The Mining Electrical Engineer.

OFFICIAL JOURNAL OF THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS.
EDITED BY E. DINSDALE PHILLIPS.

VOL. X. JANUARY, 1930. No. 112.

National Work of the A.M.E.E.

We commend to the close attention of readers the inaugural presidential address of Mr. H. J. Fisher to the North of England Branch of the Association of Mining Electrical Engineers (see page 267). After twenty years' connection with the Association, Mr. Fisher finds himself able to pay freely a generous tribute to the sustained effort by which the officials, individually and in committee have accomplished so very much for the good of men engaged in mining electrical work. Those who follow the record given by Mr. Fisher will perceive that certain important duties which the A.M.E.E. has voluntarily undertaken are essentially national service. The active co-operation of the Association in regard to Standardisation, Qualifications of Colliery Officials and National Education is inseparably a part of the great industrial reformation into which this country has entered and with which we are all to be increasingly engaged from now on.

The present need is for the far-seeing outlook and the ability to discern and discard soothing sentimental emotional doctrines in favour of tackling the hard facts of the rushing advance of a world of great industrial nations. Already it is plainly evident that our boys are not being trained for the contest. Many times and often of late has this complaint been written and said: all of which verbal seed is of no account until it germinates into movement. Mr. Fisher tells of the practical efforts of the A.M.E.E. towards giving this country an operative means of effectively training and making good men for mining electrical work. Realising that one of the greatest faults of our national educational code is that vocational or technical instruction is not available for the trades' apprentice on his leaving the elementary school to start work, Mr. Fisher suggests that colliery companies should devise an educational scheme of their own as a means of training electrical, mechanical and mining engineers. The smart and efficient youth would automatically come into evidence under this system of bringing the schoolroom and experimental theatre into immediate correlation with the work-a-day duties. To back up this suggestion to the farthest possible extent, the A.M.E.E. is prepared to modify and extend its examinations system and its grades of certificates to suit: moreover, Mr. Fisher believes that the thoroughly practical men with adequate technical knowledge who would be required to act as teachers would be available amongst members of the A.M.E.E.

One of the most difficult obstacles in the way of instituting a general public scheme of industrial education has always been local geography. Travelling facilities and density of population are factors which, in the past, have settled where and to what extent educational institutions shall be established. The principle of compressing the great and highest in learning and education into fountain heads of university centres is as right to-day as ever it was, but there is no reason why springs of industrial learning and instruction should not be as common and frequent as parish churches in this country of universal education. Times are changing rapidly and here is an insistent popular demand to be met. To be efficient and most thoroughly useful to himself and his fellows, every workman must be schooled in the theoretical and economic principles of his trade. Nor can the school teacher of academic training be expected to cope with the requirements of this post-elementary grade of education. The master craftsman used to instruct his apprentice by example, precept and painstaking practice. The deft hands of the skilful worker are still a great and useful asset to any man, but in this mechanical and lustily competitive age manipulative skill and physical attainments are always secondary to knowledge of plant and process and relative values.

Certainly, Mr. Fisher struck one of the right nails when he hinted at the difficulty there might be in finding the right teachers to put into effect the modern scheme of educating apprentices and he, doubtless, knew that his fellow members would respond to the call.

The A.M.E.E. is particularly favourably organised for bringing great assistance to mining educational affairs. There are no fewer than seventeen self-controlling independent centres, or branches, of the Association firmly established and actively and regularly at work in British mining districts. Doubtless every one of those Branches will tackle this educational question with increased vigour and enthusiasm. Aided by the goodwill and whole-hearted co-operation of the whole colliery industry and interests in their respective areas, these needed educational facilities will quickly come into being to the lasting and accumulative advantage of British Mining and National Industry.

British Industries Fair.

The section of the British Industries Fair staged in Birmingham will this year be greatly enlarged, and more representative than ever. The electrical and heavier engineering trades and the building trades seem to be responsible for the greater proportion of this highly satisfactory development. Official reports indicate that there will be an exceptional increase in the display of entirely new plants and products in engineering: metal-clad electrical switch-gear; improved machine windings; arc welding; electric furnaces; motor control and safety appliances; screening conveying and material handling, are some of the items lighted upon for particular mention. It would appear from the advance catalogue, issued thus early for the use of 10,000 overseas buyers, that there are some two hundred firms exhibiting products of electrical and power interest, of which firms nearly half are well known for their mining and industrial equipment.

The Fair is to continue from February 17th to 28th. So far as can be done in selecting for notice from the huge mass available that which will be of primary interest to our readers, we hope to publish a useful concentrate in our next issue. Will those firms, therefore, who are desirous of mention kindly send us their concise descriptive article and illustrations as quickly as possible.

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.—EXPLOSION AT MILFRAEN COLLIERY, Blaenavon, Monmouthshire. Report on the Causes of and Circumstances attending the Explosion which occurred on 10th July, 1929. J. MacLeod Carey, H.M. Divisional Inspector of Mines. Price 1s. nett.

MINES DEPARTMENT.—THE SAFETY LAMPS (Relighting) ORDER of 1929. Price 1d.

This order came into force on January 1st. It authorises and prescribes conditions for the use of flame safety lamps fitted with self-contained re-lighting devices: it extends the operation of the Safety Lamps (Relighting) Order of 1927 from 1st January, 1930, until further order of the Board of Trade, and is in the same terms as the existing Order, except that the opportunity has been taken to make clearer the intention of paragraph three in regard to the examination of the lamp to be made before relighting it underground.

The intention of this requirement is simply to prohibit the relighting, without previous examination by the light of an electric safety lamp of approved type, of a lamp which has been extinguished by a fall or blow, and may have suffered damage in this or some other way. A foot-note has been added explaining that "an electric safety lamp of approved type" for the purposes of paragraph three, includes electric torches approved for the use of officials or for special purposes.

BRITISH STANDARD SPECIFICATIONS FOR COLLIERY REQUISITES.

No. 116-1929.—Oil Immersed Switches and Circuit Breakers for A.C. Circuits.
No. 132-1930.—Steam Turbines for Electrical Plant.
No. 215-1930.—Aluminium and Steel-cored Aluminium Conductors for overhead lines.

British Engineering Standards Association, 28 Victoria Street, Westminster, London, S.W. 1. Price each 2s. 2d. post free.

Specification No. 116, deals with oil-immersed isolating switches, oil-immersed switches, and oil-immersed circuit breakers, the distinction between these classes of apparatus being defined by a statement to the effect that an isolating switch is intended only for interrupting circuit when there is no load-current, a switch being suitable for breaking a load-current, and a circuit breaker being suitable for interrupting abnormal conditions such as that of short circuit. In the preparation of this revision due regard has been given to similar work done in other countries, with a view to co-operation in international standardisation. The specification is intended to cover indoor circuit breakers up to 33,000 volts, and outdoor types up to 220,000 volts. Useful appendices are included, giving notes on the care and maintenance of circuit breakers, and also on the measurement of voltage and sphere-gaps.

The Specification No. 132 is a revision of the 1920 edition, which has been in preparation for several years, the work having been carried out in parallel with the International Specification for Steam Turbines by the International Electrotechnical Commission. It is interesting to note that so close has been the co-operation between the British and the International Committees that the new edition of B.S. Specification 132 is, to all intents and purposes, identical with the International Specification as tentatively agrees by the I.E.C. Advisory Committee at the meeting in London in July last. It is also of interest to note that, whereas the 1920 edition of the Specification was confined to steam turbines for electrical plant, the new Specification is not restricted to turbines for use in connection with electrical plant.

Considerable attention has been paid to the list of recommended standard ratings, an endeavour having been made to restrict the standard sizes to the fewest possible number. In this matter the Committee has had the advantage of the close co-operation of the Electricity Commissioners in so far as home requirements are concerned, the result being that the list of standard ratings, although given only as a reccommendation, represents a thoroughly practical series of sizes for home and export purposes.

The Specifications No. 215 is a revision of the 1925 edition and differs from its predecessor mainly in that the value of the resistivity has been slightly altered in order to conform to the value recently adopted by the International Electrotechnical Commission: the tables given in the Specification have been recalculated in accordance with the new value of the resistivity. Provision has also been made for certain of the mechanical tests to be carried out both before and after stranding. Slight modifications have also been made in the galvanising test.

Steam Joint Dangers.

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

THE making of a steam-tight joint as, for example, on a range of steam piping, or on a boiler, is one of those simple operations on which far more depends than is commonly realised. A badly made joint will not only give continual trouble by leakage, but it may be responsible for serious damage and personal injuries. As a matter of fact, a large number of accidents have occurred in the past through carelessness in the making of steam joints, and as such accidents continue to occur, the subject is one which is well worth a little consideration here.

The making of a joint usually implies the unmaking or breaking of the joint first, and much risk of damage or accident may be incurred in doing this unless reasonable care be exercised. Thus, in the breaking of steam pipe joints, accidents have happened through those concerned neglecting to support the pipes properly before commencing the work. It should be realised that a long run of piping may easily break under its own weight if it is not properly supported.

A danger which has to be carefully guarded against when a steam pipe joint is being broken is that of scalding. It is not sufficient merely to turn off the steam first; the strictest precaution should be taken to ensure that the steam will not be turned on again until the work is completed.

Numerous accidents have occurred in connection with the breaking of manhole and mudhole joints on steam boilers and other pressure vessels. These accidents have mostly resulted through the joints having been broken before all pressure has been allowed to die down. A very slight pressure acting on a large manhole cover is sufficient to blow off the cover with great violence, and it is therefore very important to make sure that there is no pressure whatever, before breaking a joint. The most reliable way of doing this is to lift the safety valve or open a gauge tap, when steam will issue if there is still any pressure. It is not advisable to rely solely on the pressure gauge, for these gauges are often slightly inaccurate, and record zero pressure when actually there is a pressure of one or two lbs. per sq. in.

In certain circumstances, it is possible for a slight vacuum to form inside a boiler, and should this happen, then any attempt to break the joint of an internal cover, i.e., one which is fitted inside the boiler, and secured by bolts and cross bars, would be attended with the risk of the door being blown violently inwards and the person breaking the joint being forcibly drawn towards the opening. The precaution of first opening the safety valve or a gauge tap would obviate this risk.

As regards the actual making of a steam joint, this is too often looked upon as a simple job which any Tom, Dick, or Harry may perform, but the fact that joints so often prove troublesome and even dangerous, shows that the operation requires care and a certain amount of skill.

One of the simplest and commonest forms of joint is the ordinary flanged steam pipe joint. Such joints are made in various ways, as for example by the aid of paint or some special jointing material, and by means of asbestos or metal rings.

Whatever jointing material is used, it should be one which can be depended upon to resist the heat without cracking or deteriorating.

A common fault in using jointing material is to apply too much of the material; provided the metal faces are thoroughly true and clean, only a very small amount is required to make a good joint. When too much material is used, a considerable quantity is squeezed into the bore of the pipes when the flange bolts are screwed up, so that it is likely to be carried along with the steam to the engine cylinders or turbines, where it may do considerable damage if it is not arrested.

When asbestos rings are employed, it is important that the width should be equal to the full width of the metal face (See Fig. 1).

Not infrequently they are made narrower, as indicated in Fig. 2, the ring lying wholly within the flange bolts. The objection to this arrangement is that when the nuts are screwed up, a severe bending stress is imposed upon the flanges, which are in consequence liable to be broken, and this is especially the case when

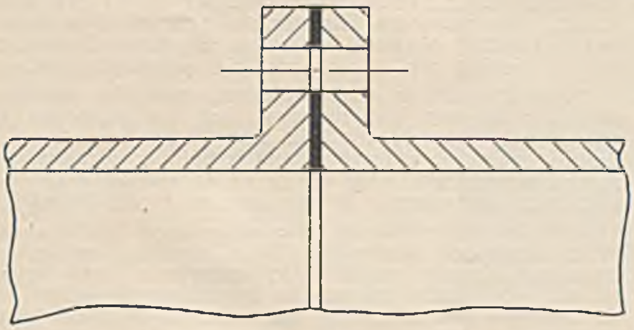


Fig. 1.

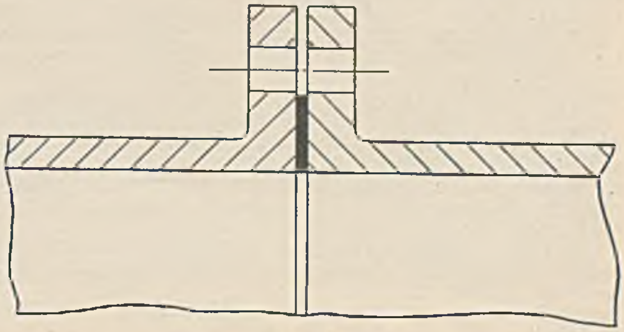


Fig. 2.

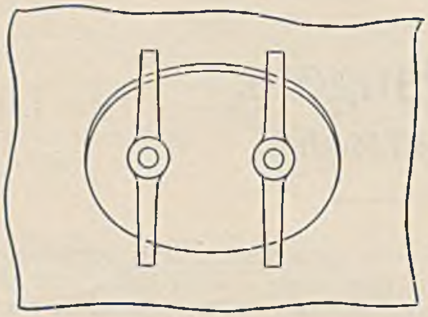


Fig. 3.

the work is carried out by men who tighten up the nuts injudiciously.

Lead and copper rings of narrow width, arranged to be wholly within the flange bolts, are of course open to the same objection.

Thick packing rings naturally present a greater area to the steam pressure than do thin ones, and are hence more liable to be blown out of position; for this reason thick rings should generally be avoided.

External cover joints, such as those of the manhole covers on Lancashire boilers, are very similar to flanged steam pipe joints, and call for no special remarks.

Internal covers require particular attention, since the design is such that unless care is taken, there is considerable risk of the packing being blown out. Should this happen with the mudhole cover of a boiler, not only is there considerable risk of the fireman being badly scalded, but there is the additional risk that the furnace crowns may become bared of water and consequently overheated, when collapse and possibly rupture may occur.

These covers, which are usually of elliptical form, are provided with a lip which bears against the boiler plate all round the opening. The cover projects a little into the opening, and it is necessary to leave a little clearance, termed " spigot clearance," between the projecting part and the opening.

It is most important that the clearance should be only very small, because the danger of the packing being blown out becomes greater as the clearance increases. When the cover fits into a vertical plate, and when it is of great weight, as in the case of the mudhole cover in the front endplate of a Lancashire boiler, the fitting of the cover evenly, so that the clearance is the same all round, is no easy matter. Thus there is a strong tendency for the cover to drop until the lower part of the spigot rests on the lower part of the end plate opening (See Fig. 3). This not only means that the packing is liable to be distorted, but the clearance at the top will be double the normal clearance. If, then, the normal clearance is large, the risk of the packing being blown out at the top is considerable, and this is especially the case if round packing is used. Obviously, after the cover has been fitted, the clearance should be tested all round, and if found uneven, the cover should be refitted. One can readily understand that some of the men who fit these covers are not fully alive to the dangerous possibilities of an improperly made joint, and they are unlikely to test the clearance, and still more unlikely to remake the joint once the work is completed. Hence it is of fundamental importance that the covers should have the least practicable amount of spigot clearance. When the clearance is large the safest plan is to replace the cover by a new one.

Training for Management.

An authoritative series of articles has recently been running in the pages of *World Power*, in which a closely analytical comparison has been drawn between the administrative business methods of this country and others. Pointed paragraphs in the concluding article are: " It appears to be more correct to say that America is the better organized for organizing industry. At the present time we may regard her as a kind of experimental laboratory where new ideas and schemes in administration and business method are being tried out. Economic research represents a product of this laboratory which has been tested and found valuable."

" Looking ahead at the increasing complexity of business operations and groupings, it is apparent that the demands on executive ability are becoming more exacting. A degree of specialized training is required."

" Considering the resources of Great Britain for training in administration and management, there are no colleges such as the Colleges of Business Administration of the Universities of Harvard, Boston and Illinois, to cite a few of the many universities with Faculties of Business Administration in the U.S.A. America has realized that business as a profession, and no small proportion of her prosperity is derived from the nation's practical interpretation of this fact," and as a firm recommendation:

" The leading universities in Great Britain should take steps to establish Faculties of Business Administration on similar lines to Harvard. The dearth of this type of training college means a big handicap to Great Britain."

In view of these opinions it is interesting to direct attention to the prospectus issued a few days ago by the Institute of Industrial Administration, in which was published the Syllabus for an Examination Scheme for the Diploma of Industrial Administration. The President of the Institute is Mr. A. S. Comyns Carr, K.C., whose legal experience has brought him into close touch with the need for such a movement, without attaching him to any particular section or theory. He is supported by a strong body of Vice-Presidents, which includes, Sir John E. Thornycroft, K.B.E., of engineering and shipbuilding fame; Sir Kynatson Studd, Bart., late Lord Mayor of London; Mr. J. Maughfling, President of the Society of Motor Manufacturers and Traders; Mr. Sam Mavor, and many other leading engineers and public men.

The Board of Examiners is headed by Principal H. Schofield, M.B.E., Ph.D., B.Sc., and Mr. E. T. Elbourne. M.B.E., the Honorary Director, is a practical manager and consultant of long experience in many industries, and a leading writer on industrial administration.

The Institute is concerned, not with the technical problems of any one industry, but the problems of management common to them all. It has laid down a definite course of instruction, and is holding examinations in the surprisingly wide range of knowledge which is, or should be, common to management in all industries.

The Institute seeks to raise management to the status of an organised profession. It is enrolling employers, managers already qualified by experience, and young people who desire to qualify themselves by study, in the common aim of raising the standard of management of British industry.

Chromium Plating and an Electro-Thermal Storage System.

THE particular advantages of using the metal Chromium as an external coating for other metals or materials are:—it will polish to a very high brilliancy; it will not tarnish; it is very hard (much harder than nickel) and, therefore, does not wear off; it will withstand great heat; and it is economical. Naturally, therefore, chromium plate has become extremely popular.

Though chromium was discovered about the year 1879, it has, as a metal only been commercially used for about five years: yet in that short period it has come to be well known to the general public. It is seen on motor car radiators, and on lamps, on household fittings such as taps, fire irons, electric fittings, and on any metal outside as well as inside, where a bright untarnishable, enduring surface is required.

In England, chromium plating is done under a large number of processes, but nearly all of them under a nickel-chrome procedure, in which the article to be chromium plated is first nickel plated. The latest of all methods, however, has just been brought to this country by a well-known European scientist, Dr. Nast, and under it, chrome is thrown direct on to the surface of the base metal.

The advantages which Dr. Nast claims are:

(a) That where chrome is thrown direct on to the base metal, it amalgamates with it and will neither peel nor chip; whereas chrome on the top of nickel is liable to both the latter defects, not because the chrome itself will chip or peel, but because the nickel underneath it is liable to do so.

(b) That the direct method is cheaper, because it saves the lengthy process of nickel plating first. An article needs a forty minutes' immersion to nickel plate as against about ten minutes in a chrome bath, meaning that apart from the cost of the extra process itself, about four nickel baths are required to every chromium bath, if the work is not going to be held up through congestion in the nickelling department.

The Northern Chromium Plating Company are exploiting the new proprocess at their Skinnerburn works in Newcastle-onTyne, where an extensive plant is operating at full pressure and with complete success.

While trade and public alike have welcomed the advent of Chromium Plating with open arms, it is not generally known that the process presents certain technical difficulties which do not occur with other types of commercial plating, but which are peculiar to chromium plating alone. Chromium is found in a crystalised ore, of which about 75% comes from Rhodesia. From the ore crystals is made the Chromic Acid from which the plating is effected. Unfortunately science has not yet found a method of producing an actual chrome metal which could be used as the anode in an electric plating bath. This is the greatest disadvantage to the plater because chromium thrown from acid will not penetrate into recesses without special apparatus and great care, whereas no such difficulty exists in the case of nickel plating. That is why the nickel-chrome process has hitherto been adopted so universally—those inaccessible places into which the chromium does not penetrate being already nickel plated do not reveal themselves as being merely coated with nickel and having no chromium deposit.

Briefly the chromium process is as follows:—

(1) An article—say a used motor lamp—is dismantled and de-nickelled.

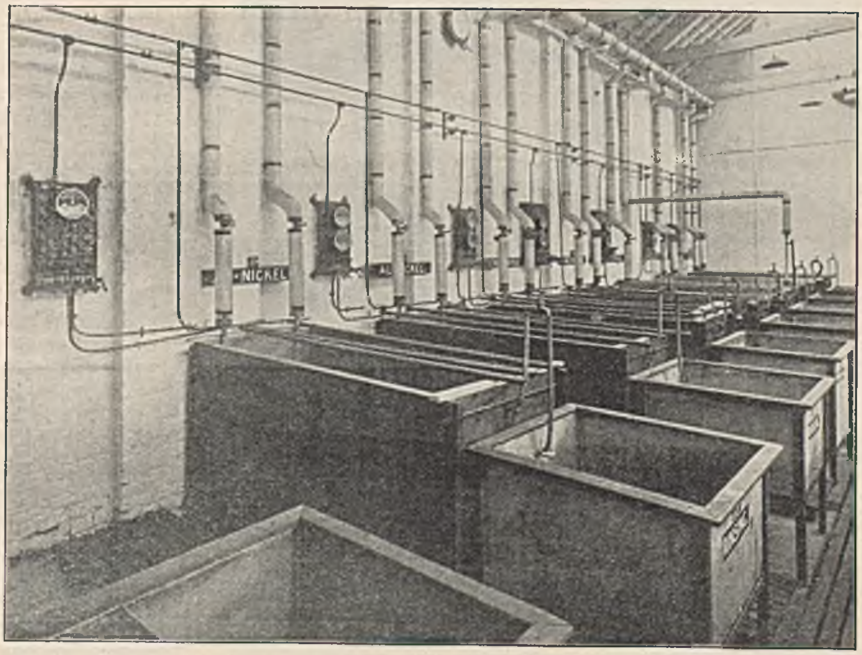


Fig. 1.—View of the Plating Room, shewing the Hot Water Circulating Pipes.

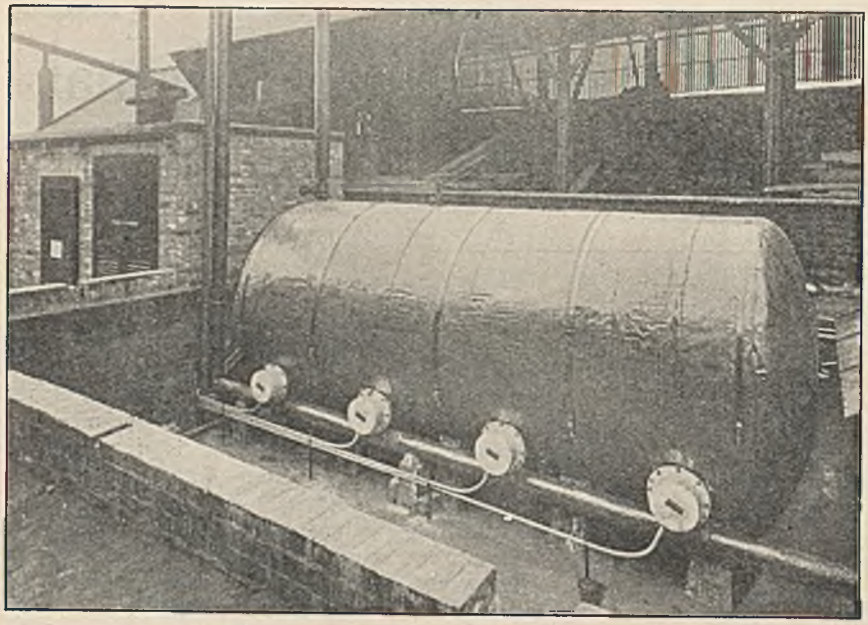


Fig. 2.—The 5,650 gallon Storage Tank shewing the Four Immersion Heaters.

(2) It is ground and buffed, until the base metal has a perfect polish.

(3) It is wired by experts for hanging into the chromium bath in such a way that all parts of the surface will get a fair share of the deposit; in other words, so that the current shall be evenly distributed over the whole surface to be plated.

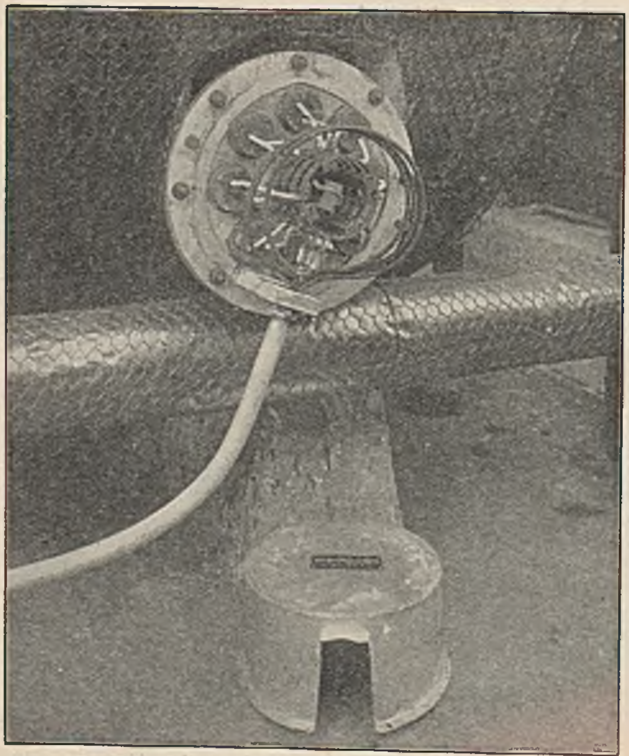


Fig. 3.—One of the 30 k.w. Immersion Heaters, with cover removed.

(4) It is de-greased in a special bath. This special bath is necessary; it is made up in accordance with a valuable invention of Dr. Nast, and it has a direct bearing on this method of plating, particularly in connection with the low cost. When chrome is being released from the acid in the chrome baths, hydrogen bubbles, thinly coated with minute quantities of chromium, rise to the surface. These bubbles are lifted into the air by the hydrogen and the chromium would form a serious menace to the health of the workers unless drawn away. An elaborate and very costly system of exhaust and filterage was the usual safeguard, but Dr. Nast has prepared an oil to float on the surface of the acid; this oil de-coats or strips the hydrogen bubbles of chromium as they ascend through to the surface to be liberated as harmless hydrogen.

The article to be plated has to pass through this layer of oil on its way to the acid. Hence the necessity for it to be thoroughly de-greased so that when it is passed through the oil, after it has been wetted, no oil adheres to the surface. The principle is the same as water flowing off a duck's back, save that it is immersed.

(5) The article comes out of the chromium bath with a beautiful surface which requires very little polishing.

Steel and Aluminium.

The new direct process throws chromium direct on to steel as well as on to brass, copper, and the many other popular alloys used for radiators, etc. But, as is well known, all chromium plating is porous, and if the article plated is left for long periods in damp places, rust is liable to form in the base metal with the result that the chromium above may crack. This difficulty is got over by treating the steel with a between-coating giving it rustless properties.

The aluminium process is a very elaborate one. The intractability of aluminium and its refusal to amalgamate with other metals has been long a gallstone to science in all branches of engineering. The Northern Chromium Company, however, claim a perfectly satisfactory method of plating this metal and are prepared to undertake to give full satisfaction with work of this description.

It is, in some cases and for certain purposes, desirable to "burn" the plating so that it becomes extremely hard and consequently gains additional heat-resisting properties. Such articles are domestic fire-irons, fire-bars, saucepans, etc. The maximum degree of hardness obtainable is actually 95% of the hardness of a diamond. The final hardness depends upon the amperage per square foot used in the chrome bath. Normally, one does not always desire the extreme hardness; for one reason, the finished article is much more difficult to polish satisfactorily, and consequently the expense is proportionately greater.

Chromium plating presents important special advantages in regard to cutting down expenses in colliery working. Some of the most likely future applications of chromium plating in this connection are the plating of haulage ropes to overcome corrosion, engine-room gear, instruments, miner's lamps, pit head bath fittings, and all metal parts on which, at the moment, time and money is wasted in cleaning, and deterioration by corrosion is serious and expensive. These are merely examples which occur immediately to mind. As this process is quite new, its possibilities cannot yet be fully realised, but there can be no doubt that its applications will be legion.

THE WORKS' EQUIPMENT.

The many advantages both to consumer and to supply authority of utilising electrical energy during off-peak-load periods are gradually being recognised throughout the country, and the demand for the cheap power obtainable during these periods is happily increasing. At the present time the field of application is somewhat restricted, and probably the largest demand is made by thermal storage systems. One of the first of these to be applied in Great Britain to industrial heating, if not actually the very first, was that used in connection with the extensive plant which was installed at these works of the Northern Chromium Co., Ltd. In all there are 24 large tanks, which have to be maintained at temperatures varying between 70 degs. F. and 140 degs. F. These tanks include chromium-plating tanks, hot-sawdust tanks, hot-water tanks, de-greasing tanks, and various acid baths used for copper, nickel, and aluminium plating. Each tank is fitted with a heating coil made of steel or lead, depending on the nature of the electrolyte, and this coil is connected through valves on the inlet and outlet side to hot water mains run round the building. One of these valves is a check valve, and is usually fully open, regulation being carried out on the other valve.

The whole system is efficiently lagged, and the supply of hot water is taken from the large thermal storage cylinder installed in a pit outside the main building.

This thermal storage cylinder, which is 18 ft. long by 8 ft. in diameter, holds 5,650 gallons of water, and is heated by immersion heaters of a total capacity of 120 k.w. supplied by Messrs. A. Reyrolle & Co. Ltd.

The heaters are arranged in four 30 k.w. banks; each bank consists of nine 3.3 k.w. heating units mounted on a common flange-plate with the connections brought out to terminals on a set of four circular bus-bars. The supply is three-phase at 440 volts, 40 cycles, and three of the bus-bars are connected to the outers while the fourth forms a star point. The heating units are so arranged that the load is equally divided between the three phases.

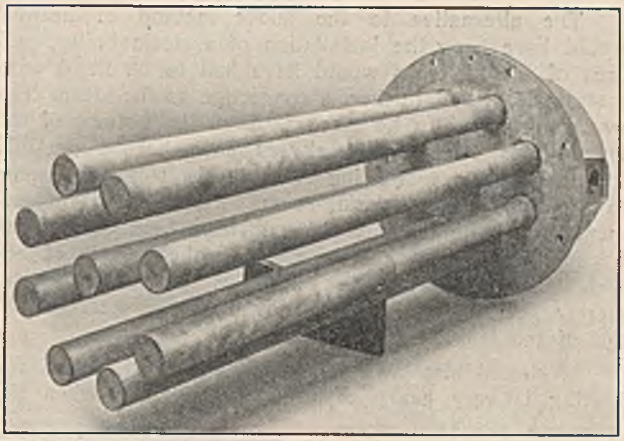


Fig. 4.—Shewing the nine units of a 30 k.w. Immersion Heater.

Energy for heating the cylinder is supplied at special rates, during the night hours only, from the mains of the Newcastle-upon-Tyne Electric Supply Co., Ltd. Current is automatically switched on by a time-switch at 7-30 p.m. and continues to flow until the water in the main cylinder reaches a temperature of 220 degs. F., when it is switched off by a thermostat.

In the morning the main stop-valve is opened and a small circulating pump is started up to pump hot hot water at a temperature of 220 degs. F., round the heating system, thus making heat energy immediately available for heating up the various tanks required for the day's work. At the end of the day the water is at a temperature of 140 degs. F., which implies a total heat storage equivalent to 1320 k.w. hours. It has been found that the majority of the tanks can be brought up to the required temperature within three-quarters of an hour after starting up the circulating pump.

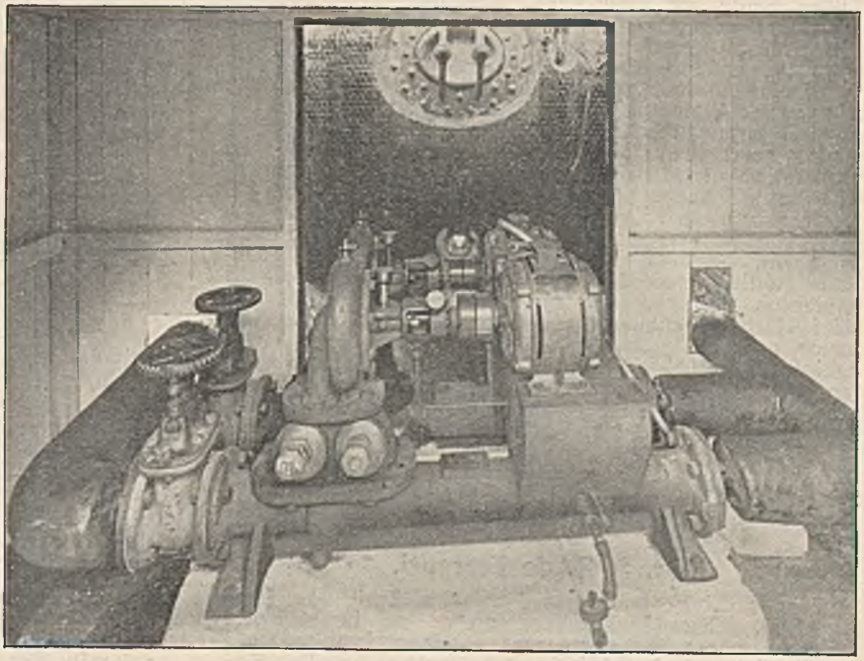


Fig. 5.—*The Centrifugal Circulating Pumps.*

The alternative to the above method of heating would have been the installation of a steam boiler, and each of the 24 tanks would have had to be fitted with a steam trap, and further, a connection to the steam trap would have had to be taken through the bottom of the tank. This joint would always have been a possible source of leakage, allowing valuable electrolyte to escape to the floor of the plating-room. Further, the replacement of a heating coil could only have been carried out by emptying the tank, whereas with the scheme of hot water heating actually in use this can be done by merely breaking the joints, and lifting the heating coil out of the tank.

It should also be remembered that the demand for heating is very heavy early in the morning when the tanks are being brought up to temperature. It would therefore have been necessary to start firing the boiler a few hours before the beginning of the day's work, so as to reduce the danger of boiler-priming, and for the remainder of the day the boiler would have been working inefficiently on a very light load to maintain the vats at their appropriate temperatures.

It will thus be seen that Thermal Storage Heating has simplified the installation of the heating coils in the tanks, and has also made the system much cleaner and easier to maintain. Labour has been reduced, because the operation of the thermal storage cylinder is entirely automatic, and the only labour involved is that of opening and closing the stop-valve, and starting up or shutting down the circulating pump.

Personal.

Mr. G. G. L. Preece, A.M.I.E.E., until recently Manager in the Manchester District for Bruce Peebles & Co. Ltd., of Edinburgh, has now been appointed to the position of Sales' Manager for England and Wales.

Mr. W. S. Naylor has been appointed Chairman of the Board of Directors of the Chloride Electrical Storage Co. Ltd. Mr. Naylor has been connected with the Company for over 27 years: his name is almost as well known as "Exide" itself. Under his management the works have grown from quite small beginnings to being the largest accumulator factory in the Kingdom. The appointment will be popular in and outside the great "Exide" organisation.

Mr. A. M. Manighetti, A.M.I.E.E., has been appointed Continental Technical Representative for the Sterling Varnish Company of Trafford Park, Manchester. He will leave England for the Continent on the 20th January.

Mr. S. Hare, formerly general manager for Messrs. Bolckow, Vaughan and Co., Ltd., Durham, has been appointed managing director of Tilmanstone (Kent) Collieries, Ltd. He was associated with the late Mr. R. Tilden Smith for some years, and had been consulted by him from time to time on matters connected with the colliery, and especially with the aerial ropeway from the mine to Dover Harbour.

Owing to the increased complexity of modern coal mining, the Ashington Colliery Co. have divided the work of their group of collieries into two sections—one purely mining, and the other general engineering work and preparation of coal for the market. Mr. F. L. Booth will be in charge of the mining section and Mr. W. J. Drummond in charge of the engineering section. Mr. J. J. Hall will retain control of the group of collieries as agent. Mr. D. Hindson, the manager of Woodhorn Colliery suceeds Mr. Booth as manager of the Ashington Colliery. Mr. McKie retains his position as chief electrical engineer and becomes Mr. Drummond's senior assistant. Mr. Paxton, the resident engineer at Ashington, will become chief underground engineer responsible for all underground machinery for the whole group, and Mr. Leithead, the resident engineer at Ellington, will succeed Mr. Paxton at Ashington.

Obituary.

Dr. S. Z. de Ferranti.

The great Ferranti passed away in Zurich on January 13th. Those who have grown up in electrical work to whom the name was so long familiar as a household word, found it hard to realise that Dr. Ferranti was but sixty-five years old. So early did his genius as an electrical power engineer manifest itself that he built his first dynamo when a school boy of fourteen: from which time he never ceased experiment and research. He was an engineer of supreme courage, always seemingly impossibly so very far ahead of the times in his notions and imaginings of what electrical engineering could and should do, he was never daunted by the task of putting his schemes to the practical test. Dynamos, alternators, switchgear, cables; steam engines, valves; rectifiers, furnaces—almost every item of plant sprang from his original and fertile range of successful inventions. Yet with all this solid record of practical work done, Ferranti continued always modest: his retiring personality was all against his being accorded due national recognition and public honours. His name and his fame will however, be prized by succeeding generations.

Lieutenant-Colonel Montagu Cradock, C.B., C.M.G.

We regret to announce the recent death at the age of 70 of Lieutenant-Colonel Montagu Cradock, associated as a Director of the Metropolitan-Vickers Electrical Company Ltd. since its early days in 1902.

Popularly known as "The Colonel" he endeared himself to everybody connected with the Company, staff and workpeople, by the unfailing interest he always showed in their welfare.

Beginning his military career in the Durham Fusilier Militia in 1877, he served through the Afghan campaign, commanded the 2nd New Zealand Contingent, and later the 3rd Mounted Infantry Corps, and the Bushmen's Brigade in the South African War, and in August, 1914, raised the 2nd King Edward's Horse, and commanded that unit until he retired in August, 1918.

Trolley Wires Underground.

In the course of the discussion of the Paper on "Modern Lead Batteries and their Application in Mining Work," read by Mr. C. P. Lockton, before the Yorkshire Branch of the A.M.E.E., Mr. Mann said that the use of the trolley system of electric haulage underground is prohibited by the Coal Mines Act and is therefore only applicable to the surface (see page 211, December, 1929). A Correspondent points out that the Regulations are frequently misread in this respect and draws attention to the fact that Regulation 137 permits of the varying of Regulation 136. He further points out that the Reports of H.M. Inspectors of Mines shew that such a system was actually installed at an English Colliery in 1928; and, as one who takes an interest in the further application of electricity belowground, he naturally does not care to see anything published which might tend to retard progress unnecessarily.

Proceedings of the Association of Mining Electrical Engineers.

NORTH WESTERN BRANCH.

The first meeting of the Session was held in Wigan on the 4th of October. Captain I. Mackintosh presided.

The following, having been approved by the Committee, were duly elected members of the Branch (Associate Member) Mr. E. H. Hancock; (Member) Mr. G. W. Thomson.

In presenting the Statement of Accounts for the last 12 months, Mr. Bolton Shaw, Hon. Treasurer of the Branch, remarked that the result of the year's working had been very satisfortory.

The President having congratulated the Branch on the success of the year's working, the Statement of Accounts was adopted on the motion of Mr. Roseblade, seconded by Mr. Spray.

Capt. I. Mackintosh delivered his Presidential Address as follows.

Presidential Address.

The Duties of the Colliery Electrician.

Captain I. MACKINTOSH.

The subject matter of this address is "The Duties of the Colliery Electrician as described by Regulation 131 of The General Regulation as to the Installation of Electricity in Mines."

The official definition of "Electrician" reads as follows :—"Electrician means a person appointed in writing by the manager of the mine to supervise the apparatus in the mine and the working thereof, such person being a person who is over 21 years of age, and is competent for the purposes of the rule in which the term is used."

Thus we are considering the duties of the man who signs the Log Book, and it is well that we should, in the beginning, be quite sure on that point.

Regulation 131 (b) reads as follows:—"An Electrician shall be appointed in writing by the Manager to supervise the apparatus. If necessary for the proper fulfilment of the duties detailed in the succeeding paragraphs of this rule, the manager shall also appoint in writing an assistant or assistants to the Electrician."

The first thing the Colliery Electrician should make sure of, is that he is actually appointed in writing by the Manager. It seems clear that until he receives this Authorisation, he has no legal right to touch any electrical apparatus. This also applies to the Assistant or Assistants.

In the memorandum on this paragraph is a rather important sentence, which states "one or more competent Assistants". This, together with the Memorandum attached to Regulation 131 (a), seems clearly to forbid an apprentice being appointed as an Assistant.

Regulation 131 defines pretty clearly the duties of the Electrician, but before going on to the duties, it would be as well to study Regulation 121, paragraph (1), which is closely allied to, and even governs the Regulation which we are considering.

Regulation 121 controls the notices which are to be exhibited, and paragraph (1) states "That a notice prohibiting any person other than an Authorised Person from handling or interfering with apparatus."

Perhaps we had better consider the legal definition of an Authorised Person, which is :—"Authorised Person means a person appointed in writing by the manager of the mine to carry out certain duties incidental to the generation, transformation, distribution, or use of electrical energy in the mine, such person being a person who is competent for the purposes of the rule in which the term is used."

The last portion of that paragraph is most important, because someone has to take the onus of being sure, or reasonably sure, that the person is competent. One at once assumes that no matter to what post a man may be appointed, the person who makes the appointment takes steps to ensure that the appointed man is competent, but in this particular case, the law in effect, says, he must be sure; which might involve serious complications should something dreadful happen which was ultimately proved to be due to the incompetency of the person appointed.

Reverting to the actual Regulation, I think it will now be quite clear why the Electrician should make sure that he has his Authorisation; because unless he has, he is actually breaking the law if he handles or interferes with electrical apparatus. Ordinarily one might assume there is no fear of anything like this happening, but after all, it is not the ordinary routine that matters, it is those sudden and unforeseen happenings which one has to guard against, and it is usually when the seemingly simple thing has been neglected, that the unforeseen does happen.

Regulation 131 (a), which for convenience sake may here be split up, states—"Every person appointed to work, supervise, examine, or adjust any apparatus, shall be competent for the work that he is set to do."

The Memorandum states :—"An assertion of competency by the person appointed does not absolve his superior of responsibility." In some cases this might not concern the electrician very much, but there are some collieries where pumpmen, haulage drivers, etc., come directly under the supervision of the electrician. In which case a certain amount of responsibility does rest on the electrician.

The second part of the Regulation closely concerns the electrician; it reads, "No person except an Electrician or a competent person acting under his supervision, shall undertake any work, where technical knowledge or experience is required, in order adequately to avoid danger." The previous remarks on making sure of the competency of the person concerned also applies in this case. If the electrician deputes one of his assistants to do a job, the electrician must make sure that the person concerned knows exactly what he has to do and, what is of more importance, is capable of doing it. The Memorandum states :—"Apprentices and other persons possessing small technical knowledge or experience, should not be permitted to do any work upon, or close to, exposed live conductors." One would at once say this is a very sound ruling, and possibly, on the face of it, there should be no need for this statement; but I venture to say that this particular ruling is more honoured in the breach than in the keeping. One has just to consider for one moment that lighting circuits are composed of live conductors, a lighting switch cover removed, or a lamp holder be without a lamp; there are exposed live conductors, and I would further venture to state that if an apprentice is put to work on anything at all, it is on a lighting circuit. This of course must be read in conjunction with the foregoing paragraph regarding the electrician making sure that his deputy knows exactly what he has to do.

There is a great difficulty when one considers apprentices. I presume the apprentice of to-day is no better, and I hope no worse than the apprentice of our time, and if I remember rightly, the apprentice often took on jobs of work, about which the man in charge knew nothing, and perhaps for the peace of mind of the man in charge it was just as well that he did not know, but it does seem to me that the electrician has a very grave responsibility in this direction.

Supervision by the Electrician is also called for and I think one might reasonably consider this to mean something more than just giving instructions and seeing that the person concerned understands his instructions. The Memorandum states:—"It will generally be necessary for the electrician to inspect during progress of the work and also when it is completed." Personally I think we would all agree that the amount of supervision required would naturally depend on the nature of the work. For instance, in a small job, and bearing in mind that the person concerned has to be competent, the amount of supervision required or expected would be small, but even so, as soon as possible after any job has been completed the electrician should have a look at the work done. It is only in this way that he can be sure all is well, and that the person concerned is competent. With a big job, supervision should be very close. There are many jobs which it is imperative that the electrician should see through to completion. This might appear rather drastic, but one must always bear in mind that very elusive component—the human element—has to be contended with, and on a vital job every precaution should be taken. Everyone will agree that a person holding such a responsible position, as the electrician holds in a modern mine, must and will do all in his power to avoid danger as called for in the Regulations.

The next regulation can also be divided conveniently. Regulation 131 (c) states "The Electrician shall be in daily attendance at the Mine." On the face of it, this might appear rather a hardship, when one considers that daily attendance includes Sundays and Bank Holidays; but when we delve further into the matter, we begin to realise that it is on Sundays and Holidays that the electrical staff usually get really busy. It is on such days, when the pit is not working, that big alterations or additions are made.

The Regulation goes on to state "He shall be responsible for the fulfilment of the following duties, which shall be carried out by him, or by an Assistant or Assistants duly appointed under paragraph (b)" There is one point in that paragraph which I think wants bringing out, and which is likely to be lost sight of, unless emphasised, and that is "The Electrician shall be responsible" which I think makes it quite clear that no matter who carries out the work, the responsibility still lies on the Electrician and I would ask all Colliery Electricians to bear that in mind.

We now come to something very definite, the duties the Law requires the Electrician to perform. (i.) "The thorough examination of all apparatus (including the testing of earth conductors and metallic coverings for continuity) as often as may be necessary to prevent danger." That is a pretty good beginning. First of all, the examination of *all* apparatus, and I want you to remember that apparatus "means electrical apparatus, and includes all apparatus, machines and fittings in which conductors are used, or of which they form part". Therefore, lampholders, lighting switches, and such like definitely come under the heading of things to be examined. We then come to rather an ambiguous statement, which gives a loophole for driving through with the proverbial Coach and Four—"As often as may be necessary to prevent danger."

When one considers the severe duties under which colliery plant often operates, there is no doubt that thorough examination is required. After all the Electrician's job is to prevent breakdowns; in this connection it may truly be said that prevention is better than cure.

As to what constitutes a thorough examination, must largely depend upon the person carrying out the examination. To carry out the daily examination successfully, a wide general knowledge of electrical plant is essential because the Electrician carrying out the examinations must be well versed in all sections of an installation, possibly from generating plant to motors and lighting. This allows plenty of scope for ability and resourcefulness. Without attempting to go into details it might not be amiss to give one or two examples of what might constitute part of the daily examination.

Generators.

Assume the plant to be modern three-phase turbo driven. In such cases there is not much scope for making a detailed examination: everything is more or less enclosed, but each and every machine appears to have a hum or tone peculiar to itself when running, and any alteration in tone, or general behaviour of the machine should receive immediate attention. With high speed machines like turbo alternators, it does not take long for a serious breakdown to develop, and apart from the costly nature of a big repair, there is the possibility of affecting the colliery output, which is probably more costly. So far as the generator is concerned, if there is excessive vibration, it usually indicates one of two things, either a derangement of some part of the Rotor, or a defective field.

Rotor slip rings should receive attention. Brushes should be tried for tension, and also to see that they are free to move in the holders. It must not be forgotten that a rotor is highly inductive, and much sparking of the brushes will cause a slip ring to be so badly burnt as to cause the shut down of the generator.

The only parts of the exciter which are likely to cause trouble are the commutator and brush gear. Sparking should be immediately stopped and field coils felt for overheating.

Switchboards.

The modern power house switchboard is usually so enclosed that it is impossible to make a thorough examination except at such times as when the plant is shut down. I always think that a man blessed ith a high sense of smell has a great advantage. However, if there is exceptional overheating, the metal doors will get hot enough to enable a cubicle containing a hot switch to be located. Hot switches are always dangerous; particularly does this apply to a main switchboard owing to the heavy currents passing.

Cables.

Nowadays the electrical plant in a modern colliery goes literally far afield, especially where electric coal cutters are employed. Therefore the inspection of cables is a real necessity, owing to their exposure to damage from falling roof, derailed trams, etc. Where cables are joined to portable apparatus, fed from gate end switches, the earthing connections should receive special attention. All armour glands should be inspected when attached to apparatus which depends on the armouring for efficient earthing. Armour glands should not be allowed to become dirty.

Transformers.

The overheating of transformers may easily be detected by feeling the outside of the tanks. There is a distinct danger in allowing a transformer to attain an abnormal temperature owing to the large body of oil used.

A humming noise is associated with most transformers, and this is usually a good guide as to their state of health. Undue noise should be noted, and traced to its origin. Loose core plates often cause undue noise, and although the temperature remains normal, it should not be taken for granted that everything is O.K. Loose plates set up vibration and, if occurring near insulation, there is a possibility of the result being a breakdown. It is not really a difficult matter to tighten a core, after removing a transformer from its tank; so that a noisy transformer is not suffering from an incurable disease. Most transformers are fitted with an oil gauge, in such cases it is an easy matter to check oil levels.

Motors.

There is usually a little difficulty in making a thorough examination of certain types of motors, such as totally enclosed or pipe ventilated. An induction motor driving a reversing haulage which is continually starting, stopping, and reversing, gives a very clear indication as its general condition. If the bearings are in good order and the rotor is central with the stator, there is a pleasing hum without jar, when the reversing switch is closed; but should the rotor be out if centre, due to worn bearings, there is a most unpleasant jar every time the motor is started, owing to the rotor pulling over to the stator at that point of minimum distance between rotor and stator.

You will note that nothing has been said about the taking of air gaps or tests. That important detail has not been overlooked, but I do not consider that such detailed work comes under the heading of daily inspection.

It is not the intention to advise that tests of motor and for continuity should be made daily so as to comply with the law; to attempt to do this daily would need a very unwieldy, and totally uneconomical staff. Many collieries take these tests monthly; obviously this is certainly going to be nearer the high-water mark of danger prevention than tests taken bi-monthly, and not as near as tests taken fortnightly. Beyond this comparative statement I am not prepared to go.

Regulation 131 (c) ii. states, "The examination and testing of all new apparatus, and of all apparatus re-erected in a new position in the mine, before it is put into service in the new position."

This Regulation is very concise and clear. It surely means that before any apparatus is put into commission it must be examined and tested by an authorised person. On power jobs we can take it that this is carried out as a matter of course; but even a new lighting circuit comes under this regulation, and it is well within the bounds of possibility for a lighting circuit to cause a dangerous occurrence.

Regarding electrical apparatus re-erected in a new position. It is quite clear that the same precautions must be taken, and quite frankly, of the two, I think the latter the more important. Usually new plant bought from a reputable manufacturer would be complete in all details; but can the same be said of apparatus which has been working for some time, is then moved, often hurriedly, for most re-erection jobs are rush jobs? It is possible that an odd bolt or two may be lost, or, if you prefer it, mislaid, an odd connection work loose, and a hundred and one little things, which we all know of, might go wrong. It is, therefore, I think most essential that the test and examination of re-erected apparatus should be carried out thoroughly by a competent person. We all know that tragic results have happened through apparently such a seemingly small detail as a missing bolt in a coal cutter.

The Memorandum to this Regulation hints at some of the points which should receive attention in the systematic examination, such as:—

Fuses—to ensure correct size and type of wire. We are all aware that there is a possibility of even an authorised person installing an incorrect fuse wire. Therefore it would appear to be a good scheme for the electrician to have a look at the fuses, otherwise he might find that instead of a 22s lead wire, there is a 22s copper; which is rather different.

Switch contacts should be examined for signs of undue wear. Oil-immersed apparatus should have a periodical and critical examination, giving attention to the correct oil level and state of the oil. Earthing contacts, interlocks, and tripping devices, should also receive attention. It is quite a good scheme to operate tripping devices to make sure they are in operating order. It is surely not much use spending money on these safety devices, if they will not operate at the critical moment.

Tests should always be recorded and most collieries now keep special record books, thus making it easy for the persons concerned to make progressive comparisons as to the state of the plant. The results more than justify the trouble taken.

We have not quite finished with Regulation 131 (c). The last paragraph reads—"Provided that in the absence of the Electrician for more than one day, the manager shall appoint, in writing, an efficient substitute."

From this it appears that even the cold calculating law of England admits that the Colliery Electrician wants a few days off occasionally, also that he might be ill. This paragraph calls for little comment, except perhaps one might wonder if the Colliery Manager who, from the nature of his work, is trained to expect the unforeseen, considers the advisability of appointing an efficient substitute before the electrician is away, in order that there might be no misunderstanding when that time arrives. This may not be an important point, but it deserves a little consideration from those concerned and who have not taken this precaution.

Regulation 131 (d) states: "The Electrician shall keep at the mine a log book, made up of daily log sheets, in the form prescribed by the Secretary of State. The said log book shall be produced at any time to an Inspector of Mines, at his request."

This Regulation does not call for much comment but that the log book, being made up of daily log sheets, it is reasonable to accept the intention that the sheets are to be filled in daily, and not in batches of seven pages at the end of the week. The Log Book, in conjunction with the Record Book, should give a complete history of the plant from day to day, and, used in this way, should be invaluable to the manager and Electrician, to say nothing of the Inspector of Mines; and it is the last mentioned who, when all is said and done, is appointed to keep up the high state of efficiency and safety to which our modern mining plants have reached.

There is one other point or duty which, although not in the Regulations, should receive the careful consideration of the Colliery Electrician, and that is Membership with this Association. I do think it is the duty and a pleasant one at that, for every Colliery Electrician to be a member of The Association of Mining Electrical Engineers. After all, the Association was really formed for him, and there is no doubt that his general knowledge and efficiency at his job is improved by his membership. To begin with, he has every copy of *The Mining Electrical Engineer*, which will keep him up-to-date as to what is being done in the mining electrical world. By his attendance at meetings he is able to hear, and take part in the discussions; he may also bring his problems. It is always true in perplexities that two heads are better than one, and it is possible that some other member has been up against the same difficulty and has successfully overcome his trouble. Again, by taking part in the discussions, or better still giving a paper, he can gain that quality which is so necessary for success in the modern world—confidence in himself.

In this address an attempt has been made to develop an interest in those vital, if rather dry reading, Regulations, and if as a result they are made a little clearer or they lead some one to turn up the Regulations again to check my interpretation of some clause, the object of the address will have been achieved.

In conclusion, with Mr. Bell's permission, this address is offered as a sequel to his Presidential Address of last year in which he emphasised that the chief thing in mining electrical work was Common Sense and again Common Sense.

Discussion.

Mr. A. M. BELL, in moving a vote of thanks to the President, remarked that it was unique to have an opportunity of discussing a Presidential Address and he hoped full advantage would be taken of it. At all times they realised the great difficulty there was in getting a correct interpretation of the Regulations and he agreed with Capt. Mackintosh that it was only by collectively reviewing such matters that real knowledge on the subject could be acquired.

Mr. SPRAY seconded. He congratulated Capt. Mackintosh on the interesting and instructive way in which he had treated the subject. He was afraid that with many it was a habit just to read the Rules through and then allow an interval of two or three years to elapse before looking at them again, with the result that at certain times they had only a vague idea of what the regulations were. The first point that struck him particularly was—Who had to form a judgment as to what constituted a "competent person"? He supposed it was the manager, but were all managers capable of judging whether a person was a competent electrical engineer?

Mr.. BOLTON SHAW said the President had performed a good service by examining the Regulations and carefully dealing with those portions which applied to the duties and responsibilities of the Colliery Electricians. The two main matters from the point of view of safety were earthing and the flameproof enclosure. both of which should be as perfect as possible. The earthing arrangements were the guard, so to speak, for the individual—the workman or whatever class he belonged to—who happened to be in the neighbourhood of the apparatus, and the flameproof enclosure was the guard between the apparatus and the possible dangerous conditions of the atmosphere in which it was situated. A want of continuity, or faultiness, in the conductors carrying the current generally gave some indication of its presence, but earthing connections gave no indication of anything being wrong, unless very careful and constant examination was made, until something happened. He always emphasised the point that it was really more important to see that the earth connections were alright than anything else, and of course in mining work the flameproof enclosure was of vital importance.

Mr. F. C. TAYLOR remarked that the address was presented in a way that every member could understand and it would, in his opinion, be a useful one to read before a meeting of Colliery Managers, because it emphasised the fact that the electrician at a colliery was of some consequence. At any rate it would have the effect of inducing the members to study the Regulations more closely than it had been their custom to in the past.

Mr. ROSEBLADE said he had not anything of a controversial nature to say, but he desired to congratulate the President on the way in which he had delved into the Rules and Regulations. It made one feel an admiration for the colliery electrician who had to keep his plant in order, and to do that it was essential that there should be mutual confidence between the head electrician and his men. So long as that feeling prevailed efficient maintenance would be assured.

Mr. A. BELL remarked that he was glad the President had taken for the text of his address, "The Duties of the Colliery Electrician". There was evidence that the colliery electrician was really a very responsible individual to have about a colliery. The first duty which devolved upon a Manager was to see that he appointed a competent man to fill the position of electrician, but there were other things than mere competency required to provide successful maintenance of the plant. Personality went a long way—the ability to encourage the staff to do their best at all times and particularly in the event of trouble. Many times a word of encouragement would give far better results than a complaint. When one looked into the question of the human element there were many problems to be faced and therefore it behoved those in authority to study the human element as closely as they studied the Regulations.

The PRESIDENT agreed with Mr. Bell that personality played a great part in the question of efficiency. A man might be technically competent and know what was wanted and how to do it, but lack the personality to get it done in an efficient manner by those under him.

"Adequately to prevent danger" was not, he was glad to say, his phrase but an official one. It was a phrase which was difficult to get over and gave a big loophole for varying opinion. In many respects the existing Memorandum was not satisfactory, and there were many passages where it was not only not clear but controversial.

Mr. ROSEBLADE remarked that there was one point on which he would like an expression of opinion. Generally speaking, for underground lighting circuits, flameproof air-break switch fuses were used, but he often noticed that the armoured cable was taken in through an ordinary gland. He was not certain that this really complied with the regulations, his opinion being that a sealing gland should be used.

The PRESIDENT replied that many people put in flameproof switchgear, particularly in lighting circuits, where it was not needed. It was an added precaution, but in some instances it might almost be described as a fad. So long as the switch was constructed in such a manner that it complied with the definition of flameproof apparatus it did not matter how the cable was finished off; provided of course that the cable connections were in compliance with the Regulations, and that there was no fear of open sparking. If it was a paper cable it would require to be sealed, but paper cables were not often used for lighting circuits.

Mr. W. BOLTON SHAW said it depended on the clearance round the cable. If the rubber portion was made circular and passed tightly up a circular tube there was very little clearance, and he should imagine that would be flameproof because of the cooling action of the metal tube outside.

Mr. A. M. BELL remarked that with trifurcating boxes used for power purposes the boxes were arranged with a terminal board, and short cables were taken to the actual connections inside the switch. The incoming feeder was connected to the terminals inside the trifurcating box and not inside the switch. It did happen that in some flameproof apparatus the whole of the switchgear did not comply strictly with the flameproof specification. The reason for that was that the flameproof specification referred to chambers in which open sparking might occur; but it was possible to have a chamber attached to a switch in which there was no likelihood of open sparking arising. His interpretation was that the specification referred to cases where gas could accumulate and open sparking might occur.

Mr. HEYES pointed out that there was a new British Engineering Standards Draft Specification for flameproof enclosures in which the cable connections had to come through flameproof boxes into an outer chamber for making off to the cables.

NORTH OF ENGLAND BRANCH.

Visit to the North-East Coast Exhibition.

On Saturday, 12th October, a party of abouty seventy members of the North of England Branch, including a contingent from Cumberland, visited the N.E. Coast Exhibition and, under the guidance of Mr. Mountain, one of the consulting engineers of the exhibition, and Mr. Wood, the engineer of the exhibition, inspected the electrical installation. Much interest was evinced in the illuminated fountain and the automatic apparatus by means of which the colours and form of jets are periodically changed. Several adventurous souls scaled the 156-step ladder to examine one of the search lights located in the tower of the Palace of Engineering. The two transformer stations, with Parsons 1500 k.w. transformers Ferranti voltage regulators and Reyrolle armour-clad switchgear were inspected.

After tea a meeting was held, when Mr. Mountain briefly described the layout and working results. Mr. H. J. Fisher (Branch President) moved a vote of thanks to Mr. Hainsworth (General Manager of the Exhibition) for his kind permission; to Mr. Wood and to Mr. Mountain for their able guidance. He further congratulated Mr. Mountain on the remarkable agreement between the actual operating results with the estimated figures for consumption and demand.

Mr. Simon, seconding the vote of thanks, expressed sympathy with Mr. Mountain on account of the illness of his partner, Mr. MacLean, and which had prevented his presence at the meeting.

Mr. Fisher then presented to Mr. E. J. Westcott, of the Cumberland Sub-Branch, the First Prize of the Association, awarded to him for his paper on "Detecting Faults in Induction Motor Winders." Mr. Fisher congratulated Mr. Westcott on his well-deserved success. He had read the paper with much interest and hoped that other colliery electricians would follow Mr. Westcott's example.. It was just papers of this kind, written by practical men for practical men, which were wanted.

Mr. Fisher also welcomed the members from the Cumberland district, and hoped that their visit to Newcastle might become a regular event. This terminated the official proceedings and members thereafter dispersed to enjoy the various attractions of the Exhibition in their several manners.

MIDLAND BRANCH.

Cascade Motors and Alternators.

LOUIS J. HUNT.

(*Continued from page* 217.)

CASCADE WINDING ENGINES.

Two-speed motor control with alternating currents is analogous to series-parallel control with direct currents, with the added advantage that the main curcuit is not opened when the connections are changed. A winder is accelerated in two stages which dovetail into one another; at starting, the slipring circuit is open and the controlling resistances are connected to a second winding on the stator. This gives the cascade coupling, and the winder accelerates to two-thirds speed. During the second stage, resistances are connected to the rotor, and the second stator winding is opened. By gradually short circuiting the resistances the winder runs up to full speed. The control is preferably automatic, but may be by hand for small winders.

For a given kilowatt input the motor connected in cascade develops approximately 50 per cent. more torque than it does when connected to resistances through the sliprings. For minimum kilowatt peak, the input is kept constant during both stages of acceleration and, as the torque during the first stage is 50 per cent. greater than during the second stage, the acceleration is also greater. This is of advantage as it gives a smoother effect. This increase in the torque per kilowatt greatly reduces the input during acceleration and for winders for moderate depths the peak is 25 to 30 per cent. less than that for similar winders driven by straight induction motors. The units consumed per wind are also reduced.

A simple method of calculating the diagram for a two-speed winder is given below, by means of which engineers can investigate for themselves any specific case.

Generally the cascade connection is only required during accelerating and retarding, and consequently the I^2R losses in the stator secondary circuit are of no moment as they simply form part of the controlling resistance losses. For this reason it is good practice to use two entirely separate windings for the stator; one the main winding of the usual type for connecting to the line; the other a similar winding, connected for half the number of poles of the main winding, with three-phase connections for coupling to the controller. The amount of copper in the latter winding is determined solely on the basis of permissible temperature rise and, as this winding is in circuit only during the first stage of acceleration and when retarding, the current density can be high. When retarding it is generally preferable to use only the cascade connection as this simplifies the control. To shut down in two stages would allow of re-generating down to two-thirds speed, but the amount of energy returned to the line would not amount to very much.

To work out the diagram of a wind we can proceed as follows:—

Let M = Total mass to be accelerated.

A_1 = Acceleration in ft. per second per second during first stage (cascade connection).

A_2 = Acceleration in ft. per second per second during second stage (slipring connection).

W = Unbalanced weight of load, shaft friction and windage.

$$Q = \frac{W}{M}$$

T_1 = Time in seconds of first stage of acceleration.

T_2 = Time in seconds of second stage of acceleration.

V_m = Maximum velocity of rope.

Then the force exerted on the rope during first stage of acceleration will be $M A_1 + W$.

And the force exerted during the second stage of acceleration will be $M A_2 + W$.

As for constant k.w. during acceleration the force exerted will be 50 per cent. greater during the first stage than during the second stage, we have

$$M A_1 + W = \frac{3}{2} (M A_2 + W)$$

$$\therefore M (A_1 + Q) = \frac{3}{2} M (A_2 + Q)$$

$$\therefore A_1 - \frac{3}{2} A_2 = \frac{Q}{2}$$

Multiplying by T_2,

$$A_1 T_2 - \frac{3}{2} A_2 T_2 = \frac{Q T_2}{2}$$

But $A_2 T_2$ is the added velocity during the second acceleration stage, i.e., the difference between cascade and full speed, and as cascade speed is $\frac{2}{3} V_m$, therefore $A_2 T_2$ is $\frac{1}{3} V_m$.

$$\therefore T_2 \left(A_1 - \frac{Q}{2}\right) = \frac{1}{2} V_m$$

$$\therefore T_2 = \frac{V_m}{2A_1 - Q} \qquad \text{.....................} (1)$$

We have to find values for T_1, T_2, A_1, and A_2, which for a given maximum velocity V_m will give us the same k.w. input during both stages of acceleration. We can proceed as follows:—

In the diagram, Fig. 16, the base represents time.

T_1 = total time allowed for one wind, exclusive of the time required for banking.

T_c = the time during which the winder is running at constant speed V_m.

T_r = time allowed for retardation.

We can start by fixing a value for the maximum rope speed V_m and then, allowing a reasonable value for the negative acceleration during retardation, we find the value for T_r. Now the whole area of the rectangle

Fig. 16.

VmT is the distance the rope would travel during a wind if the velocity throughout equalled Vm. The shaded areas represent the travel lost during acceleration and retardation.

The lost travel during retardation

$$= \frac{VmTr}{2}$$

The travel lost during acceleration can be obtained directly from the diagram.

Let L = travel lost during acceleration.

$$\text{Then } L = \frac{Vm}{3} T_1 + \frac{1}{2} \cdot \frac{2}{3} VmT_1 + \frac{1}{2} \cdot \frac{Vm}{3} \cdot T_2$$

$$\therefore L = Vm \left(\frac{2}{3} T_1 + \frac{1}{6} T_2\right)$$

$$\therefore \frac{T_2}{6} = \frac{L}{Vm} - \frac{2}{3} T_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

We know the value of L, as it is equal to

$$L = VmT - \frac{VmTr}{2} - l$$

where l = total length of wind.

From equations (1) and (2) we have

$$\frac{L}{Vm} - \frac{2}{3} T_1 = \frac{Vm}{6\ (2A_1 - Q)}$$

$$\therefore 3L - 2VmT_1 = \frac{Vm^2}{2\ (2A_1 - Q)}$$

$$\therefore 12\ LA_1 - 6LQ - 8VmA_1T_1 + 4VmQT_1 = Vm^2$$

Multiply by T_1 :—

$$12LA_1T_1 - 6LQT_1 - 8VmA_1T_1^2 + 4VmQT_1^2 = Vm^2T_1$$

but A_1T_1 is the velocity reached at the end of the first stage of acceleration:—

$$\therefore A_1T_1 = \frac{2}{3} Vm$$

$$\therefore 8LVm - 6LQT_1 - \frac{16}{3} Vm^2T_1 + 4VmQT_1^2 = Vm^2T_1$$

$$\therefore 4VmQT_1^2 - \left(\frac{19}{3} Vm^2 + 6LQ\right) T_1 = -8LVm$$

$$\therefore T_1^2 - \left(\frac{19}{12} \frac{Vm}{Q} + \frac{3}{2} \frac{L}{Vm}\right) T_1 = -\frac{2L}{Q}$$

From this equation the value of T_1 can be found, and we can at once calculate the other figures. The method of procedure will be made clear by working out an actual diagram, and for this purpose a winder designed for a Yorkshire colliery has been chosen (Fig. 17).

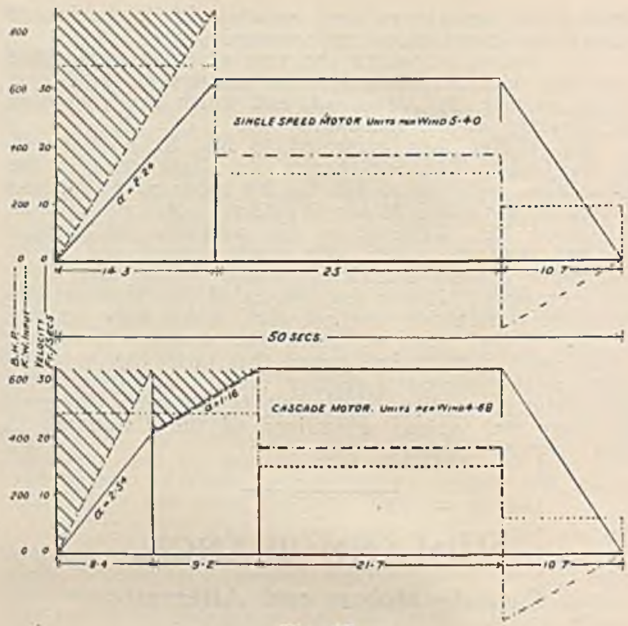


Fig. 17.

The winder was designed for the following duty:

Unbalanced load = 2 tons.

Depth of wind = 1200 ft. = l

Time allowed per wind = 60 seconds.

Banking = 10 seconds.

Net time = 50 seconds = T.

The winder has a tail rope.

The motor is wound for 500 and 333-r.p.m., three-phase, 2,000 volts, 50 cycles.

The mass M = 3,300.

Allowing 83 per cent. for shaft efficiency,

$$W = \frac{4480}{.83} = 5{,}400 \text{ lbs.}$$

$$Q = \frac{W}{M} = \frac{5400}{3300} = 1.635.$$

The maximum speed of winding, Vm, will be taken at 32 feet per second, as this winder had to be designed for as small a peak as reasonably possible. If Vm had been reduced and the acceleration correspondingly increased, the units per wind could have been reduced. Curves giving peak values and the units per wind for different values of Vm have been worked out, and are shown in Fig. 18.

Taking a value of 32 feet per second for Vm, the total area of the rectangle, Fig. 16, is

$$VmT = 32 \times 50 = 1600 \text{ ft.}$$

If we allow a negative acceleration during retardation of 3 feet per second per second:—

$$Tr = \frac{32}{3} = 10.66, \text{ say } 10.7 \text{ secs.}$$

Travel lost whilst retarding = $\frac{1}{2} \times 10.7 \times 32 = 171$ ft.

Deducting this from VmT = 1600 — 171 = 1429 ft.

The length of wind l is 1200 ft. and
$L = 1429 - 1200 = 229$ ft.

L is the lost travel during acceleration.

We can now find T_1 from equation (3):

$$T_1^2 - \left(\frac{19}{12} \times \frac{32}{1.635} + \frac{3}{2} \times \frac{229}{32}\right) T_1 = \frac{2 \times 229}{1.635}$$

Solving the equation, we find

$T_1 = 8.4$ secs. approximately

$A_1T_1 = \frac{2}{3} Vm = 21.33$

$$\therefore A_1 = \frac{21.33}{8.4} = 2.54 \text{ ft. per sec. per sec.}$$

From equation (2) $T_2 = 6\left(\frac{229}{32} - \frac{2}{3} \times 8.4\right) = 9.3$ secs.

As $A_2T_2 = \frac{1}{3} Vm = 10.66$

$$A_2 = \frac{10.66}{9.3} = 1.146 \text{ ft. per sec. per sec.}$$

and the total acceleration period
$= 8.4 + 9.3 = 17.7$ secs.

We can now find the time for steady running
$T_2 = 50 - 10.7 - 17.7 = 21.6$ secs.

The k.w. input can now be found for each stage of the wind.

First Acceleration Stage T_1:

Due to acceleration $= 3,300 \times 2.54 = 8380$ lbs.
W = 5400 lbs.

F = 13780 lbs.

$$\text{Net k.w. input} = KW_1 = \frac{F \times Vm}{737} \times \frac{2}{3}$$

$$= \frac{13780 \times 32 \times .666}{737} = 399 \text{ k.w.}$$

Allowing 85 per cent. efficiency for the gearing, &c., the output of the motor is $\frac{399}{.85}$ = 470.0 k.w.

Losses in motor; stator I^2R plus iron and friction = 34.9

Input = 504.9 k.w.

Second Acceleration Stage T_2:

Due to acceleration $= 3300 \times 1.146 = 3782$ lbs.
W = 5400 lbs.

F = 9182 lbs.

$$\text{Net k.w. input} = KW_2 = \frac{F \times Vm}{737} = \frac{9182 \times 32}{737}$$

= 399 k.w.

Gearing efficiency = 85 per cent. $= \frac{399}{.85} = 470.0$ k.w.

Motor losses = 27.7 k.w.

Input = 497.7 k.w.

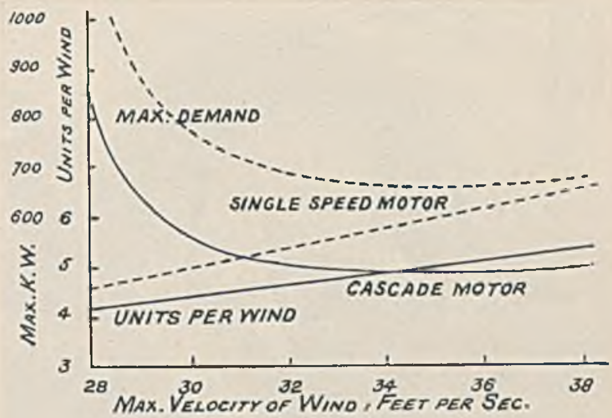


Fig. 18.

Constant Speed Running:

$$K.W. = \frac{W \times Vm}{737} = \frac{5400 \times 32}{737} = 234.4 \text{ k.w.}$$

$$\frac{234.4}{.85} = 276.0 \text{ k.w.}$$

Motor losses; stator and rotor copper losses and iron and friction = 24.9 k.w.

Input = 309.9 k.w.

Retardation (counter-current braking):

By using the stator resistances and shutting down with the motor connected in cascade (18 poles) the net kilowatts required are reduced to two-thirds the value which would be required if we shut down with resistances connected to the sliprings.

Tr = 10.7 secs. Ar = 3 ft. per sec. per sec.

Due to negative acceleration $= 3300 \times 3 = 9900$ lbs.
W = 5400 lbs.

F = 4500 lbs.

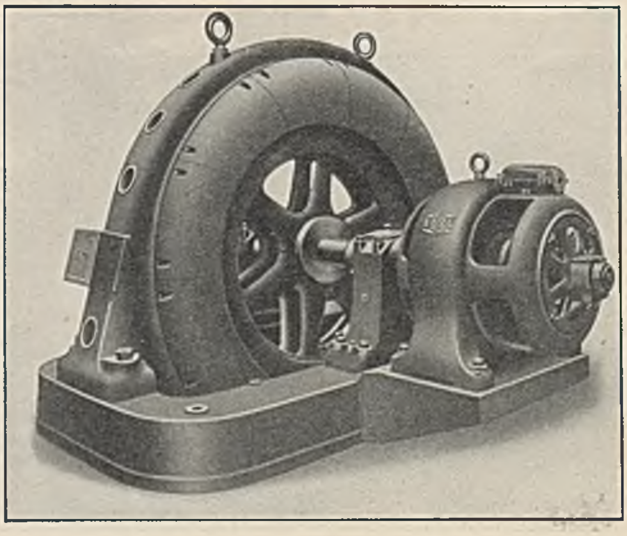


Fig. 19.

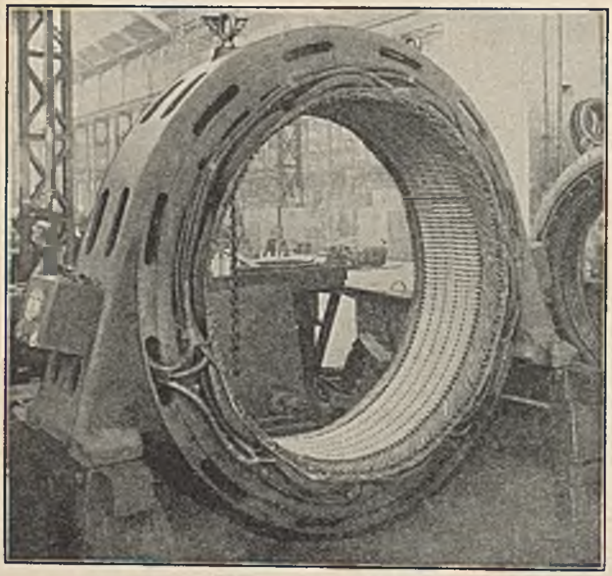


Fig. 20.

The weight is helping to stop the winder.

$$\text{Nett k.w.} = \frac{4500 \times 32}{737} \times \tfrac{2}{3} = 130 \text{ k.w.}$$

The friction of gearing, &c., is also assisting.

∴ K.W. = 130 × .85 = 110.5 k.w.

Losses in motor; stator copper losses and iron = 25.6 k.w.

Input = 136.1 k.w.

Energy Consumption:

Stage.	K.W. Input.		Time in Secs.		K.W. Secs.
Acceleration 1st	504.9	...	8.4	...	4240
Acceleration 2nd	497.7	...	9.3	...	4630
Steady running	300.9	...	21.6	...	6500
Retardation	136.1	...	10.7	...	1460
					16830

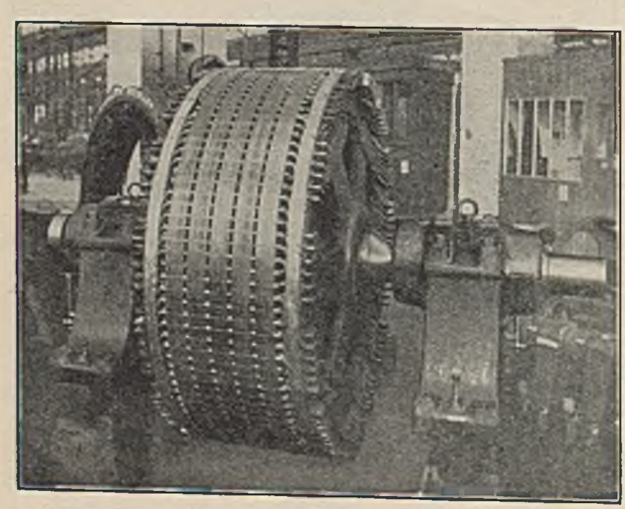


Fig. 21.

$$\text{K.W. hours} = \frac{16830}{60 \times 60} = 4.68 \text{ units.}$$

Actual work done in lifting two tons of coal to a height of 1200 ft.

$$= \frac{4480 \times 1200}{737} = 7300 \text{ k.w. secs.}$$

$$\therefore \text{Overall efficiency} = \frac{7300}{16830} = 43.4 \text{ per cent.}$$

Single-speed Winder:

We can now work out similar figures for the same winder driven by a single-speed slipring motor. Take Vm = 32 ft. per second as before and allow the same time for braking, then lost travel will be 229 ft. as before and $L = \frac{1}{2}\,\text{VmTa}$

where Ta = time required for acceleration;

$$\text{then} \quad \text{Ta} = \frac{2 \times 229}{32} = 14.3 \text{ secs.}$$

$$\text{Acceleration} = \frac{32}{14.3} = 2.24$$

Acceleration:

3300 × 2.24 = 7392
W = 5400

12792 lbs.

$$\text{K.W.} = \frac{12792 \times 32}{737} = 555.$$

Efficiency of gearing, &c., is 85 per cent. as before.

$$\therefore \text{Net K.W.} = \frac{555}{.85} = 653 \text{ k.w.}$$

Losses in stator windings, iron and friction of motor = 37.1 k.w.

Total input = 690.1 k.w.

Constant Speed Running:

The winder will run at a steady load for 50 — 10.7 — 14.3 = 25 seconds.

As the speed Vm and the load are the same as for a two-speed winder, the k.w. required will be the same. The input is therefore 300.9 k.w.

Retardation:

Tr and Ar are the same as before, and the net kilowatts will be 50 per cent. greater, as the machine is running as a 12-pole motor.

∴ Net K.W. = 110.5 × 1.5 = 165.75 k.w.
Losses in motor = 23.25 k.w.

Input = 189.00 k.w.

It will be noticed that the motor losses are a little less, as the average frequency of the induced currents with counter-current braking is higher with cascade connection.

Summary.

Type of Motor.	K.W. Accel.	K.W. Steady.	K.W. Braking.	K.W. Secs. Input. Accel.	Steady.	Braking.	Total.	Units per Wind.
Two-speed	504.9	300.9	136.1	8870	6500	1460	16830	4.68
One-speed	690.1	300.9	189	9870	7530	2020	19420	5.4

Energy Consumption.

Stage.	*K.W. Input.*	*Time in Secs.*	*K.W. Secs*
Acceleration	690.1	14.3	9870
Steady running	300.9	25.0	7530
Retardation	189	10.7	2020
		50.0	19420

$$\text{K.W. hours} = \frac{19420}{60 \times 60} = 5.4 \text{ units.}$$

$$\text{Overall efficiency} = \frac{7300}{19420} = 37.6 \text{ per cent.}$$

A summary of the comparative figures is given in the table above.

The two-speed winder takes a peak load 27 per cent. less than that required by a one-speed winder, and the units per wind are 14 per cent. less.

The losses in external resistances are, for the one-speed motor 4935 k.w. seconds, and for the two-speed motor 2890 k.w. seconds, part of which represents the loss in the second stator winding. The figures calculated for this winder have been plotted in diagram form in Fig. 17.

Calculations have been made for several values of Vm, and the figures for maximum k.w. and units per wind are shown in the curves Fig. 18. It will be noticed that a substantial reduction in the energy consumption can be obtained if a somewhat higher value of peak load is permitted.

SELF PARALLELING ALTERNATOR.

This machine is the latest and perhaps the most important development of the cascade machine, as it completely solves the problem of satisfactory parallel running without requiring the usual limitations to the cyclic variation of speed of the prime mover. It is self-synchronising and its great advantage is its suitability for coupling to engines which have large cyclic irregularity. Consequently they will run in parallel when driven by gas or oil engines which are not provided with the specially heavy flywheels required by salient pole Alternators, and require only the flywheel effects provided in engines intended to drive the d.c. type of generator. These machines are, therefore, particularly suitable for coupling to existing engines where a change-over is to be made from d.c. to a.c., and in such cases it is unnecessary to provide any additional flywheel effect. Fig. 19 is a typical photograph of an alternator with its exciter.

It is well known that an induction-generator—an induction motor driven above its synchronous speed—does not require paralleling and would be an ideal generator of alternating current but for the fact that it is not self-exciting and cannot supply magnetising current. Such a machine can only be used in parallel with synchronous alternators which must supply the whole of the magnetising current required by the network as well as the current to magnetise the fields of the induction generators. Owing to these defects these machines have proved of very little practical value.

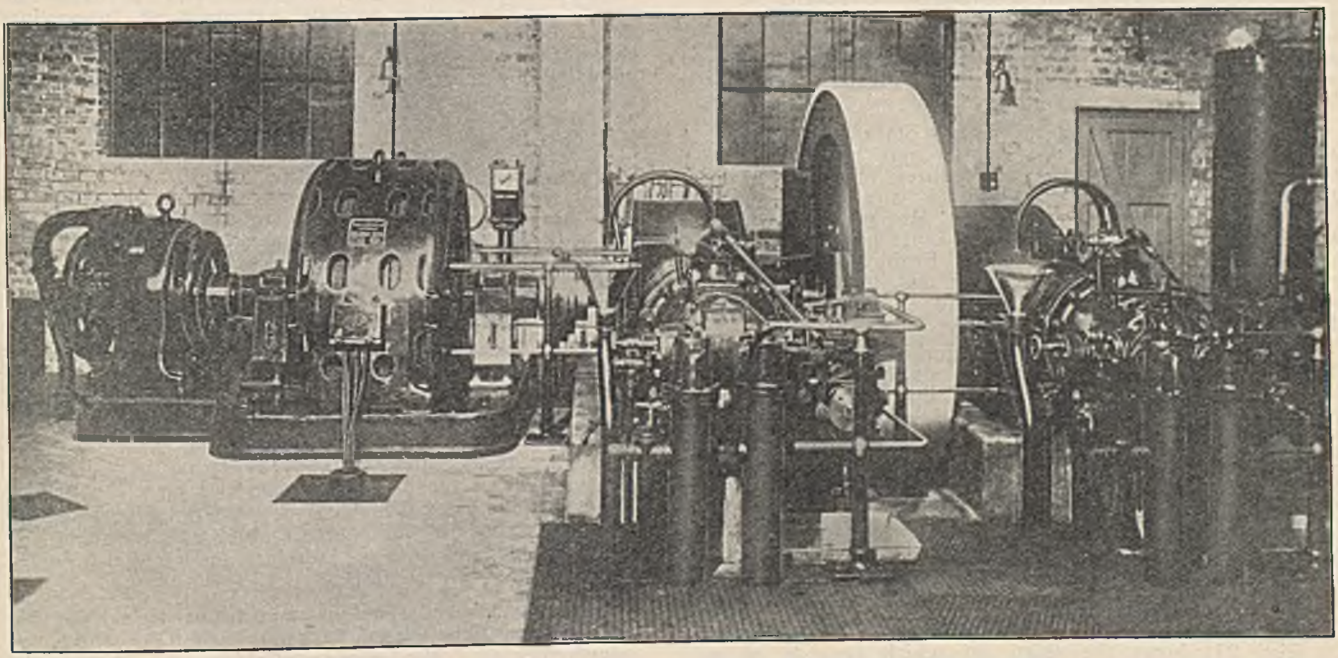


Fig. 22.—Cascade alternator driven by two-cylinder suction gas engine.

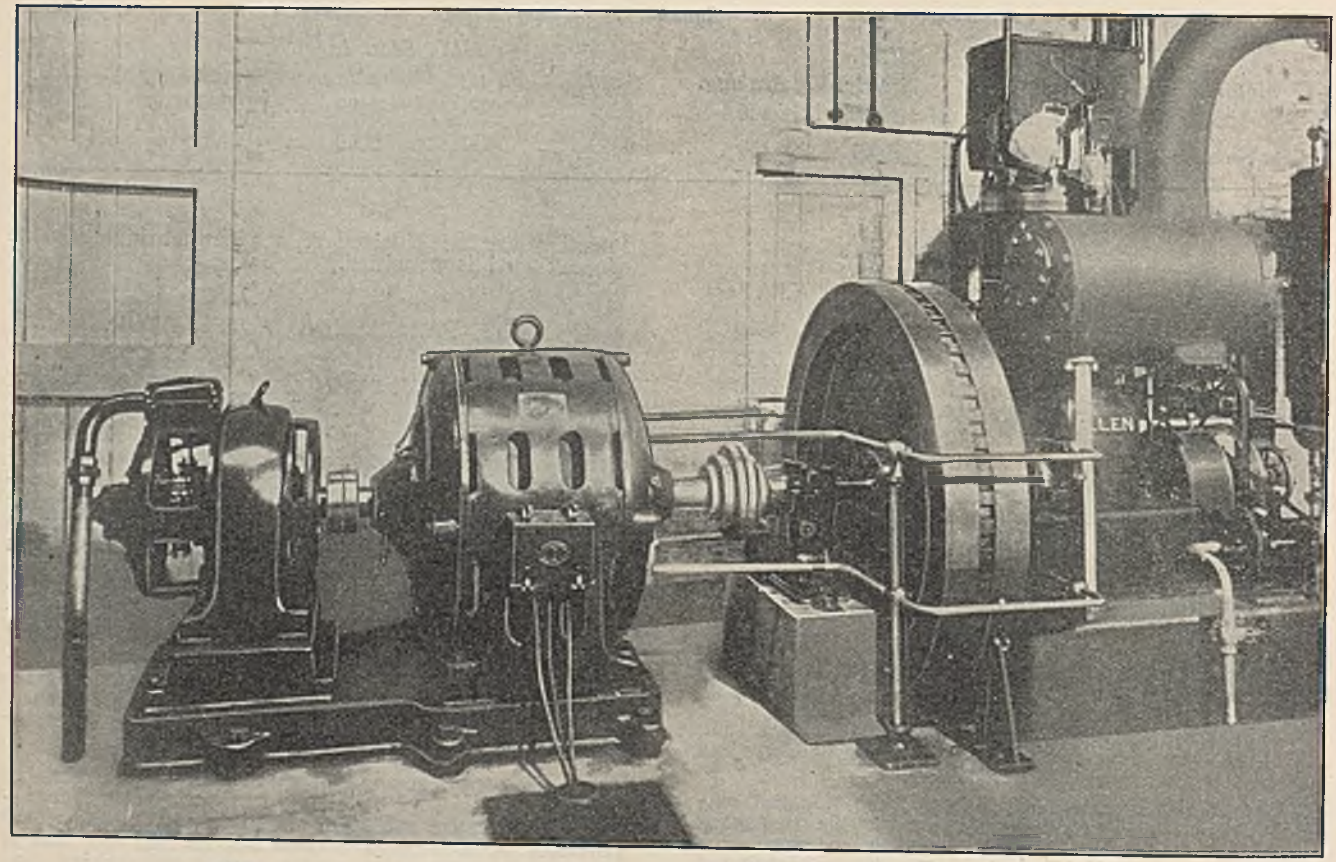


Fig 23.—Cascade Alternator direct driven by single cylinder semi-Diesel Engine.

The new alternator is in effect a combination of an induction and synchronous generator in a single machine. It is two-thirds an induction generator and one-third a synchronous alternator, the latter element supplying power and magnetising currents to the non-synchronous element. This arrangement results in a machine which does not require to be synchronised before it is paralleled with other machines, and which will run satisfactorily in parallel under conditions which would render parallel running with ordinary alternators impossible.

A short description of the Supply Station at Andover, where these alternators are in use, may be of interest as certain of the engines are entirely unsuitable for parallel running with salient pole alternators. The station is one of many owned by Messrs. Edwards & Armstrong, Ltd., and the author is indebted to the Chief Enginneer of the Company, Mr. Braithwaite, for the information included in this paper and to the courtesy of Messrs Edwards & Armstrong for permission to use it.

There are at present in operation in this station three sets of engines and cascade alternators which all run in parallel. The largest of these consists of a vertical type four-cylinder Diesel engine which is direct coupled to a 270 kva. cascade alternator, running at 200 r.p.m. Fig. 20 is a photograph of the stator showing the separate field windings which are used in this particular machine. Fig. 21 is the rotor.

The second set, illustrated in Fig. 22, consists of a two-cylinder, horizontal type, suction gas engine, originally direct-coupled to a d.c. dynamo running at 220 r.p.m. A cascade alternator has been substituted, running at the nearest available speed of 200 r.p.m., giving 90 kva.

Fig. 23 shows the third set which consists of a two-stroke, single cylinder, semi-Diesel engine, direct coupled to a cascade alternator developing 27.5 kva. The speed is 333 r.p.m.

These three machines are all designed for a power factor of 0.8 and are wound for 400 volts, 50 cycles, three-phase supply. The machines run perfectly in parallel. The writer recently witnessed an interesting demonstration of paralleling at this station. The synchroscope was covered so that the operator had no knowledge of the relative phase or speed of the machines, and the incoming machine was paralleled without causing any disturbance to the system and with a momentary rise of current which was less than twice the normal load of the incoming machine.

It may be mentioned that a large number of similar tests have been made on machines of various sizes and it has been found that the momentary rise of current when an alternator is paralleled 180 degrees out of phase does not exceed twice to 2¼ times the full load current, and is often much less.

To demonstrate the remarkable stability of these alternators a test was made with two 200 kva. machines driven by four-cylinder horizontal type gas engines. Two cylinders of each engine were cut out and the alternators ran equally well in parallel with only the remaining two cylinders of each engine in operation. The machines were perfectly stable and no visible surge between them was indicated by the meters. Unfortunately the engines would not operate satisfactorily upon one cylinder only and it was, therefore, impossible to make a test under this condition.

In conclusion the author would like to express his gratitude to the Electric Construction Co., Ltd., the manufacturers of the cascade machines, for their assistance in providing lantern slides to illustrate the paper.

STOKE-ON-TRENT SUB-BRANCH.

Annual Dinner.

The annual dinner and smoking concert in connection with the local Sub-Branch was held at the Metropole Hotel, Stoke-on-Trent, on Saturday, December 21st last. A fair number of members and friends met together for this annual function which is a regular part of the Sub-Branch's social activities.

The room had been seasonably decorated and dinner was served in admirable style. The loyal toast was honoured to musical accompaniment provided by Mr. F. Gurney, on the call of the Chairman, Mr. J. F. Aust, who presided. Contributing to the musical programme which followed were Mr. F. A. Forster and Mr. J. H. Aust who gave songs, other members providing humorous items.

The toast of the "A.M.E.E." was proposed by the Chairman, to which Mr. Gittins (Manchester) replied.

The "Visitors" was proposed by Mr. Tyson to which Mr. Dryhurst replied.

A cordial vote of thanks was proposed by Mr. A. W. Poole, and seconded by Mr. C. S. Wood to the Secretary for his continued interest and services.

SOUTH WALES BRANCH.

Visit to the Cardiff Engineering Exhibition.

The official visit of the South Wales Branch to the Engineering Exhibition held at Cardiff took place on the 30th November last, a large number of members from all parts of the district attending.

Those present included:—Messrs. W. W. Hannah (Branch President), Dawson Thomas (Past Branch President), A. C. MacWhirter (Hon. Treasurer), H. J. Norton (Hon. Secretary), Theodore Stretton (Past National President), C. F. Dennis (London Branch), T. Leyshon, S. Wilson, J. B. J. Higham, S. B. Haslam, S. Bridgen, A. T. Seymour, F. A. Brock, J. T. Kaye, S. Dwyer, W. A. Hutchings, J. W. Price, D. R. Reid, and others.

Principal GEORGE KNOX, President of the South Wales Institute of Engineers, extended a warm welcome to the Members. The mining electrical engineer, he said, was in a very peculiar position because he had to deal with a type of machinery which was used under abnormal conditions and which was hedged round with the most accurate or intricate (so-called) legislation imaginable. It said a great deal for the Association that their work should be carried out year after year with so very small an accident rate—having regard to the tremendous amount of electrical machinery installed in mines. This was due to a large extent to improved education in matters of this kind. They would find on going round the Exhibition that there were more electrical exhibits than in any other branch of the profession, which emphasised the important part played by electricity in engineering.

Mr. W. W. HANNAH, in responding, expressed the thanks of the Branch to the South Wales Institute of Engineers for their courtesies year after year, and for the loan of their buildings for holding the Branch Meetings. The Exhibition, he thought, was a tribute to the important part played by the electrical engineer in mining. The fact that a very large proportion of the exhibits were electrical brought it home to everyone concerned that electricity was playing a most important part, and would continue to have an increasing sway in mining than it had ever done previously. As an Association they felt that, apart from technical progress which was illustrated in the Exhibition, there must also be administrative progress, and they had long ago come to the conclusion that a certain measure of internal reform was necessary in the engineering side of mining work.

Personally speaking, he was beginning to wonder whether it was necessary to try and make the colliery manager a superman. Was it necessary for the mining engineer, for example, to occupy himself with the pit-top arrangements of a colliery? It seemed to him that there was no place for the mining engineer at the top of the pit. His place was below ground. One could not help but think in these days of specialists that it would be very much more to the point if the mining engineer kept to mining, pure and simple, and left the engineer to take charge and be responsible both to the colliery owners and in the eyes of the law, for the engineering work in and about collieries. It was this point of view which their Association was striving to impress upon other people. They would no doubt meet with a good deal of antagonism, but they strongly felt that the electrical and mechanical engineers should be given their proper place in the industry.

Mr. DAWSON THOMAS, in seconding the vote of thanks to the Institute, said the Exhibition gave an important opportunity to them all to see for themselves what science was doing in mining in all its phases.

Professor KNOX, in acknowledging the vote of thanks, which was warmly carried, said he would not be drawn at the moment into the vexed question of control at the colliery, but later he would be welcoming another important body of visitors to whom he would have a few words to say. It was only by educating each branch of engineering to still better methods, and inducing them all to co-operate that they could ever hope for real prosperity in the mining industry, and the members of the South Wales Institute of Engineers were always out to bring that about.

WEST OF SCOTLAND BRANCH.

Heading Work with a Versatile Machine: A New Development in Coal-Cutter Design.

FORREST S. ANDERSON, B.Sc.

The problem of heading work is one which has to be faced by every mining engineer at some time, and since the early days of coal-cutters the application of machines to this work has received a considerable amount of attention. Many different classes of machines have been tried with greater or less success, but at the present stage of development, the Arcwall type of machine, working under suitable conditions, has undoubtedly proved of the greatest advantage. Its application to stoop and room working has revolutionised production costs to such an extent that, whereas formerly the coal won in the narrow work was the most expensive to get, it has now frequently become the cheapest. This aspect of the case has also opened wider possibilities with regard to longwall retreating, panel systems, and other modified methods of working where the expense of doing the narrow work has hitherto proved a serious factor to place against the advantages likely to be derived. That the success of Arcwall machines is no illusion is amply demonstrated by the extent to which they are now employed by those colliery companies who have adopted them where suitable conditions prevail.

The Arcwall machine as originally applied in this country consisted simply of a longwall machine mounted on a suitable truck on which it could be readily transported or travelled by its own power from place to place. The saving in time of keeping the machine mounted while cutting proved to be considerable; but in order to get fuller advantage from the system, modifications in design were made to facilitate the work and make the machine suitable for a wider sphere of operation.

In this connection, one of the points which had to receive consideration was the question of cutting position. The early machines were arranged to cut at from 15 ins. to 20 ins. above floor level and this proved quite suitable in many cases, but as fresh subjects were tackled, the question of adjustment to a different cutting position inevitably arose. When the holing position was higher, the case was easily met by packing up the machine on the tram, but this led to trouble in some instances as it did not leave sufficient head room for the machine.

The difficulties have now been mostly overcome by designing different arrangements of gearhead and fitting the type most suitable for the particular holing position desired and the general conditions of the subject, though this may sometimes entail fitting a new gearhead to the machine when transferring it from one seam to another.

It frequently happens, however, that the cutting position has to be adjusted by a matter of a few inches only, and for such a purpose, the use of packing pieces between the machine body and the truck can usually be resorted to. Such a case might arise for instance after passing through a fault, due to a slight alteration in the position of a dirt band in which the cut is being made.

In some instances the cutting position varies from place to place; for example, when holing in a band the position of which is not constant throughout the seam, when cutting to a parting, or when holing at the bottom of a seam and working with a pavement brushing. Under these circumstances, the variation is frequently overcome by laying the rails so as to adjust the machine to its proper cutting level, but the difficulty is to ensure that the road is properly laid and it requires strict supervision to secure this and avoid delays with the machine which would be otherwise inevitable.

Another limitation of the standard Arcwall machine is that it is not practicable with it to hole at floor level. Many attempts to overcome this disability have been tried, but they have generally resolved themselves into holing as close as possible to the top of rail level. This, however, often gives rise to a serious difficulty in flitting. It will be readily appreciated that with a machine carrying a 6 ft. or 7 ft. jib about 1 in. above rail level it is not an easy matter to flit rapidly over even what would normally be termed a good flat road. This problem has been met by fitting elevating screws to the machine so that the jib may be raised sufficiently clear of the rails when flitting. Screws have likewise been adopted to allow for a variation in the cutting position, but while entirely satisfactory for particular conditions, they provide a limited range only and increase the cost of the machine considerably.

Bearing in mind the limitations, some of which have been briefly sketched, and in view of the the success attained by Arcwall machines generally, and consequent increased demand for such machines to suit more widely varied conditions, it was felt by the coal-cutter manufacturing firm, Messrs. Anderson, Boyes & Co., Ltd., that development in design on broader lines than hitherto was called for. In addition, there has been an insistent demand for a machine which would be capable of putting in a shearing cut over and above the usual holing cut, and it was decided to explore the possibilities of incorporating this feature in the new development.

Shearing cuts by machines have been practised at several collieries but, while the advantages have been proved, the system has been handicapped in the past for want of an entirely suitable tool. The main features specified for the proposed design were that the machine should be capable of holing in any position from floor level to a reasonable maximum height; that it should be capable of putting in a shearing; and that it must be of a size suitable for British mining practice. A machine to this specification has now been successfully designed and put to work and, by its performance at the coal-face, its ability to meet the requirements has been effectively demonstrated.

This unique machine is of the chain type and makes its cut in a similar way to the usual Arcwall machine, which it resembles somewhat in general appearance. The gearhead, however, is an entirely new departure in design, and consists of two parts—the Main Head and the Jib Head. The Main Head is mounted at the end of the machine and is capable of rotation about an axis in line with the motor shaft. The Jib Head, which carries the jib and cutting chain, is supported by the Main Head and is capable of rotation about an axis parallel with the axis of rotation of the Main Head, but eccentric to it. The construction may be likened to an overhung crank with the Main Head representing the web of the crank and the Jib Head mounted on the crank pin.

The possibilities with this construction will be clearly understood if we refer back to our comparison with the crank, and, in order to assist you to visualise it, a few slides of the machine with the heads in various positions will now be shown. Suppose the crank is at bottom dead centre, with the jib at floor level. Assume in the first instance that the jib Head is firmly fixed to the crank pin and that the crank shaft is rotated. In the starting position the jib can make an arcing cut holing at floor level. When the crank has rotated through 90 degrees, the jib will be in a position to put in a shearing; at 180 degrees another holing cut may be made—this time an overcut which, in the case of the machine under review, would be at a height of about 4 ft. from floor level; at 270 degrees another shearing cut may be made—this time on the opposite side of the machine from the first; and at 360 degrees the cycle is complete.

In the second instance, assume that the Jib Head is quite free on the crank pin so that the jib will arc in a horizontal plane in all positions and we will again start from bottom dead centre. As the crank shaft rotates the cutting position will gradually be raised until a maximum of about 2 ft. from floor level is reached at top dead centre. Assume now that the crank shaft is held stationary and the Jib Head rotated through 180 degrees. The jib will now be up on top and the machine, working as an overcutter, may make a holing cut at a height of about 4 ft. from floor level. If the rotation of the crank shaft is now continued with the Jib Head free on the crank pin, the holing position will gradually be lowered until a minimum of about 2 ft. from floor level is reached at bottom dead centre.

It will thus be understood that a holing cut may be made at any position up to about 4 ft. from floor level, and in the same way shearing cuts may be made within a similar horizontal range. The motions described are all practicable with this machine, and either head may be locked for cutting purposes at any point in its rotation.

The drives and controls are so arranged that the Jib Head may be rotated with the Main Head stationary; the Main Head may be rotated with the Jib Head locked; and both heads may be operated simultaneously to adjust the jib into a cutting plane parallel to the cutting plane from which it has been moved. The motions are carried out by power from the motor, and the controls allow of rapid adjustment. The machine as a whole has been designed for heading work and embodies the features which a long experience in Arcwall work has proved to be desirable. The machine is of a very compact design, the overall dimensions being approximately 9′ 9″ long × 3′ 0″ wide × 2′ 6″ high to the top of the body.

The actual working of the machine is on similar lines to that of a standard Arcwall machine, except that when necessary the jib can be adjusted to its proper cutting position after it has been flitted into the face. For example, if the machine were required to hole close to rail level, it would be flitted into the face with the jib well clear of the rails; the jib would then be swung round in the usual way and the machine driven forward until the head was close to the coal. The jib would now be lowered until the proper position was reached, the machine stelled in position and the cut made.

A film of the machine at work will be shown when you will have an opportunity of observing an operation of this nature being carried out. In the case demonstrated the place being driven was only about 12 ft. wide and the full arc could not therefore be cut. This precluded the possibility of holing at floor level since the jib had to be kept above the rail to allow it to be brought out of the cut, but it clearly illustrates one method of driving places narrower than that given by a full arc.

After the place has been holed a shearing cut may be put in. The position of the shearing is a matter of choice, but it will generally be found most convenient to put the shearing in the centre of the place. For places up to about 10 ft. wide with the track close to one side, the shearing may be put in at that side, but for wider places it would be necessary to lay a double track to get the shearing in that position and, as a rule, any advantage gained would not justify the extra work. With a shearing in the centre and the holing at the bottom, two comparatively light shots will bring all the coal. The shots usually do their work best when the holes are bored close to the sides and parallel with them, and with this arrangement a saving of about 50% on explosives will frequently be effected. In addition, the place will be well squared and rounder coal obtained.

The method of putting in the shearing is as follows. When the holing cut is finished, the machine is driven back until the jib is clear of the coal. The heads are then adjusted to bring the jib into position for shearing in the position desired and the jib swung up until the picks at the point of the jib are just clear of the roof. The machine is then driven forward by means of the track wheels and the jib cuts its way into the coal until the gearhead is up to the face. An arcing cut is then made until the point of the jib is down to the floor, when the arcing is stopped and the machine driven back with the jib cutting its way out, thus completing the shearing.

The time spent in a place to complete the two operations of holing and shearing where the conditions are such as to allow the work to be carried on with freedom is about 25 to 30 mins. on the average; the holing taking about 16 mins. and the shearing about 12 mins. As a further example, two holings and a shearing in one place can be put in in 45 to 50 mins. These are not record figures, but they clearly indicate the suitability and adaptability of this machine for its work and the convenience with which it can be handled.

In the early part of this paper, attention was drawn to some of the limitations of the standard type of Arcwall machine, and now with the brief description given of the construction and work of the Anderson Boyes Universal Heading Machine, it may be understood how these difficulties can be overcome. Briefly stated the claims for this new design are that it facilitates the work when cutting close to rail level or when taking a pavement brushing, allows a holing to be made at floor level, provides for adjustment to a variable cutting position and, further, combines a holing and a shearing machine in one compact unit. Like all machines of the Arcwall type its application is in practice limited to fairly flat workings but, while there may be few suitable conditions in Scotland, there are large areas in other parts of our coalfields where it could be successfully and advantageously employed.

AYRSHIRE SUB-BRANCH.

The Ayrshire Sub-Branch held its opening meeting of the winter session in Kilmarnock, on October 10th last. Mr. T. M. McGlashan, Kilmarnock, presided over a good attendance of members. The Secretary, Mr. J. C. MacCallum, intimated that Mr. Samuel Thomson, 2 Quarry Road, Auchinleck, had been admitted to membership of the Branch.

Chairman's Address.

T. M. McGLASHAN.

In rising to open the Session for another year, I thank you for the honour of being asked to occupy the position of Chairman, and trust your Council and I will carry out our duties to the credit of the Branch and the satisfaction of its members. It is pleasing to note that a number of new members have been enrolled during the past Session and your Council hope the Branch will grow steadily in numbers and energy.

Last year when I had the pleasure of addressing you, the relative merits of oil fuel and pulverised coal were occupying a prominent place in the mining world. The question of public *versus* private electricity supply was, and is still, being debated. Great things were prophesied from the more scientific methods of securing the valuable chemical and fuel by-products contained in coal, by means of low-temperature carbonisation methods, including the coke oven gas supply to large cities (with interconnecting lines from various sources) at somewhere about 7d. per 1000 cubic feet. Hopes were held out that this last scheme would lead to an economic revolution in the iron and steel industries, but seemingly the idea has not yet reach fruition.

The large number of latticed towers and pylons for electric cables springing up over the country indicate good progress with the electrical supply schemes. Of the other schemes little can be said as to actual progress made, which proves that the conversion of successful laboratory results into sound business paying concerns is a slow and difficult task. There are too many links between the un-mined coal and the gas holder to expect that the "carry over" can be accomplished by simply opening a gas valve.

The Mining Industry has lately been "sick and squeamish" and is still an anxious problem. A full knowledge of the problem is only possible to those who participate and are in daily touch with it. "The School of Experience has no Correspondence Class." The problem is a very complex one, hedged round with difficulties. It is nearly impossible to mention the coal industry without a "controversial kink" developing somewhere—it is very much like a wire haulage rope, which, if not carefully unwound off its purn, will twist and turn, and entangle the feet of all near by.

In these days of straitened circumstances and want of money, it is essential to keep waste out, to scrutinize every penny and see whether the need of a new machine is really the outcome of growth, or an extravagance which can be avoided. A distinct line has to be drawn between the two and effots made to keep on the right side of expenditure without crippling efficiency. A machine must be examined critically and made to prove its utility before being purchased.

The tendency of present day opinion is towards the use of the minimum number of machines and an increase in the speed of plant. The machine age is freeing us from much toil, and the introduction of more elevating and conveying plant, or any device for increasing output and economy, with less manual labour, is likely to extend. Synchronisation of operations all lead to a definite development in solving the problem of economical handling of coal in all its stages from "face" to boiler and shipping docks.

The coal trade has gone through a severe testing time. Some parties assert there is too much interference in making rules, regulations, and suggestions bound up with red tape. While doubtless some of these may tend to better efficiency and administration, it has to be remembered that efficiency usually involves increased expenditure. If efficiency is vital, it must grow, and provision must be made for its expansion: increased efficiency in any business means increased work.

To attain this expansion and efficiency is the wish of all sensible thinking people, but care must be taken to avoid dictatorial interference, irksome restrictions, and industrial disturbances, which frighten away capital, impair confidence, destroy that freedom of thought and independence of action which must be retained by trade if it is to work out its own salvation

We must remember that colliery officials and workers have responsibilities which must be shouldered, and it is up to them also to "do their bit" efficiently and eliminate any possibility of retrogression. In a highly mechanical mine, stoppages likely to disorganise production or output must be carefully guarded against. We are apt to forget and fail to realise how dependent the different branches are upon each other for continuity of operations, progress, and material prosperity of the colliery. Competition is keen and, where production costs are spread over so many departments, it is difficult to check leakages. This is only obtainable by systematic investigations by all parties.

The importance of machinery to the economic working of a colliery was never more fully appreciated than it is at the present moment. In the past, wastage of power occasioned by carelessness was very great. The efficiency of motors and other prime movers or appliances requires constant care and attention. Systematic and regular inspection and maintenance in keeping motors clean, externally and internally, is most essential, although sometimes one is inclined to think that cleanliness of mototrs receives scant attention.

Recent conferences held between employers and trade union councils may prove the beginning of an improved era in our industrial life. It is impossible to exaggerate the harm done to the country's trade by frequent recurrence of labour disputes leading to widespread stoppages of work.

The trouble is that we do not realise clearly the difference betwixt practical production and dream distribution: a big gulf has to be bridged before dreams can be converted into practice. Organisation is the fundamental basis of all good business, but sometimes the harassed organisers get little thanks for their labours, and endeavours to improve the nation's industries.

These general observations relating to our special niche in industry tempt me to refer briefly to the very much more expansive outlook which is exercising the minds of our statesmen and industrial leaders—namely, the question of "Rationalisation of the Empire and Trade." It is not easy for a layman to define the exact meaning of the term "Rationalisation." Its effects can be very far reaching and can be made to include every raw or manufactured article from its earliest source to its final end; in fact, it is the arbiter for regulating the laws of supply and demand, or equalising supply and demand, so as to overcome, or at least minimise the effects of trade cycles and recurring fits of good and bad trade, by forecasting cycles of trade and studying foreign markets.

Rationalisation may be compared to the Physician and Specialist who will prevent or cure fits of "Industrial Indigestion" arising either from over-feeding or starvation. He will keep his fingers on the pulse, alike of Home and Empire Industry, watch the thermometer, and take ways and means of keeping trade at a normal level and temperature. Its primary concern is not what industry will do, but what industry shall be. It is stimulating master minds to activity, in considering present day problems of supply and demand.

It is no academic question, but it is something very vital to employers and employees if it means steady employment and fair wages, with prosperity for the Empire's industries.

Every phase of industry will be nurtured and cared for on all sides by rationalisation, and kept in a healthy state; restrained from excesses with a ready at hand "tonic" to prevent collapse or breakdown. The scheme in a modified way, has been in operation and making progress in America, Germany, and even Russia, and while advocates have different ways of explaining the "workings," without a doubt it is a good idea, likely to be adopted, and tending in the right direction to give the "fillip" and stability to industry which has been wanting since the war period, due to the expansion and increased plant and machinery which was installed during the stress of war having boosted up the production barometer far beyond the limit of consumption.

Rationalisation means "The Big Unit," the amalgamating of firms and industries apparently diverse in their interests, but nevertheless capable of being dovetailed into one large concern. It means the specialisation of manufacture and goods by mass production: brushing aside and scrapping old obsolete plant: reduction of oncost charges, with a system of co-operation or bonus for all employees. Rationalisation, in a nutshell, is to be the rejuvenator of trade and commerce, having as its aim the carrying on of industry successfully, alike for Nation and Empire; and employers and employees. The pooling of knowledge, brains, experience, and practice is necessary in the development and the getting of the security of lasting peace.

It will be a great task, but will be a new starting point from which groups of industries will be able to direct their further exertions—even though we freely admit that rivalry and competition is good for business as well as mortals.

There may be some to whom Rationalisation of Trade does not altogether appeal, on the ground that restriction of output may mean restriction of labour and competition, and who would rather see our energies turned towards the broader question of Rationalisation of the Empire, directed to the expansion of our Colonies, and Empire markets, with emigration of our unemployed to those thinly populated colonies, where nature's wealth only awaits development.

Such an idea has been mooted in the shape of a Colonial Development Scheme, backed by the Government, but a much better scheme had previously been put forward in the shape of "The Empire Industrial Trust" which would obtain its financial backing, not from Home or Dominion Governments, but from Public Shareholders, on a purely business investment basis.

This scheme, if carried, would help to solve unemployment, increase the prosperity and extension of our Colonial markets, and naturally increase the wealth of our Empire.

Each Dominion or Colony would manufacture the goods or produce most suitable to its climate, or develop the resources with which nature had endowed it, so that we could substitute the products of the Empire for those of foreign manufacture. The whole subject is undoubtedly a controversial one, surrounded by "thin ice," but as it affects all classes of industry and business, it is one which every thinking man is bound to study impartially, as industries should never be entangled with politics.

We must not get the idea into our minds that either of these schemes will be a "cure-all", but there are certain aspects which, if not entirely effective, will at least be alleviating.

Rationalisation (call it what you may—Concentration, Sub-division of Labour, Consolidation, Amalgamation, Co-operation, Grouping, or Pooling—it is all, and any of these) is no new idea, it is a century old. The Grouping of States, Railways, Electricity Schemes, Individuals, and Businesses, are all samples, based on the one idea of finding a something to minimise, alleviate, or cure, some trouble or problem: and having for its main objects Unifaction, Collective Control, Efficiency, and Improvement.

In studying the matter many problems apparently small, but actually most important, arise: this was proved when governments were urged from time to time to do something, but on each occasion they adopted an attitude of masterly inactivity, knowing full well that the problem was a difficult one to tackle by means of Acts or panic legislation.

There is only one letter of difference betwixt Rationalisation and Nationalisation, and although the two schemes may in some aspects appear to have much in common, they are widely separated, alike in theory and practice.

The success of Nationalisation as a cure for the depression of our basic industries is not a fact, but merely an opinion; and, as some writers assert, an opinion which many people say is contradicted by the experience of countries who have tried it.

At the present moment sheltered industries, banking and insurance companies, are experiencing great prosperity, while the basic productive industries, at one time the foundation of our economic strength, are suffering from depression bordering on collapse. Possibly the burden of rates had something to do with this, and it is hoped the relief given to heavily burdened industrial firms will help matters.

Rates are always a first charge on the cost of production, and firms with half their plant standing, have to pay the same rates as firms who are working day and night and making large profits. Where unemployment is rampant we have the anomaly of seeing rates increasing with trade decreasing. The depressed industries of shipbuilding and engineering, coal and iron were suffering badly from the high rates. Collieries are gradually getting into a position more favourable for securing home and foreign orders, and making a gallant fight in combating foreign rivalry, but a much needed impetus is required before trade recovers. The leaders of the mining industries fortunately are gifted with an optimistic spirit, and are inclined to think an improvement is actually under way and working slowly but surely—and doubtless, with careful and cool-headed leadership, working with the full use of arbitration and sound judgement, with a little more give and take from the miners' leaders—things may continue to improve.

The steel trade is so closely allied to the coal trade, that I feel inclined to trangress for a moment, and say a word about it. We need not worry too much about those writers who belittle our methods and products, and advertise to all and sundry the high cost of British goods, ignoring the fact that the quality of all our goods is far above that of our foreign competitors. South African Railways could tell us something about the failures of Continental and American locomotives and rails, when compared with those of British make, with which failures are practically unknown. The life of British steel is unequalled by the steel of any foreign country; here we have cargo boats of 30 and 40 years old, weathering all sorts of storms, while ships made of American steel have been found unfit to cross the Ocean with a cargo 10 years after being launched.

Were it not for the high tariffs in America, British steel would flood America if based on cost; in fact, American ship-owners assert that they can get five ships built in Britain, for the price of two in the United States. So far as Germany is concerned, they can only compete against us when assisted by subsidies, cheap rail rates, export bounties, and lower wages. Our iron and steel prices are only 13% above pre-war prices, while the general price index is somewhere about 40%; American and German prices for steel practically agree with the price index of other commodities in those countries. Fortunately we are blessed in our coal and steel trades with men having courage, and there is no fear that given a fair and sporting chance these trades will hold their own in the world's markets.

At home here we see steel structural work of buildings being erected entirely of foreign girders, ordered by architects who apparently judge material by price, and not by quality—paying little or no heed as to whether the beams are "brittle' or otherwise.

Town Councils are often composed of men with but the haziest idea of the merits of steel, who force their engineers into accepting foreign material on the plea of cheapness. At Blackpool, recently, a bridge gave way with fatal results, and investigations proved that the accident was due to inferior foreign steel having been used in the construction of the bridge. Incidents like these go on to show that even our own kith and kin are not entirely blameless for some of the unemployment of the country, and if they would adopt more "Rational" methods in placing their orders, it would assist that "turn of the tide" which we have all been looking for so long.

Before concluding, I would like, on behalf of the Council, to thank those members who favoured us with papers last session, also those members, who by their supplementary remarks to those papers, added very materially in making our meetings interesting and instructive.

I would also like to express our thanks to our very active and able secretary, Mr. McCallum. Mr. McCallum has mentioned that he still holds the Prize Money gifted by Mr. Baird for the best paper submitted by a Junior member; unfortunately, no paper was put forward last session, but we trust the younger members will roll up their sleeves this session, and make a bold bid for the Prize. Mr. McCallum also wishes me to bring forward to your notice the benefits of the Question and Answer Bureau, which Mr. Baird instituted. If you have any problem worrying you, either mention it at our meeting, or send it to Mr. McCallum, and every endeavour will be made to help you out of the trouble. There may be occasions when a member cannot attend some meeting where the paper is likely to be of interest to him. In such a case, it would extend the scope of the paper, and add to its interest, if the member would put his ideas and opinions in writing, and send these to Mr. McCallum, who would bring them before the meeting, and see that they were included in the reports in *The Mining Electrical Engineer*.

Discussion.

Mr. DUGALD BAIRD expressed the pleasure he had had in listening to Mr. McGlashan's paper. It contained much useful guidance. Early in it, Mr. McGlashan had said that an ounce of confidence in one's self was worth a pound in one's neighbour. The particular object of the Association was to try to give confidence to those in charge of work in collieries. At their Branch meetings they tried by educating themselves to get just that confidence in themselves. Mr. McGlashan had drawn up a kind of skeleton programme for next year, and one feature was designed to try to increase their membership and to get the young men to come forward and give papers. If the prize which he (Mr. Baird) had offered was not big enough to tempt the young men he would be quite willing to double it at any time.

Mr. GARVEN said Mr. McGlashan had given them a fine survey of the problems of industry generally. Mr. McGlashan had referred to the need for increasing efficiency by the greater use of electricity. Some might be inclined to think that the coal industry needed something to reduce production instead of to increase it, but increased efficiency of production was absolutely necessary for the benefit of mankind and this had to be done by the introduction of electrical machinery to a greater and greater extent into our collieries.

It was possible that the problems of the coal trade at the moment were due to increased efficiency. The capacity for production had been so increased, as it had been in other industries that now they had over-production and could not sell all the coal they produced. Probably they would be having a form of rationalisation at an early date and selling prices and quotas would be fixed. This might possibly give those engaged in the industry a decent living out of it. They would be able to sell their coal in competition with other people and would—it was to be hoped—get a better price for it than they had been getting in the past. He thought the coal industry could be rationalised as readily as any —possibly more easily than many other industries. It would be largely a matter of fixing prices and the quota for output.

Any increase in efficiency must be to the benefit of the people generally, and Mr. McGlashan had pointed out how increased efficiency could be attained by helping each other, even as he had helped his fellow members, and the coal industry generally by being chairman of that meeting.

Mr. ALEX. MACPHAIL said that since last year a feature had arisen which he believed would have a tendency to cheapen coal and also to increase profits, and that was in connection with electrical work. In connection with the new Government scheme they saw cables passing all over the country. Aluminium cables with steel cores were used because of their lightness and because snow would not adhere to them. Now there were on the market motors which would overthrow all existing motors through time. He used to be a great upholder of the d.c. motor, but with this new venture he believed that three-phase was going to oust the whole thing. The motor that was coming on the market would be tended by a novice with practically no training at all, it would stand any amount of abuse, would be cheap, would not break down, and would require very little attention. If such a device came along then the amount of money saved in the upkeep of electrical machinery would go a great way towards cheapening the production of coal and raising profits. From what he had read about this machinery he believed that, so far as three-phase work was concerned, there was nothing on the market at the moment that could beat it, and he believed that through it, and with the electrical scheme providing power a little more cheaply, the mining industry of Great Britain would rise to a high standard within a very few years.

Mr. JAMES GARVEN said that whatever its present troubles, the coal industry could be said to be in a better position than the iron and steel industries. When a ton of coal was burned it was gone and had to be replaced, but iron and steel could be used over and over again. Not only that, but things were being made lighter and it was possible that in Britain we had reached a point at which we required to find a greater use for iron and steel. It might be that we had so much scrap—although it had been very scarce lately—that we did not require to smelt so much as we did in former years.

Mr. ANDREW AITKEN said Mr. MacPhail had referred to a three-phase system which a schoolboy could work, but even if we got that, the nations that were competing against us would get it too and so we should be in exactly the same position as before. His own opinion was that the British workman was not getting a fair chance. In Irvine two years ago when the shipbuilding yards were in full swing, the work was held up while they waited for steel plates to come from Germany, yet at the same time the steel works at Glengarnock, only a few miles away, were standing idle. Some people said our works were obsolete and we must put in new plant. But what inducement was there to any capitalist to put in new plant, when he was prevented by tariff walls from putting his stuff into almost every other country in the world, while this country was a dumping ground for all his foreign competitors? Coming to the practical point of view, they would see that the British miner had been agitating for a shorter day and were likely to get a half hour knocked off it. In his own colliery at the present time he questioned if more than 75 per cent. of the men were working more than seven hours. Why should the Government interfere? If legislators would leave the men alone, the men and the masters would get on quite well and we should be able to compete with anyone.

Mr. MACPHAIL said he believed the saving of the coal industry was going to be in the electrical plant, simply because of what he had seen in the last few months. The production of coal was going to be cheapened by 2s. per ton, and three-phase was going to oust everything else in the country. Once these new motors were installed, the cost of upkeep would be negligible, whether it was in the coalcutter or any other power using machine.

Mr. GARVEN said it was difficult to see it as Mr. MacPhail did. Although a great deal of capital was involved in electrical plant in a colliery, it was a small proportion of the whole, and they could not reduce the capital value very much. The motor was only a small part of it. He was quite certain that the cost of upkeep of electrical plant did not run to 6d. per ton. Even by putting in as much electrical plant as they could, he would say the cost could not come anywhere near 2s. a ton.

Mr. MACPHAIL said the Chairman had spoken about the breaking of coalcutter bars. He would suggest that whenever possible the coalcutter bar should work pointing directly north and south. Thereby the molecules of the bar would all be turned in one direction and the strength of the bar would be increased from 25 to 30 per cent. They would save the bar and would also lead to the cheaper production of coal.

Mr. AITKEN.—But suppose a man goes along the line of face and strikes three inches rib of whin. He jags up his machine to keep his bar down. The bar goes down and the machine goes up, and the bar is pointing north, south, east, and west, all at the same time. The machine is off the pavement, it is in the air.

Mr. MACPHAIL.—If Mr. Aitken examines a bar after it is broken, he will find that it has been gradually crystallising until there is perhaps only an inch diameter of fibrous steel in the centre and thus it must go. It is a molecular breakdown hastened by the direction of cutting.

Mr. GARVEN.—Often in the turning of a bar we see a crack. We turn down the crack and weld it up and true it up again. Often we have bars with varieties of cracks at different points and they only last a certain time, then break through.

Mr. MACPHAIL said what had happened there was a molecular breakdown. A bar that was working north and south would invariably last longer. If these cracks did not get into it the weight of the machine would not break it.

Mr. HUGH MURRAY said he would submit that the success of industry in this country depended on them turning out inferior stuff, because the only countries that seemed to be prospering were those that were making inferior stuff. It was no use turning out boats that lasted thirty years. They should only last ten years.

Mr. GARVEN said we used to write in our copybooks in school that what was worth doing was worth doing well, and so when we got a job we tried to do it thoroughly and sometimes perhaps put more work on it than we should. Possibly the foreigner did not have the same copy-book as we, and he did not put more work on the steel than he got value for when he sold it. He would like to refer again to the efficiency and economy they were going to get from the introduction of further electrical plant in the mines. With an output of 1000 tons per day, 2s. a ton would represent about £24,000 a year. It was difficult to see where they could introduce plant so efficient that there would be a saving of £24,000. If they could save £5000 in a colliery through increased efficiency and increased use of electrical plant he thought they would be doing very well.

Mr. MACPHAIL.—Mr. McGlashan mentioned oil. Suppose we take the oil out of the coal we are left with the coke. What is to be done with it? It was not clear that there was anything in the process to help the coal industry. He, Mr. MacPhail, had become more than ever convinced in the past few months that we were on the verge of great developments in connection with electrical machinery in mines which would give a big impetus to the coal industry. To adopt machinery that only calls for the work of about a quarter of the men at present needed would mean the saving of something like 50 per cent. or more in first cost.

Mr. D. L. McARDLE said, with regard to the 7½ hour day proposal, that one speaker had stated that already many collieries were working much less than that. He agreed with that, but his own opinion was that the figure of 7 hours mentioned by Mr. Aitken was too high. There were a great many reasons why a colliery could not work eight hours. Some of the men might be working in wet places and managers were not so inhuman as to keep men in these places when the work was finished. Some of the collieries were old and it took half-an-hour to get to the face and another half-hour to get back. These things were not taken into account by the politicians. If the working day was reduced to 7½ hours, then the problem that faced them was how they were going to get the colliers to work the same time at the coal face. He thought the solution was to take them in by conveyance instead of walking. It seemed strange that men should have to be conveyed to the pit, on the surface, but when they got underground they had to walk 2½ miles to their work and the same back again. He knew a case of men walking half-an-hour up a road with a gradient of 1 in 3. He had tried it and did not feel like getting coal at the end of it. He thought that was one of the first things required—to convey the men to their working places so that when they reached them they were ready to start work and not sit down and rest or have a meal. By the man in the street the colliers were supposed to be earning a wage of 8s. 5d. per shift. They knew that the average collier was making a much larger wage than that. He was actually getting 2s. a day more than was supposed. He agreed with Mr. Aitken when he resented the interference of people who did not know what was actually being done in the industry. Personally he did not altogether welcome the day Mr. MacPhail had been telling them about for, if the cost of upkeep of electrical machinery was to be nil, then they were all going to be out of jobs.

Mr. J. C. MacCALLUM said the principal topic of Mr. McGlashan's address was Rationalisation, but he would like to say something about Standardisation—in relation to their attendances at Branch meetings. Last session their attendance had been as low as 18 per cent. and it had also risen to 98 per cent. at the Cumnock meeting. This was organised as an educational meeting and he had had requests from some of those who attended to hold another meeting there on similar lines, and this the Council had decided to do. The attendance percentages mentioned showed too great a divergence and he thought if the members would seriously consider the advantages derived from an Association of this kind, they would make a greater effort to support those who contributed papers for the edification of those engaged in the use and manipulation of electrical plant. He considered that this Association held a unique position, not only by reason of its branch meetings but by the issue of an official journal. With regard to their syllabus for the present session, he thought this would prove to be the most satisfactory they had had for some years. They had provisionally arranged for meetings up till May, 1930, and members would be notified of these in the usual way. The Chairman had mentioned the Question Bureau of the Branch and the prizes offered by the Branch for papers by members, but the Association also offered three prizes of eight, five, and three guineas respectively, so there was also a worth-while money incentive for anyone to compete.

The meeting terminated with a vote of thanks to the Chairman, proposed by Mr. D. Cook.

WESTERN DISTRICT SUB-BRANCH.

The Problem of Peak Loads.

G. E. HIDER.

(*Paper read 9th November,* 1929)

Fluctuating energy demand has always been one of the engineer's most difficult problems and one which has affected his capital and working costs to a greater degree than any other. A little reflection will show that these fluctuating demands are widely different in their magnitude and periodicity.

Thus, on the one hand, a reciprocating engine working under conditions of constant load may give rise to a rapidly pulsating steam flow, the mean value of which is practically constant: on the other hand, the steam demand from manufacturing processes may be steady at any given time, but may vary considerably from hour to hour.

A central station plant must have sufficient capacity so that it can at any time supply the maximum demand of the system which it serves. Generally it is only for a few hours a day that such equipment is earning all the money which it is capable of earning. It follows that at some period of the day there is much capital lying idle and the essential interest on such capital must be earned by the plant when it is loaded up to capacity.

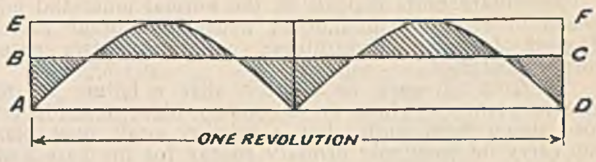


Fig. 1.

It follows that the charges for current supplied are high at peak load periods.

As is well known Power Companies will seek and accept off peak loads at rates considerably lower than those which it is necessary to charge for service coincident with the peak load. This method of adjusting charges sometimes creates difficulties, and in passing it may be stated with some confidence that the practice of giving off peak load clients the full benefit of reduced capital costs per unit generated is one which may have to be modified as the practice of purchasing current from utility companies becomes more general, as it is a little contrary to human nature to expect that widely different charges for the same thing will be helpful to such developments. It is clear, therefore, that if we can reduce those very high capital costs per unit of peak load then we are doing something towards equalising the charges which must be made for peak and for off peak demands.

However, the problem is far more complex than that of the improvement of the load factor of power stations. Let us examine it in all its phases.

Fig 1 shows a normal twisting moment diagram of a reciprocating engine. The function of the flywheel is to control the varying forces, excited at the crankpin, throughout the stroke and to maintain the cyclic variations per revolution within predetermined limits.

It will be clear, however, that the cyclical variation is not necessarily of the character illustrated, and in fact in certain rolling mill engines the torque due to the deceleration of the very heavy flywheels installed is very many times greater than the mean torque delivered by the prime mover at full load.

It is thus evident that by means of heavy revolving masses we can effect the necessary storage and release of energy to deal with constantly fluctuating external resistances and that in this way the development of power may be made more uniform, and the capacity of the power plant related to the mean load as distinct from the maximum load. The nearer we can get to this ideal the lower will be capital expenditure for a given output.

As has already been indicated variation in power load or in the quantity of steam supplied for heating and process work may obviously cause abrupt and considerable variation in the steam demand from the boiler plant.

Rarely will requirements be constant or fluctuations neutralise each other so that very wide differences between maximum and minimum requirements of steam occur, and we are faced with a thermal problem very similar to that which we have shown to be successfully solved within certain limits in mechanical engineering by the installation of flywheels, but which problem in the sphere of power generation may be much more complex.

The means and methods for improving the adverse effect on production costs of these peak loads form a common topic for discussion in engineering circles throughout the world.

We may now refer to the available methods of meeting peak loads and can then proceed to discuss in detail those with which South Wales engineers are more likely to be concerned.

Peak load plant may comprise Primary Units or Secondary Units. Primary units are self contained and may operate for two purposes, i.e., for supplying peak load power or for raising primary energy in case of necessity or breakdown. Such units may consist of peak load turbines with peak load boilers; Diesel engines; or gas engines running on available waste gases.

Secondary units depend on the normal units and may consist of steam accumulators; hydraulic storage system of peak load water turbines; and, in certain cases, storage batteries.

It must at once be noticed that a failure of the primary plant on which the secondary plant depends will close down both units, but a primary peak load plant may carry on to supply primary energy for the base load. This point must be appreciated, for the complete economic solution of any peak load problem must credit a primary peak load plant as being productive and remunerative in a wider sense than is a purely secondary unit.

The system of meeting peak load by means of thermal storage is not so fully developed in this country as in continental countries, and it is now proposed to discuss the principles of that system, as it is clear that the present trend of boiler design is towards a purely flash type with a maximum area presented to radiant heat.

The Author is distinctly of the opinion that the possibility of designing such a boiler is made easier by the developments in thermal storage. The reason for this statement will be made clear later.

It will be interesting at this stage to examine the steam flow curve taken from a battery of Lancashire boilers. This is shown in Fig. 2. Some of the audience may wonder why at such a meeting as this the type of boiler which is sometimes deemed to be obsolete is referred to. The point will emerge that due to the accumulator effect of such boilers, they are very suitable for such loads as South Wales' industries impose. Furthermore, the physical changes which occur in the working medium require exactly the same analysis whatever the type of boiler, and hence the type chosen for discussion is of little moment. Thermal storage developments may do much to displace this well tried friend of South Wales.

The rated capacity of the boilers from which Fig. 2 was obtained is 60,000 lbs. per hour, whilst it is seen from this chart that during short periods the rate of evaporation is nearly doubled.

The corresponding pressure curve shows that each peak is accompanied by a pressure drop which indicates the extent to which the accumulator capacity of the boilers is utilised.

The manner in which this combined action takes place is analysed in detail in Fig. 3, which shows how, in two instances, fluctuations of steam consumption amounting to nearly double the normal rating are met on a Lancashire boiler by falls in the boiler pressure.

In the first case, a drop in pressure from 160 lbs. to 150 lbs. occurs in two minutes, and it is shown that

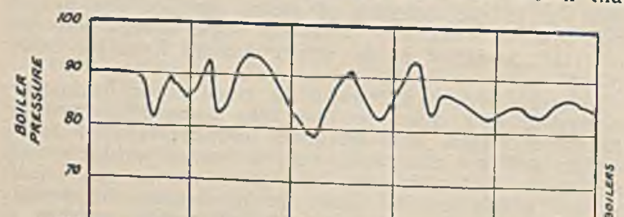


Fig. 2

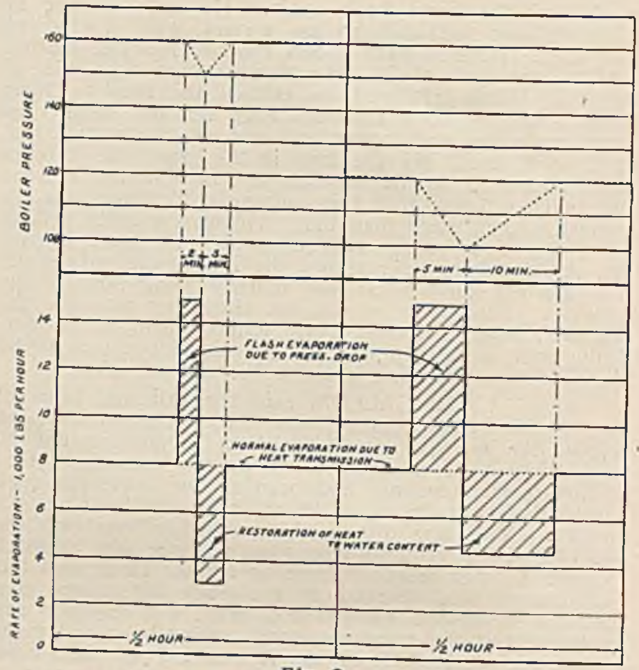


Fig. 3

this drop releases 245 lbs. of steam at the lower pressure from the 42,000 lbs. of water in the boiler. This is equivalent to a rate of evaporation of 7,350 lbs. per hour, giving a total rate of evaporation during the two minutes peak of 15,350 lbs. per hour.

Similarly, in the second case it is shown that a total rate of evaporation of 15,200 lbs. per hour is maintained for five minutes, during which time the pressure falls from 120 lbs. to 100 lbs.

In both these cases no variation has been made in either the rate of combustion or supply of feed water during the period of the peak load.

It will be clear that the "peak supply" depicted in Fig. 3 will be followed by a period in which the major portion of the heat transferred from the hot gases will be retained in the boiler, since the water which has flashed into steam by reason of the pressure drop must be replaced, and a normal water level regained. Making the assumptions that the periods of recovery are respectively 3 minutes and 10 minutes, the relative quantities are tabulated in Table I.

Steam boilers cannot meet extreme fluctuations in load, such as are indicated in Fig. 3, merely by an alteration in the rate of firing. As already said, the present trend of boiler design is towards a purely flash type with a maximum area presented to radiant heat; pulverised coal assists in providing greater flexibility and ability to meet peak loads but in every system there is a time lag, and it is impossible to meet the instantaneous fluctuation in energy demand, referred to earlier in this article, merely by an adjustment of the rate of firing. Even within the limits of such adjustment there will be a variation of efficiency which will have an important effect on the costs of steam production.

It is now necessary to refer to Tables II, III, and IV containing data relative to water and steam at different pressures and temperatures.

Let us examine the difference in the various quantities relating to steam and water at, say, 300 lbs. per square inch and 250 lbs. per square inch. The temperatures are respectively 421°F. and 406°F. a difference of 15°F. If then water is stored in a vessel at the pressure of 300 lbs. per square inch and at 421°F. and the pressure is reduced to 250 lbs. per square inch, there is an immediate liberation of energy due to the difference in the sensible heat under the two conditions. In this case, assuming the specific heat of the water to be unity between these limits, 16 B.Th.U. are liberated

TABLE I.

Pressure drop P_1 to P_2	160 to 150 lbs.	...	120 to 100 lbs.
Heat liberated per lb. of water	342.8 — 337.8 = 5.0 B.T.U's.	...	321.2 — 308.6 = 12.6 B T U's.
Water content of boiler	42,000 lbs.	...	42,000 lbs.
Total heat liberated	210,000 B.T.U.	...	529,200 B.T.U.
Latent heat of steam at P_2	858.3 B.T.U.	...	882.1 B.T.U.
Evaporation due to pressure drop	245 lbs.	...	600 lbs.
Time in which drop occurs	2 minutes	...	5 minutes
Average rate of evaporation due to press. drop	7,350 lbs./hour	...	7,200 lbs./hour
Normal rate of evap. due to heat transmission	8,000 „	...	8,000 „
Total rate of evap. during period of press. drop	15,350 „	...	15,200 „

Recovery of Boiler Pressure to P_1.

Period of recovery	3 minutes	...	10 minutes
Heat restored (steam equivalent)	245 lbs.	...	600 lbs.
Rate of restoration (steam equivalent)	4,900 lbs./hour	...	3,600 lbs./hour
Aver. rate of evap. during period of recovery	3,100 lbs./hour	...	4,400 lbs./hour

TABLE II.

Volume and Weight of Distilled Water at Different Temperatures above 212°F.

Temperature of Water in Degrees F.	*Corresponding Pressure of Steam above Atmosphere.*	*Weight of the Water lbs. per cu. ft.*
212.0	0	59.828
239.4	10	59.097
258.6	20	58.541
273.9	30	58.078
286.5	40	57.680
297.5	50	57.325
307.2	60	57.003
319.8	75	56.571
337.7	100	55.949
365.7	150	54.931
387.7	200	54.102
406.0	250	53.396
421.0	300	52.00

TABLE III.

Properties of Steam.

Temperature of Boiling.	*Gauge Pressure.*	*Heat of Liquid from 32°F.*	*Latent Heat.*	*Total Heat.*
212.0	0	180	972	1152
239.4	10	208	954	1162
258.6	20	227	941	1168
273.9	30	242	931	1173
286.5	40	255	922	1177
297.5	50	266	914	1180
307.2	60	277	906	1183
319.8	75	289	897	1186
337.7	100	308	882	1190
365.7	150	337	859	1196
387.7	200	361	838	1199
406.0	250	380	821	1201
421.0	300	396	806	1202

TABLE IV.

Storage Capacity of Water.

(Lbs. of Steam released per cu. ft. of water when pressure falls from P_1 to P_2.)

P_1	P_2	*B.T.U's. liberated per lb. of stored water.*	*Lbs. of Steam per cu. ft. of water.*
300	250	16	1.01
250	200	19	1.21
200	150	24	1.52
150	100	29	1.80
100	50	42	2.57
60	10	69	4.13

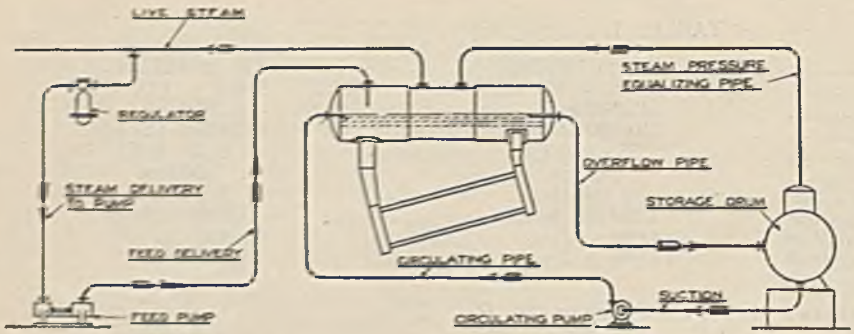


Fig. 4.

from 1 lb. of water and there is consequently a production of steam, at the lower pressure, having equivalent latent heat.

It will be seen from Table III. that the total latent heat of 1 lb. of steam at 250 lbs. per square inch is 821 B.Th.U., so that obviously we have to store a large volume of water in order to generate steam by these means. It will be clear that 51.4 lbs. of water at 300 lbs. would be required to produce 1 lb. of steam at 250 lbs. under the condition referred to.

Table II. shows that the weight of 1 cubic foot of such water is 52 lbs. so that we must store approximately 1 cubic foot of water to obtain 1 lb. of steam within the stated pressure limits. If, however, we consider a 50 lbs. pressure drop lower in the pressure range we shall find a very different condition.

Imagine that water is stored at 100 lbs. per square inch and that the lower pressure is 50 lbs. per square inch. Here from Table IV. Col. 3, we have 42 B.Th.U. liberated and a latent heat of 914 B.Th.U. so that in this case we require 21.8 lbs. of water to be stored to produce 1 lb. of the lower pressure steam. The weight of a cubic foot of water at 337°F. is 55.949 lbs. so that every cubic foot of such stored water would produce 2.57 lbs. of steam.

To make the essential principle clear we will examine the condition under a fall of pressure from 60 lbs. per square inch to 10 lbs. per square inch. In this case 69 B.Th.U. are liberated by every 1 lb. of water. The latent heat is 954 B.Th.U. so that we require only 13.8 lbs. of water to provide 1 lb. of the low-pressure steam. The weight of 1 cubic foot of water at 207.2°F. is 57 lbs. so that every cubic foot of such water will produce just over 4.1 lbs. of steam. The above results are shown in Table IV. The interested engineer should extend this table to include other pressure ranges.

Two important phases of thermal storage emerge from the preceding figures. Firstly, that steam may be stored in water until it is required to be used and, secondly, that the storage capacity is vitally affected by the pressure range within which it is necessary to operate.

Subject to most careful investigation of all concomitant factors, we have seen that in steam storage we have a means of keeping the peak loads away from the boiler house, thus allowing the boilers to be operated at the rate of maximum efficiency. It must, however, be remembered that an accumulator of the type we have discussed is a reservoir between the boiler house and the consuming units, and that an essential to its operation is that some portion of the latter units shall require steam at a lower pressure than that at which steam is generated by the boilers. It is therefore particularly suitable for use in connection with plant which supplies steam both for power and process work. In such cases the maintenance of high and relatively constant boiler pressure may be essential to the satisfactory operation of the power units, whilst the accumulator provides a reserve of steam at lower pressures to meet abrupt and fluctuating demands from process plant.

It will be seen that this type of accumulator may be used as a peak load unit within prescribed limits. An objection is that the steam at the lower pressure will be wet and thus is in that state which we try to avoid when seeking high efficiency ratio in steam driven prime movers.

It is now necessary to consider another system of thermal storage. This system is sometimes erroneously termed the Constant Pressure System but the Author is distinctly of the opinion that such a title is misleading inasmuch as, if necessity arises, peak loads of large magnitude but of short duration may be met by an allowable pressure drop.

On the water-line of the boiler an overflow pipe is connected to a storage vessel. Water is continually circulated by a pump from the storage vessel to the boiler, and is therefore maintained at the temperature corresponding to the pressure of the steam in the boiler. A steam pressure equalising pipe connects the steam space of the boiler to the top of the storage vessel.

Feed water is delivered to the boiler in the usual way, but the rate of feed is controlled by a regulator operated by the boiler pressure. When the steam demand is in excess of the normal rate of evaporation due to the rate of firing a slight fall in pressure operates the regulator and reduces or entirely stops the rate of feed. *Vice versa*, when the steam demand is below the normal rate of evaporation, the regulator allows the full rate of feed to be maintained. The excess feed then flows from the overflow pipe at working level to the storage vessel and is stored at boiler temperature in readiness for the next peak. The regulator must be very sensitive, so that very slight pressure variation serves to control the rate of feed.

It will, therefore, be seen that during a peak load period when the feed supply is stopped, the boiler is purely an evaporator transmitting only latent heat to the water. At low loads heat is transmitted to evaporate the smaller quantity of steam required and also to give sensible heat to the increased quantity of feed water which passes into the storage vessel. A diagrammatic arrangement of this system is shewn in Fig. 4.

(*To be continued.*)

MIDLAND BRANCH.

The monthly meeting of the Midland Branch was held on Saturday, Nov. 30th, 1929, at the University College, Nottingham, Mr. R. Wilson presiding. The Minutes of the previous meeting were read and passed.

The Secretary read correspondence respecting the descrption to be applied to mining plugs; Mr. Routledge moved and Mr. W. Wyness seconded, that the Branch considered they should be described as "B.S." plugs instead of B.E.S.A.

It was arranged to hold the next meeting at Mansfield on Dec. 21st, and also that ballot papers be sent out with the notices on the question as to whether future meetings should be held in the afternoon or evening on Saturdays, or a week-night.

Mr. R. Wilson then delivered his Presidential Address, the concluding part of which was a description of an uncommon system of earth leakage protection.

Presidential Address.

R. WILSON.

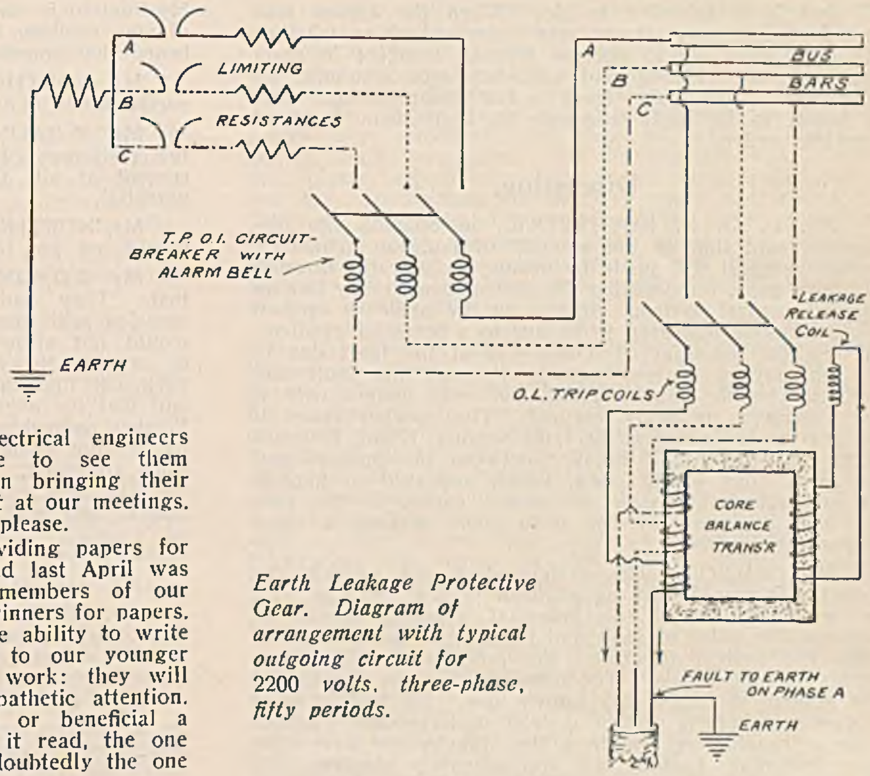
For the third time I have the privilege, as your President, of addressing a few remarks to you. On the two similar occasions I took advantage of the opportunity to speak more particularly of the work of the Association, and matters of general interest to Mining Electrical Engineers. It is now intended to refer to one or two matters about which I have spoken several times already but which, in view of their importance, can usefully be dealt with further.

The first point is that the total membership of this branch has fallen during the past year. There are probably several reasons for this: one reason may be that the organisation of the branch is not so satisfactory as it might be. Those members who have ideas in regard to improvements should bring their suggestions forward and, believe me, no effort will be too great for us to make the alterations or improvements which members think advisable. Speaking not only for myself but for the whole of the Midland Branch Council, we have no other desire than to make the Midland Branch a real, live, useful, and beneficial organisation.

I claim, with some knowledge, that we have amongst us in this branch, the cream of the mining electrical engineers in the district, and I would like to see them a little more enthusiastic and free in bringing their experiences and difficulties into the light at our meetings. Bring your problems to the meetings, please.

There is also the question of providing papers for the meetings. The session which ended last April was the first one for some years that members of our Branch had not been amongst the prizewinners for papers. We have amongst us members with the ability to write valuable papers, and I would appeal to our younger members in particular to tackle that work: they will receive every encouragement and sympathetic attention. Moreover, no matter how interesting or beneficial a a paper might be to those who hear it read, the one who derives the greatest benefit is undoubtedly the one who writes it.

There are many other matters of first interest to the branch and the Association generally which I would have liked to broach such as, for instance, Certification and the Status of Colliery Electrical Engineers. Time does not permit me to do so on this occasion, for I have to bring before you a short description of an uncommon system of earth leakage protection.



Earth Leakage Protective Gear. Diagram of arrangement with typical outgoing circuit for 2200 *volts, three-phase, fifty periods.*

EARTH LEAKAGE PROTECTION.

In submitting this system for your consideration, I do so not only with the idea of explaining the arrangement, but also in the hope that I shall evoke a useful discussion. Those who are personally responsible for the installation and maintenance of electrical plant underground at collieries must have, from time to time, had experience with the phenomenon which I call parallel earth shocks; that is to say, persons who, being in contact with earthed apparatus at the moment of the occurrence of a fault, receive an electric shock even when the earth system concerned has been in first-class condition and complying with the regulations of the Coal Mines Acts. Whilst the occurrence of this phenomenon does not appear to follow any given law, it is most frequently observed when the fault occurs at the end of long lengths of cable, and on three-phase systems with the neutral point of the system earthed. The reason is quite simple, it is due, primarily, to drop in pressure along the earth conductors. I do not suggest that such shocks are dangerous to life but I do suggest that on high tension systems, at any rate, they can be decidedly unpleasant, and have a very undesirable effect on the minds of the men who have to use the apparatus.

It is not my intention to inaugurate a discussion on whether it is best to earth the neutral point of alternating current systems or not, but one of the strong arguments in favour of earthing the neutral is, that it lends itself to simple and suitable forms of earth leakage protection gear.

The arrangement to which I wish to call your attention is shewn on the diagram, and the advantage claimed for it is that either core balance or current balance earth leakage transformers can be operated on systems with the neutral point unearthed and without the possibility of any parallel earth shocks. As can be seen from the diagram, the arrangement consists of a horn gap connected from each phase to earth through a limiting resistance, the gaps and resistances being controlled by an automatic triple pole oil immersed circuit breaker fitted with an overoad trip coil on each pole, and an alarm bell to indicate when the circuit breaker is opened.

The operation of the system is as follows: Assume a fault on phase A on the outgoing circuit as shewn on the diagram, immediately that phase makes contact with the armour or earth conductor, it comes to earth potential and the other two phases take up a potential difference equal to phase-to-phase voltage. This, of course, happens without any flow of current through the earth conductor and, as is well known, with a three-phase system with an unearthed neutral it is possible to work with any one phase earthed without interference to that system in any way. That is only by the way. To follow the operation of the arrangement we have under consideration, we find that as soon as the faulty phase A has reached earth potential, then the potential difference across the horn gaps C and D becomes equal to full phase to phase voltage voltage and the gaps are so adjusted that the current will arc across at that voltage. This also allows sufficient out-of-balance current to pass through the fault, to induce the current in the secondary winding of the core balance transformer necessary to open the circuit breaker on the circuit concerned. It should be observed that this current must be at or near earth potential only, as there cannot be any flow of current until the faulty phase is at earth potential. The gap on the horns varies according to the pressure on the system: for a working pressure of 2,200 volts between phases the gap is 13/1000 inch. The ohmic value of the limiting resistances is determined by the capacity of the largest outgoing circuit and the amount of leakage current necessary to operate the leakage protive gear on that circuit.

The system has been in operation for seven years and though there are not any outgoing circuits more than one mile in length, I claim that the system does all that it is intended to do. When the system was first installed, some doubt was expressed as to whether the horn gaps would operate without trouble; in practice they are cleaned and adjusted once a month, an operation which only takes a few minutes, and this is found to be quite adequate to keep them in good working order.

Discussion.

Mr. L. G. F. ROUTLEDGE, in opening the discussion, said that at the moment of fault an artificially earthed neutral was made by means of the paths through the horn gaps, thus making the system temporarily like an earthed neutral system. Shocks on the ordinary earthed neutral system appeared to be due to a potential gradient, the highest potential of which was at the fault due to the amount of current passing through the fault and built up by the fault current, but only momentarily if the system is properly earthed. The speaker asked if the current is limited at the fault because, if not, it would seem that the circuit breaker between the busbars and the horn gaps would open, which appeared to him to be an undesirable state of affairs, except in the case of any likelihood of the horn gaps making a short across the busbars.

Mr. WILSON.—The system does not operate the same as it would with an artificial neutral, because with an artificial neutral the potential gradient would be between the point of fault and the neutral point, whereas with the system described the potential gradient was across the gaps only. The question of these shocks did not appear to follow any known law. He had in mind a system where a certain district underground was fed from a transformer, and from this transformer there were four outgoing feeders, all approximately similar, with the same size conductors. On two of these circuits it seemed impossible to prevent a shock, and on the other two nothing happened. He thought it appeared to be something in the geological formation.

This arrangement was only suitable for high tension systems; it would not work on a 550 volt system. The potential gradient was not through the fault; before any current could flow the faulty phase had to be brought to earth potential.

Mr. ROUTLEDGE asked what was the experience of members with regard to shocks when the neutral was earthed through a resistance, and also direct. He (the speaker) had been told that with the neutral earthed direct shocks were more severe and also that protecting switches were more often severely damaged with the neutral earthed direct, than when it was earthed through a limiting resistance. He was also under the impression that the Mines Inspectorate preferred the neutral to be earthed direct.

Mr. WILSON asked whether Mr. Routledge meant through resistances or direct; if the neutral was earthed direct one did come up against the trouble of switches being blown to pieces, but he was of opinion that the potential gradient was more pronounced; the effect of the resistances seemed to keep up the pressure near to the fault.

Mr. WILLIAMS.—Would they be circuits fitted with leakage trips?

Mr. WILSON.—There are a good many systems without earth leakage gear, simply fitted with three overload trips.

Mr. ROUTLEDGE said the earthed neutral on three-phase systems had been the subject of discussion and argument for many years, at least 25 to his remembrance, but the leakage protective system as applied to mining switchgear had only come into general vogue at mines within, say, the last 14 years or so.

Mr. WILSON.—The arrangement shown is a better job for a colliery. The principle involved so far as it affected the big power schemes and industrial concerns was different. Collieries had a lot of gear underground, and the men using it were apt to get fads and fancies. He thought it was a psychological matter; he had heard of men refusing to work haulage gear because they had heard that someone had had a shock.

Mr. NORTHCOTT asked what was the effect of the partial earth, i.e., high resistance earth.

Mr. WILSON.—It would work just the same. If the resistance of the fault was sufficient to pass any current at all, that faulty phase went down to earth potential.

Mr. NORTHCOTT.—If you got a high resistance you would not get the same potential across the gaps.

Mr. WILSON replied that he had experimented with that. They had had that condition arising on one occasion with the type of fault suggested and the fault would not allow sufficient current to pass through it to provide the necessary out of balance; but at that particular time they were carrying out some experiments, and had the overload trip set very low, and the circuit breaker opened and rang the bell. They were not able to get the value, as the apparatus was burnt out that same afternoon.

The real advantage claimed was, in the first place, that if there was a fault to earth there was no possibility of a parallel shock. Otherwise they relied upon the ordinary type of circuit breaker.

Mr. HUDSON.—Does it trip the overload switch?

Mr. WILSON.—The overload switch can be set so that it will operate at any time there is a fault, and it has the advantage that the man in the powerhouse knows immediately there is a fault.

Mr. ROUTLEDGE.—The circuit breaker seems to be a disadvantage except in the case of short circuit mentioned previously. Why does Mr. Wilson call the shock he refers to "parallel shock"? Where does the word "parallel" come in this connection?

Mr. WILSON.—The circuit breaker was chosen for its rupturing capacity.

Mr. WYNESS.—What would be the effect of high resistance leak on all three phases, say in the presence of water?

Mr. WILSON.—Under those conditions reliance would be placed upon the ordinary overload protection for dealing with short circuits, which boils itself down to relative values of currents and resistances. The interesting feature is the fact that the system described will work and will do all that is claimed for it. He, Mr. Wilson, believed it to be quite a logical arrangement, and the fact that the three phases could be run so near to earth as 13/1000ths of an inch was amazing.

Mr. WILLIAMS.—What happens when surges ooccur?

Mr. WILSON.—So far as surges are concerned, they merely result in discharges across the gap. There are very heavy current machinery and large transformers on this system, and sometimes when switching in surges are induced which give these discharges across the gaps. The system was worked so that it would not be opened out until the heaviest circuit had been tripped.

Mr. ADAMS.—What is the lowest pressure on the system on which this arrangement will work? Has it been tried below 2000?

Mr. WILSON.—No.

Mr. WYNESS asked for comparison of the expense of this system as against earthing the neutral direct.

Mr. WILSON said the use of the system was warranted if only for the reason that it was worth while to prevent men getting parallel earth shocks. Some of the older collieries have high tension circuits two or three miles inbye.

Mr. PEACH.—What would be the effect of unbalanced load on the system apart from any earth. Would the core-balance operate the main switch?

Mr. WILSON.—The working of a core-balance transformer would operate on this system the same as on any other.

Mr. WILLIAMS.—Referring to the instance of two cables carried a certain distance inbye, and getting a shock on one when not on the other: the earth system could not be equal.

Mr. WILSON.—The condition of the floor varies.

Mr. WILLIAMS having said he was not convinced,

Mr. ROUTLEDGE said that, theoretically, there should be no difference, but it did occur in practice, and it seemed to him to be due more to differences in the earth circuits and connections than to anything else.

Mr. WILSON.—Every condition in that particular case was checked over and all those possibilities were wiped out.

Mr. HUDSON.—What is the size of the limiting resistance?

Mr. WILSON.—It is a non-inductive resistance, but he, Mr. Wilson, could not off-hand remember the value.

A SPEAKER asked if it was possible for the oil switch to come out.

Mr. WILSON.—If the oil switch comes out in the normal course of events there is something wrong with the resistance or the gaps. The oil switch is set so that it will pass more than sufficient current to operate the heaviest feeder.

A SPEAKER.—Would it be suitable for E.H.T. systems ?

Mr. WILSON replied that he would not like to say definitely, but thought it would.

Mr. ADAMS.—Would it prevent parallel earth shocks on a 20,000 volt transmission line?

Mr. WILSON said he believed it would, but thought there was no need to consider it under those conditions. Underground conditions were all that had been provided for in this system. He first saw it at work on an overhead line system.

Mr. WILLIAMS said he would like to express his pleasure at the extremely interesting nature of Mr. Wilson's Presidential Address and the earthing system he had put before them. It was a pleasure to all that he was holding the position of Branch President for the maximum period. He had pleasure in moving a very hearty vote of thanks to Mr. Wilson for the services rendered by him to the Midland Branch.

Mr. W. WYNESS, in seconding, endorsed Mr. Williams' remarks and stated they were greatly indebted to Mr. Wilson.

Mr. WILSON, in responding, said the Association was one of his hobbies and he did not mind what time or trouble he spent, as he felt more than recompensed for the amount of work he put into it.

WEST OF SCOTLAND BRANCH.

Annual Dinner.

A large company met at the Annual Dinner of the West of Scotland Branch which was held in the Grosvenor Restaurant, Glasgow, on 7th December last. Mr. G. N. Holmes, the Branch President, occupied the chair, and he was accompanied by Captain S. Walton Brown, J.P., B.Sc., the President of the Association.

Mr. HUGH C. C. FORRESTER, of Messrs. Robert Forrester and Sons, coalmasters, in proposing "The Association," said that the coal industry had been so hard hit that were it not for the aid of the mining electrical engineers they would have been down and out. They had helped by devising excellent labour-saving plant.

If they in the coal industry, he continued, were left to themselves to work out their own salvation they might succeed with the help of labour-saving machines. But, unfortunately, the coal industry had been fixed upon as the battle-ground of the politician, and they were not left to themselves.

On successive occasions when the industry was beginning to get its head above water they had been met by fresh demands, presumably coming from the miners, for higher wages and shorter hours. Both these things were excellent, and they all wished that the miners could have them. But the question was: Could the industry afford it? They in the coal trade said—and they knew—that the industry could not afford it. The only possibility of improvement lay in the direction of working away together to bring down costs, and, as these costs were brought down, to get back the old contracts which had been lost largely through the misguiding of the men.

The miners had been misled. Shortly after the war, when the country was in the throes of demobilisation, instead of getting quietly to work to have their part of normal industry restarted they butted in with the request for a shorter day, among other things, treating the country's difficulty as their opportunity. Then followed a series of disputes until the prolonged stoppage of 1926. That was how the industry came to be in such a bad state—through the misguiding of the miners by their own Federation, which was simply a political machine with a very strong bias towards Communism. The Federation did things in the miners' name that the miners never instigated, and the country, and especially the miners, had suffered a great deal by the political Communist bias of the Federation.

Captain S. WALTON BROWN, president of the Association, in replying, said he felt that a good deal of the troubles in the coal trade were caused by the large amalgamations under which the ownership of companies became dissociated from the individual. Mr. Forrester had alluded to troubles in the coal trade. In that connection he might mention that they had a motto in Northumberland that the coal trade might be sick but that it never died.

Professor G. W. O. HOWE, D.Sc., Wh. Sc., Glasgow University, replied to the toast of "The Guests," which was proposed by Mr. R. Rogerson.

Professor Howe made reference to the opposition of the coal industry to the Grampian water-power electricity scheme, and stated that there was a curious fallacy abroad that water power cost nothing. For that matter neither did coal, so long as you left it alone In use one was likely to cost as much as the other. There was a vast amount of water power that could not be used economically because of the great expense in securing rights, the engineering work involved, and often the long distances of transmission. These conditions might make the water power far more expensive than the use of coal.

There was, of course, the difference between the two that coal was a wasting asset, while water was a non-wasting asset, continually replenished by nature. On the same side it could be put forward that the water did not produce smoke and grime. But on the other hand neither did it produce by-products. Professor Howe, alluding to his visit to South Africa in the past summer, said there was an impression in this country that the Victoria Falls Power Co. had harnessed the Zambesi. The fact was that the Company had done no more than take their name from the Falls. When they came to the cold facts of economics they found it more economical to build coal stations at the Rand than to harness the Falls. There was no development at the Falls, and with the discovery of another coalfield in South Africa the prospect of use of the water power was more remote than ever.

In the course of the evening it was intimated that the awards made for the best papers read before the branch during the session had been won by Mr. J. W. Gardner and Mr. James Coward.

Visit to the Yoker Power Station.

In the afternoon, prior to the Annual Dinner, some seventy members visited the Power Station of the Clyde

Valley Electrical Power Co. at Yoker. This was a most interesting visit and was thoroughly enjoyed and appreciated by all taking part. After the visit, the members were entertained to light refreshment by the Clyde Valley Electrical Power Co. At the conclusion of the visit a vote of thanks was proposed by Mr. G. N. Holmes, Branch President, and was heartily responded to.

LONDON BRANCH.

Chimney Dust Problems.

J. W. GIBSON.

(*Paper read 3rd December*, 1929.)

Five or six years ago the question of flue dust emission from power station and factory chimneys was not looked upon as a source of general complaint, although there were odd cases were the dust discharge was sufficient to constitute a nuisance in the immediate vicinity of the power station. It was recognised that some flue dust was being discharged, but at that time no one had any idea what this would possibly amount to. Various rather crude arrangements were installed which were usually considered to be satisfactory so long as some grits could occasionally be drawn from the hoppers attached to the apparatus, but with the advent of pulverised coal firing a remarkable change took place in the attitude of the public to the problem.

When coal is fired upon a grate the solids which pass into suspension are produced by the mechanical action of the draft lifting the finer particles of the solid fuel off the fuel bed, or else produced by the behaviour of the fuel itself whilst undergoing the process of combustion.

Under pulverised coal burning conditions on the other hand, the whole of the fuel is deliberately placed in suspension in the gases in the combustion chamber, and burns in this condition. As might be expected, a greater percentage of solid matter reaches the chimney with pulverised fuel firing than when the same weight of coal is fired on a grate. Although with pulverised fuel firing the size of each particle of solid matter discharged from the chimney is usually quite small when compared with that which would be discharged with stoker firing, the increased number of particles tends to make the discharge from a pulverised fuel boiler more apparent than that from a stoker fired plant. A heavy discharge from the chimney can occur when the boilers are stoker fired, but this is usually and correctly diagnosed as faulty firing and, with reasonable care, heavy black smoke should never be emitted from a chimney of this character.

The very facts upon which the advantages claimed for pulverised fuel firing depend are in themselves a possible cause of a heavy dark coloured discharge from the chimney.

Boilers fired with pulverised fuel respond very readily and speedily to demands for extra steam, but if a large quantity of fuel be fed into a combustion chamber which is at an insufficient temperature or with an insufficient supply of air, conditions approaching perfect combustion may not be realised and the unburned fuel will be discharged with the flue gases in the form of a dense black cloud. With boilers fired with pulverised fuel an endeavour is usually made to carry a high CO_2 content in the flue gases. With careful firing wonderful results can and are being obtained, but it will be evident that the margin between complete combustion and imperfect combustion is much narrower than where a lower CO_2 is carried. Finer adjustment and attention is necessary.

These remarks are made entirely from the view point of the emission of dust. Obviously pulverised fuel firing must possess numerous inherent advantages, but to attempt to strike a balance between powdered fuel on the one hand and stoker firing on the other is entirely outside the limits of this paper.

In the very early days of powdered fuel it used to be stated that, as the dust discharged from pulverised fuel fired boilers would be so extremely fine, it would travel immense distances before it finally reached the ground. Experience, however, has shown the contention to be a fallacy and serious nuisance may be caused to property in the immediate vicinity of the boiler plant working under this system. When attention was thus focussed on the dust nuisance from powdered fuel fired boilers, stoker fired boilers also fell under suspicion, and it was found that in many cases they were far from being as innocent as was generally supposed.

The modern tendency is to increase boiler ratings and, whilst not so long ago the amount of dust discharged from a stoker fired boiler may have been negligible, it is far from being the case at present and it is becoming increasingly the practice to instal dust collectors upon a boiler plant irrespective of whether it is stoker fired or fired with pulverised fuel.

The problem of cleaning the flue gases of the entrained dust is usually tackled along one of four lines.

(1 By reducing the velocity of the flue gases to such a figure that the dust will fall out of suspension by gravity.

(2) By the use of an electric precipitator.

(3) By means of washing.

(4) By centrifugal means.

A fifth method has been suggested in which the gases would be cleansed by means of a fabric filter.

For a boiler plant of any size considerations of space rule the first method out of court at once.

With really fine dusts the rate of falling under gravity is dependent upon the dimensions of the particle of dust, and the settling chamber has to be of considerable length. When it is remembered that velocities as low as 300 f.p.m. will keep a considerable proportion of the coal dust as used for pulverised fuel firing in suspension, it will be seen that the cross section of the settling chamber would require to be very considerable.

Of the remaining four methods each possesses its own particular advantages with, unfortunately (since no plant can be perfect), its own disadvantages, and whilst the author may be interested in one particular method which, naturally, he considers to be the most satisfactory, he will endeavour as far as possible to set out fairly the outstanding advantages and disadvantages of both that method and the others.

Electric Precipitators.

For light dust concentrations, and where space consideration permit of a sufficiently large precipitator, this form of apparatus is probably pre-eminent. It possesses, however, the inherent defect that its efficiency falls off as the dust concentration is increased till at really heavy dust concentrations, such as would occur at soot blowing, it is practically useless.

It depends for its action upon the fact that if an electrically charged wire or plate be suspended within an earthed tube the dust travels with the electrical discharge and settles on the inner surface of the tube. Mechanical rapping mechanism is used to shake the dust from the tube so that it falls to the hopper in contra flow to the gases.

It will be seen, therefore, that the characteristic of a precipitator is exactly the opposite to that which is the most desirable, since the ideal dust separator would be one in which the efficiency rises as the volume and dust concentration increase. In other words, the ideal collector would be one in which the appearance of the chimney top is not affected whatever the load or method of firing

Washing.

Very little concrete information is yet available as to the results which have attended attempts to overcome the dust nuisance from industrial chimneys by this means. Some successes have been reported, but in other cases the results do not appear to be up to expectation. Several inherent difficulties have to be overcome before success from the cleansing point of view can be hoped for, and even then the upkeep of the plant presents new difficulties of its own.

In the first place it is essential that very intimate contact between the water and the particles of the dust must be obtained if reasonably complete elimination of the dust is to be attained, and even then some kinds of dust are extremely difficult to wet. The method usually adopted is to pass the waste gases through a water spray and then allow the water and gases to impinge on eliminator plates.

With the waste gases from pulverised fuel a proportion of the solid matter is in an extremely fine state of sub-division, and it will be seen that unless the path of the gases through the washer is considerable, and unless the quantity of water is large, the necessary intimate contact is not likely to be secured.

On the maintenace side the main difficulties would appear to be:

(1) The washing water. As has been previously stated, the quantity of water is likely to be large, and if the coal contain sulphur, the water will probably be acidulated when it is passed through the washer. Recirculation would increase the acid concentration, and the whole water circuit will have to be designed with a view to resisting corrosion. On the other hand, except for a few stations very favourably situated, it might prove difficult, or at least expensive, to provide for such an ample water supply, as to permit of the water passing once only through the washer.

It is true that the acid might be neutralised but the plant for performing this is likely to be cumbersome, and in any case the quantity of reagent necessary would be considerable.

Again, even weak acid solutions are corrosive, and since the action of the dust in the washing water would tend to keep the surfaces clean, the action of the acid upon the metal would be at a maximum.

In very few exceptional cases could the effluent from the washer be discharged direct into a stream, &c., so that some form of apparatus for separating the dust from the water would be necessary. A settling tank might be used, but this in its turn presents difficulties. In the first place a proportion of the dust is in the form of hollow spheres and actually floats; whilst, in the second place, the dust which will settle forms a glutinous mass which requires constant dredging if it is not to be allowed to form into a mud which in some cases would defy the action of a smooth edge grab.

However good the action of the washer may be, it is not perfect and some dust will pass through it. A portion of this will deposit on the fan if it is on the discharge side of the washer, and will build up on the blades. It can hardly be anticipated that it will build up uniformly and troubles due to out of balance will result. Further, once this dust has been deposited upon a surface it will be found to cake extremely hard and the labour of removing it will be found to be considerable.

In spite of the difficulties it is probable that this form of dust collection will receive very close attention in the immediate future. The recent decision in the House of Lords that a power station can be restrained from committing a nuisance by discharging sulphur fumes will inevitably mean that methods will have to be found for cleansing the waste gases of these fumes.

An interim report was recently issued by the Government Committee investigating this problem, and in the report it is suggested that the most feasible method of dealing with the sulphur fumes would be by water washing.

It is quite possible that the apparatus used for dealing with the fumes could also handle a portion of the dust in the waste gases, but it is practically certain that washing alone will not remove all the dust, whilst when the huge quantities of dust which are discharged at soot blowing is considered it would appear very unlikely that a washer would handle effectively such high dust concentrations. Details will be given later instancing the figure which the dust concentration can attain during soot blowing on a pulverised fuel fired boiler.

It has been suggested that the chimney itself could be used as a washing chamber, but the limitations with regard to time and gas velocity would be such that really effective dust extraction could hardly be anticipated; certainly both the velocity would be too high and the time of contact of the gases with the water too short to be of any appreciable use in removing the sulphur fumes.

In certain isolated cases favourable results have been reported from washing the gases in the chimney itself, but the author believes that if these cases were closely examined it would be found that in every case there was an exceptionally favourable condition such as, for instance, one boiler operating an a chimney designed for a bank of boilers.

Modern practice tends towards a boiler with superimposed economiser and a superimposed air heater with the waste gas outlet at the top. It is usual to instal the induced draft fan just under the roof and discharge into a short stack supported from the fan floor. With this arrangement a chimney some 50 ft. to 60 ft. high is considered to be sufficient. The velocity of the waste gases in the chimney will, at overload, often approach 2500 f.p.m. or 41.7 feet per second. It will be seen, therefore, that at overload when the gases will contain a fairly heavy dust concentration and even assuming that the whole length of the chimney is effective for scrubbing the gases, the time of contact of the gas and water will not exceed from $1\frac{1}{4}$ to $1\frac{1}{2}$ seconds. As far as investigations have been carried it is usually conceded that a period of contact of the order of 6 to 7 seconds is necessary, so that from this point of view good results can hardly be anticipated from washing in the chimney.

Again, Dr. G. C. Simpson in the Twentieth Kelvin Lecture entitled "Lightning" has stated that the maximum velocity which a falling rain drop can attain in still air is 8 metres per second, say 26.2 feet per second, whilst droplets 1/10 c.m. diameter would attain a maximum velocity of 4.4 metres per second or 14 feet per second. From this it would appear that if a drop of water were to be fed into an upward gas stream whose velocity was 26.2 f.p.s., it would remain stationary, whilst if the velocity were greater than this figure, the drop of water would be carried upward.

It has already been stated that the gases in a modern chimney may attain a velocity of 41.7 f.p.s., so that by this reasoning it might be anticipated that a considerable proportion at any rate of the water introduced into the chimney would be carried upwards. The result would be that the water would fall as a dirty rain in the immediate vicinity of the power house, and this in fact has been experienced in some at any rate of the stations in which washing in the chimney has been attempted.

Whilst the washing of chimney gases for the purpose of removing the entrained dust may be comparatively new the scrubbing of gases for other industrial requirements is an old problem upon which considerable research has been expended. These experiments show that mere haphazard intermingling of gases and water is not sufficient to cleanse the gas thoroughly, in fact to remove completely all the entrained dust requires the expenditure of considerably more power in actually churning the gases and water together in a specially designed scrubber than could be considered for one moment for the gases from an industrial chimney.

To obtain the best results from a washer as distinct from a mechanical scrubber it has been found necessary to carry out the washing in two stages. Firstly, the gases must be so charged with vapour by means of fine water sprays that a fog will be formed when they are brought into contact with the washing water in the second pass, and at the same time the first reduction in temperature affected; secondly, the vapour charged gases must be brought under the action of a coarse and copious water spray, which will cool the gases down below dew point, and produce a state of fog, which facilitates the wetting of the particles. The coarse spray then washes the fog with the dust out of the gases and completes the process. The reason for the necessity of this double action is that each particle of dust is surrounded by adsorbed gas and before the actual dust particle can be wetted it is necessary to break down surface tension.

At this point it may be of interest to give some very rough calculations of the quantity of water which would probably be required if the cycle of operations outlined above were to be obtained. For the purpose of these calculations it is assumed that the volume of waste gases to be dealt with is 212,000 cubic feet per minute at 280°F., and further, that the dew point of these gases as delivered to the washer would be 80°F.

The approximate weight of the dry gases

$$\text{would be } \frac{212{,}000}{18590} = 11400 \text{ lbs. per minute}$$

whilst the moisture content would be

$$0.02226 \times 11400 = 254 \text{ lbs. per minute.}$$

The total heat in the waste gases initially (measured from 32°F.) would be

Heat in dry gas: 11400 × 0.238 (280 — 32)	= 672,000
Sensible heat in vapour: 254 (212 — 32)	= 46,000
Latent heat in vapour: 254 × 966	= 245,000
Superheat in vapour: 254 × 0.48 (280 — 212)	= 8,300
B.T.U. per minute	= 971,300

Assume that the gases will leave the washer at 110°F., and saturated. Using a hygrometric table it will be found that the total heat in the gases (from 32°F.) would be:—

$$11400\ (87.66 - 11.78) = 865{,}000 \text{ B.T.U. per min.}$$

The total heat given to the water, assuming 100% efficiency of heat exchange would be (971300 — 865000) = 106,300 B.T.U. per min. Rise in temperature of the washing water (assume 60°F. initial temperature and that the water will leave at the same temperature as the washed gases, i.e. 110°F.) will be 50°F. The quantity of washing water required would be

$$\frac{106300}{50} = 2126 \text{ lbs. per minute.}$$

Allow an efficiency of say 70% for the heat interchange Quantity of washing water required for coarse sprays

$$= 2126 \times \frac{100}{70} = 3040 \text{ lbs. per min.}$$

Assume that the total heat in the gases after humidification is equal to the total heat in the gases before humidification.

Total heat in the gases per pound from 32°F.

$$= \frac{971300}{11400} = 85.3$$

To compare with the tables which are based on a datum of 0°F.

We must add	11.78
Total heat in gases at end of the first pass: B.T.U. per pound	97.08

From the tables this would correspond to a saturated temperature of approximately 115°F. when the vapour content is 0.0694 lbs. per pound.

The gain in moisture would, therefore, be

Total moisture per pound at end of first pass	0.0694
Initial moisture content	0.02226
Lbs. per pound	0.04714

Total added moisture for the first pass

$$= 11400 \times 0.04714 = 538 \text{ lbs. per min.}$$

Total water required

First pass	538
Coarse sprays	3040
Lbs. per minute	3578

say, 360 gallons per hour.

This calculation is not intended to be more than a very rough guide, and it is quite appreciated that it contains inaccuracies, but until something definite is known, for instance as to the efficiency of the heat exchange between the gas and the water, nothing would be gained by taking account of the refinements of the calculations.

Bag Filters.

In the realm of dust collection from industrial chimneys he would be a bold man who would commit himself to a definite statement as to the direction in which future progress will take place. With bag filters, all that can be said at the moment is that the outlook is not promising. The velocity of the gases through the fabric has to be low to maintain efficiency, while, in order to keep within reasonable dimensions an efficient shaking system must be installed to prevent the dust choking the pores of the filtering system. This means that the size of the filter will be large, but the main difficulty lies in the selection of a material suitable for withstanding the action of the heat of the gases, and possible acid which they may contain.

The limiting temperature for cotton fabrics would appear to be 190 degs. F., whilst woollen fabrics will withstand 250 degs. F. With these comparatively low temperatures there is a danger that the temperature of the surface of the fabric will fall below the dew point of the gases, and should this take place the acid in the waste gases would rot the fabric. Bags of camel hair have been suggested, whilst bags of asbestos have been used. These latter, though, are said to become brittle under the action of hot acid gases.

At the moment it would appear that the size of a bag filtering plant would be too great, the cost of the bags too heavy, and the life of the bags too problematical to inspire much confidence in this method of dealing with the problem, unless considerable improvements are made. With this form of apparatus, as with the precipitator and the washer, the efficiency is reduced with heavy dust concentrations. At soot blowing with its inherent heavy dust concentrations, it is practically certain that the pores of the fabric would tend to choke. This would greatly increase the back pressure against the fans and cripple the output of the boilers till the fabrics could be cleansed.

As regards sulphur fumes, the recent decision which has already been mentioned would react against the employment of bag filters. A fabric filter would, of course, have no effect upon sulphur fumes. If these are required to be eliminated therefore, it would be necessary to provide a further cumbersome plant to deal with these impurites. The space available in a power house is usually very limited, therefore it would most probably be impossible to find room for two such large plants.

Centrifugal Collectors.

Consideration of this type of collector has been left to the last, because in the author's opinion, it is the most generally suitable for boiler work. It should be clearly understood in the beginning that there is a somewhat definite limit to the fineness of the dust particle which can be satisfactorily dealt with by this method. The solid matter in suspension in the gas may, according to Prof. W. E. Gibbs, in his book, "Smokes and Clouds," be divided into three classes, as follows:—

(1) Dust: In which the size of the particle is greater than 1/1000th of a centimetre diameter, say 10 microns.

(2) Clouds: The particles of which range from 1/1000th to 1/100000th of a centimeter diameter, say 10 microns to 1/10th of a micron.

(3) Smokes: Where the particles range from 1/10th to 1/1000th of a micron.

Of these classes the first settle in still air with increasing velocity. The second settle at constant velocity according to their size, whilst the third do not settle.

The same authority gives the grading of some of the common industrial dust as follows:—

Smelter fume $\frac{1}{100}$ c.m. to $\frac{1}{100000}$ c.m. diam.

100 to 1/10 micron.

Cement kiln flue dust $\frac{6}{1000}$ c.m. to $\frac{8}{10000}$ c.m. diam.

60 to 8 microns.

and it will be fair to assume that the grading of the "dusts" from an industrial chimney will lie between these gradings. By centrifugal means we can only hope to deal with solid particles of the order defined as dusts under this grading, and even here the particles at the finer end of the scale will approach in their behaviour to those in the second category, and will be increasingly difficult to catch.

It is true that samples of the dust taken from centrifugal type collectors appear to contain some particles of solid matter in a very fine state of subdivision, but it is suggested that their presence in the collected dust may be explained by presuming that the larger particles act as big brothers to the smaller ones, and lead them in the way they should go.

At the outset one of the difficulties met with is the grading of the very fine dust. The finest sieve is the American Tyler sieve with 325 meshes to the linear inch, with this mesh the dimensions between the wires is .0017", so that the maximum size of the particle which could pass through the mesh would be 43 microns. On the Continent the German "D.I.N." sieves are favoured, and the finest of these has 100 meshes to the linear centimetre. With this mesh the opening between the adjacent wires is .00236", and the largest particle which will pass through the sieve is 60 microns.

With a large number of samples of dust which the author himself has had graded, the preponderance of the dust in the sample will pass through the 100 D.I.N. sieve, and as this dust must, in the nature of things, be the collected dust, it would appear safe to assume that the dust which escapes would be finer than the dust which was caught, and hence the "sieving" of the dust as offered to a collector would show an even higher percentage of dust finer than 60 microns. Various methods have been suggested of grading this finer dust, but most of them appear to belong to the laboratory, rather than to the engineer.

It is rather difficult to determine therefore, what the maximum efficiency of a centrifugal type of collector could be, looked at from an entirely theoretical standpoint. In point of fact the difficulties attending the determination of the efficiency of a collector upon an actual installation are almost equally great, but for the purpose of this discussion it will be sufficient to state that a method has yet to be devised which will be equally fair to the user and the supplier.

As the author is connected with a firm specialising in the manufacture of dust collectors of the centrifugal type, it would be neither fitting here to criticise competitors' designs, nor would such remarks be necessarily accepted at face value. So that, while confining attention more particularly to one line of collector design, the particulars given will, in greater or less degree, apply to all collectors working on this principle.

(To be continued.)

NORTH OF ENGLAND BRANCH.

Presidential Address.

Training, Education and Certificates.

H. J. FISHER.

(Meeting held in Newcastle, 2nd November, 1929)

In taking the chair this afternoon, I must first of all thank you for the honour you have conferred upon me, in electing me to this position. I am fully awake to the responsibilities attached to this office, in conducting the labours of this Branch, so that they may be of service to all its members, and to the industries which are so closely associated with it. As a member of this Association from its inception, I have watched its steady growth from year to year, with no little satisfaction; and, having been the first secretary of this Branch, and one of the signatories to the Articles of Association, it gives me great pleasure to have been elected to occupy the chair at the time when the Association will attain its majority next year.

When one considers the difficult times we have gone through during the last ten years, first of all the war period, then the depressed period of the last four years, it will be generally agreed that the Association stands very well to-day, both as regards membership and financial position. There is no prospect of a big increase in our membership just yet, owing to the very low wages that are being paid to working electricians at the present time. This question of low wages is having a very bad effect in more ways than one. In the first place, mining electrical work does not attract the right type of apprentice, because he sees no money in the job: for who is going to take on a job which is paid 10s. a week less than is paid to the man who sweeps the road, ar ½d. per day more than unskilled labour? However, let us hope and trust that this state of things will soon be altered.

I have very happy recollections in looking back over these last twenty years in the life of the Association, and have made many firm friends amongst the members. The things that strike me most are the great co-operative effort that exists, and the good fellowship that is to be found amongst the members of the Council, the Committees, and members generally: I do not think there can be any other Association where a greater degree of pleasant harmony exists. It is also very pleasing to see so many of our past Presidents still taking such a very active part in our affairs. The Association benefits tremendously from this, for we have had as Presidents men who are in the front rank in mining, mechanical, and electrical engineering, who still give so much of their valuable time to the interests of the Association. I think sometimes that many members do not fully appreciate the amount of work put in by members of the various Comittees, that work apart from the Branch Comittees: they deserve the thanks of the whole Association for their untiring efforts.

A great deal of useful and necessary work has been done by the Association in connection with the B.E.S.A. during this last year or two, work which is not seen by the members, but from which they must benefit in the future.

A memorandum from the Association has been presented to the Departmental Committee which is enquiring into the Qualifications of Colliery Officials, and the Educational Facilities that are available in the Coal Fields. Our representatives have attended and given evidence before this Committee. This question has also been before our Education Committee for their consideration and they are unanimously of the opinion that a great change is necessary for the technical training of mining electricians. As things stand at present, a boy leaving school and not holding a school leaving certificate is debarred from attending at once a course of vocational study at a Technical College, but he is required to spend two or three years upon Continuation Classes before he can do so.

It is very desirable that his vocational training should commence as soon as he enters upon his practical employment, and with this purpose in view, it is suggested that classes of a purely elementary and practical character, dealing with and explaining those things he meets with in his every-day work, should be made available to him.

The subjects dealt with should include only the elements of theory, such as Ohm's Law, but with lessons on its practical application: simple power calculations, and the fundamental units (keeping in view their practical application), together with practical instruction in the preparing and jointing of cables; wiring; the care of primary and secondary cells; constructional details of dynamos, motors, and transformers; the effects of phenomena such as self-induction and mutual induction; the use of the Megger, and other instruments in common use; the necessity for conductivity in earthing systems and the means of testing the same; the working and repair of bells, telephones and signals; and the study of the mining regulations.

The course would be so designed as to enable a student after say, three years, to sit for the new Second Class Certificate Examination.

It is realised that it would require thoroughly practical men with a little technical knowledge to act as teachers, and I think we should be able to find such men amongst our members.

In this way the boy's first three years in the pit would be provided for, and he would be able to pass his Second Class examination at the age of, say 17 or so. He could then, if he so desired, enter upon a more theoretical course (still, however, with a strong practical bias) to prepare him for the First Class examination at the end of a further two or three years.

It is absolutely necessary in the education of an apprentice to deal with the subjects taught, from a practical point of view, so arranged as to deal with the things he comes in daily contact with, for by doing this a greater interest in his work is created, and he is stimulated to further study.

This question of Education has been cropping up very frequently of late in various parts of the country, which implies that different people are beginning to realise the necessity for a reform in our educational systems for engineering apprentices or the like.

It has been pointed out from time to time that, if we are to increase and improve our outputs, we must train and educate our men, so that they may become reliable and efficient craftsmen and thoroughly alive to modern requirements and efficiency. In many quarters it is recognised that in order to obtain the right class of men they must be trained from the apprenticeship stage, and many of our leading engineering works have provided the means to this end by fitting up lecture rooms in the works. The apprentices are made to attend the lectures and demonstrations in the Company's time, and encouraged to extend their studies at the Technical Schools. The lectures and demonstrations are given by practical men in electrical and general engineering, the career of an apprentice is carefully watched and where special ability in any particular branch is noticeable, he is encouraged to concentrate upon that subject with the probability of his becoming a specialist in that particular thing.

In other manufacturing works the part-time apprenticeship system is in operation and has much to commend it. An apprentice spends half his time in the works and half at a Technical College day course, and he is also paid for the time spent at college. In my opinion, there are certain objections to this system, inasmuch as the syllabus of our technical colleges is, for working electricians, of too high a standard above the elementary school curriculum, and the practical side is somewhat neglected.

I believe the time has arrived when the larger colliery companies should embark upon some scheme of education of their own; and in the case of smaller companies they might adopt a part time apprenticeship scheme, or combine together and form a common Training Centre amongst themselves, where proper facilities could be provided for education not only in electrical and mechanical engineering but also in practical coal mining. Such a system would enable those responsible to pick out the smart and weed out the inefficient or unsuitable lads.

Owing to the low rates of wages that are being paid to electricians and engineers, they are leaving the collieries in large numbers, and many companies are finding it difficult to-day to get hold of the right class of men to fill the places of those who have left.

Young men who hope to make themselves thoroughly efficient must take up some form of voluntary education. I know there are many difficulties in the way of those who are anxious to acquire further knowledge and wish to attend technical classes in the scattered areas, which are generally such a long distance away from the towns where technical education is available. On the other hand many apprentices will not avail themselves of the opportunities when they have the chance to do so. Personally, I would not engage an apprentice who was not prepared to attend classes and study. Nor would I keep one who did not take a keen interest in his work and make himself efficient.

The trouble I find with many of the apprentices at the pits is that lads are made to take up an occupation for which they are totally unfitted; though in my many years' experience I have found that in the colliery districts some of the most intelligent and efficient men are to be found—men who are second to none in the whole country. I have taken and trained men who were only labourers, and they have turned out in the end to be highly skilled, intelligent, and reliable men. My experience proves that we have the right material: let us, therefore, take all possible steps to make the most of it.

Now a word about the Examinations and the Report of the Chief Examiner for the last examination; what struck me most forcibly was the evident lack of knowledge on questions regarding the Mining Regulations. Strange to say I frequently come across persons who display a very poor knowledge of the official requirements respecting the use of electricity in mines and of the ordinary precautions to be adopted to avoid danger.

The Chief Examiner also draws attention to the unsatisfactory standard of drawing or making sketches and to the answers to the Alternating Current and Lighting and Signalling questions.

It has been proposed that the Association should issue a supplement in *The Mining Electrical Engineer* devoted to a series of papers or lessons of an elementary character in electricity applied to mining, in order to help apprentices and others in their studies. It was suggested that these papers might contain examples of simple calculations worked out, and also a set of questions at the end of each paper to be worked out by the Student, with all answers appearing in the next number. This idea has certainly something to commend it, especially if the series of papers were spread over say three years. There is no doubt that they would be of great assistance to candidates who intended to sit for the Second Class Certificate Examination.

Up to the present, no workable scheme has been completed to put the proposal into operation. Personally, I rather favour the issue of a series of pamphlets that would be supplied to those who desire them. This would conserve the issue of the matter of the supplements to those who require it.

The Examinations for the Association Certificate, together with the issue of service certificates has had a great deal of consideration by the Council. In the first place, the application form for permission to sit for the examination has been modified and amended so as to overcome certain difficulties which have arisen in the past.

It has now been decided to consider the matter of issuing four classes of Certificates——(a) Honours, (b) First Class Ordinary, (c) Second Class Ordinary, (d) Service Certificates. The Second Class Certificate has been introduced because it was felt in many quarters that the ordinary certificate examination was of too high a standard for assistant electricians. A sub-committee has been formed to go into the question and to deal with the standard of the papers to be set.

A great deal of discussion in regard to the issue of service certificates has taken place, and it has now been decided that any candidate having the necessary qualifications and desiring to obtain such a certificate, should fill in the necessary form of application, setting forth the whole of his experience, the form being signed by the Colliery Manager and the Engineer or Chief Electrician. The candidate has to be not less than 30 years of age, and have had not less than five years' practical experience in the mine in the application of electricity to mining. A series of typical questions are to be drawn up as a guide to the standard necessary and they will be published in *The Mining Electrical Engineer*.

All that I have previously spoken about shows the active work that is being done by the Association. There is, however, another matter in which I think our Association could interest itself, and that is in helping to form what is termed in America a "Bureau of Mines" which consists of a committee of experts together with a representative of the Mines Department. All apparatus which is intended to be used in the Mine, has to be submitted to the "Bureau" for examination and, if found suitable, is duly put upon the list of approved apparatus and published. There is, upon the market to-day, any amount of apparatus which has been designed for mining work and which is totally unsuitable for that purpose, not necessarily from a point of view of being flameproof but weak in design one way or another. Now although the B.E.S.A. have agreed upon certain requirements in connection with standardisation this does not preclude apparatus of an unsuitable nature being put upon the market.

I am of the opinion that a "Bureau of Mines" such as I have mentioned would be of service to the Coal Trade generally and also of considerable help to manufacturers; it would greatly minimise risk of accidents and breakdowns. It is easy to see the benefit this would be to small users who are not in the position to get advice upon such matters and who are now always in danger of having unsuitable apparatus thrust upon them.

Mr. G. RAW.—When a President reads his Address he is in the fortunate or unfortunate position of being able to say what he likes, and throw as many bricks as he likes, and receive nothing but bouquets in return. However, I think you will agree with me that Mr. Fisher has not abused his position, but has rather, in what criticism he has made, seen to it that it was constructive in character. Mr. Fisher has given us the result of a great deal of very useful thought of his own as well as his own experience on the vital question of the training of the younger men who are to follow in the management of the electrical plant of the collieries. In the interests of the mining industry we will do well to ponder carefully the suggestions Mr. Fisher has outlined for us. I have very great pleasure in moving an expression of our appreciation and thanks for the admirable address delivered to us by Mr. Fisher.

The motion was carried with acclamation.

Mr. H. J. FISHER (in reply).—I must thank you all for the way you have received the address, and I must also thank Mr. Raw for his kind remarks. I could not let the opportunity pass without telling you of the tremendous amount of work the Examinations Committee have done as regards the future in the way of providing a suitable syllabus drawn up especially to meet the requirements of our junior members.

KENT SUB-BRANCH.

Stepping Stones in the History of Electricity.

H. LOWE.

(*Paper read 7th December*, 1929)

In these commercial days we are apt to forget the early history of those things which are now so beneficial and make life pleasant. This is not due to lack of appreciation for those men who struggled against great difficulties to make these blessings possible, but it is rather because we are so much absorbed in the stupendous strides still being made in all branches of science.

This paper is an attempt to bring forward briefly the most interesting discoveries in the history of electricity since the time of Michael Faraday. It is a wonderful history and one to which the author feels he can do but poor justice.

It would be difficult to find a more suitable opening than that of Faraday and his works, and probably a few words on the great man himself first, would not be out of the way. Michael Faraday, the son of a blacksmith, was born in the South of London in 1791. Early in life he was apprenticed to a bookbinder which afforded him the opportunity of reading the many books which came to his hands. He quickly showed a preference for those of a scientific nature which he studied closely. While quite a young man he attended a lecture given by Sir Humphrey Davy, the inventor of the miner's safety lamp, who was professor of Chemistry at the Royal Institution. What he heard at this lecture he carefully noted in writing when he arrived home, later sending his notes with a letter asking for assistance in entering on a scientific career to Sir Humphrey Davy. The result was that he was taken into Davy's laboratory as assistant, and ultimately became Professor of Natural Philosophy in the Institution.

About 1830, Faraday was carrying out some experiments on electricity, and discovered that a current of electricity was produced in a coil of wire when it was brought nearer to, or taken further away from, a magnet. He also found that it was immaterial whether the coil or the magnet were moved, except that the current flows in one direction when they approach and in the other when they are separated from one another.

In a similar way he showed that the magnet could be replaced by a coil having a current flowing through it, and also that in this case it was unnecessary to move the coils as previously to effect a change of strength of flow or direction in the coil having electricity induced in it, but that an increase, decrease, or reversal of current in the coil replacing the magnet would effect these changes. This brought out the discovery of Secondary or Induced Currents. As we know, and which was further found by Faraday at that time, the induced current lasts only so long as the exciting cause—that is, as long as the movement or variation of strength—continues.

Now to us all this may appear very elementary and of little note but, without exaggeration, these are the bases of all electrical-engineering principles and practice of the present day. If Faraday had not made his discovery of the result of moving a coil of wire in a magnetic field or, what comes to the same thing, altering the strength of a magnetic field in the neighbourhood of a coil of wire there is no telling how long a time would have elapsed before it was discovered how to generate electricity cheaply on a large scale. Faraday was a man so far in advance of his time that few seem to realise the practical importance of his work.

It will be interesting to give some idea of Faraday's first electrical machine. A disk of copper 12 inches in diameter, and about ¹th of an inch thickness, fixed upon a brass axle, was mounted in frames so as to allow it to revolve, its edge at the same time being introduced between the magnetic poles of a large compound permanent magnet, the poles being about ½ an inch apart. The edge of the plate and also the spindle at the point where the collecting device made contact, naturally being specially cleaned in order to introduce as little resistance to the current as possible. The conducting strips were prepared from copper and lead to serve as electric collectors placed in contact with the edge of the copper disk, one of these was held by hand to touch the edge of the disk between the magnet poles. The wires of a galvanometer were connected, one to the collecting strip, the other to the brass axle; then on revolving the disk a deflection of the galvanometer was obtained which was reversed in direction when the direction of rotation was reversed. Here, therefore, was demonstrated the production of electricity by ordinary magnets.

After Faraday produced this machine other inventors were not slow to take the lead which he had given and in 1832, Pixu produced at the suggestion of Ampère, a commutator machine which had a steel horseshoe magnet with its poles upwards and which rotated about a vertical shaft, inducing alternating currents in a pair of bobbins fixed above it.

Following on this great improvement, many men added what, at the time, were wonderful alterations; but it was not until 1848 that the idea of using the electricity generated by the machine itself was put to the purpose of exciting its own field-coils. Previously, when coils had been used, the current had been furnished either from a battery or what amounts to an auxiliary machine—in some cases mounted on the shaft of the main machine—to effect the excitation.

Nollett, in 1849, produced an alternating current machine, in the construction of which he was helped by Van Malderen. After several improvements, at the hands of Holmes, Nasson, and Du Moncel, into the "Alliance" machine, it did good work in the light-houses of France from 1863

With the years 1865 to 1867 the era of the commercial dynamo-machine was entered upon. 1866 saw the production of Wilde's self-contained machine. In this generator he used a Siemen's armature revolving between the poles of a large electro-magnet excited by currents furnished by a small auxiliary armature revolving between small permanent magnets. He also carried this to several stages and there is no doubt that this method of exciting one machine from a smaller one was in its time a very important invention.

In 1867 Wilde invented and patented several multi-polar alternating dynamo-electric machines, both self and separately excited. The self-excitation was effected by diverting through a commutator the currents induced in one or more of the armature bobbins. The first search-lights of many of the battleships of the British Navy owed their existence to these machines. It can, therefore, be seen that the machines were beginning to have a real commercial value.

1867, Siemens, in Germany, and Sir C. Wheatstone appear to have had very similar and simultaneous ideas regarding purely self-excited machines, the only difference being that Siemens proposed that the exciting coils should be in the main circuit, making what we now term a series machine, while Wheatstone proposed that the coils should be connected as a shunt.

The matter of cutting out some of the fluctuations in current strength had now been recognised as requiring attention; this was in many ways met in 1870 when Gramme produced his wound armature—wound as we understand armature winding to-day: some of the previous armatures had, of course, been wound, but this was more of a bobbin type of winding or of a two path or coil winding, known as shuttle wound.

About 1882 various ways of compounding were tried, in some of which the series and shunt coils were wound on the same cores, and in others on different limbs, the usual practice being to wind the series coils outside the shunt winding. Many people seem to claim credit as originators of the compound winding, but it is quite well-known that Brush was the first to employ such winding commercially. Brush, also, was the first to produce a machine designed to overcome, at least partially, the trouble of voltage drop when loaded, by means of the compound-windings just mentioned; again, another remarkable step in the right direction.

The years 1879-1880 saw the results of such great men's work and investigations as Elihu Thomson, Houston, Weston, and Edison. A generator by Edison was exhibited in 1879 and was termed a 60-light machine, the efficiency of which was 87% electrically but only 58.7% overall, due to wasteful eddy-currents in the bolts holding the armature together, and in other masses of metal. Edison's large "Jumbo" steam dynamos were even less efficient, and required a fan to be attached to the armature shaft to keep it cool by a forced draught of air.

Although before this time multi-polar alternating current generators had been exmerimented with, the results had not been to any degree successful, but 1881 saw a revival to the great advantage of such machines in the forms devised by Lord Kelvin (and independently by Ferranti) and Gordon, the last-mentioned constructing large two-phase machines.

Multipolar dynamos began to come into favour about this time, which again was a good step forward, and we get Hopkinson, Crompton, and Kapp giving us improved machines, after much study of the magnetic circuits with a view to improving same. Hopkinson showed how greatly the performance of a dynamo was improved by shortening and making more compact its magnetic circuit, whilst Crompton amongst many other improvements in detail, showed to advantage the increase in cross-section of the armature core. Kapp was responsible for general improvement and in conjunction with Swinburne on various modes of winding, also on machines with conductors embedded in the core disks. Then came the production of imbricated and compressed stranded conductors to obviate eddy-currents, quickly followed by the adoption of multipolar series windings for drum armatures.

Messrs. Mather & Platt in 1886 were producing dynamos which enjoyed a remarkable success and it will not be out of place to give a brief description of their work. The machine described was intended for a normal output of 320 amps. at a pressure of 105 volts running at 750 r.p.m. The field-magnet consisted of two limbs connected by a yoke of rectangular section, each limb together with its pole piece being formed of a single forging. The wrought iron used for these and the yoke was of annealed hammered scrap. The section of the limbs was rectangular with rounded corners and the yoke was bolted to the limbs, the joint being well surfaced. The iron bed-plate had a thick sheet of zinc interposed to assist in obviating magnetic leakage from the yoke. The armature coil was built up of about 1000 laminations of soft wrought iron, insulated from the shaft, and from each other, by sheets of paper. One of the two end plates was shrunk on the shaft, the other secured by a screw and locknut.

Mordey's machines were being produced by the Brush Electrical Engineering Company. The development of his "Victoria" dynamo, a 4-pole flat ring machine from the original Schuckert machine, commenced with the discovery—and also the aid of his method of examining the distribution of potentials around collectors—that by reducing the size of the pole pieces to make space for a 4-pole field, the electrical output was doubled without increasing the speed, when using the same size ring as employed by Schuckert with a 2-pole field. This might appear open to question but it must be pointed out that the original Schuckert machines had hollow iron shoes or cases which occupied a large angular breadth along the circumference of the ring. The Mordey-Victoria machines had a narrower form of pole-piece, not covering more than 35 degrees of angular breadth of the circumference of the armature. The pole-pieces were of cast-iron shrunk on the cylindrical cores of soft wrought iron which received the coils. The armature was built up of charcoal iron tape, coiled upon a stout foundation ring, contact being prevented between successive layers by means of paper tape inter-coiled between.

Simultaneously with these improvements in the continuous current dynamo, steps of no less importance were taking place in the design and construction of the alternator. The achievements of Ferranti, Mordey, Ganz, Brown, and Westinghouse, in particular claim attention.

Mordey introduced a notable departure in the use of a single compact magnetic circuit with branching poles, thus favouring the use of a revolving field magnet. Brown carried the development one stage further by the introduction of an imbricated pattern of field magnets. Then came quite a host of improvements in armature construction. Ganz & Co. were early in the field with alternators constructed entirely of laminated iron in both field magnets and armature cores; whilst at that time a method of compounding alternators was devised. The advantage gained in large machines by the flywheel action of the heavy revolving masses told, to some extent, in favour of this type, though practice has reverted to the use of magnet wheels with radial poles, each pole being separately wound. Polyphase alternating current generators have been introduced chiefly since 1891, for the purpose of furnishing two or more alternating currents differing in phase from one another; the reason for these machines being the ease of distributing power in suitable form for alternating current motors.

Although at this time power was not given nearly so much consideration as light, it had become evident to those who were dealing with such matters that the collecting device, i.e., the commutator of direct current generators was not all that could be desired to cope with the loads which were, even at that early date, beginning to be experienced. The trouble being that of the difficulties of mechanical construction in the case of low voltage large output machines, and electrical troubles such as flashing-over in the case of high voltage machines. Furthermore, commutators at any time are to a great extent fragile and a potential source of trouble.

The exhibition at Frankfort in 1891 marked the serious introduction of polyphase methods for the transmission of power. The Paris Exhibition of 1900 was chiefly notable for the disappearance of the bi-polar continuous-current machines, and for the notable development of large alternators of high voltage.

In 1886 John and Edward Hopkinson published a remarkable paper on predetermined results, from theoretical considerations, on dynamos, which enabled machines to be produced having characteristics in practice as set down in the design drawings.

Turning now to consider the Induction Motor and its early history: as in the case of most branches of science, the discovery of magnetic rotations, which is the principle of the induction motor, and to which discovery it owes its existence, was made simultaneously, or nearly so, by several persons—for all of whom priority has been claimed. About 1824 Gunbey, the celebrated instrument maker in Paris, had noticed that if a compass needle were set in oscillation about its pivot it came to rest quicker if the compass-box were of copper rather than of wood or similar material. At the same time Barlow and Marsh, at Woolwich, had been observing the effect on a magnetic needle when a sphere of iron was rotated in its neighbourhood. Arago, the astronomer, however, was the first to publish an account of such observations, which he did verbally in Paris in 1824. His method of demonstration was to hang a compass needle within rings of different material, push the compass needle aside to about 45°, and count the number of oscillations before the angle of swing was reduced to 10°. The result was: in a wooden ring the oscillations were 145, in a thin copper ring 66, and in a stout copper ring only 33.

This proved, fairly conclusively, therefore, that the presence of a mass of copper damped the vibrations of the needle. In 1825 a successful reversal of Arago's experiment was announced, when it was found that by spinning a magnet under a pivoted copper disk the latter was caused to rotate briskly. It was also discovered that if slits were cut radially in the copper disk, its tendency to rotate with the spinning magnet were dimished in the following ratios. Taking the rotatory force of the unslit disk to be 100, one radial slit reduced it to 88, two to 77, four to 48, and eight to 24. More and more experiments with copper disks in the presence of magnets were made and the results made known, but the true theory of the effect did not seem to have occurred to anyone that Arago's rotations could be made use of in the construction of a motor prior to 1879.

In that year Baily produced the first Induction Motor. His machine still had a copper disk, but his method of producing a rotating magnetic field was unique in its way. To produce this he employed four magnetic coils with iron cores joined to a common yoke. The coils

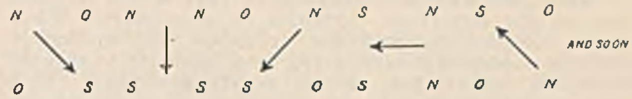


Fig. 1.

were connected two and two in series like two independent horseshoe magnets set diagonally across one another. The two circuits were connected to an ingenious commutator to effect a supply of alternating current to the coils from the batteries which were the source of energy.

Upon turning the commutator, which had a wire handle for the purpose, the copper disk, which was pivoted centrally between the four poles, was found to rotate. The result of turning the commutator being cause a rotating magnetic field in the poles as shown in the Sketch, Fig. 1. Mr. Baily had very clear views as to how far this really represented a rotatory magnetic field, and a statement he made is as follows:—

The rotation of the disk is due to that of the magnetic field in which it is suspended and we should expect that if a similar motion of the field could be produced by any other means, the result would be a similar motion of the disk."

In 1883 Deprez laid the important theorem as to the production of true rotating magnetic fields by the combination of two alternating currents, having a phase difference of a quarter period or 90 degrees. This theorem, however, bore no fruit at the time and remained a geometrical obstruction.

Professor Ferraris, in 1885, constructed a motor having a common yoke made by winding iron wire around an exterior of some other material and enclosing two pairs of electro-magnets. Two-phase alternating currents were supplied to the coils and the pivoted central body was observed to revolve. He expounded the theory of inserting in a single-phase alternating current circuit, a resistance without self induction to give one branch, and into another branch a coil of high self-induction compared with its resistance, as a means of obtaining currents as nearly 90 degrees out of phase to be effective. He then set two coils of wire at right angles to one another and supplied each with alternating current 90 degrees out of phase and suspended in the central space a hollow closed cylinder of copper which rotated when both phases were switched on. The same results were obtained when a cylinder of iron was substituted for that of copper as did that of laminated iron which was also tried. A larger and more practical effort was produced by Ferraris with a machine having as a rotor a copper cylinder of 10 lbs. weight. From this machine he deducted that the inductive action would be proportional to the "slip."

Bradley in 1887 truly described a polyphase motor when one of his claims for a motor he had produced was that it consisted of a field magnet, armature and pairs of current leading devices—the respective pairs being independently connected into the armature winding at alternating points of the same, and arranged for connection with two independent external circuits. In 1888 came an asynchronous motor, driven by means of directed eddy-currents in a stationary external mass of iron. The rotating inductor received two-phase alternating currents through four sliprings, and the whole principle of magnetic slip was explained by Bradley when he took out his patent for this machine. In 1889 the same man describes a similar armature tapped at three equidistant points and connected to three sliprings, thus constituting a three-phase machine. The researches of Nikola Tesla did much in the improvement of polyphase, and especially induction motors, and to discuss his work at length would take quite a long time. In 1888 he discovered that for two-phase machines he could use a common return and thus reduce the original number of four sliprings to three. He also showed how to take off an alternating current supply from a direct current generator by providing it with sliprings joined to symmetrical points on the commutator.

The Exhibition at Frankfort in 1891 was a stepping stone in the history of electricity in many ways. When it was decided to hold the exhibition, the matter of available supply was considered, and in order to demonstrate the advantages of the polyphase system, both for transmission and power purposes, it was arranged to obtain a high-pressure supply by overhead line from Lauffen, where there was a hydro-electric station, 110 miles from Frankfort. To transmit, as was proposed, 100 H.P. through three copper lines, each only 4 millimetres thick, and with an efficiency of 75 per cent., necessitated the pressure of transmission to be no less than 8000 volts. This was accomplished and was indeed a wonderful and sensational achievement at the time. Rather strange as it may seem, the Imperial German Post Office rendered very material assistance in the difficult task of laying out and constructing the line. Also the copper wire for the line was lent by a German firm.

Two machines at Lauffen were utilised to furnish 1400 amps. per phase, the machines being three-phase at about 55 volts. This was first stepped up to 8500 volts, and at Frankfort stepped down again to about 65 volts. The transformers were oil-immersed and were star-connected with grounded neutral. The lines were carried on about 3000 poles at a height of 25 feet, each pole supporting three porcelain insulators with internal rims for holding oil. It crossed territories of four governments. The total weight of copper in the line was about 60 tons

In the exhibition itself there was a 100 H.P. three-phase motor working a centrifugal pump taking about 60 H.P. for raising water for an artificial waterfall in the grounds. In addition to this there were smaller motors and also about 1000 glow lamps operated by the current so transmitted.

It was generally feared at the time of construction of the line, except by those who had promoted the matter, that the enterprise would be a failure owing, some thought, to the effect of capacity of the lines acting as a condenser or to leakage over the 10,000 insulators used to support the lines. It is claimed, however, that the only loss experienced was that due to resistance.

In some further researches made later in the year extra-high-pressures, in some cases exceeding 28,000 volts, were successfully transmitted along the same lines by putting two transformers in series at each end of the line. The transmission of power from Lauffen to Frankfort with a pressure of 25,000 volts between lines and with a frequency of 24 cycles per second, gave an efficiency of 75% with a load of about 180 H.P.

The Lauffen-Frankfort transmission was much more than a mere experiment. It was a daring and successful demonstration, not only of the utility of high voltages in transmission of power, but of the success of polyphase currents. As such it marked an epoch in the commercial development of electricity. It evoked extraordinary interest throughout the Continent of Europe and in Germany especially.

It is only fair at this point to say a few words about Ferranti who was, at that time making rapid and wonderful steps in the practical uses of electricity. At an early age he showed great interest in steam locomotives, but soon abandoned these in favour of the study of electrical matters in general. When he was only 18, which was in the year 1882, he had completely altered the recognised construction of alternators. To do this he did not make use of entirely new principles but applied the gift which he possessed of reducing accepted principles to their simplest forms. Also at this time he took out his first patent for the Zig-Zag armature which was taken up by Mr. Alfred Thompson and Mr. Ince who formed a company, of which Ferranti was appointed engineer. Some little time later he laid down the principle, and it is believed that he was the first to do so, that generation should take place at large stations outside great cities. The idea up to this time having been that the ideal centre of gravity of the load should rigorously be adhered to, regardless of economic considerations. The Deptford Station, London, was established on his principle, and whereas prime-movers of 500 H.P. were at that time looked on, by most people, with suspicion, Ferranti at the age of 24 was engineering schemes for employing 10,000 H.P. 1000 volts was also considered high but he was talking familiarly of 10,000 volts. More experienced—or at least older—engineers were inclined to doubt the success of this venture and being up against the difficulty of obtaining a cable by which to transmit his energy at this pressure, he designed and manufactured the cable himself.

Deptford itself is 8 miles from the centre of London, and the scheme provided for transmitting, at the pressure stated, by means of trunk mains which radiated to different transforming centres where the pressure was reduced to 2400 volts, and then distributed to consumers. The plant was to consist of four 10,000 H.P. engines and dynamos, and two smaller ones of 1500 H.P. each, while the steam raising plant was capable of supplying steam to the extent of 65,000 H.P.

As an instance of the enormous size of these machines, it may be said that the diameter of the large machine was 42 feet and the alternator when completed weighed 500 tons. The dimensions of the engine shafts were equally remarkable. Each one was 36 inches in diameter. They were forged from 75 ton ingots and, when completed, were twenty feet long and weighed 23 tons.

A rather interesting, and at the same time amusing, experiment was carried out by Ferranti before representatives of the Board of Trade in an endeavour to prove to them the perfect safety of concentric cables, the outer of which was earthed, working at 10,000 volts. The experiment was, that an assistant of Ferranti held an uninsulated chisel while it was driven with a sledge hammer through a concentric main through which 10,000 volts were passing. The result was that the chisel short-circuited the main and the supply was cut off by the fuse of the machine blowing.

The greatest wonder is that Ferranti should have carried out his scheme to the great success which he did in the face of what was world-wide criticism, especially so since there was no previous similar experience on which to base his work.

A fascinating study is the history of the Incandescent Electric Lamp. It is proposed, however, only to make here a few brief remarks as to the originators and their accomplishments. There has been much discussion as to priority of invention, but the facts can be based on the addresses given respectively by James Swinburne, F.R.S.,* and J. A. Fleming, D.Sc., F.R.S.,† before the Institution of Electrical Engineers. The earliest mention of the incandescent lamp was in 1836. This referred to miners' safety lamps and pointed out that the solution was a carbon filament heated in a vacuum. Swan, to whom we are very much indebted for the great progress in the early days, did good work in the production of satisfactory carbons which was one of the difficulties at the time. Some of his first carbons were strips of various kinds of paper carbonised in a pottery kiln. For the purpose of hardening his carbons he sometimes dipped them in gum, treacle, or the like.

Another difficulty lay in obtaining a good vacuum, but about 1865 several good vacuum pumps and methods of exhausting were known which enabled Swan to make good headway.

By this time electric lighting looked possible, but the difficulties of mounting the carbonised paper and overcoming that of local heating at the joint were still great. Experiment had still to find a glass of such nature as would take platinum and join to the soda glass of the bulbs. Again, when finished and put into service, gas was given off from the conductor and joints which spoiled the vacuum. However a method of overcoming this difficulty was found and this was to run the lamp during exhaustion, which proved so successful as to be patented by Swan in 1880. Later in the same year he found that better carbons were obtained by treating cotton thread with sulphuric acid of correct strength and afterwards washing and drying it. To

* Journal I.E.E., No. 386, vol. 67, p. 291.
† Journal I.E.E., No. 386, vol. 67, p. 293.

obtain uniform diameter of these he drew them through sharp-eyed jewel holes which proved a great success. By this time—towards the end of 1881—he had perfected the carbon lamp for pressures up to 60 volts, and he soon got carbons fine enough for a pressure of 100 volts.

In 1884-1885 Swan, with the aid of Stearn and Topham, worked out the squirting process, and other makers adopted other solutions of cellulose in a similar way.

Meanwhile Edison had been making rapid progress. His first carbons had been made by mixing lamp-black and tar and rolling it out into a thin roll which was bent into a loop. It was then carbonised by heating it in a closed chamber, had platinum wires attached to the ends and was mounted in a glass bulb which was exhausted.

Thus it can be seen that both Swan and Edison had independently produced carbon-filament incandescent lamps in a form sufficiently practical for domestic electric lighting; Swan manufacturing his lamps in Newcastle-on-Tyne, and Edison in the United States. The question of patent rights about this time became prominent with a final result that an amalgamation of the Swan and Edison interests into the Edison and Swan Electric Light Co. in 1883-84.

The result of the production of lighting by this form of lamp was very marked and the wildest financial schemes were promoted, gas shares were almost thrown away, and, in consequence, large sums of money passed from the hands of the public to those of inventors and financiers.

More difficulties with which the electrical industry, as it had become, had to contend were the means of convenient and correct methods of measuring of electric voltages and currents. Up to 1881 such measurements were generally made with a tangent galvanometer, an instrument only fitted for a laboratory, or a Siemen's dynamometer. These were used since each had "a law" or, in other words, if the constant was determined for one point the value of the readings at other points were known. About 1881 Professor Ayrton and Perry introduced a series of direct reading dead beat ammeters and voltmeters, but the idea of a law was still prevalent and the soft iron needles of the instruments were of carefully ascertained shape, so that the value of the reading was directly proportional to the current. It was at last realised, however, that a law was unimportant and that the instruments could be calibrated right through the scale with the dial marked to correspond. The effect of the ease with which measurements could be made was to accelerate an already rapid progress.

Transformers at that time were being given special attention. The idea had previously occurred to investors but lack of knowledge of the principles involved had prevented success. Gaulard and Gibbs in 1883 laid down the principle that the two sets of coils between which the transformation was to take place, must lie one within the other; in other words, all the magnetic change in the iron coil must equally effect each coil; as we would say to-day, no magnetic leakage must take place between the two sets of coils. They arranged the primary or high voltage circuits of all their transformers in series and supplied these with a constant current. The effect was a tendency for there to be a constant current in the secondary or low voltage circuit. Had the lamps been in series on the low voltage circuit it would have been possible to turn these in and out singly without affecting the rest of the lamps, but as the lamps were arranged in parallel, the whole number had to be in use, otherwise the pressure rose and broke the lamps.

By 1885 it had been realised that if instead of a constant current supplied to the primary of a transformer giving rise to an approximate constant current in the secondary, a constant voltage was applied to the primary, an approximately constant voltage would be furnished by the secondary. Working on these lines, Professor (now Sir Ambrose) Fleming demonstrated in London in 1885, and showed by tests the complete independence of the transformers and of the lamps on the secondaries and that the transformation efficiency was as high as 92 per cent.

It is hardly part of the main subject of this paper but the steam engine has been so interlinked with that of electrical machinery that a few words on progress in that direction is warranted. At the early part of the electrical history here covered, steam engines of large sizes were slow running, 60 to 100 revs. per minute; had two or three cylinders, through which the steam was expanded before reaching the condenser. For land purposes, generally, horizontal engines were used; for marine, vertical (slide valves actuated by eccentrics on the main shaft constituting the valve gear). A much better cycle of steam entrance and exhaust was accomplished when, about this time, separately lifting valves, worked with cams, were introduced with new engines. With such engines and with the high speed of dynamos, pulley and belt transmission was a necessity. Experiments then, for a period, took place in an endeavour to obtain higher speed engines, and dynamos having a higher efficiency at slow speeds. A marked success was achieved when an engine designed by Peter Willans for river launch work was directly coupled to a dynamo by Col. Crompton.

As early as 1885, at the Inventions Exhibition in London, the Hon. Charles Parsons exhibited a dynamo direct-coupled to an engine in which the steam passed through alternate fixed and moving blades after the manner of a water turbine, enabling a speed of as much as 15,000 revs. per minute to be obtained. There were many ingenious devices to enable the rotating part to run about its own dynamic centre of mass and so without vibration. The steam consumption was very high, largely due to leakage between the revolving part and the casing, but the small size of the machine for a given output made its progress rapid. It has marched on to success, until to-day, it has become nearly the universal engine for large power of any kind and it can now safely be said that for the generation of electricity the steam turbine has no rival.

In referring to transmission of electricity, it is rather interesting to note the types of cable which have been tried. Rather strange to relate the principles of to-day are practically similar to those of the year 1886 and thereabouts, the only difference being probably greater flexibility and a much wider knowledge of the insulating materials used. About that time Edison had patented a cable in which he used two semicircular copper conductors, the flat sides facing one another but separated by insulation by which the whole was surrounded. This was then fixed in iron pipes with junction boxes where joints could be made and service wires or mains tapped off. Another method was that of Col. Crompton who, in 1886, gave us the system of copper conductors strained on glass or porcelain insulators in conduits under the roadways. This system was very successful and worked in various towns up to quite recent years, but by now it has nearly all been replaced by cables. To speak again of Ferranti and his cable from Deptford, it would probably be rather interesting to describe the cable he used which, as previously pointed out, he designed and manufactured himself. The first wound paper, dried and impregnated with tarry matter, round a hollow copper tube. Over this he drew another tube of copper which was again insulated in the same way. The whole was then drawn into an iron pipe and the joints were of an ingenious nature whereby intimate electrical contact was made by forcing the tubes into one another. These electric mains have worked for 39 years and have given practically no trouble, but the chief drawback is their rigidity and the comparative shortness of lengths which can be laid in one piece. A little more than 37 years ago, the British Insulated Cables Co., Ltd., was formed to manufacture Paper Insulated Lead Covered Cable, which method of cable making had been introduced some little time previously by Jacob Atherton who had come from America. At the same time Callenders Cable Co., introduced their Trinidad bitumen insulated cables, but which were later modified to a mixture of bitumen and byproduct oils, and vulcanised. These had a very wide use for many years but were condemned by the

Board of Trade some few years ago, after numerous street explosions due to gases liberated by the cables becoming ignited.

To-day there are cables working at pressures of up to 132,000 volts, in some of which special provision is made for restoring to the cable on cooling which has a hollow core, the impregnating oils which have been forced out by the expansion of the oil, and thus the formation of air spaces is prevented (Emanueli cable). For cables working at 33,000 volts and over it has become common practice to use three single core cables, or what is equivalent, three cores each covered with a thin metal covering or metallised paper, these being finally enclosed in a lead sheath and known as the Hochstader cable.

It is not intended to go into modern practice nor into the progress which has been made in recent years, since most of you are as well, and better aware of what has been going on in a general way. Nowadays, of course, engineers in all branches must specialise in one side of the industry or another and this being so, it is only a rough general idea of what is happening in those branches with which we are not directly concerned which we can hope to get. Thirty years ago it was different: an electrical engineer could well take in all branches and be successful.

Rationalisation Explained.

Sir Josiah Stamp addressed the Textile Institute at Bradford recently on Rationalisation, and was able to throw considerable light upon what is to many people a rather confusing term. The outlook would be very serious if rationalisation meant nothing more than restricting output and keeping up prices by a system of monopoly or trustification. True rationalisation aimed at reducing costs by greater efficiency; it did not attempt to defeat or delay economic consequences, but it looked to future developments, anticipated them, and lessened their adverse effects. It was impossible in these days for for small-scale individualistic units to hold their own in foreign trade against large-scale individualistic units. In some industries there were units which could only produce at prices which would lose the whole trade. No form of merger which retained such units in production could be called rationalisation.

The principal obstacle in the way of rationalisation was a sort of optimism that conditions would not remain bad and that in due course the trade cycle would produce prosperity; the lack of an impelling agency, particularly if rival banking interests were supporting different units; a desire to preserve the status of units in a financial merger without regard to their efficiency, or the over-capitalisation of merger concerns; and reluctance to reveal the real position of an industry or the relation of its parts, leading to the arrangement of mergers on a purely financial basis.

World Power Conference, Berlin.

The papers which have been received for the Second World Power Conference, to be held in Berlin next June, include fifty from England. These are sponsored by such leading bodies as the Central Electricity Board, the British Electrical and Allied Manufacturing Association, the Institution of Electrical Engineers, the Institution of Mining Engineers, the Institute of Fuel, the Society of British Gas Industries, the Society of Chemical Industries, and others.

The list of authors from whom contributions have been received includes such prominent men as Dr. Rudolf Lessing, one of the best-known experts on coal; E. C. Evens, the Chairman of the Association of English Iron and Steel Manufacturers; Dr. C. H. Lander, the Director of the British Fuel Research Department; C. W. Marshall, of the Central Electricity Board; Hon. Sir C. A. Parsons, the designer of the Parsons steam turbine bearing his name, and many others.

A certain proportion of the papers deals with the utilisation of the solid, liquid and gaseous fuels in power economy. Modern steam-power plants, considered as the basis of cheap power development, will also be discussed in this connection, whilst a paper on the subject of water-power works is also anticipated. A large number of the papers is devoted to the problem of the distribution and utilization of electricity.

In addition to the scientific discussions of the different technical subjects, there will be a Reception in the Reighstag, an Opening Ceremony in the Auditorium of the Kroll Opera House, a great World Power Festival, and a number of informal meetings of the participants.

At present the list of Works to be visited numbers about two hundred. About half of these are power stations and gas works, and the other half are energy-consuming enterprises, such as coal mines and steel works, chemical works, factories which manufacture electric machines, steam turbines, and internal combustion engines, shipbuilding yards, wireless stations, and so on. The seven different itineraries, which radiate in all directions from Berlin, take in the immediate environs of the capital, the industrial centres of the Rhineland and Westfalia, Baden, Bavaria, Upper Silesia, Pomerania and East Prussia, and the Hanseatic Towns of Bremen, Hamburg and Lübeck.

Empire Mining and Metallurgical Congress.

The Third (Triennial) Empire Mining and Metallurgical Congress meets in South Africa from March 24 to May 9, 1930, and during that period will tour the Union and Southern and Northern Rhodesia, covering 7,000 miles of country by rail. The Congress, which will be attended by about 250 prominent mining engineers and metallurgists from all parts of the Empire, will open at Cape Town on March 24.

At Kimberley, the members will visit the diamond mines, and besides inspecting the deep level mining on the Rand and the up-to-date gold recovery plants will also visit the platinum mines of the Transvaal and many industrial works. In the Rodesias interesting developments in zinc, lead, asbestos, coal, chrome, and gold, as well as the now world-famed copper deposits, will be visited and inspected.

In the Transvaal and Natal various coal mines and electrical power stations will be visited. Visits for the entertainment of the visitors will include the great Zambabwe Ruins and Victoria Falls, also the Sabie Game Reserve. The social side will also be well attended to.

At the various centres visited technical sessions will be held at which papers of exceptional interest, dealing with the latest phases of mining and metallurgy, will be presented and discussed. Some sixty papers have already been received.

New Canadian Coal Deposits.

Coal deposits amounting to approximately 460 million tons exist in Central British Columbia at Telkwa and Copper River, according to Mr. Frank S. Taggart of London, who has paid a recent visit to Canadian mining properties as the representative of a group of British capitalists.

The coal is found approximately 200 miles East of Prince Rupert, and according to Mr. Taggart, English interests have already instituted preliminary surveys for a railway between Telkwa and Vanarsdol. Such a line would join the Canadian National transcontinental system at Telkwa and would cut through the centre of the rich coal country.

Pending the building of a railroad, collieries are being developed at Telkwa where an electrical plant is also being installed to generate electrical energy for the mines which are already at work in the district. The power will also be used to supply the towns of Telkwa and Smithers with electrical energy.

Manufacturers' Specialities.

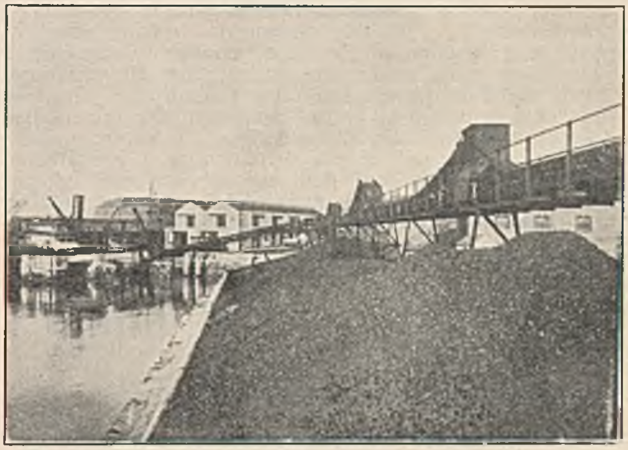
Coal Handling and Screening Plant.

For domestic and industrial purposes the demand to-day is for coal which is fairly uniform in size and free from dust. Sized coal is usually obtained by careful screening at the collieries, but during transport and the consequent frequent handling a good deal of breakage takes place, which forms fine coal and dust to the ultimate dissatisfaction of the consumer. Particular interest attaches, therefore, to a plant recently installed by Messrs. John Westcott, Ltd., with the object of supplying to the consumer coal suitably graded in size and as free from dust as possible. The plant is in operation at Plymouth, and was designed and constructed by Messrs. Fraser & Chalmers Engineering Works, Proprietors, The General Electric Co., Ltd., in association with the Robins Conveying Belt Company.

Two general views of the installation are shown in the accompanying illustrations. The plant has a storage capacity of roughly 2500 tons and the conveyors and screening plant are capable of dealing with approximately 200 tons per hour. Coal is discharged from ships by means of grabbing cranes, the grabs discharging into either of two travelling receiving hoppers, which may be placed in any position that is convenient for operating the grabs from the ships. These two receiving hoppers discharge on to the wharf conveyor, the feed from the hoppers being regulated by a belt feeder. The wharf conveyor discharges the coal on to an inclined conveyor which elevates and again discharges the coal on to a third conveyor which runs horizontally over the storage ground, parallel to the wharf conveyor at approximately 20 ft. above ground level.

The coal is also automatically weighed and totalised in transit on the inclined conveyor by a Blake Denison's continuous weigher.

Coal Conveyor: John Westcott, Ltd., Plymouth.



Another view of the Coal Handling and Screening Plant.

In conjunction with this conveyor are placed two special trippers fitted with Robins Patent "C Type" Cataract Grizzley Screens. The first special tripper trips or discharges the coal over its screen, which takes out all over 3 ins. size, and discharges through a side chute either direct to wagons or to storage. The undersize coal passes again to the conveying belt to be taken to the second special tripper and screen which, in turn, screen out all over ¾ in. size, the undersize being returned to the belt as before to go to the ordinary tripper to trip the small coal at any position as required.

When it is possible for the coal to be marketed direct, it is discharged immediately into the railway wagons or lorries, and when there is no current demand for a particular size, this size is placed into store and reclaimed by crane or other means as required. It will be readily understood that the market for a particular size of coal varies according to the season, but the flexible storage obtained by means of the travelling trippers makes it possible to use the storage ground with the greatest economy. In other words, when the demand is for large coal it can be loaded direct into the lorries, thus saving double handling, while the small coal is placed into storage. Similarly as the market changes, the small coal can be reclaimed and sold and the large coal stored in the place given up by the small coal.

The Robins Patent Grizzley Screen has been used successfully over a number of years, both on coal and coke screening plants. As the wear on this screen is very small, the high quality of screening is maintained. The use of the travelling screen together with anti-breakage chutes minimises the breakage of the coal. These screens can be traversed so that the coal discharges on to the angle of the piles, thus reducing the drop of the coal.

Metro-Vick Winders.

In the course of a Report dealing with their work and progress during 1929, the Metropolitan-Vickers Electrical Co., Ltd., refer to several important orders for electric winders. These include a number of Ward-Leonard equipments, the largest being two 2,150/4,310 h.p. sets for gold mining on the Rand.

Two 1,290/2,580 h.p. equipments for a copper mine in Rhodesia incorporate a new type of slip regulator, consisting of a hydraulic coupling between the motor and the flywheel of the motor-generator set, and a new system of braking recently developed and patented by the Metropolitan-Vickers Co. In this system the braking effort is applied as a function of the speed change of the cages, compensation being made automatically for all variations of load, speed of travel, and other conditions. The use of this new principle gives the equipment the remarkable and highly desirable characteristics that any given position of the brake lever will give a definite rate of retardation under all conditions and that any desired rate of retardation can be obtained without shock. The retardation under emergency conditions is also capable of accurate setting, a definite rapid rate of retardation being set for operation if the cages are approaching the end of travel, and a relatively slow rate of retardation selected for operation if the cages are in an intermediate position. The system thus ensures any required stoppage in a reasonably short distance of travel, while eliminating the risk of sudden stoppages, which are a cause of grave danger to passengers and plant.

Tests made in the makers' works on experimental braking apparatus of this kind have given remarkably successful results, and arrangements are at present being made for tests in actual service on a large Metrovick winder in service at the Harworth Colliery of Messrs. Barber, Walker and Co., Ltd.

Research work carried out during the year includes an installation enabling the "creep" behaviour of any steel to be compared up to 800 deg. Cent. with a standard; in this way it is possible to save much of the time normally absorbed in "creep" testing. Another highly valuable work is that on the embrittlement of steels under stress following exposure to high temperatures.

British Empire Trade Exhibition: Buenos Aires, 1931.

The response of British industry to the invitation to participate in the British Empire Trade Exhibition in Buenos Aires has been remarkably good. In spite of the length of time before the exhibition opens—it will last from February 18th to April 2nd, 1931— two-thirds of the available space was booked up within six weeks from the day when it was first offered. In addition to this, over 800 firms have approached the management with inquiries. The buildings and grounds occupy some 25 acres, but they will almost certainly prove insufficient and will have to be added to. Even so, it is extremely probable that the demand for space will ultimately exceed the supply. Applications are fairly evenly divided between firms who are already established in Argentina and firms who have hitherto done little or no business in that country. They come from all classes of manufacturer. Some sections, such as engineering, are better represented at present than others, but there is every reason for anticipating that the exhibition will prove to be a well-balanced and comprehensive showing of the industries of the British Empire. The London office of the Exhibition is at 5 Parliament Mansions, Orchard Street, S.W. 1.

LAMPS CONTRACT.

The Booth Steamship Co. Ltd. have placed a contract with Siemens Electrical Lamps and Supplies Ltd. for the supply of electric lamps for 12 months.

NEW CATALOGUES.

A. REYROLLE & Co., Ltd., Hebburn-on-Tyne.—The pamphlet No. 777 gives illustrations, dimensions, weights, and prices of an improved range of Metal-clad Air-break Switches, Fuses, and Plugs, for circuits up to 60 amperes at 660 volts.

RECORD ELECTRICAL Co., Ltd., Broadheath, Manchester.—A useful colour printed folder deals with the well-known range of "Record" portable instruments which include separate ammeters and voltmeters as well as combined volt-ammeters.

BROOKHIRST SWITCHGEAR Ltd., Northgate Works, Chester.—A folder calls attention to this Company's Automatic Control apparatus for A.C. motors.

RELAY AUTOMATIC TELEPHONE Co., Marconi House, London, W.C. 2.—The thirteenth issue of the "Relay Recorder" is as humourously informative as usual.

WARREN BROS. (Middlesborough) Ltd., Prudential Buildings, Middlesborough.—The Howard Patent Steam Separator is technically dealt with at length in the illustrated catalogue. This Company has also published an imposing list of steamships using the steam separator.

VISLOK Ltd., St. Bride's House, Salisbury Square, London, E.C. 4.—A lettercard shows application of the Vislok lock-nut, in non-corrodable metal, for battery services.

TUNGSRAM ELECTRIC LAMP WORKS (Great Britain) Ltd., 72 Oxford Street, London, W. 1.—A handy pocket size folder gives particulars and prices of the Tungsram "D" Pearl Lamps.

CAMBRIDGE INSTRUMENT Co., Ltd., 45 Grosvenor Place, London, S.W. 1.—A colour-illustrated lettercard concerns recording and indicating thermometers.

SIEMENS ELECTRIC LAMPS AND SUPPLIES Ltd., 38 & 39 Upper Thames Street, London, E.C. 4.—List No. 410 is a compact reference to Siemens Conduits and Conduit Fittings. Details of standard sizes and prices are given.

JOHN THOMPSON (Wolverhampton) Ltd., Wolverhampton.—Lancashire Boilers with dished ends and corrugated flues are a well-known speciality of this firm. The folder shows, in particular, a cross section in colours of a boiler of this type with Sectional Superheater

BRITISH INSULATED CABLES Ltd., Prescot, Lancs.—The folder P.F. 66 describes "Copperweld" Earthing Rods.

Calendars, Diaries, etc.

We are pleased to acknowledge the receipt of many useful seasonable business reminders among which may be mentioned:—

Wall Calendars: C. A. Parsons & Co., Ltd.; P. A. Mudd & Company; Anderson, Boyes & Co., Ltd.; Crofts Ltd.; Enfield Cable Works Ltd.; British Insulated Cables Ltd.; Northern Photo Engraving Co., Ltd.; Thor Lamps and Supplies Ltd.; Gaslam & Stretton Ltd.; Geo. S. Ikin & Son Ltd., J. & H. MacLaren Ltd.; Hill & Tonge.

Diaries, etc.: Chloride Electrical Storage Co., Ltd.; Simplex Conduits Ltd.; Enfield Cable Works Ltd.; United Steel Companies Ltd.; A. Reyrolle & Co., Ltd.; The General Electric Co., Ltd.; Mather & Platt Ltd.

Crompton Parkinson Ltd. invite readers who have one of the Company's Desk Diaries, and who may not have received a 1930 refill, to apply for one to their London office, Bush House, Aldwich, W.C. 2.