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The Miner and His Welfare.

The Annual Report (1930) of the Miners' Welfare Fund just issued by the Mines Department at the price of eighteenpence, is in two sections; one is the ninth report of the Allocation Committee, the other the fourth report of the Scholarship Selection Committee. Recreation, welfare, health, research and education represent the principal interests covered in this remarkably entertaining book which is much more than a financial statement of receipts and expenditure. It is a notable record of voluntary labour well done but, above all, it gives a wonderfully clear insight into the mass-personality of British miners, their ideas of domestic and social well-being; their hopes and ambitions. One might indeed say that it is, in effect, a dependable indication of the way our miners would choose to spend their surplus money and time, as and when opportunity may offer. Which delectable privilege, accorded to but few and rarely, is after all a reliable test of the innate character of an individual, family, or community. We believe the majority of readers will find their attention most closely attracted by the scholarship section; the present condition of affairs in British colliery communities and the efforts and desires of its people are here as in a mirror reflected.

It is important to notice that in the report readers are asked to bear in mind that "the object of the Miners' Welfare Scholarship Scheme is to find the best brains among the workers in or about the coal mines, and their children". Compassionate circumstances are not taken into account excepting in those cases when, having difficult circumstances to contend with, the candidate's achievements are the more valuable.

There are two classes of scholarships, one for miners and the other for the children of miners. The number of applications from working miners decreases year by year—last year there were only 152 candidates as compared with 210 in 1928. Forty-seven of the candidates had attended secondary schools and the remaining 105 elementary schools only. It is interesting to compare the proportion of secondary school candidates, 31 per cent., with the corresponding percentage figures of 37 for 1929 and 44 for 1928. Moreover, of the candidates last year only 31 were qualified to enter into a university course as compared with 43 in 1929, 42 in 1928, and 62 in 1927.

The figures quoted in the report are pointed comments in regard to the limited effect or use made of technical colleges. Of thirty miner candidates qualified for matriculation, seventeen had done so whilst at school, five through correspondence courses and private tuition, and only seven by using the adult classes of the education authorities. The Miners' Welfare Fund allocated over £22,000 last year towards the special provision of mining education in technical colleges and classes: an increased contribution which brought the total sum so applied since 1922 to more than a million pounds.

Returns of this character are not encouraging and make one disposed to ask whether the expense is justified, whether the miner is education-shy, or whether there is some important factor or link missing in the chain of administration which should make easy the road from the mine to the college.

There is a sentence in the report which reveals one possible deterrent, some may see in it the missing link, it reads "whatever opinion one may have on examinations as a test, it is by means of examinations that universities have to be entered and that university degrees have to be obtained."

The number of working miner candidates who wished to study mining was less than 22 per cent. of the total (the corresponding figures were: 24 for last year, 34 for 1928, and 42 for 1927). Is it that the educated miner is losing faith in the prospects of the industry and, if that be so, to what more promising sphere does he aspire? Of the miner candidates 27 wanted to do adult educational work and 32 others wanted to be teachers, only 25 proposed to stay in the mining industry as managers, engineers, or inspectors. Seventeen wished to be engineers (other than mining), fourteen were seeking to become church ministers, and the remainder would be journalists, artists, doctors, lawyers—in fact, almost anything away from mining.

What then of the scholarship candidates who are not working miners but who are the sons and daughters of miners? Rather more than half of the 442 entrants in this class were still at junior schools; 152 were whole time pupils at senior schools or institutions; 18 were already employed as teachers; there were 10 clerks, and the others were employed in various spheres ranging from accountancy to domestic service.

The teaching profession must surely carry some seductive charm to which mining folk are peculiarly susceptible, for no fewer than 325 of these junior candidates for scholarships wanted to be made into teachers. Nor did that overwhelming proportion represent the full cup of antipathy towards mining: 64 of the remainder selected various other careers all remote from any colliery circumstance.

Even in the face of these disturbing facts it would not be sound reasoning to conclude that the miner and his kin have lost faith in the family industry. Do not forget that the avowed object of these scholarships is to sift out the best brains and that the process of sifting is by means of examinations. It may be that our adopted systems and standards of national education are of too little help to the ambitious and studiously inclined practical worker in industry. It may be that our schools and colleges are eminently successful in making good teachers. Which contemplation sets the mind going round and round a swiftly narrowing circle. Do our present educational methods tend to create a similar unprofitable whirl in industry? Perhaps so: but let us take heart and be actively encouraged with the sure knowledge that as the circle speeds and contracts so the more imminent becomes the inevitable tangential throw—the new straight line, untrammelled by old routine, the new line to progress.

The A.M.E.E. Convention.

In this dour month, whose seasonal unpleasantness is aggravated with industrial gloom, it taxes even the most optimistic to conjure up a joyous outlook. Summer, again in seasonal and industrial variety, with its sunshine and roses may seem still far ahead but it is none the less as well to mark hopefully the good things in store. So we would at this early date remind members of the Association of Mining Electrical Engineers that the delectable month of June holds particularly rich promises for them. Whilst there are still a few important details to be fitted in, the programme planned for this year's Summer Convention is so nearly completed that members can now safely make their decisions and arrangements. From Tuesday, June 9th, to Saturday, June 13th, the Royal Hotel, Cardiff will be the rendezvous of loyal members and their friends. An excellent series of tours and visits has been agreed. There will, on the Wednesday or Thursday, be a notable Civic Reception and, of course, the great Annual Dinner and Dance will be the fitting climax on Friday.

The hospitable national enthusiasm of the South Wales people is proverbial and needs no emphasis. Will members of the A.M.E.E. therefore take this preliminary hint and mark their diaries accordingly, confident in the assurance that, whatever of their other hopes may brightly materialise, a week of real pleasure and profit awaits them in June.

B.T.H. Turbo-generators for the Largest Liner.

The British Thomson-Houston Co., Ltd., are to supply the seven turbo-generators which will be required for the auxiliary services on the giant Cunarder now being built at Clydebank by Messrs. John Brown & Co., Ltd. This liner will be over 1000 ft. long and have a displacement of over 70,000 tons, so that she will be by far the largest ship in the world.

Each of the B.T.H. turbo-generators will be rated at 1300 k.w. (normal) 225 volts, with an overload capacity of 25 per cent. for two hours and 50 per cent. for five minutes. The combined normal capacity is therefore, 9100 k.w. which is sufficient for the needs of a moderately sized town. Each set will comprise a ten-stage turbine driving a direct current generator through single reduction gearing, the speed of the turbine being 5000 r.p.m. and the speed of the generator 600 r.p.m. The sets are of the combined turbine and condenser type in which the condenser is integral with the turbine, thus enabling the whole unit to be on the one floor level.

Four of the sets are designated "Main machinery sets" and three "Hotel service sets". The main machinery sets are to supply power to the numerous motor driven auxiliaries, such as pumps for water, lubricating and fuel oil, bilge and ballast, etc. They are to operate on steam at the stop valve at 370 lbs. per sq. in. gauge, 680 degs. F. total temperature.

The hotel service sets are to supply the numerous electrical services installed for the comfort of both passengers and crew. Among these services may be mentioned heating, cooking, ventilation, lifts, pumps for sanitary service, swimming baths, etc., as well as the very heavy lighting load on a ship of this enormous size.

These latter sets will be required in port as well as at sea, and since the boilers intended for supplying steam to the main propelling turbines would be shut down when in port, these sets are to operate off auxiliary boilers supplying steam at the turbine stop valve at 230 lbs. per sq. in. gauge, 650 degs. F. total temperature. Steam will be bled from these turbines for feed heating purposes. It will be noted that by the adoption of such high pressures and temperatures marine practice is now following that on land.

Coal Owners and Accidents.

Mr. A. McCosh, president of the Scottish Coal Owners' Association, speaking at the Safety in Mines Conference held recently in Glasgow, said he would like the assurance to go forth from the conference that no one would more welcome a lower or a reduced accident rate than the mine owner. It had been said that the owners were indifferent to the accident rate. A little reflection was bound to show the absurdity of any such suggestion. Apart altogether from the humanitarian aspect of the question, it had got to be borne in mind that accidents were very costly to the industry.

Last year compensation for accidents cost the mine owners in Scotland £400,000 in round figures, which was equivalent to nearly 3½d. on every ton of coal that was sold. Not only so, but every accident entailed more or less some stoppage in the operation of the colliery or the section where it occurred. Frankly, he would not attempt to put a figure on the cost of these minor and serious stoppages, but it must be obvious to all that they meant money to the owners and the industry.

It was a truism to say that accidents increased cost, and from the £ s. d. point of view any method by which a reduction in accidents could be brought about was bound to have the whole-hearted support of the coal owners as a whole.

Because of the variety of causes contributing to accidents, Mr. McCosh feared there could no royal road to prevention. It rather seemed to him that the problem must be tackled in all sorts of ways. Admitting the pure scientist had a part to play, it would seem that still more responsibility devolved upon the mining engineer and the miner. By far the largest number of accidents were caused by falls and in haulage roads, and to the engineers and men who worked underground must fall the big problem of reducing the number of these particular types of accidents.

Coal owners welcomed the progressive steps which had been taken by the Mines Research Board in setting up committees in every district to investigate these two major problems—accidents from falls and in haulage roads. Mr. McCosh said he had not the slightest doubt that good would eventuate from the policy that had been pursued. A number of accidents were due to neglect of rules. These, it was evident, could have been avoided by the exercise of the necessary care.

Hydro-Electric Power for British Columbian Mines.

From a Canadian Correspondent.

REFERENCE has already been made in this journal to the rapid expansion in the demand for electrical power for the operation of the great Tadanac Smelter of the Consolidated Mining and Smelting Company of Canada, Ltd., at Trail, British Columbia, on the Columbia River, not many miles from the United States frontier. The needs of the constantly enlarging metallurgical plant itself, with its accompanying nitrogen and superphosphate fertiliser industries now under construction, are ample reason for activity by the subsidiary power organisation, the West Kootenay Power and Light Company, Ltd.

It should be borne in mind that the power company supplies electrical energy not only to the parent concern for the operation of the smelting and refining plants at Trail, but it is also the prop on which the fortunes of the mining industry throughout a large area of southern British Columbia must rest in view of the almost complete dependence of Canadian mining upon electrical energy derived from waterpower. Electricity is distributed to numerous towns and to large and small properties under development between the City of Nelson, on Kootenay Lake, to Copper Mountain, on the West, although the mines operated by the Consolidated Company itself in the neighbourhood of Kimberley receive the necessary power not from the West Kootenay Company but from the system operated by the East Kootenay Power Company on the British Columbia-Alberta border.

The urgency of the power situation in this neighbourhood has been amply demonstrated recently in the tension generated between the two great mining organisations of the Pacific Coast by reason of the fact that the Copper Mountain mine and concentrator of the Granby Consolidated Mining and Smelting Co., Ltd., receives its electricity from the West Kootenay Power and Light Company. Difficulty has also been experienced in view of the desire of the Reeves McDonald Mining Company to develop hydro-electric power on the Pend d'Oreille River, on which stream the West Kootenay Company contemplates the erection of a 350,000 h.p. generating station.

The West Kootenay Power and Light Co., Ltd., controls in Canada the South Kootenay Water Power

Fig. 1.—The 75,000 h.p. South Slocan Hydro-Electric System, Kootenay River, British Columbia.

and Light Company, the Rossland Water and Light Company and the Okanagan Water Power Company, as well as the Northport Power and Light Company, operating in the State of Washington, U.S.A. The earliest generating plant operated by the Company was that formerly in use on the Kootenay River at Lower Bonnington Falls, 10¾ miles downstream from the City of Nelson. Here, in 1897, were installed two 1,184 h.p. hydro-electric units operating under an average head of 37 feet. Later, in 1889, a 1184 h.p. unit was added.

The station was completely transformed in 1923, and at the present time 60,000 h.p. is being generated from a head of 70 feet. In the plant are three Canadian Allis-Chalmers, 120 inch vertical single runner, 100 r.p.m. 20,000 h.p. Francis turbines, each of which is directly connected with three Canadian General Electric 17,500 k.v.a., 7200 volt, 100 r.p.m., 60 cycle generators. For these units there are three 250 volt, 100 r.p.m., 165 k.w. exciters which are directly connected to the generators. The station transformers consist of three banks of three Canadian Westinghouse oil-immersed, water-cooled, single-phase, 60 cycle, 7200/60000 volt units, each of 5000 k.v.a. capacity.

A later plant was installed at Upper Bonnington Falls in 1906 with an initial installation consisting of two 8000 h.p. turbines, supplemented in 1914 and 1916 by two 9000 units, making 34,000 h.p. in all. This plant operates under an average head of 70 feet and contains two I. P. Morris 60 inch vertical, Francis turbines, each rated at 8000 h.p. at 180 r.p.m., and two Allis-Chambers, Francis, 65 inch turbines, each 180 r.p.m., 9000 h.p. The generators are four Canadian General Electric 7500 k.v.a., 2200 volts, 3-phase, 60 cycle machines. The exciters consist of two 150 k.w., 125 volt, 400 r.p.m., direct connected machines. The station transformers, all of the oil-insulated, water-cooled type by the Canadian Westinghouse Co., consist of two banks of three 1875 k.v.a., 2200/60000 transformers, two banks of three 2000 k.v.a., 2200/60000 volt transformers, one bank of three 1250 k.v.a., 2200/22000 volt transformers.

The Cascade Water Power and Light Company, a subsidiary of the West Kootenay organisation, operates a small 3900 h.p. plant on the Kettle River, 12 miles below Grand Falls, close to the frontier of the United States. Here there is an average head of 156 feet, and in the station there are three 1300 h.p. turbines, with generators and the necessary station transformers; the plant, which dates from 1902, was acquired by the West Kootenay concern in 1907.

The largest and most up-to-date of the existing stations being operated by the West Kootenay Company is that recently completed at South Slocan, 13 miles downstream from Nelson, and approximately 30 miles from Trail. At this plant, 75,000 h.p. is generated from a head of 70 feet. It will be seen, therefore, that the three plants on this stretch of water utilise a combined head of 210 feet out of a total water fall in thirteen miles exceeding 270 feet, the river at its outlet from Kootenay Lake being 1738 feet above sea level.

The power house at South Slocan is erected on an island about 1800 feet long, construction being carried out at the downstream end of the western channel in order to take advantage of the natural fall in the river. Dams extending upstream from the head works structure on the island and on the shore impound the water in front of the head gates. The concrete dam on the western shore is 425 feet long, with a maximum height of 60 feet, whereas the one on the island side has a length of 1311 feet and is 70 feet in height. The latter erection has also a spillway extending from a point 120 feet upstream from the headworks taking in over 1100 feet of the dam. It also contains the four foot sluice gates located close to the head works and a twelve foot sluice gate with the crest 22 feet below the top of the head works and located at a point 96 feet upstream from the headworks.

The spillway at the upstream end of the island across the eastern channel backs up the water towards the tailrace of No. 1 generating station thereby raising the elevation of the water in the forebay to provide the 70 feet head at No. 3 power house (South Slocan). The dam is of concrete, ogee section, and 500 feet long. Another dam was constructed on the western side of the tailrace to a point 460 feet downstream from the power house. This dam is constructed partly of concrete and partly of masonry in order to prevent corrosion of the bank at the side of the tailrace during high water.

Fig. 2.—Zinc Refinery, Trail, British Columbia.

The power house building is a structure of 521 feet in length, 167 feet from the upstream part of the headworks to the downstream edge of the floor over a draft tube outlet. The width of the forebay at the entrance to the penstock is 156 feet and the distance across the tailrace at the outlet from the plant is 162 feet.

The three generators are rated at 17500 k.v.a., 7200 volts, three-phase, 60 cycles, 100 r.p.m., and have vertical exciters directly connected with them rated at 165 k.w., 250 volts. A spare exciter stands on the main floor near No. 3 generator and consists of an induction motor, three-phase, 2200 volts, 60 cycles, 900 r.p.m., direct-connected to a generator of 165 k.w. capacity, 250 volts, 900 r.p.m. The three turbines are each 25,000 h.p. Francis vertical fixed runner type, operating at a speed of 100 r.p.m. The switchhouse structure, 80 feet long and 21 feet wide, constructed of reinforced concrete, is attached to the west end of the generator room. It contains two storeys and a basement. The basement contains only the main lead cables from the generators and the outgoing leads to the transformers. The first storey floor is on the same level as the generator room floor and contains :

One bank of 150 k.v.a., 2200 to 220 volts, station service transformers ;

One bank of 600 k.v.a., 7200 to 2200 volts, station service transformers.

One bank of 75 k.v.a., 2200 to 110/220 volts, lighting service transformers.

One 60 k.v.a. voltage regulator.

One battery room containing 60 cells.

One motor generator set for battery charging.

The second storey, located 10 feet above the main floor, contains 2200 volts and 7200 volts busbar structures built of concrete and supporting low tension oil switches.

A 2200 volt tie line from No. 1 power house carrying auxiliary power for No. 3 (South Slocan) plant enters the switchhouse through roof bushings. All windows have steel sashes excepting in the battery room where wooden sashes are used.

The outdoor switching station is of the modern outdoor type, with concrete foundations and steel overhead structure. The transformer section is located 60 feet distant from the end of the generator room on slightly higher ground. A tunnel has been provided at the back of the transformers for oil pipes, water pipes and oil filters. When oil is drained from the transformers it will flow to tanks situated in a separate building. Each generator has its own bank of transformers, consisting of three 6000 k.v.a., single-phase, 60 cycles, 6600 volts low tension to 60,000 volts high tension transformers.

The current of 7200 volts flows from the generators through low tension oil switches in the switchhouse to the transformers. On the high tension side the current flows at 60,000 volts through oil switches and line switches to the transmission lines. All high tension lines from the No. 1 and No. 2 (Upper and Lower Bonnington Falls) power houses are brought into the switching station and provision is made for switching the current from the three plants to any of the high tension lines that transmit power to Trail and elsewhere. All lines entering the switching station are protected by lightning arresters.

Generators, exciters, switchboards, and switching apparatus were supplied by the Canadian General Electric Co., Ltd. The turbines, with accessories, including oil tanks, governors, oil piping, etc., were obtained from the Canadian Allis Chalmers Co. Outdoor and station service transformers were built by the Canadian Westinghouse Company. Main lead cables, 2,000,000 cir. mil. lead covered, also all insulated wire for the complete electrical installation were supplied by the Northern Electric Co., Ltd., another Canadian concern. Structural steel for all structures, powerhouse cranes, tailrace gates, and bedded parts, tailrace gantry, trash racks and supports, headgates and embedded parts, with overhead structure was supplied by the Dominion Bridge Co., Ltd. Pumps by Babcock-Wilcox, and Goldie-McCulloch, Ltd., were installed. The air filters were obtained from the Read Engineering Co., Ltd.

The designing of the plant was the work of the engineering department of the West Kootenay Power and Light Co., Ltd., and these men have been actively en-

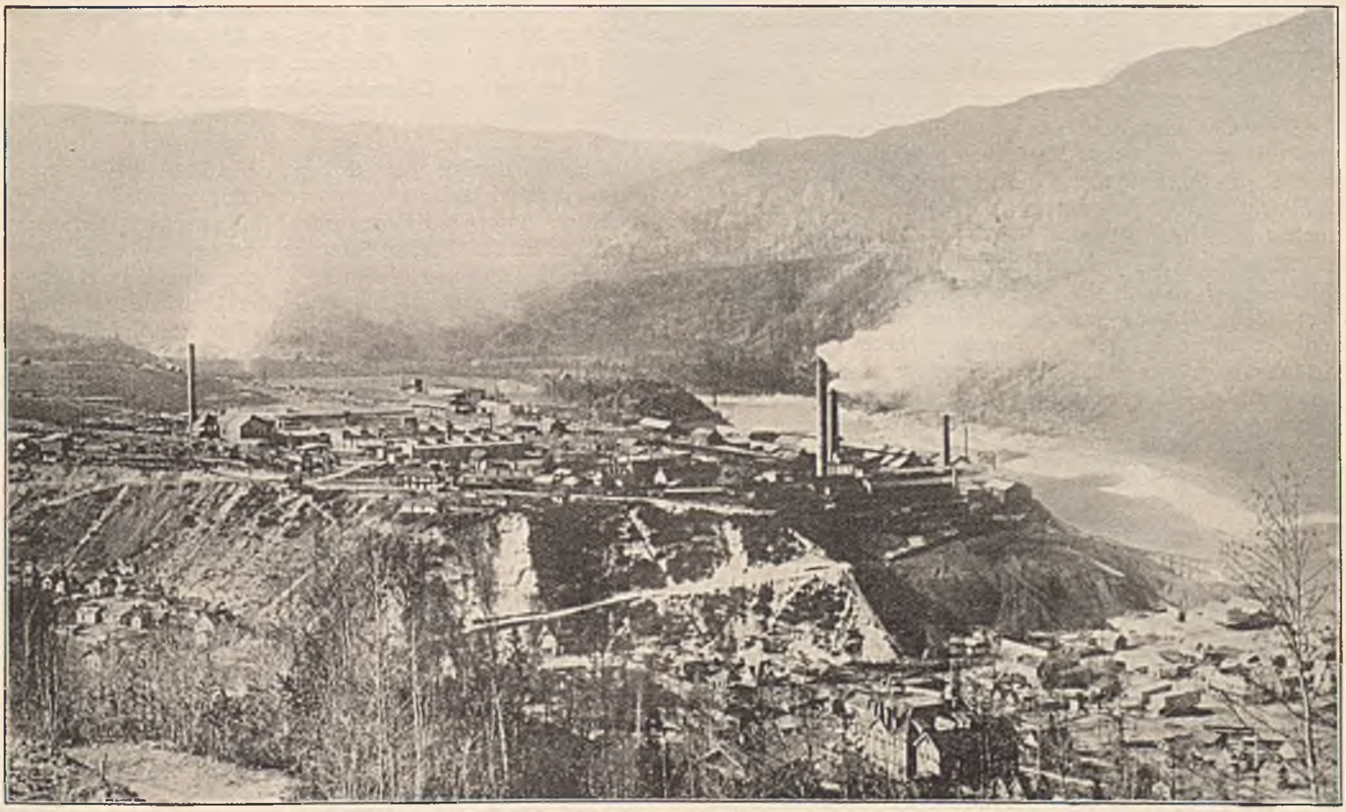


Fig. 3.—The Tadanac Metallurgical Works, Trail, British Columbia.

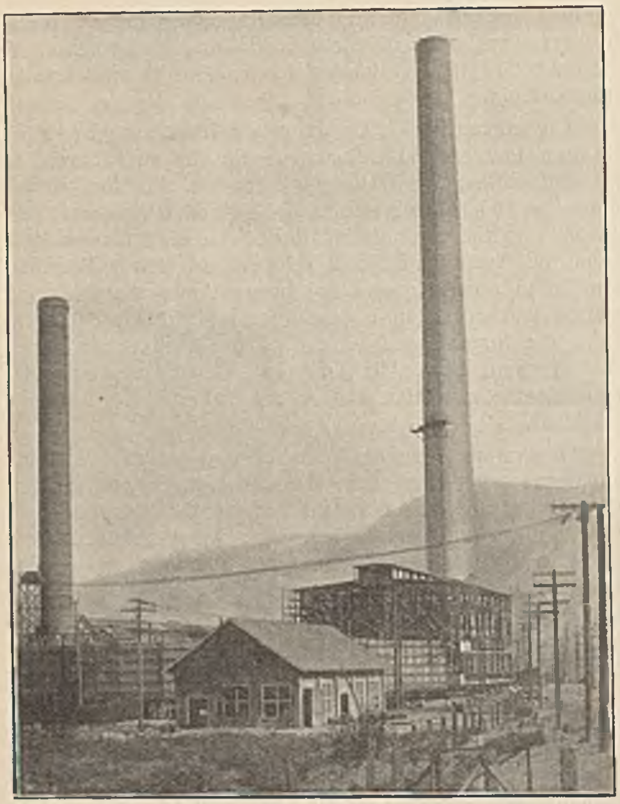


Fig. 4.—The Zinc Works, Trail, B.C.

gaged during the past few months in connection with the plans for a very much larger project to be carried out in the course of the next year or so on the Pend d'Oreille River. Plans for the harnessing of this stream which, when actually carried into execution, will be one of Canada's largest hydro-electrical projects, have been filed by the Company with the Provincial Water Board, and numerous discussions have taken place with the various interests concerned in the development of the latent power on this stream.

The Company's intention, as finally decided, is to construct one great dam 350 feet in height at a point close to the junction of the Pend d'Oreille River with the Columbia River, not many miles from the Tadanac smelter at Trail.

An alternative project, abandoned after much consideration, involved the erection of two dams on the Pend d'Oreille, one near its junction with the Columbia and the other upstream. Together these dams would virtually have controlled the entire flow of the river and permitted the development of a continuous volume of 150,000 h.p., with a maximum part time development of 275,000 h.p. The plans finally adopted contemplate the development of 350,000 h.p. about one mile above Cedar Creek.

Other schemes ready for execution by the Company are the development of hydro-electric energy on the Adams River, a tributary of the Thompson River, and this is being proceeded with at an estimated cost of $2,662,000. The new plant is expected to give a maximum of 30,000 h.p., but the actual output will vary according the quantity of storage water available. This power will be available to supply electrical energy during the low water period on the Kootenay River. The Company is anxious to secure the right to dam the outlet of Kootenay Lake in order to utilise this body of water for the storage of flood water, thus helping to maintain the minimum flow of water in the winter months for the power plants at Bonnington Falls and South Slocan. The matter has to be considered by the International Joint Commission in view of the possible effect of the engineering works contemplated upon conditions in the State of Idaho.

The Company has also secured the right to investigate the available water power on the Kokish River, which flows into the sea not far from Alert Bay, on the east coast of Vancouver Island. Upon the results of this survey may depend the decision of the Consolidated Mining and Smelting Company relative to the erection of a copper smelter and refinery for the treat- of ore mined on the Pacific Coast.

At the present time, the West Kootenay Company's system extends over a total transmission distance of about 300 miles, there being 82 miles of a double circuit wooden pole line transmitting power from the Bonnington Falls plant to Greenwood substation at 60 k.v. There are also 135 miles of wooden pole line transmitting power from Greenwood substation to a substation at Penticton, Allenby and Copper Mountain for the local mines and concentrator. It is said that negotiations are now in progress for the acquisition of the Copper Mountain mine and concentrator from the Granby Company by the Consolidated Mining and Smelting Company. If finally agreed, such an arrangement would relieve the two companies of an awkward bone of contention in power and smelting questions.

Four and a half miles of wooden pole line take power from Penticton substation to Kelowna and Summerland at 60 k.v. and 5000 volts. Thirty-two miles of double circuit wooden pole lines transmit power from the Bonnington Falls station to Rossland substation at 20 k.v. and 60 k.v. Fifteen miles of wooden pole line take power from Rossland to Northport, Washington, U.S.A., at 60 k.v. Fifteen miles of wooden pole line transmit power from Bonnington Falls station to Silverton mine via Nelson at 20 k.v. One mile of single circuit line takes power from the Tadanac smelter to the town of Trail at 2200 volts.

It will be seen, therefore, that the available power resources on the Columbia River and its tributaries are being strained in the effort to keep up with the constantly increasing load, and the experiences of British Columbia during the drought of 1927 have already demonstrated to all who were not cognisant of the position how vitally dependent industry of every description in the Pacific Province has become upon water power development, in spite of the abundant resources in coal and fuel oil to which the Province could turn at any time should the need for additional power manifest itself.

Manitoba Copper and Zinc.

By the end of March the £4,000,000 mining and smelting plant at Flin Flon in Central Manitoba will be in operation, according to the Natural Resources Department of the Canadian National Railways. This marks the culmination of what has been one of the greatest mining developments in Canada during the past decade. Flin Flon is one of two mining towns which have grown up on the Manitoba-Saskatchewan boundary over an ore body whose estimated value is at least £80,000,000. The other, Sherridon, some 45 miles to the north, will also begin production within the next few months.

Work has been progressing steadily in this richly mineralised zone for three years. New lines have been built by the Canadian National Railways solely to serve it, and on the Churchill river, 75 miles north, millions have been spent on the establishment of a hydro-electric plant to serve the whole area.

Improved Coalcutter Haulage.

The "Samson" chain coalcutter, 'H' type, made by Mavor & Coulson, Ltd., is now supplied with high and low speed controls that are thrown out of gear instantaneously by using the power of the machine itself; control is now effortless, however great the strain on the haulage rope, or in however difficult a position the machine may lie. The haulage gear has two rope drums, one on each side of the machine. The drum in use pulls the machine so that guide props are seldom necessary. Because the great strength of the gear allows the use of single rope, the gear combines the advantages of the rope and the chain type. The haulage contains no friction clutch or cone clutch; its parts last indefinitely.

Eight straight-cut gear wheels, a worm and worm wheel, and a ratchet wheel form the whole gearing for both high and low speeds. All working parts are entirely enclosed, and run in oil. No loose parts can be displaced or lost. Wide inspection doors give free access to all working parts; as all shafts are horizontal, every part is easily accessible. The set screws that fix the doors have square heads to fit the pick spanner. All the controls are at the haulage end under the hand of the operator; they are foolproof, and light to use however great the strain on the rope; they give complete command of the machine even in the most difficult positions. No tommy bar or other tool is required.

Slow Speed Haulage.

Power is transmitted to the haulage through one spur and one worm reduction. At the right hand end of the shaft carrying the worm wheel is a crank which drives a connecting rod, moving a pawl to and fro over a ratchet wheel, which is partially shrouded by an adjustable camplate. By moving the camplate, the cutting speed may be set at 10, 20, 30, 40, or 50 inches per minute; these speeds may be halved by using double rope.

The ratchet wheel is held from turning back by a stop pawl which may be withdrawn to free the haulage rope, as explained below. The ratchet wheel shaft is geared to the drum shaft. Each end of the drum shaft carries a pawl, which may be engaged with recesses in the bore of the rope drum; thus the face side drum may be used while the goaf side drum is stationary.

Each drum carries 30 yards of $\frac{5}{8}$ inch diameter rope. Long rope life is ensured by the large diameter of the drums, and by the rope passing straight on to the drum during cutting, without straining round a bollard or roller. The low rope speed saves damage to the rope during sumping.

However tightly the rope may be strained, a tap on the release lever frees it instantaneously and without effort. The drums are kept from turning back by the stop pawl on the ratchet wheel. The stop pawl is carried on a rocker, which is held in position by a crank. If the rope release lever is depressed a little, it turns this crank over the dead centre, and deprives the stop pawl rocker of support. The ratchet wheel then throws the stop pawl clear, and the rope drums are free to turn if the high speed is out of gear. If the driving pawl could suddenly touch the ratchet wheel just after the stop pawl has been released, damage would be done. Accordingly, an interlock is provided to prevent releasing the stop pawl while the feed is on.

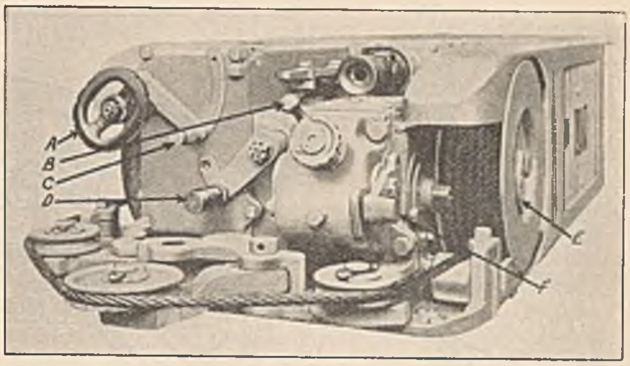


Fig. 1.—Haulage End shewing Controls: the haulage rope is passed round the pulleys for jibbing-in.

A. *Switch Handwheel.*
B. *Camplate Operating Handle.*
C. *Chain Clutch Hand Lever.*
D. *High Speed Hand Lever.*
E. *Haulage Drum Pawl Key.*
F. *Rope Release Lever.*

High Speed Haulage.

At the left hand end of the shaft carrying the worm wheel is a pinion which drives two gear wheels bolted together and running idly on the drum shaft. They drive

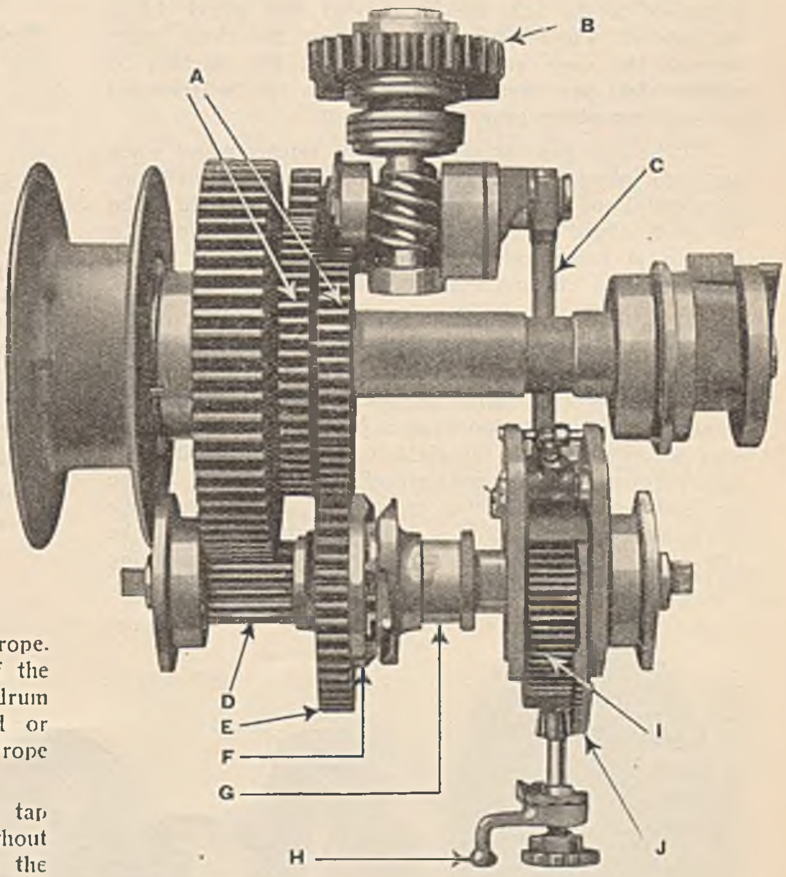


Fig. 2.—Plan of Moving Parts of Haulage: right-hand rope drum is removed to shew Hub and Pawl.

A. *Gear wheels fixed together: run idly on drum shaft.*
B. *Spur wheel driven by motor pinion.*
C. *Connecting Rod for Low Speed.*
D. *Pinion cut on Ratchet Wheel Shaft.*
E. *High Speed Spur Wheel.*
F. *Release Ring.*
G. *High Speed Clutch.*
H. *Camplate Operating Handle: varies Cutting Speed.*
I. *Ratchet Wheel for Low Speed.*
J. *Camplate.*

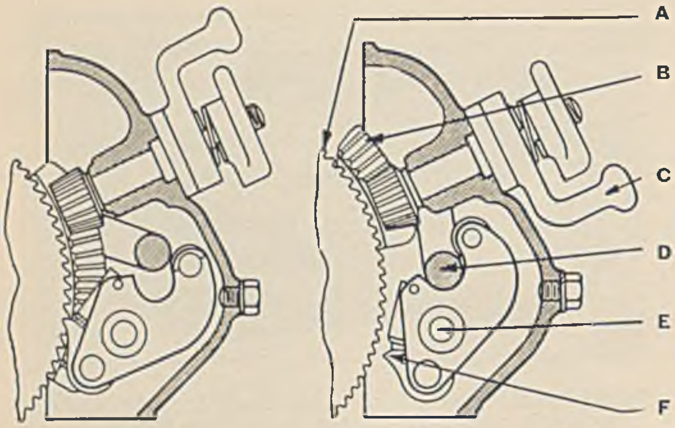


Fig. 3.—Rope Release Gear: shewing Stop Pawl engaged and withdrawn.

A. *Ratchet Wheel.*
B. *Rack to move Camplate.*
C. *Camplate operating Handle.*
D. *Crank.*
E. *Fulcrum Pin for Rocker which carries Stop Pawl.*
F. *Stop Pawl.*

the high speed spur wheel which normally runs idly on the ratchet wheel shaft. When the high speed clutch is pushed to the left, the high speed spur wheel drives the ratchet wheel shaft, which drives the drum shaft through the spur gearing, and moves the machine at about 25 feet per minute. Other speeds can be arranged by selecting other gear ratios.

If the stop pawl is resting on the ratchet wheel when the high speed is engaged, the ratchet wheel overruns harmlessly, and the stop pawl keeps the rope tight when the high speed is stopped. If the electric motor is running in the wrong direction the high speed clutch will refuse to engage, because the teeth are backed off.

The high speed clutch (Fig. 4) is thrown instat-taneously out of gear by using the power of the machine, without requiring effort by the operator even when the rope is strained as tightly as possible. The release ring (centre), which rests loose on a boss of the high speed spur wheel, shewn on the right hand side of the illustration, revolves with the spur wheel and the clutch. When the high speed hand lever is lowered, before the yoke starts to move the clutch, a trigger carried by the yoke catches a radial projection on the rim of the release ring and stops it from turning. The high speed clutch, continuing to turn, is immediately forced out of gear by axial projections on the clutch mounting axial projections on the release ring.

If the motor is not running, the clutch is put out by hand power. On lowering the hand lever further, the trigger is left behind by compressing a spring, and the yoke then moves the clutch in the ordinary way.

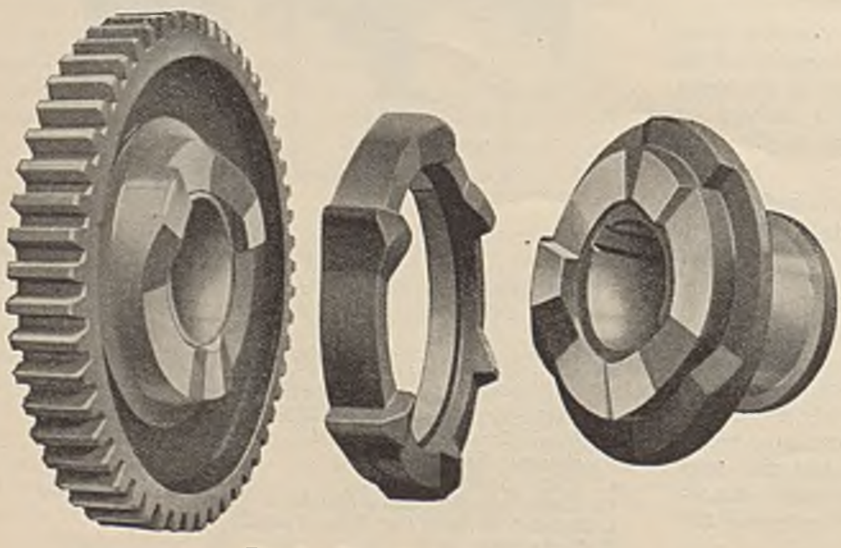


Fig. 4.—The High Speed Clutch.

NEW BOOKS.

H.M. STATIONERY OFFICE.

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

MINES DEPARTMENT.—MINERS' WELFARE FUND: NINTH REPORT of the Committee appointed by the Board of Trade to Allocate the Fund; together with the FOURTH REPORT of the Selection Committee appointed to administer the MINERS' WELFARE NATIONAL SCHOLARSHIP SCHEME, 1930. Price 1s. 6d. nett.

MINES DEPARTMENT.—PRELIMINARY STATEMENT OF DEATHS CAUSED BY ACCIDENTS in and about the Mines and Quarries of Great Britain during the year 1930. Price 1d.

ACCIDENT PREVENTION CALENDAR, 1931.—Compiled by prominent experts of British Industries. Accident Prevention and Welfare Publications Ltd., 321 High Holborn, London, W.C. 1. Price 4d.

A booklet containing interesting and convincing illustrated articles on the prevention of many ordinary accidents of industrial and domestic life. It is quoted at low rates (e.g., per 1000 at 2½d. each) so that employers and firms may distribute copies freely amongst workers: and also—with suitable advertising imprints—to business clients.

THE BLUE BOOK: The Directory and Handbook of the Electrical Engineering and Allied Trades: 1931. London, Ernest Benn, Ltd., Bouverie House, 154 Fleet Street, E.C. 4. Price £1 5s. nett.

Familiarly known throughout the electrical world, the "Blue Book" is still the standard work of reference for the whole of the electrical industry and allied trades. Everyone concerned with saturating electrical trade and professional circles with published matter automatically turns to this volume as being the only publication that contains complete alphabetical, geographical, and classified sections for the electrical industry. The handbook section is a compilation of facts, data, and exclusive information needed in every electrical office. The geographical and classified trades sections are unique, and the guide cards facilitate reference to any section. In every respect the high standard of production associated with this work of reference in the past has been fully maintained in this 49th consecutive annual edition.

Proceedings of the Association of Mining Electrical Engineers.

NORTH OF ENGLAND BRANCH.

A Modern Coke Works.

SIDNEY A. SIMON, M.A.

(*Continued from page* 226.)

Recent Developments and Additions.

Since the visit of the Association last year, the oven battery has been extended by the addition of ten ovens. These are served by the same coke oven machines, with the addition of a second coal car. This new car embodies some novel features, amongst others an electro-mechanically driven poker gear, and chimneys to carry the flames from the charging holes away from the operating platform.

Owing to the increased demand for gas by the Gas Company, an additional boiler with 5370 sq. ft. of heating surface to raise 24,000/27,000 lbs. of steam per hour at 180 lbs. gauge pressure and 140 degs. F. superheat with chain grate stoker has been erected and put into operation. Also the three original gas fired boilers are being successively similarly fitted out with chain grate stokers for burning coke ballast. Each boiler is being provided with a separate motor driven forced draught fan. A boiler house with storage bunkers and electrically driven fuel and ash handling plants is in course of completion; in this an exceptionally interesting feature is the automatic ash hoist.

A large gas holder of the waterless type with a capacity of 250,000 cu. ft. is being erected; automatically controlled electrically driven tar pumps maintain the flow of sealing fluid to the gas holder.

Other interesting additional electrical power applications are in connection with the shipment and delivery of coke from the riverside staithes. This new plant comprises electrically driven capstan and portable conveyors. The illustration, Fig. 23, shews one of the latter loading coke from a storage bunker into a motor lorry for local delivery.

GAS AND STEAM METERING SYSTEM.

As well as being the standard means for power and lighting, electricity is employed in many other important applications. Just as in a properly run electrical plant it is important to keep a check on the electrical quantities, so in a modern coke works it is essential continuously to measure and meter the gas and steam.

For these purposes an electroflo multiple metering system has been installed. It is applied to the continuous measurement of:

1. Gas to Newcastle.
2. Gas to Boilers.
3. Gas to Coke Ovens.
4. Surplus Gas.
5. Total Gas.
6. Total Steam from Boilers.

The main metering board carries six 12-inch diameter indicators, shewing the instantaneous rate of flow, and six five-figure integrators, shewing the total quantity of gas or steam to or from the points mentioned above. Beneath these integrators is fitted a multiple recorder, which provides six graphs in contrasting colours. The chart lasts for 1200 hours or approximately two months, and is driven by an electric clock. The system therefore gives complete information by indicating the instantaneous rate of flow, totalling the volume of gas and steam passed to and from the various points, and recording the variations in flow and shewing the crests and troughs against the times of their occurrence.

The metering system is entirely electrical, so that the reading instruments can be located exactly where required; they were centralised in the system adopted at Derwenthaugh and where necessary duplicated, to meet operating or supervisory requirements. In this manner three additional 15-inch diameter instantaneous rate of flow indicators are located at control points at the coke oven control room and at the boilers to indicate gas to ovens, gas to boilers, and total steam for the guidance and convenience of the operators. Figs. 24 and 25 shew, respectively, a gas meter and a steam meter.

A portable steam flow meter is also provided for test purposes. The reading instruments are permanently fixed in the power house, whilst the meter body is mounted upon a small truck and moved to any one of seven steam mains. Tests can be made at any time without interfering with the flow of steam. The steam flow meter comprises three parts:—

(a) The meter body, viz., a mercury manometer for steam, an oil sealed bell carrying a mercury cup for gas.

(b) The differential medium installed in the pipe line, viz., a thin orifice plate.

(c) The reading instruments, i.e., indicators, integrators, and various types of graphic recorders.

The diagram, Fig. 26, illustrates the operating principle of this meter. The two limbs of the meter body, are connected by short lengths of ⅜ inch bore pipe, to the upstream and downstream sides of the differential medium in the usual manner, and when there is a flow in the pipe the mercury level in the steam meter is depressed in one limb (actually an annular chamber)

Fig. 23.—Portable Electric Conveyor-Loader.

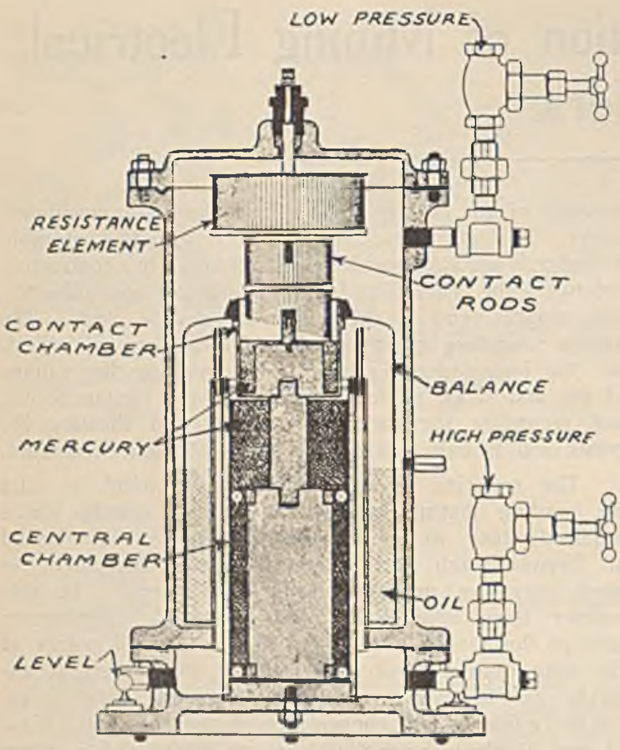


Fig. 24.—The Electroflo Gas Meter.

and raised in the other or central chamber in proportion to the impact of the flow. In the case of the gas meter the bell is raised by the increased pressure and with it the mercury contact on the top of the bell.

A unit type continuous resistor, forming part of the electric circuit in which the distantly located reading instruments are connected, is suspended over the mercury in the central chamber or cup and as the mercury level alters, more or less of this resistor is in contact with the mercury, so that the current and the reading of the instruments are varied accordingly. The reading instruments are modified forms of the indicating and recording ammeter and integrating conductance meter, calibrated to give direct readings in lbs. or cubic feet. Time lag and damping are entirely eliminated.

The internal resistor is of simple construction, and in the steam meters is completely immersed in and cooled by the transformer oil used in the meter body, which also completely covers the mercury in the central or resistance chamber.

The conductors of the resistor element are of a special metal and arranged to form a parabolic curve, so that the resultant electric current flow follows a straight line law.

The meter operates on one ampere at 40 volts, and on the rear side of the panels described above are fitted the necessary instrument transformers, fuses, and external resistances. The current supply is transformed down from the lighting circuit at 250 volts The actual current consumption of a single meter at maximum load is approximately 40 watts.

Each reading instrument is made inherently independent of voltage and cycle fluctuations by a special system, within the limits of plus or minus 10% variation. Each instrument functions independently so that, in the event of any trouble occurring in one, the remaining instruments continue in operation.

The connections between the meter body located at the measuring point, and the distantly located reading instruments, are made with 3/22 swg. wire.

TELEPHONES AND SIGNAL SYSTEMS.

Time and space prevent more than passing mention of the electrical communication systems. A private automatic telephone exchange has been installed by the P.O. in the main railway signal cabin and interconnects not only the principal points about the coke-works, but also the Company's head office at Consett, the power station at Chopwell Colliery and the Gas Company's works, so as to ensure rapid communication both day and night.

Apart from this, there are connections with the Company's private telephone system at the collieries and staithes; and a separate system, combined with signal bells, has been installed for railway traffic purposes.

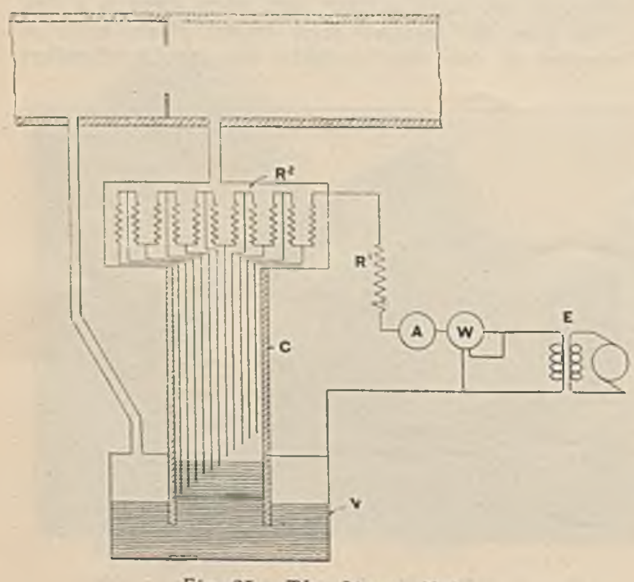


Fig. 25.—The Steam Meter.

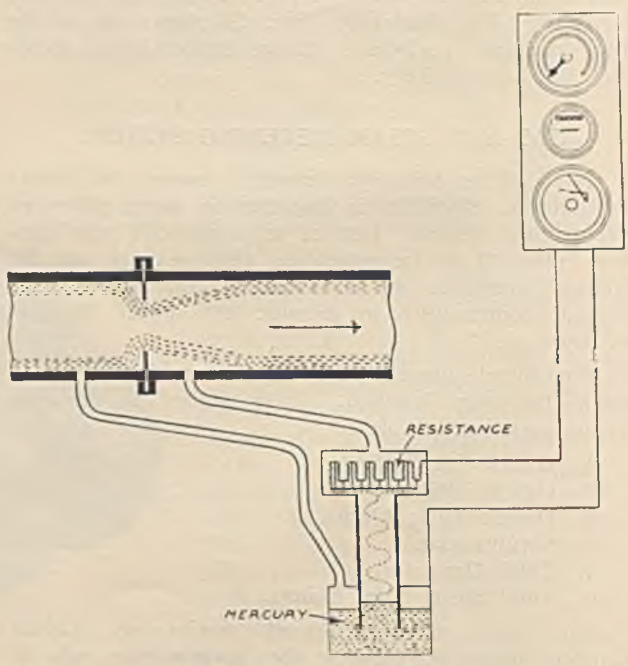


Fig. 26.—The Steam Meter.

Fig. 27.—Crushing and Moulding Plant.

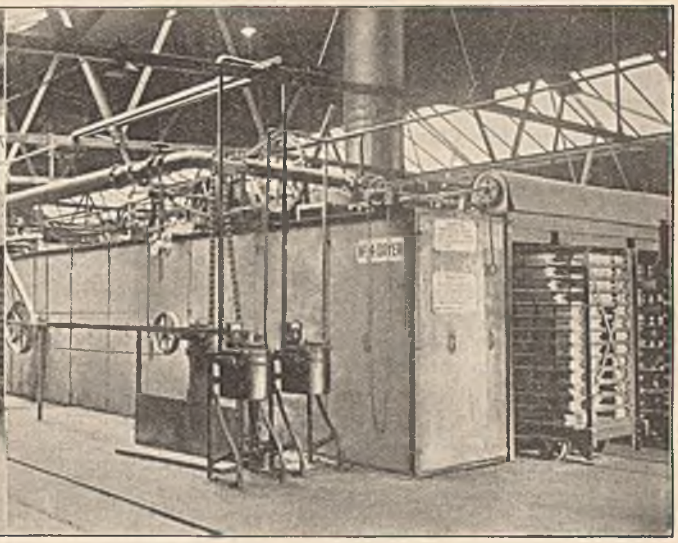


Fig. 28.—The Drying Ovens.

THE SILICA BRICK WORKS.

When speaking of the development of the modern coke oven, the important part played by the perfection of silica bricks was mentioned: a few words on the modern silica brickworks may therefore not be out of place.

The ingredients consist of ganister (a hard quartzite rock containing about 98% of silica [SiO_2]) and a small quantity of suitable flux yielding a product containing about 97% silica.

The ganister, which is brought to the works by an electrically driven ropeway is first crushed and then ground in revolving pans driven by 100 b.h.p. motors. The required quantity (automatically measured) of fluxing agent is then run into the pan and thoroughly mixed in. The resulting "Silica mud" forms the basis from which the bricks and shapes are moulded.

The illustration, Fig. 27, shews the moulding with the crusher pans above at the back. The moulded shapes are stacked on trucks, which are then passed through the drying ovens (Fig. 28). Drying takes from one to six days.

The dried shapes are then stacked in the kilns. These are of the continuous type and consist of a series of communicating chambers heated with producer gas, the necessary draught being produced by an electrically driven fan.

The illustration, Fig. 29, shews one of the special kilns. The newly-filled chamber is first slowly heated up by the hot burnt gases from the chambers which are being actually fired; the chambers are fired successively so that gradually the firing approaches the particular chamber under consideration, which is thus subjected to a gradual increase of temperature; eventually this chamber itself is fired and the maximum temperature attained; finally the firing zone passes the chamber which is then gradually cooled by air drawn through it for combustion of the gas in the firing zone, which progresses round and round the kilns. The heating up, firing and cooling down of an individual chamber takes about four weeks, and the temperature is maintained at a sufficiently high degree to ensure complete quartz conversion and subsequent entire absence of permanent expansion.

Every stage of the process from the quarrying of raw material to the despatch of the finished product is under strict scientific control. Physical and chemical tests on the ganister and on the "silica mud" from the mills are made daily. The kiln firing is regulated by means of pyrometers and seger cones. Samples are taken regularly and tested in the brickworks' laboratory, which is equipped with electric and gas furnaces and all apparatus necessary for the complete study of refractories.

Recent Tests on "Consett" Silica Refractories.

The following are typical of numerous recent tests made in accordance with the standard methods specified by the Institute of Gas Engineers, and the Refractories Committee of the Ceramic Society:

Crushing Strength (cold) ...	3500 lbs. per sq. inch.
Refractoriness	1720° C. (Cone 32-33).
Refractoriness under load of 50 lbs. per sq. in.	1670° C (Cone 30).
Porosity	Shapes 26-27%. Bricks 29-31%.
Apparent Density	Shapes 1.72. Bricks 1-62.
Density (powdered)	2.34.
Conversion of silica	Unconverted quartz = trace. Tridymite 30% approx.

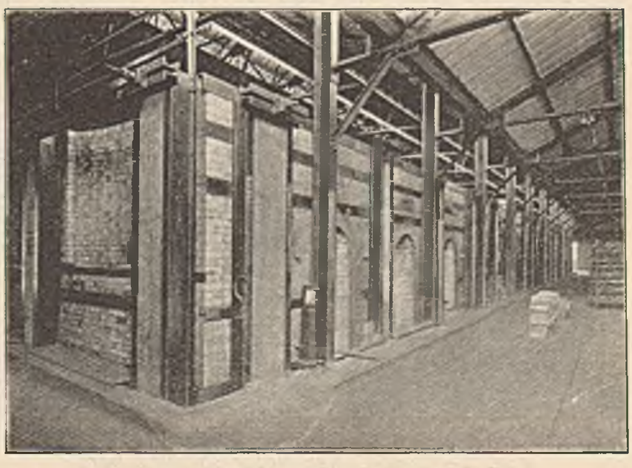


Fig. 29.—The Kilns.

Permanent linear expansion at 1350° C. (Cone 12) ... ... Nil.

(Two Hours' Heating according to Gas Engineer's Specification).

After heating for One Hour at 1600 deg C. = 0.6% contraction.

ACKNOWLEDGEMENT.

In conclusion, the author wishes to express his thanks to the Consett Iron Co. for permission to utilise information regarding their works and for able assistance in preparing this paper: he would also acknowledge his great indebtedness to many of the Contractors who have furnished details of their products and kindly lent photographs, slides, etc. In this connection may be mentioned: Messrs. Silica Machinery & Coke Ovens Ltd. (the main Contractors); The Metropolitan-Vickers Electrical Co. Ltd.; The English Electric Co. Ltd.; and Electroflo Ltd.

WARWICKSHIRE & SOUTH STAFFS. BRANCH.

Trouble.

HENRY JOSEPH.

(*Continued from page* 239)

MOTORS.

Direct Current Motors.

It is safe to say that 75% of the failures of direct current armatures are caused by commutator breakdowns and for this reason the percentage of failures with d.c. plant is very much greater than with a.c.

Commutator troubles which are liable to lead to burn-outs are as follows. Broken down mica cone rings, usually due to oil or dirt; carbonised mica segments due to the same cause and both usually due to neglect or inadequate inspection; commutator loose on shaft or spider, leading to broken conductors and sometimes finally a burn-out of a large bunch of leads spreading to the ends of the windings.

If a machine shews a tendency to oil creepage on to the commutator one must look for the cause. This may be a faulty bearing, over-oiling, or an inefficent oil thrower. Sharpening up the edge of an oil flinger may cure the trouble. Commutator troubles should be less liable to arise with ball or roller bearings than with sleeve bearings.

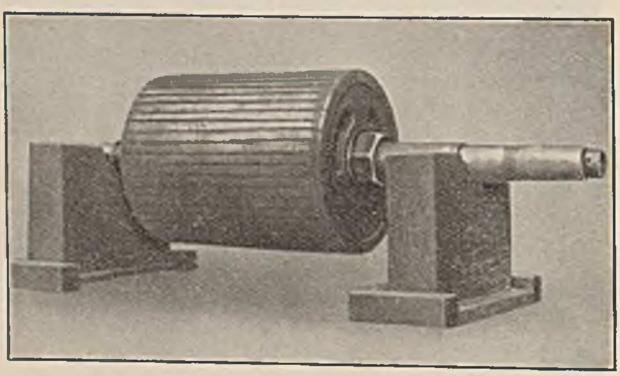


Fig. 2.—Coal Cutter Rotor shewing bars beginning to wear through the slots.

There are also commutator troubles of another kind, sparking, flats and so forth. There are so many causes of this class of trouble that a book could easily be written about them. There is the very common fault of wrongly connecting the interpoles when changing the direction of rotation of a motor. One of the author's test questions when considering an application for the post of maintenance electrician is how to reverse a compound interpole motor.

Sometimes on a large multipolar machine the brush gear is dismantled and re-assembled without undue care. With certain designs it is possible in re-assembling to get a small error in the spacing of the brushes round the commutator. Occasionally an error of half a segment will cause excessive sparking. It is best to cut a long strip of paper and pass it under the brushes round the commutator and equalise the distances carefully with pencil marks.

Very occasionally one gets another snag. A large yoke may be cast with an error in the spacing of the poles and if this has not been corrected in manufacture it may have been got over on test by compensating for the wrong spacing of the field by setting the brush positions centrally with the fields. As the user would be unaware of this when re-assembling the brush gear he would equalise the spacing and find excessive sparking in what is apparently the correct brush position.

Commutators may develop high bars or low bars. The former is usually due to re-assembly in manufacture after turning the Vees. The Vee ring has not quite gripped one bar and under centrifugal force it moves outwards and takes its right bearing. This is usually cured by careful re-turning or grinding.

Low bars, however, are not so easily cured and if not permanently rectified they lead to bad flats. The best remedy is to take out the bar and examine the Vee to see if it has anything adhering to it, preventing it from taking its proper bearing against the vee ring. Failing this file enough off the Vee to convert it into a high bar and then re-assemble and skim the commutator. A low bar which after skimming is so slightly below the level of the others as to be imperceptible may cause a lot of trouble with bad flats and be very very difficult to trace. Although the freshly skimmed and polished commutator may appear perfect the slight depression of a low bar may be enough to increase the effective brush-to-copper resistance so as to cause slight sparking which leads to the eating away of the surface copper of this bar thus leading to greater sparking and further development of the flat.

This of course is only one of many causes of flats. They often point to an incipient fault in the winding, usually in the direction of increased resistance of the coil connected to the bars in question. Look therefore first for bad sweating or a loose lug before assuming a fault in the winding.

The author need not refer to high mica as this subject is familiar to everyone: nor to such obvious causes of sparking as loose rockers, brushes chattering in the holders, wrong types of brushes, insufficiently rigid brush spindles, especially in the case of long commutators with a number of brushes per pole. All these are well known to experienced maintenance engineers.

When looking, however, for causes of commutator troubles it is well to give a thought to some of the above possibilities and to consider whether with the angle at which the brush is set the tendency is for rotation to cause it to press against the side of the brush box in such a way as to increase its pressure against the commutator face—which is the right way—or the reverse—which is the wrong way—and whether the load in amperes per square inch of brush contact surface is within the limits allowed by the makers for the particular grade of brush in question. All these remarks refer to motor speeds not exceeding 1500 to 1700 r.p.m. above which more difficult problems arise and every small trouble becomes a big one.

One can spend a long time talking about brush troubles. Sometimes there are alternate bright and black segments, or two or three black ones separated by a greater number of bright ones, the same sequence being followed right round the commutator. These peculiarities do not, as a rule, point to winding faults, but a large area of bad flats repeated on the opposite side of the commutator or a pole pitch away is practically a sure indication that there is a fault in the winding which at that stage has not yet developed into a burn-out.

Alternating Current Motors.

If the majority of breakdowns of d.c. machines are due to commutator faults so nearly to the same extent are a.c. motor troubles due to faulty bearings.

To obtain high efficiency with a.c. machines clearances have to be cut very fine and it does not take long for a faulty bearing, if not observed and remedied in time, to lead to rubbing between rotor and stator with resultant burn-out of one or both in the case of wound rotors.

Of course squirrel cage rotor machines are much more robust than silpring rotor ones, but still one does have trouble, more perhaps than is generally realised with squirrel cage rotors. The most common fault with squirrel cage rotors is bad contact between bars and end rings. One also gets a lot of cases of bars breaking in the middle of the slot. At one particular colliery there have been a number of cases of coalcutter rotors in which the bars have chattered in the slots to such an extent as actually to work themselves right through the thin walls of the nearly closed slots until they have protruded and been partly worn away (Fig. 2). In all cases of this type of fault it has been possible to trace the trouble to slackness in the bearings. These rotors drive through a bevelled pinion and are thereby subjected to considerable vibration: this causes the bearings to wear and this in turn sets up severe chattering of the bars.

There are four usual methods of attaching rotor bars to the end rings: (1) soft soldering, (2) Silver soldering, (3) Brazing, and (4) Welding. Some engineers prefer the first method because the process does not unduly raise the temperature of the copper. Overheating of the copper tends to leave it brittle and liable to fracture, but soft soldering is probably not sufficiently strong mechanically for such rough work as, for instance, a coalcutter. Silver soldering may be a happy medium. More common practice is brazing or welding, but with these methods the result is probably to give the copper an amorphous or crystalline structure and make it liable to fracture under the influence of vibration. The author invites opinions on this point.

In his own experience the author has had many cases both with rotors and armatures, of the core coming loose on the shaft. There are quite a number of ways of attaching these parts: some makers build them up on spiders which in turn are keyed to the motor shafts: one firm, in particular, uses four or more keys round the shaft in the case of crane and other reversing motors.

When core plates are built up on the shaft, especially in the case of crane, hoist, haulage and rolling mill motors which are subject to rapid reversals, the pressure of the core plates against the side of the key tends to flatten and wear the edge of the keyway in the core plates until there is a slight movement after which the effect rapidly becomes more pronounced. Sometimes individual plates will move round sufficiently to cut into the slot linings until they come in contact with the conductors. In all such cases it is best to strip down the core, fit a new key and re-assemble the core plates, submitting them to 30 to 50 tons per square inch in a hydraulic press. A loose core can usually be detected by the presence of red rust which shews in the ventilating ducts.

Another core fault, by no means uncommon is for the small distance pieces which form the air ducts to come loose, sometimes wedging in the air gap and damaging the winding. In some designs these are only held in place by the pressure between the core plates.

In course of time the paper, or insulating coating with which one side of each core plate is treated, gets flattened out or chafed until it is reduced to a fine powder probably owing to a microscopically small movement between neighbouring plates under the influence of vibration and suddenly applied stresses. At any rate, whatever the action may be, the thin insulating medium is reduced in thickness by a very small amount, which, when multiplied by the number of core plates is enough to produce sufficient slackness for these distance pieces to get displaced or come out. In such cases it is best to take the core adrift, rebuild it, and spot weld the distance pieces in position (Fig. 3).

Stator core plates are sometimes mounted on a spider and built up against projecting lugs at one end. They are then pressed up and while under pressure a number of keys are fitted at the other end (Fig. 4). This method of construction is adopted by several manufacturers and, with all respect, the author considers it to be fundamentally unsound. In course of time there is a tendency for the keys to wear and come out, sometimes with disastrous results. He has known several such cases and, while open to correction, attributes it to the slackening action caused by the gradual attrition of the core plate insulation as described above. As a matter of fact this method of assembling precludes the possibility of getting the core dead tight, for after it is pressed up the pressure has to be relaxed sufficiently to allow the keys to take up their bedding.

Control Gear.

It is an unfortunate fact that the circuit breaker and rotor starter of a reliable make cost, in the case of smaller motors, nearly as much as a slipring motor itself. One remedy is to substitute squirrel-cage motors

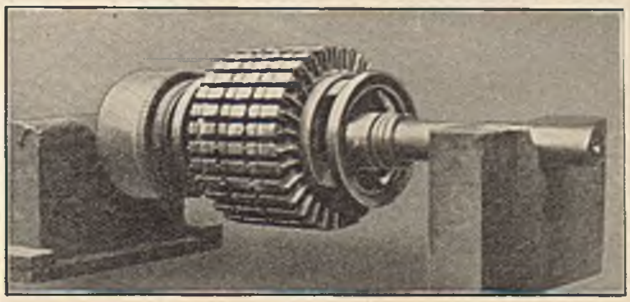


Fig. 3.—Armature Core with Distance Pieces welded into position.

with star-delta or direct-on starters wherever the exigencies of the drive permit, and where heavy starting currents do not matter. But a remedy which should never be adopted is the use of switch fuses which only lead to burn-outs as the result of single-phasing. The author has never yet quite understood why some engineers install auto-transformer starters. They are unreliable and cost more than could be saved by using squirrel-cage motors instead of slipring machines.

On the whole, barring normal maintenance, one does not get much trouble with circuit breakers or star-delta starters, but the author would venture to submit that the modern resistance starter employing metal resistances is inherently wrong. In the first place the range of capacity of the coils is so limited that each starter has to be ordered to be wound for the particular rotor current of the motor with which it is intended to be used and as hardly any manufacturers state the rotor current of their motors on the name plates this information has to be obtained as a first step, unless the starter is ordered with the motor—which is perhaps an intentional reason for the makers' secrecy on this subject.

However, having carefully got the starter graded to suit the particular motor in course of time the initial definite rating is forgotten and when trouble with the motor or its starter crops up the latter is given a new motor partner with possible unsatisfactory results. Another objection is that the resistance has to be cut out in comparatively large steps, thus advancing the speed of the motor in a jerky manner, and, incidentally, burning the starter contacts.

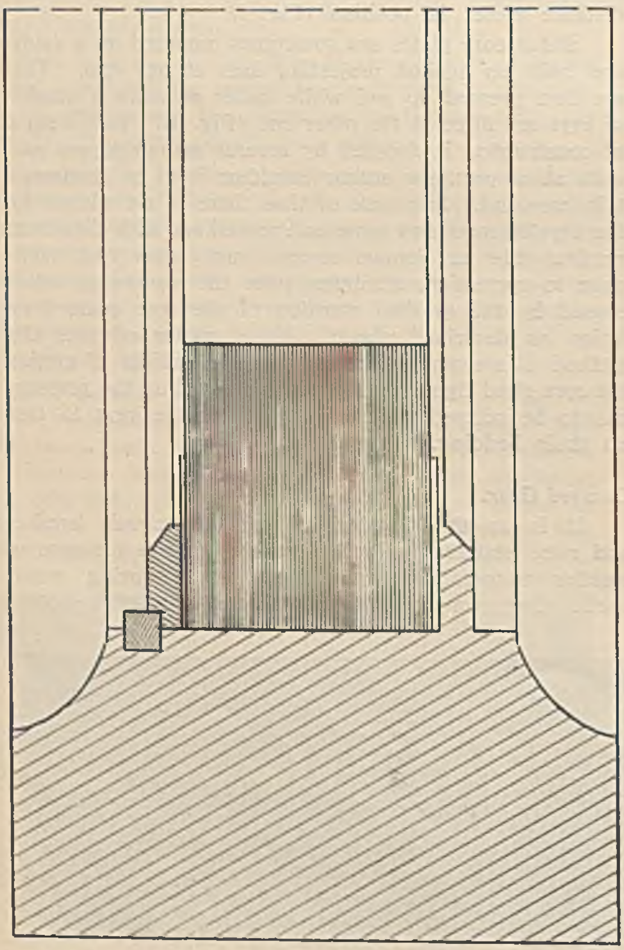


Fig. 4.—Half Section of Stator Core shewing method of Keying.

The author holds the opinion that the only correct material to use for starter resistances is carbon. Carbon has two properties which makes it an ideal material for this purpose: (1) it has a negative temperature coefficient, and (2) its resistance decreases when it is compressed. Many will remember the Ferranti compression type starter which was introduced some twenty-five years ago. In principle, it was perfect, but unfortunately it was not too well designed, was liable to breakdown, and could not as a rule be repaired without sending it to the makers. These defects, however, were not inherent to the principle of the starter: in recent years they have been overcome by other designers, particularly in America where the carbon resistance starter is gaining in popularity. It is also now being made by some firms in this country.

The principle of operation of the carbon resistance starter is ideal. Carbon having a comparatively high resistance when cold a small current is passed on closing the main switch. This heats up the carbon whose resistance decreases with rise of temperature and the current gradually rises until the motor starts up. Then, by means of a lever, operated by hand or by a solenoid, the carbon is gradually compressed and the current continues to grow until the final position of the lever brings a pair of contacts into operation to short-circuit the resistance and allow the carbon to cool ready for the next start.

The carbon resistance is in the form of a "pile" of thin discs made up of powdered carbon mixed with an agglomerate paste fired at a high temperature under pressure. These are assembled in a suitable tube. A motor started in this way can be worked up gradually from standing to full speed without the use of any contacts but the final short circuiting ones. The operation of such starters is, the author believes, now thoroughly satisfactory but he would be glad to hear of actual experiences with modern makes.

For starting large motors such as rolling mill or winding motors the modern liquid starter controlled by an electrically driven pump is really an excellent piece of apparatus. The ordinary cheap liquid starter for smaller motors is quite a good job. It looks primitive and messy but it gives very little trouble in situations to which it is suited, the maintenance is small and the only trouble likely to arise is a low insulation resistance due to moisture creeping over the porcelain insulators. It has a particular appeal to the maintenance engineer who has a mixed lot of motors and may need to change starters about in case of breakdown.

This paper is offered with apologies: it covers so much ground that it has been impossible to go very closely into any particular topic. The object has been not so much to impart knowledge, as mainly to invite criticism and induce members to recount for their mutual benefit their experiences and views on some of the many matters here raised.

Discussion.

Mr. HENRY JOSEPH replied to the several speakers who took part in an interesting discussion. In reply to Mr. Dixon, with reference to the N.O.P. process for boiler treatment, Mr. Joseph stated that the current was in the region of 2 to 3 amps.

As to the method which the author would use for locating a fault in an underground cable where there was a break in a conductor, he explained that, on electric supply mains for locating a break accompanied by an earth on armoured cable, he had used a fall of potential method as follows: His mode of operation was to pass a steady current down the cable through a radiator, then to take voltmeter readings at each service and plot the voltage drop against the distance: at all services beyond the fault the P.D. would be constant, so that the point of the curve where the sloping line crossed this horizontal line would give the position of the fault. This method however was not accurate. In the case of single-core V.B. cables he used the telephone method as described in the paper. If there was no earth he would make the cable alive and test with a lamp at each service: he would then dig up half way between the last live service and the first dead one and hope for the best.

Mr. Dixon had described to him a method of testing by capacity from either side of the fault: he, Mr. Joseph, had never tried it, but he believed that, in favourable cases, it was a possible effective method on feeders or other mains without tappings. As a matter of fact on V.B. cables Mr. Joseph said he used to " prick for juice " in such cases, instead of cutting.

Replying to the close criticism of Mr. Thompson, Mr. Joseph said that his main point in regard to auto-transformer starters was that, as the cost of a squirrel cage motor and auto-transformer starter was often as high as that of a slipring motor with a rotor starter, there was no advantage, from the point of view of capital saving, in installing a squirrel cage motor. The only remaining advantage was the admittedly greater robustness of a squirrel cage rotor machine: but, since the auto-transformer starter was unreliable, that would tend to cancel any advantage.

The undercutting of micas was also referred to by Mr. Thompson. He, Mr. Joseph, always advocated this where real mica segments were used but in the case of micanite it was not always necessary. It was however advisable in most cases, though recessing should never be too deep or finely powdered carbon would be trapped in the grooves and set up short circuits.

Mr. Maynard had referred to possible methods for ascertaining the correct mixture for liquid starters and had mentioned that he added increasing quantities of salt till he obtained the desired result and then took the specific gravity of the mixture for future guidance. Mr. Joseph conceded that this was a very valuable suggestion.

Referring to the advantages of getting the end rings of squirrel cage rotors as close to the core as possible, Mr. Joseph agreed that this was important and he had had actual cases where rotors had been improved by re-designing on those lines.

Mr. Kingsbury had referred to carbon resistance starters of the non-compression type with elements made of steel plates with carbon dust between. Mr. Joseph had himself used this type and agreed with the speaker that the design was not satisfactory.

Mr. Price considered that for frequent starting the carbon resistance type of starter would not be satisfactory: if used after a short interval for a second time when still hot its resistance would be low and it would pass too much current. Mr. Joseph admitted that for such kinds of service that type of starter would not be suitable, but for ordinary factory drives with infrequent starting carbon resistances had many advantages.

In reply to Mr. Wardle who raised the question as to how one would start a 100 h.p. squirrel cage motor driving a centrifugal pump, Mr. Joseph replied that as such a drive asked for a slow start under load he would not use a squirrel cage motor at all.

WEST OF SCOTLAND BRANCH.

Visit to Craigpark Cable Works.

Prior to holding the Dinner and Annual Reunion the members of the Association on December 6th last visited the cable works of The Craigpark Electric Cable Co. Ltd., through the kind invitation of Mr. Herbert, the General Manager. The members were received by Mr. Herbert and, under his guidance with the assistance of Mr. Law, Works Manager and other members of the Staff they were conducted through the various departments and were shown the manufacture of various cables in their different stages. Mr. Herbert had taken the trouble of having a large staff in hand with the machinery running in full operation and this made the visit all the more interesting. At the conclusion of the visit each member was presented with a memento of the occasion.

The various groups were taken round the departments in sequence of operation—from the beginning to the completed cable. The copper wire required for the electric conductors when used for rubber insulated cables must be tinned and a visit was first paid to the tinning shop, where the cleaning, fluxing and tinning of the wire was demonstrated, the result shewing that the care taken and the process adopted for tinning is well nigh perfect.

For rubber insulated cables, the close examination of the rubber to ensure that it is free from foreign materials and the compounding ingredients to be added to the rubber were shewn and explained. Thereafter the batches of rubber and compounds were seen being thoroughly incorporated in mixing rolls, and made up into slabs of rubber. These are then softened in heated rolls and passed through calenders into rolls of thin sheet, the thickness of such sheets being determined by the sizes of cable to be insulated. In the same way the pure rubber is rolled out into sheets for application next to the conductor.

The wire stranding shop was next visited, where high speed stranding machines, for small conductors from three to seven strands and larger machines providing stranded conductors for as many as 127 wires, were seen in operation.

The next process was the application of the pure and vulcanised rubber to the tinned copper conductors. The rubber sheets already mentioned are cut into the required widths by a high speed cutting machine, forming rolls which are then applied to twelve wires at a time through Longitudinal Covering Machines, first the pure rubber, then one coat vulcanising rubber and a second coat of vulcanising rubber; the three coats being applied in the one operation proved an interesting and effective process. Larger cables are covered with similar rubber but each of the coats is lapped on by revolving heads. Afterwards proofed tape is applied to the cables, and the cables are then ready to be vulcanised.

The vulcanising process consists of winding the various taped conductors on to large cylindrical drums which are placed in the vulcaniser and steam is applied for the necessary period. When fully vulcanised the taped conductors are wound on to drums or into coils and immersed for twenty-four hours in large tanks of water, a voltage test is applied and thereafter an insulation resistance test to ensure that the cable is sound in every respect.

Cables of this description are then finished either by lead covering or braiding. The braided cables are then compounded and coloured, principally red or black, and cut into the lengths necessary; for usual purposes in one hundred yard lengths, or in longer lengths that may be required.

The method of manufacture of paper insulated cables in all its phases was then demonstrated; first the plain copper conductor has the lappings of paper applied, then two or more such conductors are laid together, with jute filling, and further paper applied to comply with B.E.S.A. standards. At this point the cables are wound into large impregnating pans, first to have all moisture extracted under vacuum and then insulating oil filled into the pans under pressure to ensure thorough impregnation of the paper insulation.

The lead covering of paper insulated cables and other cables proved an interesting process. Large hydraulic cable presses are used; the lead is first melted and then filled into chambers on either side of the die box; hydraulic pumps force two rams into the lead containing chambers, causing the lead to be extruded in the form of a pipe; the cable to be covered has first of all been threaded through and the extrusion of the lead tube takes the lead covered cable out with it.

Lead covered cables, after twenty-four hours' immersion in water, are tested in the same way as rubber insulated cables, but in the case of paper insulated cables pressure tests are applied up to as high as 25,000 volts. A demonstration was given of the pressure testing of four large drums of E.H.T. cable at 10,000 volts test pressure, a most modern and efficient plant being installed for the purpose.

The next department inspected was the shop where large quantities of flexible wires of all descriptions were seen in the process of assembling. A number of machines were bunching various sizes of flexible conductors, which are then ready to be either cotton lapped or pure rubber lapped or covered with vulcanised rubber, in the same way as described for other conductors, then finished in braiding machines with glace cotton or silk in various colours. For ordinary lighting flex, two such such conductors are twisted together.

Another type of insulation, which is a speciality of the Craigpark Company is "Brumite" a material devised to withstand conditions deleterious to the usual type of rubber insulation, such as moist and dry heat, chemical fumes, acids, etc. "Brumite" insulation is applied by extrusion through a forcing machine, the material coming out in what might be termed the form of a tube and taking the copper conductor with it. A machine of this description was seen in operation.

The firm also make golf balls and the visitors had the interesting pleasure of seeing the whole process of golf ball manufacture, from the inner core to the machines winding the rubber on to form the ball, the gutta percha cups to form the outer covering and the moulding by hydraulic presses to form the complete ball, and the final completion by painting and filling in the name in colour.

Mr. ROGERSON, President of the Branch, expressed the cordial thanks of the visitors to the Company for their kind invitation, and asked Mr. Herbert to convey to his Directors their appreciation of the kindness: he also called for a very hearty vote of thanks to Mr. Herbert, Mr. Law and their able band of assistants for the way they had described the various points of interest. The sentiments were duly honoured and acknowledged.

Annual Dinner.

The Annual Dinner was afterwards held in the Grosvenor Restaurant, Glasgow. Mr. R. D. Rogerson, President of the Branch, occupied the chair. Among the many guests present were:—

Major Elliot, M.C., M.P.; Mr. J. W. Gibson, President of the Association of Mining Electrical Engineers; Mr. Mark Brand, President of the Mining Institute of Scotland; Mr. Chas. C. Reid, General Manager of the Fife Coal Co. Ltd.; Mr. George Herbert, General Manager of The Craigpark Electric Cable Co. Ltd.; Mr. W. H. Telfer, Managing Director of Coltness Iron Co. Ltd.; Mr. F. Beckett, Vice President of the Association; Mr. D J. Barr, General Manager of The Glasgow Iron & Steel Co. Ltd.; Mr. D. Archibald, President of the Colliery Managers Association (Scottish Branch); Mr. Wm. Law, Works Manager, The Craigpark Electric Cable Co. Ltd.; Prof. G. W. O. Howe, Glasgow University; Prof. J. Parker Smith, Royal Technical College, Glasgow; Mr. Albert V. Reis, Agent, The Fife Coal Co. Ltd.; Mr. Douglas A. MacCallum, Secy., Iron & Steel Institute, West of Scotland Branch; Mr. John George, Secy., Colliery Managers Association (Scottish Branch); Mr. J. Walker, Lothians Branch; and Mr. J. C. MacCallum, Secy. of Ayrshire Sub-Branch.

The following Past Presidents of the Association of Mining Electrical Engineers were also present: Messrs. A. B. Muirhead, Frank Anslow, H. A. McGuffie, and David Martin: also Past Branch Presidents: Messrs. D. Landale Frew, C. E. Hart, and G. N. Holmes.

In all about 160 members and friends attended the Dinner, which was voted one of the best yet held.

Major ELLIOT, who proposed the toast of "The Association," referred to the settlement of the coal stoppage in Scotland. They should all be glad to see the difficulties, which affected Scotland in particular, finally regulated as soon as possible. The troubles of the mining industry just now, and of the electrical machinery industry so far as it was connected with the mines, were not far to seek. Those of them who had been following the industrial development of past years had realised that the previous supremacy of this country was changing. It might be that that change was temporary, and that the factors which caused it might pass away. He believed it was not for ever that a bounteous providence would cause oil to run out of the ground in the United States. The oil supplies of the world were a relatively small percentage of the fuel resources of the world, and it was quite possible that the present phase of extreme cheapness in oil supplies was not likely to be a permanent one.

The electrical industry and its development, Major Elliot said, had been a source of encouragement in this country. Our work in the heavy electrical industry would stand comparison with that of any country in the world, and our export trade in heavy electrical goods had been, until recently at any rate, the premier export trade in the world.

Mr. J. W. GIBSON, President of the Association, in reply to the toast, pointed out that it was with a view to making mining a safer occupation that much of the attention of the Association was given to the design and use of electrical machinery.

Mr. Gibson referred to the coming-of-age of the Association: it had completed 21 years of service in the interests of mining electrical engineers and of the Mining Industry in general. It had achieved some success in the direction of establishing the status of the mining electrical engineer and the colliery electrician. Upon the membership roll of the Association there were experts connected with every section of mining—geological, mechanical and electrical engineering. In the records of the proceedings of the Association there was a fund of accumulated information and experience available for the benefit of members. This should be particularly valuable to the younger section undergoing their training and pursuing their studies. It was in the broader interests of all that information of this kind should be spread as far afield as possible, and the best way to do this was by increasing the membership, and taking full advantage of the opportunities afforded by membership of the Association.

It was possible in the early future, said Mr. Gibson, that the authorities might call for a definite scale of qualifications from those responsible for the safe and efficient working of mining electrical plant. That should be a further inducement and incentive for members and others to make full use of the facilities for study, with a view to taking examinations and securing the Association's Certificate. By so doing they would at least provide themselves with some form of indication as to their knowledge and qualifications, and a credential which might even serve to satisfy the immediate requirements of the authorities, pending the establishment of some definite standard of knowledge.

The Association was the essence of unselfishness, and those who had taken such a keen interest in its progress during the last 21 years had done so without any ulterior motive of personal gain. Their best reward would be the success of their efforts in assisting those who were willing to be helped to a higher standard of efficiency.

Mr. ARTHUR DIXON submitted the toast of "Our Guests."

Mr. CHARLES C. REID, in reply, referred to the ills of the mining industry. He thought improved health could best be attained by the industry's own exertions. He expressed gratitude that the stoppage, which had lasted but one week, had been brought to an end. They had achieved a temporary settlement, which was a fine augury for a more permanent settlement through the good sense of both sides to the dispute in the very near future. The serious troubles of the industry were plainly evident by glancing through the Stock Exchange reports and the shares lists showing coal company quotations. Their plight was not due to lack of professional advice. They had had the advice of specialists. Several professors and many other specialists had proferred assistance, but still they were no better. Doctors, too, had attempted to prescribe for them—Liberal doctors, Labour doctors, and Conservative doctors, and the curious thing about the whole business was that every one who had tried to find a cure had lost his reputation in the attempt.

There were many first-class minds in the industry to-day who believed that they were a contracting industry, and unless they could find some other use for coal that would seem to be the case. Any cure, therefor, which did not take this fundamental fact into account would leave it cold. The industry would be far better off if it could come to a state of health by its own exertions.

He greatly feared if they did not do it themselves the nation would call in a doctor—he might not be the best doctor—give him power to administer, and cause them to take medicine forcibly. He trusted that would not happen.

Presentation of Prizes.

Mr. ROGERSON, Branch President, presented a number of prizes awarded to members for Papers read during the last session.

Mr. W. Mitchell was awarded the Association First Prize, value £8 8s. 0d. for his paper: "The Operation and Maintenance of High Lift Mining Pumps." Mr. Mitchell had selected a Prismatic Binocular and a case of Drawing Instruments.

The Association Third Prize, value £3 3s. 0d., was also gained by a member, Mr. G. Denholm: in this case dividing the prize with a fellow member of the South Wales Branch. Mr. Denholm's paper was entitled: "The Routine of the Electrician-in-Charge," and he had selected as his award a copy of the standard text book "Electricity applied to Mining," by H. Cotton.

In addition, two prizes value £3 3s. 0d. and £2 2s. 0d. are awarded each session by the Branch. For the past session the following awards were made:—First Prize, value £3 3s. 0d., to Mr. James R. Laird for his paper entitled "Frequency Change Problems": Second prize, value £2 2s. 0d., to Mr. W. Mitchell for the paper which gained him the Association Prize as already mentioned.

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); and Mr. Dan Scott (Second Class).

Before the proceedings terminated, Mr. A. F. Stevenson proposed a vote of thanks to the artists who had so thoroughly entertained them. The artists were Messrs. James A. Gibson, R. W. Marshall, J. M. Hamilton, W. McClure, and Angus MacDonald.

KENT SUB-BRANCH.

Mine Shaft Sinking.

G. C. H. NASMYTH.

(*Meeting held* 1*st November* 1930).

A series of lantern slides were shewn dealing with the deposition of stratified rocks; their subsequent bending and folding; and the raising and lowering of the earth's crust, which is still in motion. Diagrammatic sections of coal basins, the Northern European and Kent Coalfield areas, were also illustrated, together with geological tables, and sections of local boreholes shewing the nature of the strata which had to be sunk through in Kent before reaching the coal measures.

The peculiarities of the numerous water-bearing beds and their incidence throughout the coalfield were next dealt with before passing on to the various methods adopted to sink through heavily watered soft overburden.

Drop Shafting and Piling.

The Chislet Colliery sinking was illustrated as an example of a very successful piece of work carried out by means of reinforced concrete drop shafts. These drop shafts were carried down to a depth of 130 ft., and although considerable trouble was experienced with beds of boulders, sand and water, which caused alternate sticking and sudden dropping, the shafts when completed were only 4¼ ins. out of plumb.

Piling and pneumatic caisson sinking were next dealt with, and illustrated by slides of the Bentley and Ardeer sinkings respectively.

Securing Ground.

Temporary lining and the permanent lining of shafts with brick or concrete was described and illustrated, special mention being made of the method of building plain and reinforced concrete walling in water-bearing strata, by the use of back sheeting and relief pipes, the flow of water being stopped off after the walling is completed by injecting cement grout into the voids between the back sheets and the shaft sides.

Details were given of a sinking where, by means of back sheeted concrete walling, a 600 g.p.m. feeder at a depth of 200 ft. was successfully sealed off behind a 100 ft. length of walling within 21 days from the date on which the feeder was first struck.

Illustrations were also given of various methods of reinforcing concrete walling. The speaker stated that concrete had, especially in big shafts through water-bearing ground, many advantages over brickwork, *inter alia*:

It was very rapidly built; no permanent walling curbs were needed; water garlands could be easily formed; less dressing of shaft sides in hard ground; the concrete keyed itself to the sides and became self-supporting; a smooth surface was presented to the air current; the density and strength of the concrete are easily controlled; it lends itself to reinforcement to carry high strata or water pressures.

Tubbing.

English and German types of tubbing were next illustrated, and the general use of each type described, together with the method of building, either by under-hanging and building downwards from a heavy anchor ring fixed in the shaft walls, or by building upwards from the shaft bottom.

Compound tubbing, as used on the Continent for pressures up to 900 lbs. per square inch, was also illustrated and described.

The speaker stated that tubbing had reached a high state of perfection on the Continent, as the nature of the strata there called for more extensive use of tubbing than was the case in Great Britain.

Sinking Pumps.

Various types of suspended sinking pumps were illustrated and their behaviour under sinking conditions discussed.

Dealing with electric vertical centrifugals, which the speaker had used under very bad conditions when passing through sand beds, he stated that the life of the impellers had varied from 5 days to 10 days; that Michell thrusts embodied in the pumps had frequently burnt out; that four balance discs had been cut to pieces in 10 days; and that the humidity of the shafts was such that the motor of the spare pump had to be kept running light constantly, in order to keep it dry.

The motors, which were 400h.p. squirrel cage, 3300 volt, 50 cycles, were housed in a drip-proof casing, but totally enclosed water jacketed motors were preferable for such severe conditions.

The value of a free sliding suction pipe on suspended sinking pumps was accentuated, as it not only enabled the snore pipe to follow the water as the ground beneath it was excavated, but, what was of more importance, should a mistake be made when lowering the pump, the suction pipe would telescope freely and so prevent the weight of the pump and rising main being taken by the suction pipe on the pit bottom; should that happen, and slack rope be given out there is obviously a great risk that the suspended rising main would buckle and fall into the shaft bottom.

Freezing.

A short description was given of the freezing process, by means of which an ice wall is formed round the circumference of a shaft prior to sinking. This method can be guaranteed to give satisfactory results under most severe conditions, and although very costly has the advantages that an excellent job can be made of the walling; that there will be no pumping charges; and that the job will be completed within a budgeted period.

Excavation of Ground.

The ground is broken by hand or explosives, dependent on its nature, and the broken rock filled by shovel into hoppits to be wound out of the shaft bottom. Whilst there have been great improvements in nearly all branches of work connected with sinking, there has been little change in the method of clearing the broken ground in the pit bottom. A man with a shovel is a very flexible tool, and able to adapt himself to the rapidly changing conditions of a shaft bottom better than any machine. Shaft sinking on the Rand is carried out at great speed largely due to the crowding of the pit bottom with natives, who "muck out" a round of shots far more rapidly than can be done in this Country with a smaller labour force in the pit bottom.

Pit Bottom Lighting.

For wet pits the present system of lighting by means of electric clusters and portable sinking lamps is not very satisfactory. The speaker thought that flood lighting would be a great improvement, and suggested that the members of the Association should look closely into this matter.

The flood lights, which could be fixed on the sinking scaffold, would have to work under extremely bad conditions. They must stand up to hard usage, be capable of being moved very quickly and easily in order to take them out of the pit when shots were being fired, and be self-contained so that they could be raised 20 ft. to 40 ft. above the scaffold when walling was in progress.

The final slides illustrated Corboniferous Flora, including ferns found in the Kent Coalfield. The speaker pointed out that each geological period had its own characteristic fossils and plant remains, from which could be recognised the period of deposition, and the relative position in the coal measures correlated.

Discussion.

Mr. HOWARD asked, with regard to the freezing method of sinking, what was the effect on the men going from the atmospheric temperature, in summer time, to the freezing temperature in the shaft.

Referring to Mr. Nasmyth's expressed preference for low lift sinking pumps and the more frequent use of lodge-rooms, Mr. Howard remarked that in most cases he supposed the minimum lift would be controlled by the length of rock that was difficult to sink through, and, therefore difficult for the forming of lodge-rooms.

Mr. COOPER asked the following questions:—

Referring to the freezing process of sinking, if there was a breakdown in the freezing apparatus after the shaft had been frozen, how long would the plant stand with safety?

Did Mr. Nasmyth think that the pumping ought to be done by large high efficiency units, or would smaller and more reliable units with lower efficiency be preferred?

Would it be more economical in the long run to instal permanent pumping equipment in the shaft insets as the pit was being sunk, instead of pumping all the shaft water to the surface with the sinking pumps?

Could not a grab be used more efficiently in sinking work instead of the usual shovels and picks?

Mr. RUSSELL asked whether it was really necessary to thaw out the ground after the freezing process: could not the ground be allowed to thaw out naturally?

Mr. WOOD, referring to Mr. Nasmyth's remarks, about flood lighting the shaft bottom during sinking, gave details of a high pressure compressed air electric lamp, which he thought would meet the case.

Mr. BARNEY said he understood there was a process used at the Betteshanger colliery sinking, which he thought was cementation and which had not been mentioned. He would like Mr. Nasmyth to give some information with regard to this process. Also, what was Mr. Nasmyth's own idea of its usefulness, and to what depth could it be worked? Further, was the cementation process cheaper than freezing?

With regard to the electrical and mechanical end of sinking, Mr. Barney said it was a trying job and he could thoroughly agree with everything Mr. Nasmyth had said, although he thought that Mr. Nasmyth had been rather severe on the electrical equipment, as he (Mr. Barney) considered that the Michell thrust was responsible for about 75% of the trouble at Betteshanger sinking. Mr. Barney also considered that another cause of trouble appeared to be that the makers of some of the sinking pumps were not sufficiently experienced in this class of work.

So far as purely electrical failures at Betteshanger were concerned, he could not remember anything very serious. One motor, 800 h.p., 3300 volts, failed owing to the stator winding sparking between the ends of the turns and the rotor. The air gap was very small, and the protection on the stator was core-balance leakage. This was so sensitive that they could not start the motor. The hole in the insulation was so minute it could hardly be traced. He thought this was a good point in favour of leakage protection. (Mr. Barney explained the trouble with the motor in detail by means of a diagram).

He added that a motor in the pit during sinking was constantly getting damp, and when it had to stand for an hour or two the insulation would go right down. One had to take risks, and he had switched on a 3300 volt motor shewing only 200,000 ohms. In order to obviate this matter of motors standing in the pit, he thought it would be useful to have some kind of quick disconnecting coupling, so as to disconnect the pump and keep the motor running. It would then be possible to have a dry motor immediately it was required to start up the pump again.

With regard to the Snowdown sinking being absolutely free from water, whereas Tilmanstone, which was quite close to Snowdown, had so much water, did Mr. Nasmyth think it at all possible that Tilmanstone was taking the water from Snowdown?

Mr. NASMYTH (in reply).—To freeze average strata temperatures down to minus 25 deg. C. were necessary, but should there be brine solutions in the strata, as sometimes found in Germany, freezing temperatures as low as minus 50 deg. C. have been found necessary.

The working conditions in a frozen shaft bottom were not severe. The sinkers worked in heavy flannels, and the chargemen needed gloves.

The length of frozen strata excavated (which was sometimes left without any temporary supports) prior to fixing the tubbing, was controlled by the nature of the strata and the depth of the shaft. Frozen ground is plastic and distorts under pressure.

If the freezing plant broke down after the ice wall was built up and sinking had begun; the ice wall would stand for some time, but sinking would have to cease and all exposed work be walled up.

As to the consideration of efficiency of sinking pumps *versus* reliability: freedom from breakdown is of more value on a sinking job than high pump efficiency. Reliability should come first and efficiency second for sinking plant.

Dealing with small quantites of water in the pit bottom. Water barrels were often used for this work, but a small pump is preferable, as the most important factor in pit sinking is to keep the bottom dry.

At great depths "mucking-out" by means of grabs is impracticable, but there is room for improvement in the method of filling rock into the hoppits; small grabs worked from the sinking scaffold might be developed for this work. The speaker had looked carefully into this matter, but so far had been unable to evolve a practicable scheme.

Replying to the question concerning the thawing out of a frozen shaft: the shaft can be allowed to thaw out gradually, which is a slow job; it can be filled with water; or warmed by means of hot air. The latest practice is to circulate warm water through the freezing pipes and thaw the shaft from the bottom upwards, which permits the caulking and making-good of the tubbing from the bottom, which is where it is subject to the greatest pressure.

The compressed-air electric portable lamp was thought to be an improvement on electric clusters for lighting a wet pit bottom, but would probably suffer severely from the bad conditions.

At Mr. Barney's request, Mr. Nasmyth gave a short description of the Kind-Chaudron method of sinking, and because this was of interest to members as having been successfully used many years ago at the Shakespeare Colliery, Dover. The method is, however, now obsolete having been superseded by freezing and cementation.

The principle of cementation is to fill the water bearing passages in the rocks with liquid cement, which subsequently sets and so stops the flow of water. The cement is introduced into the strata by means of boreholes, which could be bored either from the surface, or in a series of lifts below water level. Both methods have been practiced with great success. The aboveground method has been used extensively in France to recover the shafts which were wrecked during the war.

There is no restriction as to the depth at which the cementation process can be carried out. Cementation is cheaper than freezing, which requires so much special plant, but cementation is of no use in soft ground.

Mr. Nasmyth agreed that for the freedom of running sinking pump motors light during sinking operations, some form of clutch would be quicker and better than the present method of withdrawing the coupling bolts between the motor and pump.

WEST OF SCOTLAND BRANCH.

Rotary Converters.

(P) ROBERT WILSON.

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

The main object in dealing with this subject is to give to the younger members of this Association, to whom in course of time may fall the duty of installing a rotary converter, or remove such a machine from one colliery to another, a few points noted regarding the starting and running of rotaries; in the conversion of alternating current to direct current or *vice versa*; also where converting equipments had been successfully installed as extensions to existing plant.

The cases to be considered may be classified as follows:—

(1) Where a d.c. generating plant exists and has, through the introduction of additional modern mining machinery, become overloaded.

(2) A colliery company scrapping its d.c. plant in favour of a three-phase system where, instead of running a large alternator during week-end with light loads, the rotary was run d.c./a.c. from the old d.c. steam plant.

(3) An entirely d.c. plant. While rewinding Armatures, it became known that a drop test was not infallible. The transformer test shewing up immediately any short circuits, especially where small gauge wires were used.

(4) A fourth case might be worthy of consideration: for instance if a large d.c. plant where the voltage drop, on long lines of cables of heavy area, had become a determining factor, and the balance in cost between further d.c. generating plant and cables and high tension a.c. was in favour of the latter, the installation of a rotary underground controlled by one of the various automatic methods could be favourably put forward as a means of using up the d.c. plant.

Methods of Converting a.c. to d.c.

The generation and transmission of electrical energy in a.c. form, and its frequent utilisation in the d.c. form has called into being, a number of different types of machines, the object being in each case, to convert energy from one form into the other. The process of converting d.c. to a.c. is possible with some, though not all, of the methods employed. The most obvious method is that of the motor generator, in which an a.c. motor drives a d.c. generator, or the reverse process, but it suffers from the fact that since there are two rotating machines, each must be rated for a full output to be converted. The two machines could be constructed as one, using two windings on the armature, revolving in a common field system, but the resulting machine is not able to compete on a cost basis with others on the market, making allowance for complications that are bound to exist.

The greatest rival to the motor generator is the rotary converter, a machine having a single rotating armature, wound with a single winding. In this machine, the alternating and direct currents both flow and are superimposed on one another so that the resultant current, at any instant, is the algebraic sum of the two components, the resultant current giving rise to a greatly reduced heating effect. It is perhaps not altogether fair to the rivals of the rotary converter to call it a single machine, since it needs to have a number of auxiliaries, such as transformers, regulators, starting motor, and the exciter if the machine is to be run inverted.

The latest entrant into the field, as a competing converter, is the mercury arc rectifier, a static piece of apparatus. The author was informed, when about to compile these remarks, that the day of the rotary is past, but he does not observe any of the large municipal authorities, who are at the present time busily engaged with the frequency change installing rectifiers in place of 25 cycle rotaries to any great extent.

GENERAL PRINCIPLES OF THE ROTARY CONVERTER.

If an ordinary direct current generator be driven by external means, it will generate a steady pressure and d.c. will be collected from its commutator. If tappings be taken from suitable points on its armature winding and connected to sliprings, an alternating current could also be drawn from the machine. In one case it is acting as a normal d.c. generator and in the other as an alternator; and, seeing a d.c. generator is capable of acting as a motor and an alternator as a synchronous motor, if the machine be supplied with electrical instead of mechanical energy, such a machine can be made to generate d.c. and a.c. simultaneously. Again, the machine may be made to motor from both ends simultaneously, or one end perhaps can be supplied with electrical energy so as to make it motor, the other end acting as a generator. In this case no external driving agency is required and the machine becomes a self-contained unit. Using the machine in this manner it becomes a rotary converter whose normal operation is to receive alternating current through the sliprings and convert to direct current delivered from the commutator. The machine may be used *vice versa*, or for inverted operation, that is, to receive d.c. and deliver a.c.

General Construction.

The rotary converter is generally similar in its design to that of the d.c. generator, with the addition of sliprings mounted on the shaft at the opposite end to that of the commutator.

A machine adapted for use in workshop testing, is of 100 k.w. capacity and at one time, driven by a horizontal engine, kept a colliery, producing 300 tons per day, going. With a few alterations, it has been modified to serve its present purpose well, either for d.c. or a.c. load tests. The large pulley was taken off, the shaft cut and bored, and a new pulley and sliprings fitted.

Regarding comparative outputs of rotaries and d.c. generators, for the same size of frame, a little greater output is yielded by the rotary; however one cannot in this respect very fairly compare the rotary with the slow speed d.c. generator, the former being a comparatively high speed machine.

Voltage Ratios.

The d.c. brushes are placed so as to obtain the maximum voltage generated in the armature, i.e., when two tappings, from the armature to the sliprings coincide with the positive and negative brushes. The maximum a.c. volts generated occurs between these two tappings and is equal to the d.c. voltage.

As the armature rotates the a.c. voltage between the two tappings decreases reverses, and reaches a maximum in the opposite direction, by the time the tappings have rotated through one pole pitch. The voltage then decreases, reverses to its original direction and again becomes a maximum when the tappings have rotated through another pole pitch. In the ideal case, the voltage generated follows a sine curve, with the maximum value equal to the d.c. volts so that the virtual value of the a.c. volts equals the d.c. volts divided by $\sqrt{2}$ or is 0.707 of d.c. volts for a single phase converter.

The rotary is said to be a rather inflexible machine seeing that the voltages on either side are practically fixed in ratio; and, since in practice it is very seldom that the a.c. supply pressure is of a suitable value for applying direct to the rotary sliprings, it nearly always becomes necessary to install a transformer between the supply mains and the sliprings. If the ratio of the supply pressure to that of the required slipring pressure does not exceed a 2 to 1 ratio, then an Auto transformer can be used.

The R.M.S. volts which exists between the tappings, i.e., adjacent sliprings, are given thus and expressed as fractions of the d.c. voltage:—

Single-phase	0.707	Two-phase	0.5
Three-phase	0.612	Six-phase	0.353

or, for a six-phase rotary, the a.c. pressure required at the sliprings is approximately 71% for the d.c. voltage, thus:—

360 a.c. = 500 d.c.
420 a.c. = 600 d.c.
220 ac. = 350 d.c.

The rotary thus possesses an advantage over other types of converting machinery, as the highest pressure on the running machine is the d.c. voltage, which comes under its own regulations as a medium pressure.

Effect of Number of Phases on Armature Heating.

The neutralising effect of the d.c. and a.c. current upon each other is most complete at points midway between the sliprings tappings and it follows that the more remote the conductor is from this point the greater will be the heating experienced. In the single phase machine certain conductors are situated 90° electrically, or half a pole pitch, away from this point; whereas, in a three-phase machine, the poorest is only 60° distant. Therefore, on the whole the heating in the case of a three-phase system is much less than on the single-phase one for the same output, whilst by increasing the number of phases to six, the conditions can be improved to within approximately 26% of the value compared with an ordinary d.c. generator. It is therefore common practice for all modern three-phase supply machines to be equipped with six sliprings instead of three. A larger phase arrangement might be considered a possibility; but in those cases there would be transformer complications to overcome.

Tappings on the Armature.

The armature winding of a rotary converter may be either series or parallel, just as in an ordinary d.c. generator. Sizes up to 100 k.w., are usually series on account of their having the advantage that the size of the armature conductors are not made unnecessarily small. On the other hand, according to rules which govern series windings, it is not always possible to connect the sliprings at the desired point.

Parallel Windings.

For a parallel winding, as many brushes should be provided as there are poles in the machine, there being as many parallel circuits as there are poles. In practice, it is found extremely difficult to obtain absolute equality of E.M.F. in all the circuits, due to various causes. In a parallel winding it will be seen that conductors of equal potential may be found exactly double a pole pitch apart, or in other words are occupying equal positions in respect of the poles and also to the circuits to which they belong throughout each complete revolution and therefore may be joined together.

In this manner, the conductors of a parallel winding may be connected to equalising rings so that all circuits at any period of each revolution are provided with low resistance connections. The out-of-balance currents no longer passing through the brushes, but circulating in these equalising rings.

There is no set rule as to the number of equalising rings to be used but they are usually connected up at every 4th, 5th or 7th evolute, depending on the capacity and size of the machine.

The Pitch between the tappings to any one ring

$$= \frac{\text{Total number of Armature Coils}}{\text{Pairs of Poles}}$$

The Pitch between individual equalising rings

$$= \frac{\text{Armature Coils}}{\text{Pairs of Poles} \times \text{number of rings}}$$

Example.

500 k.w. d.c. turbo generator, 6 pole, parallel windings, slots 96, segments 288, equalising rings 16.

$$\text{Pitch between tappings to any ring} = \frac{288}{3} = 96 \text{ evolutes}$$

$$\text{Pitch between the rings} = \frac{288}{3 \times 16} = 6 \text{ evolutes}$$

A Table can now be drafted to shew the positions of the Equalising Rings:

Ring	*Evolutes*
1	1 — 97 — 193
2	7 — 103 — 199
3	13 — 109 — 205

and so on, shewing 96 evolutes between the tappings and six evolutes between each equalising ring. Finally:—

Ring	*Evolutes*
16	25 — 121 — 217

Sliprings connections to Parallel Windings (Fig. 1).

It now follows, as in the case with equalising rings, that each slipring will be connected to "P" equidistant points. Therefore, we have two pitches to determine when connecting up sliprings to a parallel winding. Thus

Pitch between the tappings to any one slipring and
Pitch between the sliprings = As previously stated.
Pitch between tappings to any slipring

$$= \frac{\text{Total number of Armature Coils}}{\text{Pairs of Poles}}$$

This being the same as in the case of tappings to any one equalising ring, it follows that a slipring may be used as an equalising ring or an equalising ring connected to a slipring as desired.

If the machine be of small capacity, it is quite possible to connect the slipring to the equalising ring, but in the case of large machines, the equidistant points are connected direct to the slipring.

Pitch between the sliprings

$$= \frac{\text{Total number of Armature Coils}}{\text{Pairs of Poles} \times \text{Sliprings}}$$

To save complications, it is usual practice to design the armature winding so that the conductors are a multiple of—Pairs of Poles × Number of Sliprings.

Take the previous case for an example for three phases, and we find that:

$$\text{Pitch between tappings to any Slipring} = \frac{288}{3} = 96$$

$$\text{Pitch between Sliprings} = \frac{288}{3 \times 3} = 32$$

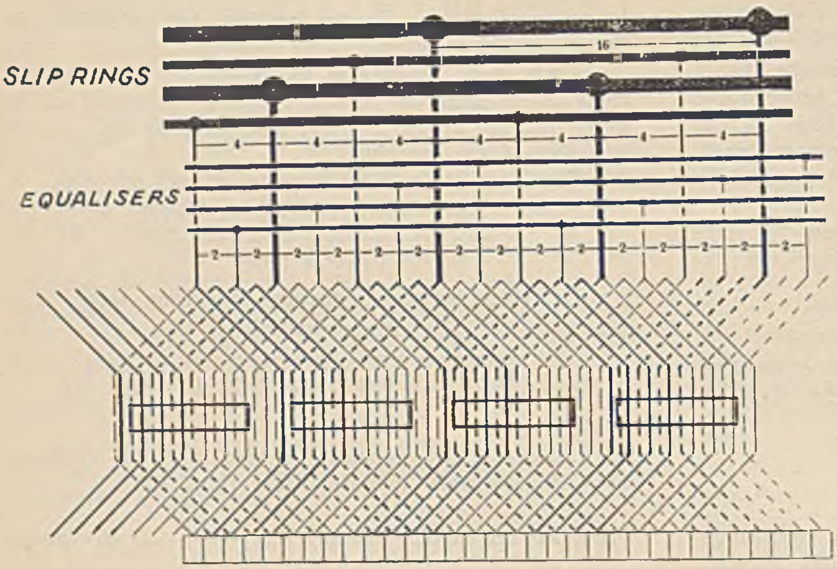


Fig. 1.—Parallel Winding for Four Poles: Two-phase.

We can now construct a Table shewing tappings connected to the equalising rings which are not connected to sliprings; and tappings which are connected to sliprings which would also be equalising rings. The example is not strictly symmetrical, but here is a correct winding:

36 slots, 36 segments, six poles, parallel, for six phases.

$$\text{Pitch between sliprings} = \frac{36}{3 \times 6} = 2 \text{ evolutes}$$

$$\text{Pitch between tappings to any one ring} = \frac{36}{3} = 12 \text{ evolutes}$$

and the sliprings would be connected thus:

Slipring	*Evolutes*
1	1 — 13 — 25
2	3 — 15 — 27
3	5 — 17 — 29
4	7 — 19 — 31
5	9 — 21 — 33
6	11 — 23 — 35

Slipring Connections to Series Winding (Fig. 2).

For a series winding only two brush spindles are required on the commutator, irrespective of the number of poles, although there can be as many sets of brushes as there are poles; the object being for the purpose of commutation. There are only two parallel circuits in the armature, no matter how many poles, so that a single tapping is all that is necessary for each slipring.

These tappings are spaced thus for:

One-phase—1 complete Pole Pitch

Two-phase—Half a Pole Pitch

Three-phase—120°

Six-phase—One-third, or 60° of a Pole Pitch.

As previously noted, with this winding it becomes necessary to resort to a varying pitch. To ascertain the points to which the sliprings will be connected in a series winding it is a much more difficult matter than when dealing with a parallel one. The essential difference between the two types of windings is that with a parallel winding each slipring is connected to "P" equidistant points and the sliprings are spaced over:

$$= \frac{\text{Total number of Armature Coils}}{\text{Pairs of Poles}}$$

while, with a series winding each slipring connects to one point only, the rings being spaced equidistantly over the whole number of armature coils, or approximately so, i.e., the pitch between any two sliprings represents the number of armature coils in series with each other.

In a parallel winding it is quite simple to trace out the pitch of a given number of units, since each unit is connected to adjacent commutator segments (i.e. Commutator Pitch = + or — 1); and to find the pitch of say 96 units, as in the previous case, this can be done by counting round 96 commutator segments or evolutes.

With a series winding, the pitch cannot be determined in this manner as the armature coils are connected to commutator segments approximately a double pole pitch apart. One method would be to construct a Table which would be suitable for a small armature. Try out an example of 83 slots, 332 segments, 6 pole, series. The method is tedious, irrespective of time and paper, therefore the most satisfactory method is described thus:

$$\text{Commutator Pitch} = \frac{332 \text{ plus } 1}{3 \text{ Pairs of Poles}} = \frac{333}{3} = 111$$

$$\text{Slipring Pitch} = \frac{\text{Total number of Armature Coils}}{\text{Pairs of Poles}}$$

$$= \frac{332}{3} = 110\tfrac{2}{3}$$

Now, multiply Commutator Pitch by Slipring Pitch:

$$110 \times 111 = 12{,}210$$

Next, divide result by total number of conductors:

$$\frac{12210}{332} = 36\frac{258}{332}$$

= 36 times and 258 over.

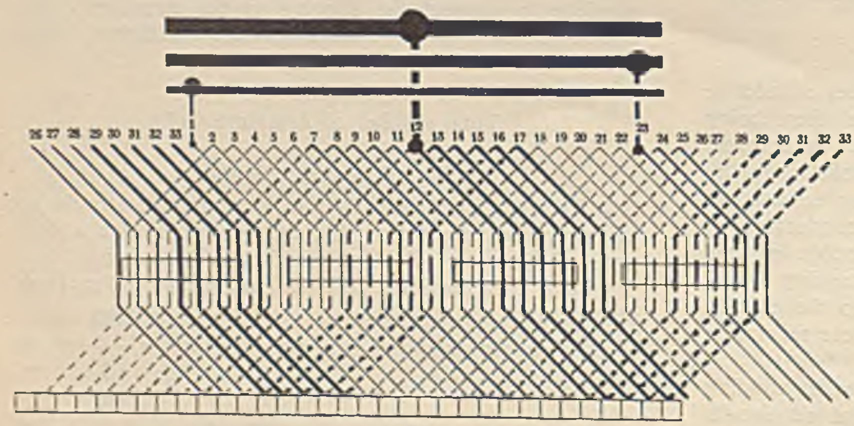


Fig. 2.—Series Winding for Four Poles: Three-phase.

The pitch of 110 units in series is 258 evolutes, or we could connect the sliprings to evolutes, 1 — 185 — 259. The two-thirds has been left out as the possibility of connecting the sliprings exactly giving a fractioned pitch depends on the type of conductors used. The example is wound with heavy copper bar so we could not enter into the slot and make a two-thirds tapping: the nearest value would be a $\frac{1}{2}$, but one half bar would be at the commutator end and this would involve the difficulty of getting the connection passed through the core to the opposite end to that of the commutator. The small phase displacement of a half bar out is almost negligible, although it is not impossible to connect the tapping at the commutator, as, in some makes of machines, the equalising rings are connected to and placed immediately behind the commutator. Those who have experienced trouble behind the commutator, due to dust, etc., will understand the magnitude of such a repair, i.e., unsweating and drawing off the commutator to get at the work.

Here is an even example :

219 Armature Coils. 4 poles series Bar Winding

$$\text{Pitch between sliprings} = \frac{219}{3} = 73$$

$$\text{Commutator Pitch} = \frac{219 \text{ plus } 1}{2} = \frac{220}{2} = 110 \text{ (Progressive)}$$

$$\frac{219 - 1}{2} = \frac{218}{2} = 109 \text{ (Retrogressive)}$$

110 Progressive 109 (Retrogressive)

$$109 \times 73 = 7957$$

$$\frac{7957}{219} = 36 \text{ and } 73 \text{ over}$$

or 73 is the Pitch of 73 units retrogressive or 74 is the Pitch of 73 units, progressive, evolutes

1 — 74 — 147 Progressive
or 1 — 75 — 148 Retrogressive } are the tappings.

Examination of a series winding will shew that in a three-phase converter, the conductor of the various phases overlap each other, with the result that any portion of the winding carries conductors belonging to two phases. At one part, the conductors will belong alternately to phase one and two, then two and three, then three and one, the repetition occurring once per pair of poles. As a consequence of this, the conductors of one phase are distributed over two-thirds of the entire periphery.

To test a series wound armature for hot coils, use this formula, and mark out the segments on the commutator; solder stout copper wires on, say No. 13 d.c.c.; wrap the core with a piece of thin planished lagging steel; apply an alternating current. This method takes a large current, unless it is conveniently possible to control the alternator field.

Another method—known in winding shops as a "grouler"—consists of a pole piece, with a pole face encircling at least half of armature, and wound with a coil to take approximately 10 amps. at lighting voltage. Any hot coils will act as a closed secondary circuit and smoke immediately.

Losses.

The losses occurring in a rotary converter are made up as follows :—

(1) Iron loss in armature core and teeth.
(2) Armature copper losses.
(3) Commutator I^2R loss.
(4) Commutator friction loss.
(5) Friction and I^2R loss at sliprings.
(6) Excitation loss.
(7) Bearing friction and windage loss.

Efficiency.

Due to the cancellation of the a.c. and d.c. armature currents and reactions and by also using the same field magnet for both sides of the machine, the rotary with its transformer has a very high efficiency. Taking the standard d.c. colliery voltage of 500 v., a 500 k.w. rotary converter at full load strikes nearly 94% efficiency. It should be mentioned here, that it is possible, by using special windings, to build a two machine converter, having an efficiency equal to that of a rotary. This rival is the motor converter.

Overload Capacity.

With a direct current generator of given field strength the armature reaction is limited by the field distortion caused therein, but with a polyphase rotary this limitation does not exist and a much greater armature reaction is permissible.

Since the heating is relatively low and the distortion of the field, which causes sparking with overload in d.c. machine, is practically negligible in the rotary converter, the practical limit of overload will be much higher for the given machine than when used solely for a d.c. generator. With the rotary the theoretical limit of overload, i.e., the overload at which the converter as a synchronous motor is pulling out of step and comes to rest, for normal frequency and impressed voltage is usually much in excess of the limit set by commutation and thermal considerations. The rotary will take 25% more overload as compared with a d.c. generator, and by the installation of rotary equipments the number of other generating stand-by sets may often be reduced. Quite recently the author had a case where three high speed steam generating sets, of total capacity 450 k.w., were required during the night-shift to run in parallel on a load of 21 coalcutters. As an extension, a 300 k.w. self-synchronising rotary was installed. With the whole load on, the rotary could be seen running without a spark from the commutator.

Questions often asked are: will a rotary converter flash over? Why does the machine flash over, even after the d.c. circuit breaker has tripped out? Suppose a heavy load is suddenly thrown on to an ordinary d.c. generator, the circuit breaker blows and the machine is instantly relieved of its load because the change in ampere turns, due to the opened circuit is simultaneously felt in the armature reaction and inter-pole fields, and the no-load distribution is established.

The case is different with rotary converters for, in the case of a sudden overload, then on the opening of the circuit breaker, the d.c. reaction field alone appears. A heavy current is still being drawn from the a.c. mains, so that the full armature reaction, due to the alternating current, will be imposed on the main field, as there is no longer a d.c. reaction to compensate it. The main field will then be distorted in proportion to the a.c. reaction and these conditions maintain until the back e.m.f. is readjusted. In the case of rotaries having inter-poles the conditions are worse because a rotary inter-pole coil only carries a sufficient number of turns to provide the necessary commutating field to compensate for the difference between the a.c. and d.c. reactions. If the d.c. reaction is wiped out, obviously the remaining a.c. reaction will overcome the inter-pole field and the inter-pole itself provides an iron circuit for the lines created by the armature reaction to close round.

To obviate partly, and to save damage due to the flash-over, all brushes with pigtails, tension springs, and holders are enclosed by spring type flash boards; there is also the provision of a high speed circuit breaker on the d.c. side. Taking the ordinary circuit breaker for open type boards on medium pressures, the short circuit value of the current may reach thirty times the full load value of the machine before it opens in a time anything up to 0.12 seconds, but with a modern high speed d.c. breaker, it is possible by opening very quickly say in a time of from 0.01 to 0.06 seconds, to limit the short circuit value to within 5 to 10 times that of the full load.

Parallel Running.

Should such an occasion arise as that previously noted, i.e., replacing old steam generating plant by a rotary and there is no data of the existing plant, it may be found on paralleling the d.c. sides that the rotary almost completely takes all the load, due to its main circuit having a very low Ohmic resistance. The author had occasion to run two rotaries along with three high speed steam sets, all of different capacities, in parallel. To gain successful equalisation of load according to the various circumstances, one of the best methods is to reduce the resistance of the series field of the existing generators, by fitting a diverter across the series terminals. Eureka strip 2 ins. × 24 S.W.G. makes an excellent diverter. Any number of strips can be used in parallel.

Example.

High Speed Set Drop across series field = 1.8 volts at 100 amp. = .018 ohm resistance.

Rotary Converter Drop across series field = 0.65 volt at 100 amps. = .0065 ohm resistance.

verified with resistance box.

To find what resistance is required in parallel with high speed generator to bring it to equal the rotary: or, to bring .018 ohm to equal .0065 ohm.

Thus—

$$\frac{1}{R} + \frac{1}{.018} = \frac{1}{.0065}$$

$$\frac{1}{R} = \frac{1}{.0065} - \frac{1}{.018}$$

$$= 153.5 - 55.5$$

$$= 98.3$$

$$R = \frac{1}{98.3} = .01 \text{ ohm required.}$$

Just before paralleling a rotary converter, a method of proving that the series field is connected up in right direction is: (1) Note the power factor on the indicator with correct d.c. voltage. (2) Lower the resistance of the shunt field regulator and this will cause the power factor to drop (i.e., lagging). (3) Close the negative and equaliser switches. A current will now flow round the series field from the busbars and if the series field be in correct direction, the power factor should shew a rise for a few degrees.

COLLIERY LIGHTING.

For this service the rotary can be used as a three-wire machine. Those who still have surface lighting on the 500 volt system, using either 2 or 5 lamps in series, might consider the question of reducing the potential at the lamp-holders. As already noted in the section "Voltage Ratios," the secondary winding of the transformer is for the particular instant connected across the positive and negative brushes. At that moment the centre of the transformer winding is at a potential half way between the positive and negative brushes. As the armature revolves the voltage across the secondary winding decreases and reverses, but the centre point still remains at half potential. It would be well worth considering when ordering a rotary equipment with transformer, to ask the makers to bring out the half-potential point in the transformer. If connected to the d.c. neutral the rotary will maintain constant potential. The difference in pressure of the two sides of the three-wire circuit not exceeding 1½% of the pressure across the outers is possible for a middle wire current of 25% of full load. Taking a case where the power required for a 500-ton colliery is 300 k.w., and the lighting load is in the neighbourhood of 15 k.w., the fluctuation in pressure between the outers would be negligible.

The armature heating of a rotary does not materially increase when used as a three-wire machine to supply out of balance current. If the rotary be run for a three-wire service, it is well to ensure that half of the interpoles are connected on either side, as better results are obtained by so doing. If the rotary be a compound wound machine it is not general practice to split up the series field, because if the machine were run in parallel with other generating plant, equalisers would be required on both the positive and negative sides, and mistakes due to incorrect switching are apt to occur as a result.

POWER FACTOR OF ROTARY CONVERTERS.

If the a.c. supply pressure be practically constant with a certain adjustment of the shunt field regulator the power factor is unity. The shunt field current required to give this power factor is of the same value that would be required to give the same voltage on the d.c. side were the machine driven as an ordinary d.c. generator. When the rotary is switched on to the a.c. mains, it must generate a counter e.m.f. equal and opposite to the e.m.f. of the mains, and in order to do this the total flux cut by the armature revolving must remain constant. If the resistance of the regulator be increased the total flux cut by the armature is reduced, and to restore the balance a lagging current is drawn by the sliprings (i.e. the power factor decreases). If the shunt field current were reduced to zero by gradually increasing the regulator resistance, the whole magnetisation of the field would be produced by these lagging currents. The opposite would happen if the regulator resistance were decreased and a leading power factor would appear at the sliprings. It might seem on first thought that this is exactly the same operation as that of a d.c. generator, but that is not so.

What is really happening is that the angle between the current and supply pressure is being varied, which causes a raising or lowering of the pressure at the sliprings.

The method of increasing shunt current to compensate for low power factor should not be used. With correct a.c. mains pressure and unity power factor, but with a low d.c. voltage, it is better to alter the high tension tappings on the transformer.

If an ordinary reactance controlled rotary running at correct power factor and load at a colliery near a generating station, where the a.c. mains pressure had little drop, were to be taken out and transferred to another colliery at the termination of a long loaded line, it might be found on running the machine on load that its power factor had decreased considerably. On opening up the transformer and finding no tappings on the H.T. side, the only method to get an increase in power factor would be to install a boosting transformer on the H.T. side. Increasing the field current would only increase the heating effect.

Rotaries can be designed to run at a leading power factor up to 0.95 and the installation of such an equipment can be used to correct a low power factor: but, should a larger increase in power factor be required it would be better to put forward some other means of correcting the lagging current.

VARYING THE D.C. VOLTAGE.

The ratio between the a.c. and d.c. voltage for a given machine being practically fixed, the only method to obtain a variation of the d.c. voltage is to alter the a.c. supply pressure to the sliprings, except with split pole or d.c. booster controlled sets. For colliery work, a variation of pressure is seldom if ever called for: the usual drop of approximately 7% from no load to full load generally meeting the requirements. However, the methods commonly used are worth taking note of. They are: (1) Reactance. (2) A.c. Booster. (3) Induction Regulator. (4) Split Pole. (5) D.c. Booster.

Reactance Control.

This method is the least expensive and simplest No extra gear is required, but the limit of variations is not more than 15%. Up to the limits of the transformer efficiency reactance can be embodied in the transformer itself: further reactance can be supplied by introducing coils between the transformer and the sliprings. The power factor is under control with this method.

A.C. Booster Control.

This method of varying the d.c. pressure consists of inserting an a.c. booster between the sliprings and the rotary armature winding. The booster is really an alternating current generator whose stator, mounted on the shaft with the armature, revolves inside a separate field excited from the rotary brushes, and which has the same number of poles as the rotary. The tappings between the slipring and the armature evolutes are formed into a winding, having the same number of phases as the rotary itself. By increasing or decreasing the excitation of this separate field, the a.c. pressure at the sliprings can be varied. The power factor is independent of either the load or the pressure, so that unity power factor can always be obtained. The arrangement is suitable for all frequencies and capacities.

There is a limit of variation with rotaries fitted with inter-poles: using the booster to raise the d.c. voltage, causes armature currents to flow in the machine, which magnetise the inter-poles to excess and upset the commutation. The limit of variation is 10% to 15%.

Induction Regulator Control.

This method is adopted for all modern rotaries, giving a variation of 30%. The regulator can be accommodated in such small space as to permit mounting it direct on the machine bedplate in line with sliprings. No extra connections are required and it works on the stator and rotor principle; the rotor position being capable of alteration in relation to the stator, either by hand or motor control. It can be constructed in the largest sizes. Machines so fitted do not require either diverters or auxiliary windings. The commutation is unaffected by large voltage variation. This method is most suitable for running at a leading power factor, at full load, at any d.c. voltage, and also should the rotary require to be run inverted.

D.C. Booster.

This method consists of introducing an ordinary d.c. generator in series with the rotary armature, as the booster must deal with the total current. The booster commutator must be constructed in about the same proportion as that of the rotary commutator.

Split Pole.

This method, which has been discarded in favour of the induction regulator, was only suitable for 25 cycle systems on small outputs. The main poles of the rotary were divided into two portions: (1) The main poles. (2) The regulating poles. The main field being excited in the ordinary way: the regulating poles were arranged for excitation in either direction. Unity power factor could be obtained under any conditions of load or d.c. voltage, without any additions. The variation obtained by this method is approximately 25%.

(*To be continued.*)

WESTERN DISTRICT SUB-BRANCH.

Calibration of Power Station and other Instruments.

R. G. ISAACS, M.Sc.

(*Paper read 13th December,* 1930.)

If there had been any doubt in the mind of the author as to the suitability of such a subject for a paper for mining electrical engineers it would have been dispelled by recent papers of our past and present chairmen.* If importance is to be attached to a knowledge of the cost of production, and probably no one will dispute this, obviously the instruments on which these costs are based must be correct within known limits of accuracy. With electrical and most other instruments it is not sufficient to know that they were once accurate, and if they are to

* Some Considerations Governing Power Costs at Collieries, by S. T. Richard. *The Mining Electrical Engineer,* Sept. 1930.

Also Western Sub-Branch Chairman's Address by W. M. Thomas. *The Mining Electrical Engineer,* Nov. 1930.

be depended upon, calibration at intervals depending on circumstances will be necessary. In these days of financial stringency the first essential is the prevention of avoidable losses and one cause of these is the use of inaccurate instruments. Electrical engineers are well aware of this and in general will try to find with the available equipment, possible means of detecting this inaccuracy. This brings us to another and more subtle form of loss which is misdirected effort to reach a desired end. It is the aim of this paper to outline a suitable testing or standardising equipment which would be suitable for a colliery group or combine, that will largely prevent these losses.

An adequate testing equipment involves the outlay of a fairly considerable sum of money but if care be taken in the initial choice to obtain apparatus that will cover as wide a range as possible the expenditure can be made reasonable and, in the author's view, justified. The case of the smaller colliery is more difficult in that for them the expense of acquiring most of the testing equipment to be described is probably not justified: but the necessity for calibration remains and this will have to be done wherever facilities for it exist. Often the tests will be more or less improvised and it would then be the duty of the responsible engineer to be sufficiently familiar with the testing methods employed to appreciate to what degree his requirements have been fulfilled.

Expenditure on costly apparatus is not usually justified if its use is only very occasional and the view is often expressed that all testing of the kind indicated should be done by a recognised standardising institution. On the other hand with certain types of instrument it is certain that calibration cannot be relied upon after a railway journey and in addition this course frequently means a considerable time before the instrument is once more in commission. As a result of these and other disadvantages practically all supply authorities and many of the larger industrial concerns have now more or less extensive testing equipment of their own. In what follows a compromise, by which certain tests are made locally and others by standardising institutions is suggested.

Location and Type of Equipment.

To prevent insulation troubles and to avoid deterioration the situation selected for instrument testing should be dry and sufficiently warm. Vibration is often a source of trouble and for some types of instrument separate brick or concrete pillars are essential if this trouble is to be avoided. The lighting of a test room requires careful attention and should be so arranged that instrument reading may not be rendered difficult by reflection and shadows. Finally, it needs to be realised that accurate results are only attained by a fairly considerable mental effort on the part of the tester and he should not be distracted by more noise than can be avoided.

Sources of Supply and Artificial Loads.

Among engineers in charge of testing stations there exists a difference of opinion on the question of the source of supply for testing, particularly for the provision of alternating currents. Errors and considerable loss of time may be caused by unsteady supplies so that many engineers prefer batteries for d.c. supplies and a battery driven motor generator for a.c. supplies.

On the other hand unless the wave shape of the testing alternator agrees with that given by the supply on which the meters are to be used considerable errors may creep in and for this reason at one of the largest supply authority's testing station all testing is done direct from the mains. The author has an open mind on this question but if a battery driven set is used care should be taken to see that the wave form is not a very distorted one as it is apt to be with small alternators. For this reason a rotary converter is to be preferred, as owing to the distributed winding employed, the wave form follows more nearly the sine law, and this wave form is not appreciably upset by a single phase load. Incidentally a rotary converter will be considerably cheaper than a motor-generator but has the disadvantage of the constancy of ratio between the d.c. and a.c. voltages.

Heavy currents will be obtained by means of a step-down transformer. When this is done the regulation of current is generally most conveniently done by varying a resistance in the primary circuit and as long as the impedance in the secondary circuit is small there is very little objection to this. For varying the resistance, the method of switching in banks of parallel resistances has much to recommend it, with slide wire resistances for fine adjustment. Above 30 amperes a carbon rheostat is suitable while for very heavy loads liquid resistances are convenient, the barrel type generally being satisfactory.

A.C. voltages are best adjusted by means of an induction regulator which can often be improvised from an old d.c. armature taken from its field system, surrounded with iron stampings and provided with three tappings and two brushes movable with respect to one another.

A little consideration will shew that energy meters of large capacity could not possibly be tested in a test room unless special means were adopted for artificially producing load conditions. This can be done by the two circuit method of testing, in which current coils are supplied with suitable current at low voltage and the volt coils fed separately with the appropriate voltage. In addition means must be provided for getting varying phase displacement of current and voltage for a.c. wattmeter and phase meter testing. The following methods are all in use:

(a) A d.c. armature with three tappings and three movable brushes on the commutator. The armature is surrounded with iron stampings. This will obviously give a phase displacement between the supply to the tappings and the voltage at the brushes.

(b) Two alternators of the same frequency coupled together. One of these is provided with a movable stator to give phase displacement.

(c) A phase shifting transformer.

(d) Certain parts of a three-phase circuit may be used giving phase displacements of 0 deg., 30 deg., 60 deg., 90 deg., but these phase displacements are rarely exact enough for accurate work.

Method (c) is the one favoured by the author and will be further described. A so-called phase shifting transformer consists essentially of a device similar to an induction motor with three-phase windings on a stator and rotor. This rotor is prevented from rotating continuously but can be turned round by hand through about one and a half turns, being joined to the terminals by flexible connections. If a three-phase supply is fed to the stator, a single or three-phase supply having any desired phase compared with the main supply can be obtained from the rotor. Such a phase shifter may be improvised from an induction motor with a wound rotor if suitable means are taken to prevent rotation.

Testing Methods.

Probably the test to which most importance will be attached will be that of watt-hour meters. The usual method would be to check such meters against a portable sub-standard. But since this sub-standard itself would need to be calibrated periodically against a standard, it will be preferable when the number of meters to be tested is small to test them straight away against a standard meter.

The actual method adopted using a phase shifting transformer is shewn in Fig. 1. It should be noted that a phase shifting transformer does not vary the voltage, so that if the correct ratio is not available from it the volts must be regulated separately, preferably by an induction regulator as previously suggested. Voltage variation by means of resistance in the primary circuit of the transformer is very risky as the result is to distort very materially the wave form obtained. With the scheme shewn in Fig. 1 the current has only to be adjusted to the desired value and with an expenditure of very little power a test can be made at any desired power factor.

With regard to the testing of three-phase meters a difference of opinion exists as to whether such meters should be tested on a three-phase load or each element tested separately as a single phase instrument. The former would seem the ideal method but this entails considerable complication and unless elaborate precautions are taken to ensure that the loading conditions and connections are the same as those obtaining under operating conditions the results are not likely to be more accurate than single phase testing. This will be satisfactory unless there is considareble interaction between the elements.

For the standard instrument to be used in these tests there is, in the opinion of the author, no better instrument than the torsion head type of dynamometer such as the Drysdale or Duddell Mather type. The feature of these instruments is the almost complete absence of metal in the construction other than the coils themselves which are wound astatically to prevent errors due to stray magnetic fields. These coils are of finely stranded wire wound in such a way that self-induction and capacity are reduced to a minimum. These design details render this type almost entirely free from errors incidental to eddy currents and low power factor. Its readings will therefore be almost completely independent of frequency and wave form. Moreover it is a type that can be calibrated with direct currents and then used with confidence on alternating currents. Change of current range is affected by a commutator which puts the coils in various combinations of series and parallel. Four ranges per instrument are usual, the highest range being ten times the lowest.

In the Drysdale instrument the volt coil circuit is arranged to give full scale reading (that is the maximum allowable twist) with the maximum current and two volts. Higher voltages are provided for by the use of external resistance. The inductance of the moving coil is so low that on 100 volts any error due to it is negligible, even on low power factors. On two volts, that is with no external resistance the error will still be negligible on unity power factor. The importance of this will be seen later. One such instrument will be sufficient because above the maximum range a modern precision type of current transformer will give all the accuracy that is required. In the opinion of the author it is well worth the extra cost to have a polyphase type consisting of the usual double elements, as with such an instrument many tests are possible that cannot be done with the single phase instrument.

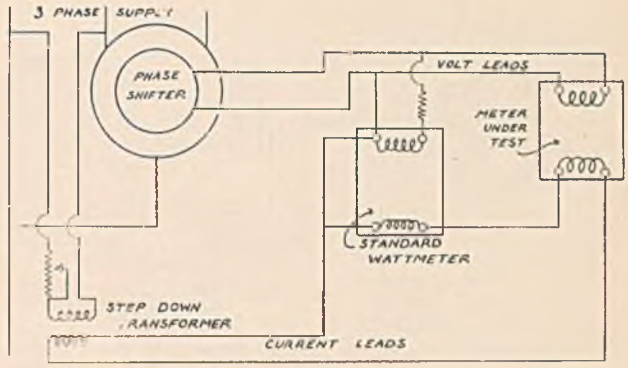


Fig. 1.

Even this type of instrument cannot be regarded as a perpetual standard, changes may take place in the torsion element or due to dirt or corrosion the current may be dividing unevenly at the commutator, so that it, in its turn, will require re-calibration. This can be achieved very simply by calibration on direct current by means of a potentiometer, a standard cell, and a standard resistance. With the type of wattmeter described this calibration can be carried out without having to make independent measurements of volts and current by the use of the method shewn in Fig. 2. A standard resistance is included in the current circuit and the volt coil connected across this resistance. The current passing is obtained by measuring the volts drop across the standard resistance on a potentiometer. Then current $I = \frac{V}{R}$, and Power $= RI^2$. This result can then be compared with the wattmeter reading. It will be seen that the absolute standards that have to be depended on are reduced to the standard cell and standard resistances. Either of these if not ill treated can be relied upon for three or four years and can very easily be returned to the National Physical Laboratory or other testing station for re-calibration.

Ammeters and K.V.A. Demand Meters.

Alternating current ammeters rarely require to be of a high order of accuracy but accurate measurement of current is required in calibrating many types of k.v.a. demand meters. The standard wattmeter already described lends itself very well to this. The connections required will be the same as those shewn in Fig. 2 except that the leads to the potentiometer will not be required in this test. The current to be measured is passed through the standard resistance and the power lost in it noted on the wattmeter. Then, since Power $= RI^2$, I can be calculated. This test is only possible with a wattmeter which will give a full scale deflection with a voltage as low as two volts and with inductance on this range low enough to give a negligible error. Standard wattmeters of the type described fulfil

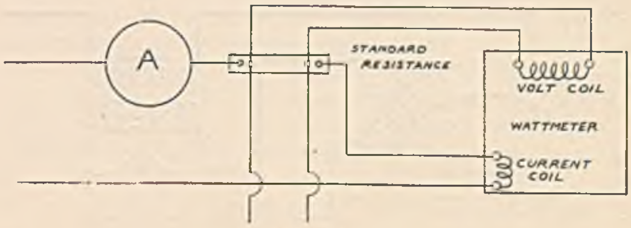


Fig. 2.

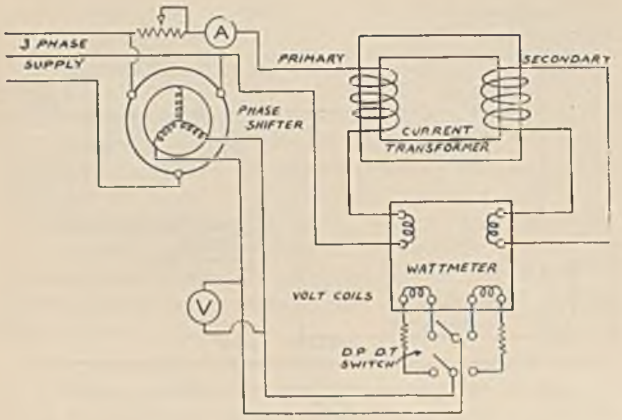


Fig. 3.

these conditions and in addition it will be noted that this test requires no further apparatus than that already mentioned.

Voltmeters.

The accuracy of switchboard voltmeters is obviously of importance and in the opinion of the author calibration is best carried out by comparison against a sub-standard of the electrostatic type reading to about 250 volts. This type is selected because, although it is not usually considered capable of an accuracy greater than first grade, it can be relied upon to read the same on d.c. as on a.c. and thus calibrated on a potentiometer and then used as a transfer instrument for checking a.c. voltmeters. Some of the precautions necessary in the use of this instrument are the avoidance of balance errors by careful levelling and the taking of reverse readings, with direct current, to avoid contact errors. The instrument should be set up for some hours before being used. In dry weather the glass may become electrified and cause errors but this can be removed by the application of moisture. If these precautions are attended to, readings on a good class instrument can be relied upon to 0.2%. The range of such an instrument can be extended with a high degree of accuracy by connecting it across a definite fraction of a high resistance across the mains. For this purpose the same resistances used in connection with the volt coils of the standard wattmeter may be utilised to avoid extra expense.

Instrument Transformers.

Series or current transformers are adjuncts that may require testing from time to time. For these two types of test are required:

(1) An accurate test for new transformers to ascertain whether the errors are within the specification limit.

(2) A rough test on transformers that have been in service to ascertain whether any turns have become short-circuited. This test should preferably be one that can be carried out *in situ.*

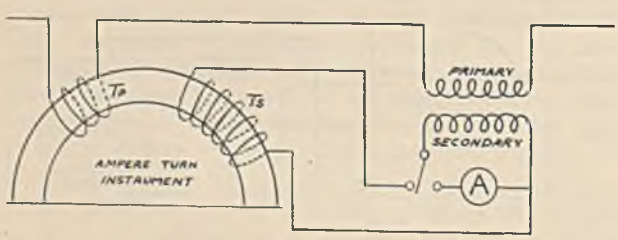


Fig. 4.

The former is one that can be most suitably carried out by a recognised standardising institution; failing this, it can be carried out with sufficient accuracy for most purposes without the purchase of additional apparatus, by means of the standard polyphase wattmeter and phase shifting transformer. Fig. 3 shews the connections of the suggested method. The voltage applied to the volt coil circuits is immaterial. The phase shifting transformer is turned until maximum readings are obtained on the wattmeter with the volt coil switch first on one side and then on the other. The ratio of the two readings obtained will give the ratio of the transformer with considerably greater accuracy than can be obtained with the usual type of ammeter. If the phase shifting transformer is adjusted to get zero reading on the wattmeter and then a reading taken with the voltmeter switch thrown over, this reading can be equated to VI Sin θ where θ is the phase angle of the transformer.

For the second type of test where high accuracy is not required the author has devised a method using an ampere turn ammeter. This instrument is of great use in general a.c. testing and consists of a moving iron movement but with no internal windings. A suitable number of turns carrying the current to be measured are taken round an external yoke and the reading of the instrument indicates the ampere turns on the yoke. If the current is greater than 20 amperes it is sufficient to pass the conducter through the yoke (this is equivalent to one turn) and as the yoke can be removed it can be slipped over a conductor without disconnection. Fig. 4 shews the method of using this instrument for obtaining transformer ratios. A reading is taken of any primary current that happens to be on at the time, the switch meanwhile short-circuiting the secondary of the transformer through any suitable ammeter, which need not be of any particular accuracy as its only purpose is to provide a load for the secondary of about its usual value. The switch is then moved over so that the secondary is connected to a number of turns on the yoke which have been made equal to twice the nominal ratio of the transformer multiplied by the number of turns on the yoke in the primary circuit.

If these secondary ampere turns are arranged to be in opposition to the primary ampere turns the reading will remain unchanged when the switch has been moved over, if the actual ratio of the transformer is equal to its nominal ratio. If, however, the transformer is incorrect the reading will change and the true ratio can then be found in the following way:

Let R_1 be the reading in ampere turns due to the primary current only; R_2 the reading due to both in opposition; I_S and I_P the secondary and primary currents; T_S and T_P the number of turns on the yoke in the secondary and primary circuits respectively. Then

$$R_2 = I_S T_S - I_P T_P \text{ and } R_1 = I_P T_P$$

from which it can easily be shewn that, neglecting the small difference in phase between I_S and I_P, the transformer ratio

$$\frac{I_P}{I_S} = \frac{T_S}{T_P} \frac{R_1}{R_1 + R_2}$$

In many cases it would be possible to carry out this test without disconnecting the primary of the transformer from the circuit in which it was in use. It should be noted that the changeover switch must be of a type that will make contact on both studs before breaking contact with either. This is necessary to avoid open circuiting the secondary of the transformer.

Potential transformers, particularly if they are for high voltages, cannot be calibrated in any simple manner and in their case there appears to be no option but to have them tested by one of the recognised standardising authorities, if at any time they become suspect.

Connecting up Polyphase Meters.

These meters will usually be of the two element type and great care is required in connecting up, particularly if instrument transformers are used, in view of the many wrong connections possible. According to B.E.S.A. Specification the terminals coloured blue are to be connected to the leading phase and the red terminals to the lagging phase so that the first requirement is the determination of the phase sequence, if this is not already known.

A simple method of finding this is as follows. Two lamps are connected in series across two of the phases. The junction between them is then connected through a reactance (a volt coil from an old meter will do) to the third phase. One lamp will be seen to grow brighter and the other less bright. The phase connected to the dull lamp is leading on that connected to the bright lamp. Assuming that care is taken to see that the current transformer in one phase and the potential transformer connected to the same phase are both connected to the same element of the meter, the following connections will indicate whether the connections are the right way round unless the power factor happens to be exactly 0.5. Break the volt circuit of the lagging phase, the meter should now rotate in the forward direction with all lagging power factors. Now break the volt circuit of the leading phase and reconnect the other, the meter should rotate more slowly in the forward direction if the power factor is above 0.5 lagging, or in the backward direction if below 0.5 lagging.

This test requires an approximate knowledge of the power factor and if this is not known it can be determined with sufficient accuracy by means of the ampere turn instrument already mentioned. For this test a multi-turn coil (in series with a resistance) is fitted round the yoke which converts the instrument into a voltmeter. The connections are as shewn in Fig. 5 the voltage connection being between one phase and neutral, and one lead carrying current being brought through the yoke. A reading R_1 is first taken of current only, the voltmeter switch being open. Then a reading R_2 with both current and volt coils acting is taken. A third reading R_3 is obtained with the volt switch thrown over to the other pair of contacts. If the two coils were assisting for reading R_2 they will obviously be in opposition for R_3. Finally the current lead is removed from the yoke and the voltage R_4 taken. It can easily be shewn that the power factor

$$\cos \theta = \frac{(R_2^2 - R_3^2)}{4R_1R_4}$$

Calibration of Air and Steam Meters.

In many cases the calibration of these meters will by equally as important as that of watt-hour meters. A comparatively simple, and at the same time a reasonably accurate, method is to measure by means of manometer the pressure difference across a plate orifice which has been placed in the pipe line.

The weight of fluid flowing in pounds per minute is given by

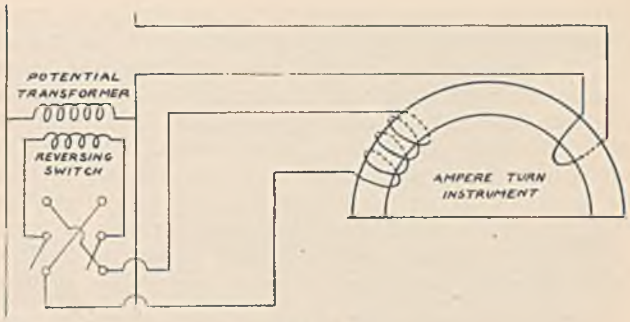


Fig. 5.

$$Q = 40\,k\,A\sqrt{\left\{\frac{\rho(p_1 - p_2)}{(r^2 - 1)}\right\}}$$

where A = the area of the orifice in the plate in square inches.

r = the ratio of the pipe area to the orifice area.

$p_1 - p_2$ = the pressure drop across the orifice in pounds per square inch.

ρ = the weight of the fluid in pounds per cubic foot.

k is a constant for the orifice under certain conditions.

For an orifice which is square edged on the entry side, bevelled on the exit side and with the pressure connections close to the orifice plate, the constant k may be taken as 0.61 for both air and steam as long as the ratios of the diameters of the orifice and the pipe is less than 0.7 and the ratios of the pressures on the two sides not less than 0.98.

The subject of air and steam metering has been very fully dealt with in two papers by Hodgson † to which reference should be made if the limiting values of the ratios given above cannot be complied with.

LONDON BRANCH.

Electric Battery Locomotives and Tunnelling.

N. E. BAYLIFF.

(*Paper read 6th January,* 1931. *In the absence of the author the paper was read by Lt.-Col. G. D. Ozanne, M.C.*)

Since the introduction of electric storage battery locomotives to this country some few years ago, a great deal of interest has been shewn in the adoption of them for haulage in situations where horse, steam, or petrol haulage are not admissible. In mines and tunnels the conveyance of heavy material presents many problems which are not met with in surface haulage. Apart from the danger peculiar to this class of work in certain mines, one of the most important tasks is that involved in the maintenance of the purity of the air where men have to work all day long within the restricted space of an underground tunnel or mine heading. A large proportion of the excavation in tunnels such as, for example, the London Tubes, has to be carried on under

† The Commercial Metering of Air, Gas and Steam, by J. Hodgson: Proc. of I.C.E., Vol. CCIV., I.C.E. Selected Papers No. 31.

increased air pressure, owing to the percolation of water through the soil; and certain portions of the tunnel are, in consequence, entirely shut off from the outer atmosphere by an air lock. Contamination of the air by exhaust vapours, particularly when that air is shut off from the outer atmosphere, is not permissible; for if not actually dangerous to life it would certainly in time be injurious to the health of the workers. Petrol is therefore not possible as a motive power, nor is horse traction with its unavoidable fouling a form of haulage which appeals to the man at work beneath the surface.

It is now generally recognised that electricity provides the ideal form of traction for underground working. In large workings electrification, either by overhead trolley or by a third rail system, is considered satisfactory, but in the case of mines with low roofed wet workings and in the driving of small diameter tunnels, whether of a temporary or permanent nature, the use of such systems has serious disadvantages, the chief of these being: firstly, high cost of installation and maintenance under general mining conditions; secondly, constant danger to workmen of contact with live wires; thirdly, the danger of fire from sparking at the trolley wheel; and fourthly, the necessity for well laid wired and bonded track where only one trolley wire is used.

With the storage battery locomotive, however, the above objections may be overcome. Constant improvement in batteries and locomotive construction generally during the past few years have made the operation of this type of locomotive in underground workings with its peculiar demand, not only possible, but highly efficient for any track system in which gradients do not exceed 3%. They are flexible prime movers, emit no objectionable fumes, are safer and more simple to operate than any other type of locomotive; moreover, the wires, which are essential to either overhead trolley, third rail, or rope haulage system, are eliminated and thus the battery locomotives can be run right up to the face as soon as any form of track can be laid. The work of removing spoil can be proceeded with immediately it is broken down.

It is proposed in this paper to deal only with the smaller types of storage battery locomotives, or those designed to haul a load varying from 10 to 15 and 30 tons, and to move those loads over the indifferent tracks which are commonly used by public works contractors, and which often have numerous curves of a radius as little as 11 ft. Storage battery locomotives of these types were first used in London by the various public works contractors engaged in the construction of Tube Railway extensions in 1921 to 1926. They were also used about the same time on the outfall relief sewers which form part of the London County Council main sewer relief scheme, and have been used on every tunnelling contract of any size in this country since that date.

Work on a scheme of the character mentioned goes on during night and day, the average working week being 144 hours, the only interval being at the week-end from 10 p.m. on Saturday until about the same time on Sunday. Stoppages through breakdown must therefore be reduced to an absolute minimum: time on these jobs is often the essence of the contract, and to enable the locomotives to work round the clock, each machine is equipped with two, and sometimes three, spare batteries, so that while one is working, the other is being charged. This method of working considerably reduces overheads. On the tube railways contract, the locomotives were employed in hauling tubs loaded with clay, a distance up to 1½ miles, the average load being about 10 tons, and returning to the face empty or partially loaded with material such as concrete, cast iron segments, tools, etc.

About that time, the attention of the Sydney Metropolitan Water, Sewerage and Drainage Board was drawn to the possibility of using similar locomotives and, as a result of extensive enquiries on their behalf, particularly in London, where over 30 of these locomotives were engaged on underground constructional work, they decided to instal two 10 ton capacity storage battery locomotives. (Figs. 1 and 2.)

The overall dimensions of these locomotives are 6 ft. 9 ins. length, 3 ft. 3 ins. width, 3 ft. 3 ins. height over rail level. The total weight in running order is 2¼ tons. The normal drawbar pull is 300 lbs., but a maximum of 1100 lbs. is possible. When hauling its full load on the level, each locomotive is capable of an average speed of 3½ to 4 miles per hour. The wheelbase is 2 ft. 4 ins., thus enabling the locomotive to negotiate curves of 11 ft. radius. All the four wheels are driven, through machine-cut steel spur gearing by a single totally enclosed electric motor. Power is provided in this instance by a nickel-iron battery consisting of 40 cells, 215 ampere hours capacity.

The pressure tunnel in which these locomotives are used, was being constructed for the purpose of providing a permanent and greatly increased supply of water for the Sydney Metropolitan area. Its length is approximately 10 miles, and in its construction, 17 shafts were sunk at an average distance apart of 300 ft. The tunnel runs in a perfectly straight line and was driven through solid sandstone formation, the diameter of the drive is approximately 13 ft. in the rough and the finished diameter of the tunnel, after concreting, 10 ft.

A train usually consisted of six loaded skips, the aggregate weight being 10 tons. The track extended from the working face to the shaft. Near the shaft the track was divided into two, one line leading into each cage. The locomotive, with its loaded train, runs on one side and continues through the cage, leaving the end skip in the cage ready for being raised to the surface.

At the surface, the skip is emptied by an automatic tippler, the remaining skips are also detached from the locomotive and left on this siding to await their trip to the surface; meanwhile, the locomotive is shunted, and returns by the other line, again passing through the cage and collecting the empty skips. The skips are then pushed to the face by the locomotive for refilling.

A similar system of working is adopted in regard to conveying concrete, which, after being mixed at the surface, is run direct into a one cubic yard side-tipping truck standing in the cage at the surface. This is then lowered to the tunnel where the locomotive again takes charge, either drawing or pushing the truck from the cage.

Very thorough tests of the locomotives' performance have been carried out by the Board's engineers under actual service conditions. These have shewn that over 20 miles can be obtained per battery charge when running with full load in one direction and returning with six empty skips, the average ton-mileage for each locomotive is 130 per battery charge. The actual input to each battery during the charge amounts to 21.65 units, based on an energy cost of 1d. per unit, thus the cost of power per locomotive is 0.16d. per ton mile.

It is doubtful whether any form of underground transportation can shew figures of operating results approaching this remarkably low cost. The cost in this case is all the more remarkable when it is considered that with these particular trucks, the tractive effort required is equivalent to 35 lbs. pull per ton as compared with the more common average of 25 lbs. per ton with mining skips.

When the distance of the working face from the shaft exceeds 1200 ft., arrangements are made to change the battery every morning before commencing the day's shift, but on shorter distances it is only necessary to change the battery every alternate day. The process of changing batteries is exceedingly simple; a plain platform trolley, which carries the charged batteries from the charging station, which for convenience is situated at the surface, is brought down the shaft in the cage and run alongside the locomotive on a siding, the side of the battery compartment is removed and the batteries are slid sideways on to the locomotive frame, the whole operation taking less than 15 minutes.

In order to expedite the completion of the pressure tunnel, the Board later decided to instal three further locomotives rated at 15 tons each, capacity.

In lead and ironstone mines, storage battery locomotives have also proved their sterling value. Some few years ago, two storage battery locomotives were purchased as an experiment for gathering ironstone to see if they could satisfactorily replace ponies. Each locomotive was engaged in hauling a train of tubs, weighing approximately 5 tons, from the face and returning with empty tubs; the duty being about 150 tons per shift, with an average run of about 16 miles. As a result of this experiment, the Company now have 14 locomotives in service, which is definite evidence that the locomotives hav eproved satisfactory.

In the Halkyn district of North Wales, the battery locomotive has also proved its worth. The lead and zinc mines of the Halkyn area in North Wales are heavily watered and their drainage has for many years been effected by a gravitation drainage tunnel. In course of time the mines became exhausted to the depth of this tunnel, which is about 200 ft., and although attempts were made to pump from this level all work was abandoned in the year 1921.

Arrangements were made to extend a sea level tunnel which, starting from the River Dee at Bagillt, had already been driven for a distance of 3¾ miles and was about to enter the area in question. Work was commenced about the beginning of 1929 and during that year the tunnel was extended about one mile, making a total length of 4¾ miles. The total tonnage excavated to date since work was renewed is about 60,000 tons; the average weekly progress up to the end of 1929 was 94 ft., but to date this average has been reduced considerably by difficulties due to the incidence of a combination of sand and water which has seriously hindered the operation. The fastest progress during one week was 169 ft., which is claimed as a tunnelling record for Great Britain. It is proposed to drive the tunnel southerly through the whole area and its ultimate length will be approximately 10 miles.

To give some idea of the water difficulty which exists in this important mineral area, and to shew the magnitude of the pumping operations necessary to deal with it by mechanical means, it may be mentioned that the present tunnel delivers about 12,000 gallons per minute into the River Dee, and the old tunnel approxi-

Fig. 1.—Locomotive placing loaded skips in the cage. Sydney Metropolitan Board.

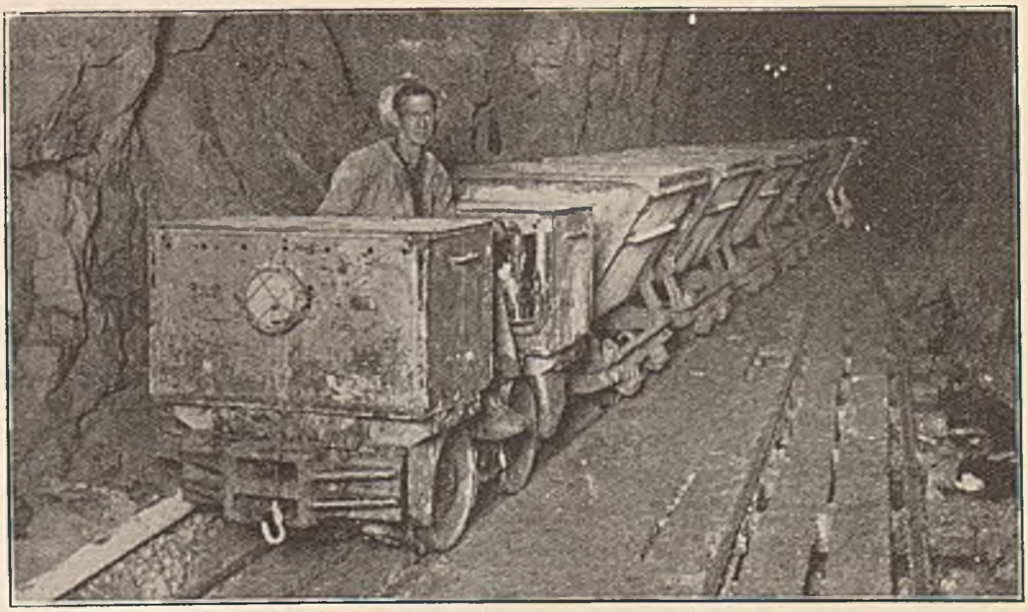


Fig. 2.—Locomotive with skips. Sydney Metropolitan Board.

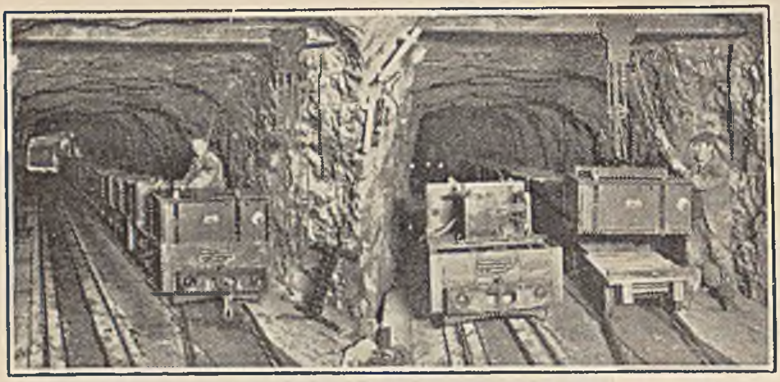


Fig. 3.—Locomotive in the Halkyn Lead Mines, North Wales.

mately the same volume, most of which will flow through the new tunnel as it progresses southerly.

Some few years ago, the tunnel intercepted the source of the flow to the famous St. Winifrede's Well at Holywell, which added some 6000 gallons per minute to the stream. The water is remarkably pure and is used for processes by an artificial silk manufacturing concern.

The tunnel is 10 ft. wide by 8 ft. high, in addition to which is excavated a waterway of about 4 ft. by 2 ft. and driven with a falling gradient of 1 in 1000. The rock is hard limestone, which necessitates the use of large quantities of high explosive, gelignite, for blasting. No support is required, except in a few short sections in which the ground is heavy, but these rarely occur.

Work is continuously carried on in three shifts from midnight on Sunday till 6 p.m. on Saturday. The rock is drilled by compressed air drills, working at a pressure of 100 lbs. per square inch, and two drills, mounted on a bar, are used for drilling about 32 holes in the face, which give an advance of 6 ft. per round. A jack-hammer is used for drilling the holes necessary for the excavation of the waterway.

The fumes after blasting are withdrawn by a motor driven fan through a 20 inch ventilation pipe, and this enables resumption of work at the face in about 30 minutes after each blast.

In clearing the debris, about 35 tons, after a round has been shot, a machine known as a "slusher" is employed. This takes the form of a truck arranged to be moved on a narrow gauge rail track and carrying at the forward end a steel ramp with low sides sloping down to the floor of the tunnel. The rear portion is so arranged that the mine tub can be pushed in underneath. Mounted on the machine is a compressed air double-drum winch with reversing clutch operating a steel wire rope to which is attached a heavy steel scraper. The rope passes over a pulley fixed at the new face so that the scraper may be pulled backwards and forwards between the face and the slusher. The scraper thus gathers the debris from the floor of the tunnel and scoops it up the steel ramp until it drops into the mine tub. Using this machine, it is possible to load and dispose of two tubs in three minutes, each holding 16 to 18 cwts.

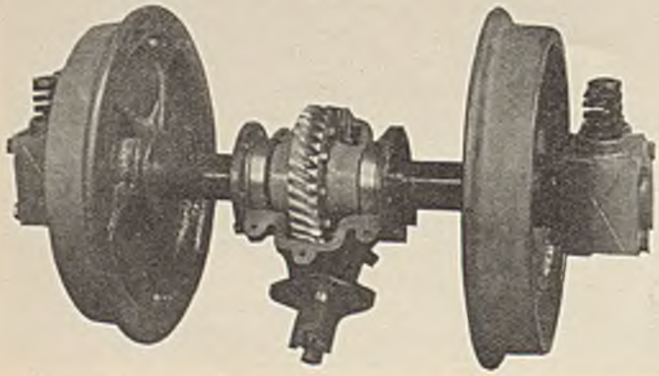


Fig. 4.—Back Axle of Worm-drive Locomotive.

During the slushing operation, the full tubs are marshalled in groups into trains of about twelve tubs, a total load of 12 to 15 tons, by an electric storage battery locomotive, which hauls them to the shaft at a speed of about 5 miles per hour.

The locomotive has been employed for about eighteen months, the work having previously been carried out by ten ponies with ten men, and shews a saving of more than £20 per week.

The chief features of interest in this locomotive is the worm gear transmission, which is totally enclosed in an oil tight casing, giving complete protection from the effects of grit and water which are inseparable from this class of tunnelling. Two motors are employed, each driving one axle independently, the total power available being 12½ h.p. at the 1 hour rating. Special attention has been given to the motors to render them proof against severe water splashing, the windings also are impregnated with a special asphaltum compound.

The battery used comprises 30 Exide-Ironclad cells, accommodated in two steel containers, each arranged for quick removal. Each battery is sufficient at the present time for rather more than the work of one 8 hour shift, after which it is replaced by a spare battery fitted in identical steel containers. This exchange is performed by the driver unaided in about five minutes, using pulley blocks on an overhead runway across the tunnel. The containers, with battery, are placed on low trolleys and are removed to the surface for charging.

The performance of this machine has been a source of great satisfaction to the chief engineer of the company, and it has never once been out of service in spite of the extremely adverse conditions under which it is employed.

When new finds of water are encountered they frequently bring in large quantities of sand in suspension: this is deposited on the track and in the waterway, choking the latter, and it has recently been necessary to clear about 4000 tons. The choking of the waterway frequently results in the track being waterlogged to a depth of several inches. This does not appear to hinder the locomotive in the slightest, nor has it apparently had any ill-effect upon the mechanism. Another locomotive of similar capacity has recently been put into service by the same Company.

The new Mersey Tunnel now in the course of construction is also well served by a number of battery locomotives, each designed to haul loads of from 5 to 7 tons up a gradient of 1 in 30 and equipped with D.P. Kathanode batteries.

Small electric locomotives are, however, not only serviceable and economical in work underground, but also good for work on the surface of mines and in connection with excavation and building operations at docks, factories, warehouses, etc.

An electric locomotive which has given good service underground can be used on the surface. This is shewn by the fact that the B.E.V. locomotives after being used by Messrs. Charles Brand & Son, on the London

Tube extension, were also used on the Port of London Milwall Dock extension. They were used to haul a load of 7 tons up a gradient of 1 in 20. The type of track in use was by no means ideal.

The above locomotives supplied to Messrs. Charles Brand & Son between 1921 and 1925, have recently been overhauled and will in the very near future be at work on the London County Council Walham Green Relief Sewer Contract, and on the new Piccadilly Tube extensions from Finsbury Park to Cockfosters. Further B.E.V. locomotives of the worm drive type have been ordered by the contractors for use on this contract. Both old and new locomotives in this case are being equipped with batteries of 42 cells, 225 ampere hours capacity. This example alone should be sufficient to prove the long life, reliability, and superiority of storage battery electric traction.

COSTS.

A leading mining engineer who has control of extensive works in North Wales, carried out exhaustive tests over a period of twelve months with a view to determining the relative cost of employing horses hired by the day with drivers, petrol locomotives, and storage battery locomotives. The results obtained are very convincing, the total costs for the three systems worked out as follows :—

Horses	£657
Petrol Locomotives	£442
Battery Locomotives	£236

In the case of both locomotives, the figures include repairs, drivers' wages, interest, depreciation, and cost of fuel for electric current. The higher speeds obtained with the locomotives represent a further advantage over horse traction.

A further example of capital and running costs may be taken as a guide for the average small battery locomotive :—

	£	s.	d.
Depreciation on Loco. say £270 at 10% p.a.	27	0	0
" Lead Battery say £155 at 33⅓% p.a.	51	13	4
" Charging Plant £108 at 10% p.a.	10	16	0
Repairs and renewals, oil, grease, etc., for loco. and sundry spares for batteries ...	8	0	0
	£97	9	4

	per week.
Standing Charges (assuming working 50 weeks per annum)	1 19 0
Power for charging battery, 24 cells, 22 units per full charge, 7 charges per week, 154 units at 1½d.	0 19 3
Total Running Cost per week of 7 days ...	£2 18 3

Note :—

(a) It is assumed that power costs are 1½d. per unit, and this is the usual figure to be charged for night battery charging service.

(b) Battery life under good conditions and with ordinary care is approximately four years, and in comparing these figures with the cost of steam locomotives, the replacement batteries, together with power costs for charging, may quite legitimately be set against fuel costs.

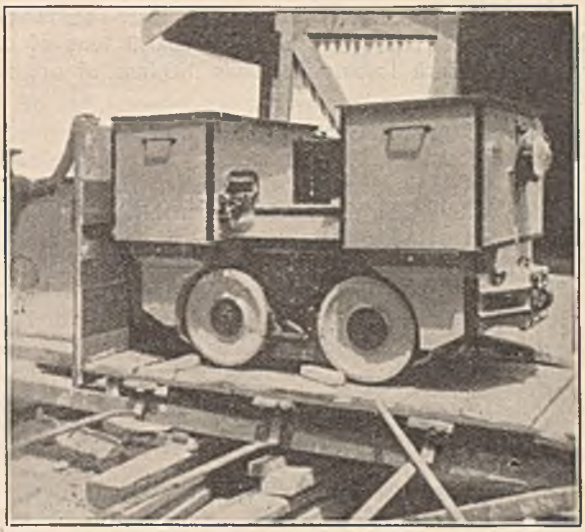


Fig. 5.—Locomotive brought to surface after three years' continuous duty underground.

Capital and Running Costs of Two Electric Locomotives.

Maximum hauling capacity, 15 tons on level track : normal duty, 8 tons ; maximum grade encountered, 1 in 75 against loaded train.

Capital Cost of two locomotives, each with one spare battery and charging plant for charging two batteries simultaneously ...	£1236 10 0

Annual Charges.	£	s.	d.
Interest on Capital, 5% on £1236 10 0	61	16	0
Depreciation on locomotive, 10% on £600......	60	0	0
Depreciation on 4 batteries, 33⅓% on £480...	160	0	0
Depreciation on charging plant, 5% on £125	6	5	0
Repairs, maintenance, renewals, etc., say ...	20	0	0
	£308	1	0

The extreme simplicity and sturdy construction of electric locomotives is responsible for their almost entire freedom from breakdown. Nothing but very minor derangements need be expected for at least the first five years' service.

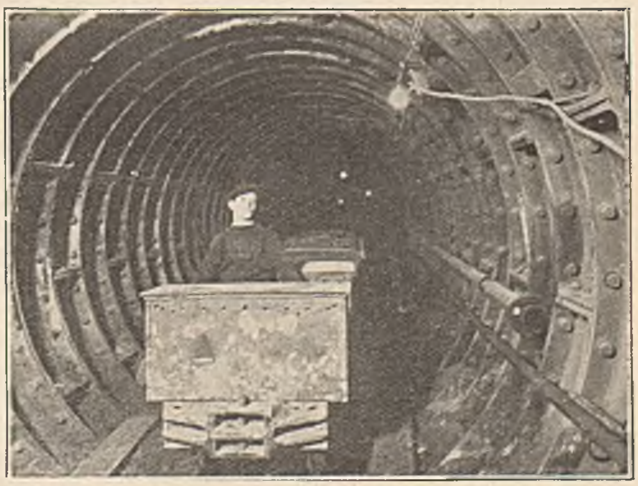


Fig. 6.—Spur-gear drive Locomotive at work in the Hammersmith Sewer.

Assuming locomotives work on three shifts per 24 hour day, 300 days per annum, 180,000 tons of ore per annum. Each locomotive hauls 100 tons of ore per shift.

Proportion of Annual Charges to be borne by each locomotive	per shift	3s. 5d.
	per ton of ore	0.41d.
Power for Battery Charging (1 charge per shift)		s. d.
24 units at 0.75 pence		1 6
Driver's Wages		10 0
	per shift	11 6
	per ton of ore output	1.38d.
Total All-in Cost per ton of ore output		1.79d.

Alternatively, per ton mile :

Mileage covered per shift with loaded wagons only		7¼ miles
Which is, with 5 ton of ore per train		36 ton miles
Annual Charges per shift, as above	......	3 5
Power and Driver's Wages „	......	11 6
		14 11
Total All-in cost per ton-mile (of ore)		5d.

(*To be continued.*)

FIFE BRANCH.

Presidential Address.

CHARLES C. REID.

The inaugural meeting of this Branch was held within the D.C.I. Rooms, Cowdenbeath on 19th December, 1930, when Mr. Charles C. Reid, General Manager of The Fife Coal Company, gave the presidential address.

There was a large and representative attendance.

Mr. Reid was introduced as President by Mr. James Dawkins, Vice-President, who explained the merging of the East of Scotland Branch with the new Fife Branch.

Mr. Reid, in the course of a reminiscent address, drew from his own active connection with mining, which extends over a period of some thirty years, and described the great progress in the application of electricity to mining. He mentioned the original installations of d.c. plants which were primarily laid down for pumps and haulages, and later the application to coalcutters, followed by the general change over to alternating current.

Mr. Reid laid particular emphasis on the fact that underground plant required proper control and maintenance. The functions of the mining electrical engineers were to organise and carry out this work and he declared that the Association could greatly assist in the training of men to obtain the necessary educational and technical qualifications to do the work ; it was imperative to have fully qualified men, if we were to obtain continuity of output and immunity from breakdown.

The President was accorded a hearty vote of thanks on the motion of Mr. R. W. Peters, Lochgelly, supported by Mr. Andrew W. Crowe, Glencraig.

Dr. Joseph Parker, Principal, Fife Mining School, thereafter explained educational facilities available for Mining Electricians and urged the younger men to come forward and qualify themselves for the Certificates by Examinations granted by the Association.

Mr. A. V. Reis, Secretary, intimated that the hospitality afforded at the meeting was due to the generosity of the President, Mr. Charles C. Reid, which was gratefully acknowledged by the members present.

NORTH WESTERN BRANCH.

The third meeting of the session was held at the Mining and Technical College, Wigan, on December 5th last. Mr. R. F. Bull, the Branch President, occupied the chair. Mr. E. Griffiths, Stoke-on-Trent, was elected a member.

Capt. I. Mackintosh read the following paper; at the conclusion of the animated discussion which ensued, Mr. S. J. Roseblade moved a vote of thanks to the author, remarking that the paper was particularly valuable in that Capt. Mackintosh had been able to approach his subject as one having practical experience. Mr. W. Bolton Shaw seconded the proposition which was carried with acclamation. In his acknowledgment Capt. Mackintosh said he appreciated the vote of thanks and confessed that, in the course of preparing the paper, he had learned so much more about switchgear that he had been amply rewarded from that point of view alone.

The Switchgear Problem and the Colliery Engineer.

Capt. I. MACKINTOSH.

In this paper consideration is given to the various types of switchgear available for use at a colliery ranging from that placed in the power station, or surface substation, to the individual switch which controls some piece of apparatus inbye. With a view to stimulating discussion mention is also made of metering equipments and protective gear.

No part of electrical equipment has shewn greater progress during the last twenty years, than has switchgear. The type of power station switchboard of twenty-five years ago was usually built up on marble or enamelled slate panels, although there were even then some sheet iron boards and the forerunner of the present truck type in use.

It is a good thing for the electrical industry that designers have been able to make progress to the extent that it is now possible to have switchgear with a rupturing capacity of 1,500,000 k.v.a., and suitable for safe operation on circuits up to 132 k.v. Thus the colliery engineer can obtain suitable and reliable switchgear to meet all his requirements, and to comply with regulation 124(a), which in effect requires switchgear to be of sufficient size and power for the work it may be called upon to do.

It is essential for successful operation of the electrical plant at a colliery, that suitable switching arrangements should be made for the adequate control of the apparatus in use, as even in the best thought out schemes, and with perfect maintenance, such troubles as short circuits and overloads will arise. It is necessary to provide for the instant isolation of a fault; that the isolation should affect only the circuit on which the fault occur and not interfere with the working of the rest of the plant. It must also be remembered that in the event of a fault, Regulation 128 (c) calls for efficient means for cutting off all pressure automatically from the circuit or part or parts of the circuit affected.

As this discussion concerns general principles it might be well to state that the author is against the introduction of any but essential features on switchgear; elaborations often only put up the cost and serve no useful purpose beyond perhaps giving the colliery engineer the satisfaction of knowing that he has every possible "gadget" on his switchboard. In these days, when economy is the watchword of all colliery managements, the engineer has not much scope or excuse for additions which are not really necessary. Personally, the author thinks this is all for the good; extra details mean additional work for the maintenance staff, and form extra links in the chain of possibilities for causing trouble. On the other hand, he believes in making adequate provision for metering and protective arrangements. The cutting down of metering equipments is a big mistake. One of the many advantages of electricity as a motive power, is that it lends itself to the keeping of accurate records which serve many useful purposes, not the least of which is accurate costing. Really useful recording can only be carried out by having adequate metering arrangements, and in the author's opinion these come under the heading of essential features.

Most members of the Association will agree that colliery switchgear has to operate under severe conditions, not only from the electrical point of view, but aso due to the physical conditions which play such a big part in mining operations. It is essential that all switchgear for use in conjunction with colliery plant should be of robust construction as, apart from other considerations, it is more than likely it will receive more than the average amount of rough handling, particularly if it is installed a long way inbye. All parts should be readily accessible. There is nothing more aggravating than working, or trying to work, on some inaccessible piece of apparatus, in semi-darkness, and possibly fighting against time in carrying out adjustment or repair.

POWER STATION OR MAIN SUBSTATION SWITCHGEAR.

Types of Gear.

In colliery work, as in all other industrial services there is a large variety of types of switchgear which may be installed, and each particular case should be considered on its merits. It is impossible to be dogmatic, as conditions are so variable. Within certain limits any one of the types mentioned below may be installed, but there is a very definite limit to the use of the truck type; and, to a lesser degree, of the sheet steel cubicle type. This limit is the rupturing capacity of the oil circuit breaker. It is clear that in the truck type it would be almost impossible to house a circuit breaker of very high rupturing capacity and at the same time provide a truck which could be easily moved in or out. One well known manufacturer has developed and put into service truck type units incorporating circuit breakers having a rupturing capacity of 250,000 k.v.a. capable of being withdrawn by hand after the fixed and moving portions have been separated by means of a racking device. This, however, appears to be the limit, and owing to the very large size of the unit it would seem to be a better proposition to instal a metalclad unit.

1. Draw-out sheet steel Truck type.
2. Interlocked or non-interlocked Sheet Steel Cubicles.
3. Concrete Cellular Type.
4. Metal-clad, compound or oil-filled.

Truck Type.

This well-known type has for many years been a popular unit for a variety of situations. Its design readily lends itself to interlocking, particularly that of ensuring that the oil circuit breaker is open before isolation is carried out. Each unit consists essentially of a fixed portion containing busbars, cable box, and sometimes current transformers, and a movable portion carrying the oil circuit breaker, and potential transformer. Connection between the two portions is made by means of contacts carried on the respective frames; the contacts are of the self-aligning type ensuring correct engagement when the moving portion is pushed home.

An advantage of this type is that no special arrangements have to be made to leave working spaces, as the moving portion can be taken right away for repair or adjustment; and, further, the unit can be placed with its back against a wall.

As already mentioned, this class of gear has limitations of service, particularly that of rupturing capacity. A further limitation is that of accommodating the large amount of apparatus, such as main ammeter and voltmeter, exciter ammeter and voltmeter, reverse relay, wattmeter, watthour meter, Merz Price protective relay and current transformers. It will be appreciated that such equipment requires considerable space and adds weight to the moving portion making it more difficult to move; moreover the running in and out of the truck on an uneven floor may have an adverse effect on the delicate Merz Price relay.

One big advantage of this type of gear is that it leaves the factory completely assembled and, in consequence, requires a minimum of erection on site.

Sheet Steel Cubicles.

This type of gear, while not having the same disadvantage as the truck type in that it is quite possible to build units to accommodate much larger oil circuit breakers, is nost as suitable for power station work. Its chief application is for use in substations. Beyond certain limits in the size of the switch, the supporting structure becomes so large that the cost is very great, while standardisation on the lines of the truck type cubicle is impossible. A detail often overlooked is that when space is restricted, the cubicles need to be placed back to the wall, with all gear accessible and operated from the front. This requirement complicates the arrangement within the cubicle, and often increases the cost. On the other hand, to leave operating space at rear of the cubicles makes inroads into the space available in a station.

Cellular Gear.

Under this heading is meant cellular gear of the moulded stone type. It has been extensively used in power stations, particularly where either mechanical or electrical remote operation is required, and for the accommodation of switches heavier than those usually associated with truck type gear.

The cell is built up of accurately made slabs of concrete, which are put together on site by experienced erectors. One disadvantage of cellular gear is that assembly of equipment cannot be made at the factory thus involving a greater amount of erection on site.

Cellular construction can be adopted for gear operating on 33,000 volts, although 11,000 volts would appear to be a sounder limit. As far as possible each piece of apparatus is housed in a separate compartment, stone barriers being placed between phases, to minimise fire risk and short circuits between phases and, at the same time, give protection to attendants working on any particular unit.

With this class of gear it is unwise to try to cut down the clearance in the cell in the endeavour to reduce the overall dimensions. It has to be remembered that it is necessary to get at the apparatus in its mounted position, and as much working space as possible should be allowed for the maintenance staff. A particularly difficult point, is that of getting at the rear tank bolts when it is desired to lower the tank. The vent arrangements on the circuit breaker should be such that gases are discharged outside the cell and clear of the operator, where the operating mechanism is on the cell front, in case oil is thrown while opening under severe short circuit. With the cellular construction it is extremely difficult to apply interlocks to give a foolproof unit, and in many cases interlocking gives a false idea of security.

This class of gear has given, and undoubtedly will continue to give, satisfaction in power stations, although the metal-clad type tends to supersede the cellular type. Many engineers, however, will continue to favour gear where all the unit pieces of apparatus are accessible in case of need, rather than have them embedded in compound or immersed in oil.

Metal-clad Switchgear.

Metal-clad switchgear is a well-established and favoured design for both power station and main substation work. In recent years, the demand for this class has increased considerably, and it is now often called for by engineers, even for remote positions. The chief advantages af metal-clad switchgear might be summed up as follows :—

(1) Better utilisation of space.

(2) Ease of interlocking and rendering fool-proof.

The space question is often very important in colliery work. The cellular type, when a high rupturing capacity is necessary, often requires a two floor arrangement, whereas the metal-clad type can always be accommodated on one floor ; and, in addition, the headroom required is often only one-half or less of that required by the cellular type. Most members of the Association will appreciate the ease with which a metal-clad unit can be rendered fool-proof, and it may, therefore, suffice to indicate briefly the more common interlocks usually fitted on this gear.

(1) Breaker cannot be racked out to isolate when it is closed. This interlock also acts in the reverse way.

(2) Tank cannot be lowered when breaker is alive.

(3) Potential transformer fuses cannot be handled until transformer is completely isolated.

(4) Interlocks between selectors on duplicate busbars.

In addition to what has already been said, there is also the question of reliability in service. The metal-clad unit is particularly satisfactory in this respect owing chiefly to its robust form of construction.

Rupturing Capacity.

It is often extremely difficult to ascertain the rupturing capacity of circuit breakers which should be specified in a purchasing specification. The author would suggest that if there is any doubt in the purchaser's mind about the rupturing capacity required, the purchaser should, before issuing his specification, place all the details of the system before any of the large switchgear manufacturers ,who will be only too glad to work out the short circuit k.v.a. to be expected at any point on the system. It should be remembered that the switchgear manufacturer has access to records and data which are not available to the average buyer. In giving details to the manufacturer it should be borne in mind that such information must include particulars of any synchronous machinery connected to the system, as during short circuit this machinery feeds back into the fault.

In the calculation of short circuit k.v.a. due notice must be taken : firstly, of the short circuit characteristics of the generators ; secondly, of any voltage regulators installed, as these tend to maintain the voltage ; and, thirdly, the time characteristics of the circuit breakers. It is assumed that the time for circuit breaker contacts to separate will not be less than 0.2 seconds, even if set for instantaneous operation. Of course, the use of time relays increases this period.

The author appreciates that the notes on this point are brief but members will readily understand that the subject is so large and important as to warrant a paper devoted entirely to its discussion. Many examples of short circuit calculations are given in a booklet written by Major E. Ivor David, and published by the South Wales Branch of the Association.

(To be continued.)

Remembrance from Overseas.

In a letter received by the Hon. Secretary of the West of Scotland Branch of the Association from Mr. J. A. Kerr, Durban, Natal, S.A., intimating his resignation owing to his inability to attend meetings, this member states :—

"It may interest you to know that I am a Founder Member of the Branch and was on the Council 1912-13, previous to coming here. I remember the first night well—we met in a Restaurant opposite Central Station in Gordon Street, Alex. Anderson, Landale Frew, Andrew Power, Dave Martin, Sidney Simon, A. B. Muirhead, and others.

"I suppose a lot of the old Founder Members have passed away—Andrew Power died before I left the Old Country. There were a lot of fine chaps on the first Council, and a great deal of the credit for the strength of the Branch is due to their early work, especially Dave Martin and Landale Frew. I don't think the latter ever tried for, or got, much recognition, but worked quietly and unobtrusively, but none the less effectively.

"H. Willis is dead too—one thing to be said for him, he always spoke his mind and to the point.

"With kind regards and best wishes for the New Year, and with good wishes for the continued success of the Branch and the Association—I am afraid the Branch always comes first to me.

"My kind regards please to Dave Martin, Landale Frew, and Alex. Anderson, if you should see them."

BRITISH INDUSTRIES FAIR, BIRMINGHAM.

NOTABLE EXHIBITS.

Ferguson, Pailin Ltd.

Round Tank Oil Circuit Breakers.

Ferguson Pailin Ltd., the switchgear specialists, have devised a very interesting display of their manufactures and have ingeniously adopted a number of novel advertising features as a means of developing further attention from visitors. The whole of the large stand is devoted exclusively to the display of the new range of Round Tank Oil Circuit Breakers, together with a number of units incorporating this type of breaker. From time to time certain particulars of these circuit breakers and their performance have appeared in this Journal; interested readers will now welcome the opportunity of examining them in detail.

The Stand is dominated by a circular platform supporting a type 'R36' 2000 amps. breaker (Fig. 3), the switch top plate being raised out of the tank and supported by a pillared framework. The breaker is shewn with the contacts opening and closing; the contacts remaining closed for 10 seconds and then open for the same period of time. Above the breaker the F.P. monogram is built up of a number of the firm's standard lamp type semaphores, these also being in operation, red light indicating the 'on' position and green light the 'off' position of the breaker. The breaker is operated by an extremely compact self-contained plant.

Other exhibits are a 33,000 volt, type VTR36 unit, (Figs 1 and 2) and an 11,000 volt type VTR28 unit. Both these units are of duplicate busbar metal-clad design, incorporating round tank breakers, equipped with all the latest developments and complete with oil circuit breaker trucks.

A breaker truck of an entirely new type and incorporating motor operated raising and lowering gear is shewn. A type BV drawout Enclosed Switch unit is also exhibited. The BV is a complete ring main arrangement, complete with transformer switch, of a very interesting nature and the exhibit reveals the extreme compactness and accessibility of this type of gear.

Immediately behind the BV unit, is the Office, which contains a display of photographs and these, together with those displayed on three revolving stands, provide a comprehensive impression of the extent of the service offered by Ferguson Pailin Ltd., and illustrate a number of notable switchgear orders which they have executed.

There are too certain novel features of the Stand which merit particular mention: two gunmetal pillars with apertures invite visitors to look in and turn the knob. One contains a pictorial visit to the factory by means of a very realistic set of stereoscopic photographs. Many of the manufacturing processes of switchgear are illustrated together with some fine examples of modern engineering machinery. The second pillar contains a further set of stereoscopic views, illustrating the story

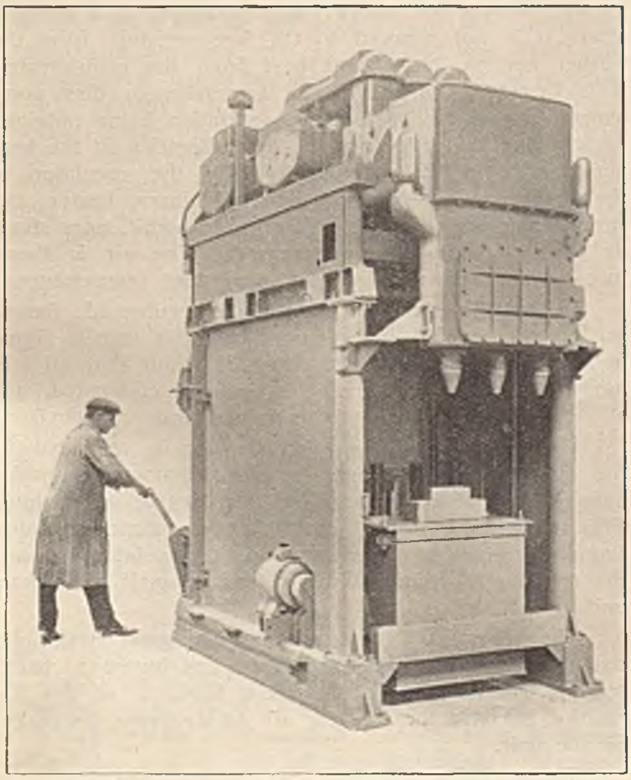


Fig. 1.—A 33,000 volt Metal-clad Unit.

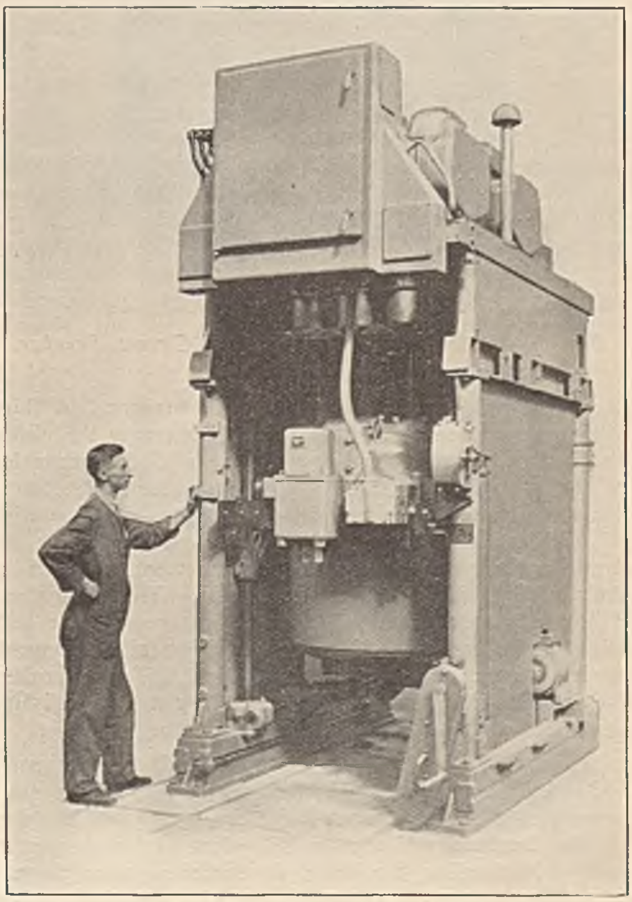


Fig. 2.—A 33,000 volt Metal-clad Unit.

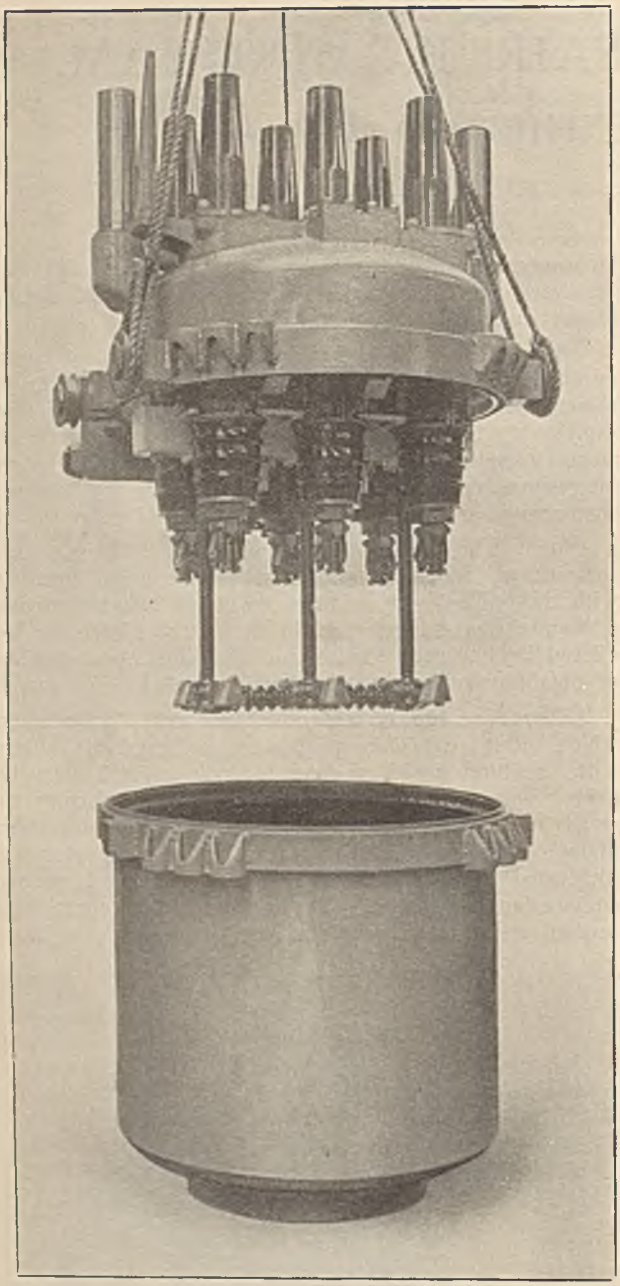


Fig 3.—A 2000 amp. Round Tank Circuit Breaker.

of the manufacture of a round tank breaker. A third pillar surmounted by a glass dome, encourages the visitor by a turn of the handle to witness a demonstration of the remarkable flexibility of the standard F.P. finger contacts, while a similar pillar illustrates the operation of auxiliary contacts. A fifth novel exhibit shews the firm's patented plug-and-socket arrangement, as used on their vertical isolated metal-clad gear. The visitor can "plug-in" and "isolate", and see the remarkable self-aligning features. A triangular, tapering pillar supports models of the complete range of Round Tank Breakers the largest being at the foot and the range diminishing upwards to the type BR1 breaker at the pinnacle.

Round tank breakers, manufactured by Ferguson, Pailin Ltd., were recently subjected to a series of severely over-rated short circuit proving tests, and the film taken of the breakers while actually undergoing and successfully withstanding the tests, is exhibited as a feature of unique interest to all concerned with electrical switchgear.

Davidson & Co., Ltd.

Air Conditioning Plants.

Messrs. Davidson & Co. Ltd., the makers of the well-known "Sirocco" fans, have for many years past been closely identified with heating and ventilating schemes for buildings of every description. Their exhibit on this occasion makes a special feature of air conditioning plants and includes a complete "Sirocco" air conditioning unit in actual work.

Generally speaking it is the aim of an efficient ventilating installation to reproduce natural conditions as far as possible, and to provide an atmosphere that is comparatively free from dust and dirt, odour and gases; which has a normal natural temperature and moisture content and which affords sufficient air movement to overcome stagnation and to cool the body surfaces and gently stimulate the skin nerves.

The growing appreciation of the pecuniary value of mechanical ventilation, whether it be for the comfort of an audience at a theatre or its influence upon the health, and therefore upon the output, of operatives in a factory has brought in its train the introduction of certain refinements in the form of air conditioning apparatus by means of which it is possible to control very closely the physical properties of the air and to maintain it automatically at a uniform standard, irrespective of outside atmospheric variations. The air conditioning unit here shewn in operation demonstrates what can be done in this respect and how it is possible to furnish an air supply not only at a constant fixed temperature but having also a definite moisture content.

The unit comprises a preliminary air heater, spray water heater, air washer, main air heater, and fan. The preliminary air heater raises the temperature of the incoming air to a predetermined degree above freezing point. In passing through the fine mist in the spray chamber of the washer the air is not only cleansed of its impurities but acquires also a state of high relative humidity. A thermostatic regulator is fixed at the outlet end of the air washer and arranged in a position where it is not exposed to the free moisture from the washer nor to the radiant heat from the main heater. It is therefore subject to the saturation or dew point temperature of the passing air, saturation being obtained by warming the spray water. Any alteration in the temperature is instantly transmitted by the regulator to the diaphragm valves on the preliminary heater and spray water heater which will open to admit more steam or close according to requirement. The air is therefore always saturated and at a constant temperature.

In the "Sirocco" air washer the number of eliminator plates provided is in excess of those usually found in most other air washers, with the result that all free moisture in the air current is entirely eliminated, and all risk of trouble due to entrained water is obviated.

Upon leaving the washer the air is re-heated by the main heater to a predetermined temperature which automatically gives the required final degree of humidity. This temperature is kept constant by a second regulator. Impulse is given to the valves and the regulators through the medium of compressed air from a small compressor unit.

The recording instruments on the panel beside the unit shew not only the temperature and humidity characteristics of the air in the main building of the Exhibition but also those of the air supply being discharged by the unit.

The use of a "Sirocco" air conditioning plant is by no means solely confined to the heating and ventilating

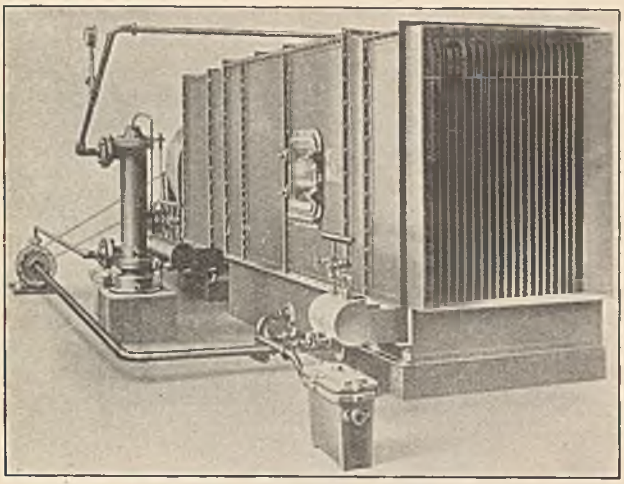


Fig. 1.—An Air-conditioning Unit.

of buildings: air conditioning is of great importance in many manufacturing processes owing to the influence that the nature of the air in the factory has upon the quality of the products and the method of their manufacture. The manufacture of some articles demands an atmosphere of high moisture content, as in the case of certain textile processes; other articles require comparatively dry air as a high degree of humidity adversely affects the quality of the goods, such as in the making of chocolate and sweets; or humid air may slow up the rate of production and even bring it to a standstill as is the case in the manufacture of matches.

The essentials of an air conditioning plant as applied to industry are similar to those of a ventilating scheme, but the requirements are usually more exacting and demand a more accurate system of control. While purity of the air supply and suitable temperature conditions require due consideration, the most important factor of all is humidity. The moisture content of the air in a factory has often to be maintained strictly within certain specified limits and as the humidity of the outside air is a variable quantity, the air conditioning plant must be so designed that it can increase or reduce the moisture of the in-coming air so as to maintain the required standard inside the building. The "Sirocco" air conditioning unit fulfills these requirements and provides a positive means of controlling the quality of the air supply: it is, moreover, capable of great flexibility in its method of application to suit individual requirements.

Large Workshop Heating.

The "Sirocco" steam turbine heater unit, exhibited in operation exemplifies an efficient and economical means of heating workshops where the cubic content of the building is large in comparison with the number of occupants therein, and where, consequently, heat is the main factor and ventilation is of a secondary importance. In this unit the power for operating the fan is provided by the steam required for heating purposes. No electric wiring is required, only steam and drain connections are necessary while the warm air is delivered near the floor level where it is most needed.

Induced Draught Fans.

A striking exhibit, of particular interest to power engineers, is the wheel of a "Sirocco" induced draught fan complete with its bearings. The wheel is 80 inches in diameter and is one of the forty-eight "Sirocco" mechanical boiler draught fans on order for the new Battersea super power station. This particular size of fan is designed to deal with a duty of 51,500 cubic feet of gases per minute against 15¼ inches water-gauge.

A. Reyrolle & Co., Ltd.

Detachable Cable Dividing Boxes.

The detachable cable dividing boxes, known as "Flit-Plugs," are metal-clad and of liberal design to withstand the rough usage generally experienced in the mining industry. Their principal use is for extending and linking up cable to gate-end switchgear or other such apparatus. They are of the plug-in type, and consist essentially of a compound-filled cable-sealing chamber having a flame-proof gland at one end, and a moulded insulator—which houses either plug or socket contacts—at the other. When these flit-plugs are applied to gate-end switchgear, they are uncoupled from the switchgear when the linking-up cable has to be extended, and a length of cable with a flit-plug at each end is interposed with no more trouble than the mere action of plugging in and bolting up. This enables such operations to be carried out very quickly and conveniently.

"Mothergate" Mining Switchgear.

The type "MK1" metal-clad portable circuit breaker exhibited is a typical example of the Reyrolle smaller

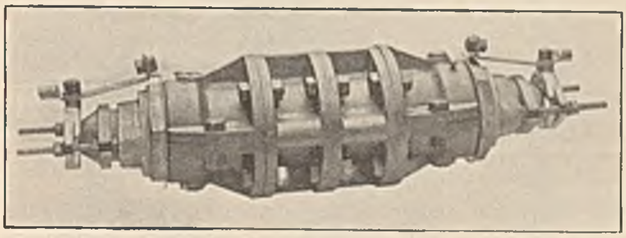


Fig. 1.—A Mining "Flit-Plug."

mining switchgear. This "Mothergate" switchgear has been specially developed to meet the many requirements of coalcutting schemes and the like, and a number of similar units may be mounted side-by-side on a skid, to provide a portable distribution centre. Each circuit breaker is fitted with a plug of suitable rating for the trailing cable; the incoming dividing box is easily detachable, and, by virtue of its plug-in feature, facilitates

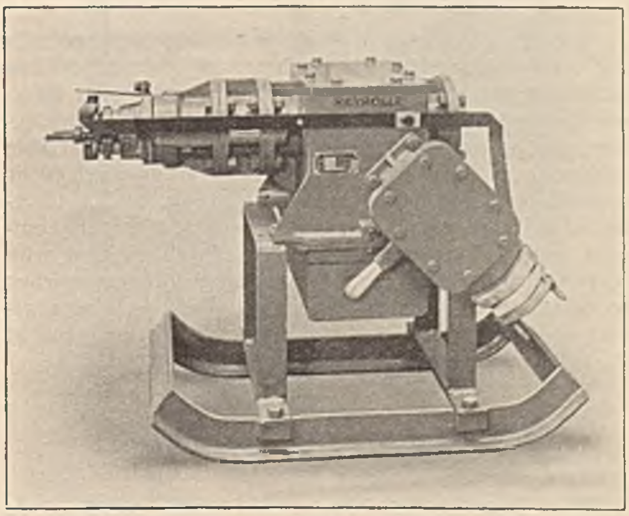


Fig. 2.—Mining Metal-clad Portable Circuit Breaker.

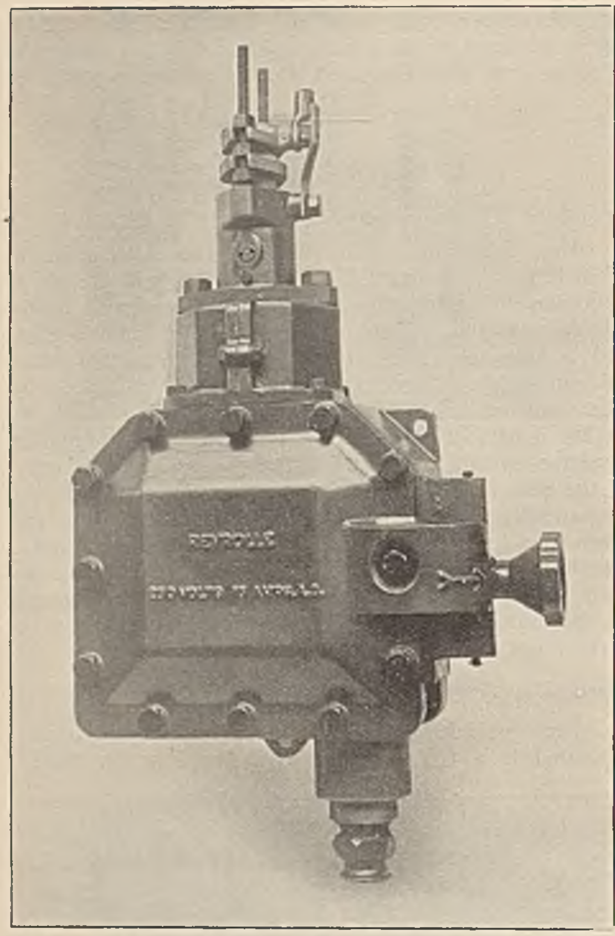


Fig. 3.—Mining Type Air-break Reversing Switch.

cable extension and obviates jointing when moving the switchgear to a new position. A complete system of interlocking is provided between the circuit breaker and the plug of each unit, so that incorrect operation is impossible.

The unit exhibited is of 100-ampere rating and is fitted with time-limit overload protection, with an adjustable time lag. Other forms of protection may be provided, such as an under-voltage release, core-balance earth-leakage, or Reyrolle earthed-pilot protection, which provides an electrical interlock with the coalcutter or other machine.

Air-Break Reversing Switch.

The new air-break reversing switch has been specially developed for use in conjunction with electric drilling machines. The complete arrangement consists of a three-pole double-throw switch and three single-pole cartridge-type fuses in a robust cast-iron case; an incoming cable dividing box fitted with a detachable sealing gland is mounted on the top of the switch casing, and a three-pin-and-earth plug and socket is provided for the outgoing cable. The plug is mechanically interlocked with the switch handle so that it cannot be withdrawn when the switch is in the "on" position. The whole arrangement is flame-proof, and the rating is 15 amperes at 250 volts, three-phase.

J. H. Holmes & Co., Ltd.

Totally Enclosed Ventilated Motors.

This Company exhibits on the same stand as A. Reyrolle & Co. Ltd., with whom they are associated, some examples of their wide range of electric motors.

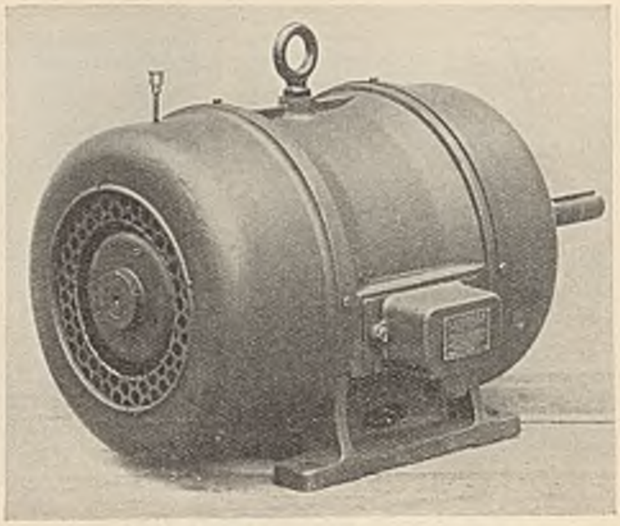


Fig. 1.—Totally Enclosed Ventilated Motor.

These include two three-phase squirrel-cage induction motors, one of flame-proof design, and the other totally enclosed, external fan ventilated. A variable-speed motor of the alternating-current commutator type is also shewn.

The totally enclosed external fan ventilated motors have been specially designed for service in situations requiring complete enclosure of the windings and working parts, as protection against dust and dampness in the atmosphere. The motor proper is enclosed by an inner dustproof and weatherproof casing and, in addition, an outer casing which is part of the motor frame provides an annular space through which cooling air is driven by means of a fan mounted externally on the motor shaft. The particular motor shewn is arranged for star-delta starting, and is rated at 28 b.h.p., at 770 r.p.m., and 440 volts.

Flame-proof Motors.

The flame-proof motor exhibited is rated at 5 b.h.p., at 760 r.p.m. and 440 volts. The design is such that, when required, a switch and trifurcating box, or a switch and a plug, or a trifurcating box only (all necessarily of the flame-proof type) may be fitted without any alteration of the standard design. The example shewn is

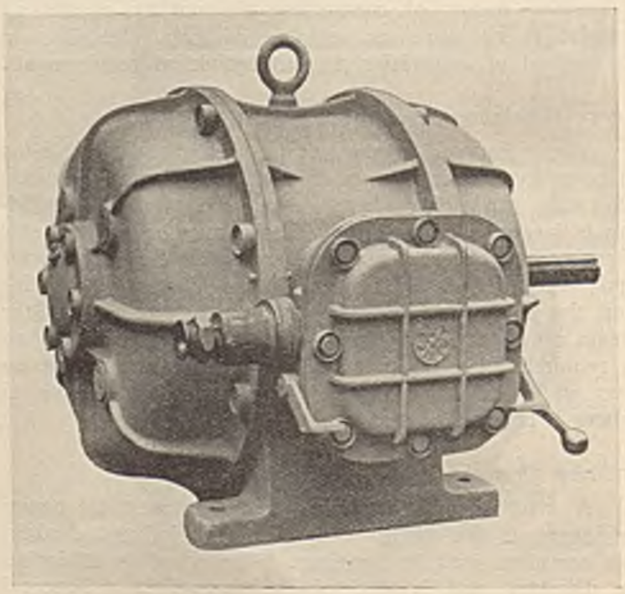


Fig. 2.—Flame-proof Motor.

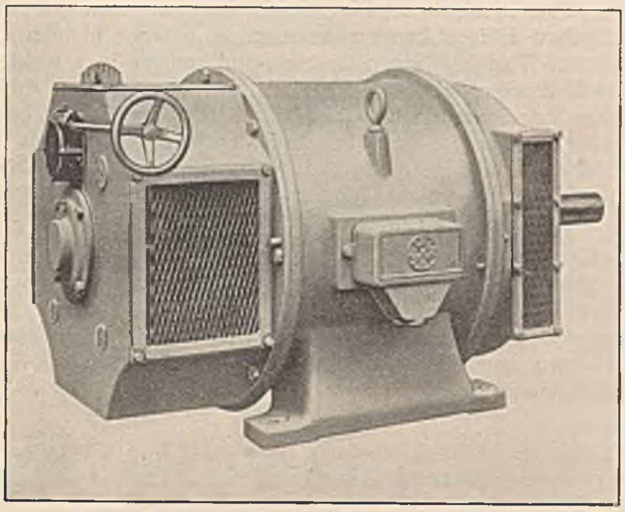


Fig. 3.—*Variable Speed A.C. Commutator Motor.*

provided with a triple-pole non-automatic flame-proof switch, and a Reyrolle flame-proof plug for the incoming cable.

Variable Speed A.C. Comutator Motors.

The commutator motor exhibited is for three-phase circuits at 400 volts 50 cycles; it is rated at 35 h.p.—11 h.p., with a speed range of 1050 r.p.m.—350 r.p.m. Although this particular machine has a speed-range of 3 to 1 only, it is possible to design similar machines for ranges of speed up to as great as 10 to 1. Complete control of the motor during starting and running is effected by movement of the brush rocker, which may be operated by means of a hand wheel or, alternatively, by a small pilot motor when control from a distance is required. A transformer connected between the line terminals and the stator, and a triple-pole circuit breaker are all that is necessary for the starting equipment. A low starting current combined with high starting torque is obtained when the brush rocker is in the starting position.

This type of motor has a speed characteristic similar to that of a direct current series-wound motor, and it is particularly suitable for driving fans, pumps, compressors, etc. where a variable output is required. It may also be adapted with advantage when frequent starting is essential. Such motors have been applied to the driving of spinning frames in the textile industry; and they are also suitable for use where the speed can be kept under constant control by hand or automatic adjustment according to the load, a condition that frequently applies to small rolling mill drives.

The speed is independent of the number of poles for which the machine is wound, and synchronous speed occurs at an intermediate value of the speed range. The power factor is high, and approaches unity for synchronous speeds and above, and an appreciable fall in power factor is only experienced when the speed falls below 75% of synchronous speed. The elimination of resistances, usually necessary in other methods of speed control, enables a high efficiency to be obtained throughout the whole speed range.

George Ellison, Ltd.

Modern Industrial Switchgear.

The Ellison exhibit comprises a range of switchgear for the control of electric power and machinery in factory, mill, mine and industrial works. The examples include pole-mounting, air-break switches for overhead power branch lines up to 33,000 volts, of which a new 11,000 volt specimen is shewn; 11,000 volt cubicle and truck type metal-clad units for indoor substations; heavy current 660 volt metal-clad switch units for the secondary side of power transformers; drawout and non-drawout types of power distribution switchgear and double-tier switchgear for substations where floor space is limited.

For controlling motor-driven machinery several types of starting and protecting gear are shewn, including drum type controllers, star-delta and auto-transformer starters and rotor resistance starters with circuit breakers. Limit switches, solenoids, cable end couplings and other accessories are included in the display. Flame-proof circuit breakers and starters for mines and places where the atmosphere may be inflammable, are also shewn.

Cubicle Type 11,000 *volt Switchgear.*

The metal-clad cubicle type of switchgear unit for 11,000 volt substations is advocated as the best from the point of view of general utility. Any combination of component parts can be arranged and suitably housed without the restrictions and limitations of a cast-iron erection. The cubicle can be sub-divided and built as required, with all connections visible and accessible and the bare copper work can be covered with insulation.

The circuit breakers are of high rupturing capacity and fitted with the usual automatic releases. The isolators

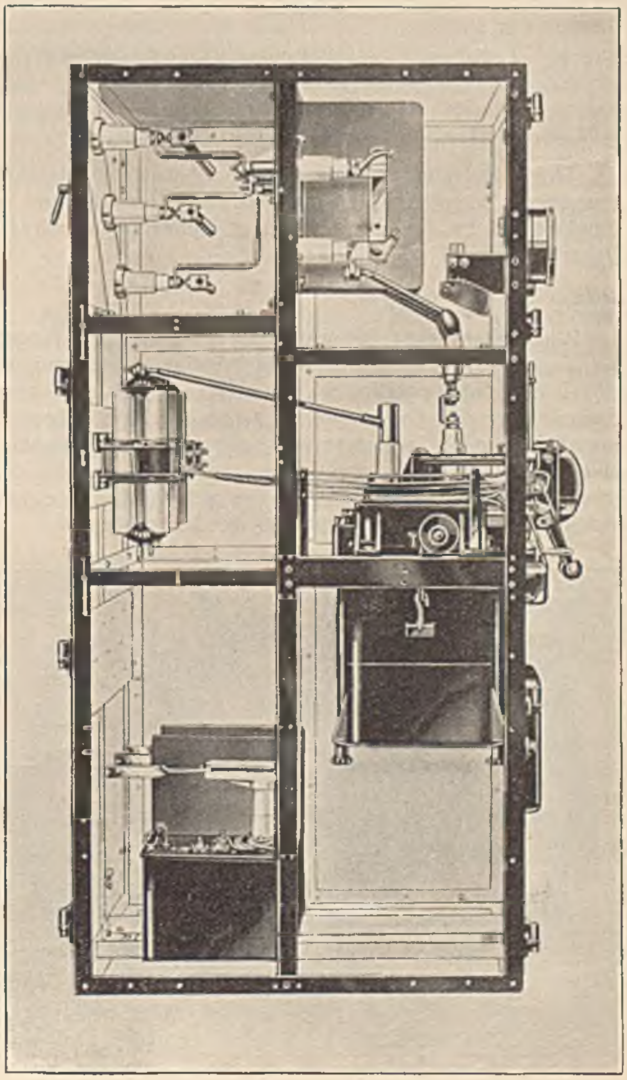


Fig. 1.

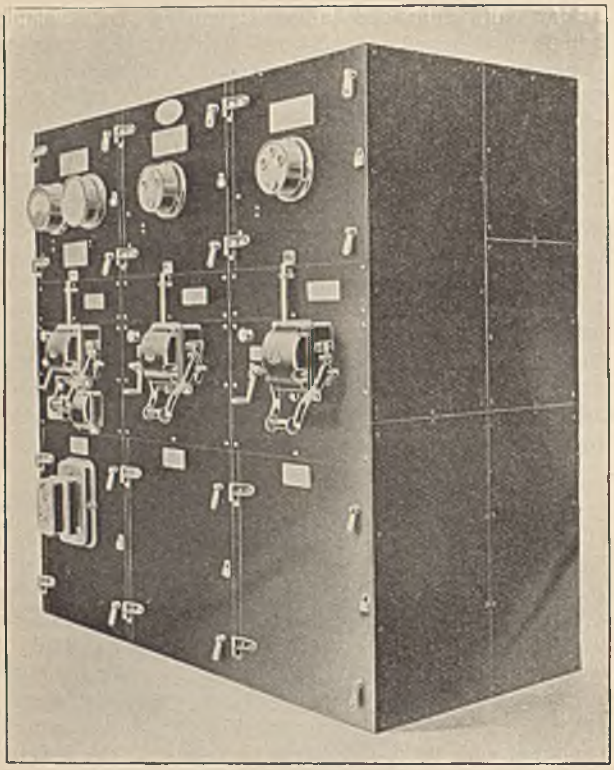


Fig. 2.

may be of the type operated by a hooked insulated rod, or may be operated by a lever-handle on the front interlocked with the breaker. Interlocks are arranged to prevent operating mistakes and secure doors.

The illustrations, Figs. 1 and 2 shew a three-unit consumers' substation switchboard of this design, as standardised by the Birmingham Corporation Electricity Department.

Mining Circuit Breaker.

A circuit breaker for use in mines requires a mounting that facilitates temporary installation work and removal from one position to another. Therefore a good strongly-encased flame-proof air-break circuit breaker mounted on a sledge frame has become the most popular switch for gate ends and other places. Generally the breaker is fitted with a plug for a trailing cable and coupler fittings for an armoured feeder cable.

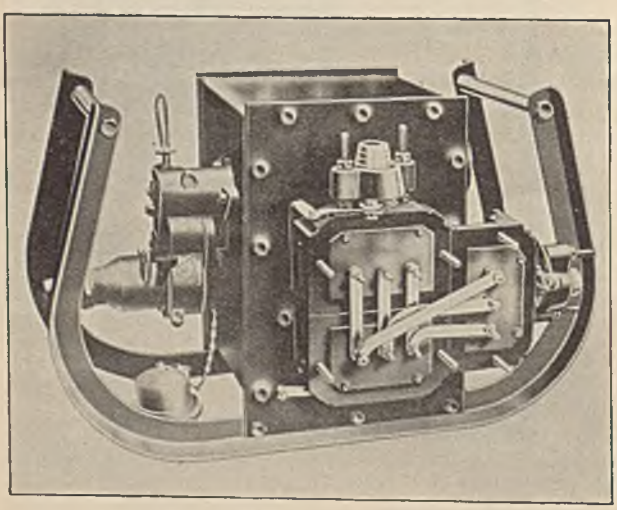


Fig. 3.—Mining Type Circuit Breaker.

The illustration, Fig. 3, is a back view of the standard Ellison breaker as used in a large number of mines. This is a magnetic blow-out breaker in a welded steel flame-proof box on skids, with a trailing cable plug interlocked with the breaker handle and feeder cable couplings at the back of the box. The cover is removed from the cable fitting to shew the links which provide a convenient looping-in arrangement.

The cable end fittings are finished off on the cable before it is taken into the pit and the assembly is then a simple matter. When the breaker has to be moved forward to a new position the cable end fittings are coupled together and the new length of cable with its own end fitting is bolted up, these fittings being interchangeable.

Record Electrical Co., Ltd.

The exhibits of The Record Electrical Co., Ltd., cover a wide range of ammeters, voltmeters, insulation testing sets, electrical tachometers, circuit breakers, etc.

Ammeters and Voltmeters.

Amongst the many items of interest is a complete series of the Company's well-known "Circscale" instruments, covering the moving coil and moving iron types,

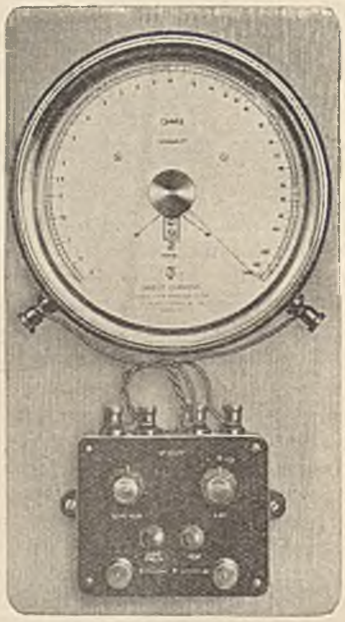


Fig. 1.

for direct and alternating current circuits. Both types have a circular scale and a pointer which deflects through an arc of approximately 300 degs. The moving iron instrument has proved its popularity by the large number specified and used on modern switchgear, the tendency being to use instruments with clear open circular scales.

Portable instruments exhibited include precision moving iron voltmeters for a.c. testing, with negligible frequency errors up to 1000 cycles, complying with B.S. Specification for sub-standard accuracy. Two types of change coil portable instruments are also shewn—a combined voltmeter and ammeter, and a multi-range ameter. The combined voltmeter and ammeter consists of two separate moving iron movements arranged in one case, the voltmeter being provided with five ranges from 1—750 volts, while on the ammeter side six scales are provided, giving ranges from 1—600 amperes inclusive.

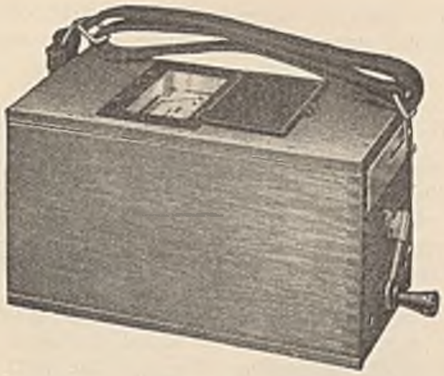


Fig. 2.

For each range a separate ammeter scale is marked on a drum, which rotates by depressing two knobs at the end of the drum, thus overcoming the disadvantages of having many scales on the one dial. The test set is complete in itself, all the coils being housed in a receptacle in the case. The other set shewn has been designed on similar lines for a multi-range ammeter only, the ranges being the same as given. This instrument is particularly useful to engineers, who generally know the voltage of the circuit, but not the load current.

Insulation and Resistance Testing Instruments.

Another interesting exhibit is the Cirscale workshop ohmmeter, having three ranges, the chief advantages being direct reading, no calculations, quick action and dead beat. The Cirscale indicator, reading direct in ohms, is complete with a special resistance box having a wheatstone bridge circuit, voltage regulator and test switch. It has 16 inches of long clear scale, differences of 1 per cent. of ohmic value are discernible, and the calibration is accurate to within 2 per cent. on any part of the scale. It can be operated from dry cells, or accumulators, or, by the addition of a suitable resistance, on d.c. supply mains. The draw from the battery is small, as the maximum current for any value of x on any range will not exceed 20 milliamperes. An illustration is given in Fig. 1.

Among the large selection of insulation and resistance testing instruments exhibited may also be mentioned a new model ohmmeter (light-weight) reading up to 2000 megohms, complete with 1000 volt constant pressure generator. Fig. 2 illustrates this model, combined in a strong teak case with special carrying handle, which can be used as a shoulder strap.

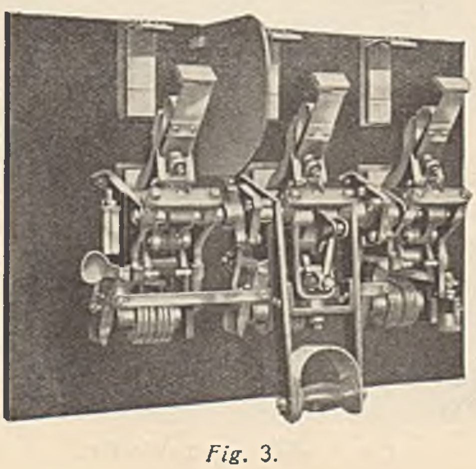


Fig. 3.

Ratiometers.

The Record Company also manufacture and exhibit a range of ratiometers for a.c. and d.c., for use as helm indicators, valve position indicators, or switch positions for transformer tappings, water level indication, etc., etc.

Electrical Tachometers.

The "Cirscale" electrical tachometers are worthy of note. They can be supplied for use in workshops, ships, and aircraft. The apparatus, which consists of a "Cirscale" voltmeter calibrated in conjunction with a magneto generator giving an output of one volt for 30 r.p.m., makes a very convenient distant indicator. The scale is twice the length of the dial diameter and is evenly divided and visible at a distance. It may be calibrated in "revs. per minute", "copies per hour", or any other desired equivalent.

Circuit Breakers.

Considerable progess has been made in connection with the Record single, double, and triple pole automatic circuit breakers for alternating current, varying in capacities from 15 to 2000 amperes. The breakers are of robust design and liberally rated, the mechanism is a simple toggle action operated by a catch and roller. A loose handle feature is provided to prevent the breaker being closed or held closed on an overload. The brush is a special feature, being self-aligning in all directions, and it can readily be removed for replacing. No-volt or shunt trip devices and time lags are separate attachments and can be added at any time. An illustration of a triple pole breaker is given in Fig. 3. All sizes can be supplied in protecting covers and arranged for front or side handle operation to suit individual requirements.

Gent & Co., Ltd.

Visual and Audible Signals, Relays, etc.

A remarkably representative display of the very many electrical signalling, recording and indicating appliances with which this Company has established a world-wide reputation provides a most attractive exhibit. It is only possible here to mention a few of the more distinctive novelties. One of these is the new relay for remote electrical control. It is suitable for operating from either a.c. or d.c. mains or from a battery circuit. When the armature is at rest, it closes certain circuits, but when attracted it closes other circuits, breaking the original circuit. The armature is locked by the armature of the coil release, and remains so until a current is sent through the release coil. One great advantage of this relay is that the operating coil cuts itself out of circuit after operating. It is therefore suitable for working with small batteries and is very useful for operating motor syrens for fire alarm purposes or from "high" and "low" liquid level contacts, "on" and "off" switches and many other purposes where reliable automatic warnings are desired.

There is also a new main switch relay operated by and suitable for dealing with heavy power currents from a distance. This is fitted in a cast-iron metal case. The switch may be of double or triple pole up to 50 amps. or more, 500 volts, and can be arranged to be closed (or opened if so designed) by a relay and tripping gear. The relay coils can be operated by a.c. or d.c. mains or a battery circuit. These coils are cut out of action on being operated, and so only a feeble current is required to operate the switch.

A new pressure gauge contact is also shewn. This has an adjustable contact arrangement for "making" when pressure rises or falls and so operates a sound signal or lamp, or other apparatus as may be required.

Other notable items include liquid level alarms, indicators and recorders for working over any distance step-by-step following the rise and fall of levels. Also a diversion relay suitable for a.c. or d.c. mains which cannot be left out of commission. Motor syrens suitable for a.c. or d.c. mains ranging from 1/10th to two h.p. suitable for fire alarm, and sound signals in mines, factories, etc. For mining service there are the familiar types of "Tangent" flame-proof bells, relays, keys of new and improved patterns, telephones and switchboards ironclad, shaft signalling transmitters and indicators.

As of general interest may be mentioned the modern police signal lamp relays passed by the G.P.O. for use in many large towns. These relays are so arranged that a call being given to a police telephone box operates a coloured light outside, which shines until the call is answered, or extinguished by the operator. In connection with this a flashing coloured signal can be given by the use of a scintillator. This latter is now being used in large works as a special signal for various purposes.

Clocks and Time Mechanisms.

Gent & Co. Ltd., have for many years specialised in the manufacture of "engineer built" clocks. Examples of their work here shewn include the new "Tangent" self-winding clocks suitable for connecting direct to a.c. or d.c. mains. These clocks do not depend on the frequency of the supply mains, being operated by their own escapements, and will "carry-on" for about 1½ hours if current is "cut off." Another exhibit is the new "Electromatic" a.c. mains clock suitable for 50 periods and for use on supply mains in which the frequency is controlled so that a standard time system is assured. Then there are the "Pul-Syn-Etic" electric clocks of various designs operated by a master clock on the stand and also the thirty clocks hung in different parts of the Exhibition. There is a "Pul-SynEtic" clock consisting of three dials operated by the "waiting train" movement; and, finally, a very large hundredweight bell, suitable for towers, and the striking apparatus which counts the hours thereon, this latter being energised from the electric mains.

British Insulated Cables, Ltd.

The B. I. people have, in their exhibit, availed themselves in a striking manner of the attractive features of divers materials and appliances which are among their staple manufacture. In the fittings of the Stand itself liberal use has been made of the copper and aluminium sheets, matting, mouldings, etc. produced at the Prescot Works of the Company. The office is entirely sheeted with metals, the roof being covered with Prescot roofing copper in the "Council Roof" style, while B.I. glazing sections are used in the glazing of the window.

Among other exhibits are bare and covered wires, extruded sections, meters, cutouts and other accessories, primary batteries, static condensers, solders, soldering paste and paper pinions.

A new range of underground cable boxes including network and service boxes: the latest type of Prescot feeder pillar with improved unit: and examples of the latest B.I. standards of pole line construction are all of exceptional interest as indicative of the very latest practice.

Electric Welding Machines.

For many years British Insulated Cables Ltd. have enjoyed the reputation of being leading British manufacturers of electric welding plant and machines. For the first time four of the latest designs are here shewn publicly, and all four in actual operation.

The four machines are: The Seam Welder, No. 102L, for work up to .048 in. added thickness, suitable for drum or bucket making (Fig. 1); the Butt Welder, No. 101, designed for butt welding fine copper wires down to 30 S.W.G., 0.0124 in. dia. (Fig. 2); the automatic Butt Welder, No. 92, for sections up to 2 sq. ins. (Fig. 3); and the 3-head 30 k.w. Rivet Heater of the latest pattern, designed to heat rivets up to 1 in. dia.

The Seam Welder No. 102L is specially arranged for welding cylinders for drums, buckets etc. It consists of a 15 k.w. single-phase static transformer enclosed in a cast-iron body mounted on cast-iron legs.

The top electrode consists of a copper roller 7 ins. dia. × 1 in. face with a welding path about ¼ in. wide. This electrode is hinged on to a travelling carriage operated by a screw. Motion is transmitted from the driving pulley to the screw through a gear box and reversible clutch. The clutch is closed by hand lever fitted on the front of the carriage rails and is opened automatically at each end of the travel. The bottom electrode is of the fixed rail type. Both the top and bottom electrodes are arranged for water cooling.

To obviate the necessity of spot welding the edges of the metal together, the cylinders may be clamped round the bottom stake, in which case a former to fit the inside of the body and outside clamps are provided. Back stops for location are provided. A line is cut in the bottom electrode to enable the operator to locate correctly the right hand edge of the body prior to clamping. The outside clamp is made in two or three sections, each with its own operating lever. One section takes care of the lower half of the body whilst the re-

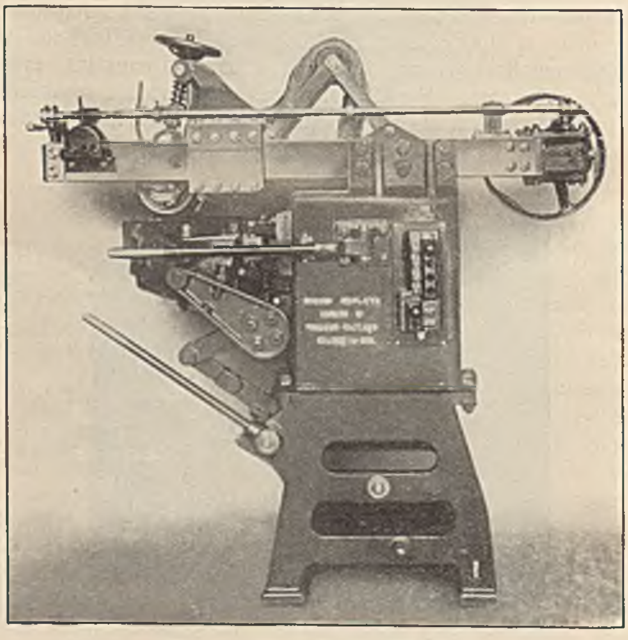


Fig. 1.—The Seam Welder.

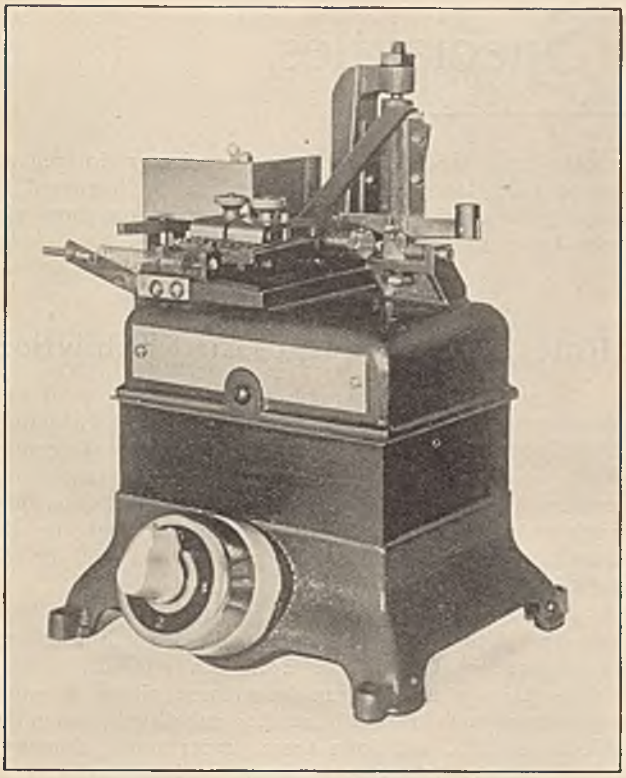


Fig. 2.—The Butt Welder for fine wires.

maining two hold the upper half, thus ensuring a constant overlap of the edges of the drum or cylinder. In certain cases the lower clamp is unnecessary.

Mechanical pressure is applied to the weld by an adjustable compression spring which is adjusted by means of a knurled nut. A hand wheel is provided to raise and lower the top electrode. Eight heating speeds are provided through the medium of a plug box.

The electrical control gear consists of a single pole double break a.c. contactor automatically operated by a throw-over switch placed near the clutch control lever.

Two regulating screws attached to the clutch operating rod are so adjusted that when the clutch is thrown in by lever the control switch automatically closes, and when the end of the weld is reached it is opened by the motion of the rod which opens the clutch.

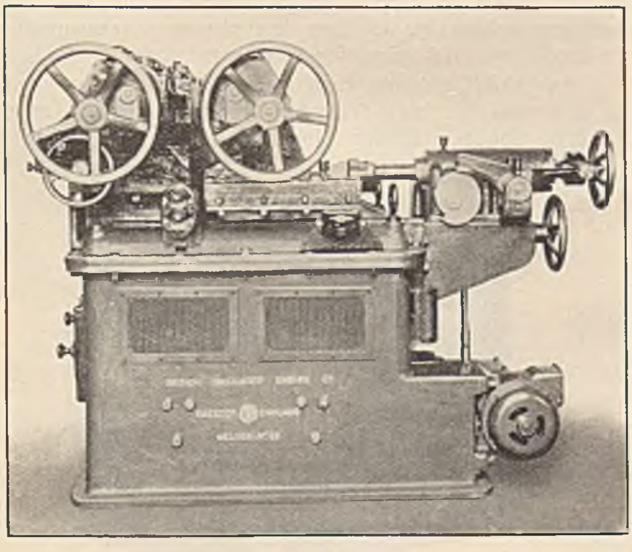


Fig. 3.—The Automatic Butt Welder for heavier work.

The Butt Welder, No. 101, has been designed to weld fine gauges of copper wire down to 0.0124 in. diameter. The wires to be welded are clamped in the machine in the usual manner, after which the swinging arm is released, the current applied by the small switch lever, and the weld is automatically made.

The machine consists of a small single phase alternating current transformer, the primary being wound for any of the usual supply voltages. There is a plug and flexible cord at the back of the machine to which must be connected the adapter or plug to suit the customer's connection.

On the front of the machine is a regulating switch with four positions. "Zero" is on open circuit, and "1," "2," and "3" are fast, medium and slow speeds respectively.

The clamps are mounted on the top of the machine, the one on the left-hand side being fixed to the base and that on the right mounted on a swinging arm. This arm is kept in an open position by means of a small lever. This is capable of adjustment by means of a suitable screw. The movement of this screw in either direction opens or closes the gap between the two clamps.

On the top of the machine is a small operating switch. This switch is double acting, the circuit being closed by hand and opened by means of a knock-off rod attached to the swinging arm of the machine.

The Automatic Butt Welder, No. 92, is for welding up to 2 sq. in. section. It has been designed for welding flanges on to tubes, mild steel forgings on to tubes, and other metal sections. Where large quantities of parts have to be produced it is essential that the correct sequence of operations should be performed uniformly every time, and it is only possible to do this by automatic means.

The machine consists of a standard transformer and clamping gear, but with special mechanism for welding. The parts to be welded are fixed in the machine with suitable clamping gear which may be either hand or power operated. The welding operation is thereafter entirely automatic.

A self-contained electric motor drives the upset gear. This is set in motion, the slide is slightly withdrawn, the current automatically switched on and then the slide moves slowly forward. When the parts to be welded make contact the usual flashing takes place and this is continued for a pre-determined time allowing the two ends to become incandescent, ready for the final upsetting pressure. This is applied by means of a powerful spring, and its energy is released after the flashing has taken place. The metal is upset and the current automatically switched off. The work is then ready for removing from the machine. The operating switch is changed over, which causes the slide to be withdrawn to its original position. Two more pieces are then inserted in the machine and the switch once more changed over, and the same cycle of operations is repeated.

By means of this machine thousands of welds can be made exactly similar, with the knowledge that the correct upsetting pressure has been applied to each one. The current is controlled by means of suitable cams on the driving shaft, and when the machine has once been set no further adjustment is required when welding one class of material.

Manufacturers' Specialities.

Dwarf Circuit Breakers.

The present tendency to use circuit breakers instead of fuse boards will be enhanced by the introduction of a small double-pole breaker made by the General Electric Co., Ltd. It is common knowledge that fusible cutouts frequently lack accuracy and dependability of operation, partly due to the ease with which their protective powers are nullified by the incorrect replacement of fuse wires. To this disadvantage is added the common inconvenience of unnecessary and prolonged interruptions of the circuit.

The G.E.C. double pole "Dwarf" circuit breaker is made in suitable capacities (2 to 15 amperes, for a.c. or d.c. up to 250 volts) for controlling smaller power and domestic appliances. Its particular advantages are: it can be used as a switch; it operates at a definite overload, with no liability to deterioration or abuse; a simple reinstatement of circuit by operating handle of breaker; a loose handle feature prevents the breaker being held closed if the fault still persists; no risk of shocks or burns as is often the case in replacing a fuse in a faulty circuit.

Under working conditions the "Dwarf" circuit breaker operates instantaneously on overload or short circuit. The breaker can, however, be used as a switch even when the circuit controlled takes an initial current much larger than the normal current, an oversetting device being provided which can be brought into operation by pressing a push-button while making the circuit; if the current exceeds the oversetting value the breaker operates instantaneously, whereas with time limit devices the fault has to exist for an appreciable time before the circuit is broken. The overload calibration is about 100 per cent. above the normal capacity, and the oversetting device increases the amount of initial current, that can be dealt with before tripping, to four to six times the normal.

Compactness has been studied, so that, when substituted for a switch and fuse, considerably less space is occupied on switch and distribution boards. A non-metallic fireproof cover of moulded insulation is mounted on a porcelain base, in which grooves are provided to enable connections to be brought in at the top and bottom. The terminals are arranged for back or front entry, and the wiring is as simple as that of a switch and fuse.

The breaker can be sealed to prevent interference by unauthorised persons, saving Supply Companies the trouble and expense of sending engineers to replace blown main fuses, as these fuses can be increased in capacity or eliminated entirely, protection on short circuits being given by the circuit breaker.

Henley's and the Buenos Aires Exhibition.

In addition to being one of the earliest exhibitors to take space at the British Empire Trade Exhibition at Buenos Aires, Messrs. W. T. Henley's Telegraph Works Company Ltd., are responsible for the supply and installation of all the cables for the distribution network at the Exhibition. It is estimated that for the electrical services a total load of 3000 k.w. will be required for power and lighting.

There are two static substations from which fourteen main feeders will be run to main distribution pillars at selected positions in the Exhibition grounds. Distribution mains will then run from these pillars to other positions at each of which another sub-distribution pillar will be erected, and from these, underground armoured cables will be laid direct to the various pavilions or illuminating circuits.

The distribution to the pavilions will be so arranged that part of the lighting of each pavilion will be taken from one substation and part from the other. This will ensure that part of the illumination system will function should either one of the two substations break down. This arrangement necessitates a larger number of feeder pillars than would otherwise have been required. All the pillars are of Henley manufacture.

Rubber insulated cable, run on insulators, will be used for the lighting installations of the Pavilions, and these cables will also be used as distributors from which to tap the service cables to the Exhibitors' Stands. The service cable will be run with the Henley Wiring System and will be connected to Isco fuses. The Henley Wiring System or a similar system has been specified for use on the exhibitors' stands.

Henley's comprehensive exhibit features a display of all classes of electric cable ranging from the super pressure cables for modern heavy power transmissions to small insulated wires for instrument work.

An exhibit of more than usual interest is a specimen of a remarkable high frequency cable which was manufactured for the British Government's radio station at

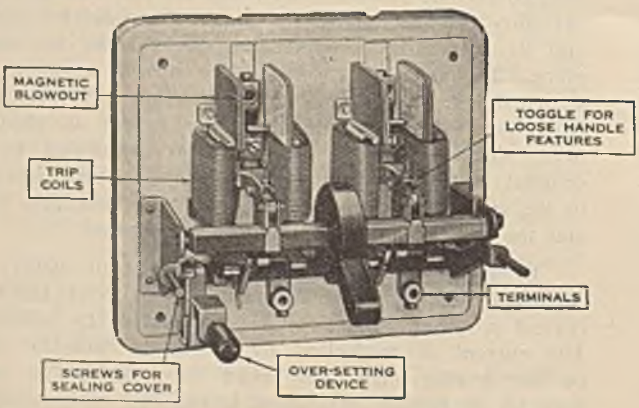


Fig. 1.—The "Dwarf" Circuit Breaker (Open).

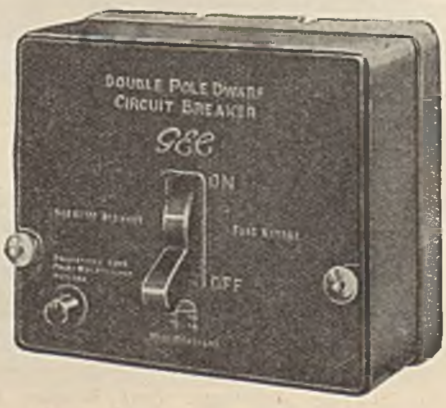


Fig. 2.—The "Dwarf" Circuit Breaker (Closed).

Rugby in 1925, and which forms part of a variable inductance in the high power radio frequency communication circuits. The cable contains 6561 single wires, each of which is separately insulated with enamel and connected together at each end to form what is, to all intents and purposes, one conductor. That is, all the wires are in parallel. The cable has two characteristics. The first is that, considered as a conductor, it is divided into a number of separate elements or wires ; and the second is that the wires are plaited together in such a way that every wire over a given length passes through the same phases as every other wire with regard to the neutral axis. Thus, there is no tendency for a greater retardation (or impedance) due to the high frequency, on any one wire more than on any other.

This interesting cable was constructed in accordance with the design and specifications of the British Post Office Engineering Department. Special plant and machinery had to be designed and constructed to enable it to be manufactured.

One Showcase is entirely devoted to underwater cables, in the manufacture and laying of which Henley's have an experience dating back to the earliest days of submarine cables.

Other specialities being exhibited are Henlex and Herculene insulated cables, the former being particularly suitable for railway signalling work and having been largely used at home and abroad ; and the latter being widely in demand for colliery installation work such as for shaft and inbye mains and for underground mains where it may not be possible or desirable to use lead covered cables.

The house-wiring section of the Company's exhibit includes rubber and paper insulated cables and specimens of the Henley Wiring System, which is being installed for some of the interior work in the Exhibition.

In the section of the Henley Stand devoted to works of the Engineering Department are shewn Unit Pillars, Isco Cut-outs, Disconnecting Boxes—fuse and link type, Terminal Boxes, Underground Cable-grip Boxes, High Tension Straight-through Joints and Overhead Line Accessories.

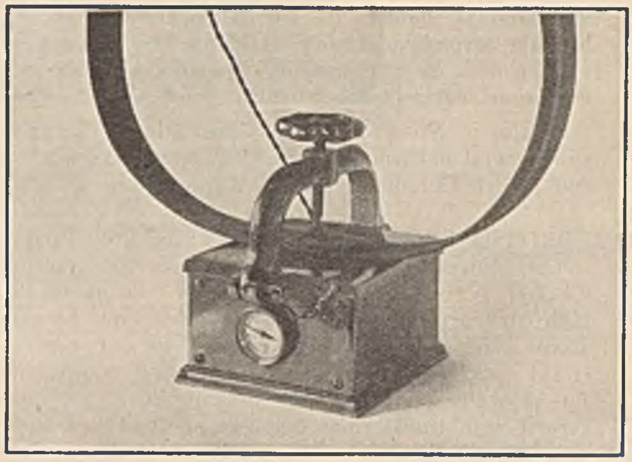
Henley's Tyre and Rubber Company, a subsidiary company of the Cable Company, is shewing a display of pyramids of tennis and golf balls.

Portable Electric Vulcaniser for Belts, &c.

"Vul-K-Lec" is the trade name under which the new portable electric vulcaniser, illustrated here, is marketed by Messrs. L. W. Bindon & Co. It is standardised in types to suit any normal voltage, and can be used wherever there is an electric point. It will make vulcanised repairs and joints in pneumatic tyres and covers, canvas belting and canvas hose, rubber belting, rubber hose, etc.

There are two sizes available ; the larger model has a vulcanising surface 8 inches wide, and the smaller model one 5 inches wide. Two clamp arms are supplied with each, one for flat subjects, and one for tubular or arched pieces.

In eight minutes the machine reaches baking heat, as indicated by the pyrometer fixed on the front of the apparatus. Once the machine has attained baking heat, it should be switched off, but the full heat can be maintained for as long as required by switching on again for about one minute in every ten.



Portable Electric Vulcaniser.

Belts can be lengthened with this machine, and at the same time made endless by letting in the extra belting required ; it has been proved in actual practice that by employing belts so made endless the saving of electrical energy is from 15 to 17 per cent. This is because there is no joint to jump the pulleys, and create slip, which is a waste of energy.

When the "Vul-K-Lec" system is applied to the vulcanising or rejointing of broken belting, the broken ends of the belt are first bevelled to one and a half times the thickness so that, when the two ends are placed together, they are the same thickness as the belt itself. Both bevels are covered with flux and joined face to face as soon as the flux gets tacky. With absorbent cloth on both sides of the joint, the joint is baked in the machine for ten to fifteen minutes on each side of the joint for 4-ply, and for longer periods for heavier belts. Thus a broken belt can be repaired in this manner, on site, in half-an-hour or so : and the average cost per joint will average less than a penny.

In the case of fire hose and canvas repairs, the edges of the tear are covered with flux, and the actual rent filled with a strip of buff compound. A small canvas patch, large enough to cover about one inch on either side of the rent for one inch at each end, is cut and pressed over the rent, rolled with the roller, and baked in the machine for ten to fifteen minutes.

It will be seen that this useful appliance can be employed in any part of the works, factory, or mine with equal efficiency and convenience. Its property of retaining baking heat without continually using electrical energy makes its maintenance a negligible quantity. Messrs. L. W. Bindon & Co. offer to give a special demonstration in any workshop or factory, and the making of a joint or repair, under normal working conditions, free and without obligation.

NEW CATALOGUES.

BRITISH INSULATED CABLES Ltd., Prescot, Lancs.—Ship Wiring is the subject of an interesting illustrated catalogue directing particular attention to the B.I. "H.R." type, Paper, and Varnished Cambric Cables.

An art publication running to over fifty pages tells mainly by illustrations the extent and scope of the Prescot and Helsby Factories of the Company. The international nature of the Company's work is brought prominently into evidence by means of photographic descriptions of installations carried out in various parts of the world.

Catalogue No. P. 256 gives illustrations, diagrams and general particulars of the B.I. Iron-clad Switches and Switch Cutouts.

THE BRITISH THOMSON-HOUSTON Co., Ltd., Rugby. —The November-December issue of the journal "B.T.H. Activities and Developments" maintains the high standard to which readers have now become accustomed. Of particular interest to our readers is the article describing special electrical equipments for oil-well service. Other notable items are concerned with transformer tappings on load and rural area distribution.

Many new publications including No. 5801/1 Alternating Current Brake Magnets; 5362/1 D.C. Motor Control Panels; 5271/1 Air-break Auto-transformer Starters; 2110/1 Alternators (Engine-driven); 5054/1 Mining Plug Distribution Boxes; 5035/1 Mining type A.C. Controllers; 3316/1 Metal-clad Switchgear (draw-out pattern); 4120/7 Isolators; 4159/1 Oil-immersed Circuit Breakers, 660 volts; 5340/L Contactor Panels for Cranes; 4101/1 Air-break Switches for aerial service; 2412/1 Motor Generators up to 250 k.w.; 2194/1 Power Factor Correction Motors; 4223/1 Air-break Circuit Breakers for A.C. and D.C.; 2156 and 2144/1 A.C. Induction Motors; 1112/1 Turbo-alternators; 1105/A Steam Turbines.

CROMPTON PARKINSON Ltd., Guiseley, Leeds.—A lettercard announces changes in prices of standard a.c. and d.c. motors. A colour-printed folder emphasises the position of the Company to give deliveries of standard machines up to 100 h.p. at 24 hours' notice.

Parkinson motors for mines and heavier industrial service with particular reference to the change-over of supply systems is the subject of another colour-printed pamphlet.

Still another broad sheet mentions that "Morris Motors" in their works use hundreds of this Company's electric motors.

THE GENERAL ELECTRIC Co. Ltd., Magnet House, Kingsway, London, W.C. 2.—The technical descriptions No. 309 and No. 310 deal with transformer accessories; the former with the "earthing device" and the latter with "coil clamps."

"Magnet" Conduits and Conduit Fittings are covered fully and in detail in the eighteenth edition of the G.E.C. Catalogue, Section C. There are several new specialities included herein for the first time.

HEYES & Co., Ltd., Wigan.—The January issue of the "Wigan Review" gives an illustrated note describing the mining and technical college of Wigan; it also directs particular attention to the Company's well-known range of flame-proof apparatus.

METROPOLITAN VICKERS ELECTRICAL Co., Ltd., Trafford Park, Manchester.—Of particular interest to mining electrical men is the descriptive leaflet 747/6-1, which gives a very complete technical description with many diagrams and illustrations, of the Harworth Colliery Electric Winders. The records of test results, giving the methods of making the tests and figures and graphs of performance, are of exceptional value.

ELECTRIC CONTROL Ltd., Brighton.—An artistic folder draws attention to the details of construction and the action of the Empire E.H.T. High Rupturing Capacity Fuses.

THE BRITISH ALUMINIUM Co., Ltd., Adelaide House, King William Street, London, E.C. 4.—Under the title "Powdered and Granulated Aluminium" this publication is not strictly a trade catalogue, but is quite a useful hand-book concerning the many ways in which powdered and granulated aluminium is used in these days. It is quite a scientific treatise and will be found very informative by most engineers.

ALLEN WEST & Co., Ltd., Brighton.—Contactor Starters and Air-break Hand Operated Starters are the subject of two exceptionally attractive folders, full particulars and several illustrations are given in each case.

BLACKSTONE & Co., Ltd., Stamford.—Mining engineers are frequently on the lookout for unchokeable pumps and will, in consequence, find this new catalogue No. 468 useful. The pumps referred to are made in standard sizes from 1 inch up to 14 inches in both vertical and horizontal types.

THE MORGAN CRUCIBLE Co., Ltd., Battersea Works, London, S.W. 11.—This publication is a reprint of an article by Mr. C. G. Heys Hallett in which the technicalities of Radiant Heating of Buildings are treated.

THE CLEAN COAL Co., Ltd., Medway House, Horseferry Road, London, S.W. 1.—This Company is distributing a leaflet of a reprint of the Paper by Dr. R. Lessing entitled "Recent Developments in Coal Cleaning".

ROBERT JENKINS & Co., Ltd., Rotherham.—Price lists of welded steel Tanks for Fuel Oil, and pressed steel ground Manhole Covers.

DAVID WILSON & Co., 40 Brazennose Street, Manchester.—Illustrated particulars and prices of "Apex" specialities including Pressure Reducing and Regulating Valves, Bye-pass Relief Valves, Swing Joints, Handhole Covers, etc.

HIGGS MOTORS, Witton, Birmingham.—The pocket price list for February shews an exceptionally complete range of machines in stock.

WILLIAM BRIGGS & SONS, Ltd., Dundee.—Bituminous paints are the speciality this firm advertises in an illustrated folder.

THE WHARTON CRANE & HOIST Co., Ltd., Reddish, Stockport.—Lifting devices and Cranes for loads of 5 cwts. up to 50 tons are described in colour-printed catalogues.

THE KEIGHLEY GEAR Co., Keighley, Yorks.—Spur and Worm Gear particulars, illustrations, and prices are the subject of this very complete catalogue.

DAVID BROWN & SONS (Hudds.), Ltd., Huddersfield. —Technical data sheet No. 1011 deals with speed increasing Gears for deep-well and surface pumps.