (XY) when the current is OI. The value of the cosine of the angle = the power factor.

With characteristics such as these it becomes necessary, unless in emergency, or in cases where efficiency must be sacrificed for lack of spares, that the motor should be entirely suited to its work.

Power Factor Correction.

In a colliery where such conditions may exist as transformers and motors operating at half or three-quarter loads, it would be necessary to introduce some form of capacity load, as was represented in Fig. 5, and this more especially if the power be purchased from a Public Supply Authority. To obtain the best results the capacity effect must be placed at the source of the low power factor. Therefore, a condenser would require to be placed at each offending motor, but to do this in the majority of collieries would mean a heavy expenditure So it is becoming the practice to instal the capacity effect inbye at the intensity centre of the load.

Static condensers form a convenient method of correction as with them no attendant is required, which forms a considerable wages item 24 hours per day where rotating machinery is employed. Static condensers are as reliable now-a-days as transformers, but one of their disadvantages is that they are designed for a fixed load, so that where a fluctuating load exists the power factor may vary between 0.85 lag and 0.85 lead.

Suppose the load in a colliery consists of 1000 K.V.A. at 3300 volts 50 cycles, and the power factor is indicated to be 0.7 lag, and it is found that 10% or so will be required in load increase in a short time. The cable system, however, has reached its economical limit. To supply this extra load demand, it will be necessary either to increase the cable sizes or raise the power factor of the system. It is decided therefore to increase the power factor from 0.7 to 0.9 and allow a margin for the future.

Referring to Fig. 10, to find the useful power (OB) at cos 0.7 = K.V.A. × cos θ
= 1000 × 0.7
= 700 K.W.

idle power (OC) = K.V.A. × sin 45.5°
= 1000 × 0.713
= 713 K.V.A.
θ = 45.5°
θ_1 = 25.5°

Still referring to Fig. 10, by decreasing the angle from 45.5° to 25.8° it will be observed that the K.V.A. required from the mains has been decreased from 1000 K.V.A. to

$$\frac{700}{0.9} = 777.7 \text{ K.V.A.}$$

OD = 777.7 K.V.A.

OG the idle power = 777.7 × sin 25.8°
= 777.7 × 0.435
= 338 K.V.A.

The idle loss has been cut down from 713 K.V.A. to 338 K.V.A. and the difference = 375 K.V.A., and this is the amount of K.V.A. which will require to be opposed by the capacity effect.

The capacity of a static condenser to accomplish this would be as follows:—

$$\text{K.V.A.} = \frac{E \times I}{1000}, \text{ but } I = 2\pi fK \times 10^{-6} E$$

$$= \frac{E \times E \times 2\pi fK}{1000 \times 10^6}$$

$$= \frac{E^2 \times 2\pi fK}{10^9}$$

$$K \text{ in microfarads} = \frac{\text{K.V.A.} \times 10^9}{2\pi f \times E^2}$$

$$= \frac{375 \times 10^9}{6.28 \times 50 \times 3300^2}$$

$$= 109 \text{ mfds.}$$

OH on Fig. 10 represents the capacity K.V.A. necessary to increase power factor from 0.7 to 0.9.

Protection of Apparatus.

Much has been done recently in regard to the adequate protection of motors, but in many of the older collieries of a non-fiery nature circuits are largely dependent upon fuses.

Fuses offer little protection for a machine, and where these still exist, the expense of conversion must be the deciding point. A three-phase motor, for instance, controlled by a fuse per phase, occasionally is made to run single phase due to a fuse gone. This is not usually discovered until an attempt is made to re-start the motor, or until some damage has developed.

Coal cutter gate-end fuse boxes are too accessible, and it should not be possible to adjust the cut-out values except by opening a padlock or similar arrangement. This is hardly possible with fuses, and much must be left to the honesty of the coal cutting machineman. The obvious requirement is a gate-end circuit breaker which must be re-set, but cannot be adjusted except by a competent person.

One type of circuit breaker called to mind possessed a "push" for re-setting purposes; a block of wood, however, forced between push and skid, saved the machinemen from coming out to re-set after an overload.

Progressive mining companies, however, are now demanding apparatus which will protect the equipment in every way, increasing the life, maintaining a high efficiency and minimising breakdowns, so that although a little more may be expended in initial cost, the whole installation proves to have been built on a solid foundation.

Discussion.

Mr. HOLMES.—In the early part of the paper it is stated that in one colliery in particular, three-phase current is carried in the haulage ways at 3300 volts: would Mr. Cowan say what type of cable is used in that case, whether it is paper insulated or bitumen insulated.

Within recent years the subject of power factor has come very much to the fore, and it is very much better understood now by engineers in general; no doubt a good deal of cable trouble has possibly been caused through overloading owing to very low power factors; the improvements in that are certainly not only a relief to the generating side but also to the distribution side of any system.

In regard to the induction motor, Mr. Holmes was rather surprised to learn that the induction motor operated at the best power factor at something below the rated full load: he had expected that the best power factor would be given by an induction motor when it was rather overloaded than otherwise. He would like Mr. Cowan to explain that point again.

Mr. Holmes said he noticed that the author had made the condenser the primary piece of apparatus for improving the power factor and possibly he was right in that respect. There is no doubt a good many more condensers are put down for the improvement of power factor than any other type of apparatus, but at the same time Mr. Holmes thought it should not be overlooked that the asynchronous motor also makes a very good form of power factor improver, especially if there is a continuous load for it. The question of condensers had to be carefully considered, or otherwise a condenser may be used which is too large and which would really impose a load on the system. He knew of one case where a condenser was put down for improving the power factor, but when the demand went over to a very light load, the actual load registered on the meter came out rather heavier with the condenser than the original load itself. It would have been better if the power factor had not been artificially raised so high.

Mr. COWAN.—In regard to the case referred to in the paper, it is one of the biggest colliery companies in Fifeshire, and they practically standardised every colliery so far as distribution underground was concerned. The cables to the entrance to the section are three core vulcanised bitumen cables, double armoured.

Mr. HOLMES having given particular reasons why he would prefer paper-insulated cables for a service of that kind.

Mr. STEVENSON said that though not many of them had had experience of 3300 volts underground, he himself thought that V.B. cables were quite as good at 3300 volts as paper; the current carrying capacity did not really enter largely into the question because of the limitations imposed by the regulations. Except in the largest cables, the currents are easy for good V.B. to stand.

Continuing, Mr. Stevenson said he was interested in the diagram showing the termination of the 3300 volts system, and wondered why the colliery engineers had stopped at that distribution point with 3300 volts. Why did he not carry that on? Were there any 3300 volt motors actually working below ground?

With regard to the capacity that was put in, was that in 600 volt units in cascade or was it just in the form of one unit? He did not consider that that question of having a condenser in when the load comes off mattered very much, because the capacity is introduced to prevent the working load becoming excessive. It might be a good thing to have sufficient capacity to make the meter at light loads go the wrong way round!

Mr. COWAN.—In reply to the question regarding high tension motors, it was found that the system had been in operation for about seven years and, whether the age of the A.C. motors may have been slightly in favour of breakdowns, breakdowns did occur, chiefly after a stoppage at the week-end, in the return airway. The expenses incurred in high tension motors are apparently not worth the trouble. He had not mentioned motors of the high voltage order at all because he knew they were a disadvantage at 3300 volts in a mine. His chief idea in showing the distribution point was to keep down the weight of the cable, which was perhaps covered a distance of two miles underground. It was only in stationary apparatus, in cable work, or in a transformer that 3300 volts is advisable. That was his experience.

Mr. DIXON said the point about high tension motors underground is chiefly a question of size. In the cases of collieries with long roads and low pumping high horse powers are required that it is uneconomical to use low tension for the job at all. He knew of one or two pits where there is 3000 volts underground and no objection had been necessary, because it is only being used for big motors, and for big motors there must be proper conditions, housing, etc., generally near the pit bottom. Therefore he did not consider 3000 volts a good thing in-bye at all: that would mean getting down to small motors, in any event limited to 20 H.P. by the regulations. It is requisite not to exceed medium tension for anything at or near the coal face.

So far as cables are concerned, he would say that probably nine out of ten high tension underground cables are paper. He did not think it was usual to put in bitumen for that; and there again the question is that once they are in they are not often changed, because they serve big permanent units, pumps or large haulages and sometimes underground winders.

Mr. Dixon said that power factor was so much to the fore now-a-days that he was beginning to feel that the thing was getting a little bit too much stressed. It is all to the good but like all good things could easily be overdone. For instance, the question of putting in motors very close to their working load: there is really not very much in that because the modern motor is generally working at its maximum of efficiency and power factor probably somewhere round about three-quarter load. It is different now from what it was in the old days when more copper was put into machines. Another point to remember is that the power factor is very bad at the lower loads, but then the currents are very low and the actual currents transmitted idly are not in the proportions one might think from merely comparing power factors.

Mr. COWAN, in regard to the last speaker's remarks, suggested that some 50% to 75% of the collieries in Scotland were still working with very old types of motors. Some of the more progressive companies have scrapped most of their uneconomical motors, but the majority still retain very old machines. Their only remedy appeared to be to rectify the power factor. Modern motors are mostly of high power factor value and also maximum torque at starting, which the old motors do not possess.

Mr. ROGERSON.—The author mentions in connection with condensers for power factor correction that one of the disadvantages is that they are designed for a fixed load. Are not modern static condensers built in sections so that the capacity can be increased or reduced according to load? Another point that arises is, does it matter very much with a static condenser whether it is designed for a fixed load or not provided it is of ample capacity to meet the average load on the kilowatt basis of charge; that is, where it is a public supply charged on a kilowatt basis? Where such conditions may exist as transformers or motors operated at half or three-quarters full load it would be necessary to introduce some form of capacity load and this more especially when the power is purchased from a supply undertaking. Is it not just as essential to have some form of capacity load for private capacity just as much as for public capacity?

Mr. COWAN.—With regard to purchasing from a public supply authority, in one particular case provided that the power factor is 0.8 or higher, 5% rebate is allowed, and if it is 0.85 or higher, a further 5% is allowed; there is really no fixed value, so that an actual fine point of say 0.95 is not always to be aimed at provided there is a stipulated minimum of say 0.85, because the 10% rebate can be got. As regards the private supply, the words used in the paper are, "Especially where it is purchased from a public supply." The same principle holds good in a private installation. In fact, on a bigger scale, it is of more advantage because in a small concern such as a private supply, a small colliery or a colliery standing by itself, the very fact of an extra motor being added to a very small installation may cause a great amount of concern or anxiety. So fas as public supply is concerned, in one particular case, 10% is allowed for a power factor above 0.85, irrespective of the load. That tariff is for purchasing power at so much per unit, and so much per maximum demand.

Mr. DIXON.—Mr. Cowan has spoken of the size of the condenser and the rebate. The Clyde Valley system, which is of course in this area, gives a direct rebate from 0.8 or 0.85, depending on the size of the installation. The higher the power factor is taken the more rebate allowed. It is not just a flat 5% or 10%, so it pays to improve the power factor to as near unity as possible. But as payment is based on the average power factor, a smaller condenser can be put in than would otherwise be done. In the Midlands the charges are on K.V.A. of maximum demand, which means an aggregate for the power factor and the maximum, not the average; the result is the need of a condenser about 50% more than in this particular area. It would appear that all over the country it is necessary to consider closely the large supply companies' terms.

Mr. F. BECKETT, Branch Chairman, before asking the members to pass a vote of thanks to the author, said he was rather surprised at the condemnatory terms in which Mr. Cowan had referred to high tension motors. There are many collieries in the South where they try to get the load up so as to use a high tension motor They group their loading so as to avoid the use of small motors with low voltages with their necessary transformers. Mr. Beckett then expressed the thanks of the meeting to Mr. Cowan, who suitably responded.

WEST OF SCOTLAND BRANCH.

Ball and Roller Bearings for Mining Machinery

JAMES ANDERSON.

The beginning of a lecture is perhaps the most difficult point, and the subject before us now is so wide that it is very difficult to know where to begin. The subject is the application of ball and roller bearings to mining machinery generally. The first thing that occurs to one is the reason for fitting these. There are really two reasons. The first is to eliminate friction, and the second is to reduce, as far as possible, maintenance charges. Friction, in its proper place, is a very good friend to man. A certain philosopher has said that dirt is matter in the wrong place, and friction, in the right place, is a great help, but in the wrong place it is a great hindrance to all mechanical operations. Without friction it would be impossible to walk, or to retard mechanical forces, and therefore in brakes a friction lining is necessary. In bearings, however, friction is in the wrong place and should be eliminated so far as possible. It was very early realised in the world's history that rolling friction was very much less than sliding friction, but it was not until comparatively recently that rolling friction was used to replace sliding friction in bearings. Undoubtedly an oil film reduces friction to the lowest possible quantity, but the great difficulty is to maintain an efficient oil film between two surfaces when there is any heavy load imposed upon them. It is impossible to reduce friction to a quantity of nothing, but ball and roller bearings of correct design have been able to reduce the co-efficient of friction to a very small quantity, approximately 0.001.

To realise what this means it is necessary to compare the co-efficients of friction in a plain journal. These may be taken as follows:

(1) For a plain bearing without lubrication	0.25
(2) For a plain bearing with ordinary lubrication	0.07
(3) For a plain bearing with continuous lubrication	0.05
and ball or roller bearings as stated	0.001

When a plain bearing has been standing for some time the oil film gets squeezed out from between the journal and the bearing and the power required to start the machine is very much greater than that required to keep the machine in motion. This may be clearly seen by watching the ammeters of motors on a Monday morning when starting up, and comparing that reading with the reading after the machinery has been working for some time. That this excess is not all due to inertia may be proved by stopping the machinery and re-starting it, when it will be found that the starting peak is not nearly so pronounced as when the machinery has been idle for some hours. With ball bearing equipment that starting load is very little greater than the running load. A very important matter where current is paid for on a maximum demand basis.

One of the earliest forms of a ball bearing, as applied to rotating journals, was the cup-and-cone type, which is still employed in the ordinary pedal bicycle. There are many serious objections to this form of ball bearing, the principal one being that it is not possible to get correct rolling motion under all circumstances, and where correct rolling motion is not possible sliding friction is set up. Under light loading conditions this amount of sliding friction in the cup-and-cone type of bearing is hardly noticeable, but where heavily loaded bearings are used it becomes a very serious item and causes early failure of the bearing.

The first successful type of ball bearing was a single row bearing in which the balls were introduced between the inner and outer races by means of a filling slot. This type of bearing has given excellent service, but there is a serious objection to this design owing to the fact that the races are not continuous. This lack of continuity in the races may cause distortion and consequently overloading and subsequent failure. It does also affect the thrust carrying capacity of the bearing very materially, as the balls may be forced into the slot under axial load, the edges of the filling slot chip off, and these chips will eventually cause the balls to fail and probably failure of the race will ensue at the same time. To overcome this difficulty a Swedish engineer, Dr. Sven Winquist, designed the well-known Skefco self-aligning ball bearing. In this type of bearing there is no filling slot. The balls run on a conical track, that is, the centre line of the balls at right angles to the point of contact with the inner and outer races, passes through the centre of the shaft at some point outside the race. It is capable of taking end thrust in either direction. This bearing has given most exceptional service in numerous applications, and it is safe to say that the majority of line-shafting ball bearings are of this type. It has been found in practice that where ball bearings have been substituted for plain bearings on line-shafting that a saving in power of 15% of the horse power is effected as a general rule, and in some cases it has been as great as 30%. The result of a number of tests show:

	£	s.	d.
Per plain bearing used 1770 K.W.H. power, costing	9	4	4
Per SKF. bearing used 1345 K.W.H. power, costing	7	0	1
Saving per SKF. bearing, 425 K.W.H.	£2	4	3
Plain bearings used lubricant per bearing	0	7	0
SKF. bearings used lubricant per bearing	0	0	8
Saving	£0	6	4

It was determined from time sheets that the ball bearings saved 7s. 0d. per year in maintenance or the total saving per year per bearing by substituting the ball bearings for plain bearings was £2 17s. 7d.

The next development was a deep groove single row ball bearing in which the filling slot was eliminated. This bearing has been found to give wonderful service as a double purpose bearing, that is, carrying both radial and axial load.

There are three types of roller bearings. One is a cylindrical roller bearing, in which the length of the roller is equal to the diameter. The earlier types of roller bearings had a length considerably greater than the diameter, and many of these types ran, and still do run, directly on the shaft without any inner race. This practice cannot be recommended, as the edge of the roller is apt to bite into the shaft and barrel it. When this barrelling takes place, owing to the reduction in area at each end of where the rollers run, it is quite a common occurrence for the shaft to snap off at this point, whereas if a short roller bearing is employed, having a properly designed inner race, hardened to carry the rollers, this source of trouble is eliminated.

It cannot be too strongly emphasised that split roller bearings, while exceptionally convenient from the point of view of assembly, are a delusion and a snare from a service point of view. No matter how carefully an inner and outer race in halves is assembled and ground, when taken apart and re-assembled there is always a slight lip against which the rollers impinge. This lip chips off and causes failure of the races and rollers. To overcome this certain makers of roller bearings have designed the break in the races to run at an angle to the axis of the shaft, but this does not overcome the difficulty, the only solution being to make the inner and outer races absolutely continuous without a break of any sort.

Taper roller bearings have been evolved to carry both radial and axial load, as of course a parallel roller bearing cannot take axial load and requires some other means than the bearing itself for locating the shaft to prevent end movement. The taper roller bearing is designed to roll upon a cone, the point of which is on the axis of the shaft, and both the inner and outer race contours are developed from this point. The taper roller bearing has many good qualities, but it is not a bearing to be used universally. Its greatest drawback is that it is adjustable, and unless careful adjustment is made the bearing may be either too slack and allow axial movement of the shaft, or may be bound up so tightly that initial load is set up in the bearing. This, of course, means that the bearing cannot take its normal working load as it already starts with a serious load imposed upon it, and if the factor of safety is too low an early failure of the bearing may be looked for under these circumstances. A further point to be noted is that it requires two bearings to locate a shaft as of course while the bearing will take thrust in one direction, thrust in the other tends to separate the outer race from the rollers.

The self-aligning roller bearing has two rows of rollers, and again in this design the centre of the rollers form a cone, the point of which lies on the axis of the shaft, and in consequence true rolling motion of the rollers is obtained. If all the forces acting upon the rollers are taken into account it will be found that there is a small resultant force tending to keep the rollers up against the inner lip of the bearing which forms a guiding track to maintain proper rolling motion of these rollers. Owing to the shape of the outer race and the shape of the rollers themselves it is possible to obtain the self-aligning features which have proved so satisfactory in the Skefco self-aligning ball bearing, with this added advantage, that the roller bearing is able to carry a very much greater load for a given shaft diameter than a ball bearing can. It will be noticed also that this bearing is equivalent to two taper roller bearings mounted back to back and so may take end thrust in either direction. That is, this design has all the features necessary for a universal bearing where heavy loads are to be carried.

The foregoing states very briefly the various types of ball and roller bearings which are at present in use, with their relative advantages and disadvantages.

It might be advisable here to emphasise one or two facts regarding the method of fitting and the lubrication of anti-friction bearings. Regarding the fitting of these, the inner race should be a tapping fit on the shaft and the outer race should be a push fit in the housing. Where two or more bearings are mounted on a shaft, all the inner races should be locked up securely on the shaft, preferably against shoulders. The outer races should not be bound up in the housings with the exception of one race which is known as the locating bearing, and this bearing should have shoulders in the housing to hold it securely in position to prevent axial movement. All the other bearings should have a small clearance to permit of expansion or contraction of the shaft and housings or any slight inaccuracies in machining.

The utmost care should be exercised to ensure that ball and roller bearings are fitted in their place without any chance of dirt obtaining access to the bearings. When these bearings leave the makers' works they have been immersed in oil and covered with a grease-proof and waterproof paper to exclude moisture and dirt. There is no more fruitful source of failure of ball and roller bearings than the removing of these bearings from their packing and putting them upon a bench, or to handle them, as the acid which exudes from the human hand very soon destroys their highly polished surfaces. The moisture of the atmosphere readily attacks them, and owing to the very fine clearance between the balls and the races a minute particle of foreign matter, such as grit or metal filling, indents the race, destroys the surfaces, and causes early failure. Extreme care and scrupulous cleanliness are the two most important points to remember in connection with the handling and fitting of anti-friction bearings.

Having fitted the bearings, a good quality of neutral grease or, under certain circumstances, a neutral mineral oil, should be employed for lubricating. A vegetable or animal oil contains certain acids which would quickly attack and destroy the surfaces of the bearings, and under no circumstances should such an oil or grease be employed. A graphite grease, or an oil containing graphite, is also a most dangerous lubricant as the small particles of graphite pack on the balls or the rollers and destroy the fine clearance between the balls and the races the result being excessive overload and subsequent failure.

It may appear a matter of little importance, but really it is on the contrary exceedingly important that a tin of grease when opened should not be left lying about without its lid. If this is permitted grit is sure to find its way into the grease and eventually into the bearings of the machine which is next lubricated. When dirt enters the housing, life flies out of the bearings; this of course is true of all bearings, but most especially of ball and roller bearings. Whilst anti-friction bearings are cheap—although not low in price—they demand extreme care in handling and will repay the extra care taken in ensuring perfect cleanliness.

Having given a brief resume of the design and care of these bearings attention may now be directed to several applications. The first thing that strikes an outsider who goes to a colliery is the pit head frame, and for this application it is necessary to use the heaviest and most reliable type of bearing. The recommendation put forward for the pit head sheave is the self-aligning roller bearing, and it is desirable here to point out that one self-aligning bearing only is unstable, but in this case of course there are two bearings and consequent stability is obtained. The advantage to be obtained by fitting roller bearings in this position is that lubrication would only require to be attended to once in six months, and then the quantity of lubricant is so little that it is practically negligible. There is no fear of hot bearings, nor would any appreciable wear occur.

Connected with the pit head gear there is the winding engine, and it depends upon the design of this engine whether anti-friction bearings could be successfully fitted. Under certain circumstances it is possible to fit the main bearings of these engines on self-aligning roller bearings, and in certain designs it is possible to fit the big ends of the connecting rods. A very successful big end application has been carried out on a crank-pin of a 500 H.P. steam engine which was fitted with self-aligning roller bearings in May, 1921. When fitted with plain bearings the rank-pin bearings gave continual trouble. There were frequent breakdowns and stoppages due to the base of the engine being on an unstable foundation. Since this roller bearing application was tried there has been an entire absence of these troubles. A remarkable economy in lubrication has been obtained; 1½ buckets of oil were used per day with plain bearings and this has been cut down to one pint of oil per week. The speed of the engine has also been increased from 64 r.p.m. to 70 r.p.m., and the engine has been able to be overloaded by 50%, making a total of 750 H.P. This engine is in a textile mill, but the conditions are so similar to those met with in winding engines that the application is included here as a matter of interest.

The application of roller bearings to the winding drum presents no difficulties and one would expect to find, and does find, the following advantages—reduced friction, reduced oil consumption, and freedom from attention and overhaul.

For rotary converters it has been found that self-aligning roller bearings at one end to locate the shaft, and a cylindrical roller bearing at the other end, to allow for expansion and contraction within the bearing itself, have given exceptionally good results; in this district there is a rotary converter which has been running now for a considerable period, trouble free, with this bearing selection.

For dynamos and motors, ball and roller bearings have been so successful that the majority of good manufacturers now fit these as standard in their machines. Apart from economy in lubrication, and power absorbed in bearings, these anti-frictional applications have this added advantage that the air gap in either the dynamo or the motor remains constant and there is no chance of the windings coming down on the pole pieces. Electric winding machines are of course merely an application of motors to a particular purpose.

Electric winding engines and haulage gears are heavy applications in which, probably in most cases, it would be necessary to fit self-aligning roller bearings and cylindrical roller bearings to give a reasonable life. The primary object in fitting anti-friction bearings to these machines would be freedom from heating, and saving in lubrication, as well as their durability, thus entirely eliminating the necessity for stripping the bearings and making certain that the gears, when replaced, were properly meshed. Should it be necessary at any time to remove a bearing one can re-assemble the machine with absolute confidence that the gears will go into their place properly without any misalignment.

For haulage gears it is recommended that two single row bearings be fitted in the mid-way rollers. In this case of course the spindle would be dead and the roller would revolve on the spindle. Suitable single row bearings can be supplied and fitted against shoulders on the shaft, of a size depending upon the diameter of the spindle. As of course there is no wear on the bearings themselves, any wear which does take place would be between the rope and the barrel of the roller, and the design is such that this barrel, when worn, can be easily renewed at a very small expenditure both of time and money.

In South Africa, in the mines there, a somewhat different type of roller is employed, and while the bearings are also of the single row construction there is a renewable tread in the centre. The ends of the roller are made conical, and the outside of the roller butts closely up to a shroud piece which carries the spindle, the idea being that if the rope comes off it can be easily put into place again over the dished end of the shroud piece.

At a number of collieries aerial rope-ways have been installed, and a very suitable selection of bearings for this application is two single row cylindrical roller bearings, and one single row ball bearing to act as a location bearing.

In all these three applications protection is of primary importance, that is, it is necessary to retain the lubricant and to exclude dirt and moisture. In the first arrangement the labyrinth is employed, whereas in the other two arrangements a felt washer is used. Both these types of protection have their individual uses, and a great deal depends upon the location in which the mechanism operates, and the conditions under which it is operating, as to which type of protection is the more suitable. Naturally, ball bearing manufacturers have given great attention to this subject of protection, and it is a great mistake to think that some of these schemes suggested by them are too elaborate. These elaborations have very often been evolved through a system of trial and error.

It is not too much to say that without the application of ball and roller bearings the modern coal cutter would not be the efficient machine which it is, nor would it be possible to design a machine with plain bearings to go into such small space as can be done where anti-friction bearings are employed. The bearings which have been selected for coal cutters are usually the result of close collaboration between the manufacturer of the coal cutter and the manufacturer of ball and roller bearings.

The number of coal cutters in successful operation and their freedom from breakdown under the strenuous conditions under which they operate should be convincing proof if that were needed, of the reliability of the modern ball and roller bearing when properly installed and adequately protected.

With regard to pit tubs, from the very earliest day up to within a very few years ago the design and construction was practically the same, showing no real advancement. This part of the machinery for a pit was so crude that anything was thought good enough. The wheels were usually forced on to the axle, and probably rivetted over. The axle ran in a plain bearing or cod-piece, and the friction between the axle and this bearing was very high. Some lubrication was necessary, and as you are aware, several means have been adopted. These were generally of a more or less automatic nature. Some designs consisted of a large sprocket wheel which dipped into a trough of grease, and as the tub passed o er the greaser the axle caught the sprockets of the wheel, a certain amount of grease being deposited at or about the bearing, and as the wheel rotated a fresh cog was presented to the next tub with a quantity of grease between the teeth. Naturally, this machine was uncertain in its application of grease, and in many cases scattered the grease about everywhere except where it was wanted—in the bearing. An oil pump was also tried, the plunger being forced up as the wheel of the tub passed over a pedal. This pump squirted a quantity of oil on to the axle, if the axle was lucky. None of these schemes were certain, and all of them were wasteful. To overcome these and other troubles, the Rowbotham type of wheel was evolved, but here again troubles could arise through the wear of the bushes permitting the oil to escape, and whilst this design was a great improvement on the old plain bearing, it was not an efficient solution of the difficulty.

After a great deal of experimenting a type of roller bearing pit tub wheel has been evolved which may fairly be claimed to have solved all the difficulties. There are two principal schemes. The first one consists of a fixed axles and wheels fitted with two taper roller bearings revolving free upon the axle. The advantage of the taper roller bearing in this application is that the bearing has been found remarkably robust and able to withstand those heavy shocks to which a pit tub is subjected. It also is a good locating bearing, and has a certain amount of adjustment which permits of any slight wear which may take place being allowed for and taken up. Great care, however, must be exercised in making any adjustments of this nature, as nothing is more easily done than to put initial load on the bearings by tightening them up to too great an extent. As was pointed out previously when discussing various designs of roller bearings. It is necessary in this application to make absolutely sure that thorough protection is provided for the bearings to exclude both water and grit and to retain the lubricant. The alternative design is to have a cast steel hollow axle and to have the wheels secured to the axle, and to have the bearings housed inside the outer cast steel tube. In this design two bearings per axle are employed and again these are of the taper roller type. In both of these schemes it is not necessary to renew the lubricant more often than once in six months, and as the lubricant is supplied to the bearings it is absolutely certain that this lubricant goes to the right place.

The fitting of anti-friction bearings to tubs has achieved the following results. In the first place, the power required to operate the tub is reduced. They are much more easily man-handled, and consequently it is possible to fit a larger tub to collieries and still have them easily man-handled. The cost of lubrication is reduced to a minimum, and the cost of renewals of the bearings is negligible. All of these statements may seem to be too optimistic, but the following figures may prove these statements and should be of interest.

To begin with, it is generally found that the cost of lubricant per ton of coal raised is in the neighbourhood of 0.35 of a penny per ton. In some cases it may be as high as 0.5 of a penny. Where anti-friction bearing tubs have been in use the cost of lubricant has been brought down to 0.02 of a penny per ton of coal raised. With regard to the saving in power, the starting effort of a 9 cwt. tub on the level with plain bearings is 29lbs., whereas an SKF. equipped pit tub is 12lbs. When the tubs travel at two miles per hour the pull of the plain bearing tub is 22lbs., and the SKF. equipped tub, 6lbs. To compare this with what follows, reducing the pull to load ratio, it will be found that these are for starting: for plain bearings as 1 is to 35, and ball bearings as 1 is to 84. The draw-bar pull ratios being: 1 to 46 and 1 to 84 respectively.

In Belgium, where the first pit tubs in that country were installed towards the middle of 1922, the sales amount to about 8,000 pit tub equipments a year, and it is interesting to note that in one colliery there are approximately 15,000 pit tubs in use; only 42 bearings have been renewed since the first installation at the beginning of 1924, and a number of these bearings have had to be renewed in consequence of accidents such as collisions, etc. Another colliery, in which there are 2,000 tubs, states that since these were installed at the beginning of 1922 they have not had to replace 1% of the bearings.

The first question which arises in the mind of a practical man is the question of cost, and whilst it is admitted that the cost of a roller bearing equipped tub of the smaller size is comparatively great, still this capital may be justified by the saving which is effected in lubrication; and further, where tubs of considerable size are employed, that is, where the capacity is in the neighbourhood of 2 tons, the extra cost of roller bearings is hardly noticeable, and the saving is so great that there is no question as to the desirability of fitting roller bearings and as to the financial benefits which will accrue from this application.

Mr. John Wilson, in the paper on inquiry into the Resistance of Traction in Mine Tubs, Transactions of Institute of M.E., 1921-22, and acticle in the "Iron and Coal Trade Review" of 16th June, 1922, details a number of experiments which he carried out in connection with this question of pit tub efficiency, and gives the results of a number of tests which he conducted. These results, as stated by him, show the co-efficient of friction of the tubs, but it must be clearly understood that these results are not the co-efficient of friction between the bearings and the journal, but total resistance to movement of the pit tub, and include several frictions such as wheel and rail friction. Two tubs were used for these experiments. One was a wooden tub with a tare of about $3\frac{1}{2}$ cwts. The axle diameter was $1\frac{1}{2}$in., the wheel diameter 10in., and the wheel base 18in. The other was a steel tub weighing $4\frac{1}{2}$ cwts., the axle being 2in. diameter, wheels 12in. diameter, and wheel base 17in. In both cases the rail gauge was 2ft. With the ordinary plain bearings, which were of the pedestal type, the wooden tub gave the following results:

The ratio of power to load on the tub starting from rest and attaining a speed of about $1\frac{3}{4}$ miles per hour was

With poor lubrication .... 1 to 30
With average „ .... 1 to 54
With good „ .... 1 to 68

and the steel tub gave the following results:

Plain bearings (open) .... 1 to 58
Climax bearings .... 1 to 60
SKF. bearings .... 1 to 135

Tests were also made by four collieries with standard equipment, and the results were found to be as follows:—

Type of Bearing.	Dia. of Wheel.	Dia. of Axle.	Lubrication	Co-efficient of Friction.
Plain	Edge Wheels 12"	$1\frac{1}{4}$"	Hand	1 — 20
Plain	9"	$1\frac{1}{8}$"	Hand	1 — 33
Plain	10"	$1\frac{1}{4}$"	Auto. Greasers	1 — 35
Rowbotham ...	$11\frac{1}{2}$"	$1\frac{1}{2}$"	Hand Pump	1 — 65

The starting effort is referred to by Mr. Wilson thus: "The results indicate that with plain bearings the effort necessary to start a tub from rest and to accelerate it to a uniform speed of $1\frac{3}{4}$ miles per hour required two to three times the effort necessary to maintain that speed. With Rowbotham types of bearings the equivalent starting effort was found to be $1\frac{1}{2}$ to 2, and SKF. equipment from 1 to $1\frac{1}{2}$ times the ordinary effort."

This confirms the statement made previously in this paper that the starting effort of ball and roller bearings was very little in excess of the running effort, whilst with plain bearings the starting effort was very much more.

Mr. Wilson's figures would have shown the plain bearings in a very much worse position had the tubs been allowed to stand for a length of time sufficient for the load to squeeze out the lubricant from between the journal and the bearing. Further on in his paper Mr. Wilson discusses the question of lubrication, and this is well worth laying before you at present when every effort is being made to reduce production costs. The figures are given by Mr. Wilson, and as such may be taken as authoritative. He draws attention to the enormous waste of oil and grease where either hand or automatic greasers are in use, pointing out the danger from fire owing to the roads being saturated with oil or grease, besides the resultant filthy state due to this misapplied lubricant. With plain open pedestal bearings dust and grit are continually gaining access to these bearings, increasing friction, and consequently causing wear on axles and bearings. One result of this of course will be that where the axles become considerably reduced in section there is serious liability for the axles to snap off and may be the means of causing very serious damage to a train of hutches.

Several cases, as stated above, are given by Mr. Wilson to show the cost of grease. He gives the case of a colliery purchasing grease at 11s. per cwt. A very reasonable figure this seems to be as a first-class grease, bought in bulk, may run about 15s. per cwt. The cost of grease worked out at .36 of a penny per ton of coal raised, or 12s. per hutch per annum, and in a second colliery the lubrication worked out at .3 of a penny per ton of coal raised, and 9s. $3\frac{1}{2}$d. per hutch per year. In comparing this with the cost of greasing anti-friction bearings Mr. Wilson gives a figure of 8d. per tub. This seems to be conservative, but allowing 1s. per tub per annum, which is based on grease at a cost of approximately 15s. per cwt., one can see an enormous saving to be effected in lubrication alone. Taking an average of the above two cases it works out at over 10s. per tub per year, which would be equivalent to a dividend of 7½% on a capital expenditure of £7 per tub, nearly. Now, as it is quite possible to purchase a first-class roller bearing equipment for considerably less than this sum it can easily be seen that money sunk in this part of a colliery's equipment would be well spent money, and able to pay not only a dividend on the capital sunk, but to reduce the cost of coal production.

A very interesting article on colliery machinery appeared in the "Colliery Guardian" of 5th May, 1922, and in it a section deals with the question of plain and roller bearings as applied to pit tubs. The figures generally corroborate the conclusions arrived at by Mr. Wilson, and it may be interesting to give a short summary of these facts.

A tram with gross weight of 3 tons was tested. In one case, where plain bearings were used, the bearings were of good design and fitted with Babbit metal, and also on anti-friction bearings. The speed at which the tests were carried out was approximately 3ft. per second, or a little over one mile per hour. The results showed, with the plain bearing tram, a draw-bar pull of 132lbs., and a draw-bar pull of 66lbs. for the anti-friction bearings which, to compare with Mr. Wilson's results, give a ratio of pull to load of 1 to 50, and 1 to 120 respectively. These compare very closely with Mr. Wilson's results. Trams with a gross weight of 2 tons were experimented with to ascertain the starting pull necessary to set the trams in motion. Two of these trams fitted with anti-friction bearings were coupled together, and it was found that 25lbs. pull set them in motion, whereas one plain bearing tram, under similar conditions, required 100lbs. pull, or eight times more than that of anti-friction bearings. This, it will be noticed, is much more favourable to the anti-friction bearings than Mr. Wilson's experiments.

To those interested in this subject may be recommended a study of the Transactions of the Institute of Mining Engineers, Volume 44, and also Handbook on Ball and Roller Bearings by the late A. W. Macaulay, who in that book reproduces a number of curves of tests on rope haulages having both plain and anti-friction bearing pit tubs, the final result arrived at by him being that the latter shows a saving in power required to drive the tubs of over 29%.

In all cases where anti-friction bearings are being considered for pit tubs, it is not only the first cost which has to be considered, but also the ease in handling, the economy of lubrication, and the low maintenance charges, but also, and especially where new collieries are being opened, the saving in power required for haulage purposes. In existing collieries one can only look for a reduction in the power required for operating the haulage, but in new collieries a considerable saving in capital cost may be looked for by the reduction in the size, and therefore the cost, of the haulage motor, and this saving in expenditure should be set against any increase in cost of the roller bearing pit tubs above that of the plain bearing outfit, and of course in this case also there would be a still further reduction in the cost of operation owing to the smaller motor installed. From the foregoing, the following conclusions may be drawn.

That plain bearings are a source of loss of power, that they are wasteful in lubrication, and that the maintenance cost is high.

To overcome these troubles a good anti-friction bearing should be employed which, being in a closed housing, has the dirt excluded and has the lubricant retained. Also, that these anti-friction bearings should run on a hard and continuous inner and outer race. The advantage of the closed housing is that it ensures a constant and efficient supply of lubricant, supplied where it is of use, and not to the roadway where it is a source of danger and annoyance.

Whilst on the subject of transportation of coal it is opportune to consider conveyors, of which there are a number of different types, such as continuous belt and shaker types of conveyors. In both of these ball and roller bearings have been successfully applied and have proved their efficiency. In the belt conveyor there are endless applications in the rolls, of which there are always a great number, and the advantages which may be looked for in these rollers are:—

The absence of any tendency to wear and heat, the reduction in power, the ease of renewing a bearing should that be necessary, and the long intervals between lubrication, whereas it would be necessary to lubricate a plain bearing conveyor every few hours. Where ball and roller bearings are fitted once in six months would be quite often enough.

If proof were necessary of the advantages accruing from the fitting of anti-friction bearings, all that would be necessary would be to point to the largest conveyors in this country or America, where it will be found that these are fitted throughout on ball and roller bearings. For instance, the largest underground belt conveyor in this country is mounted with ball bearings. It has worked considerably more than 1,000 shifts in a trunk road conveying over 300,000 tons of coal and stone up a gradient of 1 in 3. Notwithstanding this strenuous work, owing to the ease with which the guide rollers and idlers, etc., work, the belt was still as good as new, according to the latest information, and apparently no trouble has been experienced with the ball bearings incorporated.

With regard to pumps and fans, where the pumps are of the centrifugal nature, and therefore closely allied to ventilating fans, both in principle and design, it will be found that all first class makers now standardise on ball bearings. Apart from the general advantages which have been explained previously, they have the same common advantage as electric motors, which is that owing to the absence of wear, and the definite positioning of the rotating member, the efficiency of the machine is maintained as nearly constant as it is possible for any mechanical device to be kept.

Electrically driven ram pumps are becoming much more common in many instances, and it will usually be found that the gearing is fitted with journal ball or roller bearings. It is almost impossible in these applications to point to any definite power saving, but the fact that these bearings are so generally fitted as standard proves that they are considered a necessity under present-day conditions. The reason why it is difficult to point to a direct saving in power is two-fold. The loss in power in the bearings being relatively a small portion of the frictional losses always present in the pump, gearing and these are small when compared with the friction of the water through pipes, valves, etc.; also it is doubtful if pump makers have ever made any reliable tests to prove a saving over plain bearings, but the trouble-free qualities of anti-friction bearings have compelled high-class makers to fit them where possible.

Washing and screening plants have not up till the present been universally fitted with ball or roller bearings, although one or two plants have been so equipped, and here again there seems to be an entire absence of tests to show the economy effected. In both of these plants there are great possibilities for the utilisation of ball and roller bearing plummer blocks, besides special fittings, and in a previous portion of the paper, dealing with line-shafting, it has been shown the reliable saving which can be effected in fitting these anti-friction devices, so that it is reasonable to assume that where screening and washing plants are fitted with ball bearings similar results would be achieved. There is no doubt that in washing plant especially there is always a risk of water gaining access to the bearings, but with the experience which ball bearing manufacturers have obtained in other manufactures where water is present, such as in paper mills, dye works, bleach works, and chemical works, there is no reason to doubt that were the proposition put up to them a satisfactory bearing, and a housing which would exclude water, could be suggested and entire satisfaction given.

With regard to riddling plant, a very successful design has been evolved by the Ritchie-Atlas Engineering Company, and this plant is fitted entirely with Skefko bearings. There are two riddles, one within the other, placed eccentrically, and these revolve in opposite directions. The advantage of this design is that an increased surface is presented to the material to be riddled, and it has been found on test that the plant is capable of handling approximately 50% more material than the plain bearing design on the old system and occupying the same space. This plant has been erected abroad, and the author does not know of any similar plant in operation in this country; there would, however, appear to be considerable scope for it here, and doubtless similar satisfactory results would be obtained.

At present there are a number of new methods being suggested for the use of coal, such as low carbonisation and pulverised fuel. As the first named plant is only in its infancy the author knows of no application but with regard to pulverisation of fuel, several schemes have been in successful operation for some time, in some cases for a number of years, and these applications have given the utmost satisfaction. In the Herbert Atritor coal is fed through the hopper and there are swinging hammers which break it up, and from there it is passed on between two plates which each have rows of pins projecting horizontally and which enmesh with each other. The object of the pins is not to break up the coal finely, but to stir up the already powdered coal in such a way as to keep the particles in contact with one another and thus cause an abrasive action to take place between them. In one of these mills a spherical roller bearing is fitted on the atritor shaft which runs at 2,500 r.p.m. On the drive shaft, which is at right angles to the atritor shaft, a similar, but slightly smaller spherical roller bearing is fitted behind the pinion, and a cylindrical roller bearing next the coupling. Unfortunately no drawing of this plant is available. Another mill is the Kek mill. The vertical spindle on the 36in. model runs at 2,800 r.p.m., while the horizontal driving shaft runs at 800 r.p.m. The diameter of the top disc is 36in. the weight being 3½ cwts., and the horse power required to drive this mill is between 45 and 50. Quite a number of other mills are fitted with SKF. bearings. A number of these have shafts running up to as high as 5,000 r.p.m., the bearings fitted being of various sorts, including heavy roller bearings of the self-aligning design, as are in use in the Herbert mill.

The last type of machine which it is proposed to deal with is one which is not directly in use in collieries but is used in many works associated with collieries, that is, in brick-works often attached to collieries. This application is ball bearings as used in pan mills and allied machines. For the shafting for driving these the application is a comparatively simple one, and usually requires medium type ball bearings with one fixed to locate the shaft, and in certain circumstances a thrust bearing may be necessary to take the thrust of the bevel wheels. The principal bearings, however, are the footstep bearings, and for this application a self-aligning ball bearing and a self-aligning thrust bearing are usually necessary, all encased in one housing. One of the great difficulties to be encountered here is the intrusion of dust, and in one instance where this was exceedingly difficult to overcome the housing was made more or less conical in shape with a bell cover, and on the outside of the bell cover there were fins cast. This bell cover was keyed on to the shaft above the housing, and embraced the housing with a slight clearance. In rotating, the fins tended to spread any dust which was heaping up round the housing away from the bearing, and as there were efficient felt washers and labyrinths no dirt found its way eventually into the housing. This is merely intended as an illustration of how difficult problems for excluding dirt and water have to be treated, requiring great care and foresight in the proper design of the housing. When this great care is taken there need be no fear about the ultimate success of the application.

So much experience has been obtained by ball and roller bearing manufacturers with regard to the working loads which bearings will stand that, when accurate information is given to them of the loads which will come on these bearings, and the conditions under which they have to work, it is possible to suggest bearings which will give within very accurate limits a length of life which can be predetermined.

In conclusion, when putting up proposals to ball or roller bearing manufacturers for the conversion of a machine, the fuller information which can be supplied the better, and the less likelihood there is of disappointment being experienced by the user. In this respect a ball bearing is slightly different from a plain bearing. In a plain bearing rules-of-thumb are more or less applicable, in the way that a bearing may be made two diameters in length or two-and-a-half diameters, depending upon the experience of the engineer; but with a ball bearing the conditions are totally different, and ball bearings have been designed to carry certain loads at certain revolutions. If these loads are known accurately then it is possible to fit a suitable bearing. If, however, it is impossible to determine them accurately experience certainly enters into the bearing selection, and this experience has been acquired by ball bearing manufacturers after years of experiment, in many cases on the actual machine in question. It is therefore advisable that engineers in charge of plant, when making a conversion, should not take upon themselves the responsibility of choosing the bearing, but should get into touch with a reputable manufacturer.

NORTH OF ENGLAND BRANCH.

At the North of England Branch meeting held in Durham on the 8th December, 1928, a paper entitled "Notes on Modern Machine Mining" was read by Mr. Haswell Alder, B.Sc., followed by an interesting discussion. The Branch President, Captain S. Walton-Brown, occupied the chair.

Notes on Modern Machine Mining.

HASWELL ALDER, B.Sc.

On referring to statistics for Great Britain (Table I.) it is seen that whereas 30,194,306 tons representing 13% of the total output were cut in 1920, 48,133,315 tons representing 20% of the total output were cut in 1925, the annual increase being just over 1% per annum. In a short year 27,777,890 tons representing 22% of the total output were cut in 1926. This increase is generally attributed to the working of thinner seams and this is mainly true (see Table II.). An increase is noticeable in the percentage of coal got from seams 3½ feet in thickness down to 1ft. and 1ft. 6ins., and it is in these seams that the increase of machine cut tonnage is most marked. A point worth noticing, however, is that the percentage of machine cut coal has increased *in all thicknesses*. In the seams from which the bulk of our coal is obtained, namely about 3ft. 6in., *the percentage of machine cut coal has more than doubled since* 1913, and the application of cutters to seams above 6ft. in thickness is quite marked (see Table II.).

Another interesting point is that seams of 1ft. to 1ft. 6in. show a very much higher percentage of hand got coal than seams of 1ft. 6in. to 2ft., probably due to the working of associated material. With regard to thicker seams, those from 5ft. 6in. to 6ft. 6in. show the great increase in the percentage of machine cut coal, namely 8.5% for 5½ft. to 6ft. seams and 4.9% for 6ft. to 6½ft. seams in 1924, as against 2.5% for 5½ft. to 6ft. seams and 0.9% of 6ft. to 6½ft. seams in 1913.

TABLE I.

TONS CUT BY MACHINERY.

Year.	*Quantity in tons.*	*% of total output.*
1920	30,194,306	13%
1925	48,133,315	20%
1926	27,777,890	22%

TABLE II.

Thicknesses of Seams from which Coal is Extracted.

Feet in thickness.	*% of total tonnage.* 1924	1913	*% cut.* 1923	1913
0—1	Too small	0.1	79.4	67.9
1—1½	0.4	6.2	31.0	10.1
1½—2	4.2	3.2	45.7	24.7
2—2½	7.3	6.5	35.0	19.1
2½—3	10.3	8.8	34.1	15.2
3—3½	13.8	11.9	22.8	11.5
3½—4	13.1	14.6	19.7	8.3
4—4½	12.5	14.3	12.3	4.7
4½—5	11.4	11.3	8.3	2.4
5—5½	10.1	10.5	7.5	3.7
5½—6	6.9	7.0	8.5	2.5
6—6½	5.2	6.7	4.9	0.9
6½—7	1.5	1.4	2.9	1.5
7—7½	1.0	1.3	3.6	2.9
7½ and over	2.3	2.2	3.3	2.9

This undoubtedly shows that the statement made previously attributing the increase in the percentage of machine cut coal working to thinner seams needs to be qualified, and that the use of machinery is not to be regarded as due to physical difficulties altogether.

The problem is an economic one and in the past our mining economics has mainly consisted of a too rigid consideration of the individual face costs which go to form the "Colliery manager's barometer of happiness"—cost per ton. Cutters were introduced into the old systems of working to save expensive holing, conveyors were introduced to save ripping 12yd. to 14yd. gateways, and in many cases disappointment ensued.

It was often found that labour costs had been reduced by coal cutters only to be nullified by increased power cost and capital expenditure. Where conveyors were put in it was found that with existing haulages and lay-out there was frequent loss of time, irregular moving up, etc.; and generally they became a nuisance. The manager, summing up the position, found he had saved a few men by not having to rip gateways only to have to use most of them to shift the pans up, and thus many reverted to the old system.

In 1913 a manufacturer, Mr. Sam Mavor, wrote: "Viewed broadly, face conveying has not yet realised the sanguine expectations of a few years ago. The system is in a state of arrested development: it may even be said to have suffered a set-back. The fact is, that of all the face conveyors now at collieries in this country, a very large proportion are idle on the surface. It is to the best interests of all concerned that there should be frank recognition and free discussion of this situation and the causes which have contributed to it."

The key to the situation is, in the author's opinion, to be seen in the next paragraph: "The chief objects sought in face conveyors are:

(1) Reduction of ripping costs,
(2) Reduction of filling costs,
(3) Rapid clearance of the face."

Those were the objects sought, especially (1) and (2), whilst (3) was a secondary consideration. In a great many cases there was no reduction, or very little, in ripping and filling costs and therefore the scheme was abandoned.

It must be understood that the principal advantage of machine mining apart from giving better conditions and other benefits is increased output. Unless this increased output is fully exploited, the best results cannot possibly be obtained. It is no use installing coal cutters if the cut coal cannot be filled off expeditiously and a regular advance of face maintained. Similarly, it is futile to instal conveyors if their increased carrying powers are not used to the full in putting coal on them and transporting coal away from them. That is why it is being realised that coal cutting, in increasing the output per filler, naturally marches hand in hand with face conveying, with its facility for dealing with larger face outputs, and all-mechanical haulage in turn with its capacity for dealing with larger outputs delivered on to it.

Putting "new wine into old bottles" or pushing a coal cutter or conveyor into some unsuitable system of working in order to effect a saving in some individual operation has too often been the case of so much disparagement of machine mining, as the results on the final cost per ton has often not been what was anticipated. The costs per ton of individual operations are so dependent on each other that when the use of machinery is contemplated the whole system must be considered on its entirety in order to avoid saving in one operation only to increase some remote costs such as engineering and power costs.

Machine mining succeeded in the first place by what is called "mass production," thereby reducing the load of standing charges, etc., and enabling good profits to be made on small returns per ton. The pioneers who persevered in spite of the difficulties they encountered have, except in cases of bad judgment and organisation, reaped the reward by gaining on that increased output. It was often found that a substantial saving was not immediately realised in the actual cost per ton of face operations but rather in associated costs of haulage, supervision, standing charges, etc.

There is now, in the author's opinion, another page of machine mining history opening out, and we are being forced back to a consideration of the individual cost per ton of getting the coal, rather than a low overall cost per ton associated with very large outputs. The over-production of coal in the world and its effects have been shown by Sir R. A. S. Redmayne. There is talk of restricted output and so machine mining is rather at a disadvantage. Where we were content with a small return on a large output we are now faced with reducing that return with the output. The only way out is to reduce, if possible, the standing charges and the cost of getting the coal.

In answer, therefore, to the query "How do we stand at the present moment?" it may be said that the intrinsic cost per ton is being forced to the front and output, on the whole, must be made relatively a secondary consideration. Where there is an unrestricted market for the coal, output is most important, but where there is a poor demand the selling price must go down and a low cost per ton becomes imperative. The tendency of combines and restricted output will, therefore, be to increase the search for means of reducing the actual cost of production. The men have made great sacrifices and still there is not a great demand, especially in these local Counties of Northumberland and Durham, where we rely on no artificial home prices but sheer international competition. All we can turn to is the further exploitation of machinery.

The solution of the problem is intensive mining, or the extraction of relatively large outputs from small areas; that is to say, instead of working several scattered districts, concentrate if possible on a few districts or even one district, and extract the maximum amount of coal from them or it, thus reducing the costs of haulage, upkeep of roads, supervision and all the attendant costs of working widely separated districts. In short, practising large production on a small scale. Machine mining is particularly suitable for this purpose and with the stock of experience which has been accumulated in the past on this subject considerable savings should be effected.

Apart from the fact that mass production is shorn of all its glory there are the following disadvantages:—

(1) Coal is more difficult to get, shafts are getting slightly deeper, although 67% of our coal is still drawn from shafts 100 yards to 500 yards deep in 1924, as against 71% in 1913.

(2) Haulage roads are, on the whole, longer and the travelling time greater.

(3) The greater number of men are employed at collieries more than 40 years old, and the highest individual percentage for ten years is 22.19% for collieries 50 to 60 years old.

(4) Seams are slightly thinner and more coal is being got from thinner seams.

TABLE IV.

AGGREGATE H.P. OF MOTORS USED.

Year.	Below ground.	Above ground.	No. of Ponies.
1920	618,863	461,954	67,748
1925	840,401	715,834	60,852
1926	852,045	768,100	56,762

The aggregate H.P. of electrical motors in use below ground in 1927 was 878,311, composed of:

Haulage	365,619
Conveyors and Loaders	14,285
Pumping	371,570
Coal Cutters	101,157
Miscellaneous	25,680
	878,311

Percentage of Electrical Coal Cutters to total of all other types excluding Percussive and Rotary Drills:

1918	67.7%
1924	68.8%
1927	71.5%

The percentage of electrical machine cut coal was 64% in 1927.

Considering these facts it is interesting to see what changes have occurred in the use of machinery accompanying them (see Table III.).

TABLE III.

TYPES OF COAL CUTTERS IN USE.

Year.	No. of Mines.	Disc.	Bar.	Chain.	Percussive.	Totals.
1920	2851	1254	700	1216	1899	5071
1925	2721	1086	842	2524	2195	6650
1926	2840	978	767	2645	2122	6512

For a slightly smaller number of mines at work the number of coal cutting machines has increased from 1920 to 1925. The figures shown for 1926 are inconclusive on account of the general stoppage. It will be noted that the number of disc machines in use has considerably decreased since 1920 and the number of chain machines in use has doubled from 1920 to 1925, namely, from 1,216 to 2,524, whilst the number of bar machines in use increased slightly during that period. The number of percussive machines in use also increased in the same time. It would seem from the figures for 1926 that the chain type of cutter is gaining tremendously in popularity.

Considering the quantity cut it is seen that more coal was cut per machine in 1925 than in 1920.

With regard to conveyors, the number has nearly doubled from 1920 to 1925, although face conveying is, however, not being so generally adopted as coal cutting. The use of electricity above and below ground increased prodigiously during the same five years (see Table IV.): whilst the number of ponies used (a favour-means of haulage in Durham as shown by the following figures: Durham, 14,804; Northumberland, 5,122; Lothian (Scotland), 228 has slightly diminished.

The increase in the percentage of electrically driven coal cutters to all other types, excluding percussive and rotary driven by compressed air, is particularly interesting (see Table IV.).

With regard to machine mining in the respective counties and coal fields, Scotland, of course heads the list: 53% of the total output there being cut as against 33% in Northumberland (slightly above the average for Great Britain), and 17% in Durham (slightly below).

The amount of coal cut in Scotland has always interested the author and he was enabled, by the kindness of Professor Poole, Professor of Mining at Armstrong College, University of Durham, to spend some time last summer at the works of Mavor & Coulson, Ltd., Glasgow, and at the Newbattle Collieries of the Lothian Coal Company, Ltd. These collieries are examples of the most efficient machine mining collieries in a machine machine mining country.

THE NEWBATTLE COLLIERIES.

The recent history of Newbattle is practically the history of machine mining, and it is proposed therefore, to describe here some of the most interesting features of these collieries. They may be termed pioneers in machine mining as the first coal cutter was there introduced over 30 years ago and the development is a wonderful example of progressive methods and triumph over difficulties. There are seven principal seams having a total thickness of about 24 feet. The separate seams differ considerably in quality and even the same seam differs from one horizon to another. The top seam worked is called the Great Seam and is from 5 feet to 8 feet thick. It consists of moderately soft steam coal, and has dirt bands running 1 inch to 4 inches thick. The roof is hard sandstone 20 ins.—30 ins. thick, and is very strong. It often has rolls in it and may occasionally be separated from the coal by anything up to 1 ft. of shale. The floor varies and consists of a soft underclay with sandstone beneath. This seam lies 160 fathoms below the surface.

At 163 fathoms there is the Diamond seam, which is 1 ft. 9ins. thick, and consists of an excellent house coal. The bottom 15 ins. of this seam is very hard, and the roof and floor are both solid sandstone. Below this, at 192 fathoms is the Coronation seam, a second quality house coal containing pyrites, 3 ft. 2 ins. thick, with a soft band in the centre. The roof is sandstone with shaley falling or "ramble", as we would call it, 1 ft. thick. The floor is sandstone.

The next seam is called the Smithy, and is a friable steam coal 2 ft. 3 ins. thick, with a roof and floor of shaley sandstone. Below at 215 fathoms is the Splint seam—4 feet of excellent steam coal. The seam derives its name from the top section, which is very hard and from which it parts readily. In the middle of this seam a cleat is noticeable and it may be stated here that, in general, the seams are practically without cleat. The roof of the Splint is post, with a thickness of sandy shale and carbonaceous shale immediately above the coal.

At 230 fathoms there is the Kaleblades seam which, although really a series of small seams, may be treated as one 3 ft. 10 ins. seam with a shale roof and floor. It separates into three different seams in the neighbourhood.

The last seam worked is the Parrot seam—at 254 fathoms. This seam is a very interesting one in that it consists of three different kinds of coal. The bottom layer or Diamond consists of a soft bright coal 12 ins. thick, and is a good gas coal. The middle layer, or Parrot, is a high grade cannel and derives its name from the decrepitation which takes place on placing some of it on a fire. This layer is 8 ins. thick. The top layer or Jewel coal is a hard house coal and may be 1 ft. 4 ins. thick. The whole seam varies from 2 ft. 6 ins. to 3 ft. 6 ins. The roof is really strong sandstone, but it is generally separated from the coal by many feet of shale, although in cases this shale is absent. The shale varies not only in extent but also in nature and may be very tender or very hard. It often contains ironstone nodules and the parting between the roof and the coal is extremely bad. The floor is a shaley sandstone with an impure fireclay and ironstone nodules occasionally, and is undulating.

Of these seven seams five are being worked now, namely, the Great Seam, the Coronation, the Splint, the Kaleblades, and the Parrot. The inclination of these seams varies enormously in extent although fairly constant in direction. They dip at 30 degs. on the extreme east, but flatten out towards the west. A general idea of the inclination may be conveyed by stating that inclinations of 1 in 5 to 1 in 10 are usual.

It will be seen that the working of so many seams of such widely different properties and under vastly different conditions, provides a unique example of machine mining.

Method of Working.

The coal is worked to the dip. Cross measure drifts from the pit bottom, which is below the level of the Parrot seam (the lowest seam), intersect the various seams. Three of the main roads on reaching the Parrot seam follow it to the dip, and the coal from the adjacent seams is won by means of drifts further inbye. A fourth road continues until the Splint seam is reached and follows it to the dip. The coal is hauled from the face by main and tail haulage and is then fed on to the endless rope haulage in the main dip roads, either directly, or by means of an intermediate direct rope haulage.

The unit face system is used and panels 100 yards wide are carried forward in echelon. The lay-out of the faces is shown in Fig. 1. It will be seen that the main and tail haulage roads are on the dip side of each hundred yards unit face and are driven approximately level. These panels are carried forward as far as desired and may be even a mile or so in length. Each hundred yard face forms one complete unit and has its own haulage system, so that each face is entirely separate from the others. In the event of a stoppage on any face for any reason, no interference is therefore caused with the other faces. From the sketch it will be also seen that only two roads are carried forward, and one of these—the return road—is cut off periodically and stowed. At the most it is only 80 yards long before a connection is laid to the next haulage road higher up.

This unit face system has been applied throughout the Colliery, even in the 7 ft. Great Seam, with great success. Where the dip is appreciable, single 100 yds. units with the haulage ropes at the dip end of the face are worked but where the seam is nearly level, double units with a haulage between the two 100 yds. faces are general. The comment about the successful use of machines in so many seams and under such different conditions applies equally well to the system of working. It shows that the long-wall method of working is capable of greater application than the older text books would have us believe.

Face Arrangements.

It is not proposed to describe in detail the procedure at the face as this has already been excellently done by Mr. Carson in a paper read before the North East Institute of M. & M. Engineers recently, and any member interested in these details should refer to the Transactions of the Institute, Part 4, Vol. LXX., 1926.

It is desirable, however, to stress the beneficial effect of the use of steel props and straps. Under the very variable nature of the roofs and the different conditions they have proved indispensable to the efficient working of these seams collectively. It will probably have been noticed that in the majority of cases of the seams given, the roof consists of massive post and is very "heavy". Now there are roughly two methods of supporting and controlling a roof, namely one in which the roof is allowed to settle gradually and bend down in one unbroken mass on the packs thus forming a beam across the coal face, and the other is where the roof is regularly broken off in the goaf in order to relieve weight on the face.

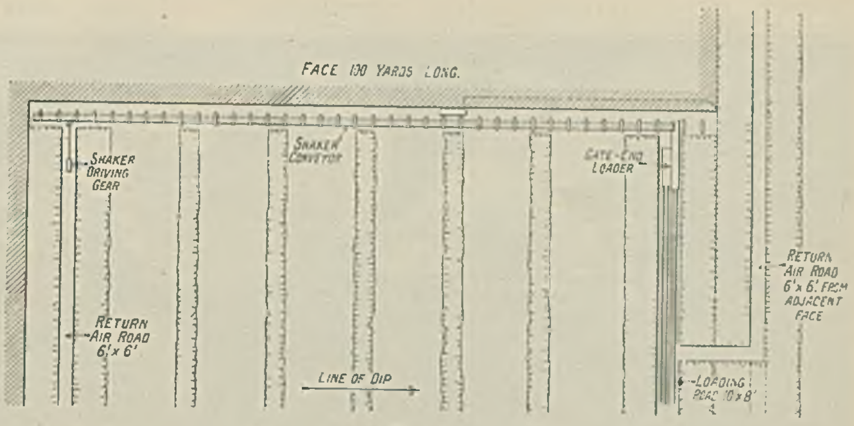


Fig. 1.

In the past the method of gradual settlement has been forced upon many collieries by reason of the 12 to 14 yd. gateways. In these cases the number and extent of the packs have been settled by the thickness of the caunch required and the distance between the gateways. Often no fall at all takes place in the goaf and thus the roof settles bodily down on the packs. It would seem that this method is safer, but from personal experience the author considers that where possible the policy of breaking off the roof behind the face is much preferable. The adoption of any method depends, of course, on the nature of the roof and floor, together with the height of the seam, and the depth from the surface; but the author has seen the system of breaking off the roof practised under such varied conditions that in a general way it may be very widely used; whereas, with the policy of gradual settlement, continuous breaking up at the face often occurs if the rate of advance or the direction of the face is not suitable, and sometimes short stepping of the face has to be resorted to. With the system of breaking off the roof regularly a few feet behind the face the roof weight is taken off the face, and not only may a bad roof be transformed into a good one but the saving in back rippings is quite considerable.

Good solid roadside packs are used at Newbattle and a notable feature was the intelligent use of goaf packs. The width and number of goaf packs are varied from time to time to suit the conditions. When the face is started a given number of packs are put in and the behaviour of the roof is carefully observed. The packs are then varied in thickness and in number until a satisfactory break is secured. If the roof refuses to break off, one or two of the packs may be run together so as to give greater space behind the breaker props. On the other hand, if the roof tends to be uncontrollable by reason of the goaf encroaching on the face, more packs or bigger packs are inserted.

Generally, two sets of props and straps are all that is required in front of the packs, but sometimes when the roof break is such that the goaf tends to fall into the conveyors, an extra set is added, making three sets in front of the pack when the cut has been taken off. In this way the roof of any face is always under control.

Where the nature of the roof is more or less constant the most satisfactory arrangement of packs and face support found in this way is retained, but where the nature of the roof alters, the arrangement may require to be altered correspondingly. In the Great seam, which is 7ft. thick and has a massive post roof and floor, the system is applied just as successfully as in the 2ft. 6in. Parrot seam. Formerly the roads were only kept open with great difficulty and the face often closed, whereas now the face can stand for a long time (and did during the strike) without any appreciable damage.

Double roadside packs with a small distance between them are being tried in the Great seam at Lingerwood

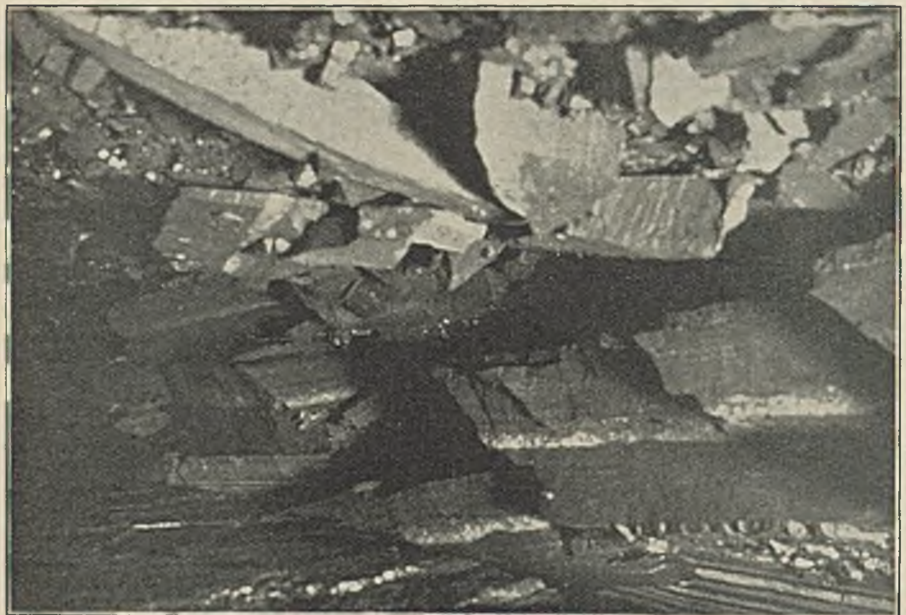


Fig. 2.

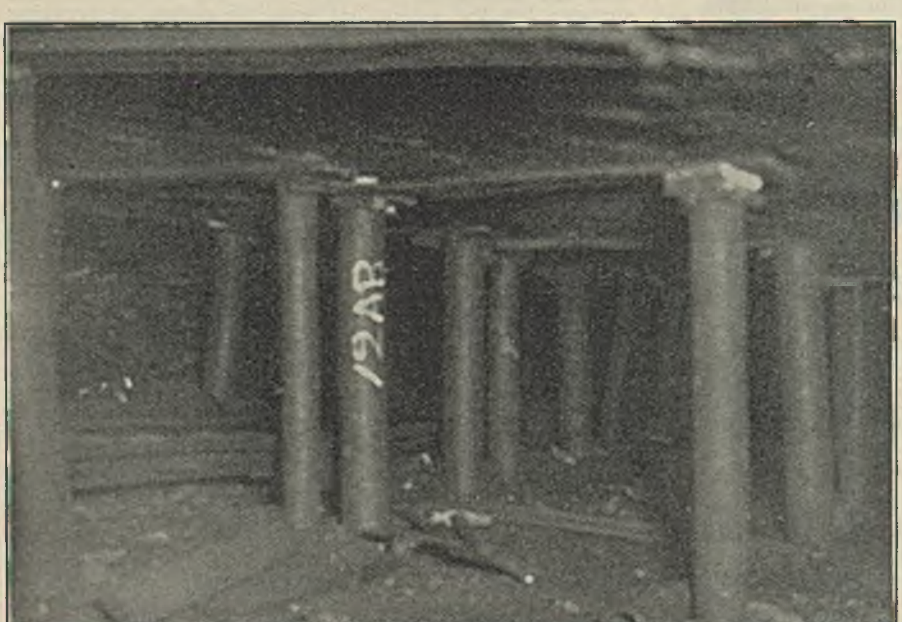


Fig. 3.

and are found successful in relieving considerably the weight on the roof. Sufficient packing material is usually obtainable from the goaf, but where the roof is so strong that it does not fall and thereby provide sufficient material, properly protected roads are carried into the goaf to where the roof has fallen (Fig. 2).

The author noticed a slight difference between the composite prop described by Mr. Carson and that in actual use at present. Instead of the short plugs projecting beyond the end of the steel tube, more reliance is being placed on lids and soles for protecting the metal and adjusting the size. I practice, two wooden soles 5i square by 1in. thick are used to gether with another piece of woo the same size as a lid betwee the prop and the corrugated scrap Where the prop is short any num ber up to three or four woode soles is used. In effect, there fore, the prop may be considere to be a steel tube completely fil led with a turned wooden cor which projects only a small dis tance at each end of the tube absolute rigidity being aimed at Where the steel tube of a pro used in a larger seam has splaye out at the end, or become dam aged, the end is cut off and th prop is forthwith sent to a small er seam. Complete records of th props given to a section are kep and from time to time the num ber is checked by the oversman An oversman sending out a num ber of bent or damaged prop receives exactly the same numbe of straightened props in retur and it is stated that now not single prop is lost, or become untraceable. This state of affair has only been secured by soun organisation.

When the props were firs introduced, great opposition wa encountered from the men, wh stated that it was impossible t tell when the "weight" was com ing on the face; now, on enquir ing of them, they think so muc of the steel prop that they woul not be without them.

Originally three escape road had to be carried forward wit 100 yards face and now thes have been entirely eliminated. A straight line of face and prop together with a uniform strengt of prop is necessary to ensur correct breakage of the roof be hind the face. The strength of wooden prop is so variable tha for breaking off purposes stee props are the only really satisfac tory support. With a row o steel props the individual strengt of each prop may be assumed t be about the same, whereas in row of wooden props due t moisture or different materia some may stand and others fai under the same load (Fig. 3).

The report of the Safety i Mines Research has shown tha face accidents have been reduce from something like 20 per millio man-shifts to about one per mil lion man-shifts by the use of these props, and ther is no doubt that for the purposes here considered, stee props are the props of the future. That they are a economical proposition has been shown by Mr. J. Bir kumshaw before the Midland Branch of the Nationa Association of Colliery Managers. They have been use for ten years at his colliery, and although the initia cost was high, namely, 5¾d. per ton, yet the cost o these props taking the average life of a prop at the lov estimate of five years was 2d. per ton, inclusive of main tenance and everything for that period.

When one sees the wonderfully straight line of breakage obtained at Lingerwood in the Great seam with a roof of massive post without any natural line of break whatever, and also the incipient line of breakage beginning to form at the next row of props, the value of these props becomes very apparent.

Machinery.

All the machinery, apart from a few compressed air percussive stone drills, is electrical. The power is supplied by three generators, a large 5,000 K.W. generator and two 1,000 K.W. generators.

The 5,000 K.W. generator supplies sufficient power for present purposes and the two 1,000 K.W. sets are kept as spares, being run in parallel at week-ends for pumping, etc., and allowing the large generator to stand. The 5,000 K.W. turbo-generator runs at 1,500 r.p.m. and is fed with high pressure steam at 150lbs. per square inch. The two 1,000 K.W. generators are B.T.H. mixed steam turbo-generators running at 3,000 r.p.m. and are driven either from the heater by exhaust steam from the main winding engine or directly from the boilers at 100lbs. per square inch pressure. The valves on the turbines are fitted so that when the pressure on the heater becomes sufficient, the live steam valve is shut.

The H.T. supply, 3,000 volts, is carried right in-bye to the landings and transformed down to 500 volts before going into the sections. These transformers are mounted on wheels, and being small and compact they are quite easy to handle. There are several sizes, the largest being 8ft. long by 30ins. broad and standing 4½ft. high from the rails. The larger sizes are oil cooled and the temperature is regularly recorded. Smaller transformers are used for supplying pumps on the engine plane. The 500 volt supply is sometimes transformed down to 50 volts by means of a small subsidiary transformer housed together with a large transformer and switch gear, and this supply is used for lighting purposes.

Compressed air is supplied when necessary from small compressors driven by a motor and housed in the district where the air is required. They are fitted with an automatic cut-out which stops the motor when the pressure exceeds a certain figure and re-starts it as the pressure falls below it.

The gate-end switches for the coal cutter and conveyor are, in the case of the single unit faces with shaker conveyors, placed in the upper return road. Where scraper conveyors are used the switch is in the haulage road. The gate-end loader switch is also, of course, in the haulage road.

Coal-Cutting Machines.

Both bar and chain machines are used and 70% of the total output is cut. Disc machines were used originally but abandoned owing to their noise, heavy upkeep, and the amount of dust they produced. At the time they were used none of the local men could be induced to work them, and Poles were imported for that purpose. Several of these men and their descendants are still working at the colliery. The scarcity of this labour led to the adoption of the bar machine and these machines are still used, together with chain machines subsequently introduced. In some cases the chain machine has proved better than the bar and in other cases the bar has retained its superiority. The choice of machine is influenced by the nature of the coal, the presence of any hard bends near cutting level (which might cause the jib of a chain machine to rise unduly), together with the usual requirements of larger kirvings, etc.

Each machine has an allotted task before it by reason of the unit face system and cuts a stipulated distance—100 yards—every shift. If the cutter men finish and turn before the expiration of the shift they either aid in the general preparation of the face (they are partners with the fillers) or clean the machine. They are paid absolutely on a tonnage basis, unless there is no work for them.

Maintenance plays a great part in the successful application of machine mining, and at Newbattle great attention is paid to this subject. The unit construction of the machines makes it very easy to alter any part of the machine such as substituting a chain gear head for a bar gear head, and also to replace completely any other part, such as the motor or the haulage end. In the event of the complete failure of any part of the machine the fitter who has charge of a section of faces can telephone to bank for the part and within a very short time have the machine going again. Small spares are kept near the face in case of minor breakdowns. Very little trouble is experienced with the machines, which are regularly and thoroughly overhauled every eighteen months to two years. In no case is any machine allowed to go over two years without a complete overhaul.

At the conclusion of each cutting shift the machine men report the condition of the machine in a book kept for the purpose in the various sections of the pit. The underground fitter examines the book every shift and any repair required to be done is done on the day shift in order to have the machine ready for the afternoon cutting shift. A kit inspection is also regularly carried out so as to keep account of the small fittings of each machine.

It is interesting to note here that many of the machines used have parts of very different ages and type by reason of their unit construction, and there are often old haulage ends or motors on quite recent gear-heads, and also motors and haulage ends originally fitted to bar machines and now used on chain machines This interchangeability has been exploited to the full in order to get all possible use out of any unit. All these machines have been supplied by Mavor & Coulson.

Conveyors.

No ponies are used at Newbattle, all the coal being mechanically conveyed to the loading road.

The conveyors used are usually shaker conveyors, as this type is superior to any other on the inclined faces. The engine used to drive the conveyor is situated at the top end of the face in the return road and consists of the usual rocking mechanism transmitting a pull to a wire rope connected to a quadrant. The quadrant is in turn attached to the pans. The rope is adjusted so that on a backward movement of the crank from the face, the whole length of pans is lifted up the face and on the forward stroke the pans fall back by their own weight. When the full length of the available rope has been paid out the engine is moved up. Roller and cradle supports are used every two pan lengths (12ft.) although, no doubt, ball cradles would be as effective under these conditions. In the flatter parts of the seam and in the Great seam scraper conveyors are used in conjunction with the double unit system.

Gate End Loaders.

Gate end loaders are used for loading the coal into the tubs. These are usually 29ft. long and 5ft. 6ins. high, but in the Great seam at Easthouses pit, there has just been installed one 11ft. high and nearly 40ft. long capable of dealing comfortably with 400 to 450 tons a shift. A scraper gate conveyor conveys the coal from the face conveyors to the gate end loader and the loader is only moved up every week-end. It is now dealing with 200 to 250 tons per shift. A 22in. scraper gate conveyor is contemplated in order to deal with the projected output of 400 tons per shift. This loader represents a further advance in the principle of dealing with large outputs at a few selected points.

Haulage.

Successful machine mining depends upon the carrying out of each operation with unfailing regularity. It is imperative that nothing shall interfere with the sequence of operations because the failure to complete any operation affects the entire scheme.

The length of face and undercut together with a suitable coal-cutting machine must be determined so as

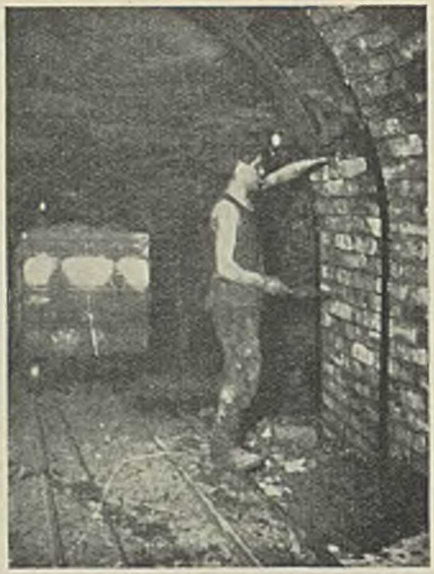


Fig. 4.

to allow of a regular cutting of the face in a given time, and all the conditions obtaining at the face must be taken into account in deciding these items. The occurrence of any minor or ordinary difficulty should be allowed for in these determinations. Similarly, the attendant operations such as moving up the conveyor, ripping the gate roads, withdrawing timber, etc., should follow-on smoothly and be easily completed in time for the next operation. Lastly, the face must be stripped like clockwork. To do this the haulage system must be carefully designed so as to deal easily with the output.

The supply of coal, and therefore the demand for empties, is practically continuous throughout the filling shift and thus the endless rope system of haulage is generally adopted. The endless rope haulage at Newbattle runs at about 1¾ miles per hour and the tubs are clipped on singly to the rope by means of ordinary screw clips. At the Lady Victoria pit, the endless rope is driven by a horizontal steam engine on the surface. Ropes are carried down the pit to a big shaft carrying pulleys with friction clutches which operate the various haulages. This method of driving the haulages although old-fashioned, is most economical with the steam conditions obtaining at bank. It is rather remarkable at first sight that this method should be retained at a colliery where everything new is exploited, but in doing so the management have only emphasised the fact that to scrap anything old-fashioned just because it is old-fashioned is absurd.

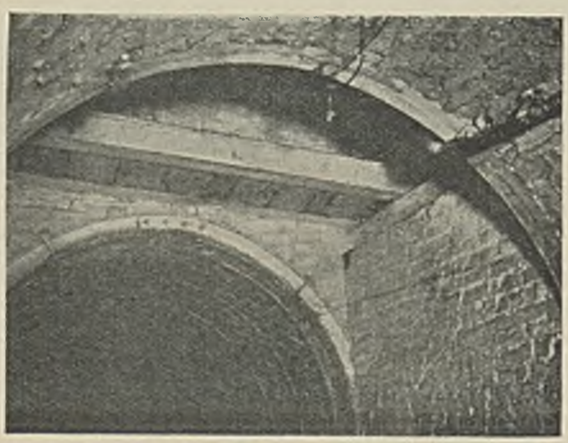


Fig. 5.

A consideration of the haulage system at these collieries is most instructive.

The main haulage roads are supported by H section mild steel arched girders with bricking between them. These girders are in two halves and on erection are joined by a fish plate. Different sizes are used, but this system of support is used throughout the pit. In the main and tail haulage roads leading from the face, 8ft. by 7ft. arched girders are used with a 2ft. extension piece for use in making the sidings. According to the conditions, these girders may be put in right up to the face or may follow the face some distance behind it. Where the girders are put in the haulage road right up to the face, some get badly twisted, but they can be easily straightened and used over again. In any case there is a substantial saving in back ripping and these roads stand quite well. No brickwork is used between the girders in these roads except near the out-bye end, which may be half bricked up. Near the face the girders are wedged in position and punch props are inserted when necessary to prevent them from twisting out. The flange of these girders is 3in. wide and the web 5in. deep, the thickness of metal being ¾in. It will be seen that the web is just big enough to accommodate a brick endways (Fig. 4).

Formerly 10ft. by 8½ft. girders were used on the main haulage roads, but these are now being replaced by 12ft. by 10ft. girders. A coarse concrete is now used instead of bricking. The girders are put in 2ft. 9ins. to 3ft. apart, and the course concrete is built up in sections between them. Special steel plates are used which clip on to the outside flange of the girder by means of tongues. The space behind each plate is then packed with the coarse mixture (four parts of producer ash to one of cement) and allowed to set. The plate is then removed and another section built up. The resulting structure is strong and very satisfactory. The main return roads are also supported by 10ft. by 8½ft. girders and bricked throughout their length. These roads are used to ride the men inbye to the districts. Main and tail haulages are used and the men ride in special steel bogies containing eight men. A set consists of 14 bogies and the rate of travel is about six m.p.h. As the distance from the shaft to the working is sometimes 2½ to 3 miles, a considerable saving in time is effected (Fig. 5).

The roads supported by these arched girders stand extremely well, and some roads made over twenty years ago show very little damage. Dry stone walls and straight girders, rough mortared stone arches, and brick arches had all been tried without success before this method of support was universally adopted. The far sighted policy of paying great attention to the roads and making them large and well supported has justified itself over and over again, not only with regard to haulage but also to ventilation. The large roads make the use of large tubs possible and although the maximum daily output from each haulage road is about 500 to 600 tons per day, twice this amount could be handled in a shift if necessary.

The way the size of the tub used at Newbattle has increased in recent years is very illuminating and shows the courageous policy of the management in meeting the demands of intensive mining. Eight cwt. tubs were first used and then they were increased to 10 cwts. The size of the tub was then further increased to its present capacity of 18 to 23 cwts. This necessitated reducing the number of tubs in each deck of the cage to the present number of four. A still larger tub has recently been decided upon, and when one considers what changing the size of a tub throughout a colliery means, the courage needed will be appreciated. Nothing but praise is due to these pioneers and we should benefit by their experience.

Accompanying the growth in size of the tub, the weight of the rails has risen from 18lbs. per yard to

24lbs., and then to 35lbs. per yard, which they are at present. Steel sleepers are used, as the old system of dogging the rails to ordinary wooden sleepers would not stand up to the heavier tubs. The gauge is at present 24in., but that will be increased also.

The lesson to be learnt from this development is that larger roads, larger tubs, and more substantial rails than have been usual are necessary if really intensive mining is to be adopted. That these conditions can be fulfilled by a courageous progressive policy has been shown by the Newbattle collieries.

It would seem that this consideration of large outputs is a travesty of the author's previous remarks concerning restricted output, but this is hardly so: for, as said, intensive mining or the production of large outputs of coal from small areas will undoubtedly increase, but whether it can be developed on a grand scale to the degree of skip hoisting as in America, it is very difficult to say at the present time.

In any case, however much may be learnt from the experience of collieries like the Newbattle collieries, they do show the gradual trend of successful machine mining.

This paper has been necessarily sketchy as it is impossible to describe fully every detail of the colliery taken as an example of a modern machine mining colliery, but the attempt has been to indicate the most interesting points. The author has to thank the Lothian Coal Company, Ltd., and Messrs. Mavor & Coulson, Ltd., also Mr. Haldane, Mr. Mackay, Junr., and Mr. Meek, the managers of the various collieries, together with the various officials, all of whom gave him every help in accumulating the information given in this paper. Before concluding he would, moreover, express his thanks to Professor Poole for his kindness in arranging the visit to Scotland.

Discussion.

CAPTAIN S. WALTON-BROWN said he was sure they were all very much indebted to Mr. Alder for his interesting address, and congratulated him on the thoroughness of his investigation into the mining practice of a Scottish colliery. The power of effective observation is a gift not conferred on everybody, but Mr Alder had certainly displayed considerable ability in the assimilation of the necessary detail and if, as Capt. Walton-Brown understood to be the case, Mr. Alder was about to be entrusted with the duty of carrying out a similar scheme elsewhere, they hoped he would be able to bring it to a successful issue.

Capt. Walton-Brown said he desired heartily to approve of and endorse pioneering work such as had been promoted by Newbattle. Doubtless some of those present would criticise the measures adopted on the grounds of the capital expenditure involved but, provided the necessary finance is available, he would never hesitate to expend sixpence if he felt assured that ere long one shilling would be returned to him. If mining costs are to be made financially sound, it will not be by a continuance of obsolete methods, and it is only those who keep in the van of progress who can aspire to reap the first fruits of any new and economic departure. One must admit, however, that a much more careful supervision of the more valuable materials employed (so that they can be utilised again and again) will be necessary if the utmost savings are to be realised.

He would be interested if Mr. Alder could supply a time study of the working of the haulage system from any group of four face units up to the point where the branch endless joins the main endless haulage: giving particulars as to:—

(1) Number of persons employed at each point.

(2)) Tubs per set on main and tail, direct and endless haulages, and the method of regulation of tubs and sets, with details as to tub reserves to be maintained at each point.

(3) The speeds, rope and drum sizes of each type of haulage.

(4) The method in which refuge holes are formed on each type of haulage road and how provision is made for the necessary clearance at points where tubs are coupled or uncoupled.

Mr. H. J. FISHER.—Everyone would agree that the intensive method of machine mining is undoubtedly the best to adopt, and one in which the output per man is increased and costs reduced. He was interested in what the author described as a co-partnership system, where every man on the face shares in the resultant output, and thought such systems were to be commended; they made everyone keen on helping in every way in order to maintain or increase the output.

He would also commend the methods of standardising the machines, so as to have a minimum of spares, and said he was very much in favour of the three-unit type of coal cutters in which the jib, motor, and haulage portions are distinct units for, with such machines, stoppages need only be of short duration.

He would like Mr. Alder to show the layout of four faces, and how these are advanced; also to show the gateways and describe the haulage arrangements and their position. Were there any double unit faces in use? If so, would Mr. Alder describe them. Is face lighting in use and, if so, has it tended to increase output? Mr. Fisher said he had been led to understand that where face lighting is in use, the output was increased by at least 15 per cent.

Mr. R. W. MANN asked Mr. Alder the sizes of the transformers that have been standardised at Newbattle. Also, have they naked lights there? Do they make any endeavour to collectively control their face conveyors and loaders?

Mr. TURNDULL.—Could Mr. Alder say what is the value of the spare parts?

Mr. McGEE said it would be interesting to have some idea of the number of machines and the size of the normal staff. He considered that there must be a very considerable amount of wear and tear.

Mr. ALDER (in reply).—In asking for details of haulage arrangements necessary to ensure clearance of the face day by day, Captain Walton-Brown has put his finger on the crux of the whole system, and to deal with this as he, Mr. Alder, would wish would take more time than was available.

Once the output capable of being expeditiously dealt with has been decided upon, and the length of face and depth of undercut fixed accordingly, after due consideration of all the conditions obtaining in the district, the problem resolves itself into dealing with a more or less unvarying output in a given length of time and yet allowing for minor stoppages. The usual outputs from the faces vary from 100 to 140 tons per day, and the number of faces delivering on to an intermediate haulage is determined by the capacity of that haulage. Generally ventilation plays a large part in the determination of the number of faces in a group. A typical number of faces delivering on to an intermediate haulage is three in the case of Newbattle, where the coal is all filled off in the one shift. The intermediate haulage at Newbattle is usually direct rope as the main and tail haulage to the face is arranged to be practically level. The output from the faces collects in the out-bye sidings common to each panel and is hauled to the main endless haulage.

In answer to the specific questions:—

Persons employed on the Main and Tail Haulage and Indermediate Haulage.

The numbers given are typical, but it should be understood that with varying conditions it may be necessary to increase or decrease this number.

Gate-end loader and in-bye siding	2 or 3 persons.
Out-bye siding and engine	2 persons.
Intermediate haulage and engine	3 persons.

The curves out of the main and tail levels are graded so that minimum handling of tubs is necessary.

A few extra persons are required for upkeep of roads throughout the sections.

Tubs per Set.

MAIN AND TAIL. The number varies according to the distance that the face has been carried forward and the amount of coal being dealt with. One ton tubs are used and the number may be 12 when the face has progressed some distance.

INTERMEDIATE HAULAGE. Same order as main and tail sets about 8—12, varying with supply, gradient, etc.

MAIN ENDLESS. Single tubs are clipped on.

Regulation of Tubs.

Sidings are provided at the junctions of the intermediate haulage and the main and tail levels in order to regulate the supply of tubs to the former.

Similarly sidings are provided at other junctions when required.

Tub Reserves.

Each unit face has an in-bye siding holding about 12—15 tubs, and this siding may be extended or reduced by varying the intervals between shifting up the crossing.

In addition, each unit face has an out-bye siding holding about 20 tubs.

Sidings are provided, where necessary, on the intermediate haulage.

Haulage Data.

Speed of Main and tail rope .... about 4 m.p.h.
" Direct haulage .... same order, varying.
" Endless rope .... $1\frac{3}{4}$ m.p.h

Size of main and tail rope .... $\frac{5}{8}$in. diameter.
" direct haulage rope .... $\frac{3}{4}$in. "
" endless rope .... $1\frac{1}{8}$in. "
" main and tail drum ...... Actually 22in., but as it accommodates 1000 fathoms of rope, much bigger in practice.
" direct haulage .... about 3ft. 6ins.
" endless drum .... 8 feet.

Refuge Holes.

These are formed in the ordinary way between girders except that the girders on each side of the hole are of heavier section (5in.×6in. instead of 5in.×3in.).

Clearances at Coupling Points.

These are provided in accordance with the C.M.A. at the side or in the middle. The roads are widened at these points.

In reply to Mr. H. J. Fisher: the general layout of the faces is seen in Fig. 1. With regard to haulage layout, Mr. Fisher might refer to the paper given by Mr. Carson before the Institute, Trans. I.M.E., Vol. lxx., part 4. The subject is too big to attempt to deal with it properly in this paper.

Double unit faces are used in the Great seam where the gradient is not so pronounced. The haulage arrangements are similar to those of the single units. The faces are generally shorter than the single units.

Face lighting has been tried in the Coronation Seam. The current is supplied by a transformer housed underneath the gate-end loader, which transforms the 500 volt supply down to 50 volts. Mr. Alder said he understood that the experiment had met with some success but was not able to give any figures showing effect on output.

In reply to Mr. Mann, Mr. Alder regretted he had not the electrical capacities of the transformers with him, but would have pleasure in answering the question by letter. There were, he believed, four standard sizes altogether.

Naked lights are used in most cases, but electric cap lamps are also used by machinemen and others on the face.

The L.T. supply to the faces is controlled by a main switch, but every unit has its separate circuit.

In reply to Messrs. Turnbull and McGee: Considering the amount of machine-got coal at these collieries, the cost of maintenance is very small. Standardisation of machinery and good organisation had reduced this cost considerably.

YORKSHIRE BRANCH.

Presidential Address.

T. H. ELLIOTT.

(*Meeting held 12th January,* 1929).

I esteem it a very great honour to be elected President of the Yorkshire Branch, and at the same time feel a great deal of diffidence in accepting the position; one reason being that I knew I was succeeding two former Branch Presidents whom I should find it very difficult to follow. In Mr. Roslyn Holiday who has been many times your President, and who has served you well not only locally but also in the Central Council of the Association, you have had a man particularly fitted for this position. His early training, I believe, took the form of a definite apprenticeship in mechanical and electrical engineering, and we all know that in his later experience he has applied those specialised qualifications at the collieries he controlled for so many years. He can be regarded really as one of the pioneers in the use of electricity underground, especially as applied to coal-cutting.

I know you all owe a great deal to him, and are sorry that he could not continue in the office he has so helpfully filled. Although we have already tendered him our thanks, I know you would like me on such an occasion as this to put again on record all that we owe to him.

Then, if that be true of Mr. Roslyn Holiday, it was in like measure true of your second Branch President, the late Mr. John Crawshaw, whose untimely death we all sincerely deplore, and regard it as a blow and loss not only to the mining industry of West Yorkshire, but to the country generally. He showed great promise of one day filling a place in the mining world which for so many years has been admirably filled by his honoured father. My connection with him goes back longer than I like to think. You may not know it, but it goes back to the days when he first left school; he was articled to my first chief, Mr. Maurice Deacon at Sheepbridge, at a time when I had completed two years or so of my apprenticeship, and he was sent to me to initiate him, not in mining knowledge, because he had that at home, but just in his way about, and in getting to know the people amongst whom he had been sent.

As you know, after that Mr. Crawshaw forsook mining for electrical engineering, and ultimately became head of the old Phœnix Dynamo Company; and so again, I say in him you had a highly specialised electrical engineer for your President, well qualified and admirably fitted for the job.

In your third choice I must at once confess that you have not been quite so fortunate, for I am purely and simply a mining man who has come through the hard school of practical experience. I am always glad that my wise and practical parent, however, saw that a part of it at least was spent as a working assistant to the electrician. Since then I have introduced electricity for the first time into three important collieries; one in its day claiming to be the biggest and deepest in Derbyshire and now another, the biggest I think, if not the deepest in Yorkshire. At the same time I should not dream of speaking on the highly technical side of electrical things or of imagining that I could claim in any way to be described as an electrical engineer. At the same time I have for 21 years been managing large collieries: none had electrical plant when I took charge, and it did fall to my lot to instal and get going two

1000 K.W. sets in one case, then again two 750 K.W. sets, and again two 1000 K.W. sets. At the moment I am undertaking a further 1000 K.W. set, with a prospective second, and a station link-up, together with all the innumerable details which a change-over involves in the way of drives; the installation of shaft and underground cables, distribution houses, underground houses, etc., so I think you will agree that of real practical experience I have had a share. That being so may I then speak as a colliery manager to colliery electricians.

No colliery equipment can to-day be considered complete without a supply of electrical energy, which it must either generate for itself or take from a supply station. Personally, I think, as coal values fall and as there is to be found at most collieries smalls, dust, slurries, crushed pickings, etc., which cannot be disposed of owing to the fact that superior smalls are much cheaper and more plentiful on the industrial market, that the tendency will be for more electric generation and increased boiler plants at the collieries in order to use up these inferior products more economically than in purchasing current from supply authorities who, if I am any judge, are not going to get their fuel given them in the future in the same way as has largely been the case in the past.

The progress in electrical usage which has already been made is full known to you all, and each year it plays a more and more important part in the maintenance of output. At one of my collieries for instance, every ounce of 4,000 to 5,000 tons a day (it used to be 6,000 until we were restricted) is hauled electrically so far as main haulages are concerned, screened on electrically driven plant, every ounce of smalls is washed in electrically driven washeries; over 1,000 tons a day washed for coke works, where again every oven is electrically charged and discharged into an electrically propelled car, sized and screened on electrically driven plant; every foot of gas from the ovens is exhausted by electrically driven exhausters and passed through the bye-product plant and, after stripping, is returned to ovens, the surplus being boosted to the gas works in the towns and district, and the remainder fed to gas fired tubular boilers, for which electrically driven fans are used for inducing the necessary draught for proper combustion, and from which steam to complete the circle goes for use in the turbines driving the generator.

Although we have mechanically cut and mechanically conveyed coal, and in-bye haulage, all driven by compressed air—in one section nearly 1,000 tons daily is never touched by man or horse after being put on the face conveyors—the compressed air depends upon electrically driven compressor plants. In addition to this, a large outside brick works depends entirely upon us for power and lighting.

Can you wonder then that when I go into the power house and think of the lines, sub-stations, transformers, and the 100 motors and of the various jobs they are doing, that I say to myself a lot depends on this: a stand here stops three shafts, and the work of nearly 4,500 men; and 4,500 men stood for one minute is equal to one man standing for 75 hours, or nearly two weeks' work.

Such is just one picture: there are many others which go to show how electricity can and has become the very life blood of the concern, at a place where five years ago there was none except for a supply purchased for the ovens; and it goes to show how the electrical part has grown to be quite the most important factor in connection with smooth and continuous running.

Who is looking after it? You will agree that it is no longer the job of the type who used to be described as "a fool with a pair of pliers." It has got beyond that, gentlemen, and it has also, in most cases, got beyond the wonderfully useful servant we are all familiar with and have a great admiration for, the colliery enginewright. He has and does continue to play a very important part, and I have not anything but praise for him, and generally regard him as one of the most wonderful institutions the coal trade has ever possessed. Sometimes I think—and here I know I am on rather thin ice—yet sometimes I think it has got beyond the average type of colliery engineer, and I am coming to the conclusion that in the future that post will need to be filled by a man of very wide and highly technical training; one who, in other words, has got to be almost first and foremost an electrical engineer. If he be wise, he will take steps to equip himself with such knowledge and experience as will enable him to lay claim to that designation and capacity.

In point of fact, so interwoven and interdependent are becoming what have in many cases been regarded as two departments, that I fail to see how eventually they can but be merged under one control. It is so difficult, for instance, to go into a power house and say that somewhere between the turbine and the alternator the one man stops and the other man starts; or that in every motor house one man finishes at the driving pulley, and the other starts with the belt. So, whilst I give the above advice to the engineer, at the same time my advice to the electrician is likewise to equip himself with all the knowledge and experience he can possibly obtain in the ordinary mechanical colliery engineering direction. Perhaps his is the easier task. So much then for the importance of electricity and the electrician.

RECORDS AND MAINTENANCE.

May I now proceed to give from a colliery manager's point of view what I think are a few essential points for the proper supervision and maintenance, and records of such a plant as I have described. First of all in regard to the power house. I would like to have taken you to the boilers, but for the present we must leave that to its proper department. In the power house there must be a complete log, recording all essential details and information. Every half hour, for instance, there must be recorded all electrical meter readings, all temperatures of bearings, inlet and outlet air, temperatures of condenser water before and after cooling, readings of vacuum and steam gauges, tachometer reading, particulars of oil added and filtered. All these should be entered by the attendant, even if, as in many power houses, recording instruments are installed: for the reason that it does ensure the attendant taking a regular and an intelligent interest in every part of the plant, and further it preserves in lasting form a record of the performance and behaviour of the plant; a record which is very often of great value for future reference, enabling responsible officials to see exactly not only what is happening, but to put a finger upon some deterioration or irregularity. It is of great value to know, by reference to past readings, exactly when a trouble or defect began to show or develop, and often in this way to get a clue as to the cause. The sheet we use is made up in book form and lasts two years. It is examined and signed each day by the responsible official, and so the electrical and mechanical engineer in addition to having recording charts before him, is kept in daily touch with the power house, and on his visit can see at a glance exactly what has happened both in the way of load and general performance of the sets.

The next thing is to ensure the prescribed daily supervision of all electrical apparatus above and below ground. Of course, opinions may differ as to exactly what this entails. In my case I construe it to mean that every motor controller, for instance those underground and also those on the surface which are constantly stopping and starting, is to be opened out, the contacts thoroughly examined, any pitting removed, and a thorough examination made of all other parts. Every slip ring cover is opened up and the rings and brushes attended to, and any dust removed; every motor is then blown out, for which purpose perhaps we are especially fortunate in having a supply of compressed air, which in each motor house is passed through a small separator to ensure dry clean air. The assistants who are responsible for this work have just to carry a small flexible hose, which attaches to each of the separators. This work is done on the night shift, and is recorded in a Report Book, together with any particulars of defects which may have been found and also a report as to the condition of the oil and oil rings.

In addition to this daily inspection by the electrical staff, the attendant or driver of every motor is required at the end of the shift to call and report if anything unusual has developed. That provides, I think, for the daily supervision.

Then, each month the air gaps of every motor are measured and recorded. Periodical insulation tests are made, and the arrangement is designed so as to cover the whole system every three months at the least, and the results are all recorded in a special form. Of course, where the alternators run continuously twenty-four hours a day and for seven days, as far as the ovens are concerned, special shut downs have to be arranged for the purpose, and then opportunity is also taken to make continuity and resistance tests of cables and bonding, which are also recorded on special sheets. Then, according to the circumstances under which each motor works, it is at convenient times dismantled and thoroughly cleaned and painted with good insulating varnish.

Another important matter is the care of the shaft cables upon which, bear in mind, the whole of the underground work depends. In my particular case the shaft conditions are not good; it is an upcast shaft with a good deal of acid ladened moisture, and consequently we have arranged that the cables are cleaned and painted at least four times per year to ensure the removal of any accumulation of dirt or salt, which so quickly forms. It is common knowledge that the weakest part of a shaft cable is where it enters the various insets, and here it is always advisable to fix a substantial shield well run with compound.

Then another point, I think perhaps the most important, is the way electrical equipment is housed both above and below ground. Too good a job in this way cannot be made. It may be in the first place expensive, but it pays in the long run. The electrical gear is expensive, and we must admit and gratefully acknowledge that manufacturers generally go to infinite trouble in regard to design, manufacture, and appearance, and it is worthy of a decent house, substantially built and cleanly kept. Nothing to my mind induces more to personal negligence and carelessness than wretched conditions, and conversely the better the provision made at the outset in this direction, the better the attention, interest and efficiency.

Whilst this is true about housing, I cannot too strongly emphasise the necessity for the greatest care in the running and suspension of cables. This is where the chief danger lies in electricity below-ground. However well protected your circuit may be with leakage trips, there is danger, I know from experience, of open sparking and fire, should a cable be cut between the sharp corner of a girder or masonry in the event, for instance, of a fall or similar upset. Pay very special care to the run of the cables and their suspension and protection: remember they contain what my father used to describe as "hell fire bottled up," and with that released in the presence of a very small percentage of gas and coal dust, you have all the ingredients for a really first-class disaster.

Much yet needs to be done in making electricity safe for mines. At the same time we have rather shamefully to admit that the majority of accidents have arisen through carelessness and lack of ordinary attention. Work is, I am interested to learn, being done and I think patents have been taken out in connection with a device which looks like providing added protection in the case of an outburst of gas. Mr. Ringrose is developing his electric gas detector in such a manner as will enable a simple device to be attached in each circuit, which will automatically shut off the current whenever the pre-determined percentage of gas is present. I look forward very interestedly to the further results of experiments now going on, and to the effect such an invention is likely to have upon the question generally.

Now, lastly, have a good earthing system: this is the spine or vital cord of the whole system. Insist upon a thoroughly sound job, complete with an earthing panel which allows the plates being tested at any time, and have ohmic resistance taken and recorded daily. In conclusion I would direct specific attention to the circular issued by Mr. Walker recently, and suggest that it be very carefully considered.

NORTH WESTERN BRANCH.

Control Gear for Coal Face Machinery.*

Discussion.

CAPT. MACINTOSH said the paper by Mr. Rea opened up quite a new field for mining work. He rather liked the name "portable sub-station," but would advise them not to take undue liberty with the word portable. The Mines Department only recognises as portable, apparatus which moves under its own power, such as a coal-cutter. This sub-station did not do that, and could not therefore be classed as portable within the meaning of the Act.

The author had mentioned the difficulty of getting sufficient space for apparatus underground. It was quite true that most colliery managers objected to giving the engineer all the room he desired, but on the other hand, his experience had been to find the managers always ready to listen to reason, and amenable to persuasion in this respect.

Mr. Rea had rightly emphasised the importance of the earth circuit being O.K.; the colliery electrician of to-day realised that point, and was as careful with his earth circuits as with any other part of his plant.

Capt. Macintosh said he could not agree with the suggestion that leakage protection should be made compulsory. With a big installation already at work, it would take quite an appreciable sum of money to equip each and every circuit with leakage protection. Whilst altogether in favour of leakage protection, as for any device which tends to make the plant safer, he was not in favour of compulsory leakage protection, because there were some circuits which he had in mind where the possible advantage of leakage protection would not justify the cost.

With regard to the ease with which it was said the portable sub-station could be moved about, he was doubtful whether that would be such a simple matter as the author would have them believe.

Regarding the dispensing with the services of an electrician for disconnecting and changing over—it would all depend on what the author meant by that expression. True, it should not be necessary for an electrician to be in attendance to take a plug out, providing the apparatus was more or less "fool proof," but if it was meant that the portable sub-station could be moved to a new position without the supervision of an electrician then, said the speaker, they were probably "standing on thin ice." Reg. 131c deals with the duties of an electrician, and sub par 2 states "the examination and testing of new apparatus, and of all apparatus re-erected in a new position in the mine, before it is put into service in the new position." It would appear therefore that if the portable gear were to be moved only ten yards or less, an electrician must examine and test the apparatus before it is again set to work.

Another matter of interest is the approximate cost of the apparatus. Capt. Mackintosh went on to say that he liked the idea of the combined transformer relay, but as he knew little about it, he would prefer to have further particulars before expressing a definite opinion. At a first glance, however, it looked very promising and quite a new feature.

* See *The Mining Electrical Engineer*, Jan. 1929, p. 243

Mr. J. H. THOMAS commended Mr. Rea upon having kept to one specific design and arrangement in contrast to many authors whose papers roamed over wide areas embracing many subjects. With regard to the little motor generator set, and speaking as a manufacturer, he welcomed new ideas but in this case there was not the new departure one might imagine, because in practically every power station to-day motor generators and storage batteries are installed for the operation of the large oil switches, relays, trips, and so on. That might be one of the things helping to justify the name of "portable sub-station," and he had no doubt it could be made a reliable piece of apparatus when it is considered what motor car starting and lighting machines can stand.

The combined transformer relay seemed to be such a good idea that one wonders it had not been put into practice or tried out before. It would certainly be very interesting to see it in practice.

Mr. HUGHES remarked that as a mining man he had been quite electrified by the ideas put forward by the author. He would not recommend putting the portable sub-station at the main gate end; his experience led him to think that the proper place would be to put a secondary gateway ten or twelve yards away parallel with the main gateway, and that this gateway or cable-road should be cut off every twenty yards with openings between the gateways, to avoid the cost of up-keep for a long length of road. This would not require any appreciable expense, as the dimensions of the portable sub-station are only very small. The main gateway ripping end with its shot-firing and the tubs being man-handled on landing plates would not lend itself to safety from damage to the portable sub-station and cables. They were all aware that with electric power used at the coal face every precaution must be taken.

Mr. SPRAY liked the idea of the portable sub-station but did not think the position suggested by the author was a suitable one. These small machines were so well made that there was no reason at all why the rotary converter described by Mr. Rea should not be a success. He agreed that the direct current was much better for working the operating coils than A.C. current. It was a practical paper, and by confining himself to one thing the author had made his points quite clear.

Mr. B. E. JONES said he presumed the system described by the author to be a fully insulated one, and if so could not the voltage be increased for the operation of the contactor relays (i.e., within limits of safety from shock)? That would result in a smaller percentage volt drop on long lengths of cable, and ensure a more satisfactory operation of the relays. The use of a rotary converter provides a very interesting departure and without doubt a very good one, since it provides D.C. current, thus ensuring a more definite operation. But, whilst admitting the benefits to be derived from the use of D.C., the rotary does not provide as reliable a source of supply as would a static transformer on an A.C. supply.

With regard to the transformer relay, he failed to see why there should be the great disparity which the author claimed between this and the Merz-Price system of leakage protection. It also possessed the disadvantage as in all core balanced systems—that it would not operate with a leakage on two phases. Consider a three-phase star connected earthed neutral system: it was quite as feasible to obtain a leakage on two cores to earth as on one core to earth, those leakage currents would cancel out in the transformer relay core which would thereby remain inoperative.

Mr. A. M. BELL (Branch President), congratulated Mr. Rea upon having brought forward an equipment containing several novel features; the very name "portable sub-station" was interesting and compelling. Mr. Bell thought the author had rather laboured the point regarding the provision which colliery managers would make for apparatus, although it was possibly true that some might have to be educated to understand that the plant must have suitable accommodation. While the efficient operation of the D.C. contactors was undoubted he would suggest that trouble due to variations in voltage, even with A.C. contactors, was not so serious as the author would make out, unless there were conditions where actually the machines ought not to be run.

Capt. Macintosh had raised the point: why have earth leakage? When one considers the great risk with portable and semi-portable machinery, and that the risk is brought to the coal face, Mr. Bell said he was firmly of opinion that faults when they do arise ought to be eliminated at the minimum current possible, and that earth leakage protection was certainly a step in the right direction. One disadvantage of such equipment as described in the paper was the multiplication of parts which had to be maintained. Every day it was brought home to them that they must trust the human element, and therefore simplicity ought to be the key note. Against that it was necessary to have automatic increased safety and control gear such as Mr. Rea had described made a very strong appeal.

A very novel feature was the one ampere primary trip. It was hardly possible to conceive a leakage current of one ampere in normal practice. Instantaneous values may be much greater, in which case the ordinary core balance transformer would operate.

Mr. Rea had mentioned a case where it would be imperative to have three overloads. Under present conditions he had suggested that the relays were sometimes inoperative with apparatus fitted with two overloads, and one leakage trip. He, Mr. Bell, said he hoped Mr. Rea did not suggest that any electrician would wittingly work under such conditions unless three overload trip coils were fitted.

Mr. REA, regarding the question of room, said that in mines between 800 and 900 yards deep there is a tremendous roof pressure to contend with, and it is very difficult to maintain insets and wide roads. It was with that in view that he proposed placing the portable sub-station in advance of the empty tubs, as that was the only space available in a road only two tracks wide.

As to the compulsory use of earth leakage devices, Mr. Bell had dealt at fair length with this, but the general opinion amongst mining electrical engineers was that earth leakage should be adopted if the system has an earth neutral, and a protective leakage device could be supplied which was a simple and robust piece of apparatus.

CAPT. MACINTOSH said he wished to correct an impression which seemed to have arisen. What he had objected to was the word "compulsory."

Mr. REA said he would make no further comment on compulsion. With regard to portability, the sub-station he had in mind weighed between 4 cwt. and 5 cwt.; so from a mining point of view it was not difficult to move about.

Regarding the presence of an electrician during the change-over of the mining machinery, if it was only a case of withdrawing a plug to disconnect for the purpose of advancing a set of face conveyors and to move the loader, there was not much object in sending for an electrician, or having one travelling all over the pit for the purpose of withdrawing and inserting cable plugs. It did not require much skill to insert a pin into a socket and screw it up, in fact the whole object of using plugs was to have a simple form of connection so that the ordinary mining man could perform the necessary operation.

With reference to cost, he might say briefly that he would be very pleased to supply a large number of portable sub-stations at the price of £188 per set, suitable for the control of four motors.

The pliable armoured cable, as far as he knew, had not been used for coal-cutters and it was only recommended for what has been termed semi-portable plant such as conveyors and loaders. For coal-cutters it was generally agreed that the ordinary cab tyre sheathed cable was a better type. The pliable armoured cable as a supply cable from the straight-through joint box to the portable sub-station was permissible, but he very much doubted whether it would be desirable for coal-cutter service owing to the possibility of constant rubbing causing fraying of the pliable armouring.

Mr. Rea, continuing, said he did not think there was anything in the wording of the Act or in the application of switchgear for mining machinery that prevented dispensing with the services of an electrician when changing over. He believed that was being done every day. At one colliery he had in mind, where there were something like 26 to 30 machine worked faces, they had one shift electrician about the pit, and if he had to attend to the dis-connection of plugs and sockets for all the change-overs, he could not walk half the distance, let alone do the work.

He was glad Mr. Thomas could see eye to eye with him on the motor generator; one of the strong points to advance when people said they did not like the idea of a motor generator in the portable sub-station was, "What have you got on your motor cars"?: it is to-day easy to obtain a motor generator set very robustly built that will stand up to a considerable amount of ill-usage and still be very reliable.

On the question of insets, on a rapidly moving face advancing at least a yard every day with the resultant frequent changing over, insets do not lend themselves very well to the method of working; and again, to have an inset 20 or 30 yards from the face means having a number of trailing cables which the empty tubs will run alongside and possibly damage.

Mr. Jones had asked "Why restrict the voltage of the control circuit to 25 volts"? The local earth circuit is necessary to obtain electrical interlocking of the plugs, and 25 volts is the maximum permitted. That condition was clearly stated in the Regulations, and the 25 volt circuit is to all intents and purposes a bare earth circuit.

Regarding A.C. solenoids, he would say that experience had taught him that A.C. contactor solenoids were very difficult pieces of apparatus from an efficiency point of view. The margin was very small and with them it would be considered quite good to get successful operation at 70% of normal voltage; and even at that voltage the contactor would chatter rather badly.

Very often there was a considerable voltage drop at the face, below that on which the apparatus was designed to operate on; that, coupled with the drop in voltage due to switching on would cause the contactors to release, if not to open entirely, and if the armature were not bedding on the magnet face there would be very little pressure on the contacts and might cause the contacts to weld together. If the contactors actually opened on the fall of voltage this would cause the contactor to close again and it would make four or five attempts before it finally settled down.

Regarding the reliability of the rotary transformer, he would point out again the successful application of generators on motor cars, and also the general application of the rotary transformer in charging stations for batteries, where they are running day in and day out with practically no attention. He would point out at this stage that the rotary transformer he proposed to employ had a definite set work to do, that was, to energise a certain number of coils each requiring a definite number of watts, so that in its application the rotary transformer could be overloaded. From a reliability point of view, he believed it would be just as efficient as a static transformer which, of course, was a very reliable piece of apparatus. It was, however, not a question of comparison between rotary transformers and static transformers, but a comparison between direct current operated contactors and alternating current operated contactors, and he would much prefer the smooth running of a rotary transformer on ball bearings, at 1420 r.p.m. on a 50 period circuit, than a large A.C. magnet chattering at 3000 times per minute on a similar supply.

With regard to leakage current, he was fairly well acquainted with the various forms of earth leakage protective devices, and the usual standard was 5 per cent; but if a guarantee were definitely wanted the figure would usually be up to 10 per cent., and that percentage generally carried a definite relationship to the capacity of the apparatus and not to the load which the apparatus was handling.

The sensitivity of the core-balance earth leakage such as he had described was obtained by reducing the iron losses of the apparatus to a minimum, and the device operated at a low value because the flux created by the leakage to earth was directly employed to operate the contacts. In the usual arrangement, an induced current from a secondary winding was used to operate the relay and it was in this transforming of flux to current in the transformer and current to flux in the relay magnet that the losses occurred.

In reply to Mr. Bell, the question of accommodation was again a matter for the mining people to decide.

As to maintenance, Mr. Rea said his idea of the arrangement of a portable sub-station was to make it so that the internal parts could be easily removed for examination, and at the very worst the whole portable sub-station could be readily disconnected from the supply cable and sent out of the pit; owing to its compact form that would be a very simple and easy matter as there were not a number of miscellaneous switches to be disconnected from joint boxes and similar details. This was one of the strong points he claimed, that not having a miscellaneous collection of joint boxes and switches there was not the same possibility of failure, as very often troubles occurred due to faults developing in the constant disconnecting and making up again of joint boxes and gate end switches.

With regard to overload protection in two phases, he agreed that if the earth leakage device were out of commission then overload protection in two phases was not sufficient. Whether three overloads were provided or not was a question for the buyer. Three certainly were necessary if the earth leakage device was out of commission, but when the earth leakage device was efficient and well constructed there was no reasn why more than overload protection in two phases should be provided.

Mr. HEYES.—The author had given the dimensions of the portable sub-station as 4ft. 6in. long by 2ft. wide by 16in. high. Does that allow of the inclusion of the rotary transformer?

Mr. REA.—Starting at the front end, on the outside of the case is the gland for the incoming main cable. Inside the case there would be contained an isolating switch to deal with the whole of the supply to the portable sub-station, the rotary transformer, the earth leakage protective device and the four triple pole circuit breakers with overload relays. In other words, the dimensions shown include everything required to protect four motors against over-load, no-voltage, earth leakage and the provision for main isolation, and give remote control as required.

Mr. HEYES.—What is the capacity of the switches?

Mr. REA.—100 amperes. Circuit breakers of 100 ampere capacity and a main switch of 200 amperes capacity. There is one earth leakage to protect all four motors, so that earth leakage on any one would cause the tripping off of all the circuit breakers in the sub-station. Separate earth leakage devices could be provided for each circuit breaker, but that was purely a question of arrangement as to whether additional accommodation had to be provided and the user was prepared to pay for it.

Mr. SPRAY.—In the event of an earth on one of the conveyor motors could that motor be cut out and the others worked?

Mr. REA.—Yes, it could be isolated by detaching the plug; the earth leakage would then be re-set and the operation carried on.

Mr. SPRAY.—That is without an electrician going to re-set it?

Mr. REA.—Yes, if the re-setting button be left available for the deputy or someone in charge to re-set it. If it be locked up it would be the electrician's job. As coal-cutter trailing cables cause the most trouble due to the insulation becoming damaged and the main core getting on to the earth conductor or pilot wire and so causing earth leakage trips, it would be a very simple operation to isolate the damaged trailing cable by withdrawing the plugs from the sockets and so remove the cause of the earth leakage.

Mr. JONES.—How do they go on with leakages of equal capacity in two phases?

Mr. REA.—That would be taken care of by the overload trip devices as such circumstances would be equivalent to a short circuit between phases.

Mr. A. M. BELL (Branch President) said they were very much indebted to Mr. Rea for his valuable paper and for giving them the advantage of his experience and technical knowledge. It was fortunate that they were able to persuade such people to come forward and give papers of that kind. Although they differed in opinions they were bound to learn something which would help them in their duties.

WARWICKSHIRE & SOUTH STAFFS. BRANCH.

Visit to the Cannock Wood Pit.

On November 1st last the members of the Warwickshire Branch were accorded a welcome by the Cannock and Rugeley Colliery Co., Ltd. With the permission of the managing director, Colonel R. S. Williamson, the Cannock Wood Pit was visited and members were escorted by Mr. I. T. Dixon and Captain T. V. Peake to view the electrical equipment installed. Exceptional interest was shown and keenness aroused by the modern development of electric drives and transmission at this colliery, and also by the general use of scientific apparatus. The visitors were further entertained to tea at the very kind invitation of Captain Peake and later were interested in a paper read by Mr. Dixon who, in addressing the meeting, fully described the equipment previously inspected.

Many lantern slides were projected to illustrate the paper and an energetic discussion ensued.

Ⓟ The Electrical Plant of the Cannock and Rugeley Collieries.

I. T. DIXON.

Previous to 1925 the electric system at the Cannock Wood Pits was direct current at 400 volts, power being obtained from steam driven generators of 400 K.W., 200 K.W. and 150 K.W. respectively.

The system at Wimblebury and the Valley Pits was 650 volts, three-phase, 50 cycle, insulated neutral; the current being generated at Wimblebury by 350 K.V.A. and 112 K.V.A. steam sets and carried by means of a three wire overhead transmission line to the Valley Pit.

About seven years ago the Cannock Chase Coal Owners sought advice as to whether they should have their own central generating station to supply all their collieries, or whether it would be preferable to take a supply from the Local Authority when available.

Eventually the Cannock and Rugeley Colliery Company arranged to take a supply from the Cannock Urban District Council at 6,600 volts at the Valley Pit where it was transformed to 650 volts for service above and below ground.

A 6,600 volt, three wire, 750 K.V.A. transmission line was erected between the Valley and Wimblebury Pits, a distance of about 1200 yards, and a similar line was erected between the Valley and Cannock Wood Pits, a distance of about 2,500 yards. In course of time a line will be erected between the Cannock Wood and Wimblebury Pits to complete the ring.

The spans of the transmission lines are generally about 200 feet, and the copper is 7/.106, .06 sq. inch section: the lines have overload and core balance leakage protection and the supply neutral is solid earthed.

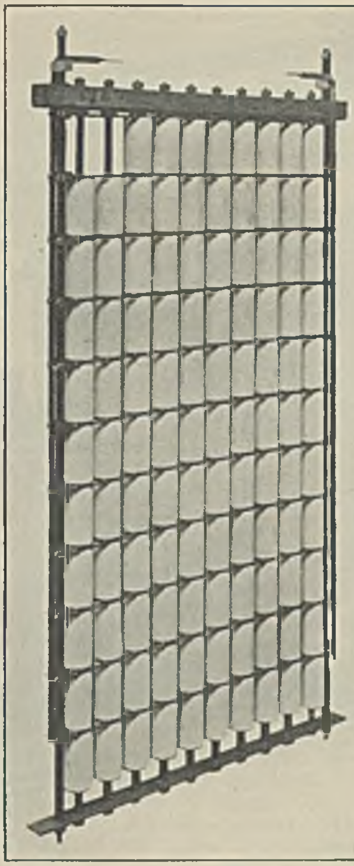


Fig. 1.—Rack of Condenser Spools.

At the Cannock Wood pits, 6,600 volt cables are taken to a sub-station underground where duplicate 500 K.V.A. transformers transform the supply down to 650 volts, at which pressure the motors are supplied.

On the surface at the Cannock Wood pits and at Wimblebury the transformers are somewhat unusually arranged. Three single-phase units, on similar lines to the usual design of draw-out switchgear, are arranged to run on rollers up to a bus-bar chamber and to couple up by means of plug contacts. In case of a breakdown of one phase a spare transformer can be run into place in two or three minutes. One spare transformer thus serves to cover both the Wood and Wimblebury pits. The overall cost came out much better than would have been the case with a three-phase spare and the single phase spare is very easily handled. The rating of the three phases is 350 K.V.A.

At the Cannock Wood pits the transformer secondary neutrals are solidly earthed. All the transformers are delta-star connected.

All the switchgear controlling the 6600 volt circuits is of Ferguson, Pailin make: it is of the fully interlocked, draw-out, metal-enclosed type. The Valley switchgear consists of five panels controlling, through oil circuit breakers, duplicate 500 K.V.A. step down delta-star transformers and the overhead lines to Wimblebury and the Cannock Wood pits. The usual meters are fitted, including unbalanced load watt-hour meters and power factor meters. The transformer panels are fitted with direct acting Merz-Price circulating current protective gear, with fuses in the pilot lines to protect against sustained overloads, and kick fuses to prevent inadvertent operation of the protective gear due to the magnetising current rushes induced when switching transformers in.

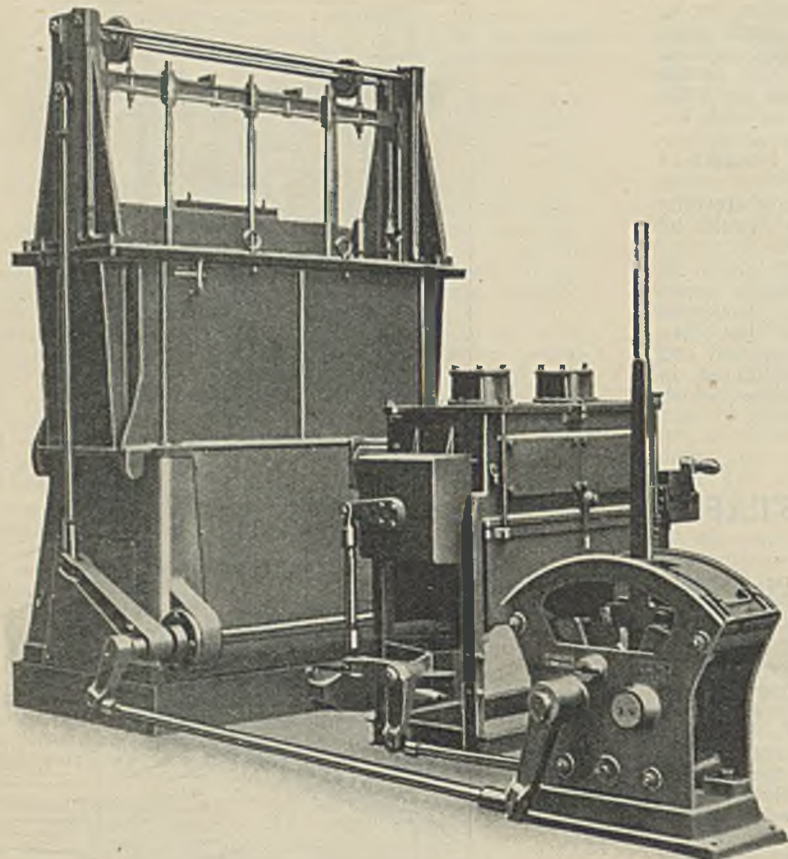


Fig. 2.—*Liquid Reversing Haulage Controller, with Gate-change Lever Operating Gear.*

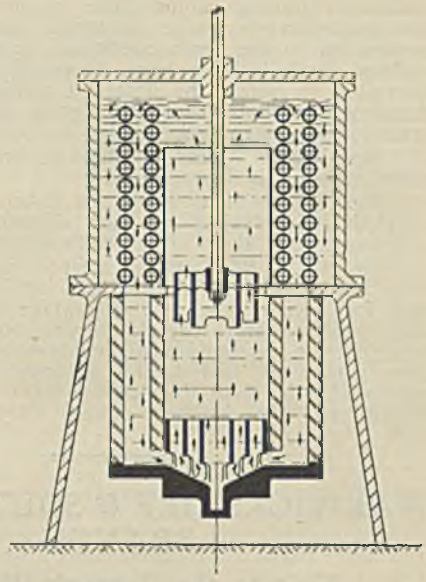


Fig. 4.—*Cooling System.*

The main 650 volt switches, also by Ferguson Pailin, are similar to the 6600 volt in construction. All the feeder switches at the Cannock Wood pits are equipped with instantaneous leakage relay trips which are adjustable from 4% to 10% of full load current. The overload trips are adjustable from 75% up to 200% of full load with time lag up to 30 seconds.

Owing to the fact that the current is charged on a K.V.A. basis it was necessary to endeavour to keep the power factor as high as possible and also the load factor. For improving the power factor there is a 113 K.V.A. G.E.C. condenser at the Valley pit sub-station and a 90 K.V.A. condenser underground at the Cannock Wood pits. These condensers are suitable for 650 volt supply, and by their use, on the normal full load of the colliery plant, an overall power factor of 94% is maintained. The illustration, Fig. 1, shows a rack of condenser spools.

Owing to an arrangement by which the load such as pumps occurs on the afternoon shift and a motor driven air compressor is driven at night, the effective

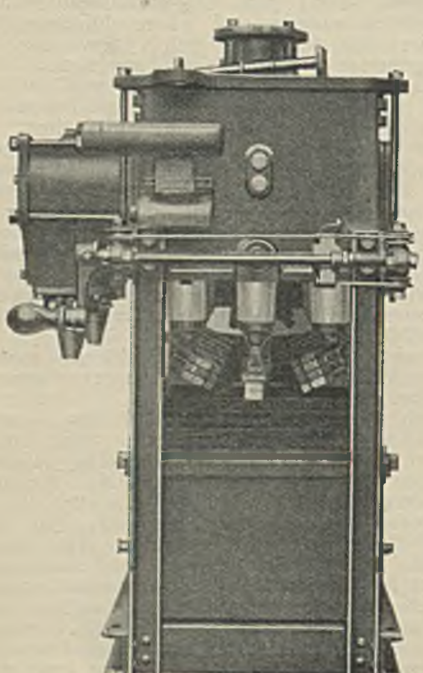


Fig. 3.—*Oil-immersed H.T. Stator Reversing Switch.*

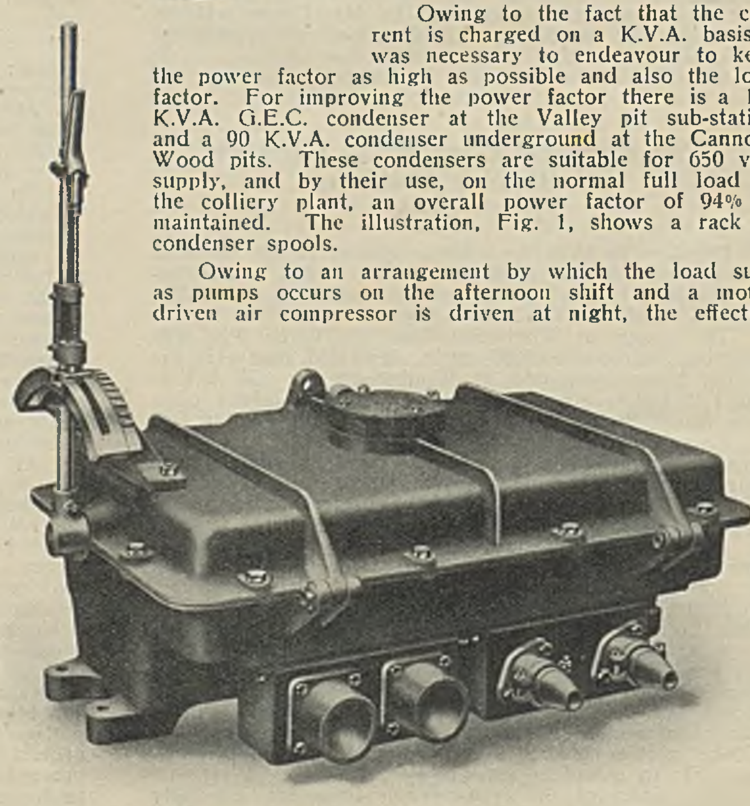


Fig. 5.—*Oil-immersed Reversing Controller: closed.*

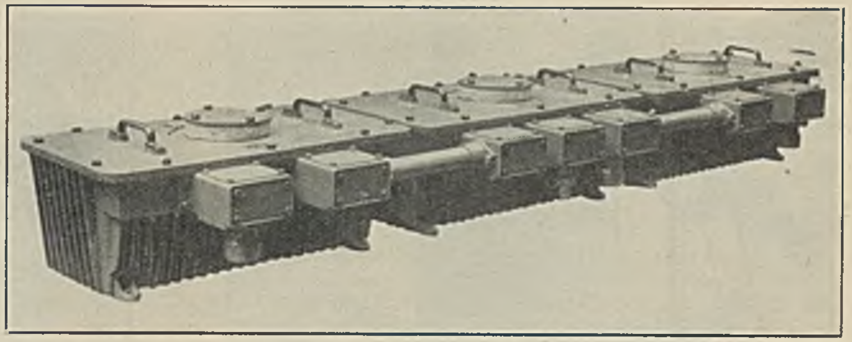


Fig. 7.—Bank of Air-cooled Resistances.

load factor is about 34%. This is of course improved when the collieries are working more regularly than at present.

The motor driving the air compressor is an auto-synchronous one made by Messrs. Crompton and developing 425 H.P. when running on a 6600 volt, three-phase, 50 cycle supply; speed 600 r.p.m., overload capacity 25% for two hours, 50% momentarily. The full load efficiency of this motor is 93%. The stator coils of the motor are insulated with moulded mica wrapped round the coils hot and the terminal coils are specially reinforced to withstand switching surges. It has a heavily insulated bar wound rotor which was tested to 4,000 volts. The stator was tested to 14,200 volts. The machine is entirely self-synchronising and will start against twice full load torque and synchronise against 1½ times full load torque.

The motors throughout the plant are generally of the English Electric Company's make; the largest haulage motor is of 150 horse power. The largest squirrel cage motor is one of 120 H.P. by the British Thomson-Houston Co., which drives a circulating pump.

The mining pumps are all, with one exception, of Mather & Platt's make, and are up to 220 gallons per minute capacity against a manometric head of 700 feet. The starting gear is of Messrs. Ellison's make.

The control gear for the haulage motors is generally of Allen West manufacture. Motors up to 100 H.P. are equipped with metallic resistance controllers, and the 150 H.P. motors have liquid controllers. Fig. 2 shows an Allen West liquid controller with stator reversing switch. It is capable of dissipating 55 H.P. continuously, being cooled by means of a circulating pump driven off the haulage drum shaft; the circulating water is contained in two tanks totalling about 600 gallons capacity. The quantity of electrolyte is 47 gallons and is a soda solution. Fig. 3 shows an end view of a stator reversing switch with tank lowered; Fig. 4 shows the circulation of the electrolyte.

The illustrations, Figs. 5 and 6, are of an oil immersed flameproof drum type reversing controller. These controllers have trip contacts arranged so that lifting up the lid trips the circuit breaker, if not already "off"; also the circuit breaker cannot be put "in" unless the controller is in the "off" position. These fittings were provided on the score of "Safety First."

Allen West oil-immersed flameproof resistances are used on the 25 H.P. haulage motors. There are numbers of these placed well over a mile in-bye. The air-cooled resistances, of which a bank is illustrated in Fig. 7, are used near the pit bottom.

Flameproof circuit breakers, by Allen West, with leakage protection, are installed in-bye for the protection of branch circuits: the bus-bars form part of the main, and the switch protects the branch feeders to the coal cutters and small haulages. The rupturing capacity of these switches is 6,500 K.V.A. The overload trips can be set from 10% to 200% O.L.; the time lag can be adjusted between 10 secs. and 30 secs., using standard switch oil, and it is independent of the overload setting. The leakage trip functions on 10% full load.

Gate-end switches with Williams-Rowley protection as made by Switchgear & Cowans have been adopted for the A.C. coal-cutters. Fig. 8 shows the general appearance of the gate-end switch, and Fig. 9 shows another pattern of the switch with its tank lowered. The diagram of connections is shown in Fig. 10. With the feeder switch equipped with leakage protection and the gate-end equipped with Williams-Rowley protection, it would seem to be utterly impossible for anyone to receive an accidental shock.

In all there are fourteen coal-cutters in use, as well as face conveyors and a sectional conveyor: this means that the vulcanising bath is kept in fairly constant use for the economical and effective repairs of trailing cables.

Ellison gate-end switches and plugs, Figs. 11 to 15, are used on the D.C. coal-cutter system.

There are some ten miles of underground armoured cable which has given very little trouble other than

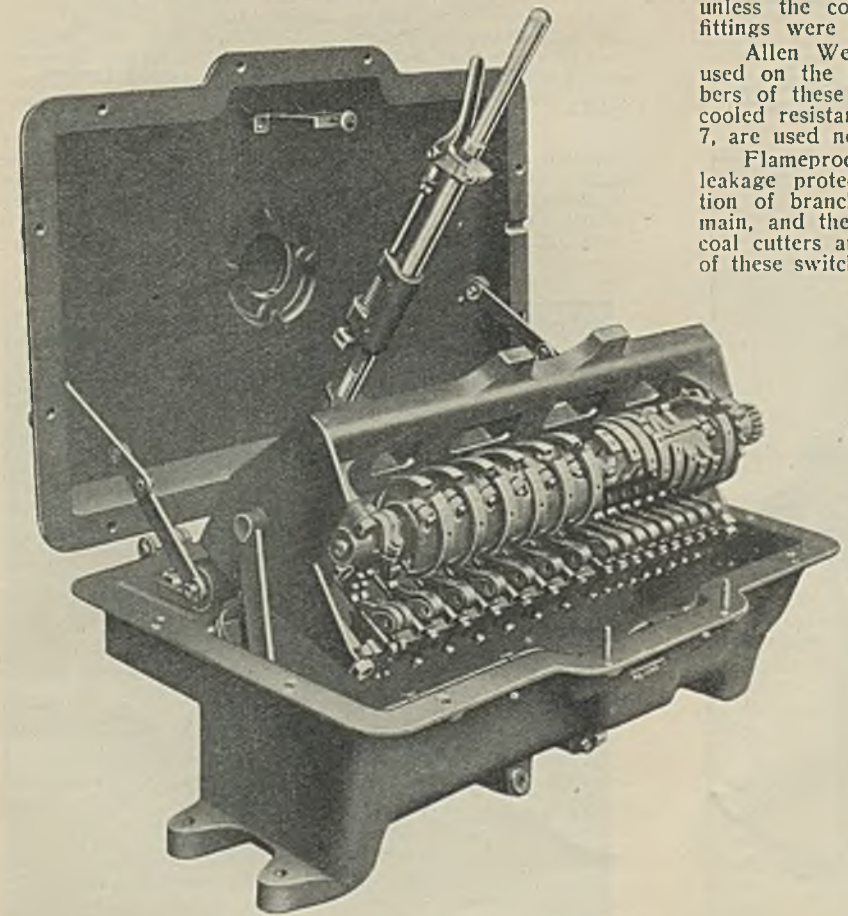


Fig. 6.—Oil-immersed Reversing Controller: open.

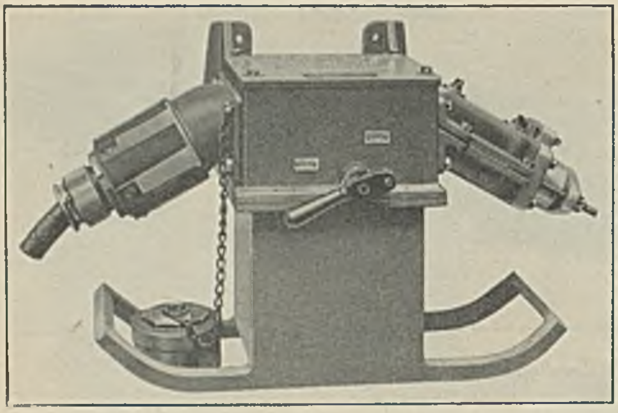


Fig. 8.—Gate-end Switch.

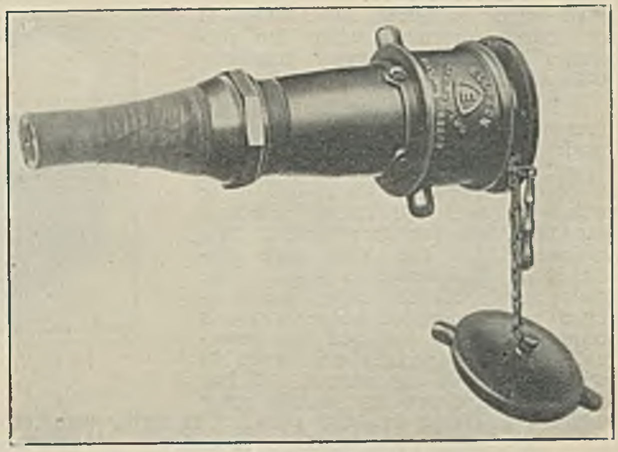


Fig. 11.—The 0.06 Cable Plug and Socket Connector.

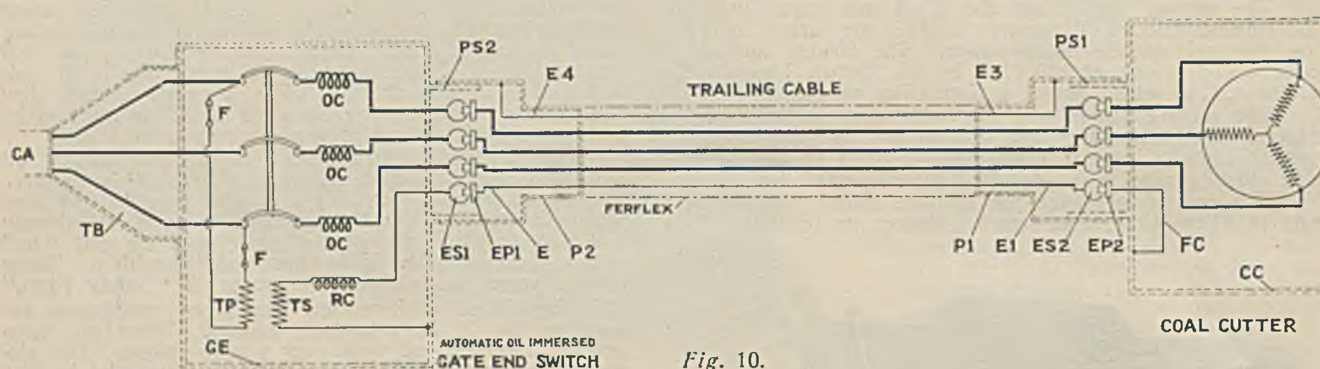


Fig. 10.

renewal of slings and an occasional coat of tar. All the cables on the surface and near the pit bottom are paper lead D.W.A. Maconite cables are used in-bye: in the shafts there are both paper and bitumen. All the 6600 volt cables are paper insulated. The largest three-core

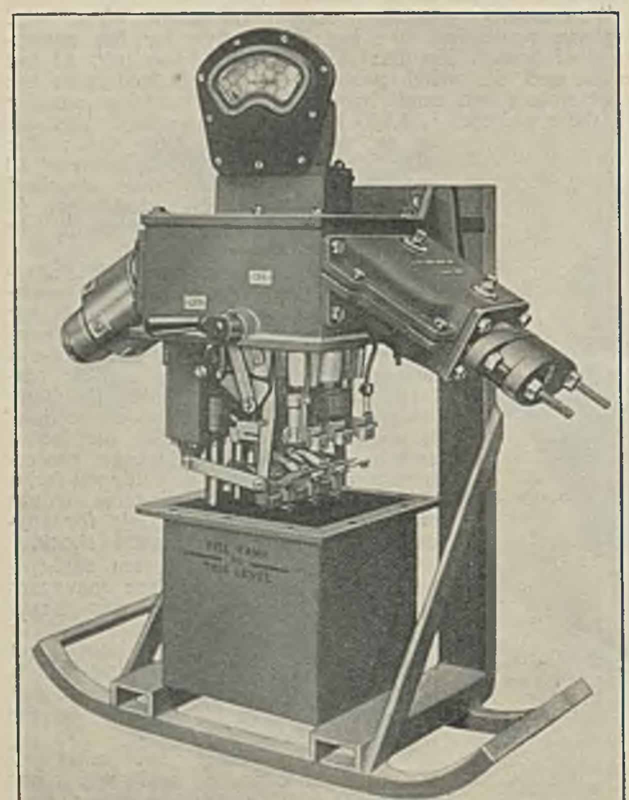


Fig. 9.—Switch with Tank lowered.

Fig. 12.—Circuit Breaker at the Gate-end.

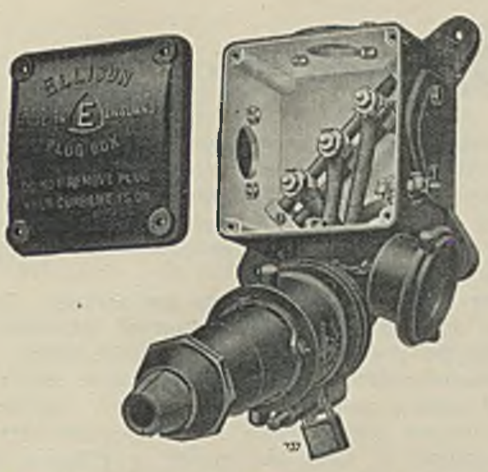


Fig. 13.—*Plug Terminal Box showing Connector in position.*

cable is .2 sq. inch, there being one of paper and one of bitumen 320 yards long in the shaft of this size at Wimblebury. The largest two-core cables used are of .5 sq. inch section. The general details of the .2 sq. inch L.T. three-core paper cable are as follow. The thickness of dielectric between cores and cores to earth is .08in., the lead is .1in. thick, the overall diameter is 2.3ins. and its weight is 26lbs. per yard: the total weight is therefore nearly 4 tons. The works test of this cable is 2,500 volts for 15 minutes.

The form of suspension in the shaft is by cleats, spaced out at 40 yards. The method of installation was to run the cable over a large pulley and attach it to a steel rope by means of cotton ties, and to lower the rope and cable by means of a locomotive and wagons, tying the cable to the rope as it left the drum.

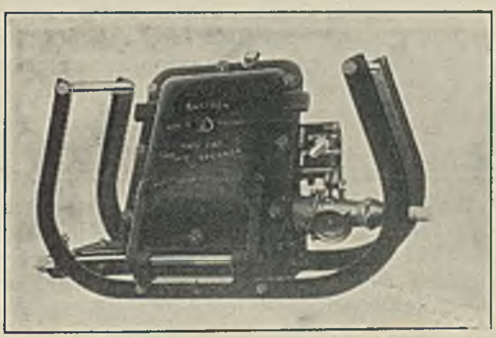


Fig. 14.—*Gate-end Switch: closed.*

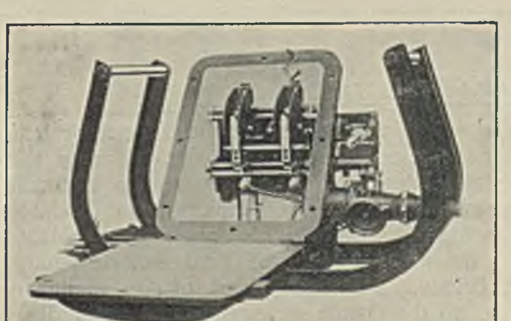


Fig. 15.—*Gate-end Switch: open.*

At the Cannock Wood pits direct current is still in use in the Shallow Seam. The total consumption of direct current is about half-a-million units per year, there being 33 motors, totalling 660 H.P., and up to 80 H.P. in size, and some 12,000 yards of two-core cable.

An interesting point relative to cable sizes is that with an equal section of copper core the 6600 volt cables carry fifteen times the power of the D.C. cables. All the extensions are made on the A.C. system.

The old D.C. motors have been remarkably reliable: one of these, an 80 H.P. motor, has been in daily service for 38 years and still does its work well. It is interesting, too, to mention that at Wimblebury there is an Edison 110 volt D.C. generator, made in 1881 and working every day still.

There are fewer breakdowns on the A.C. than on the D.C. plant, but the D.C. coal-cutter armatures have an average life of nearly six years.

In electrical service throughout the system there is over 4,000 gallons of oil. To maintain the dielectric strength of this oil a separator with a capacity of 35 gallons an hour is used. That extracts any water which may be present. There is, too, a dielectrimeter for testing the oil; this instrument consists of an induction coil with spherical electrodes, one of which is mechanically connected to a pointer moving over a scale at the base of the instrument immediately in front of the oil testing cell. The scale is calibrated to 31,000 volts. The oil testing cell is fitted with ½in. spherical electrodes which are set to a .15in. gap. It has been found that grade "A" oil in service falls to 10,000 breakdown voltage after three years; and after being passed through the separator it will withstand over 31,000 volts.

The constant endeavour has always been to anticipate breakdowns whenever possible; for no stoppage is preferable to a quick repair; and the management have never hesitated to supply any testing gear considered necessary by the electrical engineer; nor is the plant bought solely on price and, consequently, a good reliable job is expected and secured.

The A.M.E.E. List of Members: Corrections.

It is to be regretted that one or two printer's errors crept into the new List of Members of the Association of Mining Electrical Engineers which was published last month.

Mr. CHARLES LEWIS, Rose Cottage, Ponsford, Somerset, who is the chief electrical and mechanical engineer at the Ponsford and Bromley Collieries, Somerset, was inadvertently deprived of the rightful recognition due to his qualifications. Mr. Lewis not only holds the First Class Certificate but has the added distinction of heading the examination list for the year 1912. He has been an enthusiastic member of the Association for many years, and has presented several notable papers. For two of these Mr. Lewis was awarded prizes: his Paper, "The Unwatering of the Ponsford Colliery," was judged to be the best given before any Branch in 1918 and secured the Association's First Prize. It is of further interest to note that Mr. Lewis holds a number of Honours Certificates in electrical engineering as following his technical studies at the Armstrong College, Newcastle.

Mr. H. HERBERT REYNOLDS, 8 Clive Row, Calcutta, India, is shown as an Associate Member, whereas he has for many years past been a Full Member and as such has taken an active interest in A.M.E.E. affairs, particularly those connected with the North Western Branch.

Mr. L. J. HUNT, member of the North Western Branch, is at 28 Victoria Street, London, S.W. 1, he having some time ago left the address given in the list.

Manufacturers' Specialities.

The British Industries Fair, BIRMINGHAM.

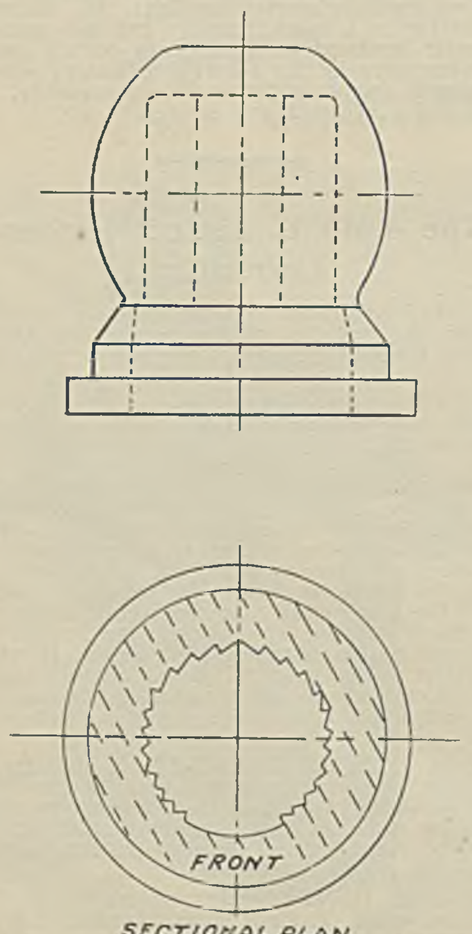
SOME NOTABLE EXHIBITS.

(*Continued from page* 316).

THOR LAMPS & SUPPLIES, Ltd.

Many examples of this firm's well-known range of miners' electric lamps and other hand lamps provided an interesting display. The lamps included electric safety lamps used by colliers, underground officials, etc., as well as a new type of pocket emergency lamp and shaft and roadway lamps. Lamproom equipment, such as charging stand, magnet opener and other necessary accessories were also shown; the charging stand has several novel features, including unbreakable insulating trays.

Probably the most valuable of several new features was the prismatic well glass, of which a sketch is reproduced here. This glass was designed in collaboration with Dr. English of The Holophane Co., and is made in accordance with the well-known Holophane principles. The new glasses are at present being tried out in a number of collieries. Photometric tests show a 25% increase in candle power through the plain front panel; the polar curve shows an even distribution through the prismatic part of the glass.



"Thor" Prismatic Well Glass.

The advantages of the glass are obvious. The collier is able to get a clear beam of increased light through the plain front panel on to his work, whilst the remainder of the glass being prismatic and slightly frosted gives a comfortable diffused light. In the ordinary prismatic glasses which have been sold there is no concentration of light, but merely a diffusion and a reduction of candle power all round. An important advantage of the new glass is that when the collier is going into his work if he directs the clear panel in a forward direction his mates following him are not dazzled by a glaring light.

CALLENDER'S CABLE & CONSTRUCTION Co., Ltd.

The manner in which this firm has adapted itself to meet the most modern requirements for all branches of electrical transmission and distribution was forcibly exhibited in an attractive display. The diversity of apparatus shown included distinctive designs of transformer kiosks, switch pillars, distribution boxes, fuse boxes, network boxes, pole type dividing boxes up to 66,000 volts, sealing ends, insulating tapes and compounds, "Kalanite" insulating material, overhead transmission poles, house service boxes, house wiring system and junction boxes of all descriptions and voltages. In addition there was, of course, a complete range of the familiar Callender cables and wires.

CHLORIDE ELECTRICAL STORAGE Co., Ltd.

It is the proud claim of this Company that it has the largest battery manufacturing works in the British Empire. The exhibit here was fittingly extensive also and included examples of the most popular forms of "Exide" and "Chloride" batteries, such as those for stationary power and domestic services, and for emergency lighting systems. Batteries for radio as well as for motor-car and train lighting were also prominent in the various forms specialised by the Chloride Company.

GENERAL ELECTRIC Co., Ltd.

The extensive range of the G.E.C. electrical manufactures must have puzzled those who, planning this exhibit, might attempt to show everything electrical from turbo-generators to Osram lamps. It was possible, however, to indicate generally the apparatus and plant turned out of the many large specialised factories dotted over Great Britain. Particular items of the exhibit directed attention to the Osram series of lamps and radio valves; dynamo-electric machinery, domestic lighting, heating and labour-saving appliances; turbo-generators; and mining electric plant.

GENT & Co., Ltd.

The "Tangent" improved mining bells and relays, suitable for working in parallel on bare-wire signalling, and passed by the Home Office, improved tapper keys, mining pushes, heavy-duty power pushes, and telephones, incombustible and flame-proof, were notable items on this stand. Among the indicators and alarms for indicating and recording step by step the rise and fall of liquid level were the new "Tangent" high and low liquid level alarm with diversion relay suitable for A.C. or D.C. circuits, and new models of float switches. Motor sirens in sizes ranging from 0.1 to 4 H.P., suitable for sound signals, fire alarms, etc., at collieries and large works, were also visibly and audibly in evidence.

HEYES & Co., Ltd.

As specialists in the manufacture of mines' lighting and signalling apparatus this exhibit was of exceptional interest to colliery men. Watertight and flame-proof apparatus included an improved design of the "Wigan" switch fuses, switch fuse plugs and unit type switchboard; prismatic bulkhead lamp fittings, lamp and well glass lamp fittings; electrical signalling apparatus, particularly for colliery use, included shaft signal indicators, bells, telephones and telephone switchboards; also cable joint boxes, armour glands and sealing boxes for armoured cables.

A New Mechanical Jumper Connector.

Although designed more particularly for overhead lines, the new patented Mechanical Jumper Connector, introduced by W. T. Henley's Telegraph Works Co. Ltd., is intended for use either indoors or outdoors wherever two free ends of conductors—copper rod, bus-bars, or the jumper loops of overhead lines at angle and junction poles—have to be jointed. Particular and outstanding advantages of this novelty are cheapness, efficiency, and light weight.

The connector consists of three parts; a seamless, parallel-sided copper sleeve containing two gun-metal wedges grooved to accommodate the conductors. The wedges fit tightly inside the sleeve and during transit or handling will not come out of position. Wires of different diameters can be accommodated together in the same connector.

The illustrations, Figs. 1 and 2, show how the connector is used. The free ends of the conductor are inserted into the sleeve over the small ends of the grooved wedges, which are then driven into position. During this operation there is no necessity to take the wedges out of the sleeve. It is recommended that a coat of bitumenous paint should be applied when the joint is made. There are no iron or steel parts to corrode and no bolts or screws of any kind.

In a recent test on one of these connectors for a 0.10 sq. inch conductor the increase in resistance of the conductor, directly due to the joint, was less than 6 microhms. After further being subjected to a tensile test, the pull-out load reached 670lbs.: the connector was in no way damaged and could have been imme-

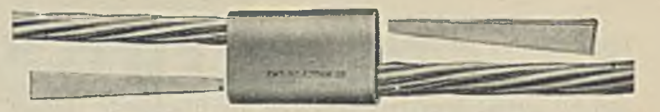


Fig. 1.—Connector Joint in the Making.

Fig. 2.—Connector Joint completed.

diately put into service. The result of this tensile test proves that the connector will safely withstand small pulls, although it is not intended for use under mechanical stress.

At present, four standard sizes are available, suitable for conductors up to half-an-inch in diameter; larger sizes would be supplied in accordance with demand. The types, together with the range of cable diameters, are:—

Type 1	.16in. to .232in.
„ 2	.246in. to .324in.
„ 3	.347in. to .415in.
„ 4	.448in. to .504in.

Small orders up to 50 can be supplied from stock; for larger quantities a special delivery time is required.

Large British Contracts for Holland.

The British Thomson-Houston Co., Ltd., have secured a large and important contract for the Municipal Council of Rotterdam, Holland, which covers the supply of the 25,000 volt three-phase, 50 cycle switchgear required in connection with the new power station. This new station is being erected some three miles nearer the mouth of the Maas than the existing Schiehaven power station, which has reached maximum capacity. The switchgear contract calls for 39 B.T.H. isolated phase equipments incorporating oil circuit breakers of the most modern construction and having a power interrupting capacity of 1,500,000 K.V.A. The ultimate capacity of the station is to be 252,000 K.W. The switchgear will be so arranged that the equipment for each phase is housed in an entirely separate gas-proof building, in a similar way to the practice widely adopted in the U.S.A. for stations of large capacity. The arrangement is extremely compact, with minimum lengths of copper connections between apparatus, and a very high degree of safety is achieved.

Duplicate bus-bars are provided, these being divided into three sections which are inter-connected by reactors to a star bus-bar and, by the provision of feeder series reactors, the magnitude of faults external to the station is definitely limited; while, by the reason of the isolated phase principle, the possibility of faults between phases in the switch-house is definitely eliminated.

The oil circuit breakers have explosion chamber contacts and a pressure diaphragm in the top cover to relieve gas pressure in the unlikely event of sustained arcing taking place. As this diaphragm is piped to a gravel catch pit in the basement the oil fire risk is for all practical purposes non-existent.

Rotating blade bus-bar selectors are provided, these being remote mechanically operated from a passage way external to the switch-house; and, as the interphase operating rods for both the isolating switch mechanism and oil circuit breaker mechanism are fitted with stuffing boxes where they pass through the phase dividing walls, the escape of hot gases from one phase compartment to another is prevented. All current transformers are of the bushing type, being fitted with oil circuit breaker terminal bushings: the voltage transformers are of the single phase type fitted with internally mounted limiting resistance and protective fuse. Each is contained in a separate fireproof compartment which is ventilated outside the switch-house.

The receipt of this order is particularly gratifying as it was obtained in the face of severe competition, especially from Continental manufacturers, and only after all details of design had been most thoroughly investigated. Moreover, it follows closely on the order for two 42,000 K.W. turbo-alternators secured by another British Company, The Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester. In this case also similar conditions as regards competition and engineering investigations were encountered. The turbines are provided with "Metrovick" central flow condensers and the steam conditions are 25 atmospheres at 400 degs. C. Each set is rated 42,000 K.W. maximum continuous, three-phase, 50 cycles, 5500/5800 volts, 87.5 per cent. power factor.

An Air-Ship Flameproof Electric Kitchen.

Automatic Telephone Manufacturing Company, Ltd., the makers of the well known Xcel electric domestic appliances, have just completed the manufacture of a special light-weight electric cooking and water heating installation for the new British Government Air-ship, R 101, now under construction at Cardington. The problem set by the Air Ministry, by whom the equipment was ordered, was not simple. Cooking accommodation for 100 persons was specified, the complete installation being restricted as to maximum permissible weight, and electric power available for this specific duty.

Furthermore, due to the proximity of large volumes of inflammable hydrogen, all elements had to be rated for low current density, ensuring "black" heat at full load and an absence of risk of ignition of any escaping gas. To this end also, all switch controls had to be of special design, in flame-proof enclosures, following the usual procedure for safeguarding electrical apparatus in collieries.

The equipment—into the construction of which duralumin, the lightweight alloy, largely enters—comprises five separate items. The cooking range has four boiling plates, and an oven 24ins. by 24ins. by 18ins. The two back boiling plates are each 8¾ins. diameter and of 1500 watts loading, whilst the front plates are each 7ins. diameter and loaded to 1000 watts. All are totally enclosed, and constructed on the latest Xcel high efficiency principle, whilst the hot plate is surrounded by a guard rail to ensure the stability of utensils placed upon it.

The oven has two heating elements, each of 1250 watts, and the entire range is wired for three-heat control through the medium of a totally enclosed control switchbox, the supply being at 220 volts, 100 cycles A.C. There are three sliding rack shelves in the oven.

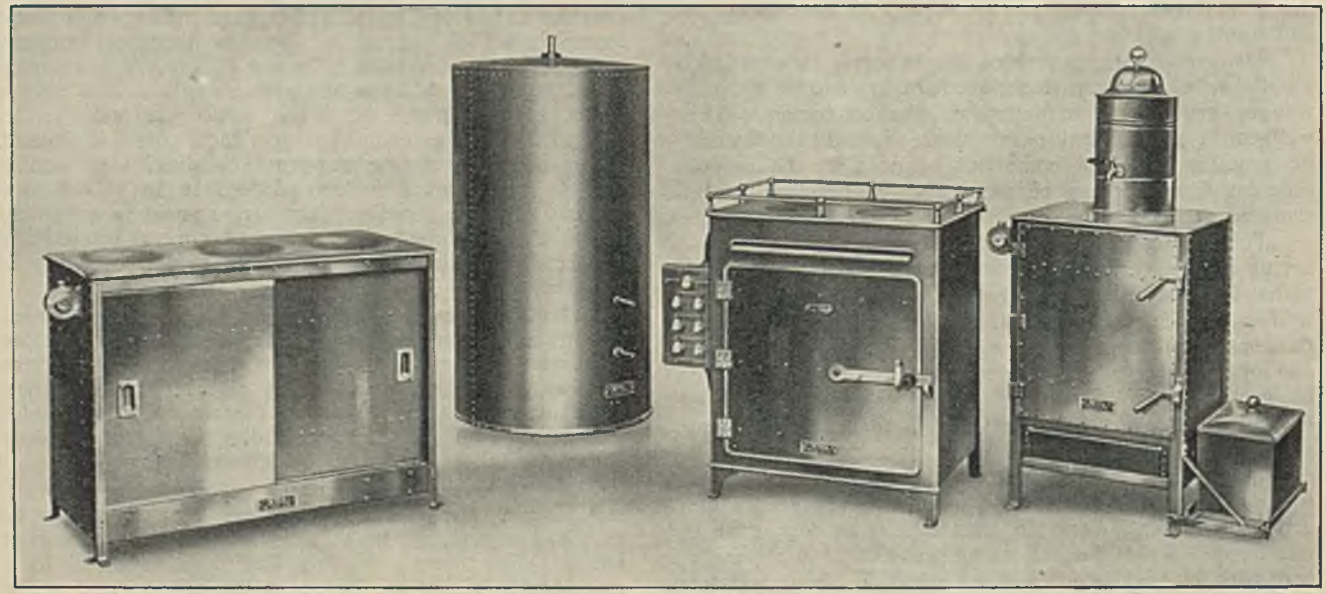
A vegetable steamer with a capacity 18ins. by 22ins. by 24ins. is equipped with elements giving a total loading of 1500 watts, and is furnished with single heat control. It is fitted with removable wire tray baskets. A ball-valve tank is attached to the right-hand side of the steamer for maintaining a continuous supply of water to compensate for the evaporation loss.

A hot cupboard measuring 3ft. 6ins. by 1ft. 10ins. by 2ft. 8ins. is heated by elements totalling 2000 watts, and is equipped for single heat control. It has sliding doors, perforated metal shelves, and the top is recessed to function as a carving table and to facilitate the retention of plates, etc., placed upon it.

To ensure a supply of hot water for dish-washing, etc., a 40-gallon cylindrical hot water storage tank is provided. It is equipped with three immersion heaters, one of 1000 watts, and two of 750 watts loading, making a total of 2.5 K.W.

Smaller demands for tea, etc., are met by a 3-gallon Xcel urn, equipped with two 750 watt units, protected against burn-out in the absence of water by a thermal cut-out connected in series with their common junction.

Having regard to the importance of weight limitations it is interesting to record that the total weight of the completed equipment worked out within 10lbs. of the limit set by the Air Ministry.



Air-ship Electric Kitchen Equipment.