The Mining Electrical Engineer.

OFFICIAL JOURNAL OF THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS.

EDITED BY E. DINSDALE PHILLIPS.

VOL. XI. APRIL, 1931. No. 127.

The Convention in June.

Daylight-saving may not be so sweetly imaginative a phrase as summer-time but, of a truth in this year of grace, it is more accurately descriptive : for in the chill of that lost hour of the morning, one has had need to draw freely upon imagination to feel the reputed cheer of the summer promise. The which grumbling thought will probably also have crossed the minds of many readers at the very mention of the Annual Convention of the Association of Mining Electrical Engineers due next June. Will they please turn overleaf and perchance find solace in reading the preliminary programme of events as so far arranged. The pleasant round of business and holiday offered therein is obviously very complete both in extent and character. The blending of works' visits, country drives and social meetings is well balanced and reflects much credit on the generous efforts of the members of the South Wales Branch. It is particularly pleasing to note that the Association is to be honoured by the Lord Mayor and Corporation of the City of Cardiff : in the accordance of this privilege of a Civic Reception the members will feel that it is at once a kindly acknowledgement of the work done by the Association and a powerful incentive to its sustained and still greater progress.

We may be permitted to remind members that it is hardly fair to the organisers to defer applications for tickets, etc., until the last moment. The best of programmes must needs be supplemented with a perfect management of detail, and that is only possible when those responsible for the arrangements possess in good time the definite knowledge of the number and requirements of the visitors expected. The honorary secretary of the South Wales Branch wishes to hear promptly from the members as soon as they decide to attend ; naturally, he wishes also to be favoured with the opportunity of shewing his ability to cope successfully with a greater number of guests than has ever before assembled at an A.M.E.E. Convention. Loyal members will see to it that the secretary is fully obliged in both respects—so much so that he and his willing co-workers will be hard put to it to cope with the attendance of the great influx of visitors from every branch throughout the country.

Enquiries and Experiences.

We began our previous remarks with a grumble. The weather was responsible. It may be that to the same insidious influence this second little grouse is in part attributable. The majority of our regular readers being members of the Association, it is reasonable to assume that they are firm believers in the value of the interchange of personal knowledge and opinion. They take great pains in writing many useful papers, they like to listen to the records of experiences put before them by fellow members, they delight in the pursuit of keen and forceful debate. Why is it that they do not more commonly indulge their wholesome argumentative and enquiring propensities in using the columns of this journal ? Our pages are invitingly thrown wide open to welcome their views and criticisms ; to enable them to put their questions, pet themes and difficulties before thousands of their fellows. They have but to ask in this way to gain the invaluable advice, answers and remedies available in that wide circle of the well informed.

There is a vast range of " literary contributions " outside the scope of Papers read at Meetings and Special Articles. The simple question in two or three lines of print is, oftener than not, the means of inducing a most profitable train of thought and study. A paragraph concerning some isolated occurrence, obscure effect, or difficulty or personal doubt will usually elicit commentary replies of extreme value and originality. It is, in fact, in regard to originality that this principle of " writing to the paper " scores heavily in value by comparison with the average of technical papers read.

We believe that now the case is placed before readers they will be quick to see the advantages. Would that they might be so ready to respond ! To help towards that, the only effect worth while, we ask them to note these answers to the unvoiced queries they have now in mind.

We do not expect to get letters written in beautiful handwriting and in high-school class English. We do not publish authors' names unless they wish us to do so ; we respect the confidential writer. We pay for all contributions published. We invite anyone who may want to know more about this, or any other relevant subject, to ask us about it.

Association of Mining Electrical Engineers. Annual Convention, 1931.

PRELIMINARY PROGRAMME.

Tuesday, June 9th.—Members and Friends assemble at the Royal Hotel, Cardiff.

Wednesday, June 10th.—Visit to the Ediswan Cable Works at Lydbrook. Members and Friends attending will proceed by Motor Coach to Tintern, where lunch will be served and an opportunity given to view Tintern Abbey. The Cable Works will be visited in the afternoon, tea being kindly provided by the Company. On the return, a Civic Reception, together with a Dance and Whist Drive, will be provided by the Lord Mayor and Corporation of Cardiff.

Thursday, June 11th.—A visit will be paid to the National Oil Refineries, Skewen ; Lunch at Porthcawl.

Friday, June 12th.—A Council Meeting at 9-30 ; Lunch by The Monmouthshire & South Wales Coal Owners' Association ; Annual Meeting in the afternoon ; Annual Dinner and Dance of the Association in the evening at The Royal Hotel, Cardiff.

The Royal Hotel, Cardiff, will be the Head-quarters during the Convention and the South Wales Institute of Engineers have kindly placed the Institute, including the Library at the disposal of Members and Friends during the Convention.

Arrangements are being made for ladies and non-council members to visit Cardiff Castle or other places of interest in the district.

Enquiries should be sent to the Hon. Secretary of the South Wales Branch : Mr. H. J. Norton, 37 The Hayes, Cardiff.

NEW BOOKS.

H.M. STATIONERY OFFICE.

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

MINES DEPARTMENT.—OUTPUT AND EMPLOYMENT AT METALLIFEROUS MINES, QUARRIES, ETC., during the Quarter ended 30th September, 1930. Price 4d. nett.

MINES DEPARTMENT.—THE EXPLOSIVES IN COAL MINES ORDER of the 4th March, 1931. Price 2d. nett

Additions to the list of permitted explosives are: Douglas Powder, Eversoft Driftex, and Polar Ajax. Certain explosives no longer made or used are deleted from the list.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH : Report for the year 1929-1930. Price 3s. 6d. nett.

ALUMINIUM : Its Production, Properties, and Application. British Aluminium Co., Ltd., Adelaide House, London, E.C. 4.

An extremely interesting and useful book giving the latest information regarding the industrial production and usage of aluminium. Many notable illustrations add greatly to the summarising of a complete story.

SWITCHGEAR PRACTICE by Henry E. Poole, B.Sc., A.M.I.E.E., A.C.G.I. London : Chapman & Hall, Ltd., 11 Henrietta Street, W.C. 2. Price 15s. nett.

An essentially practical book based on the author's experience of some years' work in the design of electrical control and switchgear apparatus. Particular attention is given to the latest and most commonly used types of distribution and industrial equipments : a special section is devoted to mining switchgears.

THROUGH A GLASS DARKLY, by C. S. Wallbridge. London : Arthur H. Stockwell Ltd., 29 Ludgate Hill, E.C. 4. Price 7s. 6d. nett.

A widely travelled electrical engineer here weaves a romantic story for the entertainment of his fellows. A skip here and there through the pages during office hours provides goodly promise of a treat in store for an off period.

ALUMINIUM OVERHEAD TRANSMISSION LINES.—British Aluminium Co., Ltd., Adelaide House, London, E.C. 4.

The use of steel-cored aluminium conductors for overhead electrical transmission systems is now definitely established as standard practice in every country, and no engineer who has to deal with matters of electrical transmission and distribution is furnished with adequate information unless he keeps at hand a copy of this publication. It is in the form of a loose-leaf collection of instruction and data sheets bound in a substantial cover of pocket size. In the beginning, under the heading of General Conditions, the comparison of steel-cored aluminium with copper is clearly set out in regard to such general facts as weights, spans, loads, frequency of supports, etc. The construction, physical properties, sag and span calculations ; jointing, anchoring, connecting, binding ; methods of erection and appliances used ; all these and many other useful relevant subjects are treated simply by concise stories and diagrams.

POWER AND FUEL BULLETIN.—The British National Committee, World Power Conference. London : 63 Lincoln's Inn Fields, W.C.2. Monthly, Annual Subscription, 10s.

This is the first issue of a monthly abstract of current literature concerning power progress, the outcome of a suggestion of the American National Committee at the meeting of the International Executive Council of the World Power Conference in 1929. The details adopted for the compiling of these records were that each country should abstract its own literature, the abstracts to be in English, French or German ; that the abstracts be indexed in accordance with the Universal Decimal Classification ; and that the published form be similar to that used by the Institut International de Bibliographie, printed on one side of the paper and capable of being mounted on 5″ × 3″ cards.

In the case of new books or monographs, patents, general articles, reviews of progress and similar matter, descriptive abstracts summarising the contents so that a clear indication is afforded of the scope and salient features will be given. Of reports, papers, etc., dealing with investigations and researches and with the nature and operation of plants and processes, the abstracts will be analytical and will indicate the purpose of the research or the nature of the process, etc., the method of carrying out the research, or of working the plant or process, the results obtained and the conclusions arrived at. Data, figures, measurements, etc., will be given so far as is conveniently possible.

METRO-VICK CALENDAR.

The latest of the "Girl" calendar series, which has for so many years been a popular item in the publicity work of the Metropolitan Vickers Electrical Co., Ltd., is duly to hand and welcome as ever. In this instance the choice of the subject has been exceptionally good. The portrait is of Miss Elsie Lawrence of "Sleeping Beauty" fame.

ELECTRICAL REPAIRS.

[From a Scottish Correspondent.]

DEAR MR. EDITOR,

You will please be good enough to excuse my daring in "rushing into print" on such a "low down" subject as "Electrical Repairs", but as I happen to be one of those individuals who once started out to make a fortune by running a repair shop I am sure I can command your sympathy.

For years before entering my "profession" I had it well pumped into me that quite a "good thing" could be made out of the number of breakdowns and overhauls that came out of the Collieries.

I find however that I have been badly let down by the friends who told me this and from experience I find that, generally speaking, colliery people know very little about breakdowns. Those colliery friends who read these notes will give a little smile and say they don't want to know anything about them, but just to

Fig. 1.

give them an idea of what some poor souls in other trades have got to put up with I will give a few typical examples.

First of all we will take the poor butcher. He buys a motor to drive his mincer and sausage machine and after a few months' running, begins to have a little trouble. He swears, as only a butcher can swear, about being foolish enough to change over from the gas engine his father installed forty years ago to one of these infernal machines which are nothing else but "paper and string." He, of course, didn't know when he bought his motor that there was any paper or string about it but after the few months' running he certainly did know. One morning his motor went on fire and when his man dismantled it he discovered any amount of string lying about, which had evidently caught fire. The ten dead mice found inside the carcass must have had a "warm time of it."

Fig. 2.

Then again, take the man who runs the "White-as-Snow" laundry. He installed a 10 h.p. d.c. motor after the old man gave up the business and retired twelve years ago. He had the usual instructions given him—"just a drop of oil now and again, that's all"—after the motor had been put into commission.

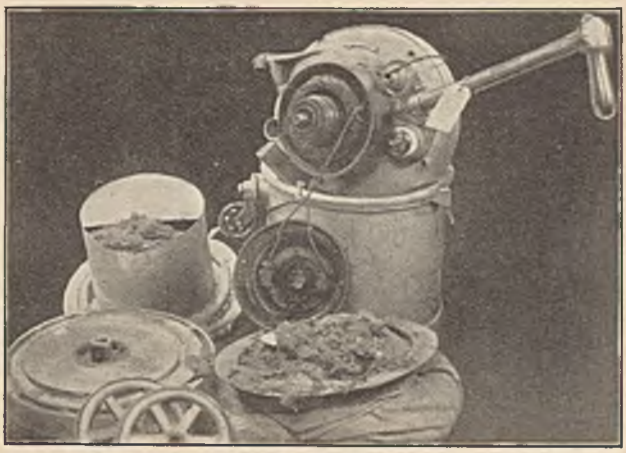

Fig. 3.

The years roll by and at long last he thinks because he has had a good year's trade he can stand overhauling his motor. So he sends for the repair shop man to come round and see him. After removing the motor to the shop the repair man is able to go home and tell his wife he has now found out where the life taken out of his collars and shirts goes to. A glance over the illustration (Fig. 1) will help readers also to understand.

Just for a change, instead of going home for our tea, after being at the pictures we go down to "The Green Bottle" for a plain tea. The wife knows the "ropes" as she has often been there with her sister when I was knocking my life out in the shop. So she just tells the lift girl, "Third, please."

What the wife didn't know however was the condition of the overhead gearing of this self-same lift. Neither did we until we were called in on the Monday morning.

There had been a "terrible noise" developing somewhere "among the works" as we were told and as nothing could be seen externally the lift was given a run up. And sure enough there was some noise then.

However, to cut this letter short, Fig. 2 will tell the rest of the story. This shews the worm wheel which had never seen oil nor heard of it since it was first put to work eight years ago! And, breathe it gently, there is a "maintenance man" on the premises.

Fig. 4.

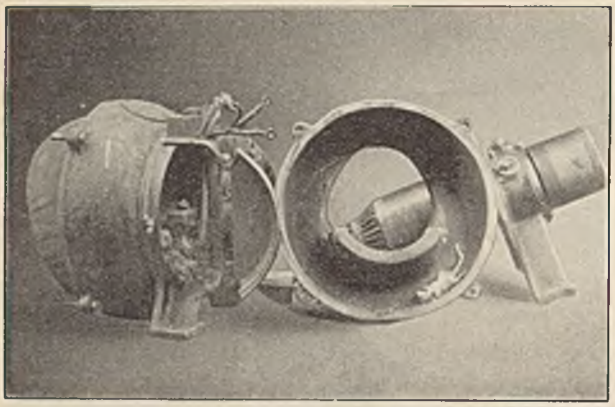

Fig. 5.

I often wonder, now that there are so many vacuum cleaners on the market and all of the "industrial type" that none of our colliery managers go in for them to keep their roads clean down below. This omission, or shall I say want of thought, may be due to the managers being under the impression that they are not much good. I can hardly blame them, because managers of such places as hotels where conditions are to some extent more favourable than down below, are also for some reason or other under the same impression.

For instance, I was instructed to send a man with the lorry to collect one of these "industrial type" vacuums and to "thoroughly overhaul it and improve it all you can as the thing hasn't been much use since it was installed three years ago."

The manager was quite right—it hadn't been much use. Figs. 3 & 4 prove this. The vacuum container tank and bag had never once been emptied. They were both so full that there wasn't room for another thread or even "a safety blade", one of which is to be seen on the pile of dirt which was emptied out.

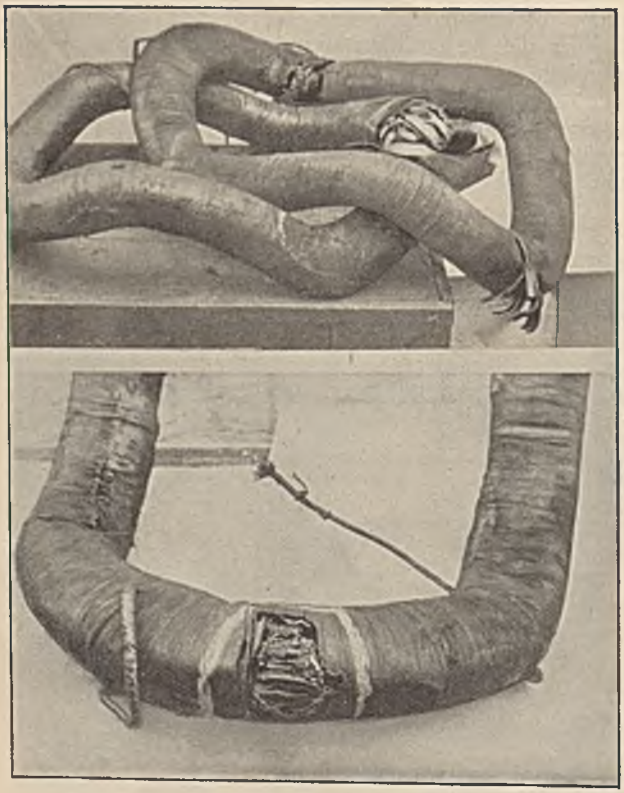

Fig. 6.

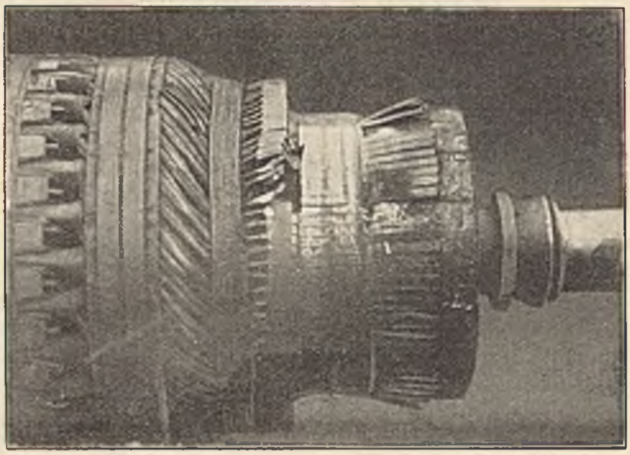

Fig. 7.

Since this machine has gone back and is behaving itself much better the manager is quite delighted "with the improvements carried out." As a result he was so much impressed with the "advantages" of completely overhauling his motors that he gave instructions for his 15 h.p. to be taken out and done up. This was duly carried out, and it certainly required doing, but now after two weeks' running the manager just doesn't know what to think. He is faced with the making and fitting of two large field coils and he can't get a spare anywhere to keep him going as the gear is of an obsolete type.

What happened was this. After cleaning out the motor, all the windings were given a good coat of anti-sulphuric enamel. Then, after re-installing the machine on site, the rats were evidently delighted with the smell of the varnish which they seem to have relished as a new sauce to be used when eating cotton tape, empire cloth and mica sheets. In any case Figs. 5 and 6 shew how far they had got through before the sparks began to fly due to a broken field.

But, just before closing time tonight, I had a "beauty" sent in. And, believe it or not, this time it came from a colliery. My instructions were "to fit a new commutator if required."

Sir, I leave it to you to make comments after you've "closely" examined Fig. 7.

"Simple Laddie."

[Na, na, simple laddie; we beg to decline, fearful lest the dropping of hot expressions into cold print might create trouble beyond repair.—*Editor.*]

37,900 K.W. OF MERCURY ARC RECTIFIERS.

The British Thomson-Houston Co., Ltd., has received orders from the London Electric Railway Company for the following mercury arc rectifiers: 17 of 1500 k.w. each and 5 of 2000 k.w. each. These rectifiers, which are of British design and manufacture, are to be installed in nine sub-stations, for which the complete B.T.H. equipment will include, in addition to the rectifiers, over 100 air blast transformers, 120 high speed circuit breakers, and 60 heavy duty oil circuit breakers. In all cases the rectifiers will be provided with automatic control gear for remote operation. This is the largest order for mercury arc rectifiers placed in this country.

The British Thomson-Houston Company also has in hand the manufacture of two 1200 k.w. mercury arc rectifiers for the Barking-Upminster electrification scheme of the L.M.S. Railway, while a B.T.H. rectifier will shortly go into service on the Manchester-Altrincham Railway, the electrification of which is nearing completion.

Proceedings of the Association of Mining Electrical Engineers.

SOUTH WALES BRANCH.

The Nickel Cadmium Alkaline Battery.

F. WATSON MANN, B.Sc.

(*Paper read in Cardiff, December 6th,* 1930.)

Secondary batteries may be divided into two entirely distinct classes—alkaline and acid or steel and lead. Alkaline batteries may be subdivided into nickel iron batteries and nickel cadmium batteries. It is the latter type on which this paper is based, although reference to the other types will be made by way of comparison. The reason for this introduction is to make quite clear that the nickel cadmium cell is quite distinct from the nickel iron cell, at any rate, as far as electrical characteristics are concerned. The active material in the positive plates is essentially nickel hydroxide. There is, however, in addition a percentage of flake graphite to give the required conductivity. The active material in the negative plates is a mixture of cadmium and iron, the proportions varying according to the type of cell. Iron only, has many disadvantages—the chief one being the poor conductivity of iron oxide which is formed on discharge. Cadmium alone would tend to cake and lose its porosity. Cadmium oxide which is formed on discharge, has a comparatively high conductivity and the presence of iron maintains porosity of the mixture.

The positive and negative plates are similar in construction, except that the former are somewhat thicker. The active material is formed into briquettes and enclosed in steel pockets which are perforated with very small holes over the whole of their surface. A number of these are assembled in a steel retaining frame to form complete positive and negative plates. They are then put through various rolling processes which, apart from giving perfect contact between the active material and the pockets, corrugates the surfaces to give additional strength and resilience. At the same time, grooves are formed on the plates which serve to keep the hard rubber insulators or separators in position. The active materials therefore, are totally enclosed, so that shedding is eliminated. The stresses of severe charge and discharge are taken up by the steel frames and pockets with the result that buckling of plates is avoided.

Plates of similar polarity are spaced along a steel connecting bolt on to which the tapered steel terminal bolt is also threaded. This assembly is then bolted together, the nuts being locked so as to prevent any possibility of bad contact. In smaller type cells, such as are used in miners' lamps, the plates are welded to a steel equaliser bar to which the terminal pillar is also welded.

The container sides are made from one piece of sheet steel, the only seam being welded. Top and bottom pressings are welded into the open ends. The terminals are brought through the top of the container in suitably insulated glands. The containers of larger types are provided with a hinged metal filler cap and valve combined. Smaller types are usually fitted with porcelain vent plugs which screw into a threaded aperture in the cell top. The stoppers used in miners' lamp cells are somewhat different and will be dealt with later in the construction of these special cells. The containers are first of all cadmium plated and then nickel plated by an electrolytic process. This very effectively prevents corrosion even under the worst atmospheric conditions.

The electrolyte is a 20% to 25% solution of potassium hydroxide (KOH) and has a normal specific gravity of 1.19 gms. per cc. This does not vary in strength during either charge or discharge as will be seen later when dealing with the chemical action of the cell.

In the larger types such as for lighting or traction work, the cells are mounted in wooden crates, usually of teak. The cells are suspended by means of steel bosses which project from the container sides and fit into ebonite insulators resting in the sides of the crates. The cells are connected together by means of special copper connectors with conical sockets at each end in order to give maximum contact with the tapered steel terminals. These connections are plated in a similar way to the cell containers.

It is seen that steel is used throughout in the construction of the cell: this is of very great advantage in view of the fact that all parts of the cell can be made with mathematical precision. The mechanical strength durability and robustness are much in advance of what can be obtained even in the best designs of lead cells—vibrations and shocks cannot dislodge the active material with the result that there is a total absence of sludge and deposit—the steel plates cannot twist, buckle, break off or grow—the active material and other parts of the cells do not suffer any damage by overcharging, heavy discharging, idleness, etc. Since the electrolyte is Caustic Potash no corrosive gases are produced on charge or discharge—a high capacity is available at heavy discharge rates; the life is long. As a result of these advantages it is obvious that the maintenance costs are exceptionally low.

Before enlarging on the electrical characteristics, the reactions of the cell must first be considered. It must be pointed out that the actions occurring in alkaline cells are not so definitely established as the corresponding actions in the lead cells. They are too complicated to be given here in detail, but a brief summary will explain the main principles involved.

A discharged cell contains in the positive electrode, nickel hydroxide in a low degree of oxidation, whilst the negative electrode contains a mixture of cadmium and iron oxides. When charging takes place the nickel hydrate in the positive plates becomes more highly oxidised, whilst the cadmium and iron oxides in the negative plates are reduced to chemically pure cadmium and iron respectively. During this process the electrolyte does not take any apparent part in the reactions, and it has the same specific gravity before and after charging.

On discharging, the active material in the negative electrode becomes re-oxidised, whilst that in the positive electrode is reduced to its former state. The charging and discharging processes are apparently nothing more than the electrolytic carrying of oxygen from one plate to the other, but of course there are a number of intermediate stages which are very complicated and, as previously mentioned, not absolutely definitely established.

The electrolyte does not enter into any permanent chemical union with the electrodes but functions only as a conductor. For this reason the quantity of electrolyte can be reduced to a minimum and the plates can be placed very closely together.

Although oxygen plays a part in the reaction, no free oxygen is given off on discharge. Oxygen and hydrogen are of course given off towards the end of charge when electrolysis of the water content of the electrolyte takes place and when these gases have abated (this normally takes 24 hours) it is possible to fit solid stoppers to the cells. On discharge, no gases whatever are evolved. This is very useful in the case of small cells required for handlamps which are only used periodically and must be unspillable. In the case of miners' lamps, however, where the cells last out one shift and must be quickly recharged, the stoppers are fitted with non-return valves which render the cells unspillable but at the same time permit charging without removal of the stoppers.

At this stage it would be interesting to compare these reactions with those of the pure nickel iron type and the lead type. The construction of the positive plates of the nickel iron cell is somewhat different—the plates being built up from tubes instead of rectangular pockets. The active material, however, is essentialy the same except that in order to increase its conductivity the tubes are fitted with alternate layers of nickel hydroxide and pure flake nickel, the latter serving to increase its conductivity, in the same way as graphite is used in the case of the nickel cadmium cell. The reactions therefore which take place at the positive electrode are essentially the same. The chief difference lies in the negative plate where iron oxide only is the chief constituent. In order to give the necessary conductivity about 6% of yellow mercuric oxide is added. The cadmium iron negative requires no addition owing to its comparatively higher conductivity.

During the discharge of the pure iron negative plate there are two distinct stages at different potentials. During the first the iron is oxidised to ferrous oxide (or hydroxide) and during the second it is oxidised further to ferric oxide (or hydroxide). The first stage results in a cell tension of approximately 1.2 volts, while the latter is only 0.85 volts. Obviously, only the first portion of this discharge process can be utilised in practice and if the second were included, then the efficiency would drop to a prohibitive figure—the voltage variation also would not be within working limits. Consequently, it is always necessary to provide a considerable excess of capacity in the negative plate even though the use of mercuric oxide somewhat obviates the oxidation to ferric oxide.

It has already been mentioned that no gases whatever are given off when a nickel cadmium cell is discharged. The same holds good when the cell is standing idle. With the nickel iron cell, the iron in the negative active material is not completely stable—it tends, gradually, to become converted when standing idle, to a lower oxyhydrate, resulting in self-discharge of the cell, accompanied by the evolution of hydrogen gas. This self-discharge, however, is very small compared with that of a lead acid cell. The cadmium in the negative of the nickel cadmium cell is perfectly stable and consequently the self-discharge is very much smaller still and is not accompanied by any gassing. It is possible therefore completely to seal the cell on discharge.

The chemical reactions of the lead acid battery are generally known, the lead peroxide of the positive and the lead of the negative being each converted to lead sulphate on discharge and *vice versa* on charge. Water is also formed on discharge which results in a fall in specific gravity. The sulphuric acid plays a definite part in the chemical reactions. When standing idle the active materials are attacked by the acid resulting in sulphation, this and the slow loss of capacity from local action and other causes necessitate a regular routine of maintenance even in an idle battery. With regard to the use of an acid electrolyte, this introduces a risk of damage to any metalwork in contact with or near the battery. As previously mentioned, the gases given off on charge with alkaline batteries are non-corrosive with the result that they can be used in the same room which contains the gear with which it is operating, such as switchgear, relays, telephone equipment and so on.

Having dealt with the chemical reactions, the electrical characteristics must now be considered. At the present moment, the general conception among electrical engineers is that the variation in voltage of alkaline cells between charge and discharge is very great and that they are, therefore, not suitable for certain classes of work. This opinion has been formed owing to the high internal resistance of the pure nickel iron cell and the association that all alkaline cells are the same. This definitely is not the case, for in the nickel cadmium cell, the internal resistance is less than half that of any other alkaline type of cell. It is very difficult to give actual figures of comparative internal resistance owing to the different methods of obtaining them, but curves of charge and discharge definitely shew that the internal resistance of the nickel cadmium cell is considerably lower.

Up to a few years ago, the nickel cadmium cell was not suitable for starting up heavy internal combustion engines unless the size of the battery was excessively large and, seemingly, out of all proportion. During the past few years manufacturers realised that the steel constructed cell was the most robust for heavy bus work, and if only internal resistance could be further reduced, it would be the ideal battery for both the lighting and starting of these commercial vehicles.

In 1928 a very definite advance was made and a method was patented whereby the internal resistance of alkaline cells could be reduced to a very much lower figure than was hitherto possible. This method is rather interesting as it has not involved any alteration or modification to the active materials or general construction of the cell: the result is obtained by purely mechanical means. Inside each pocket is inserted very thin pure nickel ribbon in corrugated form: it is as wide as the inside thickness of the pocket so that it completely sub-divides the active material into numerous sections. It extends right into the retaining side frames of the plate so that the surface of the active material which is in intimate contact with the frame is increased enormously. The volume occupied by this strip may be regarded as negligible, with the result that there is no reduction in the amount of active material in each pocket and consequently no reduction in capacity. It is used, of course, in addition to the normal conducting material in the active material. This improvement has reduced the internal resistance of the cell very considerably and, as already mentioned, the resistance can be accepted as being approximately one-half of that of the nickel iron cell.

Where heavy discharges are required the question of internal resistance is a vital factor, and when the all steel construction is also taken into consideration, preference should be given to the nickel cadmium cell. It will be interesting to note that a number of large corporations in this country are converting all their commercial vehicles to this type of cell for the severe duty of electric starting and lighting.

Having now dealt fully with the question of internal resistance, the comparative curves, Fig. 1, of charge and discharge of nickel cadmium and nickel iron cells respectively will be of interest. While with a lead battery it is general practice to charge at normal rate until the commencement of gassing when the rate is reduced to one-half, with alkaline batteries a constant charging rate is maintained throughout. The reduced rate in the case of the lead battery, especially where Planté type plates are used, is to prevent excessive gassing which throws off the lead peroxide coating on the positive plate to to the bottom of the cell. It often happens that lead cells suffer considerably on account of neglect to reduce the rate, or even by unduly prolonging the charging at the lower rate, but alkaline cells can be consistently overcharged without fear of deterioration.

It will be seen that the nickel iron cell rises on charge at the normal rate during the first half hour from 1.54 to 1.68 volts. This is frequently followed by a slight fall in voltage, due most probably to changes in temperature and internal resistance, which is not of theoretical or practical importance. The voltage then rises gradually throughout the whole of the charge and more steeply when the charge is nearing completion until it reaches a steady value of approximately 1.81 volts.

With the nickel cadmium type the voltage rises at first to about 1.33 volts and does not exceed 1.5 volts throughout the first two-thirds of the charge. It then rises to about 1.62 volts and remains at that figure, falling off slightly, if anything, to the end of the charge. Up to a few years ago the final voltage was between 1.7 and 1.8 but recent improvements and reduction in internal resistance have lowered this final figure appreciably. The difference in behaviour of the two types of cell is of considerable theoretical and practical interest. It means that the watt hour efficiency of the nickel cadmium type is appreciably higher, resulting in lower operating costs.

The high voltage throughout the charge of the nickel iron cell is due to the fact that the iron oxide formed on discharge cannot be charged reversibly but only when a considerable excess of voltage is available. As a result of this, a very low charging rate is ineffective since hydrogen can be evolved with a low current density at a lower voltage than is required to reduce the iron oxide. At higher current densities, such as at normal rate, hydrogen is evolved throughout the complete charge. This means that all the power is not being used to charge the cell and therefore a lower ampere hour efficiency is expected.

The low voltage at the start of the nickel cadmium charge is attributed to the presence of the cadmium in the negative plate. The higher voltage at the end of the charge is due to the reduction of the iron in the negative plate, but owing to the presence of strip in the pockets, it is not so high as in the case of the pure nickel iron cell.

Compare now the normal charging characteristic of the lead cell with that of the nickel cadmium cell. This commences at 2.1 volts and eventually rises to 2.65 volts after 8¼ hours. To begin with it takes 3¼ hours longer or 65% longer, which is a considerable difference.

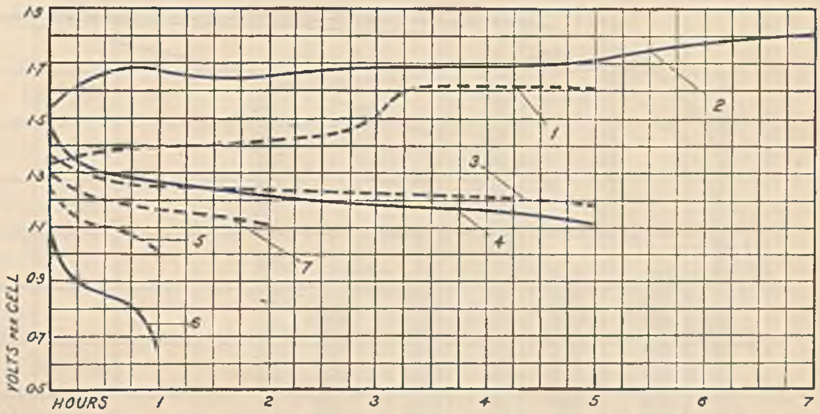

Fig. 1.

1. *Nickel Cadmium Cell* .... *Normal Charge*
2. *Nickel Iron Cell* .... *Normal Charge*
3. *Nickel Cadmium Cell* .... 5 *hour Discharge*
4. *Nickel Iron Cell* .... 5 *hour Discharge*
5. *Nickel Cadmium Cell* .... 1 *hour Discharge*
6. *Nickel Iron Cell* .... 1 *hour Discharge*
7. *Nickel Cadmium Cell* .... 2 *hour Discharge*

The variation of the nickel cadmium type is from 1.33 to 1.62 volts.

Considering a 100 volt installation 54 lead cells or 84 nickel cadmium cells would be used—the total voltage variation being as follows:—

Type.	*Start.*	*End.*	*Range.*
Lead	113	143	30
Nickel Cadmium	112	136	24

Compare now the drop in voltage which occurs in a lead cell at the 5 hour rate of discharge. It will be seen that the voltage at start of discharge is 2.04 volts and at the end of discharge 1.82 volts, the nickel cadmium range being 1.36 to 1.18 volts per cell.

Assuming once again a 100 volt installation, the comparative ranges for 54 and 84 cells respectively are as follows:—

Type.	*Start.*	*End.*	*Range.*
Lead	110	98	12
Nickel Cadmium	114	99	15

For all practical purposes, the difference in voltage on normal discharge is approximately 3 volts. Taking now voltage limits over charge and discharge: the lead range is 143 — 98 = 45 volts, while the nickel cadmium range is 136 — 99 = 37 volts. This shews that under normal conditions of charge and discharge, the variation in voltage of the latest improved low resistance type of nickel cadmium cell is less than that of the Planté type of lead cell, to the extent of 8 volts on a 100 volt installation.

If we now compare the voltage variation of the nickel cadmium battery with the lead battery when discharging at the 1 hour rate of the latter, say 70 amperes from a 140 ampere-hour battery, the following voltage figures would be obtained:—

Type.	*Lead.*	*Nickel Cadmium.*
Charge Range	143 — 113 = 30	136 — 112 = 24
Discharge Range ...	103.5 — 94.5 = 9	109 — 98.5 = 10½
Total Variation ...	143 — 94.5 = 48.5	136 — 98.5 = 37.5

It is seen therefore that the slightly greater drop in voltage of the nickel cadmium cell is more than compensated by the decidedly smaller rise in voltage on charge, the total variation between top of charge and bottom of discharge being 11 volts less than that of the lead type. Further, when a 140 amp.-hour nickel

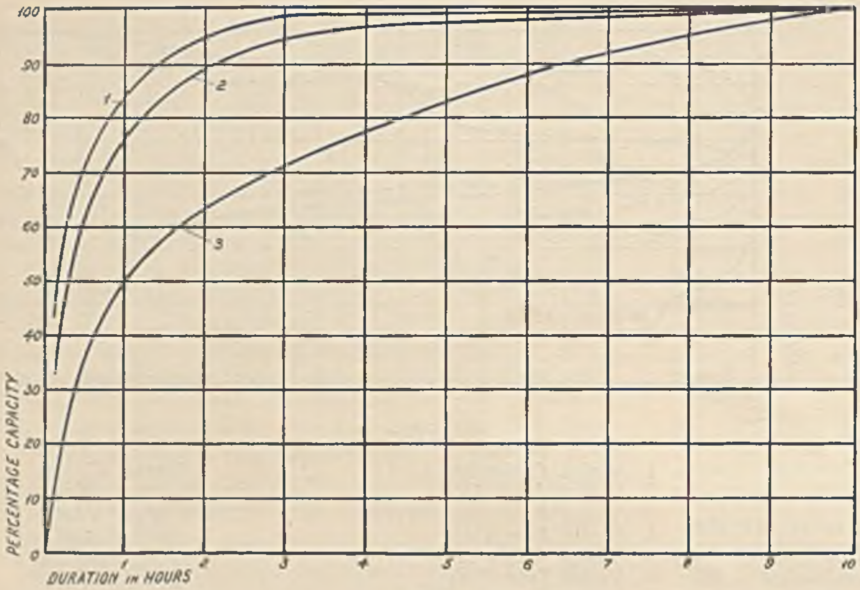

Fig. 2.

1. *Nickel Cadmium Low Resistance Type.*
2. *Nickel Cadmium Normal Resistance Type.*
3. *Lead Type.*

cadmium cell has been discharged at 70 amps. for 1 hour there is still approximately 50% capacity left in the cell.

These figures will shew the surprising degree of progress that has been made in recent years with the nickel cadmium cell. Those who have had experience with some of the earlier types will be able to substantiate that the figures just given, which are a result of recent tests, shew a distinct advance in accumulator design.

It is generally conceived that it is quite impossible for an alkaline battery to float on the line and deliver the necessary peaks of charge and discharge, but the above figures go to prove that it is possible with the latest improved type of nickel cadmium cell. This may appear paradoxical owing to the supposed internal resistance of the nickel cadmium battery being higher than that of a lead battery of equal capacity, but another factor enters into the problem, namely, the capacities obtainable from the respective cells at heavy rates of discharge.

The curves in Fig. 2 shew that the capacity of the lead cell falls off very much more rapidly at higher rates of discharge than that of the nickel cadmium cell. For example, at the 1 hour discharge rate the capacity of a lead cell is only 50% of that at the 10 hour rate while with the low resistance type of nickel cadmium cell the capacity at that rate is 84%. The curve for the low resistance type (Fig. ...), unfortunately, is not for the latest improved type which contains strip in the pockets of the plates. If a nickel cadmium cell of the improved type having a normal capacity of 140 amp.-hour be discharged at 140 amps. the final voltage is 1.02 volts which is quite a useful voltage and complete discharge is not effected until that voltage is reached. In other words 100% capacity can be taken out of the cell in 1 hour. It will be seen therefore that when the nickel cadmium cell is discharged at 70 amps. only (the equivalent of the lead 1 hour discharge rate) the cell is only half discharged.

The chief reason for this is the fact that there is no chemical action between the plates and the electrolyte as is the case with the lead cell. It follows then that on heavy discharge the chemical action in the lead cell is accelerated to such an extent that the sulphuric acid will not diffuse quickly enough. The lower gravity acid which lags in the interstices of the plates is not sufficient to allow a complete chemical change with the result that the voltage of the cell falls before the full capacity is taken out. As seen from the curve, Fig. 1, the predominance of this is more apparent at the higher rates.

If therefore a battery is required for operating on heavy discharge only and the capacity required is based on that rate, it is possible to install a nickel cadmium battery of lower normal capacity than that of the lead. This is exceptionally so in the cases of batteries required for switch closing or switch tripping.

The ampere hour efficiency of the improved nickel cadmium cell is 75% against 90% for the lead type, while the watt hour efficiency is 63%/57% compared with 75%/68% for the lead type, the highest figures being for the 10 hour rate and the lower figure being taken for the 1 hour rate. It would appear, on the surface, that those of the nickel cadmium cell are less favourable, but when the periodic overcharge which is necessary with the lead type of cell, is taken into consideration ; also the periodic discharges which are necessary to keep lead cells in condition when standing idle, the charging costs are practically the same.

From the technical characteristics which have been given, it will be seen that the nickel cadmium alkaline battery can be conveniently used for practically all the same purposes for which the lead cell is used: for house lighting, yacht lighting, emergency lighting in cinemas, electric trucks and locomotives, train lighting, bus lighting, emergency steering on ships, wireless, telephones, electric bells, operating switchgear, and so on, with many advantages in operation and maintenance.

The particular application about which special attention must be given, is that used in miners' lamps.

The illustration, Fig. 3, gives a diagrammatic representation of one of the special types of cell used. It will be noted that this is a double cell the two containers being welded together. In one container the positive plates are insulated from the container, while the negative plates are welded to the bottom of it. In the other, the positive plates are welded to the container while the negative plates are insulated from it. In this way the container acts as the intercell connector. The terminal voltage is 2.54/2.4 volts which is double that of a single cell. The plates are built up from pockets in exactly the same way as the larger types already described. The fact that the active material is completely enclosed so that it will not shed is specially important in a cell for this purpose which is given rough treatment and liable to be bumped about.

To overcome any possible troubles such as sticking plungers and broken springs, fixed steel terminals are provided, the necessary give being provided by the spring contact assembly in the lamp top. The shape of the terminals is such that the batteries can be charged in a hanging position; so that they are in mid air, so to speak, and not resting on insulating trays which are apt to collect moisture and dirt.

The gas releasing valves consist of screw plugs, drilled and fitted with a rubber band such that the gases generated on charge can escape: it is quite unnecessary to remove the plugs on charge. Such valves render the cell unspillable.

The normal capacity of the cell is 10 ampere-hours and it can be conveniently charged at 2 amperes for 7 to 8 hours. The method of charging 50 or more batteries at one time is shewn in the illustration, Fig. 4. The construction is extremely simple and there is practically nothing to get out of order. The framework of the rack is made from 1¼ in. steel tubing which ensures robustness and rigidity. The batteries are hung in slotted steel plates and contact is ensured by powerful springs pressing vertically upon the terminal heads of the battery. The standard rack is proportioned to carry 50 batteries on charge at a time but it is so arranged that it can be extended almost indefinitely to allow the simultaneous charge of any number of batteries as the installation grows.

Although this paper deals chiefly with the nickel cadmium cell, it will be of interest here to give a brief specification of the special miners' lamp case which is used with this type of cell. The body is of drawn steel, fluted vertically, giving great strength together with lightness. The flutings also have the effect of making the lamps much more easily handled than the plain round type and, owing to the manner in which the flutings are placed, they make it automatically impossible for a cell to be placed the wrong way round in the case. In the bottom of the lamp body is a ¼ in. rubber mat to protect the cell should it be dropped in too violently, and also to deaden shocks generally in the event of the lamp being dropped.

To the top of the body is welded a bayonet-joint fitting of liberal and robust design, this type of fitting having been found preferable to the screwed ring on account of wear, and also because it is a considerable time saver in the lamp cabin. The usual magnetic lock is provided, with a spring and plunger of adequate design.

The lamp top, consisting of a steel pressing known as the top ring, carries the studs of the bayonet joint, and also the magnetic lock, and four pillars to carry the protecting shield for the well glass and bulb. The lamp pillars are circular, rivetted at their lower ends into the lamp top ring and at their upper ends into the top shield. They are of exceptional strength and placed as far away from the bulb as possible so as to reduce shadow effects to a minimum. The top shield is a steel pressing on which the carrying hook is fastened through the medium of a swivel ring.

The whole of the contact and switch assembly—known as the ebonite mount—together with the well glass and bulb is affixed to the lamp top by means of of two screws only. This is a feature of the utmost importance as, by opening the lamp and releasing these two screws, all vital parts are readily accessible. The time occupied in cleaning and replacing bulbs, etc., is thus reduced to an absolute minimum. The bottom of the well glass is thickened out to a flange, protected on its upper and lower sides by rubber washers. The upper washer bears against the under side of the steel lamp top ring, and the lower washer and flange fit into the dished top of the ebonite mount. The two housing screws pass right through the ebonite mount, their knurled heads bearing on its under side and their points screwing into the steel lamp top pillars. It is thus

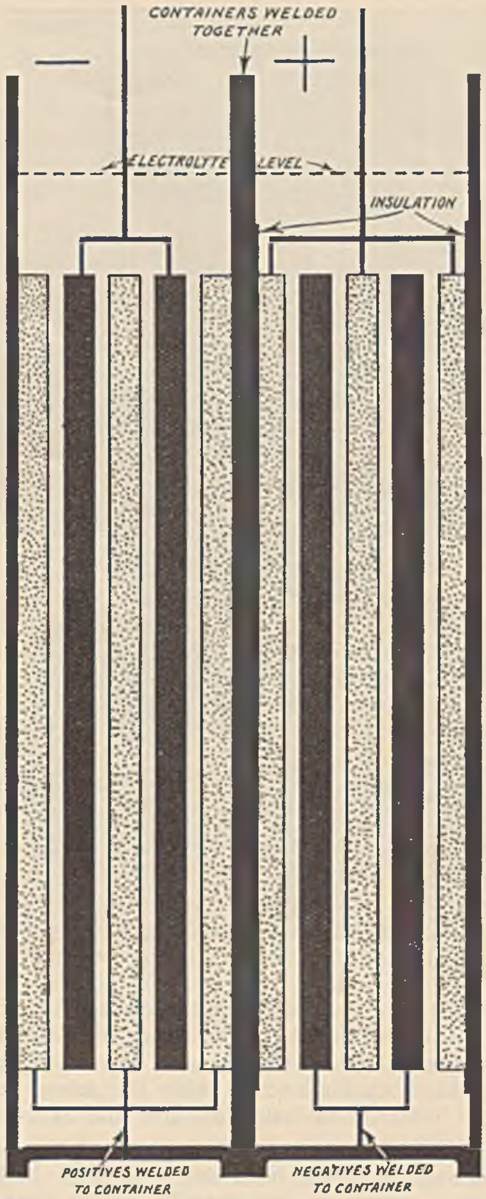

Fig. 3.

easily seen how these two screws hold the ebonite mount to the steel top and firmly grip the flange of the well glass in position between the two. On releasing the two screws the ebonite mount and well glass come away together, and the well glass with its washers can then be lifted off the mount. This exposes the bulb and enamelled bottom reflector; and on unscrewing the bulb the reflector can be lifted off, when the upper contact arrangements are exposed. These consist of a very strong screwed bulb holder and contact spring both of which are screwed into the ebonite mount. Let into the underside of the ebonite mount is an ebonite disc with four recessed steel contact plates, the whole disc floating on two powerful flat springs. These springs are fixed at their upper ends to the bottoms of the screws from the bulb holder and contact spring, and at their lower ends to two of the four contact plates. In the whole circuit throughout the lamp top there is thus only one unfixed joint, i.e., between the bottom of the bulb and the spring contact.

The lamp bulb is of the metal filament screw type and it has been specially designed to suit the characteristics of the nickel cadmium battery so that even lighting is assured throughout the shift.

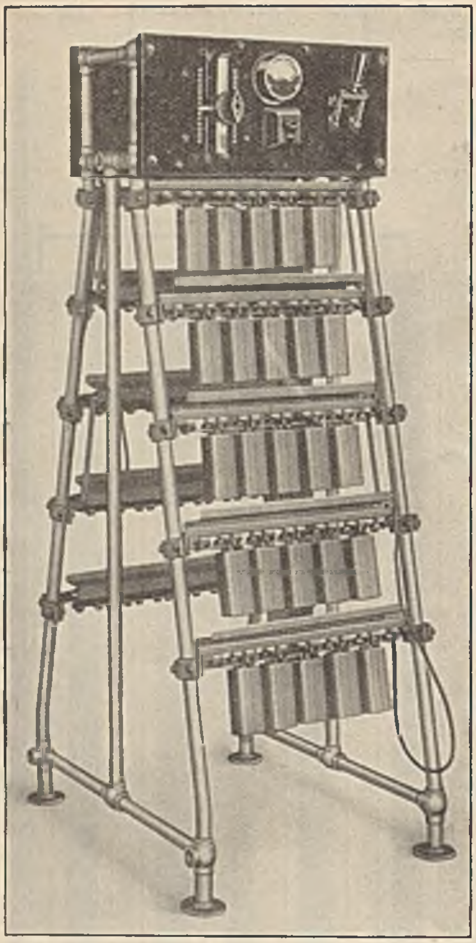

Fig. 4.

The well glass is of strong mechanical design and fine optical qualities and can be either plain or frosted. Fixed into the top of the glass is the top enamelled reflector which in conjunction with the lower reflector previously referred to helps to give the lamp unique lighting qualities.

The weight of the lamp complete with battery is 5 lbs. 12 ozs. which is considerably lighter than most types containing a lead battery. At this weight the lamp may be considered as equally strong and rugged as the heaviest lamp made for this particular purpose.

The reduction of unfixed contact points to an absolute minimum results in an exceptionally even illumination from the lamp. Even when dropped and rolled it is impossible to make the lamp flicker.

The opening magnet for unlocking the lamps provided with magnetic locks is particularly robust and is designed to withstand very severe handling. It consists of two parts: the magnet proper and the switch. The magnet proper consists of a solenoid coil surrounding a central iron core, which has specially shaped projections at each end so that it fits easily and closely round the lock, making the operation of opening rapid, simple and certain. The magnet is mounted on a cast-iron pedestal, and fitted with a circular cast-iron cover and is designed for bench mounting. The efficiency of the magnet is particularly high and it takes only 15 watts. The dimensions are 4 ins. diameter by 6¾ ins. high. The magnet is controlled by means of a foot operated switch. This switch is contained in a drip proof cast-iron container suitable for mounting on the floor, and is so constructed that it satisfactorily withstands the rough usage that is generally met with in practice. The magnet is normally disconnected from the supply and when it is desired to unlock a lamp, the lamp is held so that the magnetic lock fits into the projections of the opening magnet, and in depressing the foot switch the magnet is excited so pulling up the spring loaded plunger in the lock; the lamp can then be opened by a quarter turn of the lamp body.

With regard to other applications of these batteries in mining service it will be seen from the general robust construction of the nickel cadmium battery and its electrical characteristics that it can be very efficiently used as an emergency lighting battery in the winding room. As there is no self-discharge the battery can be left unattended for months without even being trickle charged. Topping up is reduced to a minimum, no hydrometer readings are necessary, in fact it can safely be forgotten for the time being. The space occupied is exceptionally small: for example, taking a 25 volt battery of 60 amp.-hour capacity (which is quite a common size for this class of work) the ground space occupied by the nickel cadmium battery is approximately 2½ sq. ft. as compared with 5¼ sq. ft. for a lead battery of the same voltage and capacity. This small space and also the absence of corrosive fumes eliminates the necessity of a separate battery room. The batteries serve equally well for shaft signalling purposes and quite a large number have been in operation on this duty in this country for the last six years. There are many switch tripping batteries of the nickel cadmium type in operation in mines at the present time. High capacity at heavy discharge rates and ability to withstand these heavy rates is one of the essentials of an efficient tipping battery. A 25 volt 10 amp.-hour battery will easily give a total tripping current of 25 amperes or, generally speaking, 2½ times the capacity figure.

Apart from mining switchgear batteries, it should be noted that the Central Electricity Board have installed a very large number for use in the "Grid" and they are now being specified by the Consulting Engineers. In addition to tripping batteries, a fair number of switch closing batteries have also been installed.

Legislation in this country does not permit the extensive use of battery driven locos in mines, but abroad there are many in operation. The illustration, Fig. 5, shews one of the many tunnelling locos used by the Sydney Drainage Board: the locomotive is equipped with a nickel cadmium battery.

From what has already been said it is apparent that there are many advantages to be obtained by the use of the nickel cadmium battery and these may be enumerated as follows:—

1. Sulphation is impossible.
2. Steel construction throughout.
3. No plate buckling or shedding of active material.
4. Absence of corrosive fumes.
5. Small volume and light weight.
6. Low internal resistance.
7. Will give heavy discharges.
8. Can be consistently overcharged.
9. Will stand idle without self-discharge.
10. Low maintenance costs.

While most of the electrical characteristics have been given for the new improved type of cell which has only recently been placed on the market, it must not be thought that the nickel cadmium battery is a recent invention. The original nickel cadmium cell was patented in this country in 1900 (British Patent 7768) although a few years elapsed before it became a commercial product. During recent years, its unique advantages have been more and more realised and at the present time large numbers are being supplied to practically every Corporation in this country. In addition, almost every Government Department is being supplied in increasing quantities.

Discussion.

Mr. IDRIS JONES.—Having had a certain amount of experience with the lead type of cell for lighting, switch tripping, bell ringing, etc., Mr. Jones said he would like to refer to the author's remark regarding the battery floating on the line and dealing with the peaks. One particular station in which the speaker was directly interested has a lead type of battery ; the station has grown beyond its original size ; heavier switches have been put in ; the battery had not been changed and it was necessary to run a little motor generator set for closing. Reference was made in the paper to this nickel cadmium battery being able to deal with peaks in an equal manner ; but, owing to the internal resistance being much higher, it does not deal with the peaks without introducing a large voltage drop. It was essential to keep the voltage up so that there could be no risk of switch failing to get in finally. It is at the end of the stroke that the greatest effort is needed. With a battery having a very great drooping characteristic there is danger of the switch not going in rapidly enough. That point, in Mr. Jones' opinion, was very important and it seemed to be that for such cases the cadmium cell lost its value in comparison with the lead battery. Mr. Jones said he would like to know the internal resistance of the nickel cadmium cell as compared with the lead cell of equal capacity. From what he gathered the internal resistance of this cell was about half that of the ordinary lead cell, but the author had not mentioned the relative resistances of the two types. Internal resistance has some bearing on the efficiency of the cell and as a matter of interest perhaps the author would give the figures as suggested.

Another point of interest was that the battery could be left for a very long time, the author did not say indefinitely, without having to be topped up or recharged. That was where most of the trouble started with the lead cell. In the endeavour to keep them up considerable damage is caused by overcharging and there grows a considerable amount of deposit at the bottom of the cells. The result of this overcharging was increased cost of maintenance. Would Mr. Mann say what was the percentage rate of depreciation of the cadmium type of cell as compared with the lead type with lead cells. Mr. Jones believed it to be something like 10%, which made the upkeep very expensive. For outlying stations the lead type was right out of the question and it became necessary to use either primary cells or this cadmium type of accumulator.

Mr. W. W. HANNAH said he thought the lecturer might have been forgiven had he referred to miners' lamps. As members of the Association of Mining Electrical Engineers, the application of this particular cell to miners' lamps was, after all, of first interest to them.

There were one or two questions Mr. Hannah would like to ask, seeing that they were so closely interested just now in the question of underground lighting. He would, for instance, like to know the ampere hour capacity of this type as compared with the lead acid of equal weight. As to the working of these cells the discharge curves shewn were, for the cadmium cell based

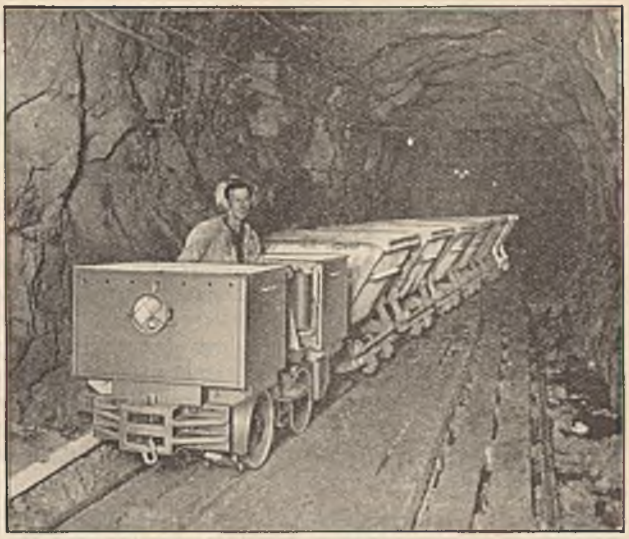

Fig. 5.

on a 5 hour discharge rate, for the lead cell on a 10 hour discharge rate curve was shewn. What is the initial voltage of an alkaline cell? Is it somewhat high? If so, is not that an objection for miner's lamp usage ? Would it not tend to blow the bulb when the cell was first put on discharge ? He would also like to ask whether the density of the electrolyte and the rate of charge had any influence on the initial voltage.

Mr. J. B. J. HIGHAM said he too would ask for information regarding the comparative costs of the nickel iron and lead cells on the basis of equal watt-hour output for a given time of discharge. For example 50 k.w. hours in seven hours for each battery. He would suggest that the discharge be carried out with a fixed value of resistance in the external circuit. That method would remove the trouble of variation of the voltage and ampere hour discharge characteristics, and the fixed external resistance would put each battery on the same footing regarding external conditions.

Some idea of the relative total costs per k.w. hour output for each type would be useful, that would include an assessment for capital cost and depreciation. The figures would be of service, for example, when selecting batteries for supplying power at regular intervals ; they would not be so important when the batteries were to be used for tripping circuits, etc. ; in which cases reliability of operation was the criterion.

Mr. Higham said he understood that the cost of the nickel iron cell is considerably in excess of the cost of the equivalent lead cell but I have not seen figures for a cell of any appreciable size, say, for one in the order of about 100 to 500 ampere-hours.

Mr. L. A. SNOW asked for the relative cubic capacities of the nickel cadmium battery and the lead battery on the same basis.

Sir A. WHITTEN BROWN (Chairman).—The alkaline battery when used for central station work is said to have an indefinite long life owing to proper maintenance and renewals, but where it was used for other work such as motor car lighting and starting batteries and for mining lamp batteries, what then would really determine the life of the battery ? It was stated that the life of the alkaline battery was longer than that of the lead cell, and it would be interesting to know where failure first occurred ; would it be a mechanical or a chemical failure ?

It would appear that the chemical action during charge and discharge must cause the active material to disintegrate, and as access for the electrolyte was gained by holes in the plates, did it not follow that disintegrated active material must slowly deposit in the bottom of the cell?

Mr. THEODORE STRETTON (communicated).—I am rather puzzled to know what it is that Mr. Watson Mann is trying to convey. He appears deliberately to divide alkaline batteries into two classes, i.e., nickel iron and nickel cadmium, and he then proceeds to shew that the nickel cadmium battery has very many advantages over the nickel iron. With this idea I entirely agree, but as far as I have been able to gather from the paper in spite of Mr. Watson Mann's assertion that nickel cadmium batteries have so many advantages over nickel iron, he proceeds to describe as his ideal battery one in which iron is used.

It is a well-known fact that any quantity of iron used in an alkaline battery tends to develop gas to a much greater extent than a battery in which cadmium only is used; also it tends to cause self-discharge. Moreover, a battery in which iron is used has a high internal resistance and it is necessary frequently to change the electrolyte.

Dealing with the positive electrode, I notice Mr. Watson Mann states that a percentage of flake graphite is used and I would like some further information as to why this somewhat unusual material is used.

I do not see any reference in Mr. Watson Mann's paper to the tubular type of positive electrode, which I understand very effectively prevents the swelling of the usual type of positive electrode as described in the paper, and which has caused so many failures in alkaline batteries. Perhaps Mr. Watson Mann will be good enough to give us the benefit of his experience, or to say whether he agrees or does not agree with this statement. He might also say whether he agrees that in the present state of our knowledge of alkaline batteries the ideal battery is one in which is combined the tubular type of positive with the cadmium negative.

I note that Mr. Watson Mann in the latter portion of his paper switches over on to a description of a miner's lamp. Having had some slight experience in the manufacture of miners' lamps, and having examined the lamp described by Mr. Watson Mann, it occurs to me to wonder why the manufacturers of the battery described by the author were not content to remain manufacturers of batteries and to leave the manufacture of miner's lamps to others who may, or may not, have had rather more practical experience. I might just add that in a miner's lamp it is the small details, some of which may appear insignificant to the inexperienced, which count most. Perhaps the most glaring example of this is in the cover plate or dome of the lamp in question: why this should have been shaped as a receptacle for coal dust is rather puzzling, in addition to which its lightness makes it quite unsuitable. The loose contact plate has an annular space which will undoubtedly allow corrosive fumes from the cell to reach the bulb contacts and the bulb cap and thereby cause flickering light. All I need say about the lower case or container is that it is far too light for use in Mines.

Mr. WATSON MANN (in reply).—The reason for dwelling so much on the nickel iron type by way of comparison is the fact that the name nickel iron is better known than nickel cadmium. The result is that as soon as anyone hears of a steel battery, the nickel iron type is thought of at once, together with its high internal resistance characteristic. On this account comparisons were made in the paper between the nickel cadmium and nickel iron types in order to shew the difference that does exist, especially as regards internal resistance. There are many cases in practice when arguments are put up against the nickel cadmium type because it is thought that its characteristics are absolutely the same as those of the nickel iron.

With regard to the question of change of specific gravity, there is of course an increase if a cell has been gassing for a considerable time. The reference was to the chemical action of the cell which takes place on normal charge and discharge apart from the gassing at the end of a charge when the chemical action is complete.

The use of flake graphite was referred to in the paper, namely, to increase the conductivity of the mixture in the positive active material.

Tubular positives were referred to in the beginning of the description of the pure nickel iron cell. Regarding the question of a combination of tubular positives and cadmium negatives, there is a cell on the market today which is built up in such a way, but the experience gained has not been sufficiently long to justify the making of comparisons.

The paper clearly states that there are no corrosive gases given off when caustic potash is used as an electrolyte; the fumes given off when sulphuric acid is used are definitely corrosive.

With regard to a nickel cadmium battery floating on the line: taking the charge side first, it is possible to absorb a small charge at a voltage as low as 1.365 volts per cell. Owing to this voltage being a higher percentage of the discharge voltage than that of the lead type the number of cells required for a floating battery is slightly less than what is desirable for a good discharge characteristic. With the improved nickel cadmium type it is now possible to obtain the necessary discharge characteristic with the same number of cells.

No figures of internal resistances were given because there is great difficulty in obtaining definite figures. Internal resistance figures are very misleading and do not convey much because there are so many methods by which they can be determined. However, figures can be quoted for the nickel iron and the nickel cadmium types. These were both obtained by the following method: a cell is put on normal discharge for 30 seconds, the voltage and current being noted. The discharge rate is then doubled for 30 seconds, voltage and current readings being noted again. The internal resistance is calculated by dividing the average drop in voltage by the average rise in current. For a nickel iron cell having a capacity of 150 ampere hours, the figure for internal resistance is 0.003 ohm, and for the nickel cadmium type 0.00112 ohm at the beginning of discharge and 0.00153 ohm at the end of discharge giving an average of 0.0013 ohm. Comparing this with 0.003 ohm for the nickel iron type it will be seen that the internal resistance is less than one half.

Coming now to the lead battery the author wrote to one manufacturer for figures but unfortunately was not able to get the actual method by which they were determined. Those given for a 150 ampere hour battery were 0.0022 ohm at the beginning of discharge and 0.003 ohm at the end. The former figure is practically double the figure for the nickel cadmium battery. It would therefore appear that the method of calculation was not the same. That is why it is very difficult to make comparisons. It will be made clearer by comparing the curves and the voltage variation.

As to the question of leaving the cells unattended the author can quote a case of a nickel cadmium battery installed in 1918 for bell ringing. It was only last year (1929) that the cells were taken out, so that for eleven years they had been operating the bells without recharging or attention. The load was certainly very light but when the cells were put on the test bench they were found to give 25% capacity. On giving them a normal charge and discharge full capacity was obtained.

There are a number of Supply Companies who use nickel cadmium batteries for tripping purposes and no charging equipment is employed. The batteries maintain the tripping loads for a period of twelve months and at the end of that time they are taken away and replaced by fully charged cells. During the twelve-month period no attention whatever is given to the batteries. The author has no figures available giving the percentage rate of depreciation. The chief expense is electrolyte renewal. In the majority of cases it is necessary to renew the electrolyte every twelve months. In some cases where the battery is used for emergency purposes or for switchgear operation it is possible for the battery to go two years, without renewal.

Unfortunately, the author cannot submit figures for comparing the capacity of a nickel cadmium battery with that of a lead battery of equal weight. With the lead battery there are so many types for different classes of work that it is difficult to make comparisons.

With regard to the initial voltage of the cell which is used in the miner's lamp, this is double that of a single cell, viz., 2.54 volts, dropping to 2.4 volts at the end of a normal discharge. If such a battery be given a normal charge and then put straight into the lamp, the gas on the plates will keep the voltage up. Only a short time has to elapse before the voltage will drop to an open circuit figure of 2.72 volts. At the commencement of discharge the voltage will drop to approximately 2.54 volts. The light from the lamp is certainly bright at the commencement of discharge but it follows that a good light will be maintained at the end of a shift. The high voltage of the nickel iron cell may cause blowing of bulbs at the beginning of discharge but this is not the case with the nickel cadmium type. The density of the electrolyte has no effect on the initial voltage. A rate of charge higher than normal would result in a slightly higher initial voltage but the period that would elapse before it settled down to a normal characteristic would be exceptionally small and not sufficiently long to have an ill effect on the bulbs.

To compare batteries on a watt-hour basis would be rather difficult and confusing. In making such a comparison, average discharge voltage is taken into account, and, therefore, the comparisons would vary with the actual rate of discharge. Take the case of a battery which is required to give 70 amperes for one hour. A lead battery having a normal capacity of 140 ampere hours will only give 70 amperes for one hour while a nickel cadmium battery having a normal capacity of 70 ampere hours will give that capacity at the one hour rate that is, 70 amperes for one hour. This is due to the fact that with the improved nickel cadmium type the falling off in capacity at higher discharge rates than normal, is practically nil. The comparison therefore on a watt-hour basis would depend on the actual rate of discharge and therefore the particular kind of duty for which the battery is required.

The figures given in the paper comparing relative space occupied by lead and nickel cadmium batteries were worked out for a 25 volt battery of 60 ampere hours capacity and on floor space only. The author cannot give corresponding figures for cubic capacity but they would be still more in favour of the nickel cadmium type.

With regard to the ultimate death of the cell, this was generally found to be due to chemical failure. The active material, after going through a large number of cycles of charge and discharge, loses its conductivity, This results in an increased internal resistance and the cell fails to hold its charge.

The Chairman mentioned the possibility of disintegration of the active material. It is not absolutely impossible under all conditions for the active material to shed. The perforations of the plate pockets are not the same size as those of a negative plate of the Faure type which are about $\frac{1}{16}$ inch in diameter. The holes in the steel pockets are such as are made with a very fine needle. They are so small that under normal conditions, shedding will not take place. One sometimes comes across a case in practice where the level of the electrolyte has been allowed to drop considerably below the tops of the plates. The specific gravity of the electrolyte under such circumstances is much higher than normal and may be of sufficient strength to act on the active material and cause shedding.

* * * * *

The Author has communicated the following further information which it is hoped may be of interest.

Internal Resistance: 100 *volt batteries.*

Capacity	*Average Internal Resistance in ohms*		
Ampere Hours	*Nickel Cadmium*	*Nickel Iron*	*Lead (Planté)*
150	0.112	0.264	0.14
225	0.074	0.176	0.0918
300	0.0562	0.132	0.0756
375	0.0445	0.106	0.0621
450	0.0372	0.088	0.0524

These figures, which are given by manufacturers, agree with the curves shewn in Fig. 1 and the details of voltage variation given in the paper.

Weight and Cubic Capacity: 12 *volt* 300 *a.h. batteries.*

Type	*Nickel Cadmium*	*Nickel Iron*	*Lead (Planté)*
Weight lbs.	330	290	1008
Capacity, cubic feet...	3.9	3.2	10

Depreciation.

A large number of the first nickel cadmium batteries to be manufactured in this country and which are installed in mines, are still giving satisfactory service. It is very difficult, therefore, to work out the depreciation, but there is no reason why a life double that of the lead battery may not be expected.

WESTERN SUB-BRANCH.

Comments on Calibration of Power Station and other Instruments.*

Discussion.

Mr. W. M. THOMAS (Branch Chairman) said the subject of the paper and the status of the author were sufficient to attract the closest attention of members. Mr. Isaacs, a former chairman of the Western Sub-Branch was held in the highest esteem and their thanks and congratulations were due to him for this important paper.

* See *The Mining Electrical Engineer*, Feb., 1931, p. 269.

Accurate records are the bases of scientific control and without accuracy in these matters, figures may be worthless, valuable time was wasted and the engineer deceived rather than guided.

Mr. Thomas was reminded of a very significant incident on a boiler range during one of the unfortunate strike periods some years ago. An inexperienced substitute stoker was remonstrated for not keeping up the pressure on the boiler—the gauge only reading 30 lbs. "Why," remarked the stoker, "you should not take notice of that there dial, it has been round twice already."

In his paper Mr. Isaacs had stressed the need for periodic calibration. Those who have to buy or sell units realised the significance of this remark. Accurate instruments were an economic necessity as giving true indications of the performance of a machine or plant. The author had given a summary of the General Testing outfit whereby the accuracy of instruments could be checked and maintained. Very often, instruments in colliery practice were sent back to the makers or to some standardising institution such as the National Physical Laboratory. Inability to carry out the standardising in collieries was due to (a) The lack of proper apparatus to carry out the tests, and (b) The inability of the person in charge to perform such work.

Mr. Thomas said he had known—only too often in survey departments and other phases of colliery practice—almost total ignorance of methods to detect or rectify instrumental errors and frequently considerable expense was incurred: the operator was often totally ignorant of what was wrong and what had to be done to rectify errors. The late Professor L. H. Cooke of the Royal School of Mines, had impressed on Mr. Thomas the general axiom for all instrumental work and that was: "Know your instrument"; surely a corollary of the admirable paper read that evening.

Mr. Isaacs had put forward as a fundamental that correct physical conditions must be maintained to carry out the work of testing. In testing work the investigator must concentrate on skilful manipulation and observation in order to bring about a result which he was able to guarantee, and valuable time was wasted if physical conditions were present to introduce variables that could not be compensated for.

In outlining the sources of supply, the need for constancy of supply and wave form was stressed by the author, who suggested an ingenious device of a.c. regulation where the induction regulator was so frequently used in a.c. circuits for varying voltage.

The importance of accuracy in watt-hour meters was in the mind of every engineer, for on the one hand if too much was debited to the consumer, the engineer may have a Court order; on the other hand, if too little was recorded the station might have to bear a heavy loss and the engineer be qualifying for his discharge.

The calibration of air and steam meters was of prime importance in colliery undertakings where a portion of the steam was diverted to the generating station and a portion to other steam units. In allotting charges for compressed air for underground circuits the apportionment to each branch was an important check on the economical working of that section. So also water-meters required recalibration at frequent intervals to determine the evaporative costs which formed the bases of charges for steam to the generating and other units. Accuracy in the work of instrumental measurement, whether water, steam, compressed air or electricity was a first essential; without it the costing systems become worthless.

Mr. REES thanked Mr. Isaacs for his excellent paper, and said he had seen less fortunate in his experience than Mr. Isaacs in the matter of sending his meters for recalibration. He had one now on its third travel, due to damage in transit, and said that in the ordinary way they were unable to notice that damage on its return. He quite agreed with Mr. Isaacs that the testing or calibration of instruments should be carried out in the situation that they are to operate in, and under the same conditions, because they could reproduce the conditions in which they were operate. He pointed out the fact that when it came to working under the actual conditions the changes were much more rapid in regard to load. It was very difficult to reproduce the variations over a wide range.

Mr. Isaacs was rather of the opinion that an ammeter was not so very important, but Mr. Rees said that one might have an ammeter in a meter circuit that might be called upon during the hour to do a fair amount of overload, and if one could not depend upon the ammeter the case was hopeless. Then again there was the temperature condition; under absolute working load the instrument was usually calibrated to work somewhere round about 60, but they hardly ever get that in an engine room. He asked why it should be 60, and thought 80 would be a better point.

Mr. Rees said that Mr. Isaacs had had better luck with his induction regulator than he had, and added that over wide ranges where they were on high voltage tests the wave form seemed to go to pieces. He obtained better results from the rotary converter method. He said this phase reading business was rather a vexed question, and did not know whether they were inclined to mix up phase reading with phase relation. Regarding steam metering, Mr. Rees said there were a lot of things coming into that which they could not get over; a tee or a bend, for instance.

Mr. S. T. RICHARD congratulated and thanked Mr. Isaacs for his valuable paper, which was especially welcome at the present time when accurate costing was such an important matter. He stated that he was particularly interested in the ampere turn meter as described by the author and also the various tests that could be carried out with it. He had used the meter referred to for the checking of switchboard ammeters and had found in a good many cases, that the meter served as a good check on the original and correct readings. It had shewn up several errors on doubtful meters.

The question of metering was an all important one when one had to balance out power supply costs, whether electricity, compressed air, steam or water, and it was particularly so when losses had to be kept down to a minimum. The calibrating of such meters was an important matter. Small errors on a large meter installation led to a high percentage loss on the whole installation. How else could this loss be kept at a minimum without a periodic system of calibration?

Mr. Richard quoted a colliery village lighting installation where a loss of 40% existed, and by means of systematic testing this was reduced to a figure of 16%, and the matter was still being pursued further; this gain had been secured by simply checking up against a sub-standard meter, which he thought would be the most suitable for colliery undertakings.

Mr. Richard was very interested in the manometer method of compressed air meter testing, and quoted an instance where after the installation of compressed air meters the readings obtained did not check with the number of running hours of the compressors at full load. The meter manufacturers were emphatic that the meters were correct, and also the air compressor makers were equally emphatic on their side that the compressors were giving full output. It was decided to use the method described by Mr. Isaacs as a means of checking both, and the discrepancy was eventually traced to the orifice plate which was of the wrong size, although its number- and serials corresponded with the correct size. This would have been extremely difficult to locate if it had not been for this method of testing. It also served as a very useful method for the periodic testing of all air and steam meters. The effect of moisture on the pipe lines on meter readings must also be borne in mind, as in one case sumps had to be fitted before the readings could be relied upon.

With electrically operated steam integrator meters supply voltage fluctuations have to be guarded against. Taking a general view of the subject he enquired of Mr. Isaacs how often should a meter be calibrated from a routine point of view.

Mr. G. VEATER said he was particularly interested in the latter portion of Mr. Isaac's paper, with regard to meters for compressed air and steam. He thought they were inclined to take things too much for granted. It was very important when purchasing a meter, that full and accurate particulars should be supplied to the makers, as to the conditions under which it would have to work, especially in regard to compressed air. It was equally important that they should have accurate readings on the steam, water and compressed air services as on the electrical side. In the case of feed water meters, there was the Lea Recorder which, all would agree, is one of the most accurate meters in use. There were other types of feed meters which were fixed directly in the feed main. The accuracy of these meters was affected by the different kind of feed pumps; pieces of packing found their way into the meter and often gave false readings. He would have liked Mr. Isaacs to have dealt with the calibration of these meters on site.

In the case of the feed water meter it could be checked against a tank of known quantity, which was quite a common method of testing a boiler. As far as the steam flow meter was concerned, it was essential that where steam flow meters were used, feed water meters should also be installed; the one being a check to the other.

The engineer in charge should know his plant and be able to tell whether his plant was working efficiently, and from this experience see whether any inaccuracy was occurring in the meters and be able to carry out tests to prove their accuracy. In the case cited by Mr. Richard, they had taken the meters for granted, assuming them to be correct and relying upon the manufacturers. In this case again the engineer knowing his plant, doubted the accuracy of the meters and after a great deal of testing, indicating of engines, etc., it was proved that the meters were incorrect. If insufficient attention was given to the plant itself and too much reliance placed on the meters, the engineer was liable to be let down.

Mr. McSHEEHY said this was a most interesting paper, and by Mr. Issacs springing down to two simple pieces of apparatus the question of meter testing, he derived some feeling of relief. He confessed ignorance of the actual effect of wave form on instruments, meaning the degree of effect. At the power station they had certain definite wave forms, but by the time it got to a substation some miles away would the wave form be altered, and could Mr. Isaacs give some idea of the difference in percentage, or in distortion of the wave form? He referred to a short circuit test with a phase shifting transformer, and asked whether, when moving the rotor between one slot and the next slot on the stator there was a considerable variation in the current. Further, were they not likely to be misled, with a phase shifting transformer, unless they were very observant, by that variation in current? With regard to steam flow, he said that instruments based on the orifice plate method were very accurate provided they were looked after and not damaged. With regard to mill engines, he said it was necessary to have a rapid rotation of the drum to get an accurate reading. He described a method by which he checked the results in the works with which he was connected.

Mr. E. D. C. OWENS said that when taking instruments for official tests, and he had had some experience of this, he always found it necessary to have them under his own supervision. On the question of testing watt meters by the suggested method of testing against a sub-standard, he did not think this was a good method. On the point of the difference of opinion as to whether meters shall be tested on three-phase load or each element separately, he thought three-phase meters could only be roughly tested by testing separately. Tests had to be referred to d.c. as an absolute standard; there was not an a.c. standard. As to standard resistances, it was very important that these should be of good quality and of a recognised make. He referred to the potentiometer method for determining the phase angle.

Meters, of course, should always be calibrated with their respective transformers. Students having the opportunity of going to the testing laboratories should make a point of doing so. He thought that very much more accuracy of instruments would be called for in the future.

Mr. CASWELL said that the calibration of instruments in industrial plants was important because the readings which the instruments gave were usually regarded as a true indication of the conditions under measurement. Unless the instruments were periodically checked there was considerable risk of error, and this, in some cases, might lead to serious consequences, as Insurance Company Reports would shew. He thought, therefore, that it was a first requirement in any industrial undertaking of fair size that all instruments should be under the care of one person or more, who would be responsible for the care and accuracy of the instruments.

The methods of calibration of a large number of instruments were simple. Steam meters of the orifice type, which were properly installed, could be relied upon if the orifice plate was kept clean and the indicator periodically tested against the stipulated manometric head of water.

Instruments might be damaged in transit, and it was often desirable in such cases to give the manufacturers an opportunity of putting the instruments in order. Much regarding the calibration of instruments could be learned by collaborating with the manufacturers, and it was only by so doing that a reasonable guarantee of accuracy could be secured.

On the question of low pressure measurements, the ordinary type of pressure gauge was unsuitable and such measurements should be made with gauges specially constructed for low pressure measurement.

Mr. COPE.—Mr. Isaacs had dealt with his subject so clearly as to make testing appear easy and simple; as a result every colliery electrician would now feel that he had to get some testing apparatus. But Mr. Isaacs had not pointed out some of the dangers of getting inaccurate results, which would perhaps be worse than doubtful instruments. He referred to an experience he had about eight years ago with two meters which started very well, working to about 1 per cent. After a time one watt meter began to gain. The supply people said the other one was beginning to lose. The supply people said they were satisfied with the meter, and took their meter to London and came back with it sealed with a certificate of accuracy. The next month's bill was based on the reading of the meter. Mr. Cope's people sent their transformers to the same laboratory and obtained a certificate of accuracy for that meter. It was brought back, duly installed, and there was still 10 per cent. difference between both meters. That shook his faith in these certificates of accuracy. If they did have any testing apparatus at a colliery, they must have a man, also, upon whom they could rely, with the ability and knowledge to adjust the meters so that they would read accurately. He understood the power supply authorities always took about two and a half per cent. high.

The calibration of meters was very important, but it must be thoroughly gone into and wisely supervised.

Mr. Eccles said it was very gratifying to find at the present day a great increase of interest in meter testing. Manufacturers of switch boards had not considered the lay-out, and the colliery electrician was faced with considerable trouble on many jobs with which he had to deal. It was amazing to find the amount of inaccuracy taking place in meters. There was no doubt that the time has come when special care should be taken to revise the whole question of metering in collieries and works, not only for their own benefit, but to check their bills for the supply of power. Adequate provision of facilities for testing would have to be considered.

Mr. ISAACS, in reply to the discussion, said he was glad that the Chairman agreed as to the necessity of periodic calibration but the present difficulty in colliery practice was the lack of proper apparatus and personnell for such work.

Referring to the comments by Mr. Rees, it was satisfactory to note that he regarded ammeter calibration as of importance. Some instruments were very affected by temperature changes and they should be calibrated in an enclosure and maintained at the temperature at which they were to be used. It was true that some induction regulators did give a very distorted wave form and they would not be satisfactory for really accurate testing.

In reply to Mr. McSheehy as to the effects of wave form on instruments, that would depend very much on the type of instrument, some being very much more affected than others. It was possible for the wave form at a distance from the station to be considerably changed. In a well designed phase shifting transformer the effect of the slots was negligible and no change in volts would take place as it was rotated.

Mr. Owens had said he considered that three-phase meters should be tested as such ; Mr. Isaacs agreed that was the ideal method but only if the three-phase test actually reproduced the load conditions, and that would introduce many complications.

The steam meter test described by Mr. Caswell was interesting but it should be realised that it relied upon the accuracy of the orifice which operated the meter under test.

Mr. Cope's experience of standardising institutions seemed to have been very unfortunate. Mr. Isaacs agreed with him that if testing had to be done it must be by a properly qualified person.

Mr. Eccles had pointed out that testing *in situ* was often very difficult owing to the fact that in the lay-out of switchboards the question of testing had not been considered. Perhaps before long, as the importance attached to meter testing increased, designers would take this matter into account.

Mr. C. E. YATES proposed a vote of thanks to Mr. Isaacs. The formation of collieries into groups had brought about the elimination of small power stations, and the result was that the majority of colliery power stations now existing were selling electricity. It was therefore essential that the electricity meters should be accurate, not only for the ascertainment of generating costs, but to enable an accurate account to be submitted to the consuming undertakings.

Mr. EDMUNDS seconded the vote of thanks which was carried with enthusiasm.

LONDON BRANCH.

Ⓟ Mining Costs, Data and Economics in reference to the Engineering Department.

C. F. MEES.

This Paper was read on 2nd December, 1930, in the absence of the Author, by Mr. J. R. Cowie. Mr. Mees is stationed in West Africa and the several interesting photographs reproduced herewith are of the Abbontiakoon Mine, Tarkwa, Gold Coast the present centre of his activities.

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This subject may appear at first to be outside the duties of the engineers but an endeavour will be made, to shew that it is most important for the personal satisfaction of the engineer, whether or no he is called upon to make such returns to the management; and also to enlighten him to what extent the data compiled enables the tracing of leakage of costs and the possibilities of economy.

From the commencement a clear understanding must be had of mining costing accounts. The engineer may think that the unit of cost is the electrical unit or horsepower. This is not the case—the final product must always be the unit of cost—however interesting any other figure may be to a particular official: whether it be for a colliery or a metalliferous mine, the unit of cost is essentially "Tons Mined". Again, the manager of a mine does not of necessity realise the meaning of a unit of electricity whereas "Tons Mined" is the term of which he is thinking all the time. The accountancy department of a mine will not consider a final allocation of cost to power and engineering, the power cost will be spread over the departments according to their respective consumption of power, and all items of repair work

Fig. 1.—General View of the Abbontiakoon Mine.

will be placed under the various headings for which they are effective; for instance, repairs to a pump underground will be general mining cost, a pane of glass in an office window will be office expenses and repairs to a stamp battery will be milling. The final cost heads with their subsections will be similar to the following list with the obvious alternative substitution in the cases of tin, iron, coal or whatever class of mine it may be.

1. Management.
   - A—Salaries of Manager, Assistant and personal.
   - B— „ Accountant, Paymaster, Clerks, etc.
   - C— „ Surveyor, Assayer.
   - D— „ Storekeeper, Clerks, etc.
   - E—Rent, Rates, Taxes, Insurances, Bank and Legal charges.
   - F—Office expenses.
   - G—Lighting and Heating.
2. General Mining.
   - A—Salaries, Mine Capt., Assistant and Clerks.
   - B—Timbering.
   - C—Pumping and repairs.
   - D—Lighting Shafthead and underground.
   - E—Pipe fitting.
   - F—Laying tracks.
   - G—Power consumption.
3. Development.
   - A—Shaft sinking.
   - B—Levels.
   - C—Crosscuts.
   - D—Rises and winzes.
   - E—Boxholes and shutes.
   - F—Ore bins and shutes.
   - G—Salaries of Shaftbosses and wages.
   - H—Repairs of Machines.
   - J—Shovelling, trucking and hoisting.
   - K—Ventilating.
   - L—Power consumption.
4. Productions—Mining.
   - A—Salaries of shift bosses.
   - B—Wages Hand Labour.
   - C— „ Machine Labour.
   - D—Drill sharpening.
   - E—Repairs to machines.
   - F—Trucking, shovelling and hoisting.
   - G—Power consumption.
5. Milling.
   - A—Conveying and sorting.
   - B—Crushing.
   - C—Stamping, milling and classification.
   - D—Engineering repairs.
   - E—Lighting.
   - F—Power consumption.
6. Reduction.
   - A—Amalgamation.
   - B—Cyaniding.
   - C—Retorting, calcining, smelting.
   - D—Lighting.
   - E—Power consumption.
   - G—Engineering repairs.
7. Tailing.
   - A—Disposing of final waste product.
   - B—Lighting.
   - C—Power consumption if any.
   - D—Engineering repairs.

Fig. 2.—The Native Village.

From the foregoing it will be seen, as already stated, there is no heading for Power & Engineering but that there is at least one sub-section under each heading which is a charge thereto.

The next important fact to consider is the difference between Capital and Revenue. The line separating these is very fine and is subjected to personal opinion and varies under different circumstances. Whatever items are charged to capital immediately become a lasting charge in that they are subject to interest and also depreciation. In consequence the engineer is well advised to consider carefully before so charging out any items, although by not doing so his working cost may have to shew a larger amount than he wishes for any particular month. Of course such a thing as a new engine or alternator is necessarily a capital charge which will also include the cost of supervision and labour of installation. Small tools issued to other than the engineering department will be charged direct under the various headings; those issued to engineering department will be dealt with later on in this article.

The charging of the above and similar things is obvious, but from time to time items arise which call

Fig. 3.—A Street in Tarkwa.

Fig. 4.—Native Hammer Boys going underground by Incline Shaft.

for careful consideration. Two instances will be given which may occur on any property.

Consider the building of a dam to prevent the tailing becoming a public nuisance by silting up a river or flooding a road. Should the cost of this be a capital expenditure subject to depreciation and interest with the necessary repairs charged to No. 7, or should the whole be charged direct to No. 7 and also the repairs as they occur? It may serve its purpose for say ten years. Will it be a tangible asset at 50% of the original cost after five years in the event of disposal of the property? With a heavy storm it may be washed away after a month and leave a permanent charge on the capital of the mine.

Again, if a consignment of rock drilling machines costing £1000 is sent down the mine, their real value the next day will be perhaps £500, in one year it will be £400 if properly maintained. If the whole value is capitalised with 20% depreciation, the book value in one year would be £800 or 100% above their true value. Should half of the amount be charged direct to 3 or 4 and half to capital with depreciation of 20%?

There are a number of mines at the present time which take current from a public supply company and on the other hand many mining properties are too far from any source of current for it to be economical to pay a supply company for their bulk needs. In these cases they necessarily have prime movers of their own: as this class of mine embraces the first in every way respecting the subject of this paper, it is the second class which will be considered. The power and engineering costs must be divided up into the fundamental heads all of which have tonnage as the unit of cost.

The engineering side can be dealt with in one of two ways which will be determined by the manager and the chief accountant. Every job which is done in the shops is costed and allocated direct to one of the various headings according to the department for which the work is done and all repairs to power supply plant will be carried over to power. These costs will include labour, material and an 'on-cost' charge which will cover supervision, cost of small tools, power used by machines, light, and a percentage of chief engineer's salary.

Alternatively the whole of the engineering cost can be grouped with the power cost thus giving one sum to be split up against the department according to the quantity of power they use respectively. This has the advantage of less clerical work for the cost department and also that any department that is so unfortunate as to incur heavy repair expenses has its burden shared by the whole of the mine. The first method shews more accurately the departmental costs and brings clearly to light the repetition of any repair that may be economically eliminated by replacement of the item of machinery which is the cause of the trouble.

The power cost must now be considered and this is the very important item concerning the chief engineer. This cost will include fuel, lubricating oil, cost of repairs, spare parts, stores, issues of waste, paraffin and other cleaning materials, wages of such labour as is required for the direct handling of fuel, oil, etc. and of engine drivers and shift electricians.

There will be no account taken of depreciation as this is dealt with by the accountant as an overhead charge. Insurance, if any, is covered under heading No. 1, but a percentage of the salary of the chief engineer, will be a direct charge.

Presuming it to be an all electric mine the consumption of power can be read directly from the main wattmeter. In other cases when there are steam winders, steam compressors and possibly other steam engines, it will require careful observation over a period to get a reasonably correct figure for the steam power. There may also be oil engines driving line shafting for various purposes for which there must also be an allowance. This can be obtained fairly correctly by the amount of fuel oil consumed and checked by comparison with the total of the various loads on the line shaft.

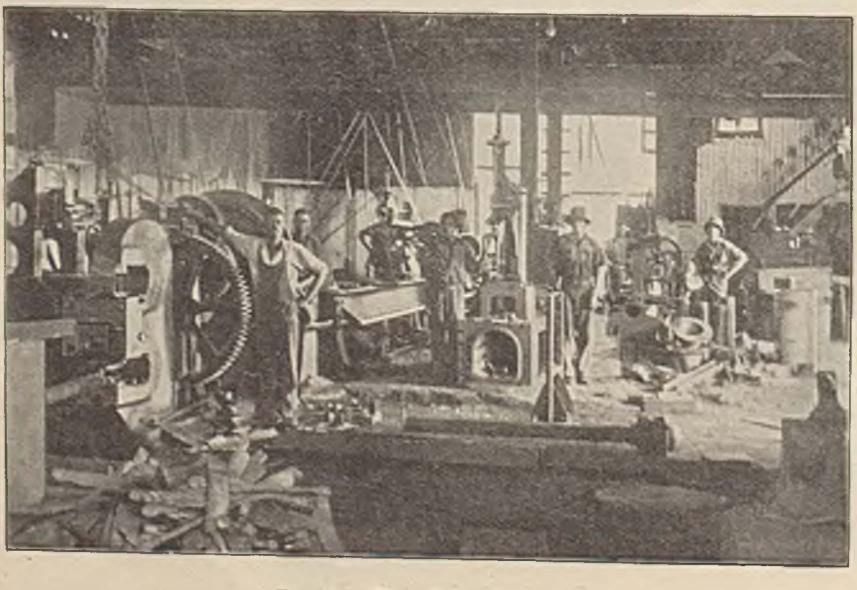


Fig. 5.—The Fitters' Shop.

Having arrived at the three essential figures tons mined, power used, and total power cost, it will next be considered how best to use these to furnish the fullest information of value to the manager and the heads of the different departments. The total power cost per ton mined—to be allocated to mining—i.e., to total of the general mining, development and production mining power charges—is the first figure for which the management will ask and the three figures should be shewn on this return. The detail cost of such subheading as pumping, hauling or air compressor charges should be recorded for reference.

Next there will be power cost per ton mined for milling; this is generally accepted as one figure but in specific cases it should be possible to give a separate charge for any detail operation on request. Treatment cost per ton mined require a little consideration. The tons treated per month will not be the same as the tons mined the variation being a small percentage up or down. In working over a period of a few months it will be found that the total difference is so small that it is preferable to neglect it in favour of the common unit.

It is seldom that there is any power used for tailing but should there be any, the corresponding amount should be charged for.

Having satisfied ourselves on the allocation of power cost let us consider what other figures are of useful interest. The cost per unit is obviously the first as it gives us the idea whether current is being produced at such a price as can be considered economical and a chart shewing the month to month variation, together with the cost of fuel per unit is a valuable guide to any unusual happening which may have occurred, although fuel cost may be subjected to variation over which the engineer has no control.

The horse power per ton mined per hour and per ton milled per hour plotted together give another pair of useful graphs. The latter should be only slightly above unity and effort should be made to reduce it as near as possible to that figure which is recognised as economical for all classes of metalliferous ores. The former should run parallel with a tendency to converge, every change to divergency should be investigated immediately.

The quantity of fuel per horse power will also be a great help especially where it is realised that the fuel bill is the largest item in the power cost. The power factor in the case of a.c. plant calls for considerable attention; to what extent it can be economically corrected is a subject which must be very carefully studied before any steps are taken in this direction. It will be shewn later in this article how certain corrections can be effected by varying the arrangement of the plant, changes which will incur little expense or inconvenience. The last figure to mention is the load factor and this is possibly the most important to the engineer in that by careful adjustment of the load and various times of the day this can be altered to a great extent and with its increase a vast saving will be found in the cost of fuel. This is most marked in prime movers when the throttle and governor act directly on the fuel supply but although less marked it is of equal importance in all cases.

Owing to the fact that the unit of cost—that is tons mined—will vary from month to month it is convenient for purposes of comparison to reduce all figures to a basis of 10,000 tons mined, also it is advisable to correct every month to thirty days.

Having a clear idea of the value of the figures given it must now be considered in what manner and to what extent economy can be brought about by acting on the information thus gained.

To illustrate this a gold mine in the tropics will be considered which brings forward several interesting points. A few words about the plant will enable us to follow the steps taken. It is a steam layout, the fuel being firewood cut in the forests.

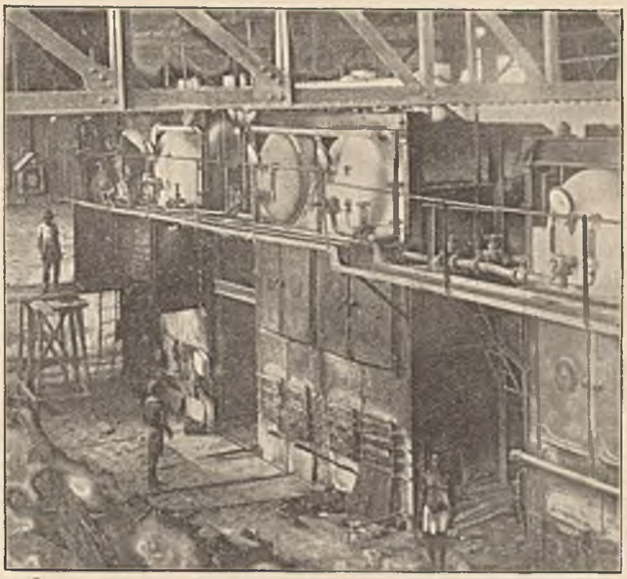


Fig. 6.—Part of the Boiler Plant.

There is a buttery of six water tube boilers four of which are required to run the plant leaving two off range for cleaning and repairs. Feed water is taken from the condensers and together with other make-up water passes through an economiser to the feed pumps. Both the engines are triple expansion condensing type. The one is 1100 h.p. and the other a 300 h.p. These are direct coupled to 200 volt alternators of 940 k.v.a. and 275 k.v.a. respectively. The whole mine is electrically driven with the exception of steam winding and there are also two standby steam air compressors which are only used as circumstances demand.

At this mine the engineering costs are allocated to the various departments according to their consumption of power and the power and engineering figure is inclusive of all these costs. The particulars given in Table I will also be referred to—the figures being reduced to the unit of 10,000 tons mined in a 30 days' month. The engineering cost has been grouped with the power cost and the allocation to the various departments is directly proportional to the power they use.

In July steps were immediately taken to reduce all leakage to a minimum at the same time general notice was taken with the idea of improving the load factor irrespective of the power factor but with a possible

Fig. 7.—Group of European Residents, Tarkwa.

TABLE I.

	Cost P. & E. 10^4 T.M. 30 Days.	% on July.	Cost Firewood 10^4 T.M.	% on July.	Per 10^4 T.M. Total Power in Unites.	% on July.	Cords Firewood 10^4 T.M.	% on July.	Horse Power per T.M. per Hour.	Horse Power per Ton milled per Hour.	Cost per Unit.	Firewood Cost per Unit.	Load Factor.	P.F.	Steam Powers % of total.
July ...	3985		2890		866487		3000		1.55	1.37	1.14	.79	50.2	.76	37
Aug. ...	3832	— 3.84	2923	+1.14	873716	+ .83	3052	+ 1.73	1.54	1.25	1.09	.80	53.2	.76	37
Sept. ...	3727	— 6.47	2665	—7.78	836858	— 3.42	2968	— 1.06	1.54	1.24	1.06	.74	55.1	.76	37
Oct. ...	3949	— 3.41	2628	—9.06	846530	— 2.3	3058	+ 1.93	1.51	1.37	1.13	.75	60.1	.78	30
Nov. ...	3934	— 1.28	2790	—3.46	849774	— 1.93	2983	— .56	1.57	1.46	1.13	.80	70.2	.80	25
Dec. ...	3639	— 8.68	2726	—5.33	772808	—10.81	2837	— 5.43	1.39	1.23	1.15	.84	70.3	.82	25
Jany. ...	3697	— 7.22	2844	—1.59	730026	—15.75	2568	—14.4	1.31	1.17	1.25	.93	72.6	.84	25
Feby. ...	4502	+17.96	3105	+7.44	796394	— 8.09	2630	—12.33	1.58	1.30	1.27	.94	74.2	.84	25
March ...	3769	— 5.4	2763	—4.27	771590	—10.72	2752	— 8.07	1.56	1.15	1.21	.86	74.4	.84	15

improvement of each. On the property there is a total of sixty-seven motors in commission ranging from 5 h.p. to 440 h.p. The mill which is driven by a 375 h.p. motor was running approximately ten hours per day. This is augmented by various motors driving centrifugal pumps. At the same time a steam air compressor was working but after the mill was shut down there was only the pump underground and the lighting on the alternator and steam hoisting. Arrangements were made for the electric compressor to run after the mill shut down at night and such drilling machines and air pumps as possible to work night shift. However it was still found necessary to run the steam compressor for certain works in the mine, the drill sharpening and other blacksmith's works. This was adopted in the middle of October which month shews an improvement in the load factor of 50.2 in July to 60.2 in October and a further increase to 70.2 for November. This arrangement remained fixed until March 1st, when it was found possible by introducing a small ventilating fan in the mine to put all the machine work on the night shift, and we now see the load factor up to 74.4 It can also be seen in the Table that the percentage of power used direct by steam has fallen from 37 to 15 and the total power used for 10,000 tons has decreased by 10.72%. In fairness to all it must be stated that no extra expense has been incurred by the arrangements.

The power factor was dealt with to the best extent that the existing plant would permit. A typical case will be quoted to shew that when there are spare motors of various types and horsepowers considerable improvement of the power factor can be brought about. One of the crushers was noticed to take 29.3 h.p. to drive it whilst actually crushing and it was driven by a 65 h.p. squirrel cage motor with an auto transformer starter. Further, the starting torque was equivalent to 67 h.p. but even then the crusher had to be helped to move. The carcase of a 30 h.p. slipring motor was available and this was wound with due consideration for high starting torque. With a liquid starter this motor will now start the crusher with no help and no overheating of the winding. The important fact is that it is working practically up to full load. Cases of this kind have been carried out at every place on the property where a motor was underloaded and a suitable spare was to be had. During the months mentioned the power factor has risen from 0.76 to 0.84. This has not been accepted as the best possible and constant watch is maintained to find when further improvement can be made.

It has already been mentioned that fuel cost is the largest item of power cost and a few details respecting this are of interest. The firewood is cut in the forest within a radius of 4 to 8 miles of the mine. This is bought by the cord—128 c.ft.—loaded and brought to the main railway line by a narrow guage loco on trucks and unloaded. When there is sufficient a main line train is chartered to bring in a full load to the mine siding. Next it is loaded on trucks and hoisted up an incline to the boiler side and unloaded again, where it is hand stoked.

Owing to these arrangements every piece of wood is handled seven times between buying and burning. The prime cost is about 11s. per cord and, delivered boilers is roughly double. To this must be added the cost of maintenance of the firewood locos, trucks, and lines, which is about 2s. per cord. This appears to be very heavy but the climatic condition and the nature of the country tend to cause rapid depreciation of sleepers and trucks.

There are also the cost of rents of wood concessions, surveying and extensions of lines, all of which increase the overhead charge of the mine.

It has proved very difficult to bring about any reduction in the cost of firewood and the question of an alternative fuel is being considered. Coal is too costly shewing no saving over the present arrangements. The proposition of converting to fuel oil is however more attractive, and the following data will be of interest in this respect. During a definite period there was a total of 3,739,186 b.h.p. hours generated from 9854 cords of firewood costing £11,116. The equivalent weight of fuel oil with the same plant would be approximately 1700 tons. At the present moment there is no quotation available for fuel oil delivered on the mine, but supposing it cost 90s. a ton, the corresponding total cost would be £7650 whereby there would be saved £3466. In all the calculations respecting this there has been allowed a margin in favour of the firewood.

Discussion.

Mr. J. R. COWIE (Branch Hon. Secretary), discussing the arrangements referred to by the author as having been made with a view to reducing load factor, drew attention to the statement that, on March 1st, it was found possible, by introducing a small ventilating fan in the mine, to put all the machine work on the night shift; and to the subsequent statement that no extra expense had been incurred by the arrangements. It seemed, said Mr. Cowie, that there should have been an entry on the cost side of the accounts in respect of the ventilating fan, unless it had been available beforehand and had been lying idle.

Mr. MEES (communicated by mail).—This fan was previously working in another position in the mine which, by virtue of stopping, had become self ventilating. The only cost incurred was that of the labour of moving it from the one place to the other and no new material was used.

Mr. J. W. GIBSON (President of the Association), after expressing his interest in the figures given in the paper concerning the running of a power station on wood fuel, commented on the author's statement that "Whatever items are charged to capital immediately become a lasting charge in that they are subject to interest and also depreciation". He pointed out that depreciation charges were made continually in respect of machinery until that machinery had been depreciated out of value, and after that it was no longer a capital charge.

With regard to the point raised by Mr. Cowie that, although a ventilating fan was put into operation, there was no extra charge in respect of it, or the power required to drive it, Mr. Gibson suggested that possibly, by improving the working conditions and equalising the load over the twenty-four hours of the day, the author and his colleagues had so improved the generating conditions that the provision of power to drive the fan did not constitute an extra charge.

Mr. COWIE agreed that that was probably what the author had meant, but the statement in the paper might be read in two ways.

Mr. GIBSON added that fan power constituted one of the heaviest running costs in mining. For example, in the case of a coal mine with an output of 1000 tons of coal per twelve hours, the amount of air in circulation through the mine might be as much as 3600 tons, which represented a considerblae amount of power.

Mr. MEES.—The artificial ventilation in metalliferous mines is a very small item when compared with that of coal mines. The only important factor is the clearing of dynamite smoke after blasting and, with the exception of development heads, this is generally accomplished by natural circulation. The remark in reference to depreciation as a lasting charge is appreciated.

Mr. J. W. WILKINSON (Branch Hon. Treasurer) pointed out that, although the cost of maintenance, insurance and interest on capital, in respect of locomotives, railway tracks, and other equipment connected with the supply of firewood had not to be incurred if oil firing were adopted; there must be, on the other hand, a capital charge for the conversion of the plant to oil burning. With regard to the fan mentioned by Mr. Cowie, it appeared as though it had been lying about the mine doing nothing; again, the carcase of a slipring motor was wound so that it could take the place of a squirrel-cage motor, to improve the power factor, and one gathered that there had been quite a lot of machinery lying about. If it were in a fair condition, presumably it would represent a capital charge; it might have been depreciated down to the point at which it was written off, but he felt that some entry should be made for machinery which was brought into re-commission after it had been lying about for a time.

The author and his colleagues were to be congratulated upon the efficiency of their steam engines; 940 k.v.a. from a 1100 h.p. engine, and 275 k.v.a. from a 300 h.p. engine were rather good results.

Mr. MEES.—Respecting machinery lying idle in this country, there is a large quantity of every description, against which there are no book charges. I know of four large water-tube boilers, new, dumped eight miles from the property for which they were destined.

Mr. GIBSON was interested to know why item K (ventilating) should be charged against development, for one would expect that ventilation would be required at all times.

THE BRANCH PRESIDENT suggested that perhaps the item referred to represented the ventilation required during the process of development, and that when the shafts had been sunk the artificial ventilation would be replaced by natural ventilation.

Mr. GIBSON, referring to the figures in Table 1, said that the P. & E. cost for February had increased tremendously, although the fuel cost had not increased very much. The power factor and load factor seemed to be alright and, unless very serious breakdowns had occurred, there seemed to be no explanation for the greatly increased expenditure in that month.

Mr. MEES writes in reply, confirming his answer to the earlier question by Mr. Gibson, that artificial ventilation is only required for development. It will be interesting to know that our shade temperature is now 97 degs. F. to 103 degs. F. maximum every day, and underground on No. 15 level, 2970 ft. below the shaft top, the temperature is nearly constant at 74 degs. F.

The increased cost of P. and E. for February was greatly due to a tornado which struck the district. We had seventeen motors struck with lightning and a H.T. cable cut in two 1400 ft. underground.

Mr. G. M. HARVEY said that the figure of 17.96, representing the percentage increase in P. and E. cost in February as compared with July, appeared to be wrong. He had worked it out at 12.9 per cent. It did not seem good to allocate power charges to the different departments and not to have a separate item for power generation. It would be better to consider power generation as a separate department, to work out the costs, and to charge each department which consumed power a definite figure per unit for the power it consumed. By that means the engineer-in-charge could watch his generating costs closely. The power factor figures were interesting, as shewing what could be done by selecting motors of horse powers commensurate with the loads they had to carry. A figure of 0.84 was good.

THE PRESIDENT said that that figure was attained without special steps having been taken for power factor correction, but by using reduction gear correctly.

Mr. HARVEY said there was no power factor correction at all.

Mr. MEES comments that apparently he had not made it quite clear to Mr. Harvey that the list given is to be the final allocation of costs. To arrive at these items, the cost of power must be obtained and the departments charged according to their consumption of power. He thanked Mr. Harvey for correcting the figure of 17.96 to 12.9.

Mr. A. S. CALDWELL, discussing the method of charging power costs, suggested that it was hardly fair to take the cost per ton of ore treated. A mining organisation might have plant which was not altogether up-to-date, and which consumed a large amount of power in proportion to the output, and in that case the heavy power cost per ton of ore treated would constitute a reflection upon the engineer-in-charge. In the paper it was stated that there should also be a figure shewing the cost per unit generated, and that, of course, was the only reasonable basis so far as the production of power was concerned. He added that in a dye works, for instance, where there was a battery of boilers supplying steam for process work, the departments would usually take as much steam as one could give them, and it was fair to debit them with the actual cost of the steam they used instead of a proportion of the total cost of power production based upon the quantity of material treated. The same principle applied in a mining undertaking.

Mr. MEES writes: I do not agree with Mr. Caldwell that a heavy power cost needs be a reflection upon the engineer-in-charge. If monthly records are kept and the tonnage is reasonably constant, providing the power cost is kept within a small percentage, the engineer can in no way be blamed for out-of-date machinery. One might say that 1.25 pence per unit prime cost is exorbitant for electricity, but when local condition are considered it is a very fair result. I personally have had charge of some modern Diesel sets when the prime cost was below 0.6 pence but it is impossible to draw a comparison between the two stations.

In the dye works the steam generated for process work is not converted to mechanical or electrical power and is therefore not a power cost, nor can it affect the load factor of the power station. On the other hand it will probably be an asset to the calorific efficiency of the boiler plant. The two cases are not analogous and the dye-works must be considered as a specific example which does not follow the general line applicable to metalliferous mining.

Mr. HARVEY pointed out that depreciation and interest charges on the generating plant would have to be fixed at a rate different from that fixed for the mining plant; the generating plant would have a very much longer life than the mining plant. That would complicate the costs considerably.

Mr. COWIE said that there might be a flat rate for depreciation, because the climate was tropical.

Mr. MEES.—Interest is charged on capital expended irrespective of the class of goods purchased. But every class of goods has a recognised rate of depreciation which must be written off its value annually from the time of the purchase. This naturally varies for each item in any particular year as they are not all bought at one time. Ultimately, the book value is reduced to nothing, although if properly maintained the article may still be good for considerable further use.

Certainly a coat of paint does not last long in this locality.

Mr. J. A. B. HORSLEY (Past President of the Branch) said that perhaps the most interesting fact which emerged from the information given in the paper was the extraordinarily high cost of wood as fuel, even when it was cut in forests adjoining the mine at which it was used. The author had estimated that if, instead of burning that wood, he were to use oil at a reasonable price delivered at the mine, he would effect a considerable saving in fuel costs. The reason was obvious, i.e., that the timber, as felled, consisted very largely of water and had comcomparatively little cellulose, whereas, when nature had finished with it, it consisted mainly of combustibles; it was the manufacturing process undergone by cellulose at the hands of nature that converted plant life into an economical and efficient fuel in the form of coal.

Mr. MEES.—A few details respecting firewood will be interesting. The woods here are divided into four classes, only three of which are bought for firewood. The other includes cotton wood and similar white woods of low density. Below particulars of calorific value and weights per cord are given.

	Cal. Value B.T.U.	*Weight per cord lbs.*	*% Purchased*	*B.T.U. Mixed*	*Weight Mixed*
(1)	4000	4200	30	1200	1260
(2)	3520	3800	50	1760	1900
(3)	2000	2900	20	400	580
				3360	3740

A calorific value of 3360 B.T.U. compared with 18790 for fuel oil.

NORTH OF ENGLAND BRANCH.

A Modern Coke Works.*

Discussion.

Mr. H. J. FISHER, in opening the discussion, congratulated Mr. Simon on the splendid paper he had given and in which he had, as usual, gone into details very minutely. Mr. Fisher said he would like to ask Mr. Simon a question as to his experience with regard to the trolley wires and the effect of the gases upon the trolley wires and what kind of trolley wires were being used on the plant described. Were the wires of copper alloy? Could Mr. Simon provide any details of the relative state of development of super coke oven works in this country, the U.S.A. and Europe. Mr. Fisher believed there was a great future before coke oven plant and anticipated that it would be very many years before we saw the synthetic production of oils and spirits. The production of petrols and benzols could be easily done in the laboratory, but the practical impediment to industrial development appeared to rest in the fact that nascent hydrogen was very difficult to combine with the carbons.

Mr. S. A. SIMON, in reply, said the live conductors for moving coke oven machines, used at Derwenthaugh are a standard grooved (or figure of eight) hard drawn copper trolley wire supported at intervals of from 5 to 10 yards by tramway type insulators with screw clip ears. The trolley wires for the coal charging lorry are laid to one side of the battery, where they are least exposed to the heat and flames from the ovens; the coke guide trolley wires are similarly placed and supported on the same standards. No special protection from mechanical contact with tools is required because, in the type of oven at Derwenthaugh, the regular use of long pokers or other similar tools which might inadvertently come into contact with live wires is not required, as is the case with some other types of ovens. When work of such a nature has to be done, the trolley wires can temporarily be made dead.

The trolley wires for the pusher machine on one side and for the coke quenching locomotive on the other side, are carried along the sides of the oven battery walls, below the level of the oven soles, and are protected from above by sloping sheet iron roofs.

The collectors consist of trolley wheels pivoted on the ends of short trolley poles about 2 ft. long, and are held in contact by strong springs. This type of collector has proved reliable and satisfactory in practice.

* *The Mining Electrical Engineer*, January, 1931, page 232 and February, 1931, page 253.

At Fell Coke Works, which is a slightly older plant but still quite modern, the oven machines are driven by d.c. 250 volt motors and steel conductor rails with copper bonds, and slipper collectors are in use. Some trouble was experienced with the original porcelain conductor insulators where exposed to heat, but the substitution of Siluminite has overcome this.

The question of the use of tools on the oven tops should be taken in careful account when considering the adoption of medium pressure a.c. or low pressure d.c. and in the choice of conductor and collector systems.

With regard to the relative development of coke ovens in the U.S.A. and on the continent of Europe, Mr. Simon regretted he had no information regarding the latest American practice, but he had mentioned in the paper what had been done in Germany. There they have some ovens which are somewhat larger than the biggest in this country. Where the Germans seemed particularly to have gone ahead of this country was in the bulk distance transmission of gas. The use of coke oven gas for town supply locally was not anything new ; it had been done in this country for many years, for example, in the Sheffield and Middlesbrough districts; but the long distance transmission was something different. Companies were formed to collect gas from a large number of coke ovens in the industrial area and not only to distribute it locally within the district, but to carry it far beyond the boundaries to distant towns and districts.

One of the largest gas-grid systems had been developed jointly by the Thyssen Gas Corporation and the Rheinish Westphalian Electric Power Corporation under the auspices of the Coal Utilisation Company (later called the Ruhr Gas Company), formed by practically the whole of the members of the Rheinish Westphalian Coal syndicate. Their pipe lines stretch from the Dutch frontier on the West through the Ruhr and Westphalian Industrial district to Hannover on the North East and to Darmstadt on the South East. The distance from the centre of the coalfield to Hannover is about 140 miles—to Darmstadt a like distance. For comparison—Newcastle as the centre of the N.E. Coalfield would, under similar circumstances, supply gas to the Scottish border in the North, to Chester and Liverpool in the S.W., and to Nottingham and Grimsby in the S.E.

The Ruhr Gas Company have a network of pipelines exceeding 600 miles in length. In May, 1929, the total amount of gas supplied by the Company was 41,000,000 cu. ft. per day. A portion of this gas is distributed by the Westphalian long distance Gas Co., which takes 14,000,000,000 cu. ft. per annum. Another bulk purchaser for distribution is the Westphalian United Gasworks, a company formed in January, 1928, by the United Electricity Works of Westphalia. It is significant to notice the extent to which the large electricity undertakings have interested themselves in this gas distribution.

The long distance gas pipeline is a valuable means of counteracting the prevailing concentration of industry in the coalfields. It enables works outside the coal area to eliminate the disadvantages relative to rival works close to the sources of coal. It favours the decentralisation of industry and the prevention of massing of population in congested districts; affording the social, hygienic and economic advantages of less thickly populated localities. It also contributes to the solution of the smoke problem.

The question naturally arises as to what will be the ultimate effect of bulk gas transmission on electrical development, whether it will be directly competitive or indirectly helpful. Mr. Simon said he, personally, was inclined to think the latter.

Mr. E. E. GROVER said he had especially enjoyed the short historical introduction of the paper ; the remainder of the paper was a very comprehensive and detailed description of the processes at the Consett Iron Company's new works, which, he understood, were the most modern coke ovens in this country.

To Mr. Grover there were several very interesting features about the plant described. Why was three-phase supply for the coke ovens adopted in preference to the direct current ? Were the three-phase trolley wire easier or cheaper to manipulate than a d.c. two-wire line ?

In this installation Mr. Simon made use of the induction regulator. Understanding that this must have some definite advantage for this particular line, Mr. Grover asked whether its use had done away with the necessity for an automatic voltage regulator. Was there a heavy loss in the induction regulator as compared with the losses which are trivial in the ordinary voltage regulator ?

There is also the point that the power factor of the system was improved by running the generating station at Derwenthaugh, which was made to rectify partially the bad power factor at Chopwell. Would Mr. Simon say whether standing instructions were issued to operators at the various stations as to what power factor to maintain.

Another interesting point in this installation was the use of a high torque squirrel cage motor. Mr. Grover said he would be interested to know whether consideration had been given to the three-phase commutator motor and whether the initial cost of that type of machine ruled it out when comparing the capital cost with the value obtained by the improvement of the power factor.

Mr. SIMON.—With reference to the question of the relative merits of d.c. and three-phase a.c. for coke oven machines : one objection to d.c. is that a special source of d.c. must be made available continuously ; the demand is however very intermittent and highly fluctuating, so that the d.c. source is running at light load most of the time. If, however, there are circumstances which make d.c. preferable, then probably the best solution would be to drive the d.c. generator by means of a synchronous motor which could be used for power factor correction.

As already explained, at Derwenthaugh, there was no objection to a.c. for the moving machines and, moreover, owing to the large number of pumps and other high speed motors, a really bad power factor was not anticipated sufficient to warrant the extra complication of the conversion and double system.

Mr. Grover had further asked whether commutator motors were considered with a view of improving the power factor. Mr. Simon replied that he did not think the use of that type of motor arose in connection with power factor correction. Certainly to his knowledge the commutator motor had not established itself for that purpose. It introduced the complication of a commutator, and in addition was more expensive. Undoubtedly the squirrel cage motor offered enormous advantages, in dusty and dirty situations where the conditions were very exacting, by its simplicity as apart from its lower cost. The question of the use of commutator motors for certain special applications was considered, and examples of both three-phase and single-phase commutator motors for driving the locomotive and rams were investigated ; it was suggested that the characteristics of the d.c. series motor which had been particularly suited to these motions, could be obtained by their means leading to more satisfactory results than would be possible with induction motors, but these claims were not substantiated.

In reply to Mr. Grover as to whether the use of an induction regulator obviated an automatic voltage regulator with the generating plant. The induction regulator does not take the place of the automatic voltage regulator. The latter is provided with the turbo-generating plant and maintains constant voltage with varying load. The induction regulator enables the voltage difference between the two ends of the transmission line to be varied at will, without interfering with the constant working voltage in each station. This regulation of the voltage difference is necessary in order to vary the Power and Power Factor independently. By increasing the voltage at the Derwenthaugh end of the line additional lagging wattless current was taken at Derwenthaugh; by lowering the voltage the lagging wattless was thrown on to the other stations.

Mr. W. BAXTER.—The waterless gas holders mentioned in the paper may appear to have no interest for the electrical engineer, but in connection with this apparatus there are electrically driven tar pumps for the purpose of pumping tar to the upper side of the piston for sealing.

In spite of the search for a tar which will not vary in viscosity throughout the year, he, Mr. Baxter, understood that material with this desirable characteristic had not yet been found and other users of these waterless gas holders had experienced a certain amount of trouble owing to the variations in starting conditions as between the height of summer and the depth of winter.

Where three-phase motors were used, fuses, if used at all, should be of ample capacity to obviate the possibility of motors attempting to run on single-phase.

Automatic time-limit protection on all three phase was the correct thing to instal.

Mr. SIMON was interested in hearing Mr. Baxter's comments regarding the automatic control of the pump motors for the waterless gasholder; they introduced a feature which would have to be watched.

Referring to the question of how speed control of squirrel cage motors compares with that of slipring motors, Mr. Simon quoted as an example the 40 h.p. squirrel cage motor on the coal lorry. The controller was similar to that for a slipring rotor; it had not merely one but several steps, and it was not possible when in the car to notice any difference from a slipring motor control. The control was quite as smooth as with a slipring motor.

Mr. BAXTER asked Mr. Simon if he was prepared to say that the method of control was equally satisfactory on the ordinary squirrel cage motor.

Mr. SIMON.—No. It would be necessary to have a high torque squirrel cage motor; a motor which starts with about double the normal torque.

Mr. GRAHAM.—Could Mr. Simon give any information regarding the efficiency of Derwenthaugh compared with other ovens and as to the cost of production compared with the others?

Mr. SIMON replied that such particulars were outside the scope of the paper which was intended more particularly to shew what was to be expected from the electrical side.

Mr. LAMBERT.—Would Mr. Simon say why turbine driven exhausters were selected, whereas the bulk of other coking plants use motor driven exhausters.

Mr. SIMON said he could not say definitely excepting that the turbine driven exhausters were supposed to be in advance of other types; but that again was outside the scope of the electrical engineering on the works. He could, however, say that the turbo-blower acts as a centrifugal tar extractor, and removes the last vestiges of tar from the gas.

NORTH WESTERN BRANCH.

Annual Dinner.

The Annual Dinner of this Branch was held at the Engineers' Club, Manchester, on Saturday, January 10th, the Branch President, Mr. R. F. Bull, being in the chair.

The usual loyal Toasts having been duly honoured, Capt. I. Mackintosh proposed the toast "Our Guests" coupled with the names of the President of the Association, Mr. J. W. Gibson, and several other distinguished men who were interested in mining electrical work.

It was hardly necessary to remind the members that Mr. Gibson had taken a leading part in the inner circle activities of the Association, and had helped in no small measure to get it moving along the right course. He was a Gold Medallist of the Association, and they had a President well versed in the practice of mining electrical engineering. They appreciated his visit and hoped he would be convinced that though the North Western Branch was not the strongest in point of numbers it was very much alive.

It was also a great pleasure to have with them their friends the Inspectors of Mines. It would be noticed that he described them as "friends" because the day had passed when colliery officials were inclined to mistrust the inspecting officials of the Mines Department. It was now fully understood and appreciated that the inspectors came round with a spirit of helpfulness and with no desire to make trouble. It was a good thing that those responsible officials were present at such gatherings as they were holding that evening because they were able to exchange views under different conditions than those generally prevailing when meetings took place. At the pit people were often "hot and bothered" but on occasions like a dinner both sides found that the other fellow was not so bad after all.

Mr. J. W. GIBSON (President of the Association) in responding thanked the members on behalf of the guests for their hearty welcome. The Association had now completed 21 years of service in the interests of mining electrical engineering and the Mining Industry in general. Some success had been achieved in the improvement of the status of the mining electrical engineer, but there was need for continued and greater effort in that direction: in particular he would urge members to devote more time to systematic study in order to qualify for the Association's Examinations. It would be agreed that this counsel was exceptionally appropriate now that there were prospects of certification being made compulsory in the near future. Apart from that consideration any young colliery electrical engineer could only gain great benefit by devoting as much time as possible to study and by the possession of a certificate proving him to have theoretical knowledge as well as a sound practical training.

The time to study and prepare was when trade was slack so that when times became more active one would be able to take advantage of the opportunities offered.

Some students, said Mr. Gibson, seemed inclined to slack off because they had the feeling that coal was a dying industry. The volume of production may have shrunk a little because we were now using coal scientifically: we got more out of coal than we did twenty years ago: but coal, fundamentally, was still just as much a necessity for industry as was water for the health of a big town and mining would not fade away.

Continuing, Mr. Gibson referred to Official Returns of trade and noted we were importing steel into this country at the rate of three million tons per year. Allowing three tons of coal per ton of steel—that is calculating right from the ore to the finished steel ingot—that represents nine million tons of coal per annum. Whilst Mr. Gibson would not say that our steel works at present were capable of turning out all the kinds and brands of steel used in this country, they could do so if the works were properly equipped for it, and orders for the additional nine million tons of coal would be a very nice step towards an improvement in industry.

He was very pleased to have the opportunity of meeting His Majesty's Inspector of Mines for the North Western Division, Mr. Charlton, and Mr. McBride. He had hoped to have the pleasure of meeting the two newly appointed Electrical Inspectors but they not being present that pleasure was deferred.

Mr. Gibson then passed to other useful work, which the Association had spent a good deal of time on during the past three or four years, namely, the preparation of a syllabus for the training of the mining electrical engineer. The outcome was tangibly available in the booklet recently published in which a course of evening class tuition is outlined. The booklet had been circulated among the educational authorities in the various districts with a view to securing a standardised schedule of training which would encourage members to enter the examinations and qualify for the certificates of the Association.

As far as study is concerned, and particularly evening class study, Mr. Gibson said he could claim to speak with some personal authority, because it was in that way he found the only opportunity of improving his position as a colliery electrician. Had it not been for the facilities which were provided in that direction, which were not nearly so complete then as they are today, he could not possibly have availed himself of the opportunities which presented themselves. Young mining electrical engineers should not come to the conclusion that, because they can only see the one small area in which they work, that opportunities are limited. Since his first association with mining in this district, Mr. Gibson had been identified with mining work in all parts of the world, principally gold mining abroad and coal mining at home. As a result of his travels he could tell them that in whatever part of the world he had been engaged he had come across British trained mining, mechanical and electrical engineers. It spoke well for the training of the British engineers that they were preferred for those appointments abroad, and he would impress upon the youth that it was abundantly well worth while to work and study hard while they were still young, for with added years responsibilities increased, the time at their disposal was shorter, and the aptitude for acquiring theoretical knowledge was less acute.

Presentation to Mr. B. E. Jones.

THE CHAIRMAN at this stage presented to Mr. B. E. Jones the prize for the best paper read before the Branch during the past year which was entitled "The determination and effects of a protection against short circuit currents."

Mr. W. J. CHARLTON (H.M. Divisional Inspector of Mines) thanked the members for their kind reception. Speaking personally, he had had a long association with coal mining. In fact he was bred of a line of colliery people. His father was a colliery engineer who thought that pit men were poor fish, and that the mechanical side only was worthy of consideration. Then electricity came along. Up to that time coal had been got by a good man behind a good pick and the mechanical engineer's job had been to introduce mechanical haulage to get the coal to the pit bank. The pick point today was very different to the pick point of thirty or forty years ago; it had now some power behind it and that power might be electricity. As developments took place the colliery engineer realised that he was expected to be an electrical engineer and people who could go back as far as he could would remember what happened. He could recollect when, as a boy, the first arc lamp wire was introduced in the sidings at the colliery he was engaged at. They were quite large and a colliery joiner was appointed to look after those arc lamps. Electric signalling followed and once again the joiner was expected to look after the apparatus. This was succeeded by much more ambitious schemes and the mechanical engineer was expected to make himself an electrical engineer at quite short notice.

Capt. Mackintosh had referred to the days when Mines Inspectors were not as welcome as they were today. He did not think there was very much in that because the Inspector now was a much more highly trained man than thirty or forty years ago. He had to be. When Parliament first began to take an interest in the conditions of mining there was some doubt as to whether the Inspectors ought to go into the pits at all because of the personal violence to which they might be subjected. It was a fact that the first Home Office Inspector was a sort of jack-of-all-trades in his department. He found out a great deal about the social conditions of the miner, matters which needed the attention of Parliament and eventually at that time, caused quite an outcry, resulting in the appointment of a Royal Commission.

Reference had been made to the Regulations. He agreed Regulations were rather irksome things and he supposed coal mines were more bothered with regulations than almost any other industry, and yet he did not see how they could be avoided. Every Regulation had a history behind it and had reference to something which had happened and needed amendment. As far as the electrical regulations were concerned, as a representative of the Mines Department, he felt there was not the slightest need to apologise for them. The Mines Department did not make them alone but in consultation with outside people, and without doubt they had served a very good purpose indeed.

As time went on it pleased the powers that be to say that the Inspectors needed some electrical assistance and there again he thought the Department were extremely fortunate in the men who were chosen. In the present Electrical Inspector of Mines (Mr. J. A. B. Horsley) they had the right man in the right place.

The Association of Mining Electrical Engineers, he understood, was composed not only of colliery electrical engineers but also electrical manufacturers and people associated with mining. The fact that the different sections were represented in the organisation was very valuable because by having different opinions on a subject they were able to get a proportionate prospective view. The Electrical Inspector by getting into consultation with the manufacturers of cables, and switchgear, and so on, without even going near the pit, was able to perform a very useful function.

Electricity had its dangers but if the apparatus were manufactured in a certain way it could be regarded as being pretty safe under certain conditions. The great point was that it was not of much use for manufacturers to design apparatus which would perform the necessary operations if the question of maintenance did not receive full and careful attention. That was where an organisation such as the Association of Mining Electrical Engineers proved of great service. It was a band of men who knew the functions of the various items in an electrically equipped mine, and realised the vast importance of keeping them in a good state of efficiency.

He agreed with the remarks made by Mr. Gibson with reference to the training of young engineers. For every possible reason, but particularly from the point of view of safety, he hoped Mr. Gibson's advice would be given the greatest attention and that the scheme for evening class tuition would prove an immense success.

There was another matter Mr. Chorlton said he would like to mention. When he was a member of the South Wales Branch he suggested that it would be an excellent thing if one meeting each year were devoted to a discussion of the Electrical Inspector's Report, and he desired to recommend the idea to the Lancashire Branch. There was always "meat" enough in that Report for an instructive debate. When he was at Swansea he made a further proposal, namely that Mr. Horsley should be invited to take part in the discussion, and he had done so for some years past. The Lancashire Branch, in his opinion, would do well to follow the same course, because it enabled them to keep in close association with the ordinary Inspectors, who were quite decent fellows, and with the Electrical Inspectors also. The use of electricity in mines was looked upon by the Mines Department as being of such importance that during the past year no less than five Electrical Inspectors were appointed. Up to then there had only been one, who was more or less a consulting engineer. Mr. Harvey had been appointed Deputy Electrical Inspector with four juniors scattered about the country, and the action of the Department, he took it, had been approved by the Association.

Mr. W. T. ANDERSON (Past President of the Association) proposed the toast of "Kindred Associations" coupled with the name of Mr. Sills. He remarked that during the current year they would celebrate the 21st anniversary of the founding of the Association, and as Mr. Sills was a young man he would hardly be aware of the troublous times the organisation had to pass through when first it came into being. Had the existing great Institutions done their duty the Association, probably, would never have been formed but, thanks to the perseverance of the founders, it was established and had become a powerful body with a membership of something like 2000. All the jealousies which had existed at the outset however had been buried and forgotten.

So far as the electrical industry was concerned all was well, and in making that observation he was reminded of the story of an American who was eulogising the Niagara Falls to a Lancashire man, explaining that so many billions of gallons of water came over those wonderful falls in an hour. The Lancashire man did not seem very much impressed, and to the American's query as to what he thought of it he merely replied, "There's nowt to stop it!" That really expressed the flow of the electricity industry today. He wished it applied equally to the mining industry; unfortunately, that was far from being the case. The opportunism of the politician and the devious ways of the paid agitator had played havoc with the trade and many of their own members were the unfortunate victims of the circumstances existing at the present time. They were however carrying on with their jobs in spite of prevailing difficulties. In this respect their enthusiasm and loyalty to their work reminded him of the story of the Schoolmaster, who, doubtful as to the observation and concentration of his class, asked various boys to call out numerals which he purposely wrote down incorrectly on the black-board. Thus 146 was transposed to 164 and so on. This continued for some time without any comment from the lads until the tension was broken by one youngster who suggested "333 sir, and muck that up if you can!" It was this "333" attitude which the Association's members were adopting with regard to their own particular jobs during the present deplorable state of the mining industry.

Mr. G. F. SILLS, responding, thanked the Branch for the invitation to attend as the representative of the North Western Centre of the Institution of Electrical Engineers. Mr. Anderson had mentioned that the membership of the Association was 2000. Some might say, "2000 is not a lot" but after all 2000 specialists in a particular section of an industry constituted a very important body. If all sorts of engineers, provided they were up to a certain standard, were admitted to membership of course it would be much larger, but 2000 specialists were equivalent to many times that number of ordinary engineers of all classes.

He was pleased to hear of the steps the Association was taking in connection with the agenda for the technical classes, because knowledge was an important factor in assisting to achieve success in any sphere of industry.

It was a source of satisfaction to know that their Chairman had one of the finest electrical winding equipments in this country, and as an electrical man he (Mr. Sills) naturally was very much interested in the installation.

Mr. R. AINSWORTH submitted the toast of "The Honorary Treasurer and Secretary." In Mr. Bolton Shaw, he said, they possessed one of the stalwarts of the Association. From the inception he had taken an active part in its operations. For a time he was the Secretary of the Branch, subsequently filling the position of Chairman, and since vacating that post he had carried out the duties of Honorary Treasurer. His extensive technical knowledge had always been of great value to the Association, and throughout he had rendered great service not only to the Branch but as a representative on the Special Committees of the Association.

In Mr. Heyes they had an exemplary Honorary Secretary. He (Mr. Ainsworth) had carried out the duties attached to that office and was, therefore, in a position to realise how manifold were the calls upon the time and energy of those who undertook the position of Secretary to an active and important Branch. When Mr. Heyes relieved him of the position he accepted appointment as a member of the Publications Committee thinking that the work would be comparatively light, but he found he had made a mistake. Later he was appointed Chairman of the Publications Committee and he was wondering now whether he had better give up his own business and confine his attention to the work of that Committee. We are very much indebted for all the work and service Mr. Heyes has rendered.

Mr. W. BOLTON SHAW, responding, expressed his appreciation of the kind words spoken by Mr. Ainsworth and the hearty reception of the toast. He remarked that he had been connected with the Association of Mining Electrical Engineers from its inception and, in the Lancashire Branch, he believed he had occupied every office it was possible for a member to hold. He had now apparently settled down in the position of Treasurer as a permanency or for so long as the members would retain him. It was not exactly a sinecure; the work took up a good deal of time but it was interesting and pleasant.

Mr. V. HEYES, Hon. Secretary, thanked Mr. Ainsworth for proposing his Toast, and stated that if his little efforts on behalf of the Branch had benefitted the Association, he was amply rewarded.

MIDLAND BRANCH.

Visit to the New Works of Derby Cables Ltd.

About 130 members of the Midland Branch of the Association of Mining Electrical Engineers paid a visit on Saturday, January 17th, to the new works of Derby Cables Ltd., Alfreton Road, Derby. They were received by Mr. Sewell (General Manager) and conducted round the extensive works in small parties by members of the staff and shown cables in all stages of manufacture. After the inspection the party were entertained to tea at Kings Restaurant by the Company.

Mr. C. D. WILKINSON (Branch President), in proposing a vote of thanks said they were deeply indebted to Mr. Sewell and his Directors for an afternoon which had been most instructive and enjoyable. He was sure the excellence of the manufacture must have struck all present, he personally was impressed with the great care taken with the copper itself before any insulation was placed on it. Another point which interested him was the very modern plant installed and the care taken with every process of manufacture. They had also seen a very up-to-date laboratory, and he thought the whole plant reflected great credit on Mr. Sewell in particular.

This visit appeared to be a very popular one, judging by the attendance, and he thought an invitation to inspect modern processes in cable making was always a great attraction to progressive practical engineers. To him personally there was a special interest, as it was really on a visit to Mr. Sewell's old works that he had been led into joining the Association. He was sure they would all wish to join in extending cordial thanks to the Directors of Derby Cables Ltd. and to Mr. Sewell and the members of his staff for their kindness and courtesy in showing them round and answering the questions put to them; and also to the Company for their hospitality.

Mr. G. P. GRICE, in seconding, said he had greatly enjoyed the visit. He thought considering the short time the firm had been established they had made great progress. It must have given Mr. Sewell much pleasure in the building up of such works.

Mr. SEWELL, in responding, said he had been very glad to see them that afternoon, and personally he took it as a high compliment to see that so many had come to look round the new works. He thought he had been able to show them a plant really up-to-date and to prove that this firm could make cable. It had been a bit of a strain, but he would like to pay a tribute to his Directors for backing him up, and would like to take this opportunity of thanking Mr. Ransome and the other officials, who had so ably assisted him in putting down the plant and running it. In making this expression of appreciation Mr. Sewell said his whole staff had worked most enthusiastically; hours had not mattered: the plant was not started until March, 1929; manufacture commenced in October of that year: and in 12 months from then they had doubled the size of the Works.

Mr. RANSOME on behalf of the staff, acknowledged the very kind things Mr. Sewell had said about them. They were always willing to impart such knowledge as they possessed to any technical society who cared to come round.

Mr. SEWELL said he would like to take the opportunity of announcing that Mr. E. R. Hudson, who had been for many years chief electrical engineer to the Manners Colliery Co. Ltd., had joined the staff of Derby Cables Ltd. and began his duties with them on the previous Thursday: he was sure they would all wish him a very successful career.

Mr. C. D. WILKINSON said on behalf of the Branch he would like to endorse Mr. Sewell's remarks with respect to Mr. Hudson.

Mr. E. R. HUDSON, in responding, said it was a big break after 20 years in his previous appointment. He thanked all present for their good wishes and said he realised that his future success would very largely depend on his old friends.

At the meeting of the Midland Branch, held at the University College, Nottingham, on Saturday, January 31st, 1931, the following new members were elected:

Member—Hy. Everton, Broomfield, West Hallam; colliery electrician. Student—H. Sandford Edwards, Lime Tree Avenue, Skegby; colliery electrician. Associate—Wm. Hugh Maxwell, Crow Hill Drive, Mansfield; mechanical engineer.

Dr. H. Cotton, M.B.E., then gave the second lecture on "Electricity applied to Mining", the sub-title being "Power and Energy", and being illustrated by examples on the blackboard, with regard to mine ventilating fans and electrical winding engines.

At the close of the lecture the Chairman, Mr. C. D. Wilkinson, moved a vote of thanks, and said that Dr. Cotton's lecture had been very interesting and would make some of the members consider the working of mine fans and electrical winders. He was sure all present had enjoyed it and would look forward to the next lecture.

Mr. Walker, in seconding, said he was sure they all knew that by the means of these lectures Dr. Cotton was anxious to stimulate interest in the annual examinations, and they would no doubt be of great value to prospective candidates.

The monthly meeting of the Midland Branch was held at the Nottingham University College, on Saturday, February 28th, 1931, Mr. C. D. Wilkinson presiding.

It was announced that the Annual Examinations would be held on April 25th and May 2nd, also that the Annual General Meeting would be held in Cardiff in June.

A vote of thanks from the General Council was conveyed to Dr. Cotton for services rendered to the Midland Branch in giving the series of lectures, and Mr. Wilkinson said it gave him great pleasure in passing this on to Dr. Cotton.

It was arranged to hold the next meeting on March 28th at Nottingham University College at 5-30 p.m., when the fourth lecture would be given.

Dr. H. Cotton, M.B.E., D.Sc., then gave his third lecture on Electricity applied to Mining, taking as his sub-title "The Efficiency of Electrical Machines", of which he proceeded to work out several examples.

At the conclusion, Mr. Wilkinson said he was sure it had been very interesting, and he had great pleasure in moving a vote of thanks. The subject of efficiency was interesting to all, and there was invariably an item on this subject in the examinations. Dr. Cotton had emphasised the desirability of candidates making sketches of circuits on which calculations were being carried out and he personally could endorse that it was very necessary to keep before one the circuit which was being used. Unless candidates did make a sketch of the particular machine on which the question was based it was quite easy to get wrong in calculating the current.

Mr. Pidcock, in seconding the vote, said they all very much appreciated the time and trouble that Dr. Cotton was sparing them in giving these lectures, and he could also endorse the Chairman's remarks as to the value of the lectures, not only to intending candidates but also to others; first principles were always of interest.

SOUTH WALES BRANCH.

Annual Dinner.

A very successful dinner of the Branch was held on February 7th, at The Royal Hotel, Cardiff, with Sir A. Whitten Brown, Branch President, in the chair. Mr. J. W. Gibson, the President of the Association, was the Principal Guest. Owing to a large number of other dinners being held on the same evening, a number of influential men of the district were unable to be present.

Mr. G. D. Budge, Past President of the South Wales Institute of Engineers, Deputy Chairman of the Monmouthshire & South Wales Coal Owners' Association, and member of The Safety in Mines Research Board, proposed the Toast of Association of Mining Electrical Engineers to which Mr. J. W. Gibson, President of the Association, replied.

Major E. Ivor David, President Elect of the Association, proposed the Toast of the Kindred Association and Guests, to which Captain J. MacLeod Carey, H.M. Divisional Inspector of Mines, replied on behalf of Major F. K. Cartwright, Branch President of the National Association of Colliery Managers, who unfortunately was unable to be present owing to illness.

The enjoyment of the evening was also contributed to by Mr. G. Avery, who kept the assembled company in roars of laughter, Mr. E. R. Hobbs and Mr. H. H. Coope at the piano.

Mr. G. D. BUDGE said it was a very great pleasure to him and he counted it a great honour to be asked to propose the toast of the Association of Mining Electrical Engineers. The Association was a virile body and it was fitting that it should have as its Branch President so distinguished a man as Sir Arthur Whitten Brown. He had been told that the Association was now in its twenty-first year and those years had been very active and full. It was absolutely essential in the electrical industry as applied to mining that there should be a means of discussion, a means of education, and a means of helping along the younger members and these the Association provided. Mr. Budge said he understood that one of the leading aims of the Association was to bring forward well-qualified men capable of stimulating the industry. By so doing it had greatly promoted the development of electricity and been of immense assistance in the cause of safety in mines. There was no question about that and it was a thing of which, as members, they had every right to be proud: he was sure Captain Carey would also associate himself with these remarks very heartily.

Electricity applied to mining had not been easy work. The electrical engineers had to cope with very difficult conditions—dust, gas, and water—and all sorts of adverse circumstances: one had only to consider the type of plant in the mines thirty years ago and compare it with the plant of today to get a clear idea of the work that had been done and the work in which the members of the Association had made so great a contribution. He would very strongly urge younger members to take the advantages of contributing and discussing papers.

Referring also to the Association Examinations, Mr. Budge said they were already very important, and likely to become still more so in the early future: the trend of events was in that direction. Mr. Budge said he had personal knowledge of the work done by the Association: he had met members on various Committees—for example, The Engineering Standards Association Committee and others of that kind. He, further, considered that the work done recently by the National President of the Association, Mr. Gibson, was extremely valuable, and reflected great honour on the Association.

During his year of office as President of the South Wales Institute of Engineers, Mr. Budge continually had the Institute's very valuable Secretary, Mr. Martin Price, bringing forward some point about the Mining Electrical Engineers; he believed that the South Wales Institute had been able in the past to render the Association some service, and he knew it was the intention to do so in the future as fully as possible. He had very much pleasure in submitting the Toast of the Association of Mining Electrical Engineers, coupled with the name of Mr. Gibson.

Mr. J. W. GIBSON, President of the Association of Mining Electrical Engineers, acknowledged with pleasure the toast of the Association so ably proposed by Mr. Budge, and so enthusiastically responded to. The Association started in a humble way a matter of 21 years ago, and in the intervening period it had, by virtue of its useful work, received the recognition of all departments of the mining industry. The Association had put in 21 years of service in the interest of the mining electrical engineer, mining electrical engineering, and in the interest of the mining industry, and he thought he could claim the Association had achieved some measure of success. It had been able to establish the status of the mining electrical engineer, who is no "rule of thumb" man, but who must know his work right through. In the early days of the application of electricity to mining, arguments were used against it in the way that there would be no one sufficiently qualified to look after such highly scientific machinery and apparatus, and it was when arguments of this sort were in common use that the pioneers of the Association set themselves together to develop the means for helping and training men who could be depended upon to handle this new branch of mining.

With regard to the application of electricity to mining, Mr. Budge had referred to a matter of 30 years ago. He, Mr. Gibson, could go back (although he might not look it) even further than that. As a colliery apprentice the only electrical work which was put in during his time was single stroke bells for shaft winding. The next stage, a few years later, was small electric lighting sets with carbon lamps. He remembered how on one occasion he was unfortunate enough to break a 16 c.p. lamp, and after getting the usual talking to was told that the cost was equal to his week's wages. The next step was an effort to provide some power other than human behind the point of the pick. He was very proud to be able to say that he was associated with what at that time he thought was one of the earliest efforts in the way of electric coalcutting, the apparatus being one of the undercutting wheel type. He had since learned that other experiments were carried out previously so could not claim absolute novelty. At that time the sparking from the open type coalcutter motors was almost sufficient to light the coal face. There was no gas : the coalcutters were worked at low pressure continuous current, and he was not quite sure whether it was earth return system. Whether it was intended or not, it was very often the case that they did have earth return. If the fuses went it was not uncommon for the helper to use a piece of iron wire or a four inch nail in place of the blown fuse.

Among the members of the Association were included experts in every branch of engineering and mining, and it had been the object of the Association, and of those well informed in these sections, to place at the disposal of members the experiences they had gained ; on that account he believed they could claim to be a live association. It was generally understood that those members who are expert in their several branches should disperse that information as broadly as possible, and usually the members would find their contributions recorded in their journal, *The Mining Electrical Engineer*.

There might be a tendency on the part of junior members and young mining electrical engineers in these hard times to think that perhaps they had not the opportunities before them which they would like to have. These were the times when a young engineer should put as much time and energy as possible into his training. The Association had devoted a considerable amount of time to the study of the educational side, and recently had compiled and distributed in the right quarters a suggested course of evening class instruction in mining and electrical engineering ; the printed booklet had been circulated around the educational centres and authorities, and the Association was hopeful that it will serve as a sort of regular standard of instruction for all the mining areas of the country, so that if it should be adopted by the Educational Authorities there would be a level plane of instruction enabling junior members to qualify for the examinations of the Association more evenly and surely than at the present time. Mr. Gibson said he believed the educational facilities in South Wales were, if anything, better than in other parts of the country.

Speaking further with regard to qualifications, Mr. Gibson said that, after a life of association with mining, starting with a colliery apprenticeship, following on as a colliery electrician, and from that to the high sounding title of colliery electrical engineer, and associated with mining work in all parts of the world—mining in coal, gold, and copper—he would like to say that in all those different areas he had come across electrical and mechanical engineers who were Britons who had had British training. He did put that forward as an all-sufficient reason for the younger members of the Association, and those who would become members, that it was worth their while to study and qualify in order to gain the certificate of the Association, which was world-wide in its effects and value. He felt sure they would find the certificate a hall mark indicating the possession of theoretical as well as practical knowledge. There was also the point of greater importance, the possibility in the near future, that posts of importance would have to be filled by certificated men. There was no standard yet fixed by the Mines Department, and in the absence of any other standard he felt sure that the certificate of the Association would be held as of great value.

Major E. IVOR DAVID (President Elect of the Association).—The toast of the Kindred Societies which he had the honour to propose was, in that area, almost superfluous. In that district they were fortunate in having a central body, the South Wales Institute of Engineers, which housed and fed and taught kindred associations and set them an example of organisation and sympathy which was a model to other districts, particularly in the person of its Secretary—Mr. Martin Price. While, therefore each of the several associations retained its separate entity, most of them supported the parent body as well.

Mr. Budge, who represented the South Wales Institute, had just concluded a most successful year as its President, during which in spite of bad times there had been an increase both in the number of members and the quality of the membership. The Institute had sustained a great loss in the death of Mr. Allan Johnson, whose courageous fight against adverse circumstances and never-failing cheerfulness was a splendid example to the younger generation. The Institution of Electrical Engineers, represented by Mr. Haslam, with its huge membership, had great powers and had an important task to educate and advise the general public in the great electrical development that must follow the fructifying of the central board scheme. The I.E.E. had always helped the Association which, in its turn did its best to co-operate with the Institution. The Institution of Mechanical Engineers was now a Chartered Institute. Major David said he was not quite sure how that would benefit the members but he supposed it did so as most technical institutions seemed to thrive after it.

The Institute of Civil Engineers, the oldest engineering body, was the first to attempt to make engineering a co-operative science by publishing papers and encouraging meetings and discussions. It recognised the fact that no man was sufficient in himself, that progress was to be made only by giving of what we have to those around us. If we have a little knowledge that somebody else has not, let us pass it along. That is the spirit of the Civil Engineers and that same spirit has been evinced by other institutions and societies, and it is the basis of our own Association of Mining Electrical Engineers in particular

The Institution of Mining Engineers was sufficiently close in its sphere of interests to The Association of Mining Electrical Engineers. Each of these purely engineering institutions did much useful research work both alone and in conjunction with the National Research Association, and all assisted in the great work of the British Engineering Standards Association. We who sit on some of the Committees of that body, said Major David, know what a tremendous amount of work is done in standardising engineering apparatus. Even with such a simple thing as a mining type plug, as Mr. Stretton knew, it took over two years to arrive at a satisfactory basis of standardisation. Shortly after that was done an S.O.S. was sent out to all members urgently to appear in London on a very important matter. There were twenty-four members and the average cost of the meeting per member was about £5 or £6. It was then found that a man in Fifeshire had been "stung" for £5 because his plug was not standard, and it was going to cost £5 to put it right. It eventually cost the members of that Committee about £150 to meet together and decide that the Scotsman had got to pay that £5.

Before turning to the final kindred association, Major David said he must refer to the position that their own Association, the A.M.E.E., occupied. It was in a peculiar position just at the moment: it was the link or liaison body between the Mining Industry—the most badgered, bothered, and blackguarded industry of the day—and the Electrical Industry—the pampered pet of the politicians (*vide* the Chairman of Gas Companies). As electrical producers the miners were not in the full rays of sunshine and blessing, but as very large potential consumers they were promised some of the crops of plums that would fall from the easily raised funds of the Central Electricity Board. The electrical mining industry had been much in the public view lately, but the searchlight of investigation that followed new regulations was not an unmixed blessing. In these hard times to be called upon to spend hard earned money because a flame-proof device was not of the latest type tested at Sheffield hardly seemed to be a way to help a struggling industry. None will object to a keen watch over compliance with all regulations in this new plant, or reasonable maintenance of that old plant, but to call upon the industry to replace plant which had given good and safe service and had years of similarly useful and safe life before it, was not, in the speaker's opinion, helping either the industry, the management, or the men. Major David mentioned that Capt. Carey was to reply to this toast, and he would like to make it clear that this statement was made in all good faith and without any severely critical intention. The Association of Mining Electrical Engineers welcomed the Mines Inspectorate to its membership and its meetings, and was always ready to hold discussions on doubtful or difficult points arising out of the Coal Mines Acts and Regulations. The South Wales District had again a clean record for fatal electrical accidents, and Major David said he would repeat that this highly pleasing state of affairs was due to the high standard of knowledge amongst mining electrical staffs as proved by the strong local membership of the Association and the high percentage of Awards won by the members of the South Wales Branch and its Western District Sub-Branch. They had again collected the Medal for the Second Class Paper and the Junior Medal. Mr. Pring had gained the Second Class Medal, and Mr. James, of Ogmore, the Junior Medal.

Finally, of the kindred associations, there was the Colliery Managers' Association, whose Branch President—Mr. Kemp Cartwright—was to have replied to this toast, but who unfortunately was unable to be present. The colliery managers were the masters of the electrical engineers at work but he trusted they were friends at all times. They had had several joint meetings during the last session when interesting papers were read and discussed. Major David hoped that one result of the joint meetings had been to give the managers more appreciation of the difficulties of the electrical engineers' job, and would help to stave off many a harsh word when things unavoidably went wrong.

The Coal Owners Association had lent the A.M.E.E. much very great support on many occasions and he hoped they would continue to do so; especially during this year as the Association was to hold its Annual General Meeting and Summer Conference in the Cardiff area.

Major David had one further thing to say. At this time when the Government was considering certification of the technical staff and possibly a Board of Trade examination may be instituted as a final test, in the meantime the Association could refer to its certificate as a definite certification of technical training making the holder a man suitable for the position of colliery electrical engineer. There was not only an Honours Certificate but also a Second Class Certificate, both of which were definite proofs of qualification; there was also a Service Certificate constituting a proof of service and experience in the position of Mining Electrical Engineer. These Certificates did not take away any of the responsibility of the colliery manager in making an appointment, but it was the fact that these certificates would shew the manager that there was one thing he need not worry about and that was the qualifications of the men who had gained these awards.

Captain CAREY (H.M. Inspector of Mines) said the dinner of the Mining Electrical Engineers was a function which he felt, whatever happens, he must attend because of the good work the Association had done in the collieries of South Wales. He, that evening, found himself in the remarkable position of taking the place of a colliery manager. Therefore, as a colliery manager, he would congratulate the members of the A.M.E.E. upon one outstanding thing. There was in South Wales at the present moment as much electrical power, if not more, generated and used underground at the collieries as in any other mining district in the country. He was credibly informed by the Inspector of Mines for South Wales (!) that there were ten fatal accidents owing to the use of electricity in the whole country last year, and in South Wales only one man was killed, and he—poor fellow—was killed because he chose to climb up to the top of a telpher crane, fell and caught hold of the bars. Still speaking on behalf of the colliery managers, Capt. Carey claimed this as very creditable and considered they were entitled to congratulate themselves upon that outstanding fact.

Major David had referred to the fact that there were so many rules and regulations which the managers had to carry out. Capt. Carey would suggest that he write to the Inspector about it. He believed that electrical engineers felt themselves to be in rather an equivocal position in their relationship to the managers. The unfortunate part about it was that when anything did go wrong the poor managers had to carry the baby, and so long as that position continued—that the managers hold the certificate and carry the responsibility—they must have the last word. "It is unfortunate," said Capt. Carey, still speaking as a colliery manager, "but as things stand we cannot concede you the right."

In conclusion, Capt. Carey quoted the well-known saying, "Do right and fear no man", asserting that to go through life with that thought in mind ensured that they would all be successful. He thanked them all very heartily on behalf of the Members of the Kindred Societies for their hospitality and the way they had honoured the toast.

YORKSHIRE BRANCH.

Electric Winders.

A. T. GREIG.

(*Paper read 12th December*, 1930).

The work of any winder is to raise loads of mineral to the shaft top or bank, and its capacity is dependent upon the weight raised and the vertical depth of the shaft. In this paper only vertical shafts are considered and inclined and compound shafts will not enter into the discussion.

The mineral may be raised either by frequent winds with a small load, or by few winds with a large load.

The load is usually fixed, particularly in existing shafts, by the number of trucks or tubs per cage, weight carried per truck, and size of cage, depending on the size of the shaft and the strength of the rope. It is clear that the heavier the load carried per wind the less time will be spent, proportional to the time of a number of winds, in loading and unloading; and also that longer time can be taken for accelerating and retarding, thus keeping down the size of the motors, for high speed hoisting means quick acceleration and consequently large motors to dissipate the heat generated.

Power Estimates.

Whether few or many winds are made per hour, a fixed amount of work is done; this is called the "shaft horse-power," and is expressed by the formula:—

$$\text{S.H.P.} = \frac{W \times S}{T \times 550}$$

Where, W = Wt. of mineral per wind in lbs.
S = Vertical depth of shaft in feet.
T = Time per wind in seconds.

This unit (S.H.P.) is usually adopted as a comparative basis for winders and is most useful in the case of steam driven winders. It will be seen, however, that the loading and unloading periods are neglected, and in the case of two winders of the same S.H.P. one may have a far more arduous task than the other. A better comparison in the view of some experts is to find the foot-tons of work done in a given time, say one hour, and in this figure to include the losses when the cage is stationary, for, if this period be of long duration, these losses may have an appreciable effect on the energy count.

The essentials of any winder are a drum, upon which two ropes are coiled in opposite directions, so that when one rope is fully paid out, the other is all wound on the drum; a motor to drive the drum; and sheaves in the pit head gear over which the ropes pass to the cages. The drum may be made in one piece or, as is very often the case, may be made in two identical parts, and driven from the motor shaft by means of clutches, so that only one drum and therefore one cage may be wound if desired. This is known as unbalanced winding.

In considering the problem involved in winding, first take a plain cylindrical drum with the ropes coiled upon it as previously noted. Having fixed upon the time per wind, from the hourly output required, and decided upon the loading and unloading times, take the normal figures of a hoisting speed of about 3000 to 4000 feet per minute for fairly deep shafts, an acceleration of from 5 to 6 feet per second per second, and similarly for retardation. It is then possible to draw the diagrams of the winder, as shewn in Fig. 1.

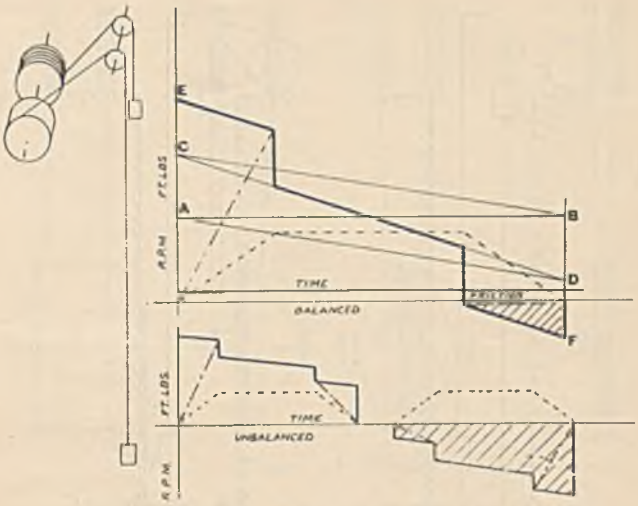


Fig. 1.—Winder Diagrams.

These diagrams are of the utmost importance in winder design and form the basis of all calculations; they are modified of course to suit the particular conditions.

The dotted line shewn is the speed diagram plotted from information received regarding time per wind, as r.p.m. of the drum on a base of time. The speed commences from zero, accelerates to a certain value, runs at constant speed, and then decelerates again to zero. The general form of this diagram is usually a trapezoid as shewn.

Now consider the two cages, as in this case the system under consideration is balanced winding. Generally speaking, as the upward travelling cage ascends with a number of full tubs, the downward travelling cage descends with the same number of empty tubs. Therefore, the nett load lifted is that of the mineral, and neglecting for a moment the acceleration and retarding moments, it is obvious that the torque for the load is constant throughout the wind. This is shewn on the diagram by the horizontal straight line AB, which is plotted as foot-pounds torque at drum radius on the base of time.

When the ascending rope is all paid out, there will be a maximum weight hanging from the drum; this gets less and less as the rope is coiled on the drum until, finally, at the top of the shaft, there is practically no hanging rope load on the drum. The weight of the rope hanging at different parts of the wind and therefore at different times, can be found from the formula

$$\text{Wt.} = W\ (L - d)\ \text{lbs.}$$

where W = Wt. per ft. of rope;
L = total length in feet;
d = distance travelled in feet.

The various values obtained from this formula, multiplied by the drum radius, gives the torque due to the rope at various stages of the wind; or, seeing that one wind corresponds to a given time, the figures may be expressed in terms of time.

In the diagram is shewn a curve drawn from rope torque values, but these are plotted, not on the original base line, but on the load torque line AB. This is purely a matter of convenience for, since in the final result all the various torques have to be added together, it is as well to add them in proceeding. It will be seen that the rope torque curve has a maximum value at the start and becomes zero at the end of the wind.

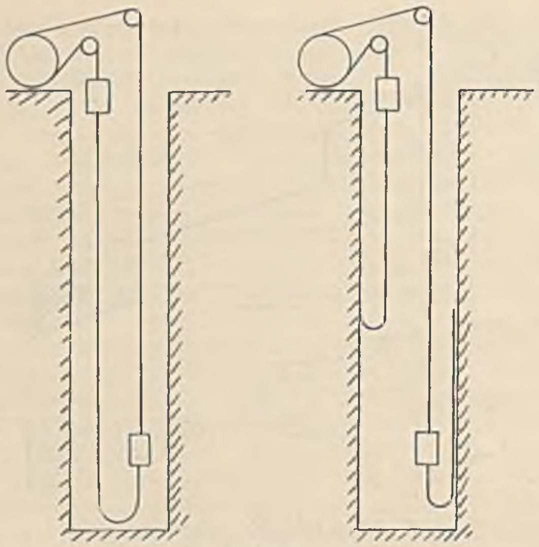


Fig. 2.

Consider now for the descending rope. It will be seen at once that this is similar in every way to the ascending rope excepting that the conditions are reversed, so that another curve drawn parallel to the first rope torque curve, only starting at zero and continuing under the assumed base line AB, will be the curve for the descending rope. The resultant curve is the difference between these two rope torque curves, and is shewn by CD in the diagram. The line CD, by reason of its construction, shews the torques due to the load, cages and ropes, referred to the original base line.

From the moments of inertia of the various moving parts, and the angular acceleration, can be calculated the accelerating torque, which is constant for the accelerating period. Similarly, for the retarding period.

By adding the accelerating torque to the rope and cage torque line for the accelerating period, and subtracting the retarding torque for the retardation period, the stepped curve shewn as EF is obtained.

The only factors now remaining are the effects of the friction of the cage and guides and the windage losses. As the sum of these is practically constant throughout the wind, and equals from 7½% to 10% of the cage and its load, this can be allowed for by dropping the original base line by this amount. This is the absolute line from which all measurements must be taken.

The curve EF is the torque curve of the winder. It will be seen that in the curve the torque reaches a high value at starting, maintains this practically constant for the acceleration period, then falls, remains practically constant again for a while, and then falls below the base line. The area under the base, shewn shaded, is the braking torque which may be wasted as heat in the brake shoes, dissipated in the controller, or perhaps returned as regenerated power to the supply.

The h.p. curve is obtained by multiplying the torques obtained from EF by 2π times the speed, from the speed diagram, and dividing by 33,000. To obtain the mean power all that is necessary is to find the area of the diagram and divide by the base, which is the time taken.

As is well known, the maximum torque that can be exerted by a good electric motor is usually two or more times its full load torque, and so it would be folly to put down a machine with a rated output equal to the maximum h.p. required per wind. The most important consideration is the heating of the motor.

The problem, therefore, is to find the constant h.p. which will give the same heating as the cycle of operations shewn on the diagram, continued indefinitely. Such a problem is solved by what is known as the root-mean-square method. This method consists of squaring a number of ordinates to the curve and finding the square root of the average value of the squared ordinates; this method is used in various problems involving cyclic operations such as, for example, haulage gear calculations, etc.

Applying the method to this problem, and considering the torque curve, it is known that the torque can be assumed to vary directly as the current with constant field; and that the heating of the motor, for all practical purposes, varies as the square of the current. So that to square a number of ordinates of the curve and find the square root of the average is to get the root-mean-square torque. This, multiplied by the speed of the drum in r.p.m. multiplied by 2π and divided by 33,000 will give the horse power.

A little consideration will shew that the weight of the rope plays a very important part in the winder diagram, and that the heavier the rope the steeper will be the diagram and, consequently, the greater the torque. Various methods have been suggested for reducing the rope torque and the two most common are by means of (a) tail ropes, and (b) alteration of the drum profile. With tail ropes a rope, usually of equal weight to the main rope, is connected at each end to the bottom of one cage and hangs in a loop down the shaft. When unbalanced winding is to be used a single rope equal to half the length of the shaft hangs from the bottom of each cage, the other end being fixed at a point mid-way down the shaft, as shewn in the diagram, Fig. 2. When the weights of the main and tail ropes are equal the lifting and dropping ropes balance each other throughout the wind.

The chief objection to this method is the surging and whipping of the ropes, but as this has usually been associated with steam driven winders, and seeing that electric motors have a much smoother turning effort, this objection may not prove to be so serious with an electric winder. In fact, it is noticeable that when electric and steam driven winders are running side by side the hoisting rope of the electric system runs steadily like a rigid rod, while the other is whipping and surging all the time.

Drum Shapes.

The most commonly adopted method of reducing rope torque is by introducing an alteration of the drum profile. Turning to the consideration of the types of drums in use (Fig. 3), the first to be noted is the cylindrical drum. This consists of a cylinder the ends of which are of cast-iron or steel bored to take bushes which run on the drum shaft; the ends are united by a barrel usually of steel plate lagged with wood, which may or may not be grooved for the rope, and which is secured to the barrel plates with countersunk screws. The drum barrel is usually stiffened with T or angle irons.

The conical drum, as its name implies, is in the form of a truncated cone, and by suitably proportioning the diameters, it is possible to obtain a greater, equal, or less torque at starting than at the finish of the wind.

A third shape of drum is the cylindro-conical, a modification of the conical drum, which has come into use because in some cases the conical drum would have become too wide. In the cylindro-conical type the rope may be wound in two or more layers on the cylindrical portion. The same remarks regarding the conical drum apply here.

Then there is the bi-cylindro-conical drum. This is the latest development in drum design and consists of a small cylinder and a large cylinder united by a cone or scroll. In this drum the rope is wound on the small cylinder during the acceleration period, and at the end of that period it is transferred rapidly by the scroll to the large cylinder. Under reverse conditions the rope is wound off the large cylinder and, near the end end of the wind, climbs down the scroll to reach on to the small cylinder as the retardation brings the machine to rest. By suitably proportioning the cylinders and rope distribution the heavy torque at starting can be materially reduced.

The last type of drum, or in this case more correctly termed a reel, is the Koepe pulley. This is not much used in England, but it is fairly common on the Continent. It consists of a large diameter friction pulley with a grooved face packed with wood or leather to increase the friction. The rope from the top of one cage passes over the head gear, round the Koepe pulley, and over the other head gear to the other cage. A balance rope goes from under the first cage, down the shaft and up to the underside of the second cage The illustration, Fig. shews the general arrangement. There are other modifications of this system such as the Whiting sheave, but these have not met with any very considerable success.

A few dead turns of rope should be allowed on all types of drum to take the strain off the rope fastening.

The Electrical Equipment.

The first to be considered in this connection is the three-phase induction motor type. Here, the drum is driven by a three-phase slipring induction motor, either direct-coupled, or geared to the drum. With direct-coupled machines the speed of the motor is necessarily low, which has the bad effect of introducing a low power factor and efficiency; consequently the geared type of winder is being much more used with alternating current motors.

The usual plant arrangement consists of a stiff bed-plate carrying reducing gear and motor, the drive from which passes on to the drum shaft. The motor pinion should be mounted on two bearings, and driven through a flexible coupling. Under no circumstances should the pinion be overhung. The usual speeds for these motors at 50 cycles are about 375 r.p.m. up to 1000 h.p.; and about 250 r.p.m. up to 2500 h.p.

The only method of control in general use is that of resistance introduced into the rotor circuit for starting, with a reversing switch in the stator circuit, usually two-pole up to 500 volts and three-pole above. This switch may be either air-break or oil-immersed and, for the former, magnetic or air-operated contactor gear may be used. The oil switches are usually mechanically operated. All things considered the author is inclined to prefer the air-break type because of the constant attention needed by oil switches due to arcing contacts the renewal of the oil, etc. The resistances in the rotor circuit may be metallic grids up to about 200 h.p. if the duty is not too sever.

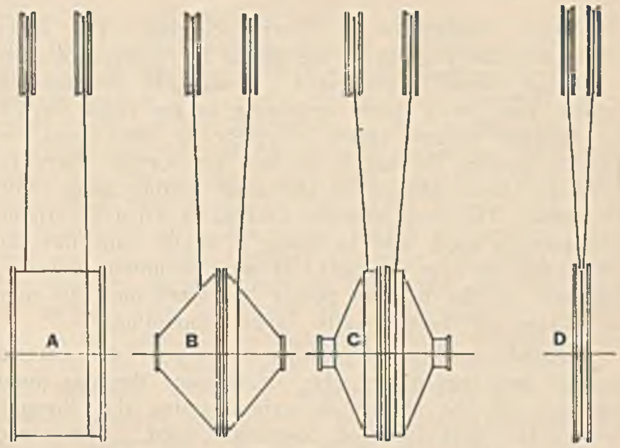


Fig. 3.—Types of Winder Drums.

A—*Cylindrical.* C—*Bi-cylindro Conical.*
B—*Conical.* D—*Koepe Pulley.*

For arduous duty contactor operated resistances controlled by a master switch are to be preferred. These contactors should be arranged with series relay coils which cause the contactors to operate at predetermined values of current and thus secure automatic acceleration.

The stator circuit-breaker should be furnished with an inverse time element relay to prevent it opening due to sudden peak loads. Also, should the breaker trip due to overload or failure of supply, the contactors in the rotor circuit will open automatically, and a no-volt relay should be provided so as to prevent them closing when the current is again supplied unless the master switch is in the "off" position. It is desirable to provide interlocked relays to prevent the stator change-over switch being reversed too quickly, i.e. until the arc is broken.

For higher horse power plants, liquid controllers with the stator reversing switch incorporated in them are generally used. The rotor section is usually of the moving electrode type and essentially consists of a tank containing the electrolyte in which are three electrode chambers of insulating material. Each chamber is closed at the bottom end by a cast-iron plate fitted with terminals which are connected to the sliprings of the machine, and in each move the cast-iron electrodes which are short circuited at the top to form the star point. Suitable means for maintaining circulation of the electrolyte are provided. The electrolyte usually consists of a solution of ½ lb. to 1 lb. of washing soda per gallon of water. An allowance of 4 gallons or more of cooling water per h.p. hour is required.

It must always be borne in mind that controllers should be very liberally rated, for when winding at slow speeds, or during unbalanced winding, the controller may have to dissipate an equivalent of 50% or more of the motor output at full load.

The most difficult problem with three-phase winders is the braking of the load. Four methods may be used and these will now be examined. The first is by running the motor above synchronism. As is well known, an induction motor driven above synchronism becomes a generator and feeds back to the line, and when no resistance is in circuit with the rotor gives a high negative torque at very small values above synchronism. If the resistance is increased then the speed is increased greatly.

It will be seen that other means must be adopted bring the motor to rest and this is done either by mechanical braking or by reverse current. The latter means that the current in the stator is reversed, and so a braking torque is generated. It must be remembered though, that for a given resistance in the rotor circuit, the braking torque varies inversely as the speed, so that the greater the speed the less the torque; there is, therefore, some chance of the load getting away with the motor. The most effective braking is when a variable resistance is used, and by using a liquid controller the torque may be kept constant. It must be noted, however, that here all the braking power is wasted and this may necessitate an exceptionally large controller.

Another method of braking is to pass d.c. current through two legs of the star, or to open the star point and join all the phases in series passing d.c. through them. The first is most commonly used. The speed control with this system is obtained by varying either the resistance in the rotor circuit or the excitation current. Resistance control is most used. The main objections to this method are (1) that for a given torque the heating of the motor is much greater than when running as a motor; (2) if too much resistance is cut out when running at high speed, the torque is reduced, and the load will take charge.

It must not be inferred, however, that counter-current or d.c. braking are at all impracticable, as many sets are running to-day. It is more a question of efficient design, and the difficulties have been mentioned here only to emphasise the problem which has to be faced.

The most reliable method of braking is by an eddy current brake, but the cost may be prohibitive.

The next type of winder to be considered is the plain Ward Leonard control type. Generally speaking, if conditions of supply allow, this is the best type to use. The general arrangement of a W. L. equipment is the motor generator set which consists of a three-phase slipring induction motor driving a variable-voltage dynamo together with an exciter. This set drives the d.c. winder motor, which is usually direct coupled to the winder drum. Sometimes, to improve the power factor of the whole plant, a synchronous motor is used instead of an induction motor. This method has been used very successfully by the English Electric Co., Ltd.

The variable-voltage dynamo and the winder motor are both separately excited, in this case from the exciter, and the armatures of the variable-voltage dynamo and winder motor are joined in series. The field of the motor is kept constant, and the dynamo field varied by a resistance. The principle of operation can best be followed when it is remembered that, with constant field, the speed of rotation of a motor is proportional to the voltage across the brushes, irrespective of load, and also the voltage of a dynamo is constant with constant field irrespective of load; and, further, that it is sufficient to reverse the motor field to reverse rotation.

Therefore, it will be seen that any speed of the motor can be obtained by varying the voltage across the brushes, which is simply done by varying the dynamo voltage by increasing or decreasing the dynamo field.

All then that is required is a controlling resistance in circuit with the exciter and dynamo field, and a controlling lever to operate it. This series resistance can be varied by means of tappings and sliding contacts, so arranged that when the regulator is in the "off" position the field of the dynamo is disconnected from the exciter and coupled across the dynamo armature in such a way as to demagnetise the field magnets.

A favourable point of the Ward Leonard system is that the braking is perfectly automatic, as, when the motor is driven by the load it becomes a separately excited generator, which drives the variable-voltage dynamo as a motor, which in turn drives the a.c. motor, and returns current to the line.

This is assuming the circuit breakers are not opened. If that should occur, a relay would cause the mechanical brakes to operate. The increase in speed of a Ward Leonard set when braking is usually very small and the mechanical brakes can be brought into action by a centrifugal switch and relay should overspeed occur. The electric braking is so good that the duty of the mechanical brakes is extremely light.

Another system is used on the Continent, an instance of which is at the Czeladz Mines in Poland, 250 h.p. winding from 700 ft. This consists of adapting the single phase Deri motor (which is a commutator compensated repulsion motor)to run on a three-phase circuit, by connecting two such motors across the three phases: the set thus consists of two stators with two rotors each having a commutator coupled on one shaft. All starting, reversing and regulating are accomplished by shifting the brushes. The stators may be coupled straight on the H.T. line and this system has the advantage of large starting torque and is regenerative at all speeds; also, it can be used for electric braking.

A system in use at the New Madderfontein Mines in South Africa consists of two series wound d.c. motors controlled on the series parallel principle.

(To be continued.)

SOUTH WALES BRANCH.

Ⓟ Earthing of Electrical Apparatus.

J. VAUGHAN HARRIES.

(Paper read 10th January, 1931.)

The application of electric power for mining work, represents one of the greatest developments in the electrical industry during recent years. Although its use in relation and comparison with other motive powers has been proved and accepted as being of high commercial and economical value, there are persons to be met with who view its application to mining with fear and mistrust when judging it from the standpoint of safety. There is no greater means towards securing safety in the generation, transmission and usage of electrical energy than the effective earthing of apparatus. It gives maximum protection to plant, reduces to a minimum the possible danger to life: thus, it serves dual purposes of vital importance. It gives ample assurance for capital expended in the layout of an installation: it creates a favourable impression on the mentality of those engaged in the working of such plant.

It is surprising, when decisions and ultimate arrangements are made to install power stations and sub-stations by supply authorities, works and colliery companies, that the nature of the earth and soil surroundings are rarely thought of, from the viewpoint of earthing as accepted by the electrical mind. Plentiful supply of water, easy access for coal supplies, close proximity to railway, water charges, wayleaves and rates all receive due consideration, but rarely do such reports mention that the geological conditions were tested and found ideal for the discharge to earth of leakage current. Again, when brochures are compiled setting forth certain commendable features of systems, plants and works, the usual procedure is to acquaint the reader with the various types of machinery, such as the generators, winders and other auxiliary plant, rarely is any reference given regarding earth connection. When visiting installations, it would be the exception that proves the rule if the guests were taken to see the earth plates. Whatever may be the commercial considerations due to charges, rates, etc., a good connection to earth has also an important value when considering reliable and safe working. Little has been done to make generally known the results of research in this important matter. Literature on the specific subject of earthing is very limited and when referred to it is usually treated in a somewhat perfunctory and superficial manner. The tendency in modern electrical practice towards extra high voltages and the resultant increased severity of the duty which the insulation is called upon to perform, has re-awakened interest in matters pertaining to the earthing of electrical apparatus. It is with a view to helping in the furtherance of research and discussion on that subject that this paper has been written.

EARTH CONNECTION PLATES.

In building the earthing system, the form of earth connection should have very serious consideration. It is the amount of thought given to this matter in the the initial stages that goes to prove its ultimate efficiency. Too often has the provision of a sound earth connection been looked upon as of secondary importance, something which could be put in a day or two before starting up the plant.

The generally accepted constituents of an earth connection are a metal substance in the form of plates or pipes, soil, and water. In the attempt to secure a reliable earthing metal, copper, cast-iron, steel and galvanised iron in various shapes and forms have been tried; however, it is either copper or cast-iron that is almost invariably resorted to.

Viewed from the aspect of conductivity, copper at once suggests itself as a most suitable metal; however, when embedding metal in the ground we have to reason with the electrolytic properties of the soil and its effect upon the buried metal. Copper is particularly subject to galvanic action when surrounded by metallic substance in the soil either in the form of salts, metal-pipe lines or adjacent structures having a differing potential. When copper is used in an earth connection, its surface is usually tinned, this is done as a prevention to the ill effects of corrosion and oxidisation. Sight must not be lost of the fact that this tinned condition also increases the effective contact area of the plate to the anode and cathode action which takes place between the copper plate and metals of lower potential. So it can be seen, that what has been done to guard against oxidation due to moisture condition, increases the possibility of galvanic action, with an effect similar to that which takes place in an ordinary cell, the positive element becomes pitted and is eventually eaten away.

Copper plates, when surrounded by coke that is not free from sulphur, present yet another disadvantage. When the coke is maintained in a wet condition, a sulphuric acid solution will always be present, exercising a detrimental effect upon the surface of the plate. If a connection is made from the copper plate, through a sensitive milli-voltmeter, to a distant point in the coke, it is possible to have a deflection on the meter. Sometimes this is accepted as indicating a good contact to earth, but it is not so, rather should it be taken as evidence of the destruction that is going on underneath the surface of the earth connection.

Cast-iron in the form of pipes or plates, although having less than 50% of the specific conduction of copper, is extensively used because of its comparative cheapness and its resistance to corrosion in ordinary soils. Cast-iron is not immune from the bad effect of local electrolytic action but, owing to its low potential, these attacks are not so destructive to the metal. In order to assure long life, plates of large dimension are usually used, this can be done with cast-iron for a very much lower cost than would be the case if copper had to be purchased to give the same length of service. Dry rust on the plates certainly increases the resistance to the flow of current between the metal and the mass of earth. This is where the importance of keeping the earth connection permanently wet is subject to the effect of the moisture upon the metal. Rust kept in a wet condition offers no appreciable resistance to the flow of current and since it is important that the contact resistance between the metal and earth should be as small as possible the earth connection must be permanently wet, either by natural conditions or by an artificially arranged supply of water.

The cast-iron earth plate commends itself by its low first cost and, in the case of works and collieries, it is an easy matter to bury plates of large area and good thickness ; the former virtue giving good contact surface, the latter, longevity.

THE EARTH STRATA.

To the engineer constructing the earth-connection, the metal is one of choice but the earth is there by natural circumstance, and there is no greater factor contributing to a successful ground connection than that of the contact resistance between the metal and the soil. It is universally recognised that the nature of the ground in and about mines offers a problem to be solved in the selection of the type and position of the earthing centre ; the different strata, ores, etc., have their independent iron and salt content, some assisting and others resisting the passage of current.

The part of the earth structure which affects the question is that which is nearest the surface. The depth and nature of soil and sub-soil vary to a great extent. The underlying strata vary in composition and thickness in different districts, and when making a statement concerning these conditions it must always be of a particular character applying to that particular coal-field.

In the South Wales coalfield the formation of strata may be assumed to have the following downward progression: clay, soft shales, hard shales, rock-like shale, pennant sandstone. Lower still the order is reversed—rock-like shale, hard shale, soft shale, clay, and then the coal measures. In general terms this is the formation from the surface to the first seam of coal, measuring about 1 or 2 inches in thickness, and it is repeated between successive seams. It will be noticed that the soft shales are nearest the seam and by almost imperceptible changes they become harder as they get nearer to the sandstone.

The soil on the earth's surface may be clay, marl, or loam. Clay is a soil having a large silica and alumina content. Marl is clay which contains a rather large amount of carbonate of lime. Loam is clay with a large content of sand. Water percolates rapidly through loam. Shale, which is next to the surface strata, is hardened clay, and splits up into thin layers along the lines of bedding. Progressing downward it gets harder by amalgamation with sand, until the sandstone, a granular non-crystaline rock composed of grains of sand cemented togethed is reached.

The clay which appears under and sometimes over coal seams, is very thin and is called fire clay. This

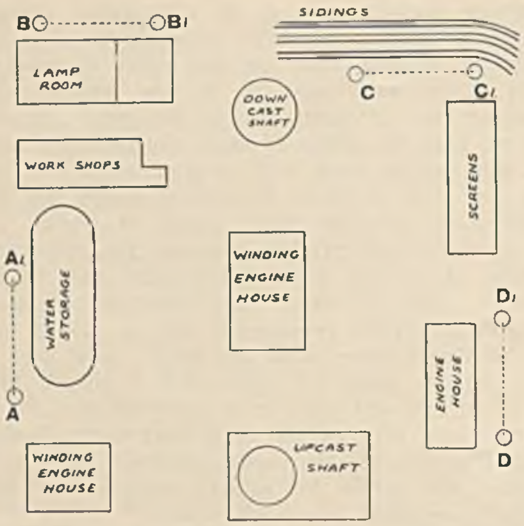


Fig. 1.—Surface: Shewing Testing Points.

has a very low alkaline content, a fact worth remembering when making an earth connection in the mine.

It will be seen, from the foregoing remarks, to what extent the various kinds of soil and rock can be depended upon to dissipate a charge of electricity. The best conductor of current is clay, its value being greatly increased when the clay contains natural alkalines and permanent metallic properties. Shales, sandstone and and hard rock offer great resistance to a passage of electricity and cannot be depended upon to assist the flow of current from the earth plates. The value of made ground for the purpose of earthing will depend largely on the soils contained therein, and its contact to the natural surface strata.

RESISTIVITY OF SOILS.

With a view to proving the resistivity of soils, the author experimented with a specially prepared wooden box of one foot cube dimension. Two sides were covered with sheet tin and terminals placed in the centre of each electrode. The well-known formula:—

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

was used as a basis of measurement.

It can be safely assumed that there was but little voltage drop due to the testing leads and connections. The soils chosen were rupple, underground soil, coke and clay.

By reference to Table I., it is possible to become acqainted with the characteristics of soils, effects under varying moisture conditions, amalgamations of soils, and the presence and effect of metallic parts in the soils or agglomerate.

Table II. gives a detailed analysis of the soils. A study of this table explains the reasons why various kinds of soil offer more or less resistance to the passage of current and also their respective corrosive actions. It is difficult to state a specific resistance for any one kind of soil. Clay taken from the mouth of a river would offer less resistance than clay taken from the course of the river, this is affected by brine from the ocean due to tidal inflow. Again, soil which is compact or under pressure has a higher conductance than that which is loose, although the physical contents may be the same. In this country, seasonal change of temperature, will have very little effect upon soil resistance, Earth connections will be more affected by moisture condition, and the treatment given in construction and maintenance.

TABLE I.

RESISTIVITY OF SOILS. ONE FOOT CUBE.

Soil.	*Condition.*	*Temp. Fah.*	*Weight (lbs.)*	*Ohms.*	*Remarks.*
Clay	Damp	50	77	2400	Large in silica and alumina content very little moisture content.
Clay	Wet	50	102	850	Improved conductivity due to large water content, which is represented by the increased weight : town supply water was used.
Clay	Damp	50	—	1900	Improved conductivity due to a copper bar inserted of the following dimension:— 10 ins. × $1\frac{1}{2}$ ins. × $\frac{1}{4}$ in.
Coke	Damp	50	60	0.6	The coke was in a ground condition, the particles bearing closely to each other. Sample contained a large percentage of carbon.
Coke	Wet	50	82	0.9	Increase of resistance due to water between the particles of coke, the reduced surface contact tending to a higher resistance.
Coke	Damp	50	40	0.66	The coke was of larger mesh.
Rupple	Wet	50	90	1450	Consisted of shale, mudstone and other refuse such as ash. Iron oxide and alkalies content rather high when compared with other soils.
Underground Soil	Damp	50	52	—	Apparatus not able to measure resistance.
Underground Soil	Wet	50	82	110	The increased water content was very large. This soil consisted of coal, shale, stone-dust, and dirt.
Clay	Damp	50	81	6.5	A salt solution was added proving the effect of adding a solution high in its hygroscopic properties.

TABLE II.

ANALYSIS OF SOILS.

Content	*Rupple* %	*Boiler Ashes* %	*Underground Soil* %	*Clay* %
Loss on Ignition: Organic matter, Water and CO_2 ...	11.5	33.5	42.4	5.2
Silica	46.5	34.8	22.7	58.9
Alumina	13.0	14.6	18.4	27.3
Iron Oxide	17.5	12.5	9.3	1.8
Lime	.8	.6	2.1	1.9
Magnesia	1.4	.9	.9	2.4
Titanic Oxide	1.0	.6	.8	—
Alkalies	7.0	.9	3.4	1.6
Undetermined	1.3	1.6	—	.9

When considering the resistivity of soils it is a good thing to consider large masses of earth. The comparative resistance will be very much less than when considering small quantities, as the law of conductance can be said to be the same for soils as for metals. Fig. 1 illustrates and Table III. gives the results obtained with driven pipes at a distance of 40 yards apart.

Great difficulty was experienced in taking tests of masses of earth having mixed ingredients. A direct current supply was first tried, but owing to electrolytic action creating a back e.m.f. the results were most confusing and could not be relied upon. An alternating current supply was then tried by means of a Megger Earth Tester. Consistent readings were obtained over a period of 14 days and the results can be accepted as a true representation of the soil resistivity.

Where earth plates should be situated is therefore obviously a matter for local consideration. The main idea should be a good contact to the natural soil or to a soil which has a large contact area with the mass of earth. Novel methods of placing plates or pipes in ponds, feeders, or sumps, are only effective when the water has a large salt or metallic content; and then only inasmuch as good contact is made with the surrounding earth.

Methods of increasing the conduction of soil, lay in adding some solution or material which is highly retentive of water. Common salt and calcium chloride are sometimes used, but their effect is only temporary: the salt solution percolates through the ground, disappears, and has to be renewed at frequent intervals. They are moreover highly corrosive and when used care has to taken as to what metal should form the earth plates. When it is necessary to increase the conductance of earth connections it is always best to do so by placing a number of electrodes in parallel and so increasing the area of plate in contact with the earth. Multiple electrodes are a permanent job and guard against the danger of broken connections.

TABLE IV.

RESISTANCES OF WATER. ONE FOOT CUBE.

Supply	*Ohms.*	*Remarks.*
Town Water	666	Water for human consumption.
River Water	515	Taken from source of river.
River Water	345	Includes deposit and strata water from levels and headings along its course.
Strata Water	165	Taken from the mine workings.

TABLE V.

ANALYSES OF WATER.

Content	*Town Supply*	*River Water*	*River and Strata Water*	*Strata Water*
Total Solids	10.8	13.9	34.4	8.12
Suspended Matter ...	1.0	Trace	9.1	Nil.
Solids in Solution	9.8	13.8	25.3	8.12
Total Hardness ...	5.9	8.8	13.7	4.82
Permanent Hardness	5.9	8.8	13.7	3.30
Temporary Hardness	Nil	Nil	Nil	1.52
Chlorides	1.31	1.30	1.31	1.11

A good supply of water is essential in an earth connection, but it must be of the kind that will prove useful in making the connection effective. Table IV. evidences the resistances of different kinds of water, whilst Table V. gives analyses of their contents.

EARTH PLATE.

Fig. 2 represents an earth connection, simple in construction and one which could be adopted at little cost. It will be noticed that there is an unusual amount of coke. Compared with other soils, coke is on excellent conductor and should always be used freely and in such proportion as will ensure a large surface contact area with the natural soil. The common practice of including coke simply as a moisture container and packing it into a limited area as shewn by the broken line in the diagram (Fig. 2), does not represent the best use that can be made of coke. A fault to earth can only be dissipated in the proportion that the natural soil is able to accept the current leakage. Under such circumstances every effort should be made to increase the contact area between the metal earth plates and the mass of earth. The coke should be void of sulphur and it is best when crushed into small particles. If under the discharge of an extremely heavy current a rise in temperature were experienced, coke which has a negative co-efficient of resistance has an enhanced value. A water supply is provided for at three points in order to obtain even distribution and the maintenance of full saturation. Three such earth connections as described, placed at the surface of a mine would give ample assurance for the discharge of leakage current. This

TABLE III. GROUND TEST.

Driven Pipes: 6 feet long, outside diameter 6 ins., inside diameter 4⅝ ins.

Area.	*Distance*	*Ohms.*	*Remarks.*
D — D[1]	40 yards, apart	180	Clinker, coal ash and unburnt coal.
C — C[1]	40 yards, apart	120	Clinker, coal ash, unburnt coal, assisted by siding rail lines.
B — B[1]	40 yards, apart	300	Surface clay, similar to clay at the bed below No. 2 Rhondda Seam.
A — A[1]	40 yards, apart	250	Clay, assisted by water in storage bond.

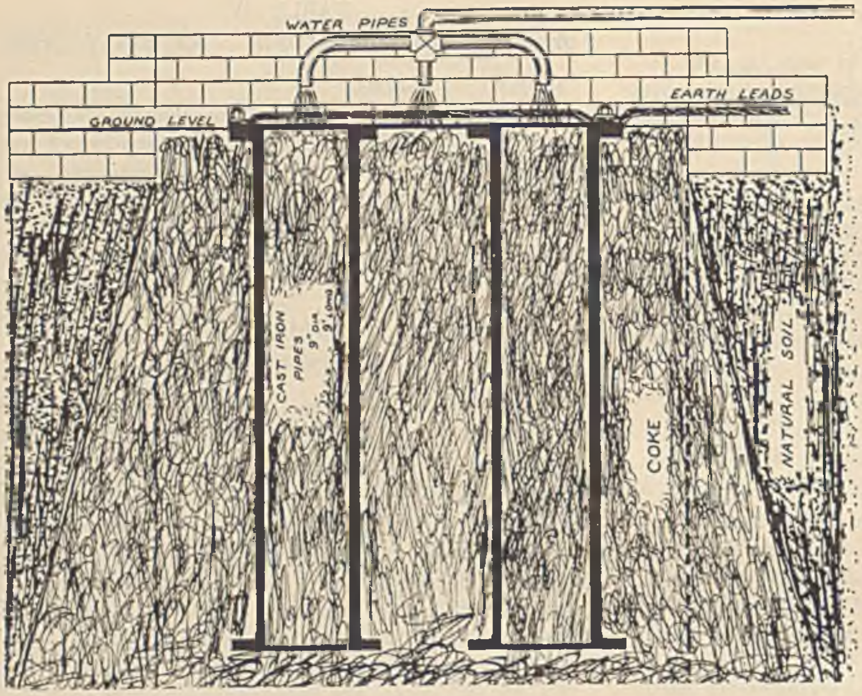


Fig. 2.—Earth Connections.

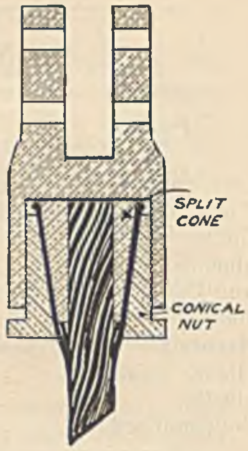


Fig. 3.—Mechanical Joint.

number of connections permits also of systematic examinations: one plate may be examined every twelve months, its condition would be a criterion of that of the others left in the earth, and in three years all would have received attention.

Connectors.

Where possible it is better to rely on a mechanical connection rather than a soldered or sweated joint for all earth plate terminals. When solder is exposed to weather conditions and water, electrolysis occurs at the point of contact between the dissimilar metals and reacts on the conductivity and life of the joint.

Fig. 3 shews one form of connector which could be adopted and standardised for all bonds in the earthing system. It has the feature of double contact area, two pins for security and when the inner cone and tightening cone are well fitted a sound mechanical and electrical joint is the result.

Distance between Plates.

To be able to pass two amperes at a pressure of four volts between earth plates is not a sure indication of adequate connection to the mass of earth. The effect of the electrode is to concentrate the current to limited areas, thereby the effective resistance of the general mass of earth is increased. The aforementioned test only indicates the conductivity of earth length between the plates and not the value of the contact between the plates and the mass of earth. The resistance of is always low when there are considerable lengths of rail tracks and pipe lines. Modern collieries and works having little steam and compressed air pipes in the ground are not likely to yield the earth conductivity tests that would be expected from collieries not electrically equipped and with the ground thickly laid with metal lines. It should be the aim of the electrician-in-charge so to place the earth connections as to assure them of good contact area with the mass of earth, distance having no appreciable effect in this respect.

To obtain accurate tests of any circuit which contains soil the tests should always be made with alternating current, results thus obtained are not affected by stray currents encountered in the soil nor by electrolysis. Direct current measurements are only effective when the distance between the electrodes is small, when the testing pressure is low and when the soil does not include materials introducing varying potentials. Surface contact is the factor that counts most in an earth connection, whether the plate is on the surface or in the mine.

(*To be continued.*)

CABLES SYSTEM AT THE B.A. EXHIBITION.

The cable network distribution outside of the sub-station at the British Empire Trade Exhibition at Buenos Aires, for which W. T. Henley's Telegraph Works Co., Ltd., were responsible, called for the supply and installation of approximately 5500 metres of cables of varying sizes and twenty-seven Henley Unit Type distribution pillars. Mr. F. H. Harris, Henley's Buenos Aires Manager, placed the technical experience of his staff at the disposal of the Exhibition Authorities. The lighting scheme was evolved in conjunction with Mr. H. A. G. Cartwright, the Buenos Aires representative of Messrs. Holophane Ltd.

Power is taken in bulk from the Compagnie Hispano-American de Electricidad. A complete sub-station with a capacity of 2000 k.w. has been built to supplement the output of the existing sub-station, which has been increased to 1000 k.w., and which in the past has supplied all the power to the Rural Society. This enables four-wire alternating current at 380 volts to be supplied to every pavilion. In addition a three-wire d.c. network at 440 volts supplies the direct current needs of exhibitors.

The transformers, each of 500 k.w., 13,000/380 volts, supplied by the Anglo Argentine General Electric Co., Ltd. ; and the switchgear, ten L.T. panels and six H.T. panels, by Reyrolles Ltd.

The feeder cables are connected to Henley unit pillars at suitable distribution points, from where the main distributors are run to the individual distribution system of each pavilion. Within the pavilions the distribution systems are rather complicated. The general lighting of the pavilions is at 220 volts a.c., the stall-holders lighting and power is at 380 volts and 220 volts a.c., while there is a separate distribution system for special window lighting in the pavilions representing Hampton Court Palace, old Tudor buildings, and so on ; and there is a d.c. supply at 440 and 220 volts.

Manufacturers' Specialities.

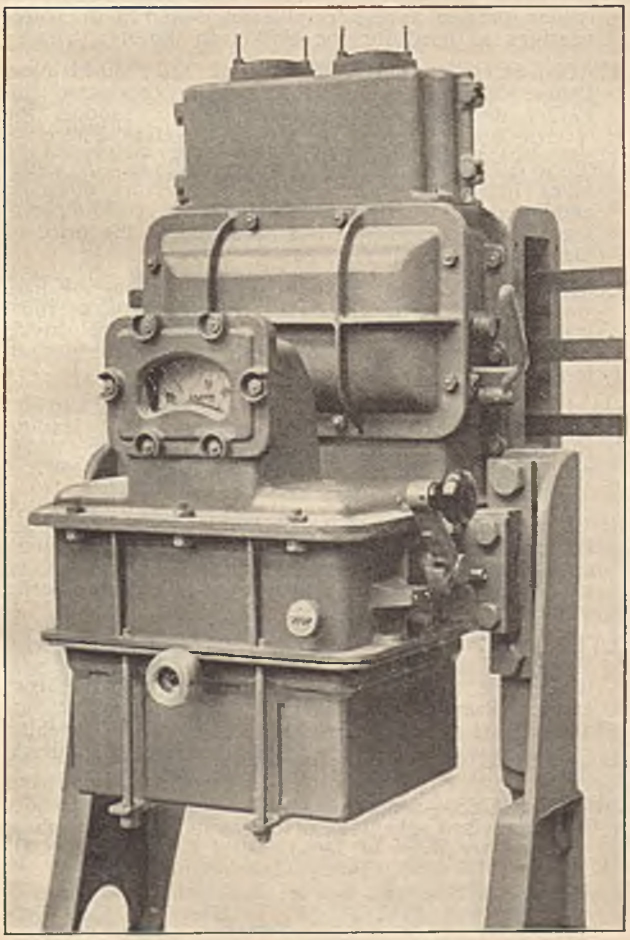
New Flame-proof Switchgear.

The illustration reproduced here shews an example of the new type of flame-proof Mining Switchgear which has recently been placed on the market by Erskine, Heap and Co., Ltd. In general, the gear is of a practical and robust design, complying fully with the most recent official regulations and suggestions, particularly those outlined in pamphlet M.D. Circ. No. 23.

The interlocking arrangements are very complete, it being impossible to remove the tank, switch cover or isolating cover, until the switch and isolating gear have been brought to the "off" position. The interlock mechanism operating in such a manner as to prevent the isolating switch being operated unless all covers, etc., are in a position of safety.

The switch, as will be gathered from reference to the above regulation, is complete with earthing contacts, these contacts forming part of the actual oil switch unit, thus obviating the necessity of separate earthing plugs being necessary when earth conditions are required.

The arrangement for earthing is designed on such lines as to prevent accidental earth contact being made unless conditions are suitable for this contact to be closed. Once the earthing contact has been made it can be locked in position to prevent interference by unauthorised persons.



New Type of Flame-proof Switchgear.

Other commendable features are: The busbar chamber, which is provided with separate compartments which can be compounded, through which the busbars pass, the bars being bushed in such a manner as to prevent the possibility of outside gases being fired in the event of the end plate of the busbar chamber being omitted by a careless workman.

The trifurcating box arrangements, which are so designed so as to avoid the necessity of compound being removed from the chamber in the event of an alteration being necessary in regard to the cabling arrangement, or the switch requiring to be transferred to a new position.

The apparatus is designed on the unit principle so that terminal switches, through switches, starter gear, etc., can be built up in the form of a switchboard, if so desired.

Coal and Steel in Nova Scotia.

A history of the coal mining and steel industries in Nova Scotia was the subject of an interesting radio address broadcast from the Canadian National Railways station at Moncton recently, by Michael Dwyer, Mayor of Sydney Mines, N.S. The first mention of the famous Cape Breton coal fields, Mr. Dwyer stated, was in a report by Nicolas Denys to France in 1633, during the beginning of the French regime. In this report Denys stated: "There is a mountain of very good coal four leagues up Cibou of a quality equal to any in France as I have proved by actual tests." Cibou is now known as Sydney Harbour. Smugglers also mined this coal to sell to the colonists in New England.

The first real development occurred in 1825 when the Duke of York, brother of George IV. of England, to replenish the exchequer, gave the sole rights to all minerals in Nova Scotia on a royalty basis to a group known as the Gentlemen Adventurers, the name being afterwards changed to the General Mining Association of London, Eng. Richard Brown, a geologist, was sent out to Nova Scotia to report on the coal possibilities and he commenced operations at once. He built a railway system with wrought iron rails on which horses were used to haul the trucks loaded with coal and which was in operation in 1828; in 1838 the first locomotive was imported. This old locomotive may still be seen at the Canadian National Railways station in Halifax, N.S.

The steel industry in Nova Scotia got its start from the activities of two young men, Graham Fraser and Forest McKay, who were employed as blacksmiths in the shipyards at New Glasgow. They noticed it was becoming increasingly difficult to obtain a proper supply of wooden knees for ships and the thought occurred to them to use iron knees, something which had never been attempted previously. The scheme was a success and they subsequently branched out into other lines. A company was formed under the name of the Nova Scotia Steel Company which, in 1899, bought out the interests of the General Mining Association and became known as the Nova Scotia Steel and Coal Company. Mr. Fraser and his associates in this Company were the first to work out a process for the successful utilisation of the famous iron deposits at Wabana, in Newfoundland, from which the greater bulk of the ore used by the steel mills at Sydney and elsewhere in Nova Scotia is now obtained.

Mr. Dwyer, in emphasising the importance of the coal and steel industries in Nova Scotia, pointed out that some 13,000 men are employed in the collieries and some 4000 are engaged in the steel plants at Sydney and Trenton, the car works at the latter place and the quarries and lumber mills in Cape Breton, representing in all an annual payroll of over $25,000,000.

Jubilee of the S.C.I.

Leading scientists from all over the world are to attend the Jubilee Celebrations of the Society of Chemical Industry, which will take place in London during the week commencing July 13th, under the patronage of His Majesty the King. The proceedings will be under the Presidency of Sir Harry McGowan, President of the Society, and will comprise a wide programme of scientific discussions, social functions, and visits to industrial centres. Several hundreds of the Society's 7000 members are to attend from overseas, and the celebrations will open with a Reception by the Lord Mayor of London at the Guildhall.

Tha Annual General Meeting of the Society will be held in the Duke's Hall, Marylebone, on Tuesday, July 14th, when Sir Harry McGowan will deliver his Presidential Address. In the afternoon a Garden Party arranged by the Shell Royal Dutch Oil Group will take place at Teddington. Wednesday will see the Presentation of the Society's Medal to Dr. Herbert Levinstein, and the Annual Dinner at the Great Central Hotel. On Thursday evening a Reception is to be given by the President at the Savoy Hotel.

During the Celebrations Honorary Membership of the Society—a very rare distinction, only previously awarded on six occasions during the 50 years of the Society's existence—is to be conferred on representative leading members of the chemical industry in each of the world's principal industrial countries, and a feature of the proceedings will be the delivery of addresses by these distinguished scientists on various days during the Celebration Week. In addition there will be meetings for the reading and discussion of papers, lectures, and addresses, and an interesting meeting at the Great Central Hotel when papers presented by the Canadian Sections of the Society will be read.

A very wide selection of works and factory visits will be available for Members of the Society. Amongst the well-known firms whose works will be visited may be mentioned Achille Serre Ltd., British Drug Houses, the General Electric Co., South Metropolitan Gas Co., Burroughs Wellcome & Co., Huntley & Palmer Ltd., and J. Lyons & Co., Ltd. The Anglo-Persian Oil Co.'s Research Station at Sunbury, and the National Physical Laboratory and Chemical Research Laboratory at Teddington, will also be inspected by large parties.

Throughout the week of the Celebrations a comprehensive Exhibition of British Chemical Plant and Research and Recording Instruments, arranged by the British Chemical Plant Manufacturers' Association, in co-operation with the Chemical Engineering Group of the Society of Chemical Industry, will be held at the Central Hall, Westminster. The Exhibition, which will be opened by Sir Harry McGowan on Monday morning, will cover the whole range of the industry, and practically every important firm of British Chemical Plant Manufacturers will be exhibiting.

A section of the Exhibition will be devoted to the work of the Department of Scientific and Industrial Research, and of various Research Associations dealing particularly with the following industries: Boots, Shoes, and Allied Trades; Cast Iron; Leather; Linen; Non-Ferrous Metals; Paint, Colour, and Varnish; Rubber; Wool. Full details as to the exhibition can be obtained from the Secretary of the British Chemical Plant Manufacturers' Association, Mr. J. Davidson Pratt, O.B.E., 166 Piccadilly, London. W. 1.

The social side of the occasion has not been neglected and there will be motor drives, river trips, visits to Oxford, Windsor, Eton, Hampton Court, and the Zoological Gardens, and conducted tours through London.

Oil Engines for the B.B.C.

The B.B.C. has placed an order with Crossley Brothers Ltd., for four 350 h.p. vertical oil engines, to be installed in the new Scottish Regional Station at Falkirk, the latest of its type.

In the installation of their new stations the B.B.C. pursue a progressive policy in regard to the choice of power machinery and equipment which shall ensure absolute reliability in hard service. These new Crossley engines represent the latest development in vertical compressorless Diesel engine design. Many installations with this type of engine are running in various parts of the country and of the world, and give the greatest satisfaction.

Personal.

Mr. E. B. Vignoles, who retired on March 31st from the post of managing director of Evershed and Vignoles, Ltd., held that position from the formation of the company thirty-five years ago. As he was also connected with the company's predecessors, W. T. Goolden and Co., and Easton, Anderson and Goolden, Ltd., his service in the business extended over no less than forty-three years. Mr. Vignoles intends shortly to start on a world tour, embracing Canada, the United States, New Zealand, Australia, the Federated Malay States and Ceylon, in the course of which he will visit the company's agents in the countries he touches. Mr. A. Vines and Colonel W. A. Vignoles continue as managing directors of the company.

NEW CATALOGUES.

ALLEN WEST & Co., Ltd., Brighton.—An illustrated folder, colour printed, gives full details of a range of control pillars for d.c. motors.

CROMPTON PARKINSON Ltd., Guiseley, Leeds.—A colour printed folder emphasises features of roller bearings as used for the Parkinson motors.

SIEMENS-SCHUCKERT (Gt. Britain) Ltd., 30-34 New Bridge Street, London, E.C. 4.—The catalogue No. 4773/1 describes a standard range of models for electric boilers for steam and hot water services.

A. REYROLLE & Co., Ltd., Hebburn-on-Tyne.—A leaflet gives illustrations shewing the numerous domestic and industrial services to which the Reyrolle "earthing" plug is applicable; a reduction in the price of these fittings is announced.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2—Leaflet No. X5622 gives illustrations and description of a contactor type direct-to-line starter suitable for squirrel cage motors up to 10 h.p.

J. H. HOLMES & Co., Ltd., Hebburn-on-Tyne.—Pamphlet No. 821 gives dimensions, weights, and leading characteristics of the "Castle" low-centre three-phase motors, the range covered being up to 150 h.p. 650 volts.

MIDLAND ELECTRIC MANUFACTURING Co., Ltd., Barford Street, Birmingham.—M.E.M. Kantark cut-outs, Memrex-senior Switches and other well-known specialities of this Company are described in a series of several new catalogues.

HEYES & Co., Ltd., Water-Heyes Electrical Works, Wigan.—The April issue of the "Wigan Review" devotes its technical side to interesting remarks concerning flame-proof equipment. Catalogue E.P. 1 is a price list covering the complete range of "Wigan" explosion-proof apparatus. Catalogue F 2 similarly deals with "Wigan" lighting fittings.

CABLE PRICES.—Several leading makers of cables have issued revised schedules of discounts: amongst those received are those of The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C. 2.; W. T. Henley's Telegraph Works Co., Ltd., Holborn Viaduct, London, E.C. 1.; W. T. Glover & Co., Ltd., Trafford Park, Manchester; British Insulated Cables Ltd., Prescot, Lancs.