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EDITED BY E. DINSDALE PHILLIPS.

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Convention Notes.

From beginning to end the Summer Conference of the Association of Mining Electrical Engineers went with a swing and with that spirit of enthusiasm which has for so many years characterised these annual reunions. For the A.M.E.E. is prosperous; the latest annual report as submitted on this occasion shewed increases in membership, in candidates for certificates, and in finance. Such were pointed facts capable of expression in hard figures; there were on every hand other signs of progress.

The attendance must have been something like a record and all the good people who so kindly undertook to entertain the members and friends must have felt sorely taxed in their hospitable efforts to cope with so many more guests than had been anticipated. At the same time there was a genuine ring of pleasure in their acknowledgments of the thanks so freely accorded them by the visitors from all parts of the kingdom.

The calendar decrees that the publication of the customary full account of the Conference shall be deferred until our next number but there is time, and it is our first duty, to publish in this issue a tribute to the many people who without stint gave so much of their best towards contributing success and enjoyment to the week. The genial and energetic hosts were many in number and, though they ranged in rank and influence so as to include the Lord Mayor of Cardiff, leaders in the civic, professional and commercial spheres of the district and the comparatively lowly engineer-in-charge, one and all richly deserve the earliest acknowledgment.

The several tours and works' visits which took place on the Wednesday and Thursday were duly made according to programme, though the weather unsuccessfully attempted to damp the ardour of members. Of course the weather, persistent in contrary mood, provided a real touch of summer for the Friday, the one day when members as in duty bound were kept in-doors with the statutory council and annual general meetings.

In these affairs one naturally takes particular notice of the tenor of the speeches made by influential guests and others at the several festive gatherings. We hope to report and comment upon some of these in due course. For the present we can mention the very general gratification which all the members must have felt in the sincere and wholehearted acknowledgments expressed by leading men commenting upon the work and worth of the Association. Every member could pardonably plume himself, in the happy assurance that the A.M.E.E. is definitely to-day a power in the land: that it has built up a solid reputation in regard to international industrial and scientific affairs: that the commercial and the technical interests of the country, in so far as electricity and coal are concerned, are effectively welded into its constitution. It was therefore as if in the natural order of things and not at all a surprise to hear Major Ivor David, the newly installed President of the Association, in his inaugural Address stress the view that the effective restoration of our coal trade could not be done by non-technical committees and advisory boards. Following this line of argument Major Ivor David was able to compare the condition of the coal industry with the vigour of those industries—for example, the electrical and chemical manufacturing industries—who built their directorates up largely from their technical staffs. He deprecated the practice which placed the control of industries of this character into the hands of financial experts. Furthermore, in his opinion, our coal trade would be greatly helped by placing the sales business on a technical footing. Attempts had been made to impart some measure of technical instruction to the coal salesman, but without any noticeable success. It was easier and, therefore, wiser to make a good salesman of a technical man.

In this connection it will surely not be counted as presumptuous to suggest that to equip a man with the combination of a broad outlook and its resultant diverse knowledge, and a studiously cultivated fine regard for accuracy in facts and figures there is no training to equal that of the engineer. Those are some of the essential qualities which mark the successful director of industrial concerns. There will be few of our readers who are not acquainted with, or do not know of, many successful business men who were well trained as engineers and who by turning their efforts into other channels secured for themselves positions and rewards far above what would have normally been their return had they remained in the purely engineering field.

Electricity has so closely entered into every branch of human activity that to-day the good

CONFERENCE SNAPS.

The Editor would be glad to have Prints of the Snap-Shots taken at the A.M.E.E. Convention. All Prints (or Negatives) would be returned safely, and payment made for those selected for publication.

electrical engineer must have an understanding and intelligent interest in all other industries and branches of business. His ability to analyse results, to foresee effects, to adapt and adopt the means at hand, and to be all eyes and ears all the time, these are the ordinary stock-in-trade of the matured engineer. The board of directors which is void of these characteristics is worse than useless.

International industrial rivalry, under conditions of fierce competition, ultimately becomes a contest between opposing directorates. There are surely plenty of examples reported frequently and oft in the general newspapers: examples of wonderful success and of sordid failures, or worse, to drive this point home without further ado.

Another view emphasised by Major Ivor David was that the present time offers great facilities for confidence in spending money. He strongly urged coal owners to decide at once which pits they would close down and which they would develope and increase. They should proceed now and not wait for improved trade. They should anticipate the inevitable improvement of trade. Plant of all description, especially electrical plant, would never be cheaper than it was to-day. Copper, tin, steel and iron were at bed-rock prices. Manufacturers were starving for work, and were prepared to grant exceptional facilities for finance and to accept prices at nearly factory costs to keep their money "turning over" and their staffs and workmen employed. Skilled engineers were ready to prepare and carry out improvements, and capital was available at very low rates. All that industry needed to-day was confidence in its ultimate success, and a liberal exhibition of initiative and action.

CORRESPONDENCE.

Electric Winders.

SIR,

I have read wi h great interest the paper by Mr. A. T. Greig on Electric Winders in your issues of April and May 1931, and would like to make a few comments.

Near the top of column 2, page 358, Mr. Greig says: "This is assuming the circuit breakers are not opened." Will Mr. Greig explain this point in more detail?

He mentions in the 5th paragraph of column 1, same page, that a synchronous motor has been successfully used with a Ward Leonard equipment, but he does not say anything about the combination of Ward Leonard Equipment and Flywheel, driven by a Synchronous Motor.

At the bottom of the same column he says the braking with a Ward Leonard system is perfectly automatic; would it not have been better if he had put the words "within limits" after "automatic"?

At the beginning of the article in the May issue. Mr. Greig explains a very complicated slip regulator and in his diagram illustrates the much more simple one generally used.

It would be interesting if members with experience of electric winding would give their opinions as to the advantage of being able to finish a wind by means of the energy stored in the flywheel.

With regard to Mr. Greig's remarks about the Stubbs-Perry system; the word "alternator" seems to have got into the text in several places where it ought not to be.

The remarks at the bottom of column 2, p. 372, are not clear to me; does Mr. Greig mean that the "braking induction motor" can return energy to the line whilst the turbine is drivinig the set?

It the dash pot, referred to in the remarks on "braking," the cataract cylinder which can impede or hsaten the movement of the brake weights by the operation (electrical if desired) of a valve?

Mr. Greig does not give us any information about a modern type of brake control which can be made to give definite rates of deceleration by the operation of a flywheel (geared to the drum) working on a system of oil relays and pistons.

The figures given by Mr. Wadeson in the discussion don't help us very much—would he give us more details?

Will Mr. Stafford explain what he means by "superior"? My recollection is that Mr. Mountain tried to shew that steam winding was "economically" superior to electric winding. Electric winding seems to me so superior in all other respects that it is bound to supersede steam for every case in which it can be shewn to be economically superior. In this connection I would like to quote the following figures:—

During 1924:

Total mines at work in Great Britain	2855
Shafts equipped with Electric winders	182
Accidents with steam winding engines	102
resulted in deaths	22
resulted in injury to persons	471
Fatal accidents with electric winders	—
Accidents with electric winders	1
Injury to persons	5

In the Prussian Mines at beginning of 1925:

Steam winding engines	737
Electric winding engines	441

During period 1919-1924:

Cases of overwinding with steam winders	145
Deaths	34
Injuries	117
Cases of overwinding with electric winders	31
Deaths	—
Injuries	5

"On March 22nd, 1927, Colonel Lane Fox informed Mr. Paling that about 2440 collieries had steam and 240 electric winding engines. In the five years 1922-26, 58 accidents had occurred causing injury to persons employed including 14 deaths, since December 1st, five such accidents had occurred causing 3 deaths. One of the former causing injury but not death, and none of the latter occurred with an electric winder."

With reference to "Mr. Stafford's Storm in a tea cup": is it not a great point with electric winding that whilst electric motors can be built for very high rates of acceleration it is, generally speaking, more economical to lay-out where possible for heavy loads and long winding times, so as to keep down the accelerating peaks, the consequent capital costs and demands on the supply

Mr. Stafford might have told us more about making a steam winder very nearly as smooth running as an electric motor driven winder. Was he thinking of the application of the steam turbine to the winding drum through gears etc., or was he trying to resuscitate the "Multiple Energising Momentum Engine" which burst on us like a meteor several decades ago?

EASTWOOD, L. G. ROUTLEDGE.
9th June, 1931.

Coal Face Machinery Exhibition.

Conferences and Meetings of Associations and Institutes concerned in the Coal Mining Industry are being convened in connection with the above Exhibition to be held in Sheffield during October, and the following organised visits have already been definitely fixed:—

Saturday, October 3rd. Organised visit to Exhibition by Midland Branch, National Association of Colliery Managers, to be followed by Branch Meeting specially fixed for Sheffield.

Advanced students from the Wigan & District Mining and Techinacl College.

Thursday, October 8th. Visit by the South Wales Institute of Engineers followed by a discussion in Sheffield on two papers, "Modern Belt Conveyor Practice" and "Longwall work in the red vein (Antracite)."

Friday, October 9th. Meeting of the Association ot County Organisers and Chief Mining Instructors to be held in Sheffield in conjunction with an organised visit to the Exhibition.

All available information and invitation cards can be obtained from the Organising Secretary, Mr. H. A Beckenham, City Chambers, 65a Fenchurch Street, London, E.C. 3.

CONCERNING THE SUPPLY OF SPARES.

W. H. PETERS.

The relief felt when an order for a sorely needed replace part is followed by receipt per return of the correct part is only fully appreciated by those responsible for the maintenance of plant ; and they also know the homicidal feelings aroused by a long wait and finally the receipt of a part either quite unlike what was wanted or similar but non-interchangeable.

Comprehensive spare part lists, giving illustrations, descriptions, and reference numbers, are usually supplied by motorcar manufacturers, but such comprehensive lists are not so common in the electrical field, possibly because they are unnecessary in some instances. Certainly the plant to which they are related is usually maintained by properly qualified men, but in some applications, and in mining work especially, wear and tear is heavy and replacements are frequently required.

If plant is to give service of such a character that renewals will obviously be required from time to time, spare parts lists with all necessary information should be asked for and supplied with the plant or, failing this, obtained well in advance of the time when replacements are likely to become due.

To supply correct replacements collaboration is necessary between the user and the supplier. A correct interpretation of the order is impossible if the description is vague or faulty and, if careful attention is not given to instructions, wrong parts may be sent and inconvenience caused.

Much annoyance would be eliminated if care were fully exercised when ordering replacements. Every machine, starter, switch, etc., should have a label bearing a serial number, type, rating and other leading data ; these should be quoted, for it is far better to give excess information than not enough. Following this should be given a full and correct description of the part itself, quoting from the spare part list if one is available ; and if not then, in addition to the description, further information definitely indicating the portion of the complete assembly to which it belongs, for apparently similar parts may not actually be interchangeable and the wording of an order which generally describes more than one part may lead to a spare being despatched with the hope that it is correct, not always with happy results.

It is particularly desirable to quote the serial number if a number of machines or other gear are in service, even if all were supplied by the one maker. Possibly they were not all delivered at the same time and while they may appear to be identical, yet they may incorporate differences in details with the result that some parts are not common throughout. In this connection it may not be out of place to mention the necessity of correctly quoting serial numbers. These are not always distinct and the exercise of particular care in correctly deciphering the label inscription may prevent much waste of time later, for while the correct number may sometimes be guessed and checked from the works' records, this is not always possible.

The stocking of spares is in itself something of an art and one of the considerations is the period of years over which spares should be stocked after the adoption of a standardised type of design. Different manufacturers probably decide differently, but in few cases only is it likely that replace parts can be supplied promptly, if at all, for plant installed perhaps fifteen to twenty-five years previously and in any case records and patterns become lost in the passage of time. When ordering replacements for really old plant, especially if such are only required infrequently, it is probably best to forward a sample if possible, but parts may not be held in stock and while they can sometimes be made to sample it is of necessity a relatively expensive business.

Lists covering spare parts should be so arranged that components assembled together are so grouped in the lists, and their reference numbers should be allocated in such a way that inspection indicates to the assistant dealing with the order the part required, if not exactly at least very closely. A system which uses the same reference numbers for different parts, depending upon a master reference for correct interpretation, gives scope for errors.

Plant lying idle is money lying idle and a good after-sales service is of the utmost value in retaining the goodwill of customers, but it can only function at its maximum efficiency if adequate means are provided and used for rapidly and correctly identifying the parts required.

HOW A COLLIERY ELECTRICITY ACCOUNT WAS REDUCED.

From a Scottish Correspondent.

In these days of education, great store is set on efficiency. The symptom is healthy. It shews the gradual impress on the mind of the nation of scientific forms of thought. Efficiency in a machine is measured by comparing the output with the intake ; intake may be in the shape of coal or other fuel of which the "energy" content may be scientifically estimated. In machines the most efficient are not the noisiest. It is a suspicious sign when a machine calls attention to its power by loud creakings and cranky movements. So is it with human beings.

The facts relating to a reduction in electricity charges at a colliery in which the writer was put in charge are perhaps worthy of being put in print. A saving of almost £500 per annum was effected without one penny piece being expended in carrying out the change. Had there been any additional expense necessary, the change would in all probability not have been made. The possibility of gain without risk, however, led the writer—a canny Scot—to pursue the problem with a large degree of enthusiasm.

The colliery consisted of two winding shafts each sunk to a depth of 150 fathoms. Both shafts were sunk a distance of 20 feet below the lowest banking level and were connected by a roadway 10 feet by 8 feet. This connection was made to serve the purpose of a water lodgment. The growth of water at this point was 300 gallons per minute, approximately. Two three-throw ram pumps, each capable of dealing with 250 gallons of water per minute and driven by 85 h.p. motors, were situated in a pump room between the two shafts, the floor of which was 4 feet above the cage-seat level in the pit bottom.

One pumpman was in charge on each shift and the practice was to run one or both pumps intermittently during the twenty-four hours.

The power supply was obtained from a public supply undertaking at 11,000 volts and transformed on the surface to a working pressure of 440 volts. A three-part tariff was in operation and was arranged as follows :—

(1) Unit Charge of 0.25 per unit.

(2) Maximum Demand Charge of 40s. 7d. per k.w. per quarter.

(3) Power Factor Rebate, or Penalty :

(a) Percentage reduction on maximum demand charge equal to the percentage increase over 0.8 average power factor.

(b) Percentage increase on maximum demand charge equal to the percentage reduction of the average power factor below 0.75.

The maximum demand meter which was in use was read weekly by a representative of the supply company and the maximum demand charge for the three months was based on the highest of the thirteen readings obtained during that period.

The colliery was electrically equipped throughout, and for the three previous quarters the maximum demand had varied between 335 k.w. and 350 k.w. It will be observed, therefore, that the shaft pumping load had a large influence on the peak load and this was made more apparent when the effect of the two 85 h.p. motors driving the pumps at simultaneous periods was considered.

After some little consideration, the writer came to the conclusion that it might be possible to obtain a reduction in maximum demand charges by arranging, if possible, to have only one pump working during the period of highest demand. According to the plant load on the dayshift, it was estimated that the peak was highest during that period. A check was made on the unit meter to confirm this. Readings were taken at the beginning and end of each shift over a normal working period of twenty-four hours. No expense was incurred in obtaining the readings, as they were taken by officials in charge on the respective shifts. By this means, the units consumed on each shift were ascertained, and when those figures were divided by the number of hours the results gave the Average Demand in k.w. for each shift. This was considered to be adequate in finding the peak load shift, although readings of half an hour duration on each shift would have been more useful in ascertaining the shift with the highest peak load. The maximum demand meter in use was, of course, under the control of the supply company.

Although the colliery wound coal on dayshift and nightshift, after the readings were taken it was found that there was sufficient difference in the load between the two winding shifts to enable the full benefit of the proposed change on the dayshift to be secured without in any way incurring the possibility of transferring the maximum demand on to the nightshift. This, in other words, meant that if it were possible to work with the one pump during the dayshift, i.e., from 7 a.m. till 3 p.m., the full benefit of an 85 h.p. load would be deducted from the maximum demand charge.

After this data had been obtained, it was proposed to make a test the following day. It was arranged that only one pump had to be at work at the same period between the hours of 6-45 a.m. and 3-15 p.m. If desired, one pump could be worked for an hour or two, when it would be stopped and the other one started up. The pumpman was warned, however, that the second pump had not to be started until the first one had been stopped. It was also arranged, of course, that the lodgment had to be as nearly empty as was possible prior to the test commencing.

On the day of the test, each pump was worked intermittently and, nearing the end of the shift, close attention was given to observing the position of the water level in the lodgment, which, of course, had been slowly rising from the time the test had started. It was arranged that if the water rising was likely to affect winding operations in the shaft, the second pump would require to be started. At 3-15 p.m., after the equivalent of one pump had been running since 6-45 a.m., it was discovered that the water was still 6 feet below the banking level. After the test had proved successful, it was arranged to carry it out assiduously each day, even if no gain was to be obtained, until the commencement of a new quarter. The normal maximum demand having been already raised during the quarter, the extent of the reduction could not be ascertained until the meter was reset at the commencement of a new quarter.

On the completion of the quarter about two weeks later, the maximum demand reading was given as 344 k.w. At the end of the next three months, the maximum demand had dropped to 280 k.w. Some slight reductions in other parts of the colliery load may have accounted for a small proportion of this reduction of 64 k.w., but this could only account for a few kilowatts at the most. In later account periods it was found that the reduction varied but slightly in the region of 60 k.w., and the calculated saving was based on this figure.

The Saving on Maximum Demand Charge

= 60 × 40s. 7d. × 4 quarters.

= £500 per annum approx.

The output of the colliery was about 400 tons per day. The cost of electricity per ton of coal raised was about 9d. prior to the change. After the change had been made, the cost fell to 7½d. per ton, and this saving continued for a number of years.

In the quest for lower costs of production, every little counts, and this reduction was appreciated not altogether for its value, but also for the simplicity in its achievement.

LITHIUM.

A special article published recently in *The Mining and Industrial Magazine* of South Africa opens up an alluring prospect for the ultra progressive engineer, miner and financier. The author writes of the potentialities of the mineral lepidolite, also known as pink or lithia mica. Lepidolite is the principal source of the element lithium, and there are known to be very extensive deposits of lepidolite in Southern Rhodesia (probably in Northern Rhodesia as well), in South-West Africa (Karibib District), and Tanganyika Territory.

Lithium, which has the symbol Li. and atomic weight 7.00 (0-16) is an alkali metal, discovered in 1817. It is only found in combination, and is a constituent of the minerals petalite, triphyline, spodumene and lepidolite. In Southern Africa the principal source is the latter mineral. It occurs in small quantities in sea, river and spring water, and is also widely but very sparingly distributed throughout the vegetable kingdom. It may by obtained (in the form of its chloride) by fusing lepidolite with a mixture of barium carbonate and sulphate, and potassium sulphate. It has also been obtained by electrolysing the chloride in pyridine solution, a carbon anode and an iron or platinum cathode being used.

It is a soft silvery white metal, which readily tarnishes on exposure. Its specific gravity is 0.59, and it melts at 180 degrees C. It burns on ignition in air, and when strongly heated in an atmosphere of nitrogen it forms lithium nitride, Li_3N. It decomposes water at ordinary temperature, liberating hydrogen and forming lithium hydroxide.

Lithium has been identified in a tantalum proposition some 21 miles from Steinkopf in Namaqualand. The occurrence is a well-defined body containing columbite, lepidolite and muscovite, associated with massive felspar. Three main pits have been sunk on this occurrence or in its vicinity. The main working is situated right on the top of the kopje, where a shaft has been sunk to a depth of 22 feet. In this shaft there was encountered, in descending order: columbite, lepidolite (from two feet to six feet thick), spodumene, tantalite.

This occurrence was discovered by the late Mr. Labahn in 1912. Messrs. Heyes and Labahn commenced work on the kopje in 1912, and in 1914 they proceeded to England with 330 lbs. of tantalite ore containing about 84½ per cent. tantalum oxide, with a view to floating or otherwise disposing of it. The outbreak of war appears to have temporarily destroyed the chance of negotiations being carried through. Negotiations for the working of the deposit have recently been resumed, principally on account of the lithium content of the lepidolite.

As to deposits of lepidolite in Rhodesia, it may be remarked that there is a large kopje in South-Eastern Mashonaland which is believed to contain many millions of tons of lithia mica. The occurrence is situated at a short distance—only a mile or two—from the main Rhodesian Railway System. In this respect, therefore, the Rhodesian deposits would appear to possess a very considerable advantage over the lepidolite occurrences in the Steinkopf region of Namaqualand. Before, however, any definite statements can be made as to the comparative values of lithia mica in the two localities named much further development work and chemical research will have to be conducted.

It has been stated that occurrences which contain less than four per cent. of lithium oxide are of no real commercial value. The occurrences which have been observed in Mashonaland would appear to be of commercial value as well as those of Namaqualand, because samples which have been subjected to little concentration have been mined, transported to the railway, marketed and sold at a figure which covers costs.

The writer of the article indicates that lithium is still much of an unknown element to scientists and commercial men, and that very little information concerning the many uses and values of lithium has as yet reached the public.

The first results of the analyses of raw material by scientists are only now being reported to those intimately concerned. Once, however, the industry is established it is stated it will have far-reaching and in some respects revolutionary effects on the manufacture of aircraft and motors, on the process of extracting radium—as well as on its price—and on the manufacture of stained glass windows, pottery and enamelled articles.

It is significant to note the statement that chemists are working on and experimenting with samples from South Africa day and night in the huge Metallgesellschaf factory at Frankfurt-on-Main, in Germany.

Deep secrecy is maintained in the investigations. Not only has this mineral been found to be radio-active, but from it a metal lighter and stronger than aluminium can be extracted: all of which has been discovered in the past few months.

Rich Mineral Discoveries in Canada.

Radium.

The recent discovery of radium in Canada's Northwest Territories has aroused great interest. Samples of pitch-blende from the vicinity of Great Bear Lake, tested by Government assayers, have been found to contain from 144.51 milligrams to 162.39 milligrams of radium per ton. With radium valued at £10 per milligram the ore samples tested had a value of between £1400 and £1600 a ton. According to the Natural Resources Department of the Canadian National Railways the Bear Lake pitch-blende deposits were discovered early in 1930 by the Eldorado Gold Mining Company, at that time prospecting in the Mackenzie River area some 700 miles north of the end of steel at Fort McMurray, Alberta. There are two veins, one 2000 feet long and from 5 feet to 20 feet wide, the other 700 feet long and 6 feet to 10 feet wide. In the veins are outcroppings of solid pitch-blende from 2 inches to 9 inches wide running with the veins. The ore deposits are now being studied with a view to determining their commercial value. The discovery of radium in this little-known part of Canada gains in importance from the fact that radium-bearing ore in commercial quantities is scarce, the bulk of the world's supply coming from Joachimsthal in Czechoslovakia and the Belgian Congo.

Iron.

The discovery of a rich deposit of iron ore has also been reported in the steep rock lake area near Atikokan, Ontario, on the Canadian National Railways west of Fort William. The ore is a hæmatite and apparently of the best quality. This discovery is not to be confused with the Atikokan Rim Range which is a high sulphur magnetite. By analysis the new ore is reported to contain 65 per cent. iron and 23 per cent. silicon with 0.03 per cent. phosphate. The analysis shews no trace of sulphur.

Attention was recently drawn to the interesting deposits in the Steep Rock Lake district by Dr. Tanton, of the Geological Survey, Ottawa, who spent some years in this area. He recently published a complete report and maps of the silver area immediately west of Fort William.

"Crushing and Grinding."

Under this title the Electrical Press Ltd. have launched a new monthly review. In this case the voice of complaint regarding the redundancy of technical journals will hardly reach a whisper for there is only too obviously room and to spare for a specialist organ of this character. Mr. E. Kilburn Scott as editor is the experienced pilot in charge and in his introductory leader he makes out a convincingly strong case. A few quotations from his remarks will be of interest if only to bring to mind the enormous extent to which crushing and grinding processes enter into practically every branch of modern manufacture and industry. Thus he says:

"The world-wide mining industry is entirely dependent on the breaking down of ores from rock formation to fine powders and in the various processes many forms of crushing and grinding machines are employed.

"Modern road construction demands immense quantities of crushed and graded materials. Concrete construction for dams, buildings, sea walls and all other purposes, depends primarily on crushing and grinding machinery.

"An example of how fine grinding can effect important changes is seen in the pulverising of coal in order to burn it as a 'mechanical gas.' This method is used for large water-tube boilers of super-power stations, for marine boilers, industrial boilers and metallurgical furnaces.

"Cement depends for its usefulness on the fineness to which it is ground, and in the last decade, superfine grinding has created a revolution in cement making. It is essential for quick-drying cement.

"The high finish and the permanence of paints and enamels is largely dependent on modern methods of superfine grinding, and this is especially the case with enamels for motor cars, advertising signs, etc.

"Chemical manufacture has been greatly improved by mechanical reduction of materials in order to facilitate chemical reactions. This is particularly true of colloidal grinding.

"The pottery trade is dependent on the fine grinding of clays, flints, etc., for the making of 'slip' and for grinding of materials for glazes. Classifying and elutriating plays an important part.

"Artificial fertilisers, particularly phosphates and basic slag, depend largely on their fineness for the quick absorption by growing plants. Efficient farming depends on the correct mixing of ground fertilisers.

"In the preparation of foodstuffs, machines of many varieties are employed. The grinding of cereals is itself a very large industry."

Published monthly, at one shilling, it is well printed and illustrated; and being replete with articles and comments ranging effectively over the wide field of the industries and interests involved it is assured of a wide circle of the publishers' best friends, the "regular readers."

Proceedings of the Association of Mining Electrical Engineers.

AYRSHIRE SUB-BRANCH.

Running Repairs of Electrical Machinery.

ALEX. McPHAIL.

(*Paper read 21st February,* 1931.)

Many running repairs to electrical machinery in and about mines are done by inexperienced workmen and often the last stage is worse than the first. The author means by the term inexperienced workmen, some of those who are operators of the machinery: they try their hand at repairs for the purpose of helping them to get on, as they say; unfortunately it is not at all unusual for them in their hurry to reassemble the gear with bolts left loose or out altogether and the machine put into a most dangerous condition for a fiery mine. This kind of thing is, obviously not a running repair.

The best way to prevent trouble is to meet it in its incipient stage. It is frequently the case that machinery is run to death and the call is for breakdown repairs; whereas, a little routine attention in systematic order would have prevented any unexpected and more or less serious breakdown. Electrical machinery must be kept under routine inspections, and continuous records entered of all inspections and tests so that the electrician understands at any time exactly the condition of his plant.

Every man operating an electrical machine should be held responsible for the care of the machine and apparatus pertaining thereto. He should examine every part at the beginning of his shift for loose nuts and bolts, and adequate oil or grease in bearings and boxes, everything external should be examined carefully by him and a report given to the manager or electrician. Where gear is running in oil baths, these should be examined and cleaned at least once a fortnight.

Many accidents from electric shock occur each year, while examining or testing apparatus. This should not be so, and is easily avoided be the exercising of a little common sense and elementary precaution of seeing that the gear is properly earthed before attempting the examination. The surest method of ensuring effective earthing is to have the best switchgear that can be got, with all its modern safety features as provided for security in examination and testing.

There are many points in the C.M.R.A. with regard to electrical examination and tests that would necessitate a somewhat different style of switch box to those commonly in use. Boxes may be this-proof and that-proof but what about being proof against risks whilst making examinations and tests?

It is emphatically the author's experience that the time taken up for regular examination and testing is time well spent, and should always be encouraged. It ensures that breakdowns will be reduced to the minimum.

An example of a usual running repairs job may be cited. A breakdown has to be repaired in a three-phase system, 500 v.; the electrician is sent for and when he reaches the spot he finds that the section is about 400 yards long and there are an endless rope haulage, an electric fan, an electric pump and also a coalcutter on this section of cables. The fan and haulage are still running. The pump is running above its speed, and the coalcutter will not start; although the switches at the gate-end box are always tripped every time the cutter is switched on, the coalcutter operator says that something must be wrong with the cutter when it will not start.

Examining the position as it stood the author came to the conclusion that there was a phase cut out between the motor pump and the fan. He stopped the pump, and having connected two lamps in series across the mains, found that his surmise was correct. The cable was not earthed and gave a high insulation test, and it was found that a core was broken somewhere between the fan and the pump. The next move was to the jointing box on the road, there were two boxes. On examination it was found that a joint was broken and had lost connection on one cable. This was made good and everything started away as usual. The nett effect was one hour lost in work.

It is not always right to depend on an ohmmeter for testing the insulation of a cable. The author has used the ohmmeter a number of times in his experience and found high insulation tests; but, at the same time there were faults in the nature of shorts of high resistance and the trip switches would not stay in. It was only after careful testing by a Wheatstone bridge that faults were discovered in coils etc. Coils of trip switches ought to be tested regularly to ascertain if the proper resistance of the coil was being maintained. These tests are very easily made and save the time and money which inevitably result should one of these coils fail at any time.

About 70% of the money spent on repairs is due to dirt; the obvious thing is to keep apparatus clean.

Another breakdown which may be mentioned concerned a three-phase slipring motor of 40 h.p. Every time the three-pole switch was closed it tripped. With trouble of this kind test the stator for earths and also the rotor; it will, however, be found very often that the fault is in the starting resistance, or that section, which should also always be examined in the beginning. About 90% of breakdowns on these motors will be found in the resistance elements and they are very often caused by the attendant leaving the starting switch on when starting up.

Another repair was with a liquid controller for a three-phase motor 550 v. and 200 h.p. slipring induction motor. When starting up the motor everything seemed all right until the brush disengaging gear switch was crossed over and then the breaker tripped. A repair of this kind is very simple, a little more soda added in liquid form to allow for a higher speed of motor before throwing the crossing-over switch is all that is required.

During the author's experience he has only twice seen a cable puncture to earth before the fault was discovered. One was on a shaft cable where the positive core had been welded to the armouring of the cable. The circuit was d.c. 500 v. and was earthed between the pithead and the dynamo. As this earth immediately caused the whole system to be working at 500 v. below earth potential, he definitely earthed the positive bus bar and was able to run the system until the day was finished and the permanent repairs were then made. The effect of this trouble was the loss of an hour and a half.

Another repair was on a 60 h.p. d.c. 500 v. motor haulage. The armature had a broken coil, as was indicated by seeing the mica which was burned out between the segments of the broken coil. The armature was parallel wound so the coil was identified, the corresponding commutator bars were bridged by a piece of cable round the armature from end to end of the coil and fixed securely. The piece of cable took the place of the coil. This saved an idle day and the motor was repaired properly at the week-end.

In testing to find the position of a fault care is required for d.c. work; test the field coils for earths from each and every coil, and also the resistances from each side; also test the field coils for conductivity so as to find whether any turns are shorted on themselves; also test the resistances of the armatures to earth. If these records are kept, breakdowns should not occur, even with a coalcutter motor.

A trailing cable can easily be replaced by another one with no loss of work. Earth conductivity tests should be made, at regular intervals, of the whole system to prove conductivity of armouring and also conductivity of cores, this can be done by a Wheatstone Bridge of simple construction which will give very low readings. It is always better to make conductivity tests instead of continuity tests, because by this means all cables, cores and earths are kept up to standard, and the electrician knows at all times how he stands in regard to this all-important matter.

SOUTH WALES BRANCH.

Mining Type Control Gear.

WILLIAM ROBERTS.

(*Continued from page* 391.)

Feeder Switches.

It is here necessary to return in greater detail to the main idea mentioned at the beginning of the paper, i.e., the advantages of air-break gear as compared with oil-immersed. One manufacturer, in an advertisement dealing with air-break gear, says that in the new gear, risk of flashing across and considerable trouble and expense are avoided. Furthermore, because of the absence of oil, it has been found possible to make all

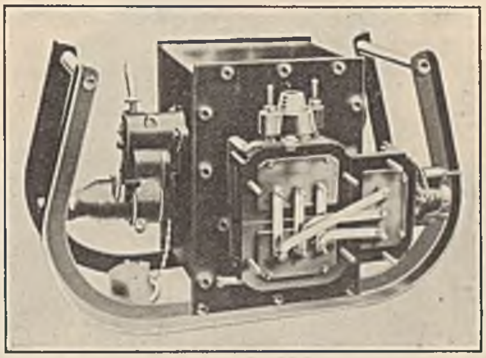


Fig. 10.

the parts more readily accessible and convenient for inspection and adjustment. The absence of oil and greater accessibility make for appreciable reductions in maintenance charges.

It is the author's contention that for some time past the use of oil-immersed gear has been persisted in where there has really been no definite need for it.

Fig. 11.

Oil-immersion allows the designer to do several things which in themselves are not good, i.e., put the phases closer together than could safely be done in air, damp the arc to increase the rupturing capacity, and rate resistances higher by depending upon the oil to dissipate the

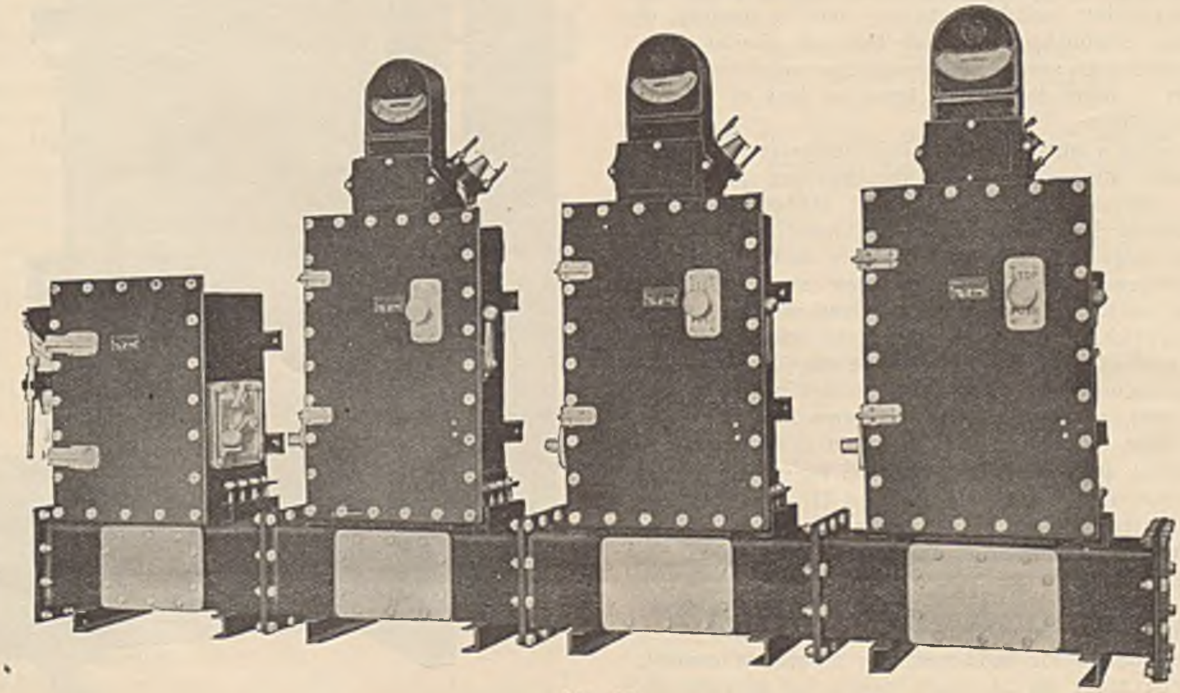


Fig. 12.

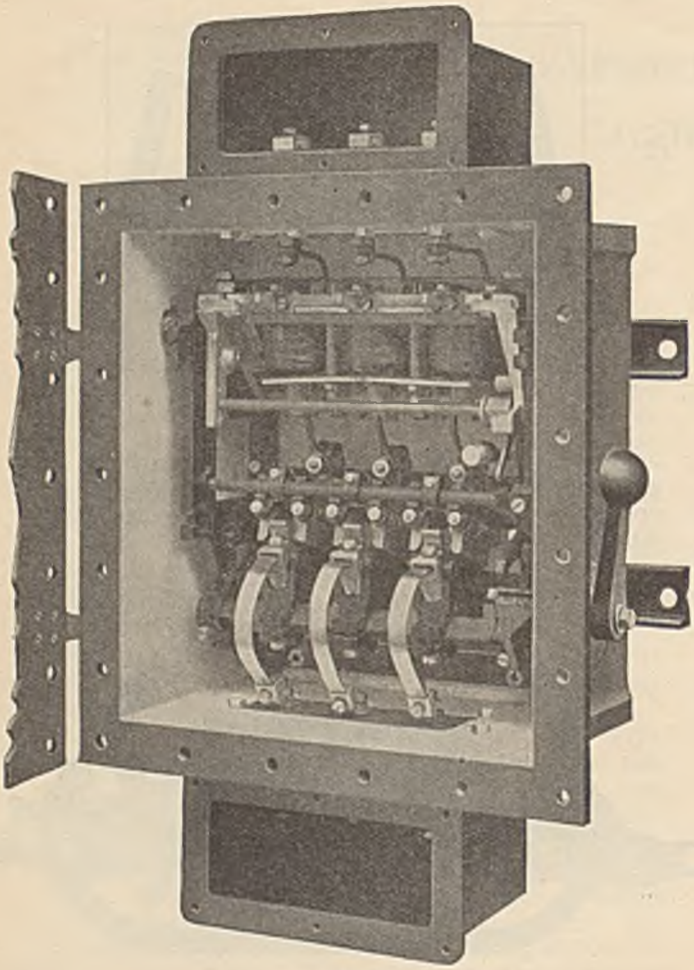


Fig. 13.

extra heat; but, as mentioned before, the use of oil has so many disadvantages in itself that any means of avoiding it should be welcomed, providing great care is observed in effecting the alterations necessary due to its abolition.

The experience of a large colliery in this district on some heavy duty winding engines over a number of years, has established the fact that on similar duty the pitting due to arcing on contact tips of oil-immersed contactors is more than three times as bad as on air-break contactors.

Excepting a situation where it is necessary to exclude a corrosive atmosphere from the working parts, the author's conclusion is definitely that air-break gear is more suitable in most cases. He strongly deprecates what one large firm has done recently in its efforts to supply air-break gear, of taking their standard flame-proof oil switch and selling it without the oil as an airbreak switch. As already mentioned, clearances and a number of other factors have to be carefully designed and it is undoubtedly a subject wherein those who have studied most, are best able to overcome the difficulties, because there is still a lot to learn in this design.

Air-break apparatus is quite suitable for use at the coal face, and the illustrations, Figs. 10 and 11, shew standard air-break gate-end switches which are offered by leading manufacturers specialising in this class of apparatus. It will be seen that in one type the economy of space has been in width, and the apparatus is fairly high whereas in the other the minimum dimensions is the height. Both types are suitable for hand-operation or remote control, and can be made up as single panels or extended to control more than one machine from the same point.

The main contention is that the conditions favourable to oil gases generating high pressures should be done away with, and that designers can then get back to the safer and easier conditions where a 9% mixture of methane capable of developing 110 lbs. per square inch is the worst case with which they have to contend. Experiments have been carried out at this pressure, and the Mines Department are quite satisfied that a minimum flange width of 1 in. with a gap of 1/100 in. will stand up to an explosion of this nature.

The question of venting is, of course, important. In a comparatively small enclosure no special steps are necessary. The volume of the gas and air inside the enclosure bears a moderate ratio to the surface of the inside of the casing, and consequently the burning gas is appreciably cooled while burning, so that no high pressure is attained and the gas passes out rapidly between the flanges without danger of external ignition. On larger enclosures the escape of burning gas without danger of igniting external gas is provided by vents. There are various types, but one which is quite efficient is the ring relief device, consisting of a number of steel plates assembled on support rods with washers threaded on the rods in such a manner that there is a suitable gap between adjacent plates. The plates are annular rings, the hole through the centre of them connecting

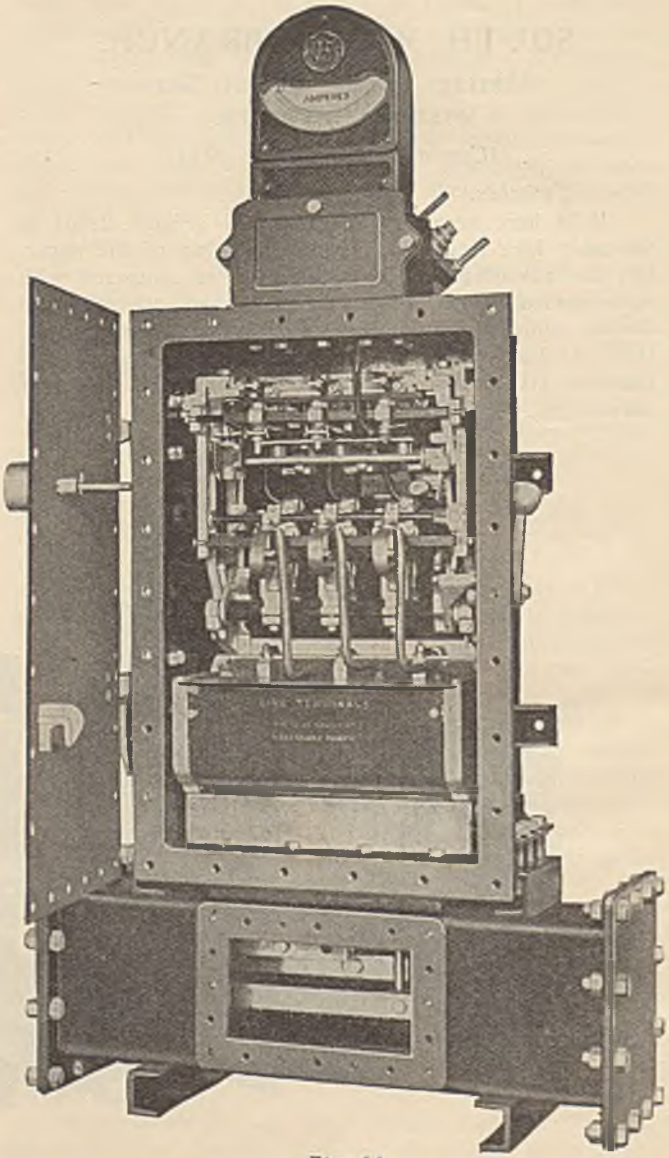


Fig. 14.

with the inside of the main enclosure. Gases are therefore free to pass from the enclosure through this hole, from which they escape to the atmosphere by passing radially through the gaps between the plates.

The illustration, Fig. 12, shews a flame-proof air-break board used in collieries in this district. Fig. 13 shews the internal arrangement of a flame-proof switch with terminal chamber top and bottom : these switches can be made for a.c. or d.c. The last illustration, Fig. 14, shews a flame-proof switch complete with busbars ; it will be noted that the busbar chamber is the floor mounting pedestal of the switch, the isolator coming in its natural place between the busbars and the switch itself. By this arrangement standard unit switches can by the provision of three connectors, be at any time made up as part of a complete board.

WEST OF SCOTLAND BRANCH.

Annual General Meeting.

The Annual General Meeting of the Branch was held in Glasgow, on 15th April, 1931, when Mr. R. Rogerson, Branch President, presided over a good attendance. After the minutes of the last Annual General Meeting had been read, approved and signed the Secretary submitted his report for the Session 1930-31. There was also placed before the meeting a certified copy of the accounts for the session. The Treasurer replied to a number of questions. The accounts and Balance Sheet were considered highly satisfactory, and were unanimously adopted on the motion of Mr. A. F. Stevenson, seconded by Mr. James Lawson.

Mr. ROGERSON in congratulating Mr. Arthur Dixon on his election as Branch President assured Mr. Dixon of his earnest support. Mr. Rogerson also thanked the Council and Secretary for the able assistance rendered him during his term of office.

Mr. ARTHUR DIXON thereupon presided and thanked the Council and members for the honour they had conferred on him in electing him their President, and assured them that everything possible would be done by him to uphold the prestige of the Branch.

This concluded the business.

Thereafter tea was served, and a high-class musical programme was sustained by Messrs. Mailer, Laird, Holmes, McAndrew, and Howat ; ably assisted by Mr. Arthur Dixon at the piano. The meeting was acclaimed one of the most successful yet held, and at the close cordial thanks to the artistes, on the motion of the Chairman, were duly rendered.

Abstract of the Secretary's Report.

The opening meeting of the Branch was held on 15th October last, when the Branch President, Mr. R. D. Rogerson, gave his Presidential Address.

On 14th January, 1931, a paper on "Rotary Converters" was read by Mr. Robert Wilson.

On 28th February, 1931, a Joint Meeting with the Colliery Managers' Association was held, at which a paper on "Double Unit Conveyor and Machine Mining in conjunction with Steel Supports for Roof" was read by Mr. D. S. Harrison, of the Colliery Managers' Association. The Joint Meeting with the Colliery Managers' Association is an established event, and is much appreciated by both sections.

On 25th March, 1931, Mr. Alex. Lightbody read a paper on "Leakage Protection."

Three visits to works of interest were made during the session. The first visit was to the works of The Albion Motor Car Co., Ltd., at Scotstoun, and was largely attended. The second visit was to The Fife Coal Co., Ltd.'s Power Station at Kelty, followed by a meeting at their Workshops, Cowdenbeath, in the evening. This meeting was also largely attended. On 6th December, 1930, the cable works of The Craigpark Electric Cable Co., Ltd., at Springburn, were visited, and the interest taken in this visit was shewn by the large number who took part.

The Annual Dinner of the Branch was held on 6th December, 1930. This was attended by a large number of members and friends, and all spent a most enjoyable evening. The principal guest was Major Walter Elliot, M.C., M.P. Mr. J. W. Gibson, President of the Association, was also present.

Regular meetings of the Branch Council have been held during the session, when various matters were discussed. The Technical Committee have dealt with a large number of B.E.S.A. Specifications, and their reports on same transmitted to Headquarters.

The Branch has taken a prominent part in the Propaganda Meetings held in Kirkcaldy and Cowdenbeath for the development of the East of Scotland Branch, and it is gratifying to know that the efforts made in that direction were successful. The Fife Branch, formerly East of Scotland Branch, is now in a flourishing condition and has a large membership. Special mention in regard to these services should be made of the untiring efforts of Mr. A. B. Muirhead and Mr. F. Beckett, to whom are due the thanks of the whole Association for their exertions in this connection.

Prizes to the value of five guineas were awarded during the session to two Members of the Branch for papers read. In addition, one member of this Branch was awarded the Association first prize, value eight guineas ; the Association third prize, value three guineas, was also gained by a member of the Branch, in the latter case the prize being divided with a fellow member of the South Wales Branch.

In connection with the Association's Examinations held last year certificates were presented to the following members :

Mr. James Cowan, Honours.
Mr. Joseph Hastings, First Class.
Mr. Dan Scott, Second Class.

During the session the Branch lost through death, one of its Founder Members and Presidents in the person of Mr. J. B. Thomson.

The members on the roll of this Branch and Ayrshire Sub-Branch at the end of the financial year were as follows :

Life Members	4
Patrons	12
Members	258
Associates	13
Students	14
	301

Election of Officers.

The following members were elected to the principal offices for the ensuing twelve months : Session 1931-32.

President : Mr. Arthur Dixon.

Vice-Presidents : Mr. A. F. Stevenson and Mr. James R. Laird.

Hon. Auditor : Mr. John A. Brown.

Treasurer and Hon. Secretary: Mr. W. G. Gibb, 63 Greendyke Street, Glasgow, C. 1.

Hon Assistant Treasurer: Mr. W. McCallum.

Members of Council: Messrs. D. Baird, James Howat, George Boyes, Herbert Smith, Ivan C. Rushton, James Dinnen, Stewart Chambers, T. T. D. Geesin, John Lindsay, Alex. Lightbody, H. M. Hodgart, and A. Napier.

LONDON BRANCH.

Visit to the Works of Fuller Electrical and Manufacturing Co. Ltd.

On March 7th last a party of members of the London Branch including a number from the Kent Sub-Branch paid a visit to the works of the Fuller Electrical and Manufacturing Co., Ltd., at Walthamstow. This Company is associated with the "ASEA" and the Walthamstow works were a few years ago largely extended and modernised with a view to dealing with the demands of the transformer and regulator market, both in this country and the Dominions. So far as the ASEA Company is concerned it may be mentioned that it was founded in Sweden as far back as 1883 and today it is stated to be the largest electrical concern in Northern Europe. The head office and works are at Vesteras, where large a.c. and d.c. generators and commercial motors are manufactured. There is also a large factory at Ludvika, in Sweden, which is chiefly engaged on switchgear and transformers, a steam turbine works at Finspong and a cable works at Stockholm. There are also factories at Oslo in Norway, and Jaroslavl in Russia, whilst the Company also has interests in forests, iron mines and ironworks. The steel works at Surahammer (Sweden) owned by the Company, is one of the largest and most up-to-date. The Walthamstow works deal mainly with the production of transformers, ratio regulators and motors.

In the first place it is fitting to acknowledge the courtesy of Mr. Clifford Smith, Sales Manager, Transformer Department; Mr. Olley, Works Manager; Mr. Nutt, Chief of the Drawing Office; and Mr. Adney, Testing Room Superintendent, and thank them for the great trouble they took in explaining every detail to the visiting members.

It may be said that the chief interest during the visit was centred in some of the 44 transformers and ratio regulators now being built at Walthamstow for the Central Electricity Board and destined for various parts of the South East England and Mid East England electricity supply schemes. The main transformers are all wound for a primary voltage of 132,000; the secondary voltage varying according to the voltage of the local supply. These voltages are either 33,000, 11,000 or 6,600. The transformers are double rated, i.e., they are designed for 7500 k.v.a., self-cooled, and 15,000 k.v.a., with external oil circulation and air blast cooling. This is carried out by an arrangement in which the cooling plant is automatically started up when the temperature of the transformer reaches a pre-determined figure, corresponding to a continuous load of 7500 k.v.a. or its equivalent. A special pair of contacts are closed on the indicating thermometer and in conjunction with a relay operate the motor control gear, thus starting the oil pump motor and the fan motor. The cooling plant consists of a separately mounted air blast oil cooler with fan and oil pump. Special attention has been devoted to the design of the fan to ensure as near as possible noiseless operation, a condition insisted upon by the consulting engineers, Messrs. Merz and McLellan.

The coil insulation is not graded at the earthed end of the windings but it is designed to withstand, in the reinforced section at each end of the winding, a test voltage of 132,000 volts for three seconds without breakdown. When this test was carried out at the works before the visitors a very much higher figure was obtained.

The E.H.T. windings are star connected with the neutral points brought out for earthing. The secondary windings are delta connected. The 132,000 volt windings have a special winding designed to give 10 per cent. of the range with seven tappings, each giving 1.43 per cent. steps, to enable a voltage regulation of plus and minus 10 per cent. to be obtained. The winding itself has a range of 10 per cent. only and bucks or boosts according to the position of the regulator.

The ratio regulator switches are contained in independent tanks fitted on the side of the main transformers and are operated by a three-phase motor and relay equipment designed for a 400 volts a.c. supply at 50 cycles. The regulators are arranged for remote electrical control as well as for hand operation.

It was fully explained to the party, by actual manipulation, how the equipment is designed for 60 operations per hour and is fully protected so that it is impossible for the switches to stop in a midway position or for the switches to be driven through the end positions. A feature of the equipment is the fact that the operating switches are contained in separate tanks, i.e., the oil in these switches is not in contact with the oil in the main transformer and, further, the switch tanks can be easily lowered to the ground full of oil for inspection of contacts at any time, which can be done without disturbing any of the connections.

The transformers are pressure tested by an induced pressure test of 2.73 times the service voltage, i.e., each line terminal is tested at 208,000 volts above earth.

When completely assembled, the ratio regulator equipment has been tested over its full range 500 times, making a total of 7500 tap changes. In addition, a pressure test of 88,000 volts is carried out for three seconds between adjacent tappings of the ratio regulator connections and also between adjacent fixed contacts on the switch terminal board. The main transformer, when completely assembled, weighs 60 tons, including the oil.

Each earthing transformer is rated to carry for 15 seconds, without the temperature reaching dangerous limits, an earth fault current of 1310 amperes in the case of the 6600 volt windings, 790 amperes in the case of the 11,000 volt windings, and 400 amperes in the case of the 33,000 volt windings.

The official tests made by the consulting engineers on both the main and earthing transformers have been very satisfactory; the efficiencies obtained were higher than those called for in the specification. Three complete units are now being despatched each month, and the fact that the deliveries are actually in excess of the requirements of the Central Board indicates that these works are well able to handle large contracts of this description. The first 132,000 volt transformer to be put into operation on the Grid system was installed at Bedford and was manufactured at Walthamstow.

The tour of inspection of the works began with the small motor department and it was noticed that the closed slot principle is adhered to, all the wires being pulled through the core tunnels. To some people this might seem a cumbersome and perhaps unduly expensive method, but the firm hold the view that any excess on those counts is more than compensated for by the facts that the machine is so much stronger mechanically and that there is no possibility of the windings flying out through over-speed in normal working.

So far as the manufacture of transformers generally at these works is concerned, there are a few points of special interest. The iron and the copper are both insulated in the factory. To ensure the copper being free from sharp edges and copper dust before the covering is applied, there is a special examination prior to passing into the covering machine, where it is treated by a series of rollers and brushes before covering. The sheet steel laminations are insulated by means of a special paper which is claimed to be more reliable than varnish. The latter is liable to disintegrate under heat and pressure, thus causing a gradual increase in the iron loss. The copper covering machines have been designed by the ASEA engineers. The paper is obtained from the Company's own factory and as it has a thickness considerably less than that usually employed for conductor wrapping, this results in a higher voltage for a given dielectric thickness.

The windings shops are equipped with impregnating tanks and drying ovens. Where possible all H.T. coils are wound on adjustable steel formers, which give great accuracy. The heavy current windings are wound direct on to a bakelite cylinder with a number of insulated strands in parallel, and each turn is spaced from the other by means of presspahn distance pieces and horizontal oil ducts. The strands are crossed in a special manner to reduce eddy currents to a minimum, the method being known as helical coil winding.

The assembly shop includes a special steam heated vacuum drying tank large enough to accommodate a 45,000 k.v.a. three-phase 50 cycle unit. In this tank the complete transformer can be dried out and filled with oil under vacuum.

A very complete testing department is installed and great care is taken with regard to the measurement of losses, wattmeters being used employing special resistances so that they can be placed in high tension circuits where necessary, without the use of either potential or current transformers. For the measurement of voltage ratio, where accuracy is of considerable importance, an instrument built at the factory called a ratiometer is used. This comprises a transformer and auxiliary transformer both provided with a great number of tappings which are controlled by suitable selector switches and a sliding contact switch, and adjusted so that the ratio is made equal to that of the transformer under test. With an adjustment of the ratio above and below the ratio of the transformer under test, a circulating current flows in proportion to this out of balance ; that current is measured by an ammeter and the calculated mean figure indicates the exact ratio. An accuracy of 0.1 per cent. is claimed with this method.

The main assemby bay of the works is 235 ft. long by 50 ft. wide and is served by two cranes which can handle loads up to 75 tons. There is also a small assembly bay 150 ft. long by 25 ft. wide served by two 5 ton cranes. The test bed is adjacent to the assembly shops and the equipment includes a 1800 k.v.a. three-phase variable frequency generator, and a 1200 k.v.a. three-phase set for carrying out induced over-potential tests at a frequency considerable in excess of the normal. The high voltage plant includes two testing transformers one built for 500,000 volts and the other for 250,000 volts.

AYRSHIRE SUB-BRANCH.

Uses and Abuses of Electric Haulages and Conveyors.

HUGH MURRAY.

(*Paper read 17th January,* 1931.)

Heavy Haulage.

For heavy haulage the author considers the endless rope type to be the best. This form of haulage gear can, with proper care and a little attention, run for years without a breakdown. With this plant an oil-immersed trip switch is desirable. Once the load is known, the trips can be set so that even a hutch derailing will trip out the switch and save perhaps a rope, and maybe prevent an accident. An oil-immersed starting rheostat is also a big advantage as, often, in the case of putting on a new rope, the haulage has to be run slowly for a time and the body of oil in the starter keeps the resistance from getting too warm.

In the case of an a.c. motor, a short circuiting device may be fitted to the sliprings, thus taking all current off the starter when the haulage is running. The short circuiting device should, however, be built to take a small auxiliary switch, and likewise in the starter, to prevent the main switch being closed on a short circuited rotor. The author has seen this happen and the results, as can well be imagined, were not to the advantage of the main switch, or that section for a period of the day.

Another thing to which attention may be directed is the matter of overload. Overloading a motor is not a wise policy. It may mean getting an extra few tons on the day's output, but in the long run something serious will happen to the plant, which will cause delay and probably more expense than the extra output was worth.

An advantage of the endless haulage is that a magnetic brake may be fixed to the coupling between the motor and the gear, and the main switch can be tripped by remote control. This may well mean the continuous saving of a man's wage, as there is usually someone working on the rope outside the haulage room who can easily start the motor when the signal is given.

Main or Direct Haulage.

This type of haulage is most suitable for developing workings on a decline. The author believes this haulage is put to more abuses than any other. A controller is the usual thing with this type—a tramway type, where permitted, or an oil immersed. When the developing work is being done the rails are sometimes not as they should be, and it will be of interest to relate an actual instance of abuse to this type of haulage. Word was sent for an electrician to come down to the resistance of a main rope haulage, and the manager, who had been in the vicinity, decided to accompany him to see what was the matter. One of the cables in the resistance, where it was connected to the grids, was burned through and looked as if it had been on fire. However, the electrician soon put matters right and tried the motor. Everything was right, so the attendant (an old man, by the way) took charge again. The manager and electrician waited to see him draw the hutches up the dook, and to their amazement he went on as far as the second step of his controller, and past that he would not go. When told by the manager to go right on to the last step, his answer was—" If I do that the hutches won't keep the rails, and I'm not going down there every rake to lift hutches." The manager laughed, but the electrician didn't see the humour of it. It was, however, seen to that the rails were put into good order. That is a typical example of some of the things that are very often done and serious consequences may arise from such a simple cause.

Another abuse is to bang the controller right on. Some attendants seem to imagine that in that way they get a good start, which means a good speed all the way up.

Main and Tail Rope.

This type of haulage can be used to great advantage on levels and circuitous and undulating roads, and is really a very speedy and efficient means of conveying coal. The usual controller is similar to that generally with main haulages, and it is just as liable to the same abuses as with a main rope haulage. An instance where there was a bad breakdown with one of this type of haulage was as follows. The two drums were each fitted with a separate clutch, and, although the plant was quite a big and comparatively new haulage, it had no indicator for the rope distance. This resulted in the attendant having to count the turns of the drum and, what with that and the distraction of the bell being rung so often, he became a little bewildered and put in the clutch of one drum without drawing the other. Both end frames were drawn out and a rope broken. The author, however, considers the trouble was partly the maker's fault in the design of the separate clutches.

The instances quoted are typical of some of the abuses to which the electrical haulage is liable to be subjected. It may not always be appreciated that a badly laid haulage way, or a few wheels or rollers amissing, would have much effect on the safety aspect. Apart from actual delays and loss of output, due to derailment, etc., the haulage is subject to extra vibration, studs get loosened on trifurcating boxes and electric connections, and unless a haulage attendant realises the dangers that may arise from such, serious consequences are likely to result before an inspection may be made by an electrician or other authorised person.

Conveyors.

The use of conveyors in mines has greatly increased in the last few years. The jigger or shaker type is probably the most commonly used, and it is to this type that these comments refer. The layout of conveyors varies according to conditions and opinions. There is the single conveyor on a wall and filling direct into the tubs on a level road, or a gate conveyor; then there is the double unit, filling into a gate conveyor or a gate loader. Any of these installations requires a fair complement of electrical gear. Taking a layout of, say, a double unit with a gate conveyor, and having a wall on each side of, say, 90 yards each, quite an elaborate arrangement of electrical gear is necessary. With the end in view of having the cables and gate-end boxes centralised as much as possible, the minimum that would be required would be to have the service cable in the gate road coming into a gate-end box fitted with a busbar chamber. From this box comes the trailing cable to give the power to the gate conveyor motor. The situation of this gate-end box is in a more or less stationary position as, with a gate conveyor, the troughing only requires extension as the wall advances. To supply the face conveyors, service cable is taken from the busbar chamber of the gate conveyor box and taken into a double unit gate-end box at or near the coal face. As the position of the driving gear on the shaker conveyor in a wall is in the vicinity of two-thirds behind and one-third in front, this means the gear on the walls is about 30 yards away from the gate road. To connect this gear, trailing cables are taken from the double unit box to each machine. With a lay-out of this type, safe and good results can be had with proper care and attention to the various units. With this lay-out there is tendency to have remote control: a system which, in the author's opinion has its limits. In one instance a pull wire to the switch handle was tried, thus controlling the motors from the gate road. One of the difficulties was to get the pan shifters to remove and replace the wire every night, and to see that it was working properly. The first comment would be: "Why not have a proper system of switchgear to give remote control?", but this was a little experiment in remote control. Perhaps it was just as well that there were difficulties in shifting the wire, for so long as an attendant is in control, one may feel fairly sure the machine is getting some attention and oiling and greasing, and while it may mean an extra hand, the author considers the security well worth the expense.

The abuses to this method of transporting coal are very numerous. Sometimes the driving gear is not in line with the troughing, there are also loose trough connections, dirty cradles and rockers, and (the worst fault of all) a curved wall. These bring great strains both on the electrical and mechanical parts of the gear and, of course, overloading of the motors, and also the breaking of mechanical parts; moreover, as the trailing cables for the coalcutting machines come from the same double unit gate-end box, the fuses that are used for the machines are probably still kept in use for the lighter gear. Obviously, serious trouble is likely to occur under such conditions.

By having an attendant on each machine, he can be instructed how to use and not abuse what might well be termed, the weakest link in this chain, viz. the trailing cables. In the case of these, a little common sense is what is required, and a simple explanation to the attendant, such as to see that the plug sockets are thoroughly clean, and not to have recourse to a 7 lbs. hammer to drive the plug home; also to see that proper care is taken to have the cables properly tied up and clear of all moving parts.

As most machines are now fitted with a B.E.S.A. plug and socket, it will be suitable to conclude with the mention of an instance where the ingenuity of the attendant caused the section an idle shift. This machine had no plug interlock from the switch, and as the switch was a little stiff to work, this bright youth thought out an easier way of switching on. He screwed out the B.E.S.A. plug until the plug and socket terminals were just touching. All that was required then was a little twist of the thumbscrew and the circuit was broken —easy wasn't the name for it! However, this procedure was followed once too often, and the insulation of plug and socket broke down and was completely burned. Had the earth circuit been faulty, there would almost certainly have been serious consequences to this attendant. He was not given another opportunity for exercising his ingenuity on electrical plant!

Discussion.

Mr. A. McPHAIL said he had listened with great interest to Mr. Murray's paper and there were many points in it which he could corroborate from his own experience. Trip switches were required for three-phase work, fuses were bad because operators could not be depended upon to replace them correctly. Often a new fuse was put on the top of an old one with the result that there was a bad connection: a dangerous condition leading to the upset of the whole system. The great merit of the trip switch was that it could be set exactly to the load. The heaviest load was when the motor was starting, and the lightest load was when it was running, so the trip had to be set to correspond with the heaviest load. Should the rake go off the road there was trouble. It therefore became necessary to have time-lag attachments to trip gears. With time-lag the switch could be set to the minimum for the haulage running load.

Another point mentioned was the resistance. Like Mr. Murray, he had many times had trouble with operators switching half-on, or possibly only so far as the first contact, and running on the resistances had burnt them out. The way to prevent that kind of thing was to have the operators trained to be aware of the danger. Many operators seemed to have got it into their heads that the slower they could manage to run the machine the better for them.

Mr. GARVEN said Mr. Murray had mentioned oil-immersed gear. He would have thought that air-break was preferable.

Mr. MURRAY said he preferred oil-immersed gear simply because modern air-break mining gear was still in the nature of being experimental. He had not had any considerable experience with its use. It had been his aim only to give opinions on those types with which he was familiar by practical experience. He did not mean to condemn air-break gear.

Mr. McPHAIL asked if there was any boiling of oil in the switchgear.

Mr. MURRAY said one could detect abuse by the boiling of the oil. An attendant who was thoroughly instructed in his machine saw when his resistance got too hot and, being warned when the oil got hot there was not the same danger to the resistance as in the other type.

Mr. McARDLE said Mr. Murray, when dealing with endless rope haulage, had referred to putting in fuses so finely set that if a hutch went off the road the fuses would cut out.

Mr. MURRAY.—The reference was to the setting of trip gear.

Mr. McARDLE.—An endless rope haulage might be fed from three different points and he, Mr. McArdle, did not know of any satisfactory way of regulating the supply so that the load on the rope would remain constant. He knew a case where an empty rake on an endless rope came off and met the full load. The haulage was fitted with a friction clutch which the attendant had screwed up too tightly. The motor was controlled by an oil-break switch fitted with overload releases provided with time-lags, but these were set for the maximum load on the haulage. In this case they did not trip early enough with the result that the rope broke. He did not think it was possible to set an endless rope overload trip so finely that the switch could cut out and save further trouble under such emergencies.

With regard to doing away with remote control and putting on an attendant, his experience was that this was the better way. They could get a young lad to sit beside the conveyor and they had the knowledge that it was being operated by the same person every time it started or stopped. He wondered if they could have an oil switch with an overload that could be operated by an authorised person, so that the overload could be set to a greater value, say 30% or 40% higher, at night when the machine was cutting. Incidentally he might say that he understood fuses were to protect motors and not to allow the management to have bad roads.

Mr. McPHAIL said that at one time he had charge of a mine where there were ordinary brakes for the motormen to operate, but to act in case of emergency they had an automatic electric brake also. When the current was switched on the electric brake sometimes held on for a good few seconds before it let go. What was happening there was that it was not getting rid of its charge. By applying a condenser across two transformers, the moment the current was put on to the motor it let go.

Mr. GARVEN said Mr. Murray had referred to a case where a motor was short-circuited and the operator switched on with the result that he damaged the switch. There must have been something wrong there if the switch was damaged, because the switch cut-out was intended to cut out automatically under just such circumstances.

Mr. MURRAY said Mr. McArdle had referred to the derailing of a hutch on an endless rope haulage. To get full advantage of an endless rope haulage there must be some system of regulation. When the haulage was regulated there was a certain load known and the trips could be set on that load. It might happen that the haulage was running a little light but in most cases when a tub got off the rails it travelled all over the place and probably caught on the sides of the haulage roadway and caused a stoppage. With that type of haulage the trips could be set so that if a tub caught on the side it would trip out the gear before much damage could be done.

Mr. McPHAIL.—On an endless rope haulage working with a C pulley how many turns of the rope would Mr. Murray use, and what would be the best method of ensuring that the rope would always take up its right positions, going on and off the pulley?

Mr. MURRAY said he understood that with a C pulley the full area of the groove should be filled with the rope. He had had practical experience with an endless rope haulage on an undulating road. It was sometimes, what they termed, self-acting. A new arrangement of pulleys was tried to get larger diameter but it gave trouble. When a new rope was required the whole area of the C pulley was filled with so many turns of the rope and since then it had given no trouble.

Mr. McPHAIL said he had always thought it should be filled but he had never seen it tried. The most he had seen was about 2½ turns. A groove was formed sometimes and the rope could not get sliding: he thought if it was full that would be avoided.

Mr. MURRAY said that was so. If two and a half turns was sufficient to drive the load the haulage was designed for, the maker would only make the pulley for two and a half turns. He thought the whole pulley should be filled.

Mr. GARVEN said he had an endless rope gear running now which at one time was run with three turns on the drum and was quite satisfactory. Then a new rope had to be put in and with three turns it slipped a good deal. At the first opportunity, when the rope stretched, they would put on another turn. With regard to the C pulley, if the segments were good the rope slipped over and took its position well, but when the segments got worn it did not get over quickly enough.

Mr. McPHAIL asked Mr. Murray, in connection with his haulage, whether the operator was allowed to leave the operating room at any time when men were working on the haulage road; and, if he were allowed to do so, what was done with the switch gear before he left so that no person could inadvertently put it on. He had occasion once to be putting a box on a main cable, and at the other end he switched off. He drew the fuse and put the box on and locked it. A bottomer came along, put his jacket on it, and later when he was lifting his jacket he looked at the switch and saw it was off and thereupon he switched on. If the fuse had been in he (Mr. McPhail) would have been killed, but he had taken the precaution required under the Mines Act. Would Mr. Murray tell them what the operator did before leaving to prevent anyone switching on?

Mr. MURRAY replied that it would depend on circumstances. If there was a breakdown or an accident the man who was in charge of the tub room and also in charge of the haulage must not leave the room while workmen were on the haulage doing repairs, so as to prevent anyone tampering with the switches.

Mr. COLVIN said that with regard to fuses or overloads on oil switches there would always be a tendency to put in heavier fuse wire in the one case or to alter the time lags in the switches. The matter should be one of conscience for the electrician in charge. It was a duty he should never delegate to another person. However they might advance electrically they could never eliminate the human responsibility.

Mr. McGLASHAN said that he would have to enter the discussion from the mechanical side. It seemed to him that electrical plant was blamed for a lot of trouble which was really due to neglect in keeping the roads in order. How would it do to put a fly-wheel on to ease the loads sometimes? If they were to put on a fly-wheel to steady up the haulage and speed it would help their roads very materially. With a wire rope an increased speed on a haulage reduced the strain on the rope, and to lower the speed would increase the strain.

Mr. MURRAY said that reduction of gear was what was being done. He was afraid they would have to sink new shafts to get down some of the fly-wheels that would be required.

Mr. HUTCHISON said Mr. Murray had not mentioned the case of the attendant of a main rope haulage who, to effect a stoppage, would put the motor right round into reverse, using his control as a brake.

Mr. McPHAIL said that possibly the motor was built for that purpose. Some motors were.

Mr. MURRAY said he had one experience with an endless rope haulage where as a prevention against the load running back there was a ratchet on the driving wheel on the pulley. One day there was an extra load on and the motor was unable to take it. The haulage did run back and the pulley broke. The attendant realised what had taken place and suddenly put on his controller. The ultimate result of it all was that they had to get a new controller.

LONDON BRANCH.

Drills and Drilling as applied to Coal Mining.

D. Y. MARSHALL.

(*Paper read 14th April, 1931.*)

Rock drills may be divided into two classes, viz.—(1) hand drills, (2) machine drills. In the first class the work is performed by manual power alone, while in the second class other methods are employed, such as steam, compressed air, electricity or sometimes, though very rarely, hydraulic pressure.

Hand Drills.

Perhaps the oldest method of drilling a hole in rock, and one certainly used long before the use of explosives, was by a simple "Jumper". This consists simply of a round or octagonal bar of steel having a chisel-shaped cutting edge at one or both ends. When only one end is provided with a cutting edge, the other is frequently enlarged in order to add weight. Jumpers as used in colliery work vary in diameter from ¾ in. to 2 ins., and in length from 4 ft. to 10 ft. or more.

Drilling with the Jumper, or "jumping" as the operation is termed, is performed by percussion, the chisel edge being struck against the rock in the bottom of the hole and the tool slightly rotated after each blow. This method is only applicable to soft varieties of rock.

For harder materials, the former method is replaced by the system in which the tool is struck a blow with a hammer, the drill being lifted slightly and turned through about 20 degrees after each blow. In single-handed drilling, the operator holds the drill in one hand and strikes the blows with a hammer weighing 2 lbs. to 7 lbs., held in the other. In double-handed drilling, one man holds and rotates the drill while another man strikes the blows with a hammer weighing 6 lbs. to 10 lbs. In some cases two strikers hit the drill alternate blows.

From time to time the finely-powdered rock which forms at the bottom of the hole due to the action of the cutting edge, must be removed, otherwise the effectiveness of the blow is seriously diminished. This is usually done by a scraper—a metal rod on the end of which is a disc.

The rate of drilling by the jumper depends upon the nature of the rock and the direction of the hole, progress being more rapid in a vertical direction than otherwise. In coal or soft shale, the rate of progress may be as much as 7 ft. per hour, but in hard rock it may be as slow as 3 or 4 inches per hour.

By the single-handed method of drilling an experienced workman may drill a hole 3 ft. in depth in ordinary sandstone in about an hour, and by the double-handed method one could expect a hole 4 ft. to 5 ft. to be drilled in the same period.

Hand Machine Drills.

The general type of these consists of a screwed spindle working through a nut, with a socket for the boring tool, or auger as it is commonly called, at one end and having a square on it for the ratchet handle which communicates the power.

The commonest type of this class (Fig. 1) consists of a screw spindle *a*, terminating in a hollow square which forms the drill socket, and working through a screw-nut collar *b*, which is either fixed to or forms part of the hollow sheath for the screw-spindle to work in. The screw is revolved and the auger is pressed gradually against the rock or coal by turning the ratchet handle *c*, small pieces of rock are broken off and the hole is bored. When the full length of the drill is bored, the screw spindle is again worked back into the hollow sheath and a longer drill substituted, the same process being repeated until the hole is bored to the depth required.

To prevent the waste of time taken to return the screw spindle to the sheath after each auger has been used, these hand machines are sometimes fitted with a split-nut, having lugs on each half tapped with right-hand and left-hand threads. These lugs are connected by a screw, cut with a right-hand thread at one end and a left-hand thread at the other, and can therefore be brought in contact with or disengaged from the main propelling screw. Consequently, the drill and the screw can be withdrawn without being wound back.

With this type of machine a prop has to be set near the face to support one end of the machine. To speed up the work, many of these hand machines are supplied with a stand or column, whose length is adjustable to suit the working place. Many forms of this type of machine have been, and are still used in great numbers in the collieries of this country.

Whilst drilling with such so-called "machines" as these may be all right for very small collieries, they should not be tolerated in any pits having pretensions to being up-to-date. The days of this sort of thing are gone, hand power having been replaced by power-driven machinery.

POWER MACHINE DRILLS.

Coal or rock drills—in future they will be referred to simply as rock drills ; the term rock will be assumed to include coal, though this is not strictly correct—are usually driven by one of four sources of power :—

(1) Compressed Air.
(2) Steam.
(3) Electricity.
(4) Hydraulic Power.

As steam and hydraulic power are not applied to rock drills in use in collieries, we may leave these two types and confine our attentions to drills using either compressed air or electricity.

Compressed Air Drills.

The mechanical inventions of importance are of necessity developments which, in many cases, have no definite starting point. France, Germany, and America have each put forward claims of having invented the first rock drill. We know that rock excavations were carried on even before the discovery of America, and it is easy to understand that those engaged in the removing of rock would look for some means by which a hole might be drilled with greater rapidity than by striking a piece of steel with a hammer.

In 1683 a "drop hammer" machine was used in Germany, and history states that "with 10 blows it would sink a hole 1½ ins. deep and a hands-breadth wide and long." We learn that in 1803 a machine said to be "quicker than a miner" was made at Salzburg, and we are also told that Richard Trevithick, a distinguished English engineer "suggested" rock drilling by machinery. If men who have acted as "suggestors" could get their names in history as inventors, the lustre that belongs to the names of Stephenson, Watt, Fulton, and Ericsson would be considerably obscured.

J. J. Couch, of Philadelphia, first patented in 1849 a percussive Rock Drill. In the same year but a little later, Joseph W. Fowle, of Boston, U.S.A., patented and built a drill, the first one that had ever been introduced where the drilling tool was attached directly to the engine, or was an elongation of the piston rod. Subsequently, Charles Burleigh constructed a drill on Fowle's patents embodying some important improvements. Since then many designers have associated more inventions and patents with the Rock Drill than any other piece of machinery of equal weight and volume.

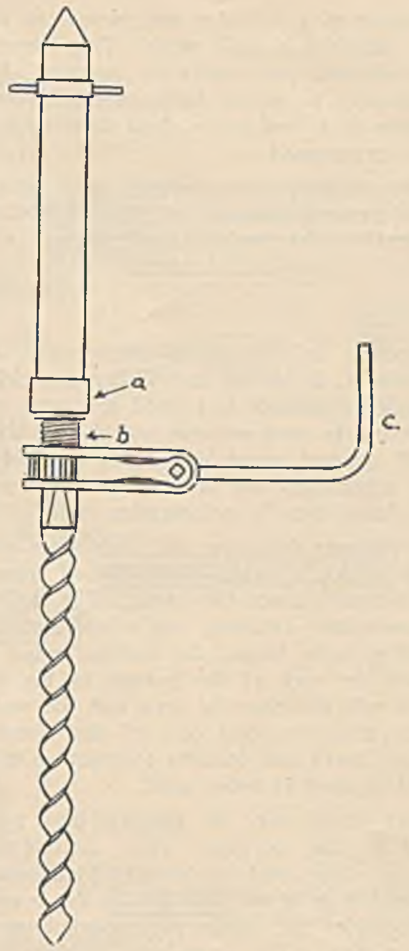


Fig. 1.—Hand Machine Drill.

All the early drills were what is known as "tappet" drills—that is, the movement of the valve was effected by "tappets" projecting into the cylinder, and struck or moved by the piston. This construction does not follow one of the most important requirements of a good rock drill, * in that "a part other than the piston is exposed to violent shocks."

Henry C. Sergeant made the first departure from tappet-moved drills in 1873, at the time he constructed the "Ingersoll Eclipse" drill. The valve motion of Sergeant's drill was of the spool or piston type and had an auxiliary valve also of the spool type introduced between the main valve and the piston, by means of which the movement was made more positive.

About this time (1875-1900) America was busily engaged in driving at least twenty of her famous tunnels and these served to test the worth of the rock drills of the day and to cause manufacturers to enter into keen competition for the great volume of business being placed.

The Rand Gold Mines of S. Africa had also taken to power drills and great numbers of machines of the "piston drill" type were supplied and handed over to the keeping of Kaffirs who in a very short period of time were trained to be quite efficient drill operators.

There does not appear to be any definite date recorded of the first power drills used in coal mining, but it would appear to be about 1886 or perhaps a year or two earlier. The drills were all of the "piston"

* Andre.—Coal Mining, 1891.

type, consisting of a cylinder and piston, to the rod of which was attached a drill steel. They were all very heavy, complicated, and costly to operate. It was, of course, necessary to mount these machines on a cradle, and by means of a feed screw, feed them up to the rock as the hole progressed.

The developments of hammer drills in the early part of the present century and their introduction into collieries marked the beginning of the age of machine mining.

Hammer Drills.

All modern drilling, using compressed air as the source of power, is by the use of hammer drills, which possess many advantages and yield the most satisfactory results. Owing to their extreme portability, high drilling speeds, and general adaptability, this type of drill has practically superseded the heavier and far more complicated "piston type" reciprocating drill.

In the hammer drill, the drill steel does not reciprocate but is struck a rapid succession of blows by the piston or hammer, hence the name. The drill steel has only one movement—rotation—and except that it rebounds a little after each blow, the cutting edge maintains contact with the rock at the bottom of the hole while drilling. It will therefore be seen that the weight to be moved each stroke consists only of the piston ; this is comparatively small and remains constant no matter what length of drill steel is being used.

Hammer drills may be divided into two classes, those held by the operator while drilling and those mounted in a cradle, and fed forward by a hand operated screw, revolving in a nut attached to the machine. For work in collieries the cradle is supported on a column or stretcher bar. The hand-held machine is usually referred to as a Hammer Drill or Jackhammer, while the mounted drill is classed as a Drifter. It should however be remembered that both types are, by virtue of their construction, hammer drills.

Hammer Drills or Jackhammers.

There are in use in this country at the present day about ten or a dozen different makes of hand-held, compressed air, drilling machines, differing greatly in details such as valve arrangement, rotation mechanism, steel retainer, etc., but all more or less following similar broad lines. The usual weight of machines employed in coal mining is anything from 24 lbs. to 50 lbs.; though, for shaft sinking where all the holes are down holes, drills up to 70 lbs. and 80 lbs. weight may be used to advantage.

They consist in general, of a cylinder having a diameter of from 2 ins. to 3 ins. and a stroke of about $1\frac{1}{4}$ ins. to 3 ins. Inside the cylinder is a piston, the shape of which can be seen from the sections shewn in Fig. 2. This forms the hammer, which has to deliver a succession of rapid blows on the shank end of the drill steel. The distribution of air within the cylinder is accomplished by an air-thrown valve, which may vary in design and include the ball, spool, butterfly, piston, and flapper type. Attempts have been made to let the piston uncover live air and exhaust ports in the correct sequence and so make the piston act as the valve, but these designs are extravagant in air consumption.

Means are provided either by a ratchet and pawls or by some other system for rotating the sleeve which takes the square or hexagon shank of the drill steel, this in turn rotates the steel either on the up or down stroke of the hammer or piston. A distance piece or fronthead

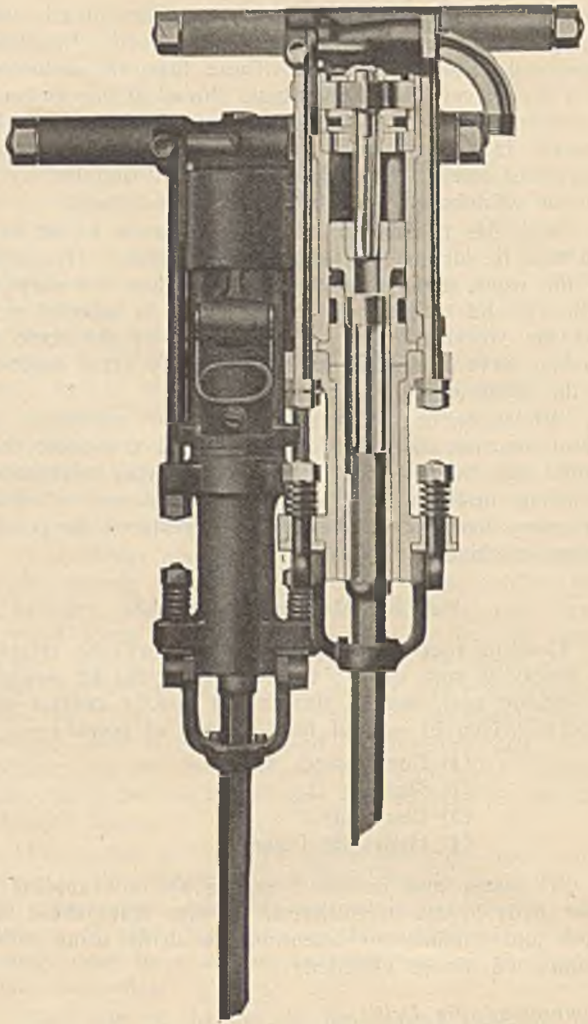


Fig. 2.—Ingersoll-Rand "Jackhamer."

washer, a fronthead, a handle which forms the cylinder cover and a steel retainer complete the machine, the whole being held together by two through bolts which are sometimes fitted with strong springs to reduce the damage to certain parts of the drill when it is not working against a resistance, causing the piston to strike the front end of the cylinder.

The operation of a "butterfly" valve may be followed from the three sectional views shewn (Fig. 3). The valve itself consists of a single piece of alloy steel shaped to form a cylindrical trunnion or body, integral with two flat wings, one on either side, which are ground to a perfectly true surface. The trunnion rests in the valve chest with a free working fit. A longitudinal groove or slot in the valve chest accommodates the wings of the valve, and is of sufficient width to permit a slight oscillation of the wings with the trunnion as a centre, and is actuated by the mere unbalancing of pressure on each wing alternately, requiring a negligible amount of power to operate.

The supply and exhaust ports open into the faces of this slot and the wings of the valve close the ports by seating flat over them against the sides of the slot. There is a separate and distinct supply and exhaust port to each end of the cylinder making two supply and two exhaust ports in all. The two supply ports open directly opposite one another at one ond of the valve chest slot, with the two exhaust ports similarly placed at the other end. The valve trunnion in place closes any opening direct from exhaust to supply through the slot. Adjustments are such that when one face of one wing of the valve rests over and closes the supply port to one end of the cylinder, the opposite face of the opposite wing closes the exhaust port from the opposite end of the cylinder. This leaves open the supply port to the one end of the cylinder and the exhaust port from the other end—the condition for one half of the operative cycle.

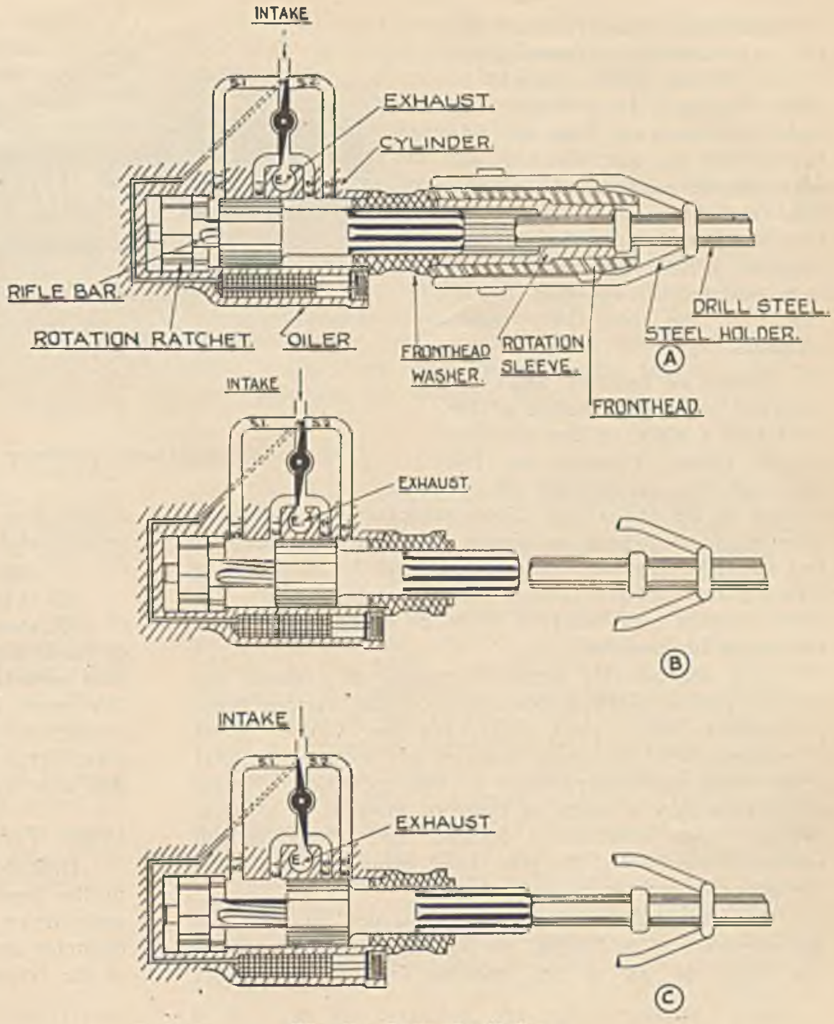


Fig. 3.—Butterfly Valve.

The three diagrams shew valve positions and pressure conditions at three critical points in one stroke. The forward stroke is illustrated, but the cycle is the same for the back stroke, so no separate explanation is made for the latter.

A. The piston is assumed to have just started its movement. The valve closes the front supply port S. 2 and the back exhaust port E. 1 leaving open the back supply port S. 1 and the front exhaust port E. 2. Air admitted at the supply passes through the port S. 1 to the cylinder forcing the piston forward, while the exhaust passes out through the exhaust port E. 2. In this particular position of the piston, the exhaust port E. 1 is covered by the piston and the valve is in an unbalanced condition, live air holding it to its seat over the supply port S. 2.

However, the moment the piston uncovers the port E. 1 live air passes through this port, its pressure on the valve wing balancing the live pressure on the opposite wing facing port S. 1. Thus, the valve after the stroke is fairly started is in equilibrium. But the impact of the supply air on the valve face opposite S. 1 holds the valve stationary, with ports S. 1 and E. 1 fully open.

B. At this part of the cycle, the valve is in the same position as in A. The front face of the piston has passed the cylinder port E. 2, just closing it and shutting off the exhaust from this end of the cylinder. Live air pressure, however, is still exerted on the back of the piston, forcing it forward and causing a cushion pressure in the clearance space at the forward end of the cylinder. This cushion pressure, communicates through the port S. 2 and exerts pressure on the valve, and throws it over to the position shewn in C.

C. The blow has been delivered, and the back stroke is just beginning. Live air enters through S. 2 and exhaust from the back of the cylinder escaping by E. 1. The valve is unbalanced but will become balanced the moment the piston uncovers E. 2 which will admit live air to the valve.

The next important detail of the modern hammer drill is the rotation. In nearly all machines today this mechanism is located at the handle end of the cylinder and when so situated it is called "rifle bar rotation."

The drill steel shank in general is either hexagon or square in section and should be a nice fit in the chuck or rotation sleeve, the length of shank allowed to enter the sleeve being limited by a collar on the drill steel. The rotation of the chuck is effected by means of a rifle bar and ratchet wheel, situated at the rear of the machine, in combination with a number of straight grooves cut in the piston or hammer. These straight grooves engage with similar grooves cut on the inside of the upper half of the chuck. During the back stroke the piston is forced to rotate under the influence of the rifle bar which works in a rifle bar nut screwed into the top of the piston. On the forward stroke the piston and drill steel are not rotated, the ratchet pawls being allowed to turn within the ratchet ring, thus allowing the rifle bar to turn and the piston to descend without rotation.

The exception to this method of rotation is when the piston itself is rifled and the rotation parts are located near the fronthead. The front end of the piston has straight grooves, but beyond these are a series of rifled grooves similar to those cut in a rifle bar. These engage with a rifle nut or ratchet wheel as it is called, the outside having the ratchet teeth cut on it.

Pawls engaging with this wheel allow it to rotate only on the down stroke. On the up stroke the ratchet wheel is held from turning, the piston having to rotate, due to the rifled flutes on it working through the flutes cut on the inside of the wheel and so turning the chuck and the drill steel.

This system of rotation is simple and can be incorporated in a machine at much less cost than the more general "rifle bar rotation." It has not found general favour however, owing to the piston being a costly part to replace when excessive wear takes place on the rifled flutes.

With rifle bar rotation the rifle bar nut which is screwed into the top of the piston, should be made of some metal which will wear a little faster than the rifle bar so that the nut, which is not an expensive part, should get the wear and be renewed from time to time when the wear has become excessive. Rifle bar rotation has been adopted as standard by almost all the big drill manufacturers.

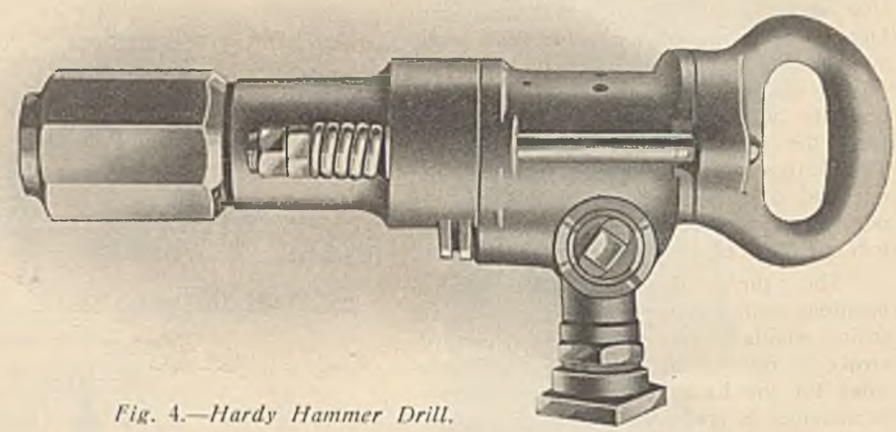


Fig. 4.—Hardy Hammer Drill.

Nearly all hammer drills are designed with the rotation of the drill taking place on the upstroke of the piston, allowing the full force of the downstroke to be exerted on the drill shank. Some manufacturers, however, offer machines which by simply changing the rifle bar and the rifle bar nut, can be arranged for downstroke rotation, this being of considerable advantage where soft coal or other such material is to be drilled and auger steels can be employed.

It is not possible within the scope of a paper like this to give a detailed description of the various types of machines being used today, but the Table I gives a comparison of the main features of the most popular drills employed underground in our collieries. Nearly all makers have a range of three or more sizes of Jackhammer, each of which is designed and offered to suit particular conditions, the size listed being a typical drill for general work in a coal mine.

Hammer drills are normally designed to work on air pressures of 60-100 lbs. per sq. inch, but it is seldom one finds the air at the working face at a pressure approaching the higher of these two figures, more often, unfortunately—due to the compressor being overloaded—the pressure may not even reach the lower limit.

All drilling in coal mining is not, however, in coal or soft stone. It is very often necessary to drive drifts or roads through limestone, slate, gypsum, or some other such material. Usually a slightly heavier drill is used for this work and in some cases machines mounted on a cradle and supported on a column or stretcher bar are used. Hammer drills when designed for a mounting of this kind are usually known as Drifters.

Drifter Type Drills.

Drifters are in all the essential features similar to the hand held machine, though the piston diameters and stroke are increased up to about 3 ins. to 3½-ins. diameter and 2½ ins. to 3½ ins. stroke. Along the bottom of the cylinder and parallel to its axis are two machined

TABLE I.

Make.	*Type.*	*Weight in lbs. with drill steel holder.*	*Principal Features.*	*Bore and Stroke. ins.*	*Standard drill steel shank. ins.*	*Remarks.*
CLIMAX	F.2	31	Tubular valve, rifle bar rotation, blowing device, drilled or solid piston, cap or spring type drill retainer, oiler in handle	2⅜ × 1¾	Square ¾ × 3⅛	For coal and soft stone drilling
DEMAG	F.55	31	Spool valve, rifle bar rotation, blowing device, drilled piston, spring drill steel retainer	—	Square ¾ × 3¼	Suitable for all light drilling work
FLOTTMANN	AZ.11	29	Double ball valve with blower, solid or drilled piston, fronthead type rotation, oiler in cylinder alongside valves	2.36 × 1.64	Square ¾ × 3⅛	For soft and medium hard material
HARDY	B.5	29.5	Roller valve, rifle bar rotation, blowing device, cap type drill retainer, standard, oiler in handle	2⅜ × 1 $\frac{7}{16}$	Square ¾ × 3⅛	Largely used for drilling coal on long wall faces
HOLMAN	H.D.1	32.5	Thimble valve, rifle bar rotation, drilled or solid piston, blowing device, spring type steel retainer	2⅜ × 2⅜	Square ¾ × 3¼	Suitable particularly for colliery use
INGERSOLL-RAND	B.A.R.33.	28	"Jackhamer" butterfly valve, strong blowing device, rifle bar rotation, spring drill retainer, heart beat oiler in cylinder	2⅜ × 1½	Hexagon ⅞ × 3¼	Coal, medium hard rock. Holes to 8ft.
MECO	3.B	35	Flap valve, fronthead rotation, automatic lubricator in handle, strong blowing device, spring type drill retainer	2.36 × 1.1	Square ¾ × 3⅛	Coal or medium hard rock

projections like long keys. These run in the guides of the cradle so that when the cradle is rigidly secured, the machine can only have movement either backwards or forwards in a direction parallel to its axis. Projecting from the bottom of the cylinder is a boss machined out to take a renewable feed screw nut.

The feed screw, which has a square thread and is about 36 inches long, is supported by two bearings, one at either end of the cradle. One end of the feed screw has a small crank handle with which the machine can be fed up to its works or drawn back when the steel has drilled its length. The cradle is supported by means of a cone about 5 ins. or 6 ins. diameter cast on the bottom of it and about the middle of its length. This engages with the clamp fitted either on the column itself or on an arm fixed to the column.

A drill steel of slightly heavier section than that used for jackhammers is employed for use with mounted drills and very often, instead of a square or hexagon shank being used, the steel is of round section and has two lugs forged on it to form the shank end.

At present drifters are not extensively used in collieries. This is partly due to the existing mines regulations which limit, even in a stone drift, the number of holes which may be fired at one time. It is not, therefore, practical to drill a round of holes with one or two settings of the drill column, where only three or possibly four holes can be fired together. If it were safe and permissible to fire a round of shots wired up in series with delayed fuses, as is done in ordinary tunnel work, then drifters would very quickly be introduced for driving headings in rock, where such work is necessary in coal mining.

Source of Compressed Air Supply.

The air power to the drills may be supplied from one of three sources.

(1) Piped from steam or electrically driven compressors on the surface.

(2) Piped from electrically driven compressors installed in a compressor house underground.

(3) Generated and piped to the drills from inbye mine car compressors, electrically driven. The complete power unit is mounted on a carriage and designed to run on the standard rail gauge of the pit.

Where it has been found possible to introduce electric coalcutters and electric haulage, the amount of air used for power purposes has been greatly reduced. This has made possible the introduction of the small mine car compressors. These outfits are being manufactured in suitable sizes to run one, two, three or more hammer drills or coal picks. They are small, compact, self-contained compressed air plants, which may be readily moved from place to place and make possible a greater footage of hole in a shift than is usually done from air delivered from a compressor on the surface. This is in great part due to being able to rely on 90 lbs. or 100 lbs. pressure at the drill, as there is practicaly no pressure drop in the short hose line conducting the air from the compressor to the working face.

Electric Drills.

The direct application of electric power to a rock drill is a much older problem than most people realise. At least 40 years ago drills were being made employing the principle of the solenoid.

In the early drills using this principle, two solenoids were placed end to end, and a plunger or hammer was allowed to play freely from the centre of these solenoids. The whole was placed in a boiler tube casing having a spiral spring in the back part. The plunger was composed of a central portion made of wrought iron, and a forward and backward portion made of aluminium bronze, all rigidly connected together. The generator furnishing the current was of the simplest kind, so that the polarity of the wires was reversed at each half revolution of the armature, with the result that through the action of this current on the solenoids, a reciprocating action of the plunger was obtained as first one and then the other of the solenoids attracted it and pulled it in opposite directions. The object of the spiral spring was to store up the energy of the back stroke and return it in the forward stroke, helping the magnetic impulse, and greatly assisting the strength of the blow. Drills of this type are said to have bored a $1\frac{1}{2}$ ins. diameter hole three inches deep in granite in a minute.

These drills failed, due to heating of the solenoids and pistons caused by the rapid reversing of the electric current through the coils; they became so hot that it was not possible to employ them in small headings.

Hope of employing solenoids to reproduce the blow struck by an air powered drill has never been given up;

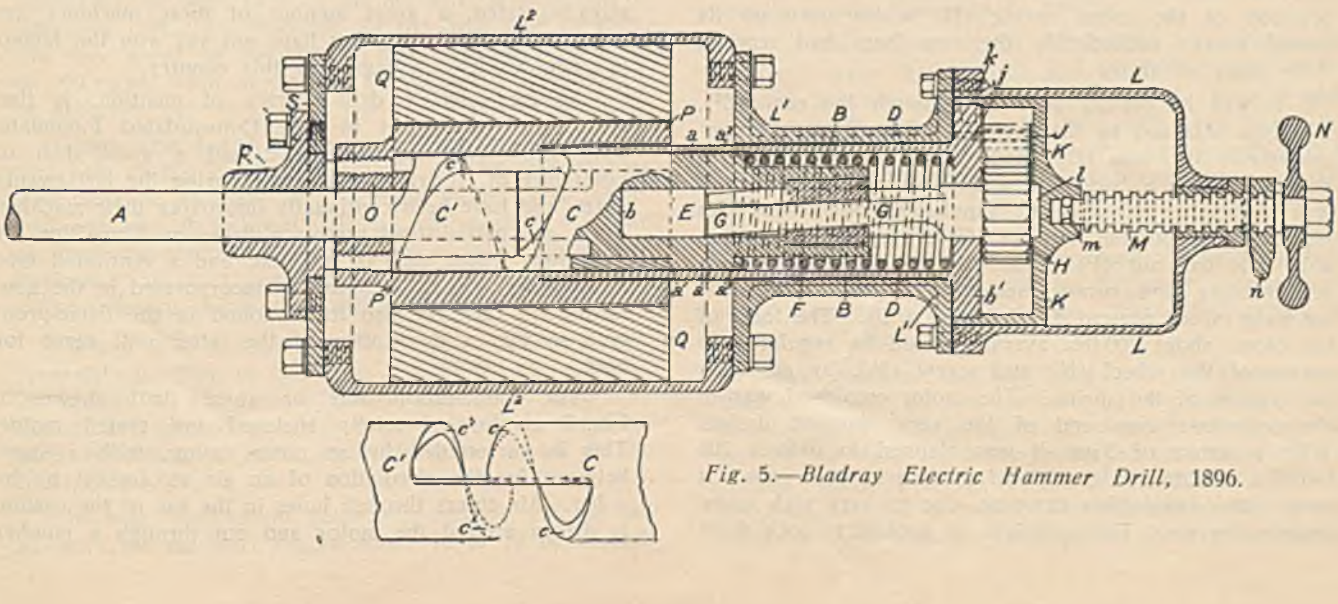


Fig. 5.—Bladray Electric Hammer Drill, 1896.

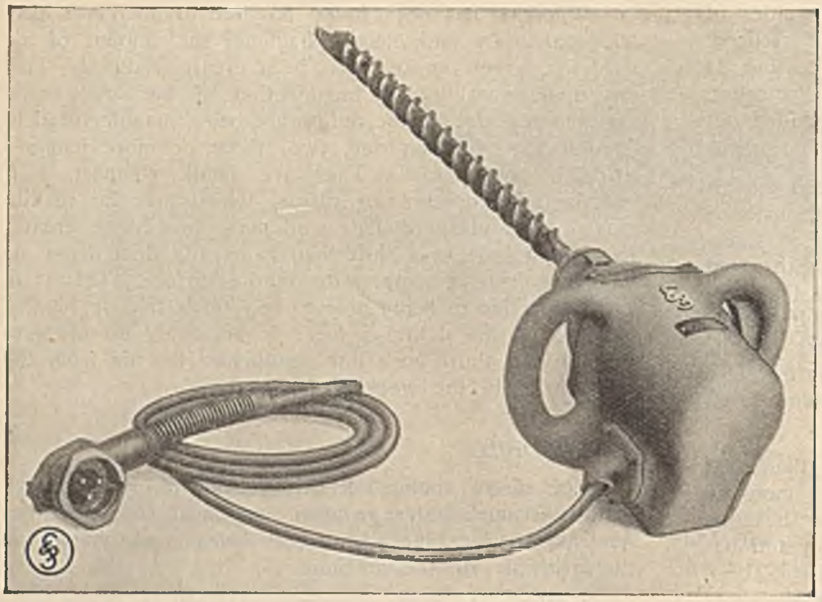


Fig. 6.—Siemens-Schuckert Electric Drill.

as late as the latter part of last year, experiments of a "solenoid concrete breaker" were taking place, but with no success.

In 1897 there was produced in S. Africa an electric drill, the joint invention of three eminent engineers, Blackmore, Gotch, and Way. Their machine, which was known as the Bladray Electric Drill, was certainly very ingenious though it did not shew up in actual practice as well as its inventors anticipated. However, as it was so far ahead of anything that had been done on electric drills at that time, it is well worth a brief description.

The Bladray drill (Fig. 5) was of the motor electric type as opposed to the solenoid construction. Fixed to what we would call the shank end of the drill steel was a hollow cylindrical piece (C) formed with a spiral cam or screw surface. This worked in combination with an electric motor, to which a corresponding hollow cylindrical piece (C^1) formed with a spiral cam or screw surface, was attached. The cam on the drill shank was connected with a spiral spring to import the requisite percussive motion to the drill immediately the cam fixed to the shaft reached the limit of its throw or maximum point of expansion. The drill steel and cam (C) were therefore made to reciprocate, the cams effecting the compression of the spiral spring (D) which gave up its stored energy immediately the cam faces had reached their limit of throw.

It will be readily seen that though the cam (C^1), which is attached to the motor armature, has a rotary movement, the cam (C) fixed to the end of the drill steel has only a backward and forward movement. It was therefore necessary to supplement the drill with rifle bar rotation, the rifle bar (G) operating in a renewable rifle bar nut (F). Thus the steel now had both reciprocating and rotary motion very similar to what we have in our present day hammer drills. The force of the blow, about 200 lbs. average, could be regulated by means of the wheel (N) and screw (M), by adjusting the tension of the spring. The motor employed was of the polyphase type and of the very simplest design. With a stroke of 3 ins. it was claimed to deliver 700 blows a minute and capable of drilling in hard rock. It never gave satisfaction however, due to very high maintenance charges. This principle, as applied to rock drills has long since been dropped, though several of the small electric tools such as chipping hammers and scaling tools offered today employ the cam idea for obtaining a reciprocating motion.

Practically nothing has been done since in the design of reciprocating electric rock drills ; the problem which faced the engineers of nearly 40 years ago, still awaits a satisfactory solution. The electrical engineer has had to content himself with a purely rotary design of machine and it is drills of this class which are being offered to the collieries in competition with the air driven hammer drill.

On the continent and especially in Germany where the coal is very soft, and very little stone is encountered in the mining of it, a drill with a purely rotary motion has very quickly established itself. These same conditions account for the much greater number of pneumatic picks to be found in continental collieries. They can be employed there to far greater advantage than in our mines.

One of the most successful of the electric drills in use on the continent and one which has been introduced to our pits during the last few years, is the drill manufactured by Siemens-Schuckert. This drill is specially designed for drilling shot holes in coal. The motor is wound for three-phase alternating current at 125 volts, 40 or 50 cycles and weighs 33 lbs. The switch, which can be seen in the illustration Fig. 6, is located in one of the handle grips so that "in the event of the machine being wrenched out of the miner's hand, owing to the drill having jammed, the machine will be automatically disconnected from the supply."

These machines are put forward for materials other than coal, such as gypsum and slate, and are claimed to attain a speed of 20 ins. to 28 ins. per minute, with an average hole of $1\frac{5}{8}$ ins. diameter. Slightly over 1 h.p., they have a gear ratio of about 5 to 1.

A similar machine, though of about double the power, is used for drilling stone. This size, due to its weight, 230 lbs., has to be mounted on a double column support. It has automatic feed and is fitted with a clutch which acts as a safety device in the event of an overload on the drill. The spring of this clutch can be arranged to exert pressures between 1300 lbs. and 2000 lbs. Although, as already stated, a great number of these machines are used on the continent, they have not yet won the favour of many colliery managers in this country.

Another electric drill worthy of mention, is that placed on the market by The Consolidated Pneumatic Tool Co. This company have had a good deal of experience of electric coal drilling during the last twenty years, and have been continually improving their machine. There are two distinct types : a flame-proof machine for conditions where such is essential, and a ventilated type for non-fiery mines. All that is incorporated in the non-flame-proof drill is also to be found in the flame-proof type so that a description of the latter will serve for both.

The flame-proof coal or stone drill shewn in Fig. 7 employs a totally enclosed and sealed motor. This is surrounded by an outer casing, with a space between for the circulation of an air stream set up by a fan. Air enters through holes in the top of the casing, is driven around the motor and out through a number of holes at the other end. The motors can be supplied for either a.c. or d.c. current and by means of transformers to suit all voltages. Between the motor and the drill spindle is a train of reducing gears, all mounted on ball races, which races also take up the thrust. The final gear reduction transfers the power on to a long drill spindle having a square thread cut on its entire length. On this spindle there are cut two long keyways which pick up the drive from two keys fitted in the bore of the last gear wheel. This wheel has a boss of about 5 ins. long permitting keys of this length to engage with the keyways in the drill spindle or feed bar as it is called. The keys are not, however, let into the boss of the wheel itself, but are fitted into a loose bushing which by means of a friction clutch may be either rotated with the gear wheel or allowed to slip.

The amount of power transmitted by the clutch may be regulated by the operator simply turning a small handle on the outside of the clutch casing. When this has been properly set, taking into account the nature of the material to be drilled, the machine will drill as long as it is not overloaded, but in the event of the steel jamming or the rate of feed being too fast, the bush carrying the keys mentioned in the last paragraph will slip and the drill spindle will not rotate.

Just forward of the clutch is the box housing which contains the feed nut. This is made in two halves, which are hinged by a bolt passing through two lugs cast on each half. This enables the two halves to be opened and in so doing disengages the nut from the feed spindle. This arrangement is similar to that employed on the automatic feed on a lathe. When the nut has been disengaged, the feed spindle may then be pulled back by hand, the next longer steel inserted in the chuck, the feed nut closed and locked by means of a small lever provided, and the machine is then ready for drilling again. It has been found advisable to make the feed nut of bronze, the two halves being let into the cast steel housing, thus making the nut an inexpensive part and easily renewable.

The machine may be supplied either reversible or non-reversible. The reversible type will have a distinct advantage where the ground is difficult, for then the miner will be able to back off his drill at intervals or whenever there is a tendency for the drill steel to stick. The free speed of the spindle may be about 130 r.p.m. to 200 r.p.m. while the motor speed may be 3000 r.p.m. or higher.

Much attention has been given to the switch and this part of the machine is as safe and as foolproof as it is possible to make it. Like the motor it is totally enclosed and flame-proof. It is not possible to make or break the electric circuit with the switch at the "on" position, nor is it possible to take the cover off the switch housing unless the switch handle is at "off."

Whilst it is possible for two men to handle a non-reversible machine of this type, this is not desirable as its weight is all against this method. In general a mounting is necessary, which may either be in the form of a column or a small truck rig-up as shewn in the illustration.

In coal, some quite good performances can be put up with the machine, boring about 10 to 12 holes each 4 ft. 3 ins. deep, in an hour. This requires the service of a drill runner and a helper.

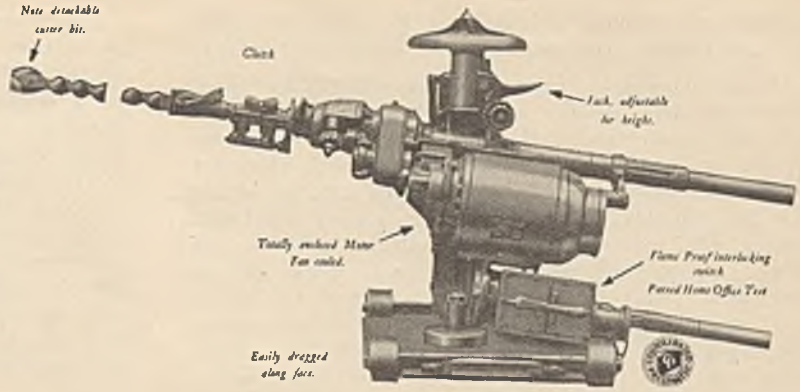


Fig. 7.—C.P.T. Electric Flame-proof Drill.

COMPARISON OF PERFORMANCE.

It is very difficult to make a comparison of the performance of air and electric rock drills as applied to coal mining. There are so many jobs to which the air driven hammer is put, which no electric tool could face. The electric drill of today would not be put forward even by its most enthusiastic advocates for such headings as have to be driven in say, the S. Wales district. To make a comparison at all we should have to suppose that all drilling in a mine is in coal or the softer bands of shale and the softer rock formations.

It is highly probable that the electric drill would figuratively "walk away" from the air drill in very soft deposits, the best drilling methods undoubtedly being a rotary motion applied to auger steels, thus bringing the cuttings away from the bottom of the hole as fast as they are made. This advantage begins to fall off rapidly as the material to be drilled gets harder and the point is reached where purely rotary motion is useless and the percussive method has to be employed.

The hard coal and shale bands of our mines have just about that degree of hardness at which the two machines begin to draw even. If both drills were hand held it would be difficult to say which would be the faster, and while a mounted electric drill would perhaps outdrill the other by 50% this advantage would be more than eaten up by the loss of time in flitting and setting up, and also by the fact that the mounted drill would usually require two men to operate.

For the colliery where all drilling is in fairly soft coal and easily drilled shale and where all other underground machinery is electrically driven, then electric drilling machinery may be adopted with advantage. But for all other collieries very careful experiments would have to be made before a change over to all-electric drills was adopted. Perhaps the fairest claim for the electric machine is the very candid expression used by the manufacturers of one of the best electric coal drills in use today, when they say they "now produce a flame-proof machine to meet conditions where compressed air is not available."

Now consider the h.p. used and the actual work done by each of the two machines. If we take an average hammer drill and calculate the h.p. delivered on the end of the drill shank by means of the formula ($WV^2 \div 2G$) where W is the weight of the piston and V its speed at the time of impact, this will give us the energy of the moving hammer. Multiplying this by the number of blows per minute and dividing by 33000 will give the horse power. This works out at approximately 1 h.p.

Now, to operate such a drill should require about 40 cu. ft. of free air per minute at a pressure of say 90 lbs. per square inch. If we assume single-stage compression and an electric motor efficiency of 95%, the input to the motor to give the required capacity would be 8½ h.p. In this we have taken into account 5% losses between the compressor and the drill. So that the efficiency of the air drill on this basis works out at about 12%. This figure would be reduced to 7% or 8% if steam driven compressors running on the surface were being used, as not only would the efficiency of the prime mover be lower, but the pipe line losses would be greater than the 5% allowed for.

It may, therefore, be taken for granted that a mine car compressor should have a driving motor of 8½ to 9 h.p. per drill, assuming the capacity of the hammer drill to be about 40 cu. ft. of free air per minute at 90 lbs. per square inch.

On the other hand, an electric drilling machine to do the same amount of work—providing the material were not too hard for it—would only require an input of about 1¾ h.p. Always assuming therefore, that either of the two power supplies may be used for any particular drilling job, the cost of running the electric drill is all in its favour.

MAINTENANCE CHARGES.

The severity of the work performed by a hammer drill is not equalled by any other piece of machinery in use in any other mechanical process. A modern hammer drill has only to be run for four hours actual drilling time, to deliver 250,000 blows of 500 lbs. each on the end of the drill shank. A typical week will account for nearly 2,000,000 impacts, in which time the drill will have rotated about 400,000 times, and the valve have seated 4,000,000 times. The ratchet wheel will have turned the same number of revolutions as the drill, and the small pawl springs compressed and expanded at least ten times this number. It seems hardly possible that the material of the various parts can stand up to this duty as well as they do, and yet, given the lubrication they require, and kept reasonably clean from dust and dirt, they will work day in and day out with exceedingly low maintenance charges. Many examples can be given where the cost of spare parts for the first three years has not exceeded an average of 15% per annum of the first cost.

The parts which are most likely to require renewing from time to time are the rotating pawls and springs, the rifle bar and nut, and the rotation sleeve or drill holder. It is usual to renew the piston only when it has broken, due perhaps to fatigue or want of lubrication, but it is a far wiser course to renew it when there is undue clearance between the piston and the cylinder walls. Any colliery with a number of machines should possess an air meter, such as a Drillometer, by which to measure the actual air consumption of each machine, and when this has increased 50% over what it was when the hammer drill was first supplied, then it will pay to have the cylinder skimmed out and an oversize piston fitted. This may be necessary at the end of the first year or eighteen months, and again after another similar period of service, but the cost of new pistons and the work of skimming out the cylinders will easily be made up for by the greatly increased rate of drilling and the vast saving in compressed air.

The upkeep costs of electric drills may be taken as equal to or higher than that of air machines depending on the difficulties of drilling encountered. A clutch even on a motor car or motor boat can cause more than its share of trouble, but when fitted to a rock drill, and when the amount of power it can transmit is regulated by the miner, trouble and expense of spare parts can be expected. When the clutch slips, the drill operator applies more and more power by screwing up the clutch adjustment until the point is reached when the whole drive is solid and the motor becomes overloaded whenever the drill becomes jammed. This will also cause the feed bar to buckle and probably attain a permanent set requiring it to be sent "to bank" to be straightened.

It cannot be said that the electric drill is as accessible as the air machine. The former is assembled by a number of screws with slotted heads for a screw driver, while the latter has only two bolts with nuts and springs holding the whole assembly together. One might easily be taken apart for inspection underground by a driller or an overman, but it would not be advisable to allow this procedure with an electric drill.

FIRST COST OF AIR AND ELECTRIC DRILLS.

When comparing the h.p. required by air and electric drills the power was taken in each case as the current used by the air compressor motor and the drill motor respectively. It will be fairest, therefore, to compare the all-in costs of the two complete drilling equipments, including in the case of the air drill the cost of the power plant required to generate the air.

A mine car compressor plant complete with two hand drills, hoses and steels, will cost about £400, and the useful life of this equipment will be about 8 to 10 years; or it may even be greater, depending on the service required of it and the care which is taken of the compressor and drilling machines.

Two electric drills either mounted on columns or on the small truck and short column mountings suitable for doing similar work to that performed by the air plant can be supplied for a little over £300, so that there is a saving in first cost of about 25% in favour of electric drills. It would, however, be too optimistic to expect the electric drills to have the same lifetime as the air drills, as their construction does not allow for the abuse which all machinery in a coal mine has to withstand. Taking into account the shorter period in which the plant would have to be written off, it will be found that there is very little difference in the initial cost of the complete equipments.

There is at the present time a strong desire on the part of a section of coal mine management to supersede the compressed air drill by an electric machine, and those having this desire have conducted experiments and trials of every electric drill available, but in practically every case have had to admit that at least for the present the air drill cannot be replaced by its rival. The electrical engineer will not, however, accept this as final, and the day may yet come when the higher efficiency obtained from the drill using electricity direct may be taken advantage of. He should, however, remember that he has to produce a machine which will do all the work which is at present done in coal mines by the jackhammer and not be confined to drilling only in the softer measures. The electric drill can only justify itself when it can do all the drilling, whether in coal or stone, at a cost at least equal to that of compressed air drilling.

PURPOSES OF DRILLING.

The purpose for which holes are drilled in either coal or stone is usually for blasting by means of explosives, but in some cases mechanical wedges are inserted. These take the form of two "feathers" which may be anything up to three feet in length and, when inserted in the hole, leave a wedge shaped space having its widest part at the mouth of the hole. Into this space is driven a wedge, or plug as it is commonly called, having a taper corresponding to the taper of the hole formed by the two feathers. As the plug is hammered in, the two feathers exert a great pressure on the sides of the hole and, provided the coal is not too hard or springy, it may be wedged down in this way. The hole required for plug and feather work may be $1\frac{3}{4}$ ins. to $2\frac{1}{4}$ ins. diameter, depending on the size of feathers.

Hydraulic cartridges making use of water at high pressure have been used as a means of blasting, but except in one or two particular cases the success of the hydraulic cartridge has been questionable.

The cartridge consists of a cylinder of steel about 20 ins. long by 3 ins. in diameter and having a number of small rams fixed radially along it. By a suitable arrangement of passages a communication is made between each of these rams whereby simultaneous action can be obtained. By an ingenious contrivance a greater traverse can be obtained than the diameter of the cylinder. This traverse is essential for the complete forcing down of the coal. Thin liners are used to prevent the rams sinking into the coal.

The cartridge is operated by a hydraulic pump to which it is connected by a pipe. The pump has a water tank attached, the whole being supported by a small stand. Only about a pint and a half of water is required for the operation, most of this is returned to the tank when the hole has been sprung and can be used again. A short handle applies the power to the pump, and a pressure of about 3 tons per square inch can be reached, representing a total of about 60 tons of coal. This is found adequate for ordinary seams and the standard 3 ins. size of cartridge is quite suitable for this duty.

Hydraulic cartridges have been in use in Lancashire coal fields for a number of years and for certain seams have been quite successful. They are usually employed to bring down coal which has been undercut to a depth of about 3 ft. or 4 ft. The hole required for the cartridge is about $3\frac{1}{2}$ ins. in diameter and should be a little shorter than the depth of the undercut ; the cartridge is pushed to the back of the hole and the pump applied to give the necessary pressure. The whole operation takes about ten minutes, including the drilling of the hole. This system is absolutely safe, being immune from explosion, miss-fires, poisonous fumes, etc., and the coal is not so shattered as when explosives are used. One "thrust" will average about 2 tons of coal when working in a a 3 ft. seam.

DRILL STEEL.

Drill steel used in coal or shale is either of the auger type or what is known as "spiral." Auger steel consists of a blade of steel twisted over its entire length. Usually it has a heavier section at the middle and tapers towards the edges. It may be obtained in various diameters, the more usual being $1\frac{1}{2}$ ins. to 2 ins.

Spiral drill steel consists of a core of about $\frac{3}{4}$ in. diameter around which there is a fin about $\frac{3}{16}$ in. square, coiling round the core like a screw thread but having a pitch of about 3 ins. The core may be solid or hollow, the latter having a hole through the centre through which either water or air may be passed to help the spiral fin to keep the hole free from cuttings.

For drilling rock a stronger section should be used; it is usual therefore to employ either hexagon or round steel and, as it is very necessary that the hole be kept clear of chippings while drilling, the steel is hollow, having a hole of about $\frac{1}{4}$ in. diameter throughout its length, through which water or air may be passed.

The best cutting edge for auger steel is a simple arrow head coming to a point and having the cutting edges backed off, as is done with a twist drill. For spiral steel what is called a "reversed Z" bit is employed, the centre portion doing the actual cutting and the two wings cleaning the sides. In rock where round or hexagon steel is employed, the best bit has been found to be either a four point cross + or an X bit, though a single or double chisel bit can be used if there are no fissures in the rock likely to jam the drill steel.

In drilling it is usual to start with a steel either 20 ins. or 2 ft. in length, and when this has been drilled, to substitute a 40 ins. or 4 ft. drill, at the same time reducing the bit diameter by $\frac{1}{8}$ in. to ensure that the drill will clear itself in the hole made by the first steel. Thus the length of drill is increased by stages of about 2 ft. until the required depth of hole is arrived at. The depth of hole needed in collieries rarely exceeds six feet.

The making and sharpening of drill steels can be performed by a blacksmith by hand, but where a number of drills are in use, and especially if they are being used in rock, then the steels should be dealt with by a "Sharpener." This is a machine usually worked by compressed air, by which a blacksmith can make the drill bits and shanks and also sharpen the steels after they have been blunted in the mine, at a rate at least twenty times as fast as this work can be done by hand. Drill steels dealt with by a sharpener are more uniform in shank and bit than hand wrought steels and will stand up better as the forging is done at the correct temperature and not on a falling temperature as is the case when hand sharpening is employed. It can quite safely be said that with more than four hammer drills in use in coal, shale or harder material, it will pay to have a sharpener.

Some drill sharpeners may be used for purposes other than the making and sharpening of drill steels, the Leyner No. 50 for instance, has sufficient power to make and sharpen the large 5 prong picks used in coal punching machines, the picks used in chain or bar type coalcutters and for producing small drop forgings.

In order to get good drilling results care should be taken to ensure that drill shanks and bits are well made and properly tempered ; that the type of bit best suited to the material to be drilled is employed and that there is a sufficient quantity of sharpened steels on hand to supply the drills, as if the latter condition is not fulfilled the drill runners will continue to use steels after they are blunted, and the rate of drilling will badly fall off.

MITIGATION OF DUST WHEN DRILLING IN STONE.

The human lungs can successfully deal with, and eliminate, quite large quantities of dust which may be

Fig. 8.—Shewing construction of "Sgonina" Dust Trap.

drawn in with the breath. In the case of most coal and stone dusts set up by a hammer drill, this process does not appear to affect the health of those working the drills. It has been observed however, that where silica is present in the stone, particles of this substance which enter the lungs eat their way into the walls of the lungs and set up a disease known as Miners Phthisis, a form of consumption. Fortunately strata of a silicious nature is rarely found in our coal mines so that the dust-laden air near where hammer drills are at work is not a danger to health.

Where there is any doubt, however, the Mines Inspectors will insist on some method being used to mitigate the dust evil. At present there are three methods of accomplishing this object. (1) Water Sprays, (2) Passing water down the centre of the drill steel, (3) Dust Traps.

(1) A water spray is directed on the mouth of the hole and is intended to catch the dust particles and prevent them from remaining in suspension in the air. Tests taken shew that smaller particles, which are the most dangerous, are not trapped by this method and it cannot be accepted as an efficient way of combating the silica danger to health.

(2) Water under pressure is introduced into the back of the hammer drill in such a way that while it is sealed off from entering the drill cylinder, it is allowed to flow through a water tube of about ¼ in. diameter which passes down through the centre of the rifle bar and piston, and enters the shank end of the drill steel to a depth of about 2 ins. The water is therefore forced through the hollow drill steel right to the cutting surface of the bit, where it effectively prevents there being any free particles of dust. The water washes the cuttings out of the mouth of the hole, thus helping to keep the drill steel free, and greatly assisting the speed of drilling, besides keeping the drill bit cool, preserving the cutting edges and gauge, and reducing wear. Small individual water tanks are used for each drill, the necessary pressure being put on the water by means of a compressed air line connected to the top of the tank. A valve on the water line near where it enters the machine serves to control the amount of water flowing.

Wet drilling, as the system is called, has been in use for a number of years and has been found particularly suitable for rock which would be dangerous to the drillers if dry drilling were adopted. The machines are easy to operate and the speed of drilling is increased rather than decreased, due to the water feature. Apart from the health factor, it will be found advantageous and far more comfortable for the men to use "wet" hammer drills whenever drifters or mounted hammer drills can be used. Wet drilling can be used with hand-held machines with only a pound or two increase in the weight of the drill.

(3) The application of dust traps to catch the dust as it leaves the mouth of the hole has been greatly in favour during the past two or three years. This is partly due to the experimental work carried out by the Safety in Mines Research Board and their recommendations contained in the paper issued by them in 1926—"A Method of Trapping the Dust Produced by Pneumatic Rock Drills" by P. S. Hay.

There are a number of dust traps on the market today all more or less working on the lines suggested in the paper referred to.

One of the best and most effective traps is that patented and manufactured by Compressed Air Limited. It is compact and complete with filter bag, weighs only 9 lbs. and is made up of very simply component parts. The sectional drawing Fig. 8 is almost self-explanatory. The trap takes the form of a soft rubber cowl about 6 ins. in diameter; through a hole in the centre there is a divided tube piece, the ends of which can be expanded by means of a locking screw into the mouth of the hole being drilled, thus securing the trap rigidly in position. The cowl is pressed against the face of the rock and forms the front joint, the back joint consisting of a flexible rubber pad through which the drill shank or bit may be readily passed.

The tapered piece to which the bag is attached functions as a venturi, an air jet with a 1/16 in. hole serving to inject into the filter bag the dust blown out of the hole by the air passed down the hollow drill steel. There is an opening at the bottom of the bag to let out the dust when necessary, this is closed by a simple clip. The trap can be used with any make of hammer drill, the only special provision to be made being a threeway cock on the air line so that when air is fed to the drill, it is also "on" to the venturi of the trap.

A hole 2¼ ins. diameter and about 4 ins. deep has to be drilled before the trap can be placed in position. This can be drilled without using the trap or the cowl may be held up to the face of the rock by hand while this short hole is put in. The trap remains in position during the entire drilling operation, the drills being removed and inserted through the back rubber in the usual way.

In cases where large bits are being used, the drill steel shank first is inserted through the front of the divided tube; an example of this is when the trap is used when drilling the preliminary hole. The trap is made in two sizes the larger being used where big diameter bits are being used.

In some of the larger makes of traps the dust bag is enclosed in a light metal casing with holes in the sides to allow the air to escape. Traps of this type are all more or less effective though perhaps just a little cumbersome to use. The question of trapping the dust caused by hammer drills is one of increasing importance, and where for any reason wet drilling cannot be used, the alternative method of using a dust trap of the type described should be insisted on whenever there is the least danger to the health of those operating the machines or working nearby.

The author wishes to thank those firms who have kindly supplied information which has been of considerable assistance in the preparation of this paper. Also for the loan of lantern slides used to supplement the illustrations printed along with the paper.

Discussion.

Mr. HUMPHREY M. MORGANS (Past President of the Branch) said there was no efficient electric percussive drill available. With regard to pneumatic picks, although large numbers of these were used in German mines, it was significant that a colliery manager who had visited a pit in Germany where such picks were in use had borrowed a hand pick and is said to have been able to cut more coal with it than the miners were cutting with the pneumatic picks. Mr. Morgans expressed the view that a man with a hand drill, having a cutting edge made with one of the special metals, such as Widia would drill as fast as he would be able to do with a portable electric rotary drill, in the same material. With regard to hammer drills or jackhammers, he said it was stated in the paper that the rotation occurred on the up or down stroke. That statement, by itself, would be rather misleading, and later in the paper it was stated that nearly all hammer drills were designed with the rotation of the drill taking place on the in-stroke. Mr. Morgans also pointed out that on the Rand air hammer drills weighing as much as 150 lbs., and having handles 16 ins. across, were used for drilling in shafts as compared with the 80 lbs. limit mentioned in the paper. With regard to drill steels, they were experimenting with $\frac{7}{8}$ths inch hexagon steel; they had also tried tapered drill steels, with good results.

Finally, commenting on a statement by Mr. Marshall, with regard to compressed air drills, that compressed air pressures at the drills ranged from 60 lbs. to 100 lbs., Mr. Morgans suggested that at pressures above 80 lbs. most of the drills used today would be knocked to pieces, and charges for stock would be high, at any rate under some circumstances.

Mr. A. E. DREW, referring to the solenoid type percussion drill, said that its failure was largely due to the inefficiency of all solenoid devices. Unfortunately the pull on the plunger was not constant over the whole length of its travel and, indeed, reached the maximum at one point only, falling off very rapidly at all other points. The heating was a measure of its ineffiency and was in some measure due to the fact that the impedance of the winding varied with the position of the plunger. The excessive heating was due to this cause.

The ideal form of converting electrical into mechanical energy was a rotary motion and the successful electric percussion drill would have to convert a rotary motion into a reciprocating motion. It was suggested that the solution might ultimately be found in one of the fluid transmission systems which had been recently described in the technical press.

In comparing the cost of electric and pneumatic drills the power consumption was a far more important consideration than first cost. The input of a compressor was given as 8 h.p. as compared with $1\frac{3}{4}$ h.p. required by an electric drill. It was evident that the first costs and maintenance would be comparatively small as compared with the cost of power and, other things being equal, the compressed air drill could never successfully compete with the electric drill so far as costs were concerned.

Finally, referring to pneumatic drills, Mr. Drew enquired whether piston rings were used. He would have thought they would be advantageous since, unless very effective lubrication was maintained, there would be considerable leakage of air past the pistons as soon as wear began to shew itself.

Mr. J. W. GIBSON (President of the Association), who was particularly interested in the history of the development of machine drilling during the last 25 or 30 years, said that during the past week a well-known colliery had closed down after 275 years' continuous operation—apart from interruptions due to strike, etc.—and although for 225 years of that period the only power behind the picks had been manual, drilling had been adopted there since drill steels had become available. The development in pneumatic machine drilling reflected very commendable enterprise and the position constituted a challenge to electrical engineers to tackle the problem of drilling electrically. After all, they had overcome greater difficulties than those associated with drilling; not many years ago, for instance, electric colliery winding had been regarded as impossible, but it had been brought to an economical proposition. Mr. Gibson thanked Mr. Marshall for his paper, and congratulated the Branch upon having had the privilege of its presentation.

Mr. H. H. SPENCER (Vice-President of the Branch) suggested, in view of the fact that the paper was of such great interest to all concerned with the practical work in collieries and quarries, that it might be read at a meeting of the Kent Sub-Branch, or that written comments with regard to it might be invited.

The BRANCH PRESIDENT replied that any Branch was at liberty to ask the author to read the paper at a meeting of its members, or to reply to written questions.

Mr. D. Y. MARSHALL, replying to the discussion, expressed the view that the electrical engineer had not given sufficient time and thought to the problems which arose in the design and development of electric drills. In this connection he said the Bladray electric drill delivered a blow of something like 200 lbs. about 700 times per minute. It was invented nearly forty years ago, but since that time the application of the principles involved in that drill had been attempted only in connection with small pneumatic tools such as scalers, chipping hammers, etc. He knew from his experience in the north that colliery managers and mining people in general were willing and even keen to adopt all electric tools, and were prepared to place orders for drills of an electric type which would yield results equal to or better than those that were got at present from the air driven tools.

It should be borne in mind, however, that the drilling problem in coal mines was not merely one of drilling coal, but of drilling stone, gypsum, slate, and other formations as well, and the drills must be able to stand up against such substances. The electric drills on the market today were quite capable of drilling coal, but this alone was not sufficient to warrant their adoption in the majority of mines in this country.

With regard to power costs, Mr. Marshall said that it had been more or less admitted in the paper that they were proportional to the h.p. used, and if the electric drill could do the work which was required of it, it had a great advantage over the pneumatic drill from that point of view.

The electric machine was capable of drilling fairly hard coal quite satisfactorily, but as harder materials came to be dealt with it lost the advantage of lower power costs as it was not capable of drilling at anything like the same speed as the air drill. When a certain degree of hardness of rock formation was reached it was only possible to drill by means of compressed air.

Answering Mr. Drew's question as to the use of piston rings, Mr. Marshall said that attempts had been made to use them on some pneumatic drills but they were found only to be a source of trouble due to breakage. The air ports which enter the cylinder, very often at acute angles, were about ⅜ inch in diameter. Where these ports enter the cylinder they form an oval hole about ¾ inch long and ⅜ inch wide. The ends of the rings would be apt to catch on edges of these ports, and there would be considerable breakage. As the piston had to be rotated it was not practicable to pin the rings as was done in the case of a two-stroke engine so that the ends of the rings could be kept clear of the ports.

With regard to air pressures, he stated that drills were offered by most manufacturers to run up to 100 lbs. per square inch pressure, and many of the drills, especially of the big drifter type, would run at pressures up to 110 lbs. per sq. inch. On some of the big tunnel jobs in this country pressures of from 90 lbs. to 100 lbs. had been maintained at the drills. Pressures above 90 lbs. were perhaps severe and would increase the upkeep costs, but in some cases such considerations had to be sacrificed in order to get additional speed of drilling.

In conclusion, Mr. Marshall intimated that he hoped to receive written contributions to the discussion, and he would be pleased to reply to them through the medium of the Association's journal.

WARWICKSHIRE & SOUTH STAFFS. BRANCH.

Electrical Application to Loaders and Conveyors at the Coal Face.

L. C. GUNNELL.

(*Paper read 11th December,* 1930).

In presenting this paper it is not intended to deal with the economical or commercial values of conveyors and their allied accessories; but, rather to put before those mining, electrical, and mechanical engineers who are responsible for the maintenance and efficiency of underground machinery and who are answerable for the all-essential factor—"output," some of the everyday problems attendant upon underground equipments.

Having in mind the enormous expense which progressive collieries are called upon to bear in providing up-to-date installations to "win" coal in their efforts to meet the keen competition of the foreigner, it is obvious that the onus of responsibility will fall upon the electrical and mechanical engineers.

Conveyors and loaders, which are considered to be subsidiary plant, will be used to a greater extent in the future for handling the raw coal in its crude unmarketable condition after it has been "won" from the earth. Conveyors and loaders are indispensible to the efficient working of the mine, but, unfortunately, they are not yet held in such respect as is due to them. To overcome and meet the increasing and multifarious problems, the colliery engineer will be called upon to select the best possible apparatus suited to the conditions, and to keep himself familiar with the daily progress and advancement of the coal face.

The engineer responsible must have before him, and constantly under his observation plans of the underground workings, shewing the positions of all machines, and marking thereon the weekly advancement of each.

Fig. 1.—Cable Joint made by utilising detachable dividing boxes (Reyrolle).

By this means he will see at a glance the progress (whether satisfactory or not) of each unit, and it will enable him to have at hand the cable and accessories necessary to keep pace with the rate of advancement. One can imagine the seriousness of being caught "out of stock" of cable, etc., when a face is waiting to go forward. An arrangement existing between the author's firm and cable manufacturers as a safeguard in this contingency, is that they shall hold cables in stock for immediate supply to demand.

Another important point is the keeping of an efficient card-index record for the purpose of maintaining a complete history of each machine. Such a record giving details such as test experiments, repairs effected, the different positions in the pit where the machine

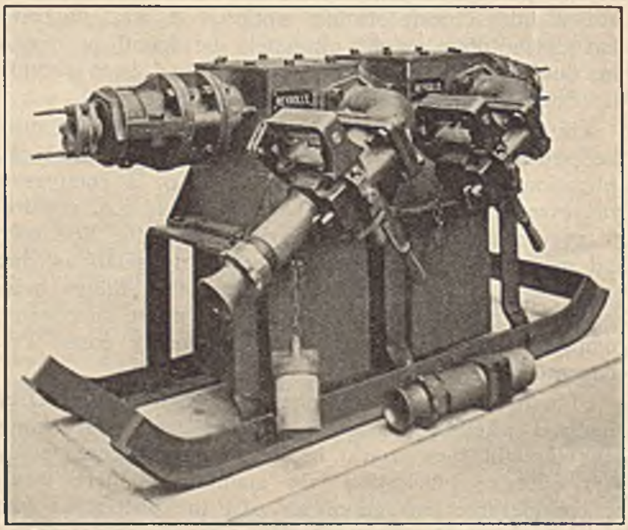


Fig. 2.—Two-panel "Mothergate" Switchboard with 100 amp. Plugs for Trailing Cables (Reyrolle).

and apparatus has been installed etc., is most essential to the engineer and management.

The Supply System.

The most common supply system, i.e. alternating current, three-phase, 50 cycles, will no doubt be in operation, and there is every likelihood that this supply will be adopted generally in the near future. This supply is the standard adopted by the Electricity Commissioners of Great Britain.

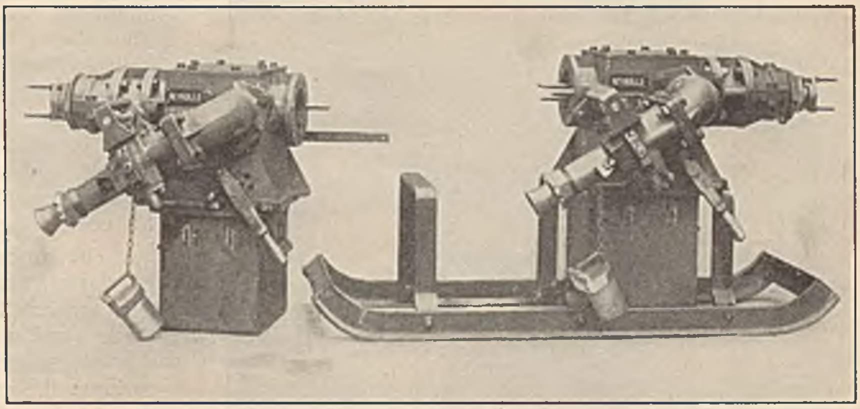


Fig. 4.—Two-panel Switchboard mounted on Skids; one Panel removed to shew the Bus-bars (Reyrolle).

Transmission.

The question of transmission is usually governed by local conditions, but the author's experience prompts the suggestion that 3300 volts is a reasonable pressure for transmission in-bye. This pressure would be stepped down to a medium pressure at a place as near as possible to the work. Assuming a seam or district where, perhaps, three or four coal faces are worked entirely by machinery: the first consideration is to fix upon the most suitable position for housing the distribution switchgear. This position should be as central as possible so that a convenient form of distribution can be obtained. Each face will have an independant feeder from the main distribution centre: although such an arrangement may not always be possible, it is a matter worthy of consideration. It is not necessary to incur expense in building an elaborate house for the switchgear, as owing to the rapidity of advancement of machine-mined faces the life of the gear in one particular place is very short. On the other hand, control gear should be reasonably housed and guarded against possible danger or damage by being run into by trams.

For the purposes of machine mining, the author considers that the most suitable form of control gear is a main switch, of the oil-immersed circuit breaker type, to control the incoming supply. The switch should be equipped with full automatics and perhaps including leakage protection. The supply is passed to the busbars of a three or four panel switchboard of the ironclad, air-break, flame-proof type, pillar pattern; each of these switches feeds its respective circuit through a combined switch and fuse.

This is necessary for compliance with the Coal Mines Act (Rule 128C). As it must be understood it is only necessary to install cables from this point having a sufficient section to carry the load of the branch feeder taking into consideration the distance the sub-mains or branch feeders will have to reach. It is from this point that difficulties confront the underground electrical staff.

As regards cables, the type most suitable for advancing purposes is a cable having its cores insulated with V.I.R., bitumen filled, served, D.W.A. taped and braided. It is good practice to have the cables in lengths of approximately 150 to 200 yards.

The type of joint box most suitable for this class of work is so designed that it can be converted as a through disconnecting link box, a Tee junction or a four-way junction. To enable cables to be disposed of in doubles, good gate roads are necessary and this is made possible by carrying the roads right up to the face on steel arches. This is absolutely necessary if the highest results are to be achieved, especially where gate conveyors are in use.

Gate-end Switchgear.

Careful consideration is called for in the selection of gate-end switchgear. There is considerable diversity of opinion on this subject, but the whole matter resolves itself into the choice of an arrangement most suitable to the particular working conditions. It is beyond doubt that automatic switchgear, whether oil-immersed or air-break, is far preferable to fuse gear. The distinct advantage of automatic gear is that, once the overload settings have been adjusted to the load conditions, it is out of the hands of the machine operators. With fuse gear the temptation exists to strengthen the fuse against

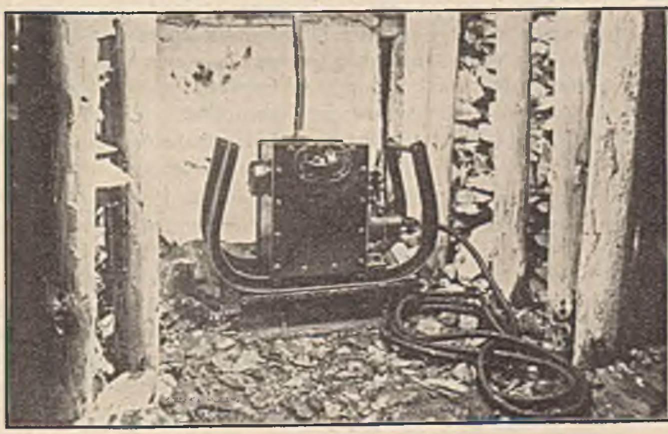


Fig. 3.—Circuit Breaker (Ellison).

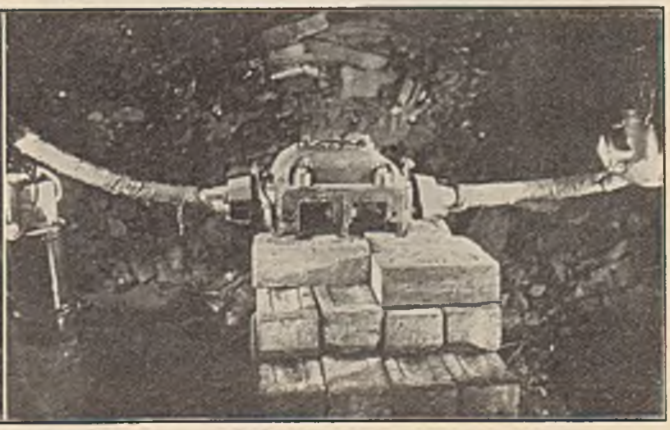


Fig. 5.—Cable Coupling (Ellison).

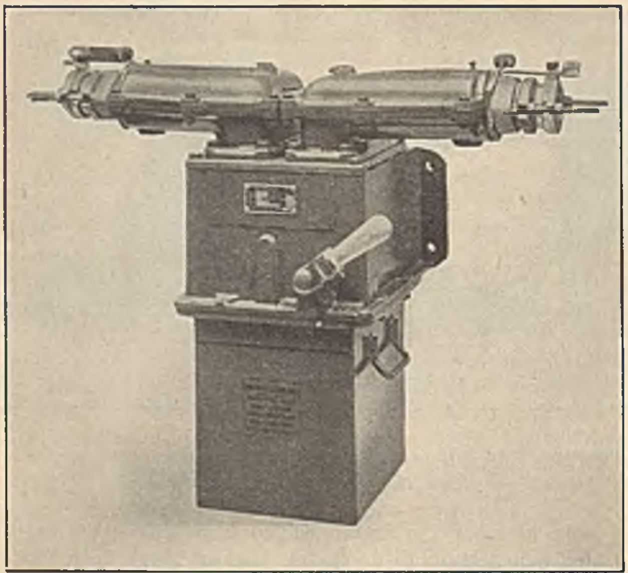


Fig. 6.—660 *volt,* 100 *amp., Three-phase, Flame-proof Circuit Breaker with detachable Dividing Boxes.* (*Reyrolle.*)

abnormal working loads such as are frequently brought about by adverse face conditions. In consequence, burnt-out motors are a common result.

Modern types of gate-end switchgear offer other forms of protection of which advantage can be taken. Apart from instantaneous over-load tripping devices, a form of time-delaying action can be introduced to prevent the continual tripping out of the switch when momentary "peak" loads are encountered, or when starting up a three-phase squirrel cage motor from rest. It is now becoming a common practice, since the introduction of the high torque motor for coal face machinery, including coalcutters, conveyors and gate-end loaders, to use direct line starters. It is doubtless a step in the right direction. The chief feature of this motor is practically the indestructibility of the rotor. The starter provided for it is well constructed and built on the lines of contactor gear, but for hand operation it has quick make and break movement and is proving quite satisfactory. The maintenance of this class of gear is very low compared with that of the earlier types of starters such as the star-delta starter, which at one time were used extensively and particularly for coalcutting machine control.

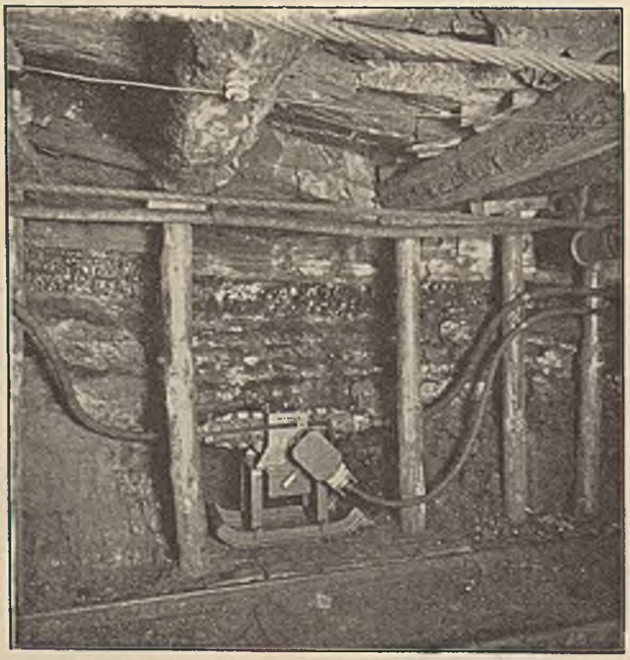


Fig. 7.—*A* 60 *amp. portable Gate-end Switch fitted with detachable dividing boxes; placed in a recess in the main haulage road-way* (*Reyrolle*).

The author does not seek to depreciate this class of starter, for it has its own particular fields of usefulness, but for coal face machinery the more simple the control, the greater the reliability. Delays, whether due to starter trouble or any other cause, are most serious: the coal face must be turned over completely in the 24 hours, or otherwise the objects and value of intensive mining practice are wholly lost.

Whilst referring to starters it will be useful to raise the point as to the advisability of arranging the starter to be self-contained in regard to overload protection for small units, such as shaker motors, gate-end loader motors, and small haulages. The question of space is the trouble but it offers no supreme difficulty: it would appear only that manufacturers have not yet considered the question seriously.

Considering that the motors are connected to the supply by means of trailing cables through the gate-end switch, and are in commission on the opposite shift to the coalcutting shift, and whereas the coalcutter motors range from 30 h.p. to 50 h.p., the conveyor motors are only of 12 h.p. to 15 h.p.; loader motors of 5 h.p. and haulages from 15 h.p. to 30 h.p., it stands to reason that adequate protection against overload is not normally afforded to the smaller units. One method of surmounting the difficulty would be the adoption of unit type gate-end gear and such multiple equipments would be costly.

Reverting to gate-end switchgear; the embodiment of some form of leakage protection or earth circuit protective system, can be utilised. The earth circuit protection should be considered seriously as a safeguard against the possibility of inefficient earthing in connection with face machinery and trailing cables. The protective system entails the provision of an additional core, termed the pilot core, in the trailer cables. It is not necessary here to describe protective systems in detail, such systems as the Williams-Rowley and others are now well known.

The earthed pilot form of interlock to prevent the withdrawal of a plug controlling a flexible lead to portable apparatus and at the same time to demonstrate the continuity of the main earth connection, was first proposed by Fisher in 1908. Objection was raised, however, to the supply to the earthed pilot circuit from one phase—which was done through a resistance—owing to the possibility of the earth connection between switch and bank, in the case of underground working, being broken, which might result in the portable apparatus being made alive.

In order to obviate this, Messrs. Reyrolle & Co. Ltd. have devised a modified arrangement based upon the use of a supplementary winding on a tripping device, such as a low volt release which also is normal energised from one phase to the "live" side of the switch, but the pilot is connected to a circuit in a shunted magnetic path. The pilot wire now only carries a low potential circuit. The current in this circuit has the effect of reducing the magnetic leakage through the auxiliary limb to a minimum, allowing the armature to be attracted in the usual way. If, however, the earthed

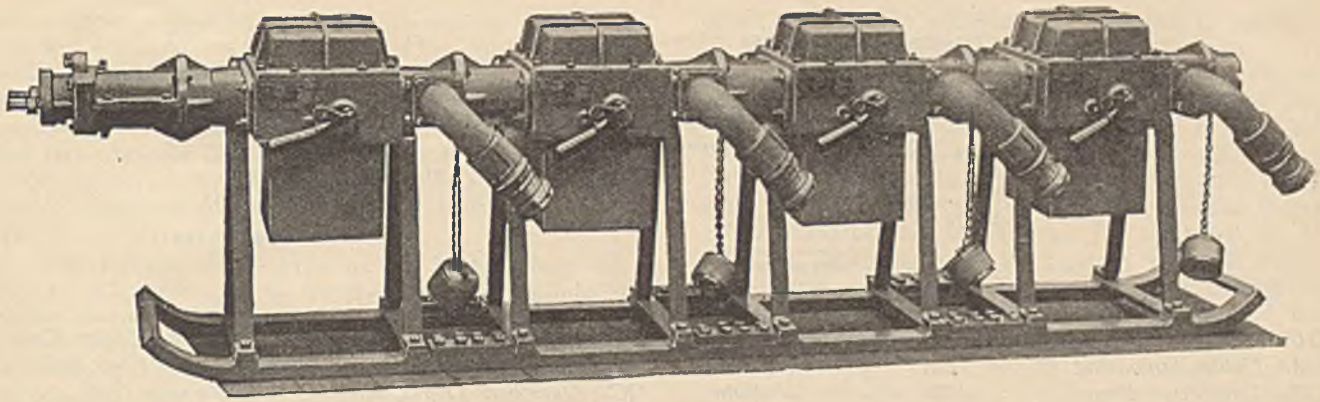


Fig. 8.—Mothergate Switchgear, with easily detachable units, for controlling Coal Face Portable Electrical Machinery (Switchgear & Cowans).

pilot circuit is broken and the current in the subsidiary winding thereby interrupted, the main magnetic flux is allowed to pass through the auxiliary limb and the armature is released. This forms an electrical interlock, which, used in conjunction with auxiliary contacts on standard plugs and sockets, such as are used for coal-cutters in mines, prevents a plug being withdrawn without also tripping the controlling switch, and at the same time automatically interrupts the circuit should there be a break in the main earthing connection.

Leakage Protection.

Some form of leakage protection is worthy of consideration. Such a system can be embodied in conjunction with the main circuit breaker controlling the district, or it can be embodied in each individual gate-end switch. Should the district be a large one having, say, three or four machine worked faces, then beyond doubt leakage protection in the gate-end switch is preferable. This gives the benefit of selectivity in the event of an earth fault, as each gate-end switch looks after its own circuit, thus avoiding considerable delay which would otherwise be the case where leakage protection is installed out-bye.

It is very surprising the amount of time that can be lost under the latter arrangement, on the occasion of an earth fault which has tripped the switch. Firstly it is necessary to localise the fault; very often no cause can be found and the conclusion drawn is that flashing to earth has occurred in one of the starters. There is always a great uncertainty regarding these happenings and fault localisation; even under the best of conditions it is very often a lengthy procedure.

Trailing Cables.

The subject of trailing cables is one which calls for great care and deliberation both by the manufacturer and the user. The problems encountered by the mining electrical engineer have been made a special subject of study by the cable makers, and they have produced several types of trailing cables in an endeavour to meet with the various conditions prevailing. Every mining man, more or less, knows the anxiety attending the use of trailing cables at the face under the severe treatment to which they are subjected.

The author has used trailers with the pilot core inserted in the centre web and with the pilot core laid up in lay with the power cores. Sooner or later the usual trouble arises, i.e., the breaking of the pilot core. This is due to its mechanical weakness as the sectional area of the pilot core is much smaller than that of the line cores. The pilot cores are not of sufficient comparative mechanical strength to withstand the rough usage, the twisting and the bending to which the cables are subjected: when the pilot core breaks there is frequently considerable delay before the nature of the fault becomes known to the machine operators. To overcome the frequency of breakage of the pilot core, the author has strongly recommended that the trailing cable cores should all be of equal section. That would increase the overall diameter of the cable, but the actual increase would be negligible, and the extra cost necessarily involved would be justified by the additional life of the cable and the number of expensive delays obviated.

It will be well to enter a little more fully into this matter. The earthing screen of the produced type of cable, surrounding the conductors, suffers breakage of the individual wires due to the continual bending and twisting. This cannot be avoided, but it can certainly be lessened by stowing away the cables, when not in use, on suitable bollards. The broken wires of the screen sometimes penetrate the insulating sheath and cause a short circuit. Another great disadvantage in the use of the earth shield is the rapid destruction of the fine wires by corrosion, resulting from the action of free sulphur in the dielectric. As to the most suitable type of trailer, protected or unprotected, there can be no question, provided that in the case of the protected type the troubles mentioned here can be overcome successfully. Lengthy tests and great pains have been taken by the makers in an endeavour to correct this particular trouble

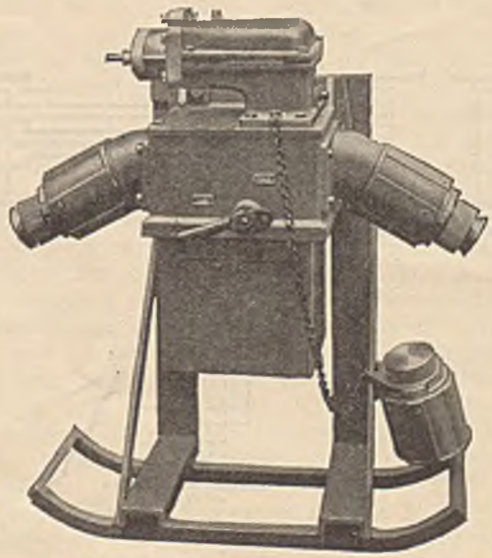


Fig. 9.—Duplex Gate-end Switch for controlling alternatively Two Trailing Cable Circuits such as Coal-cutter and Drill (Switchgear & Cowans).

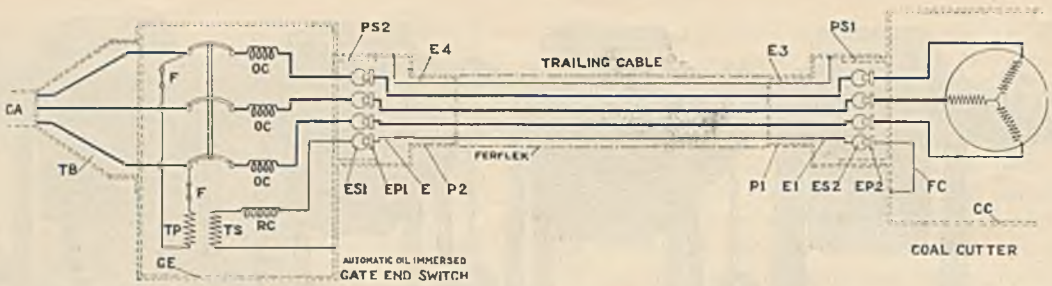


Fig. 10.—Earth Protective System (Switchgear & Cowans).

GE. Gate-end Switch Casing	*E. Earth Core*	*F. Auxiliary Fuses in Transformer*	*PS1. Adapter, Cutter End*
CA. Cable Armouring	*E1. „ „*	*OC. Overload Trip Coils*	*PS2. „ Gate-end*
CC. Coalcutter Frame	*E3. „ „ Main*	*P1. Pommel, Cutter End*	*RC. Retaining Coil*
EP1. Earth Pin, Gate-end	*E4. „ „ „*	*P2. „ Gate-end*	*TP. Transformer, Primary*
EP2. „ „ Cutter End	*FC. Flex Connection to Cutter Frame*		*TS. „ Secondary*
ES1. Earth Tube, Gate-end			*TB. Trifurcating Box*
ES2. „ „ Cutter End			

(i.e., the breaking of the fine wires in the earth shield) and they believe their endeavours have been successful. The makers in one case are having a strong twine woven in with the wire woven screen. Time proves all things, and usage must prove under actual working conditions the success or otherwise of these endeavours.

Again there is great diversity of opinion and design as to the method of applying the earth shield. Should the screen be embodied in the sheath surrounding the whole of the conductors or should it be applied to individual conductors? Each method possess advantages and disadvantages, but undoubtedly the latter has distinct advantages over the former.

Another form of cable for use with coal face machinery has an outer protective screen of pliable armour composed of a number of galvanised wires, over which a "snooker" wire is wound and caught (soldered) at intervals of one yard. The usefulness of this cable is especially pronounced for work on semi-portable machines, jigging conveyors or engines, as it is greatly resistant to the abrasive action which is likely to occur by the backward and forward action of conveyor pans should the cable come into contact with them. To obtain a cable for this purpose was one of the author's difficulties. He was pleased to say that the cable (a sample was exhibited) which he eventually got quite satisfied the requirements.

Electrical Layout at the Coal Face.

Here again the difficulties are numerous and are mainly governed by the local conditions. The electrical engineer must study the problems in the mine and instal arrangements to suit the prevailing practice. There is no doubt that the usefulness of automatic and remote control contactor gate-end gear commends itself for this duty; but where there is a possibility of some 18 to 20 equipments needed for the colliery, it is going to be a very costly matter. The author made a number of experiments regarding the most suitable layout, and found that the best results were gained by an arrangement of switchgear installed at the loading point in the gate road; at that point it is necessary that the man should have complete control of the face conveyors.

As regards the most suitable layout for the electrical control of face conveyors and loaders, that would depend to a great extent upon local conditions, but it must be borne in mind that where face conveyors are delivering coal on to a gate end loader, the loading

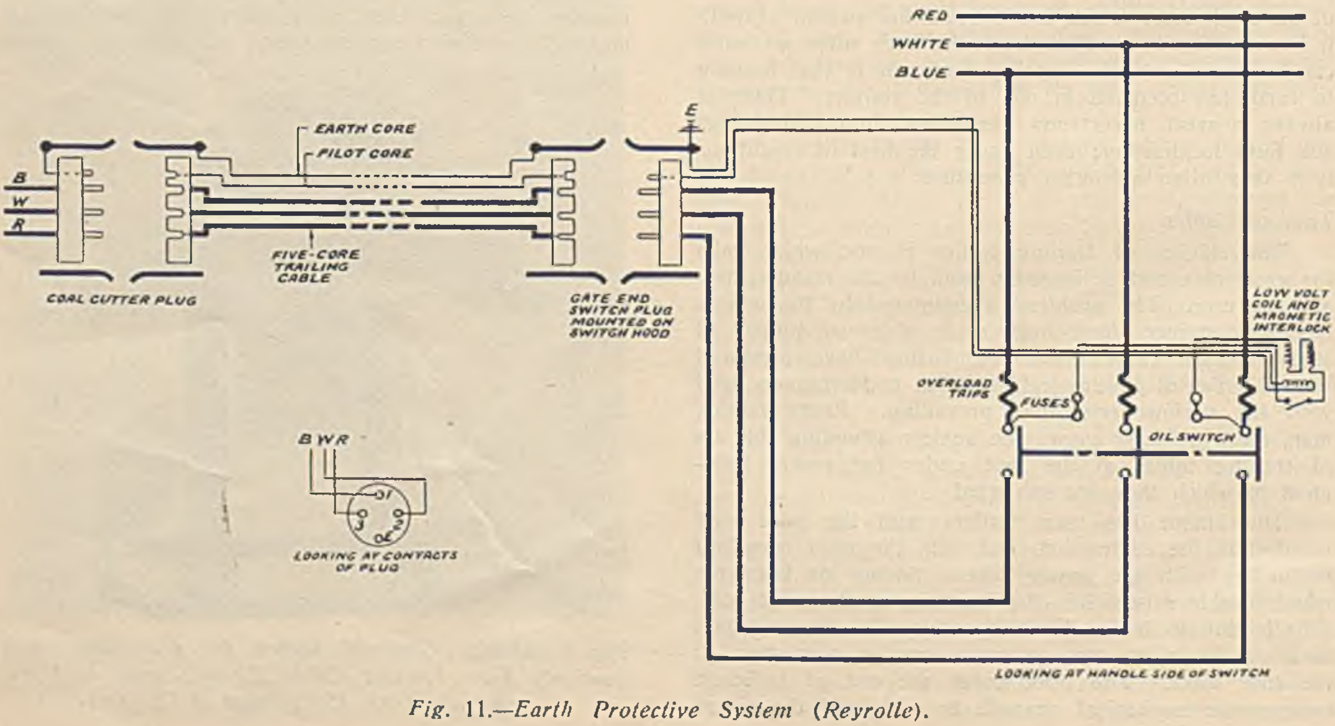


Fig. 11.—Earth Protective System (Reyrolle).

point must undoubtedly be the controlling point. If for any reason it be found necessary to stop the loader, which often happens say for want of tubs, it is most essential that the face conveyors should also be stopped as, otherwise, piling up of coal would take place where the face conveyor delivers on to the gate road conveyor. Such an occurrence would be extremely serious, and would cause considerable damage to belts, chains, etc. due to excessive overloading.

For the purpose of breaking the load of both conveyor and loader, it is quite convenient to instal a switch having full automatic features to take care of all contingencies that may arise on the load side. In addition to this switch the conveyor and loader plant is equipped with a switch; usually of the hand operated contactor type.

The gate-end switch, where both the coalcutter and face conveyor trailers are attached during their respective working periods, is placed near the gate-end of the coal face.

Where a shaker conveyor motor is situated at some point along the face, or at the farther end of the pans, a pliable armoured cable is used for reasons already indicated. The cable arrangements must be given very careful consideration; the length of cable from the control switch at the loading point should coincide with the maximum length of gate road conveyor. This might be anything from 85 yards to 150 yards, depending upon the type of conveyors used. By adopting a universal type of joint box, advancement can be carried out in a very convenient manner, and by having the main cables in lengths of twice that of the gate conveyors' cable, unnecessary jointing is avoided. It is a wise practice to have a short length of cable, say two or three yards, with a half box attached, already connected to the line side of the gate-end switch so that when it becomes necessary to add a new length of main to the system it can by done quickly. As a matter of fact, there is very little time available between the coal turning shift and the cutting shift.

The layout which the author has in mind is a typical example of a single unit face, where coalcutting, conveying and loading is carried out. At the colliery where he is engaged electric drilling is carried out on all machine faces: this method has been extensively adopted and with very good results. In conjunction with the shot hole drilling is a coal face lighting system. The pressure at which drilling and lighting takes place is 125 volts, three-phase, 50 cycles. The lamps, 75 watt, gas filled, used for the lighting system are spaced one every six yards. This spacing was not divided by mere guess work, but only after exhaustive scientific experiments. The same cables are used for both drilling and lighting. The lamps are balanced across the phases and are made up in groups of three, having a plug at one end and plug socket at the other end of each group. It is at each of these junctions where the drilling machines can be connected by means of a standard plug and a length of cable sufficiently long to enable the driller to reach from one section of lamps to another section.

The results of the installation of combined coal face lighting and drilling have given every satisfaction it enables the work to be carried out most efficiently and the coal obtained is cleaner. A considerable amount of time and trouble was spent before arriving at the most suitable type of cable for the combined purpose of drilling and lighting. The first cable used was a cab-tyre sheathed, having four cores, i.e., three line cores and one earth core, 0.003 sq. ins. sectional area per core. The use of this cable was permitted only after the issue of an exemption by the Mines Department, in pursuance of Regulation Nos. 130A, 125B. On Account of the continual breakage of cores, owing to their mechanical weakness, a cable with a greater cross sectional area of cores was tried. The cable now in use is a cab-tyre sheathed cable of four cores each core of equal strength, 0.01 sq. ins. Since using this cable the results have proved very satisfactory, but the author is of opinion that to a great extent the success can be attributed to the fact that since combining the lighting with the drilling it has been possible to dispense with the necessity of using a cable drum, which was formerly required with drilling operations only. Doubtless, the coiling up of long lengths of cable on to small diameter drums accounted for the cable cores breaking so frequently.

Concentration of Out-put of Coal.

At Birch Coppice Colliery the percentage of hand-got coal is very small indeed. The change-over from hand-got coal to machine-got coal, and the general change of conditions, has taken a considerable time. The adoption of a general change of conditions must be done in stages, as both officials and men have to be taught and trained in the way of machine mining. The whole state of affairs is altered and the lot of the management is not to be envied. During the period of transition, difficult problems are encountered daily.

The author's first experience of machine mining was on a 2 ft. 9 ins. thick seam. A double unit face, left and right hand, was worked, longwall advancing. Each of the faces was approximately 85 yards long and the coal was undercut 4 ft. 6 ins. The cutting was accomplished by a chain haulage type machine in about 6½ hours. It was on this face that electric drilling was first tried out at a pressure of 125 volts, three-phase, 50 cycles. A system of coal face lighting was also tried out, but in this case at 25 volts, single-phase, with 15 watt lamps enclosed in a well glass. It was an earthed concentric system.

The coal was filled off these two faces on to a Mavor & Coulson jigger conveyor, driven by a 15 h.p. motor. The coal was then delivered on to a selfcontained portable gate-end loader driven by a 5 h.p. squirrel cage motor which delivered the coal into tubs. It is necessary to advance every shift with this type of loader, and of course routine work in the shape of ripping down the lip to allow sufficient head room for the loader to pass under has to be done. Good features of this loader are the four air-break hand-operated control switches, operated by control rods, erected on the same frame. Complete control of both right and left hand face conveyors is given, also of the loader and lighting transformer. This outfit handled 300 tons of coal per shift and as the results were so successful it warranted the extension of machine mining: to-day there are 12 faces in operation on various methods of concentrated output. A recent piece of work was the advancing of a double unit face of 200 yards, worked longwall, to a distance of some 500 yards. The coal from one side of this face was turned over on to a Mavor & Coulson shaker conveyor, and on the other side of the face the coal was turned over on to a conveyor of the scraper chain type, driven by a 12 h.p. squirrel cage motor. These two units delivered the coal on to a sectional scraper chain conveyor, which was installed in the main gate road. The maximum length of conveyor was 170 yards. From this conveyor the coal was passed on to a 24 ins. troughed belt conveyor (belt speed approximately 110 feet per minute) and this belt reached a maximum length of 400 yards. The belt delivered into the tubs at the junction of a main haulage in the district and did actually handle up to 380 tons per shift.

Here again the man at the loading point had complete control over both face conveyors and both gate conveyors, so that in the event of there being a shortage of tubs, he was able to cease the conveying of the coal. The full length of coal face, i.e., 200 yards, was turned over each shift or once in 24 hours, the procedure adopted being as follows: Both face conveyors were moved forward with the advancing face; the sectional scraper conveyor in the gate road was lengthened 4 ft. 6 ins. each move forward, by means of the addition of a pan at the face end, such operation being repeated each shift until the full length, 120 yards, was in use. When the full length was in use (120 yards) the driving head was taken forward towards the face and re-erected.

As regards the rubber belt, this was increased in length to the full distance of 400 yards. The "holing" on this particular face was moderately "soft" and the whole of the 200 yards cutting, with a 4 ft. 6 ins. undercut, was completed in about 5½ hours, by an electric chain cutter, rope haulage, with a maximum haulage speed of 54 inches per minute, and a cutting speed of 500 feet per minute. A 40 h.p. motor drove the machine.

Various methods of roof supports have been tried out by means of solid and compressible props, and steel tubular props, with a wooden core. The girder section steel joists, with both ends rounded, have given every satisfaction, being easier to handle, easier to set and, in the long run, cheaper. The main gate roads are carried on 10 ft. by 8 ft. steel arches which for taking compression, are mounted on "stilts."

Where single faces are in operation, independent gate roads are kept. The length of face open is about 100 yards, and jigging conveyors are used where the condition and gradient is in favour of the load. The jiggers in use are of two types fitted with 12 and 15 h.p. motors respectively. The coal is turned off on to the jigger, which in turn delivers to a gate-end conveyor of the scraper chain type; two types of these are in use. When fully extended the length of these scraper loaders is approximately 100 yards, and their maximum output for 7½ hours is 250 tons.

The electrical equipment comprises a 12 h.p. motor operated through a direct line starting switch. The older type of conveyor has a friction clutch, so that it is necessary to operate the clutch only for starting and stopping, and this avoids continual stopping and starting of the motor. Experience soon proved, however, that the clutch could be dispensed with, as it was necessary to stop the jigger when stopping the loader, and under such circumstances it was found more convenient to have a switch to operate both the jigger on the face and the gate loader also. Such an arrangement not only simplifies matters, but it prevented troubles that are not infrequent on control types of starter switches.

Fig. 12.—Electric Driving Gear for Shaker Conveyors connected to the end of the troughing. It may also be placed at the side of, underneath, or at right angles to the troughing (Mavor & Coulson).

To prevent damage to the gears, driving chain or other parts of the machine, which is quite possible should a piece of coal become wedged when being conveyed by the scraper chain, a simple device in the form of a shearing pin takes the drive. In the event of any abnormal load this pin immediately shears, thus disconnecting the driving section from the scraper chain.

When the scraper conveyors have reached their maximum lengths the process of moving forward is quite a simple job, provided certain preliminary arrangements have been carried out. When once the maintenance staff, both mechanical and electrical, have become familiar with the procedure, flitting or moving forward becomes simple and inexpensive. This type of conveyor has proved quite a satisfactory job for face and gate road working.

The sectional conveyor consists of an endless scraper chain, built up in six feet sections, which make it convenient and light to handle. The chain runs in steel troughs, the troughing being supported by an underframe; supporting also the return chain. The troughs are also made up on six feet sections. The troughs are dished at one end so that when joined up a good overlapping joint is obtained, thus preventing leakage. The chain flights and links are of malleable iron, and any renewals or replacements to the chain can be carried out with very little difficulty. A telescopic trough at the tail end of the conveyor is the means of tensioning the chain. A totally enclosed motor of about 12 h.p. drives by means of a Coventry chain, through a reduction gear, controlled by a hand wheel operated friction clutch. This gives the man at the loading point an easy control of his work.

The larger sectional conveyor has a scraper chain having long flights by which large size coal is conveyed —the small coals lying at the bottom of the trough. Its maximum length is 120 yards and its coal handling capacity is 350 tons per 8-hour shift, from a seam three feet thick.

The jigging conveyor is a useful type of machine, particularly suited for low seams, on account of its compactness: its overall height is about 15 ins. and it is 22 ins. wide: the machine is suitable for end drive, side drive or under drive and can work either right or left hand without any alteration to gearing or transmission. The gear is totally enclosed. Forced lubrication is applied to the phosphor bronze bearings carrying the rocker shaft lever. The drive is by bevel and spur wheel gearing. The reciprocating motion imparted to the jigger pans is by means of a crank. The pans are carried on wheels and axles. An angle-iron path is fixed to the underside of the pans. Another such wheel track is fixed in the form of a cradle and the curvature of the track is such that sudden kicks are avoided at the reverse of the stroke. The driving gear is coupled up to the troughs or pans by means of connecting rods. A method of drive can be introduced that is best suited to the particular conditions, i.e., either direct side drive, direct end drive, or direct under drive. The troughs are carried on rollers or balls which, in turn, run in cradles or runways. The driver unit imparts to the troughing an oscillatory movement which results in a gradual accelerated movement of the coal in the direction of the delivery end, and the sudden reversal causes the coal to move forward at each stroke.

The troughs can either be bolted together, or held together by means of haulage ropes. In the latter case, one rope on each side runs the whole length of the conveyor. After taking up tension on the ropes the troughs are pulled together by means of a screw buckle.

For electrical drive the motor is totally enclosed and flame-proof. As a rule the motors fitted are capable of 30 h.p. at one-hour rating.

The advantages gained and claimed for underground mechanical conveying systems may be summarised as follows:

1. Concentrated production of coal.
2. The getting of a maximum output per yard of face per man.
3. Greater output of coal per man shift.
4. Larger outputs can be dealt with per working shift.
5. A reduction in the number of gate roads, consequently less cost on roads and material.
6. Larger tubs can be used, since these are not taken on to the face.
7. Better ventilation.
8. Better roof control, since the regular progressional working has a tendency to more uniform roof weight.

Coalcutting.

It is hardly necessary to mention that where mining is being carried out on an intensive scale, much depends on the success of the coalcutting machines. Any delay in getting the coal cut, spells delay in getting through with the whole operation of turning off the face. Whatever the conditions of cutting may be, it is essential that there must be allocated periods of cutting, to which strict adherence must be observed. In the event of failure to observe such periods, there is the possible risk of the face not being turned over, with the consequent serious results. The author has had considerable experience with various types and makes of coalcutters working under conditions where cutting was reasonably "soft" and also where cutting was "hard."

In a seam four feet thick a rope haulage machine is cutting a 200 yard double unit face in 5½ hours, at a rate of 36 inches to 54 inches per minute, an undercut of 4 ft. 6 ins. and a cutting chain speed of 500 feet per minute. The cutting at this face is very soft and the machine cut 31,500 yards before being brought again to bank. The machine will cut, on average, 350 tons per shift, and the cost of repairs and maintenance is very small. Never once has this machine failed: a performance reflecting credit upon the efficiency of the maintenance staff. The conditions are, of course, favourable; unfortunately, these results are not got everywhere.

The same type of machine is being used in the seven-feet seam at Birch Coppice, and, on an average cuts 85 yards in about the same time as the machine in the four feet seam, viz., 5½ hours. The holing is very hard, and incidentally the cost of repairs and renewals is heavy in this case.

To have coalcutting as successful as machine and conditions will permit, a great deal depends upon the co-operation of the underground staff: in fact it will be found that this is a factor which governs to a great extent successful machine mining.

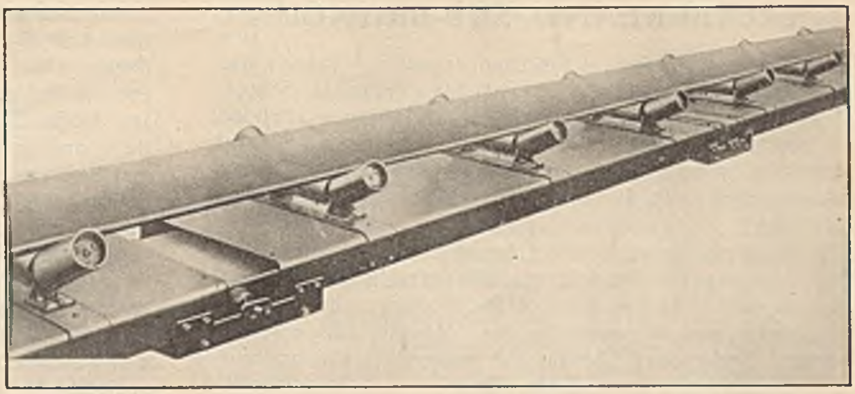


Fig. 13.—Belt Conveyor. The top belt is made to appear transparent in order to shew the idlers. The top idlers are supported on steel troughing that forms a light rigid structure and protects the return belt (Mavor & Coulson).

Organisation.

The question of organisation and supervision cannot be lightly dispensed with, but must receive every possible thought. The mechanical and the electrical department must work hand in hand, or the success of any installation would be jeopardised. The introduction of a definite programme of maintenance is necessary and it must be undertaken as thoroughly and conscientiously as possible.

The author would suggest that a reasonable period to fix upon for having coalcutters brought to bank for a thorough examination and overhaul would be after cutting about 20,000 yards: but conditions of working and the state of cutting would have to be the deciding factor as to the actual distance worked. Conveyors of any description should be brought out for overhaul about every four months: it would always be good to have a spare unit available.

Conclusion.

In concluding these notes the author would express his firm conviction that machine mining has become a permanency. The various operations allied to the system follow in definite sequence. The whole "turn-over" must be completed in 24 hours. Every advantage must be taken of machine cutting and drilling, and coal face lighting also, where permissible: and the plant must be used to the maximum extent.

He has finally to record his appreciation and thanks to the school authorities for the use of the lantern and lecture-room; to Mr. Kingsbury for his assistance at the lantern; and to several firms for the loan of lantern slides, particularly Messrs. Mavor & Coulson Ltd., Geo. Ellison Ltd., A. Reyrolle & Co. Ltd., Switchgear & Cowans Ltd., Macintosh Cables Co., Ltd., and Dunn & Sons Ltd.

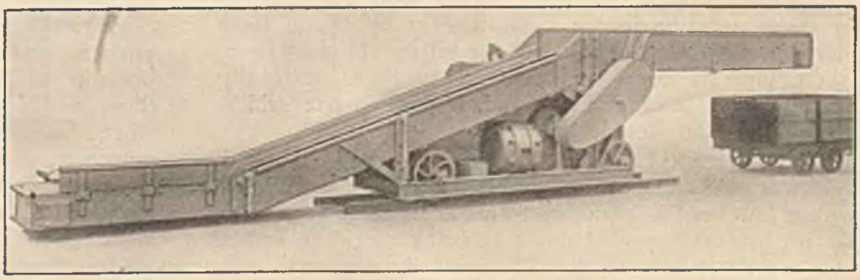


Fig. 14.—Gate-end Loader, Scraper Type with a.c. Motor. The motor is bolted to the worm reduction gearing ensuring maintenance of alignment (Mavor & Coulson).

CUMBERLAND SUB-BRANCH.

A special meeting of the Cumberland Sub-Branch was held on February 13th last at the Technical School, Workington, when over 70 members and friends attended to hear Mr. A. C. Moonie give his lecture. Several prominent members of the Cumberland coalfield were present and joined in the excellent discussion that followed.

The lecture was followed by an extremely interesting film, shewing the heading machine actually at work at the coal-face. At the close of the meeting a hearty vote of thanks was accorded to Mr. Moonie and also to Messrs. Anderson & Boyes, the makers of the machine described, for the loan of the film.

Arcwalling Practice with Special Reference to the Universal Heading Machine.

A. C. MOONIE.

The driving of headings is a primary consideration in the working of coal seams and the question of driving these cheaply and quickly for rapid development has always exercised the minds of mining engineers. In these days of trial for the coal trade when cheap working is so essential, the question has assumed even more importance and the position is further aggravated by the gradual dying out of the better class of hewer. The hewer kirved his place and then nicked it up one side to produce the maximum of round coal with the minimum of shot firing. Today the objective is the same but to do it by machinery, and so gain a larger output, more rapid advance, and greater concentration.

The attempts to apply machines to the driving of headings before the development of the arcwaller were many and varied. Breast machines and bar machines were tried and while they gave good results in a few pits they never had a wide application, due principally to the difficulty of flitting from place to place. Percussive machines had a spell of popularity for some years but these too have fallen into disuse, due to the inefficiency and expense of compressed air, and the difficulty of getting a sufficient number of places cut with each machine. It was obvious that a machine with much more power and greater cutting capacity was necessary.

The first really successful effort in arcwalling was made in the Northumberland district when a longwall machine was mounted on a tram with a drive taken from the side of the machine to an axle. Much good work was done and is still being done with these old machines.

In recent years the design of arcwallers has advanced greatly and they have now a high degree of reliability and cutting capacity. Some very cheap costs have been achieved with arcwalling, particularly where the seam was high enough to allow the machine and the tub to travel without any stone work having to be done. The pillars would also be extracted with the machine by taking off lifts in the usual way or by taking complete slices off the goaf side of the pillar. In most cases where there is no stone work, the cut is made in the middle of the seam or in a band, if there is one, which of course means double blasting.

For seams of moderate thickness where the full thickness of the seam could be blasted at once, a machine with a low head is available. This is the gear head with the jib bracket extended down to bring the picks within two inches of rail level. To avoid leaving crop coal to the thickness of the rail and sleeper, the last pair of rails is dipped on to the floor from the lost sleeper, and the point of the jib touches the floor at the back of the cut, leaving a wedge shaped piece of crop coal at the front of the cut. There is a certain disadvantage in flitting with this arrangement as the picks being so low are apt to catch the crossings or the sleepers if there are undulations. In spite of this difficulty many of them are in use, as it is a question of weighing this disadvantage against the disadvantage of having to take bottom canch or blast the coal in twice with a middle cut. A machine has been designed with elevating screws to raise the jib of the machine for flitting purposes. With this design the jib cut at floor level and it then had to be raised with a ratchet and gearing high enough to clear the rails for flitting purposes. This design did not have a wide application as there were practical difficulties in operation in addition to the extra cost.

The most successful arcwalling system is that in which a seam is laid out on a panel system and the extraction of the pillars is kept advancing at the same rate as the narrow places, with only two or three rows of pillars between the advance work and the pillars being extracted. The benefits accruing from this system are great, as the pillars do not stand for any length of time, thus avoiding crush and shift work in redding out pillars where the roof is heavy. The pillars can also be made smaller, thus lessening the flitting time and tending towards concentration of output.

The application of arcwallers in the thinner seams is a question of conditions in each particular case and no rules can be laid down as to where arcwalling should cease and longwalling work begin. There have been successful cases of the use of arcwallers in thin seams for the extraction of the whole of the seam and of course arcwalling in thin seams under property is common.

With the great increase in recent years of intensive mining involving the use of face and trunk conveyors arcwalling has come much into use for the development of thin seams. The three main roads are driven in the solid to enable them to stand better. This means the driving of five roads and four lines of pillars and stentons driven between them for ventilation. The longwall faces are laid off on both sides in the road next to the solid coal. The method is similar when developing for retreating faces.

In thick seams it is a simple matter to raise the cutting position by inserting packing between the body of the machine and the under carriage, but in thin seams where the cutting has to be done over a canch twenty-four or thirty inches thick, the body cannot be raised owing to lack of height and a design of gearhead for overhead cutting has to be developed. These are now to be had suitable for cutting up to various heights. The overhead cuts are often necessary in thick seams where it is advisable to cut in a band or, where the band is thick, to cut in the coal on top of the band so that the top coal can be filled away first, then the band blasted and cast back and, lastly, the bottom coal filled.

Arcwalling on gradients has received considerable attention and attempts have been made to overcome the difficulty of flitting arcwallers on gradients steeper than those which can be negotiated by the friction of the wheels on the rails. Arcwallers can flit under their own power on gradients up to 4 ins. per yard and cases are known of successful arcwalling up to 6 ins. per yard in dry conditions with the use of sand. There is a case of successful arcwalling on 9 ins. per yard in Northumberland with machines flitting under their own power. This is accomplished by driving the headings at 45 degrees across the strike of the seam thus forming diamond shaped pillars.

Machines have been built to travel up gradients with the rack and pinion as used on mountain railways and with special rope haulage arrangements, but in both these cases, owing to practical operating difficulties and lack of perseverance, they have been discontinued.

Arcwalling in deep mines with compressed air as the motive power is making steady progress. Flitting with compressed air arcwallers is not so handy as with electric machines, owing to the air hoses being less flexible to handle than electric trailing cables. The hoses are in shorter lengths and stops have to be made whilst flitting to change the flitting hose from one valve to another. With the seams being at greater depths much larger pillars have to be left and this takes more time between places.

The arcwall machine is limited to a certain extent in its application by the fact that it is suitable for making a horizontal cut only, and in the past this cutting position has been fixed at a definite height, or within a limited range of height above rail level. Under some circumstances such arrangements are quite satisfactory, but with other conditions the provision of a wider range of cutting positions offer an undoubted advantage. In the ordinary way each machine has to be specially mounted to suit the cutting position in the particular seam in which it is to be installed. In the event of a variation in the cutting position, or the transfer of the machine to another seam with a different cutting position, alterations to the machine have to be made. The necessary adjustment can frequently be made by packing pieces inserted between the machine body and the truck but, if the difference in cutting position is too great for this, a new gearhead has to be substituted. In these circumstances it is apparent that it would be an advantage to provide a machine which would be capable of immediate adjustment to a wide range of cutting positions.

Where the cutting position is in a dirt band, difficulty may be experienced if the cutting position varies. In such cases the rails require to be carefully laid and packed to the proper level. If this work is not properly done the machine gets off the rails or the machine is cutting in the coal and not in the band as intended. By making provision for adjusting the cutting position whenever desired in the regular course of working, these difficulties can be overcome. In seams which are thick enough to work without stone work, it is desirable to cut at floor level, but with the usual form of arcwaller it is not a practicable proposition to cut below rail level.

To overcome all the difficulties in variation in cutting positions, undercutting and overcutting, floor level cutting and so on, a machine has been put on the market known as the Anderson Boyes Universal Heading Machine. This machine is claimed to be the most outstanding advance in coalcutting machine design for many years as, in addition to overcoming the difficulties mentioned, it can cut on the inclination of the seam and make a shear either vertically or at any angle.

The body of this machine is made of cast steel to give the utmost strength and rigidity, the gearing is oil lubricated, and the electric motor and switchcase are of flame-proof construction.

All operating controls are grouped at the driver's end of the machine and stays are provided for staying the machine in the place with the least effort and in the shortest time. The jib is slewed or swung by totally enclosed direct gear running in an oil bath. The machine is permanently mounted on the truck, which is power propelled and fitted with a robust and effective braking gear.

An auxiliary rope haulage, similar to that which is used on longwall machines, is fitted and can be used for negotiating steeper parts of the roadway or in any circumstances where the friction of the wheels on the rails is not sufficient to give the tractive effort required. The Universal Heading Machine is of very compact construction, the overall dimensions being 9 ft. 9 ins. long by 3 ft. wide, 2 ft. 6 ins. high to the top of the body, and weighs about four tons.

The gearhead is the outstanding feature of this machine. It consists of two sections, the main head and the jib head which carries the jib and the cutting chain. The main head is mounted on the body of the machine and is so supported that it can be rotated in line with the motor shaft. The jib head is mounted on the main head and also capable of full rotational movement. The axis of rotation of the jib head is parallel with the axis of rotation of the main head but is eccentric to it. The rotation of each head is quite independent of the other and the operating drives are self-locking. Each head therefore may be rotated to any position desired and the machine is capable of cutting with the jib in that position.

It will be seen that with this construction it is possible to obtain an infinite number of cutting positions within the range of the dimensions of the machine. That is to say, the machine can cut in any horizontal plane from floor level up to about 4 ft. 6 ins. high and from the set of rails in the centre of the place can put in a shear at any point in a vertical plane across a width of 4 ft. 6 ins. If the pick clearance were suitably arranged it could cut out a circular tunnel as did the old Stanley Heading Machine. In inclined seams the horizontal cut can be put in on the "siddle" of the seam and the shear can be at right angles to the dip and rise of a seam, or in a perpendicular plane.

The position of the undercut and shear have to be determined from a general consideration of the conditions, but in most cases it will be found convenient to shear in the centre of the place. If it is desired to make a shearing on one side of the place this can be done by laying the rails close to that side but if places wider than 10 ft. are wanted, then a second set of rails will be required. With the horizontal cut and centre shear two comparatively light shots will be sufficient to shoot all the coal. The place will be well squared, thus enabling the miner to produce a greater output, and the coal will be rounder and in better condition.

The uses to which the Universal Heading Machine can be put are varied. Besides making the horizontal cut in the desired position and putting in the centre shear, which would be the ordinary procedure for maximum output and round coal, the machine can be used for cutting out two or more dirt bands and shearing the coal from roof to floor through the two cuts.

The driving of special main roads for rapid development with a shearing on one side or both sides would leave the coal as smooth and straight as a wall, and would ensure the roads standing much better in any seam, and particularly in soft coal. Roads can be driven any width from 6 ft. up to 15 ft. In a seam with bottom canches the machine could cut over different sizes of canches where large canches were necessary for main roads.

There is a Universal Heading Machine working in the High Main Seam in Northumberland. The seam is

5 ft. thick with a post roof which is troubled with rolls coming down into the coal. The machine is cutting with a 6 ft. jib driving places about 5 yards wide. The undercutting is put in just above rail level to a depth of 6 ft. leaving only a few inches of inferior coal which is lifted later to get the rails on to the floor. The coal is of a tough nature which makes it difficult to hew but it is not particularly hard. The average cutting in this seam is 10 places per shift undercut and sheared, with about 600 yards of flitting. If the places were not sheared, 14 places could be undercut. In the places which are not sheared three shots at least are required to shoot the coal. In the sheared places two shots only are required, resulting in a 50 per cent. saving in explosives, which amounts to about ¾d. per ton. In each of the places with the shearing there is a saving of half an hour, which is the average time required to bore and fire the centre shot. Where the centre shot is carefully fired to get round coal, there is usually a lot of pick work to get the coal released for filling. With the Universal Machine this time is all available for filling, which means increased output per filler per shift. With the shearing there is practically no pickwork, each side is shot and filled separately. The benefits of shearing are evidenced by the anxiety of the fillers to have their places sheared, especially in view of the fact that they have ¾d. per ton less for the places which are sheared.

With regard to the effect on the coal, it is perfectly apparent, when a place is being filled out, that the shearing considerably increases the amount of round coal produced. No overall figures in this direction are available as all the coal from the different workings goes over the screens together. On a rough check on a small scale, however, approximately 10 per cent. more round coal was obtained from a place with a shear than from a place not sheared. From observation, this is probably a conservative estimate but even this figure means a considerable increase in the value of the coal in certain seams. With less shattering effect on the coal from shot firing the coal carries better and arrives at its destination in much better condition. There are also the questions of greater safety, due to less shot firing, and better health conditions, due to better ventilation, which, while they cannot be estimated, are nevertheless real. The advantages to be gained with the use of this machine are :—

1. Reduction in explosives.
2. Reduction in filling costs.
3. Increase of round coal with consequent increase in selling value.
4. Coal in better condition for transport over long distances and will therefore arrive in better condition.
5. Greater safety.
6. The machine can be applied in any seam without alteration.

(The author then introduced the film demonstrating the machine at work in the pit.)

In the film the machine is shewn cutting with a 6 ft. jib in a seam 6 ft. 6 ins. thick composed largely of strong hard bands of splint coal. The headings are being driven 12 ft. wide. The machine commences by cutting in from the right hand side and arcing round to a point to give the 12 ft. width and then travelling and cutting back out to leave a straight side.

The heads are then turned over into position for a cut in the middle of the seam and with the jib at an angle to give a straight side, the machine travels forward, cutting in on left side. When the jib is full in it describes an arc to the right and cuts out.

The machine is then driven back and the heads adjusted to bring the jib into the vertical cutting plane The jib is then swung up until the picks are just clear of the roof when the cutting chain is put into gear and the machine driven forward by the road wheels. The jib cuts its way into the coal until the gearhead is against the face. The truck gear is then disengaged and an arcing cut made until the point of the jib is down to the floor, when the arcing is stopped and the jib cut out by drawing back the machine by the road wheels. This completes the shearing.

The film shews very effectively the facility of the machine for undercutting and shearing and for adjusting itself to any cutting position desired. If cutting over a canch the jib can be swung over with freedom and then lowered on to the canch, and if cutting near floor level the jib can be raised for flitting purposes.

WARWICKSHIRE & SOUTH STAFFS. BRANCH.

Visit to the Works of George Ellison Ltd.

The Branch had the pleasure of visiting the Perry Barr Works, Birmingham, of George Ellison Ltd. on March 26th last and a good attendance was recorded. The party, received by Mr. John Ellison and Mr. Hanks, was escorted to view the factory and see the manufacture of switchgear, from the making of small component parts to the assembly and testing of the completed units and switchboards. The neighbouring factory of Ellison Insulations, Ltd. was also visited by the members during the afternoon, where they saw the processes of making "Tufnol" and other resinoid moulded insulations as used in Ellison switchgear.

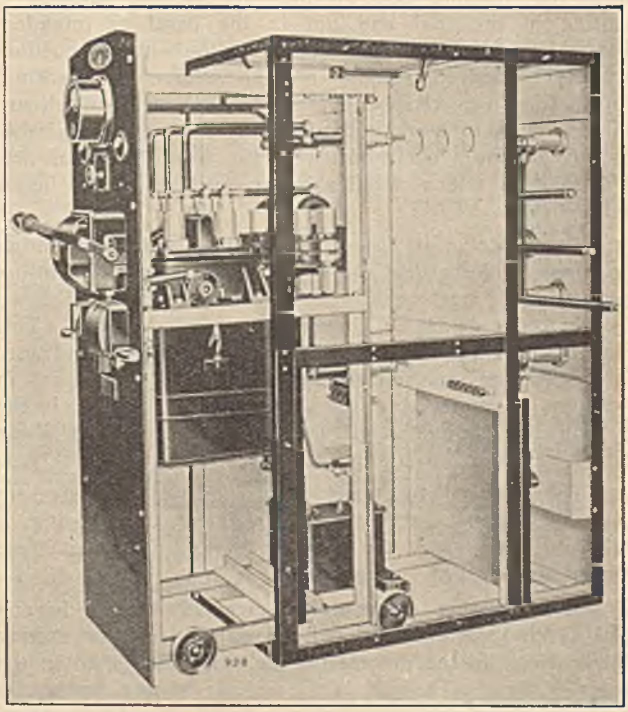


Fig. 1.—Ellison 11,000 *volt, Truck Type Unit.*

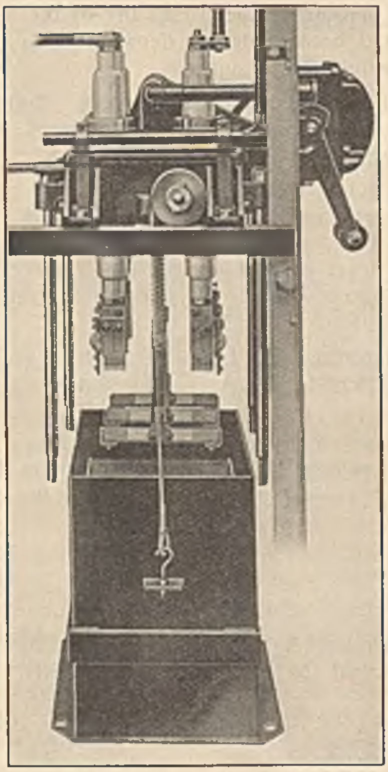


Fig. 2.—Ellison 11,000 *volt,* 150,000 *k.v.a. Circuit Breaker.*

In the switchgear factory the members saw a wide range of industrial switchgear and motor control gear, but their interest was mainly attracted to the various types of high tension substation switchgear and flame-proof medium tension gear. The steel cubicle 11,100 volts switch unit, illustrated in Fig. 1, combines the principles of the cubicle drawout types in subdivision of the cubicle, ample clearances between phases and to earth, easy access and complete isolation. It is imperative to adopt a very rigid construction for the truck, to assure alignment and interchangeability and this has been obtained by welding the framework. The circuit breaker, which has a rated breaking capacity of 150,000 k.v.a., Fig. 2, is bolted to the framework and is totally enclosed, with a piped vent to discharge outside the cubicle any gases which might be generated when the circuit is interrupted. A complete system of interlocking is arranged to prevent mistakes of operation.

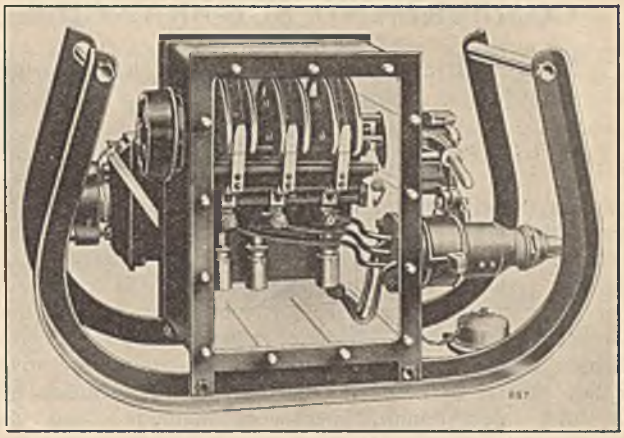


Fig. 3.—Ellison Flame-proof, Air-break Circuit Breaker on Skid (Cover removed).

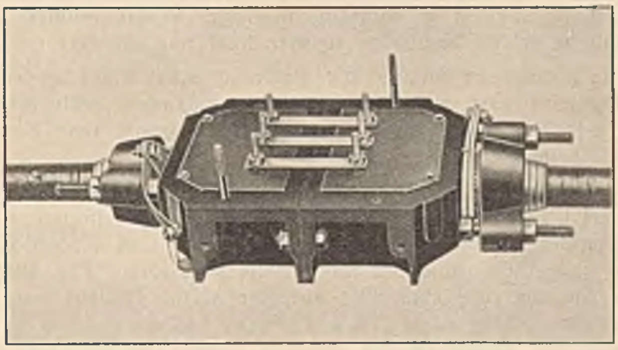


Fig. 4.—Ellison Mining Type Cable End Coupling (cover removed).

The Ellison air-break mining circuit breaker for use at the gate-end, Fig. 3, has become very popular and its robust welded steel case and skid frame, together with the practical cabling arrangements, leave little to be desired in a piece of apparatus designed for the rough service of a coal mine. The breaker has magnetic blowout, and the usual automatic releases and time lags. A reversible or non-reversible trailing cable plug can be fitted.

The feeder cable is connected by a link coupling fitting, Fig. 4, which dispenses with cable jointing and compound filling underground. The half of the link coupling which forms the cable end is interchangeable with the parts used for the cable couplings which serve as joints in the cable run. This method of cable jointing saves three hours, as compared with other methods, when the circuit breaker is moved forward. Only a spanner is needed to disconnect the cable end, and the new length of cable fitted with similar end parts before laying, is bolted up between the breaker at its new position and the existing end which remains in the old position to form a coupling in the cable run.

Tea was later taken in the Company's canteen at the invitation of the Management, and Mr. John Ellison in responding to the cordial expressions of the Branch President (Mr. I. T. Dixon) mentioned their pleasure in being able to entertain the Branch and trusted that the tour had been one of interest and enjoyment.

Fig. 5.—The A.M.E.E. at the Ellison Works.

CUMBERLAND SUB-BRANCH.

(P) Mining Electrical Engineering Economics.

E. J. WESTCOTT.

(*Paper read 6th January*, 1931.)

The conditions of the coal trade to-day present many difficulties to those in charge, and one of the chief worries is the detrimental effect on costs of production, resulting from diminished outputs. To counteract this effect, mining engineers are continually looking out for new methods by means of which the cost of production may be lessened. The modern mining executive is not content to guide the destinies of his company by the old rule-of-thumb, guess-work methods; and his time is of too much value to be spent in collecting, from the numerous branches of the industry, the necessary data to serve as the basis of his decisions. To enumerate all the economic difficulties faced by the mining engineer, and to suggest a solution of them, would require a volume which would be neither final nor satisfactory.

In modern mining the electrical plant plays a predominant part and has become synonymous with progress. In the future it is certain to be more than ever the principle power agent.

As the representative of the mining engineer on the electrical plant the electrical engineer is expected to shoulder his share of the burden and to be in a position to ease the formidable task of his superiors. The duty of the electrical staff does not stop at the efficient maintenance of the plant; it goes much further and, as the economic aspect of the problem should be considered, it becomes the function of the head to prepare the necessary data in such a way as to enable the true conclusions to be drawn.

The modern tendency towards rationalisation of industry is creating considerable doubt and fear in the minds of all classes of mining engineers but, whatever the result, it can be taken for granted that the mining industry will become more economically organised with improved machinery and equipment. Such conditions will lead to the ultimate selection of the trained man.

Every colliery engineer can recall instances in which wasted energy attracts disagreeable attention to itself. Typical examples of this are the blowing of a steam valve and the noisy sqeaking of moving machinery. The mere fact that these faults are so glaring acts as an automatic incentive to improved conditions. As opposed to this the majority of electrical wastes are noiseless although in the aggregate they may be no less serious, and this in itself should be an incentive to the electrical staff to reduce the silent inefficiency to a minimum.

VALUATION.

To purchase electrical plant capital is required; and whether the capital takes the form of a secured loan, or is drained from the reserves of the company in question a rate of interest equivalent to that which could be obtained elsewhere with the same security, should be allowed for.

The money expended is expected to produce additional wealth and, providing the interest on the borrowed capital is payed regularly, there is very little obligation to repay the loan. Unfortunately, the wealth-producing electrical plant will wear out, or become obsolete due to new inventions or methods, therefore it is essential that provisions should be made to replace the plant; in other words, to make good all depreciation. If at the end of the useful life of the apparatus no allowance had been made for depreciation a fresh supply of capital would be required.

The following equations will cover the majority of the capital and costs problems to be faced by the electrical engineer.

Where I = total interest earned;
P = principal or money loaned in £;
T = time, period, or life in years.
A = total amount (principal + interest).
r = interest on £1 for one year = rate % ÷ 100.

Then for
Simple Interest: (1) $I = PrT$; (2) $A = P(1 + rT)$
Compound Interest: (3) $A = P(1 + r)^T$

Present value of P of A due T years hence:

(4) $$P = \frac{A}{(1 + r)^T}$$

Total amount A to which a redemption or sinking fund will accrue by depositing P annually:—

(5) $$A = P\frac{(1 + r)^T - 1}{r}$$

Annual deposits P required to accumulate a sinking fund amounting to A.

(6) $$P = \frac{Ar}{(1 + r)^T - 1}$$

Example 1.

How much will an investment of £1000 amount to in 10 years at 5% compound interest.

(Formula 3) $A = (P)(1 + r)^T$
$= 1000(1 + 0.05)^{10} = £1628.89$

Example 2.

What is the present value of £500 due 5 years hence at 4% compound interest.

(Formula 4) $$P = \frac{A}{(1 + r)^T}$$

$$= \frac{500}{(1 + 0.04)^5} = £411.18$$

Example 3.

The estimated life of an alternator costing £2500 is 20 years. What will be the amount of a sinking fund at the end of that period if £100 is invested annually at 3% compound interest?

(Formula 5) $$A = P\frac{(1 + r)^T - 1}{r}$$

$$= \frac{100(1 + 0.03)^{20} - 1}{0.03} = £2687$$

Example 4.

A transformer costs £1000 and has an estimated life of 25 years with a zero salvage value. How much must be invested annually to replace the transformer if compound interest on the invested money is 4% ?

$$\text{(Formula 6)} \quad P = \frac{Ar}{(1 + r)^T - 1}$$

$$= \frac{1000 \times 0.04}{(1 + 0.04)^{25} - 1} = £24.01$$

Depreciation.

Mining in practically all its branches is characterised by a steady diminution in value depending upon the output, wear and tear of machinery, etc. : and the electrical plant being no exception to the rule is also a wasting asset. The chief factor in the disintegration is the deterioration of the insulators and the wearing away and ageing of metals, the former resulting chiefly from temperature and in a lesser degree from use and age, whereas the latter is mainly governed by length of service.

In ascertaining depreciation of an electrical plant, one should not lose sight of the fact that the designs of electrical apparatus are continually changing, due to new inventions and developments, and it may pay to scrap plant in good working order.

A depreciation fund is a very necessary working expense and should be met before any allocation of profits ; and, further, the electrical engineer should be in a position to ascertain accurately precise depreciation costs of his plant.

Depreciation funds are based upon the anticipated useful life of the asset in question and no hard and fast rule can be applied because each unit must be taken on its merits and individual judgment. Due allowance should be made for scrap or salvage value of the apparatus, and one should not overlook the fact that a point may be reached where the equipment in question is uneconomical, and should be replaced by more efficient plant although it may be far from worn out. Care should be taken not to overestimate salvage value especially if it is of a non-standard voltage, frequency, or design, etc. ; as it may be difficult to find purchasers.

Formulæ (5) and (6) should be regarded as the chief equations of a sinking fund, and shew the method of arriving at the annual costs of providing renewals for plant subject to depreciation. Before it is possible to make a choice between available alternatives, it is essential for the engineer to be in a position to calculate the cost per year of the particular apparatus.

The yearly costs consist of two items, an interest charge on the first cost (Pr), plus a depreciation charge equivalent to

$$(6) \qquad P = \frac{Ar}{(1 + r)^T - 1}$$

Example 5.

The first cost of a motor is £300 : salvage value £30 with an estimated life of 20 years. With money worth 5% compound interest what is the annual cost of owning this motor ?

First cost Interest charge :—

$$Pr = 300 \times 0.05 = \quad £15.$$

Depreciation Fund yearly charge :—

$$(6) \qquad P = \frac{Ar}{(1 + r)^T - 1}$$

$$= \frac{(300 - 30) \times 0.05}{(1 + 0.05)^{20} - 1} = £8.165$$

£23.165 total

Example 6.

Two quotations are obtained for an equipment of electrical coalcutters and conveyors. The total cost of machinery in quotation A is £2000 ; and in quotation B is £2500 ; both with an estimated life of 10 years ; with tender B representing a saving in labour charges of £150 per annum.

Assuming no salvage value, with maintenance the same, and money at 5%, which is the cheaper installation ?

Quotation A. *per annum.*

Interest on first cost $Pr = 2000 \times 0.05 =$ £100

$$\text{Depreciation on Deposit} \quad P = \frac{Ar}{(1 + r)^T - 1}$$

$$= \frac{2000 \times 0.05}{(1 + 0.05)^{10} - 1} = £159$$

Extra labour charges .... = £150

Total £409

Quotation B.

Interest on first cost $Pr = 2500 \times 0.05$ = £125

$$\text{Depreciation on Deposit} \quad P = \frac{Ar}{(1 + r)^T - 1}$$

$$= \frac{2500 \times 0.05}{(1 + 0.05)^{10} - 1} = £198$$

Total £323

TABLE I.

ANNUAL SINKING FUND TABLE.

Shewing Amount to be set aside at the end of each year and Accumulated at Compound Interest to realise £100 at the end of any number of years.

Years' Life	3 per cent.	4 per cent.	4½ per cent.	5 per cent.	5½ per cent.	6 per cent.	7 per cent.
1	100	100	100	100	100	100	100
2	49.26	49.02	48.90	48.78	48.66	48.54	48.31
3	32.35	32.03	31.88	31.72	31.56	31.41	31.11
4	23.90	23.55	23.37	23.20	23.03	22.86	22.52
5	18.83	18.46	18.28	18.10	17.91	17.74	17.39
6	15.46	15.08	14.89	14.70	14.52	14.34	13.98
7	13.05	12.66	12.47	12.28	12.10	11.91	11.56
8	11.24	10.85	10.66	10.47	10.29	10.10	9.75
9	9.84	9.45	9.26	9.07	8.88	8.70	8.35
10	8.72	8.33	8.14	7.95	7.77	7.59	7.24
11	7.80	7.41	7.22	7.04	6.86	6.68	6.34
12	7.05	6.66	6.47	6.28	6.10	5.93	5.59
13	6.40	6.01	5.83	5.65	5.47	5.30	4.97
14	5.85	5.47	5.28	5.10	4.93	4.76	4.43
15	5.38	4.99	4.81	4.63	4.46	4.30	3.98
16	4.96	4.58	4.40	4.23	4.06	3.90	3.59
17	4.59	4.22	4.04	3.87	3.70	3.54	3.24
18	4.27	3.90	3.72	3.55	3.39	3.24	2.94
19	3.98	3.61	3.44	3.27	3.11	2.96	2.68
20	3.72	3.36	3.19	3.02	2.87	2.72	2.44
21	3.49	3.13	2.96	2.80	2.65	2.50	2.23
22	3.27	2.92	2.75	2.60	2.45	2.30	2.04
23	3.08	2.73	2.57	2.41	2.27	2.13	1.87
24	2.90	2.56	2.40	2.25	2.10	1.97	1.72
25	2.74	2.40	2.24	2.10	1.95	1.82	1.58

TABLE II.

ANNUAL COSTS.

Ref.		*Formulæ.*	*Example.*
A	Rated H.P. of Motor		40
B	Estimated Load in H.P.		30
C	Efficiency at H.P. required		89%
D	Watts lost when giving required H.P.	$\left(\frac{\text{H.P.} \times 746}{\text{Efficiency } \%}\right) - (\text{H.P.} \times 746)$ or $\left(\frac{100}{\text{Efficiency } \%} - 1\right) \times 746 \times \text{H.P.}$	2766
E	Estimated Life		15 years
F	Hours of Service per annum	Hours per day × Days per year	4800
G	Price of Energy	Per k.w. hour	½d.
H	Interest on Capital Expenditure		6%
I	Depreciation Rate	See Table I.	4.3
J	First Cost	(Assume Zero Salvage Value)	£74
K	Capital Charge	Interest (H) + Depreciation (I) × First Cost (J) ÷ 100	£7.62
L	Inefficiency Charge	Watts Lost (D) × Hours of Service per annum (F) × Cost of Energy (G) ÷ 1000	13.83
	Total Annual Cost of Machine	Capital Charge (K) + Inefficiency Charge (L)	£21.45

It will be seen that the quotation B although £500 dearer in first cost, represents a yearly saving of £86 over the quotation A.

Table I gives the annual end-of-the-year payments necessary to provide £100 at the end of any given number of years, at different rates of compound interest.

MOTORS.

Of the various classes of electrical plants installed at a colliery, the selection of suitable motors offers the greatest opportunities for economies. The duties undertaken by these machines are numerous and varied, and each of course must be taken on its merits. It is obvious in the space of this paper only a few typical instances can be illustrated.

To shew in which direction economies can be looked for, and to illustrate how first cost without efficiency may become a very expensive proposition, take for instance a 50 h.p. squirrel cage 1000 r.p.m. protected type motor with a full load efficiency of 89% and running on a 24 hours per day duty with energy at ½d. per unit. A machine such as this driving a condenser pump would in 20 years consume £13,614 of energy, and of that sum £1682 would be wasted in overcoming the losses in the motor, the remainder would of course be expected to perform useful work.

At present day prices the motor in question could be purchased for £55, and it will be seen that in its assumed life of 20 years it consumes 247 times the first cost and wastes 30 times the original cost in internal losses. An improvement of only ½% in efficiency would mean a saving of £76 in 20 years, equivalent to 1.4 new motors, or an annual saving of £3.8 which if invested annually would be equivalent to a sum more than ample to pay for the more efficient machine.

Admittedly there are only a few machines on the average plant running on a 24 hour per day duty, but on the other hand there are a large proportion running for 16 hours per day at speeds considerably less than 1000 r.p.m. and with correspondingly lower efficiencies.

In the selection of a motor all the different requirements such as efficiency, high torque, power factor, reliability, cost etc., must be taken into consideration, the whole balanced not only electrically but financially. Unfortunately for the purchaser some motors excel in one direction but fail in others, therefore consideration of first cost only, without going into the other factors should never be tolerated.

From the economic point of view the small amount of attention paid to efficiencies by engineers is probably due to the difficulty in calculating any particular case, and assigning to each factor its equivalent cash values.

The simplest method of ascertaining the cash value of a motor is to calculate the annual costs, and a reference to Table II will shew in a simple manner the method of arriving at these figures.

The first two items—rated h.p. of motor, and estimated load in h.p.—call for no comments, but the next—efficiency at the estimated h.p.—must be either estimated from a test in the case of an old machine or obtained from the makers in the event of a new article. The watts lost or the power required to overcome the losses when giving the required h.p. is the most important from the economic point of view, and all means possible should be tried to keep these figures as low as possible. It will usually be found that the cheap motor is inefficient when compared with those of greater initial cost. There are several methods of improving the efficiencies of motors, the most reliable of which is to use higher grade steel with better insulation, thus lowering the iron and copper losses.

Probably the small buyer would be compelled to take a standard article as the additional costs of improved efficiencies would not be worth while, but a large buyer of duplicate motors would be in a position to obtain increased efficiencies at a reasonable additional cost.

The estimated life, hours of service, price of energy, and interest on capital expenditure are all items depending upon the local condition and experience and judgment of the engineers in charge. Comment was made on the very necessary depreciation rate and method of obtaining same under the heading of valuation.

With regard to capital charges some engineers take into account the sinking fund only, and forget interest on first cost. This however ignores the elements of economics for capital expended in the purchase of machinery, would in the absence of any such purchase, be expected to bring in some return in the form of interest therefore it is only right that the equivalent of such interest should become a charge on the motor in question.

It will be seen in column 3 under the heading of typical example, that the inefficiency charge is the largest cost item and depends chiefly upon the hours of service and price of energy. The last item the sum of the inefficiency and capital charges gives the total annual cost of owning the particular machine.

From the electrical point of view high speed motors mean high efficiency and low first cost, and an all-round gain in electrical efficiency. For instance, a 50 h.p. squirrel cage motor running at 1500 r.p.m. costs only half that of a 50 h.p. machine running at 600 r.p.m. Further, the high speed machine will have a higher efficiency, better power factor, a smaller frame size and simpler and cheaper switchgear. To-day, splendid results are being obtained from high speed reduction gears, friction and magnetic clutches, high speed pumps, etc.; and the selection of high speed apparatus is well worth the earnest consideration of mining engineers, and calls for a happy collaboration between the mechanical and electrical staffs if economy is to be the watchword.

The larger the motor the better the efficiency, and the less room there is for further improvements between makers of high repute, although one must not lose sight of the fact that the larger machine consumes a greater amount of energy, and a slight improvement in efficiency may lead to an appreciable saving. Then again choice may be between a low voltage machine together with a transformer, as against a high tension motor.

It is quite obvious that local conditions will determine the choice: therefore in giving the following example the assumption is that the only problem concerned is the selection of the most economic machine for a given h.p. and speed, for different hours of duty. at different energy prices, namely ½d. and 1d. per unit.

The duty calls for a 30 h.p. three-phase 550 volts continuous rated, protected, wound rotor motor running at a synchronous speed of 750 r.p.m., with an estimated life of 15 years running 300 days per year with zero salvage value.

A considerable number of quotations were obtained from makers both for machines at 30 h.p. and for larger outputs, as very often by underrunning especially at the smaller horse powers, a larger machine will give a better efficiency at the h.p. required.

By weeding out motors obviously unsuitable, both as regards price and efficiency, the choice remained between the following three machines namely :—

Machine A.

30 h.p. costing £59 with a full load efficiency of 88%

Machine B.

40 h.p. costing £74 with a full load efficiency of 89% when running on a 30 h.p. load.

Machine C.

30 h.p. costing £50 with a full load efficiency of 86%

The annual costs of the above motors were obtained as previously explained, and plotted on the chart, Fig. 1, shewing hours of service per day and annual costs.

It will be seen that the cheap motor is only worth consideration when running at less than 2 hours per

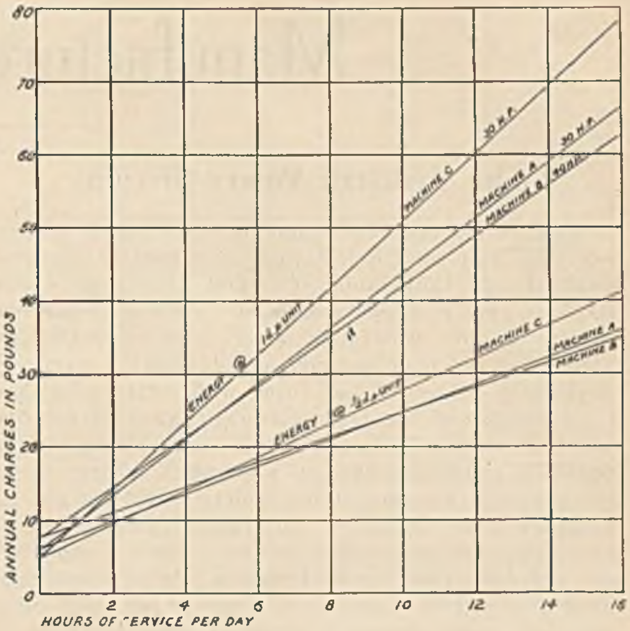


Fig. 1.

day, and only then with energy at ½d. or less. For duty up to 8 hours daily machine A would be the choice with energy at ½d. but is only suitable up to a 4 hour duty with energy at 1d. Above 8 hours on the ½d. rate and 4 hours on the 1d. rate, the larger 40 h.p. machine B, with the higher first cost would be the most economical selection; and would shew up to greater advantage on duties exceeding 16 hours per day, and higher energy rates.

On the 16 hours duty with energy at ½d. machine B is £6.4 per annum cheaper than Machine C, and on the 1d. rate is cheaper by no less than £15 per annum equivalent to 20% (Twenty per cent). The inefficiency charges of machine C on a 16 hour daily duty with energy at 1d. are £72.96 per annum, whereas the total annual cost of Machine B on the same duty is only £62.82; therefore it follows that if machine C were given away with an annual Christmas present of £5, it would still be cheaper to refuse the offer and spend £74 on the 40 h.p. machine B.

A further advantage in the larger 40 h.p. motor as compared with the 30 h.p. motors, lies in the fact that it would be worked at a lower temperature, and therefore could be assumed to have a longer life and greater freedom from breakdown.

It may come as a surprise to many that the smallest possible machine for the h.p. required is only justified at exceptionally low rates for energy, and low daily services.

(*To be Continued*).

TESTING BY THE COLLIERY ELECTRICIAN

(*Correction*).

In recording the discussion on Mr. Horsley's paper, published in our last issue, the reporter misquoted Mr H. J. Fisher (page 397, par. 2). Mr. Fisher indicated that to test the air gap of a motor at rest was sometimes misleading, especially so in the case of a geared drive with which when running on load the motor pinion is apt to "climb up" the spur wheel.

Manufacturers' Specialities.

The Kirkstall Power Station.

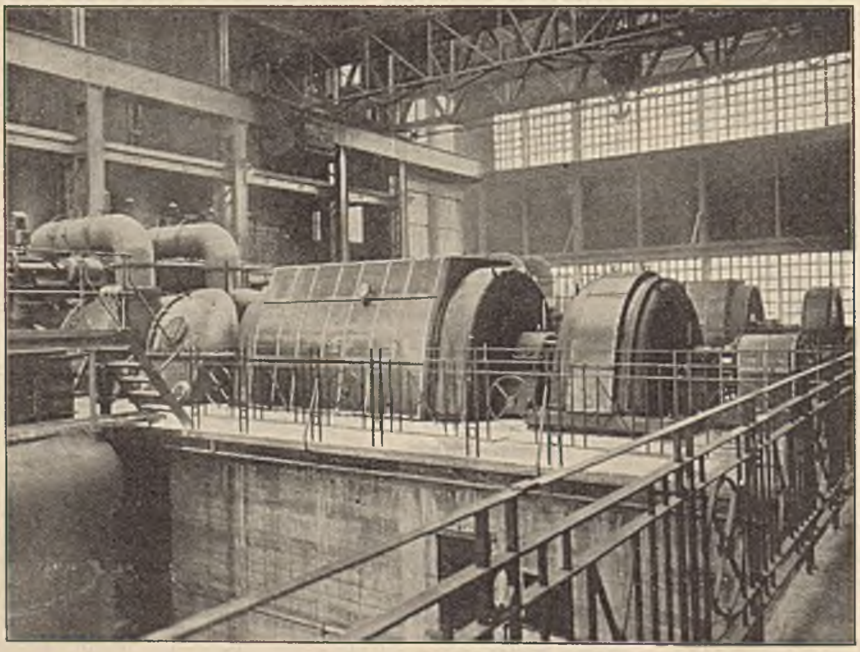
One of the most interesting new stations in connection with National Electrification is Kirkstall, belonging to the Leeds Corporation, the first section of which, 50,000 k.w. has just been completed. The main equipment consists of three water-tube boilers each of 160,000 lbs. evaporation per hour capacity and 184,000 lbs. overload, operated by pulverised fuel firing with rotary cylindrical driers because of the high moisture content of the coal and two British-Thomson-Houston turbo-alternators of 25,000 k.w. each of which an illustration is here given. The maximum pressure at the boilers is 490 lbs. per sq. in. gauge with 750 degs. F. superheated steam temperature, while both air heaters and feed water economisers are installed, along with Ferguson Pailin switchgear, distance electrically controlled steam valves and other equipment, and "Sirocco" centrifugal dust collectors as well as forced and induced draught fans.

The main turbines are of the pure impulse, two-cylinder type and the high pressure cylinder in each case has sixteen stages, while the low pressure cylinder is on the double-flow reaction principle, running at 3000 revs. per minute, both cylinders being divided horizontally to facilitate inspection of the rotors. Standard operating conditions are 450 lbs. per square inch pressure and 725 degs. F. superheated steam temperature at the stop valve. The constructional details include stainless steel blading, three bleeder steam off-takes for feed heating, and pressure lubricated bearings. For this last purpose a gunmetal pump is fitted with positive drive from the turbine shaft, and there is also a secondary turbine driven oil pump which comes into operation when the oil pressure falls below some pre-determined figure. Each turbine has three oil coolers, one of which is a standby, and there is further provided a centrifugal oil purifier.

The turbines are coupled to the alternators through flexible couplings of the "claw" type. For supplying the cooling air for the alternator a fan is mounted on an extension of the main shaft. Further, the main condensers are of special design, on the re-generative principle, for dealing with the very dirty water of the River Aire, each set having a centrifugal circulating pump of 2,400,000 gallons per hour capacity.

The main contractors for the complete generating equipment were the British-Thomson-Houston Co., Ltd. The turbine house at Kirkstall, of which one third is completed with provision made for an additional 100,000 k.w., that is four more 25,000 k.w. turbo-alternators, is 83 feet high from the basement level to the overhead crane rails, 84 feet wide between the crane rails, and 144 feet long. The overhead travelling crane is of 100 tons capacity.

It is of relevant interest to note that the British-Thomson-Houston Co., have just recently secured the contract for the new extensions at the Barking Power Station of the County of London Electric Supply Company, to be ready in 1932. The main generators in this case will be two 75,000 k.w. turbo-generators, amongst the largest ever constructed in Great Britain.



The two 25,000 k.w. Turbo-alternators, Kirkstall Power Station.

Underground Oil-Immersed Disconnecting Switch.

Ferguson Pailin Ltd. have developed a disconnecting switch to control underground network systems up to 1200 amperes at 11,000 volts. The switch is oil-immersed, manually operated, and is watertight and drip proof. Provision is made for three positions of the switch:

(1) "ON"—Incoming cable connected directly to feeder.

(2) "OFF"—Incoming cable disconnected from feeder.

(3) "EARTH"—Incoming earthed, and feeder terminals free.

The design is such that the switch is quick and positive in action; safe and reliable in operation; robust and designed to give long service; simple in operation and compact in design. All parts of the switch can easily be rendered accessible for inspection or adjustment. Provision is made for testing without opening. The switch is capable of making and breaking load. The tank is of fabricated steel construction throughout and supports the entire mechanism. Provision is made for cable entry by means of boxes which can be located in a number of positions to suit requirements. The top plate is of sheet steel and has an aperture for oil filling and insertion of oil gauge. A double hand robust handle operates the switch through direct rotary motion. "On," "Off" and "Earth" positions are indicated and the handle can be padlocked in any one of the three positions.

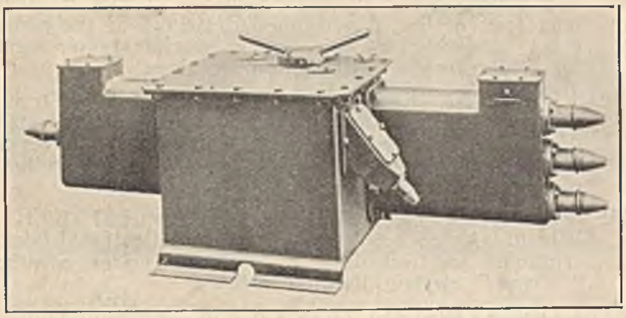


Fig. 1.—The F.P. Underground Disconnecting Switch.

Provision is made in the top plate for the insertion of testing plugs. These are bakelite insulated and will stand the full voltage of the system. It is possible to carry out any tests considered necessary: the cables can be tested, each phase separately to earth or at full pressure; insulating tests can be carried out on the cables, the leads from the testing instruments being connected directly to the terminals of the plugs.

The cable boxes are of cast iron construction arranged for compound filling and provided with adequate expansion chambers. These latter have bolted on covers through which the cable boxes are filled, the level to which the compound should be poured is clearly indicated. The auxiliary cable gland is also of cast iron construction and is arranged for a six-way auxiliary switch.

The permanent contacts are copper fingers between which an extended curve on the moving contact arm passes, thus making contact in all three "on," "off" and "earth" positions. The feeder contacts are similarly designed finger contacts with the addition of flared jaws to receive the moving contacts easily. It is necessary to remove a catch before it is possible to earth the feeder cables. The earth contacts are of the copper clip type. The moving contacts are copper blades designed for perfect alignment with the flared jaws of the feeder contacts. Spring controlled arcing tips are provided for each pole so that burning of the main contacts is prevented and the final rupture of the circuit is effected with a quick break action. These tips can be easily replaced at small expense.

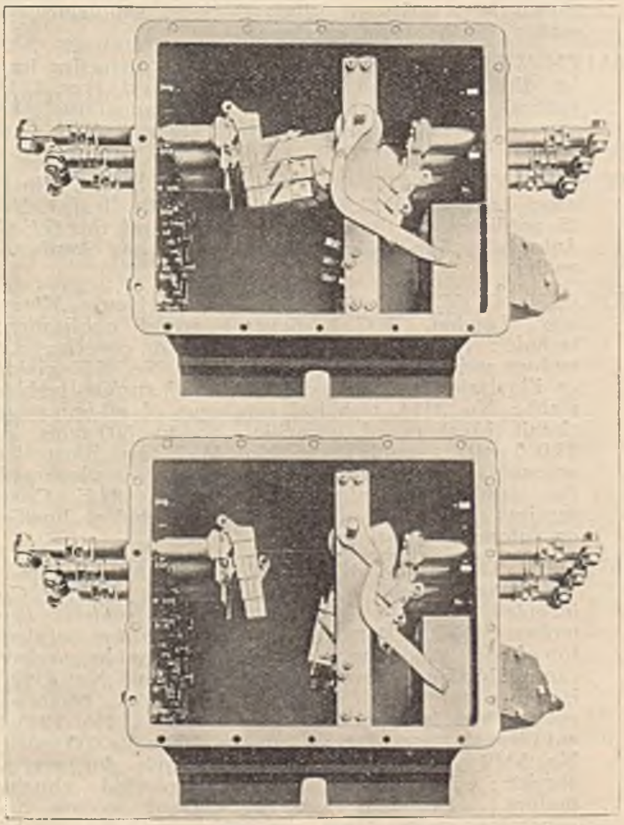


Fig. 2.—The F.P. Underground Disconnecting Switch, shewing (top) Contacts in the "On" position and (bottom) Contacts in the "Earth" position.

The E.C.A. visit the B.T.H.

On June 1st a party from the Birmingham Branch of the Electrical Contractors Association (Inc.) paid a visit to the Rugby works of the British Thomson-Houston Co. Ltd. The party were entertained to lunch when they were received by Mr. H. A. Lingard, a director of the Company, Mr. H. N. Sporborg, director and chief engineer, and a number of Head Office and branch office officials. After lunch the visitors were conducted in small parties, through a considerable portion of the Works, where a very interesting time was spent. In the Mazda Lamp Factory they were able to see lamps in various stages of manufacture.

In the heavy machine shops, electrical plant for several important contracts was seen under construction, including a 50,000 k.w. turbine for the Ironbridge Power Station of the West Midlands Joint Electricity Authority, the alternator for which is being built on site, parts of the two 67,200 k.w. turbo-alternators for the Battersea Power Station of The London Power Company, a 30,000 k.w. turbo-alternator to operate at a steam pressure of 1200 lbs. per sq. inch gauge for the new Ford Works at Dagenham, etc.

In the Transformer department many transformers of various ratings up to 60,000 k.w. were in course of manufacture for service in this country and overseas.

In the Controller factory it was interesting to note the Instrument Panel for one of the new P & O liners "Strathnaver" and "Strathaird" which, when completed, will be the most powerfully electrically propelled passenger vessels in the world. The propulsion equipment for these vessels and also for the "Rangatira" the Union Steamship Company's new ship, was manufactured in the Rugby Works.

Having made an extensive tour of the works, tea was served and afterwards a demonstration of the Company's talking film equipment in the Accoustical Laboratory was much appreciated.

Aluminium Buildings.

From America comes the claim that architects have at last created a house fitted to the needs of modern life. The "Aluminaire," as the new house is called, is the creation of A. L. Kocher and Albert Frey, New York architects. Its designers have made no attempt to follow the rules set down by house builders in the past. Thick walls of masonry have been replaced by light three-inch sections of insulation protected on the outside with aluminium sheet, slightly ribbed in fine corrugations to break the glare. This type of construction allows for expansion and contraction of the metal due to temperature variations. Aluminium and steel beams and girders are used for the frame of the house. All flooring is of light steel battledeck construction surfaced with rubber and linoleum. Heavy supporting walls are eliminated by using slender Aluminium columns which uphold cantilever beams, from which the outside walls are suspended. This arrangements permits considerably more window space than is available in the ordinary building.

A spacious living room, extending two floors in height, occupies the major portion of the upper floors. One entire side of it is glazed with a 17-foot section of ultra-violet glass, making the room a veritable sun porch, light and cheerful.

Neon tubes paralleling the tops of the windows provide night illumination. Either white, coloured or ultra-violet light is available at the turn of a dial.

The "Aluminaïre" is unique in that it is built entirely of materials that are readily available. Aluminium, steel and glass are essentially dependable and the progressive architects consider it is time that builders of homes utilised their advantages.

In practically every pretentious building recently completed or planned for American cities the use of aluminium for structural and decorative service is common. This definite movement towards the adoption of aluminium as the architectural metal now shews signs of spreading to Canada and Europe. Thus, a notable feature of the new building of T. Eaton & Co. in Toronto is the use of light alloy castings for the cresting details, while cast aluminium spandrels are used on the Office Speciality Manufacturing Company's building in Montreal; interst in the wide possibilities of the new medium is now being aroused in British and Continental architectural circles as well. The perfecting of various processes, notably anodic oxidation ones, to enable light metals to be provided with various finishes and colourings, together with the development of light alloy structural pieces, will soon provide the architect with commercial products in aluminium which will give him still greater scope in his designs and enable him to use the light, rustless metal for further numerous purposes for which this easily worked and handled and essentially modern material is particularly suited.

NEW CATALOGUES.

CROMPTON PARKINSON, Ltd. Bush House, London. W.C. 2.—A pocket price-list sets out the reduced prices of the range of Crompton Lamps. Another Crompton price-list covers fractional h.p. motors; the motors range in sizes from $\frac{1}{8}$ h.p. to 1 h.p. This price-list is accompanied by a broad sheet printed in colours and shewing typical applications of these small motors.

BRITISH INSULATED CABLES Ltd., Prescot, Lancs.—An attractively printed art catalogue gives general particulars and a series of views relative to the B.I. Railless Traction Equipments.

"Copperweld" is the name given to a cable conductor in the form of a wire in which a core of tough steel wire carries a heavy welded covering of electrolytic copper. The copper coating is completely welded to the steel and, as a result, there is no possibility of the penetration of moisture and the "Copperweld" wire can be safely put through hot rolls, drawn cold, forged, bent, twisted etc without damage. A very interesting booklet gives particulars of the method of manufacture, uses, standard sizes and weights, electrical characteristics etc. of this useful innovation.

The Prescot Wiring System is the subject of the B.I. catalogue No. P 262, which contains many illustrations of the accessory parts, prices, dimensions etc.

Contractors and buyers generally will find the list of publications of the B.I. Co. extremely useful. It is so arranged with blank pages that it can be kept up-to-date by making entries of additional catalogues as they may appear from time to time.

Of particular interest to mining men is the B.I. catalogue No. P 260, which deals with mining boxes and which is exceptionally valuable in that it gives numerous outline dimensioned drawings of the many types available to suit every specific requirement for underground distribution services.

BECKETT & ANDERSON, Ltd., 59-63 Greendyke Street, Glasgow, C. 1.—The list H 12 gives an illustrated description of the "Becander" Scraper Conveyor Hauler, shewing the machine itself and its method of operation underground.

HEYES & Co. Ltd., Water-Heyes Electrical Works, Wigan.—A pocket price-list gives illustrated descriptions and schedule of reduced prices of the "Wigan" electric lighting fittings.

ELECTRIC CONSTRUCTION Co. Ltd., Ingersoll House, 9 Kingsway, London, W.C. 2.—The sheet S 901 gives technical details of the "Human" system of power factor improvement for squirrel cage motors. There are figures of tests given shewing that with 20 h.p. and 10 h.p. motors the power factor was raised by 9% at full load and by 15% to 18% at half load. The apparatus is self-contained in the form of a panel and can be readily connected to existing motors.

MIDLAND ELECTRIC MANUFACTURING Co. Ltd., Birmingham.—Fuse boards rated at from 5 amps. to 15 amps., ironclad and teak cased, are illustrated and priced in a colour printed pamphlet.

A new price-list of the M.E.M. "Kantark" Fuse boards advises a reduction of prices over the whole range.

ELECTRICAL APPARATUS Co. Ltd., Vauxhall Works, South Lambeth Road, London, S.W. 8.—Leaflet G 161 gives general particulars, dimensions and prices of moving iron Ammeters and Voltmeters.

MAVOR & COULSON, Ltd., 47 Broad Street, Mile End, Glasgow.—The new catalogue of the Samson Coalcutter is a revised and greatly enlarged edition. The construction of the machine is dealt with in detail: particulars of the work done, and its use as a shortwall and an arcwall machine, are described fully together with a valuable series of illustrations. Other items of M. & C. Coal Face machinery are shewn in a series of illustrations as supplementary matter to the main catalogue.

ALLEN WEST & Co. Ltd., Brighton.—An attractive leaflet directs attention to the Allen West type O.D. vertical draw-out switchgear. This apparatus possesses several distinguishing features which are clearly indicated here.

GENERAL ELECTRIC Co. Ltd., Magnet House, Kingsway, London, W.C. 2.—The installation leaflet No. 25 publishes an illustrated description of the G.E.C. Automatic Sub-Stations as installed at Southend-on-Sea.

ENGLISH ELECTRIC Co., Ltd., Queen's House, Kingsway, London, W.C. 2.—Several recent publications include: A pocket price list No. 1026 covering a.c. motors and control gear; publication No. M56 giving an illustrated technical description of surface turbine plant; No. M54, technical catalogue of oil-immersed circuit breakers of capacities up to 600 amps. at 13,000 volts; publication No. M57, an illustrated account of installations effected in connection with the standardising of frequency on the N.E. Coast services; publication No. 802A, a technical booklet on automatic substations.

BRITISH THOMSON-HOUSTON Co., Ltd., Rugby.—The many recent publications of the B.T.H. Co. include: No. 2145/1, screen protected squirrel cage motors; No. 4101/1, air-break switches for out-door top-of-pole mounting; No. 2140/2, double squirrel cage induction motors; Nos. 4120/8/9 and No. 4122/1 isolators for aerial circuits; No. 4325/1, combined cut-out and isolator for aerial circuits; No. 5275/1, auto-transformer starters up to 200 h.p. 600 volts; No. 5312/1, d.c. motor control panels for marine service; No. 2163/5, screen protected slipring motors; No. 2252/1, direct current motors and generators up to 40 h.p. per 1000 r.p.m.; No. 2162/1, squirrel cage induction motors; No. 5112/1, oil-break switch starters for s.c. motors; No. 3350/1, ironclad draw-out switchgear for circuits up to 3300 volts, including flame-proof patterns.