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More About Education.

The failure of present educational systems is that they do not develop business ability. Some would go so far as to say that a high degree of education acquired in accordance with the established national code is sometimes a positive disadvantage to the pupil and to his employer when they come to try and pull together in the effort for livelihood. It is perhaps not reasonable to generalise in that manner but it has often been the fact that the sharp boy taken from school and put early into business is, when of age, capable of doing more good for himself and the community than is the equally sharp youth who keeps to the schoolroom and college until his majority. Nor is it assured, as is claimed by "educational" partisans, that the college man ever will overtake the other in the business race. The important point which eventually emerges in any consideration of this subject is that the early cultivation of business ability is an indispensable part of effective education. For, when all is said and done, the education of a people is pursued with the sole intention of providing it with the means of gaining the greatest advantages which life can offer. It is all very well enthusing over the spiritual joys of the man of education who can see further than his neighbour into the deeper mysteries of material and mind; but the sane healthy man, be he never so "clever", is still prone to wretched misery when faced with poverty and servitude. It is farthest from our intention to indulge in lamentations of our country's decadence, but it is evident that had we not for the past few decades been doing our utmost to make every man (not to mention woman) "clever" and a "black-coat worker" under legal compulsion we might have been spared some of the trials which have beset us of late. Our educational code concentrates almost wholly upon "study" it does not really sufficiently act upon the truth that trained intelligence and craftsmanship are inseparable and that neither can usefully exist without the other. "Dignity of labour" is the high sounding theme of many an orational and philosophic spasm—but it became void and empty when the legislation for education demeaned honest toil by ignoring it and, worse still, by seeking only to induce and compel every man to strive for the sweetly phrased "university standard". In the light of present difficulties the absurdity of such measures is apparent—and, as was always so when folly or injustice were sought to be imposed—the commonsense of the people demands something better.

Possibly there was no need to go into this subject of education in such general terms; for these opinions are quite commonly held in business circles, excepting perhaps amongst professional educationists. These generalities are introduced for the purpose of indicating how in particular and so very closely they apply to the training of mining, electrical, and mechanical engineers. Moreover, they are put forth in the hope that they will be helpful to parties interested in the movement for an improved educational code by throwing up clearly the simple light of the business world to dispel the murk of the scholastic experts—those who, with all due respect and sincere appreciation, have always been scholars, who have trained and practice as such, who have never been concerned as to the profits and loss of any commercial work, who have themselves the surety of a cheque each month. It is hoped too that these pointed remarks will serve as a guide to the parents of the boys and to the youthful workers who are to make headway in mining engineering.

Planned on the lines here outlined is the scheme just inaugurated by the Powell Duffryn Steam Coal Company. The offices of the Britannia Colliery have been converted into a school in charge of an experienced lecturer, Mr. M. D. Williams, under the Glamorgan County Council. The new school will be connected with the schools of the Glamorgan and Monmouthshire County Councils; it is close to the Bargoed Colliery, one of the most up-to-date collieries in the world, where the students will be enabled to acquire concurrently the best technical education with practical experience in the mine. When any important departure from the orthodox is announced the usual Press Comment is "Its progress will be followed with interest"—which implies a dubious head-shaking and introduces a wary deterrent suspicion. There need not be any waiting to watch developments in this case. Success is assured.

It is a great good thing, and to the credit of both parties that a leading colliery firm and its ruling county councils should have come so closely together and so thoroughly understood and successfully grappled with a national necessity.

Elsewhere in this number we reprint an abstract from the new Annual Report by Mr. J. R. Felton, H.M. Inspector of Mines for the North Midland Division. Under the heading of "Training of Boys" Mr. Felton gives an outline of the compulsory educational apprenticeship system which is enforced in Germany. From the age of fourteen the boy begins to work for a wage—the magical master-touch in starting any boy on his career—and the scheme pays its way. His working hours are divided between classroom, workshops at the mine, and, from 16 years of age, underground in the mine. At the larger collieries there are 80 to 100 of these apprentices. Mr. Felton has himself studied the merits of this system on the spot and he recommends it as one worthy of the consideration of colliery companies in this country.

What are we to reply to those who, having read thus far, would damp enthusiasm by saying that there is no sort of argument in urging young men to educate themselves for mining work when already the field is more than full, and likely to be still more restricted in its future labour demand? On looking just a little deeper into the subject of the trend towards betterment of coal mining it is at once apparent that whilst the need for the services of the "labouring" miner will decline, the scope for the man of modern method will greatly increase. The competitive success of any colliery is wholly dependent upon its engineers—the men skilled respectively in the several branches of engineering which cut the costs in every stage from getting the coal to signing the receipts for the coal, coke, gas, electricity, oils, spirits, etc., etc., sold. The future of the coal industry is in their hands; they carry the responsibility of making or breaking the commercial strength of British coal interests. They are the men of which we have not got anything like an adequate number and they are the men to be made by this real "education".

SOUTH WALES ENGINEERING EXHIBITION.

The eighth annual exhibition, under the auspices of the South Wales Institute of Engineers, is to be held at Cardiff from November 27th to December 7th. Previous exhibitions, which have been held annually at Cardiff since 1922, have proved of much value to collieries and works owners, managers, engineers and others in the district. They have also been of use to manufacturers of engineering and mining plant, bringing them into personal contact with prospective buyers. There are no extraneous attractions, and the attendance consists entirely of people who are directly interested in mining or engineering. Electrical apparatus is always prominent among the displays.

SCHNEIDER TROPHY, 1929.

Everyone knows of the recent wonderful achievements by British airmen in British machines: the Schneider Trophy was won by Flying Officer H. R. D. Waghorn with a Supermarine Rolls-Royce S6 Seaplane (Rolls-Royce engines) at an average speed for the course of 328.63 m.p.h., and Flying Officer R. L. R. Atcherley, also with a Supermarine Rolls-Royce S6 Seaplane (Rolls-Royce engines), set up a World's Record for the 100 kilometres closed circuit at a speed of 331-75 m.p.h. It is of particular interest to electrical men and motorists to learn that the B.T.H. magnetos as fitted to both machines again demonstrated their remarkable reliability under the most exacting conditions.

Those who are familiar with the merits of Sterling Varnishes will not be surprised to hear that the Sterling Varnish Company have been forced by pressure of work to acquire new premises. They are now centred in fine modern buildings at Fraser Road, Trafford Park, Manchester, which will enable them to cope with the widely increasing demand. The Sterling Varnish Company have always been keenly alive to the requirements of the mining industry and its peculiar conditions, wet situations, etc. As a point of general interest, it might be added that in practically every outstanding motor vehicle or aero achievement, including the Schneider Trophy victory, Sterling-insulated magnetos were used.

AN £80,000 SWITCHGEAR CONTRACT.

A contract for 33 K.V. metal-clad switchgear for the North West England National Electricity Scheme has been awarded to the English Electric Company, by the Central Electricity Board. The contract, which is of the value of over £80,000, covers 39 metal-clad units, of which 29 are Class O.L.F. with a rupturing capacity of 500,000 K.V.A., and 10 are of Class O.L.G. having a rupturing capacity of 750,000 K.V.A. All units have duplicate bus-bars with plug changing and are electrically operated from a remote control board. The contract is a comprehensive one and includes protective gear, control boards, cabling, batteries, handling gear, L.T. auxiliary switchgear, etc. It will be remembered that a large order for 33,000 volt transformers for this Scheme was also placed recently with The English Electric Company.

EDISON BATTERIES.

New Distributors of Edison Storage Batteries, Ltd., have a Stand at the Olympia Shipping, Engineering and Machinery Exhibition, on which they are demonstrating the famous Edison steel alkaline battery made at Orange, New Jersey, U.S.A. Due to its engineering construction —it is practically made on precision machine tools—the makers are able to offer, for the Edison battery, practical guarantees of maintenance of capacity during periods extending from ten to sixteen years, according to duty. The Edison steel cell has now been in use for twenty years and has demonstrated its power to stand idle for many months without loss of charge or deterioration of its nickel-iron elements or alkaline solution. This characteristic makes it especially suitable for any emergency current or lighting service. The Edison battery is, moreover, exceptionally robust and for this reason has considerable vogue for traction purposes, such as industrial trucks, tractors, locomotives, portable cranes and commercial and municipal vehicles. On this Stand are also shown the Edison Nite Box, a simple but effective stand-by source of illumination, comprising a portable Edison steel battery, complete with searchlight and fifteen feet of extensible flexible cord. It is claimed that this Nite Box can be depended upon to give anything up to twenty-four hours brilliant light, even though the battery may have remained out of service from six to twelve months.

Testing for Faults in Machines.

F. MAWSON.

(This is the sixth of a series of Articles intended more particularly to help Students and Junior Engineers: the preceding Article appeared in the August number).

MANY of the defects to which electrical machines are liable are apparent from a mere inspection of the machine. The position of some of the defects, such as short-circuited or open-circuited field coils, short-circuited or open-circuited armature coils, etc., can only be found by testing.

Testing Resistances.

For measuring resistances, the drop-of-potential method is generally most easily applied. This consists of sending a measured current through the unknown resistance and noticing the pressure between its terminals. Then applying Ohm's Law, the resistance can be found by dividing the drop in volts by the current flowing in amperes. If the resistance is very low, as, for example, an armature coil, a voltmeter capable of reading millivolts (thousandths of a volt) will be required.

The resistance to be measured is connected in series with an ammeter and a battery. The terminals of the resistance should be connected with as short wires as possible to the terminals of a suitable voltmeter, as an example, if the ammeter indicates 1.2 amperes and the voltmeter registers 4 volts, then the resistance will be 4 divided by 1.2=3.33 ohms.

Testing of Open Circuited Field Coils.

A machine may not exite due to the absence of residual magnetism. A voltmeter connected across the brushes will not give any deflection when the machine is run up to speed. If there be any residual magnetism a small deflection will be noticed, then it may be taken for granted that the cause of the machine failing to excite is that the field circuit is broken. When suspecting broken coils this should be the first test carried out and a careful examination made for loose connections. It is very often found that the break is at the point where the connecting leads join the field coils, but the insulation may be intact and the break not visible.

Method of Testing for Broken Field Circuit.

If current is available from some other source, either from another dynamo or battery, the faulty coil may be detected by coupling the defective field coil with the source of supply. No current will flow if the the circuit is broken. A voltmeter connected across each coil in succession, will show a similar deflection for each coil if the circuit is in good condition. If, however, there is a break in one coil, then the voltmeter will give no registration when coupled to the ends of the sound coils, but will give full potential difference if coupled to the end of the faulty coil: due, obviously, to the fact that one end of the faulty coil will be on the positive side and the other on the negative.

Another method is to uncouple each coil and test separately for continuity by means of a simple battery and bell, that is, by placing the coil, battery and bell in circuit, no sound will be given from the bell when coupled to the defective coil, but a clear indication will be given with the good coils.

Short-Circuited Field Coils.

A field coil may be short-circuited either by adjacent layers coming into contact or by the insulation becoming carbonised by excessive overheating and thereby causing the current to pass through the front insulation to the next layer. Each coil should be tested for conductor resistance and if one coil shows a lower potential difference than the others, a total or partial short-circuit may be looked for.

Faults in Armature Windings.

These may be tested for by the bar to bar method. The test consists in passing a current through the armature windings: two points are chosen on the commutator so that any current passed through will flow equally through the two or more windings. These two points are usually diametrically opposite and should be connected in series with a battery and variable resistance. If current is taken from a supply line a bank of lamps will be found useful for varying the resistance. A sensitive galvanometer is connected to any two adjacent bars on the commutator and the resistance adjusted until a good reading is obtained in the galvanometer. This is now tried on the next two commutator bars and if the windings are in good condition the reading should be the same or approximately the same as before.

If the armature has a high resistance, a small current will be required, if of low resistance, a large current will be required to give the same voltage drop between the bars. Several bars should be tested and the average noted.

If there is a short circuited coil there will be no deflection of the galvanometer when coupled to the two commutator bars containing this coil. There will be no deflection of the galvanometer as the contacts are moved round the commutator; but if there be a broken coil anywhere, then the deflection of the galvanometer will be practically equal to the full voltage on the connection points. These two bars should be bridged, and the testing carried on.

If a sound coil has been coupled in the wrong direction, the galvanometer will reverse, because the potential difference will be in the wrong direction. Bad contacts or loose joints may be detected by the increased deflection of the galvanometer.

With good winding, a short circuit is comparatively rare, but sometimes the copper strips are liable to become hot and the lugs become loose. These should be re-soldered but great care should be taken to prevent solder from dropping between the lugs or at the back of the commutator.

Test for Earth Connections.

The most convenient method is by the aid of an insulating testing set, an ohmmeter, or "Megger." This consists of a hand-driven generator with an instrument measuring in megohms, or 1,000,000 ohms.

The test is made by connecting one terminal of the testing set to the winding, and the other to the frame of the machine. The generator is then turned, and the deflection of the pointer noted. According to the conditions of insulation the instrument will indicate from zero in short circuit to infinity in perfect insulation. If a leakage to earth be detected, it will then be necessary to test each coil separately, until the defective coil be found. All the windings of all new machines, and those which have been overhauled or repaired should be tested for insulation before being put into service.

Load Tests.

When testing a machine under load, some form of resistance is required, this is put into the main circuit, with an ammeter and voltmeter of suitable size. If the machine is small, a bank of lamps will be found to be a very convenient test load, as the resistance can easily be altered by switching the lamps "on" or "off."

Where heavy currents have to be used a water resistance is most convenient. This consists of a trough filled with salt water in which are hung two moveable lead plates which can be connected to the terminals of the generator. The circuit is completed through the water and can be varied by altering the distance between the plates or the depth to which they are immersed.

A large barrel makes a good test tank for machines up to about 15 kilowatts; for larger outputs a number of barrels may be used, connected in parallel; or a special tank should be made, especially if it is likely to be useful for other tests from time to time. The size of this tank will depend entirely on the machines to be dealt with. Washing soda or coarse salt should be added to the water to reduce the resistance, the greater the quantity added the less will be the resistance, a small quantity should be added to begin with and then increased until the resistance is of the proper value to allow the requisite load current to flow.

Apprentice Miners in Germany.

The following is an abstract from the Annual Report for 1928 of Mr. J. R. Felton, H.M. Inspector of Mines for the North Midlands Division.

During the year six boys of 16 years of age or under were killed and 67 seriously injured, and of these 55 were in connection with haulage operations. As has been pointed out in previous reports, a number of these accidents arise through lack of training and inexperience.

In September last I had the pleasure of visiting a number of mines in the Ruhr Coalfield of Germany, and was much interested to see the Apprentice Training Shops in operation there. Some particulars of the system may be of interest.

In Germany the school-leaving age is 14, and the minimum age at which boys can commence work underground is 16. The law requires that boys after leaving school and until they reach the age of 18 shall attend continuation classes for at least four hours per week.

Apprentice shops have been established at a considerable number of mines with a view to the giving of vocational training to the boys, and qualifying them as skilled and intelligent miners. I was informed that 50 per cent. of the mines in the Ruhr now have such a scheme in operation.

Under this scheme separate shops (with properly equipped carpentry, smithy, fitting and in some cases electrical departments) are provided for the boys. A classroom is attached in which educational instruction is given, and a gymnasium is also provided; there is also a mess room where food can be warmed and hot water, etc., obtained. In some cases provision is also made for a training in the use of pneumatic picks, the timbering of roadways and other underground mining operations.

The whole establishment is under the supervision of a qualified head with an experienced assistant in each department.

No charge is made for the educational instruction given, and the boys receive payment as apprentices at special rates as follows:—

Age	14—15	2 marks per day.
	15—16	2.65 ,, ,, ,,
	16 & over	3.30 ,, ,, ,,

The hours of employment are 9 or 9½ hours per day, with intervals for meals. The details of the timetable vary somewhat, but generally a minimum of four hours per week are occupied in ordinary school lessons, two mornings or afternoons per week for theoretical instruction, part of one day for gymnastics, swimming, etc., and the rest in practical work in the shops.

The theoretical instruction includes lessons on the mining regulations and safety matters generally. The boys receive a thorough training in the shops, and are occupied in repairs and carrying out new work for the colliery in the various departments. The boys continue their apprenticeship underground (after the two years spent in the shops), being employed on underground locos, at staple lifts, and other haulage work, and are still under special supervision while engaged underground. Part of their time is, as before, spent in the classroom on the surface.

At one colliery they had 100 such apprentices, while at another there were 80 apprentices, and these figures may be taken as representative of other large collieries.

As the new work and repair work done in the shops for the colliery is charged up at current prices, the scheme practically pays its way.

The advantages likely to accrue from the training of boys under such a scheme will be apparent; this is likely to be increasingly the case with the rapid growth of machinery and mechanical devices of various kinds underground. A general knowledge of the mechanical devices in use, the proper method of utilising them, and the precautions to be taken while doing so, are all imparted to the boys during their training, and the result must be a more alert and intelligent type of workman. Such training also will enable the management to mark sharp lads who are likely to make the officials of the future.

In my opinion the scheme is one which is worthy of the careful consideration of Colliery Companies in this country; where there is a group of collieries belonging to one company training could perhaps be centralised in apprentice shops to serve the group. Greater attention to this question of training should result in a reduction of the number of accidents, and an increase in the efficiency of the youths.

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AYRSHIRE SUB-BRANCH.

Starting Switches for A.C. and D.C. Motors and how to use them.[4]

Discussion.

The CHAIRMAN, Mr. T. M. McGlashan, said that Mr. McPhail, when choosing the subject of switches and starters, apparently had in his mind the idea that if efficiency and reliability of starters could be attained, many of the everyday troubles and stoppages of the Coal-Cutter would be eliminated. Switch-gear must, to be efficient, control or keep under restraint the supply of electricity to a machine, and must also be capable of protecting it from damage if any untoward circumstance should arise. Those "snags" would persist in cropping up at the most unexpected and awkward moments, and while our make of machine might overcome the obstacle quickly and effectively, another make would collapse and cause no end of worry and anxiety. For instance, a machineman having D.C. motors (that is, the compound wound motor) cutting fairly hard coal containing whin checks lying at an angle of 45 deg. would have difficulty in cutting into these: the machine would tend to travel up the check instead of penetrating it, with the possibility of the machine jamming: but if the travel were relieved possibly the compound motor would lift the machine out, while with a three-phase motor the machine would very probably have to be dug out. That was one of the cases where the D.C. motor had the pull over the A.C. motor in mining. D.C. machines have a greater starting torque. A.C. machines are the more reliable, are equally efficient in haulage and pumping, but slightly deficient in coal-cutting. The general principles involved in switchgear for use on D.C. and A.C. systems were the same, provided it was remembered that electro-magnectic principles governed all the points which had to be considered. The automatic protection necessary applied alike in D.C. and A.C. systems for overload, failure of supply, earth leakage and emergencies, the only exception being protection against reversal of current. Overload control was the most important of any automatic device, and should be effective at all times. Then comes the question of effective earth current and protection from and against development of earth faults. The efficiency of the surface system was the safeguard against shock from metallic armouring of cables, metal work of motors, and also switchgear and cutters. If the earthing was bad, the whole system was bad. The earthing system was the life-saver and the electrician's best friend. It was doubtful whether some collieries had reached the point of realising that the reliability of a machine was more important than its initial cost. Sometimes inferior machines were installed and placed under the care of men limited in experience and training, with the result that inefficiency and the expense occaisioned thereby ran away with any apparent saving in first cost. Switchgear was installed as an assurance of safety, but if it was of a flimsy or unsuitable make it was looked upon by the attendant with a feeling of suspicion. In all electrical installations, switch and control gear was of the highest importance and too much care could not be given in choosing reliable and suitable makes.

Mr. MURRAY asked Mr. McPhail if he thought an A.C. coal-cutter was better than a D.C. for the average operator of a coal-cutting machine.

Mr. McPHAIL said that with D.C. machines there was the liability of careless operators burning out the insulation on the starting gear by running on the resistance too long. In the case of A.C., with careless operators the machine was liable to jam, with the result that it might be taking excessive loads, and only getting one quarter of their value. In other cases an operator might cut with his machine partially jammed—might cut dozens of yards, then when he got it on to the level he was off in another direction. There again, in A.C. work, they might only be getting a quarter of the value of the load taken. He had seen many operators who ought never to have been in charge of a coal-cutting machine. There was a great difference in operators. He remembered one young fellow who only used about three-quarters of the power that the other men were using, and often did the work in about half the time of the others. With electrical machinery, and more especially with A.C., a man who thoroughly understood what he was doing saved the colliery company a great deal of expense. Taking it all round, he thought A.C. was the better, simply because the starting gear was so much less troublesome: but apart from that factor, he would give D.C. the honour.

Mr. MURRAY said he was in thorough agreement with the policy of inviting the machinemen to their meetings when subjects relating to their practical work were being discussed. He had induced two of his machinemen to attend the Branch meeting at Cannock three months ago. He did not say it was entirely due to the information these men received at that meeting, but the fact was that during the past three months these two men, using the same types of machine, and cutting the same coal seam as other two machines in his charge, were doing 60 per cent. better work than these others. He was quite convinced that was not all due to luck. The men had been very interested in what they heard at the meeting and had discussed it together afterwards. He thought that in the coming session they should make it a point to issue special invitations to the men to attend the Association meetings when practical subjects were to be discussed. From Mr. McPhail's answer to his last question he gathered that there was more likelihood of starting breakdowns in the case of D.C., and that there was more chance of excessive current being used by a careless operator in the case of A.C. In Mr. McPhail's opinion which would be the more expensive if an ignorant operator were in charge?

Mr. McPHAIL said that was a very pertinent question. They had to consider, in the case of an A.C. machine, the amount of excessive current used by a careless operator and which could have been saved by an efficient operator in the course of one night's cutting: then in the case of D.C., they had to consider the cost of a careless operator burning out the whole starting apparatus. He was confident that if they took the results of both over a period of a month the wasteful cost of the A.C. machine would be three or four times that of the D.C. If there was a break-down in the starting gear in either case resulting in an earth, then in the cse of D.C., with many of the other machines running, cables might be punctured, but in the case of A.C., the whole motor might be burned out within itself, and the stator through the surges might be burned out as well. The costliest feature in the long

(4) The *Mining Electrical Engineer*, July 1929, p. 20

run, however, was paying for power from which nothing was gained. The machines might get jammed, and the whole way through the run they were using current from which the company were getting no benefit; that was a costly business, more especially where the power was bought from a power company. It was in such circumstances that they saw whether an operator was really fit for his work. Much could be done if the operators received some education in regard to their machines.

Mr. MURRAY—Is it not possible to calculate the units required for an A.C. machine to do its work under normal conditions and when in charge of a fair operator? To get, say, 100 yards of coal on a certain cutting, is it not possible to find out by the units used whether the work was done efficiently or not?

Mr. McPHAIL replied that at one time he took a number of tests from the gate-end box of the machine in coupling up suitable power-factor meters, and was able to see what the machine had done during the night. The test was made over several nights, then the meter was put on another gate-end box and the tests repeated. Different men were put on the same machine, and the results noted. By these observations one could learn quite accurately the power factor and the efficiency of the machine in each cut handled by any individual man.

Mr. McGLASHAN said the trouble was to make the operator realise what power factor meant. They had cases of a motor running with a power factor of only 0.6: it was taking the full current and nearly half of it was going to waste: it was going back into the power station. If they could bring their power factor up to 0.9 they were allowed a rebate off their total bill by the power company.

Mr. McPHAIL said that low power factor was a serious thing for the colliery company. Where they had a machineman who had studied his machine and his cut, he would go through with very little loss. But in twenty-four years he (Mr. McPhail) had only come across two men of whom that could be said, and strangely enough they were both in Kilmarnock.

Mr. McGLASHAN—Is there no way by which a man could be made to realise whether he is wasting current or not?

Mr. McPHAIL—To counteract waste the first thing I would suggest is to put up power factor apparatus on each section. Thereby you would discover who was who among the machinemen, and you could pick the best possible men for each machine. Speaking as an electrician who has had a long experience of coal-cutters, Mr. McPhail said the first thing he did before putting a man on a machine was to give him definite instructions and information about it, and when there were difficulties, the faults and errors were shown to him so that he could avoid them in future. But despite all the careful instructions given, many of the men were of no use at all: some of them were impossible to train: others had already got into systems and habits of their own, from which it appeared they could not depart.

Mr. J. C. MacCALLUM said that in a colliery generating its own power there was an idea among the men that the power was there anyhow, and it did not matter how much they used. The power factor ought to be very carefully studied there.

Mr. McPHAIL—Quite so. The men have the idea that waste of power is quite a different thing if payment has to be made to a power company. In many instances the power bills of colliery companies could be easily reduced by 25 per cent.

Mr. McGLASHAN said that for a colliery company paying, say, £1200 a year for power, it would be a saving to them to pay a man to superintend power factor.

Mr. MURRAY said the operator was engaged to cut coal on an output basis. The operator's idea was to get through the run as quickly as possible, with as deep a cut as possible. That being the case, he did not think the operator would care how much current he used so long as he got his cut done; nor would he care how many breakdowns there were so long as they were not on his shift.

The meeting terminated with a vote of thanks to Mr. McPhail, moved by the Chairman.

MIDLAND BRANCH.

Visit to the Ransome and Marles Works.

About thirty members of the Midland Branch of the Association paid a visit on June 19th last to the works of the Ransome & Marles Bearing Co., Ltd., at Newark-on-Trent, by courtesy of the Managing Director, Colonel H. J. Higgs, and were conducted round the works by the managers of various departments, Messrs. Hickling, Storer, and others. After the inspection the party were entertained to tea by the management.

Mr. R. WILSON (Branch President) expressed thanks to Messrs. Ransome & Marles for their courtesy and hospitality, and also to the gentlemen from the various departments who had conducted the party.

Mr. W. WYNESS, in seconding, said it was a real pleasure to do so; he had enjoyed every minute of the time spent in the works, and had found it very instructive. It was very gratifying to know that amongst all the unemployment current at the present time there were firms who were on full time and overtime. Messrs. Ransome & Marles were deserving of the success which was coming to them, and he had much pleasure in seconding the vote of thanks.

Mr. HICKLING responded on behalf of the firm, and said it was very pleasing to show a party like the present one round.

Mr. STORER endorsed what Mr. Hickling had said, and added that they were glad to show anyone round in the interest of their manufactures, as they looked upon it as an advertisement, and he thought it was one of the best forms of advertisement. If visitors were interested in the products they were likely to become customers.

The Manufacture and Inspection of Ball and Roller Bearings.

A ball or roller bearing appears at first glance to be an exceedingly simple object, yet one would make bold to say that for its size and cost there is probably no other product which calls for the same degree of engineering skill in its efficient manufacture. Metallurgical, manufacturing, and organising sciences must all be exercised to the highest level obtainable, in this industry. The raw material supplies the steel manufacturer with his greatest problems; indeed in spite of all precautions being taken, which experience has shewn to be necessary, it is no uncommon thing for the whole consignment from one cast to be returned as faulty, the faults being frequently only discovered after the finish grinding of the tracks. Defects which are usually met with in steel for general engineering products do not occasion the bearing manufacturer much trouble, for they are usually noticed in the rough machining of the material, and no further work is done on the defective consignment. The faults which cause the most trouble are such as would not be looked for in any other product, being very fine hair lines discernible only by an experienced viewer and then not without the aid of a strong light. On the manufacturing and inspection side of the industry, one would claim that manufacturing science of the very highest order is required. The external dimensions of ball and roller bearings, outside and inside diameters, and width are made to published tolerances of 0.0005 in. in the first two cases, and 0.002 in. in the last. In a general case a tolerance of 0.0005 in. is not very alarming

Fig. 1.—The Laboratory.

Fig. 2.—Bay of the Grinding Department.

the general engineer, but when this is called for on, say, a 6 ins. diameter, and has further to compare strictly with national standards, the difficulties of manufacturing are increased. Actually, instead of a tolerance of 0.0005 in., as stated, only approximately a tolerance of 0.0003 in. can be allowed with safety in the works, and this has to cover errors in parallelism and sphericity, as well as errors in diameter and changes in dimension which occur whilst the work is in progress (sometimes many weeks), due to want of stability in the structure in the steel.

With regard to those dimensions which do not directly concern the user, such as diameter of ball track, track clearance, etc., an even greater degree of accuracy is called for; 0.0001 in. is the unit used in the comparison of the race diameters, and the balls employed in individual bearings are graded to 0.00002 in. The finish on both balls and race tracks is the best that special facilities and years of experience can produce, and the state of perfection reached in this direction is somewhat startling to the general run of visitors who inspect these products in course of production. Extreme care has necessarily to be taken with work in progress on account of the danger of the fine finish being destroyed by tarnishing. Weeks often elapse between the components being finish machined and the packing operation, and in the meantime the finished surfaces must be covered with specially prepared greases to minimise any risks of stains. The manufacturing departments and stores are maintained at a temperature of 62 F, plus or minus 5°F, to reduce the alterations in dimensions to a minimum.

Reference gauges of both the inch and metric systems are compared periodically with the national standards of the N.P.L. at the standard temperature of 62°F.

Inspection methods involved in the conditions just outlined call for very many special and highly developed testing fixtures and devices; in addition to this, though subsidiary to and involved in it, are several important considerations affecting factory efficiency and organisation, the chief of which are:—

(1) The prevention of further work being put on to work already useless; this, of course, effects a monetary saving.

(2) The rapid discovery of faulty work due to defective jigs or tools; this enables the necessary rectifications to be made to prevent a repitition of bad work.

(3) The provision of such information with regard to the work inspected as will enable the Wages Office to determine the pay due to a workman on bonus or piecework.

(4) The provision of such information with regard to work inspected as will enable the Progress Department to keep its records up-to-date.

The Ransome and Marles factory is, roughly, divided into five sections: the Turnery, Hardening Shop, Grindery, Assembly, and Ball and Roller Department, and in each of these is an Inspection Cage centrally situated with regard to the machines and having a work stores adjacent to it, as for efficient production it is necessary to keep a certain volume of work in progress and not rely on work passing from machine to inspection and thence straight back to the machine.

Naturally, the question of materials is one of primary importance, and generally speaking the present practice is to manufacture races and balls from high carbon chrome steel, though case-hardening steel is still used to some extent for this purpose. The progress made during recent years in alloy steel manufacture has practically rendered the case-hardened ball bearing obsolete. It is not contended that the carbon chrome steel race is greatly superior to the case-hardened one, if the latter is correctly heat treated; but no doubt the comparative simplicity of the hardening process for the direct hardening of steel is responsible for the much greater regularity and reliability of product. In certain cases, however, where the shock load might destroy the bearing and where complete fracture might have serious consequences, it is preferable to employ case-hardening steel. Chemical and physical specifications are given to cover

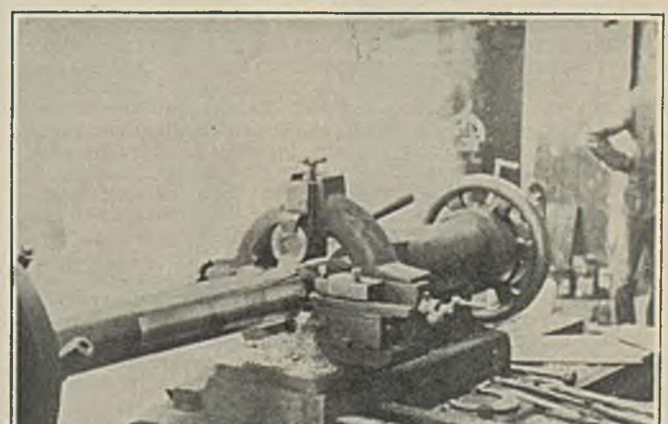


Fig. 3.—Turning Bars with Roller Steady.

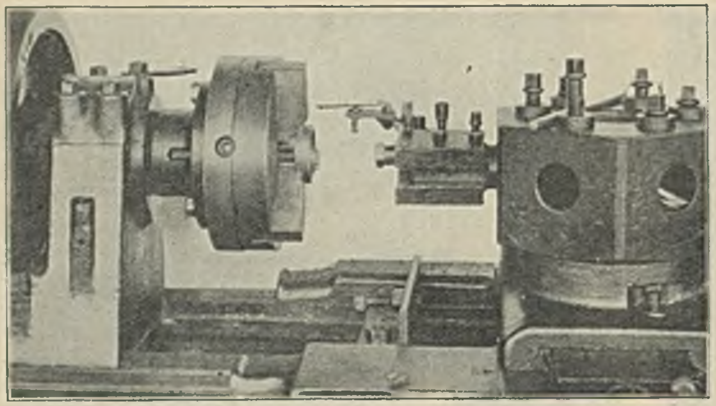


Fig. 4.—Indicating Device for Track Forming.

carbon chrome and case-hardened bearings of a standard design; also case-hardening specification for bearings subject to shock loads, such as engine crankpins, etc.

The chemical specification for balls is similar to that of races, except that for sizes below ¼" the chromium content is a gradually reducing quantity.

Hydraulically extruded brass tube and bars of high quality are used for the manufacture of cages, and a very high degree of ductility is required in respect of this material.

The bar or tube on receipt in the steel stores is examined to see that it falls within the specified limits of size, and a Brinell impression is taken simply with the object of seeing that the material is machinable. No other physical tests are imposed at this stage, as the nature of the duty a ball bearing is called on to perform renders such test entirely useless. Every cast of material received is analysed, and several blanks are cut off bars or tubes from each cast, hardened and fractured to ensure that not only is the analysis correct, but that the heat treatment of the material before receipt has been correct, and to ascertain that there are no mechanical flaws. After this inspection the material is either rejected or released to the steel stores for use in the works: in the latter case it is suitably marked for future identification purposes.

Bearings are made either from the solid bar or tubes, according to the size of bearing and the quantity required.

MANUFACTURE.

Solid Bars.—Solid Bars are ordered rough turned (leaving a light cut to be removed) in order to give the steel manufacturer an opportunity to examine the material before despatch. The bar is machined over its entire length in a lathe using a roller steady, and no further machining is done on this diameter until after hardening.

The roller steady, shewn in Fig. 3, was designed and made by Messrs. Ransome & Marles, and it is probably of interest to other than ball bearing manufacturers. In a length of 6 feet and upwards a bar of 8" diameter can be turned to within a tolerance of .002" at one cut. Previous to this roller steady being designed a grinding operation was necessary but that has been eliminated by the use of this attachment.

Next, the bars are parted down with double parting tools, using tool blanks of inferior cast steel with high speed tips welded on. After being tested for width, the centres of the blanks are removed by trepanning, if the core is worth saving. Otherwise, they are drilled in machines specially designed for the purpose, a feature of these tools being the power bar-raising device.

Facing the sides of the blanks follows trepanning, and for this operation a simple lathe with an automatic cross traverse is employed.

The inspection for outside diameters are made in testing fixtures: the parts are tested by comparison with standard parts to which the indicator has been set and to which it is regularly checked during the inspection of a batch of parts of the same size. The clock indicators used in this instrument, and in all the turnery inspection fixtures read to .001", and as the limits are coarse the work is very rapidly checked by practically unskilled labour.

After inspection for width, the blanks are stamped with the firm's trade mark, the type and size of bearing, and a symbol indicating the quality of steel used, the month and year of manufacture, and the maker of the steel. The same symbol is impressed on the blanks in two places to suit the position of the inner and the outer after trepanning.

The next operation is to separate the blanks and at the same time perform a few minor operations. The shaft hole is bored to a tolerance of 0.004", leaving approximately 0.006" to 0.01" in the bore for grinding, and the standard radius turned. Trepanning comes next, cutting half-way through from each side, and whilst the outer ring is still in the chuck the inside diameter is bored to size.

Proceeding now with the outer ring, the edges are chamfered inside and radiused on the outside. The radius tool is of circular formation and is ground on the face only. In the case of a standard roller bearing the turning operations on the outer ring are now complete, but for a ball bearing the ball track requires forming.

The outer track is next formed, again using a circular tool mounted as shewn in the illustration, Fig. 4. It will be noted that a Starrett indicator is secured to the tool holder and the shoe arranged to run in contact with the top diameter of the chuck turned true to receive it; the pointer is set to zero from a ring of known size, and all the operator has to do is to feed the tool in until the required reading is given on the indicator. This method does away with trouble from spring of stops and tool holder. This is, in fact, a good illustration of the production and gauging methods adopted in the shop which materially reduce the possibility of variation and consequently lighten inspection duties.

This outer race is now tested for track diameter. It is essential, in order to keep grinding allowances low, that the track should be both central and true with respect to the faces, and concentric with regard to the outside diameter. The first feature is examined in the fixture shewn in Fig. 5. This consists of a slightly inclined flat plate carrying a V-grooved bar mounted at right angles to the flat surface. In the groove is a ball of the same size as is used in the bearing, and this rests against a plunger of a clock indicator. When a ring is held firmly against the plate and pressed down until the ball is at the bottom of the track, the reading on the indicator records the distance from the centre of the track to the face of the bearing; the race is then slowly revolved, keeping a light pressure on the ball and against the plate, and any variation in the distance of the track centre from the face is immediately indicated on the dial. Reversing the ring and repeating shews whether the track is central or not.

The concentricity of track with outside diameter is tested on the fixture shewn in Fig. 6. In this it will be seen that a ball pointed peg is provided, on which the outer track locates, the thickness from this ball to the outside diameter being measured on the indicator which has a plunger in the same axis as the peg; a fixed point is provided against which the outside diameter bears, so that by revolving the ring with the outside diameter in contact with this and the ball point at the bottom of the track, the variation in section round the ring (and hence the eccentricity) is read the dial. The formation of the track is tested by n of a plain disc gauge.

The bore of the inner ring is tested on the shewn in Fig. 7. This has two fixed points and movable one attached to a clock indicator arra that for a ring under examination this point metrically opposite one fixed point, the other fixed point being used as a guide. When a ring is put over these points and revolved, the clock indicator records any variation from standard size and roundness, the fixture having been previously set to a standard ring.

The inner ring is next gripped on an expanding collet in capstan and turned on top, tracked and chamfered. After the operation of tracking, the track is tested for diameter, roundness, out of centre, and out of truth with face; all of which features are inspected in one fixture. Three ball-pointed pegs all mounted in the same vertical plane, the bottom one being fixed whilst the other two can be adjusted along their axis; to the top one is attached a clock indicator. These are set to a standard ring to give a zero reading on the dial, and at the same time the dial to the left of the fixture is adjusted with its plunger in contact with the face of the standard ring to zero. Rings under test are now put in the fixture and revolved, the top dial giving size and roundness, and the side dial truth of track with face, and, by reversing the ring, indicates whether the track is central or not.

The foregoing outlines the general method of turning bearings from bar, but modifications are made in some cases. For instance, in very large bearings, where the gap between the rings is wide, the rings are machined from separate bars to avoid excessive waste of material.

The alternative method of machining rings from tubes is now generally employed by Messrs. Ransome & Marles. The primary operation is to rough turn and bore to a sufficient depth for four or five rings, and then to part off that number with the aid of multiple parting tools. No radiusing is attempted at this setting, because the increased time necessary to set up is not compensated for by the time gained on the quantities handled. The inner races are made either from tubes or bar according to the relative cost of material and labour. Radiusing, chamfering, and notching are carried out precisely as outlined for rings made from solid bars. Stamping is done singly, and not in duplicate as for solid blanks.

Hardening.

The next group of operations is carried out in the hardening department. All furnaces are fitted with suitable temperature-recording instruments, which undergo periodical checks against a standard instrument made by the Cambridge Scientific Instrument Co., whose instruments are used exclusively in the hardening department. The usual hardening temperature for carbon chrome steel is from 780°C. to 820°C., according to the size of the ring. Quenching is done in oil, which is kept at approximately 65°F.; after hardening, the rings are tempered in oil at a temperature approximating 170°C., according to the area of the section. Rings scrapped in the turning operations are used as test rings for the hardening process, and the fractures are systematically examined by experienced metallurgists.

Case-hardening is carried out in two Richmond furnaces, the rings being packed in a standard casing mixture and raised to and maintained at 900°C. for a period determined by their size and the depth of the case required. This case is much deeper than is customary for ordinary machine parts. After cooling, the rings are raised to 900°C. and quenched in water. They are then raised to 760°C. and again quenched.

The hardening of carburised rings is carried out on a special fixture in order to prevent distortion. Fractures are obtained and examined in the same way as for chrome steel rings, and occasional analyses are made of carbon content at varying depths. There are also of course, tests for hardness and resilience. In the case of chrome steel, these comprise a file test for hardness, after which the parts are dropped from a predetermined height on to a steel block as a test for resilience. The "ring" of the steel is a sure indication of its quality, and any with mechanical flaws fail, or are indicated by the sound given in bouncing. The tests for case-hardened bearings are similar, but in addition, the depth of case is tested by dropping a loaded ball from heights previously determined as being sufficient to break down a case of minimum thickness. A proportion of each batch of rings put through is fractured and the fracture examined by the metallurgist before the batch is released for further operations.

The final and deciding test for hardness is not applied until after the tracks are ground. This is known as the scraper test and is carried out with a round silver steel scraper of maximum hardness ground square to its axis. Very little more than the weight of the scraper is applied, and that at the correct angle. This apparently crude method gives very effective results, its chief drawback being that its correct use demands considerable experience.

One further material test is carried out after finish grinding when the rings are examined by the aid of a very strong diffused light; the object of this is both to examine the finish and also detect any of the minute hair lines or flaws which do occur in the finished product and which no previous examination is capable of

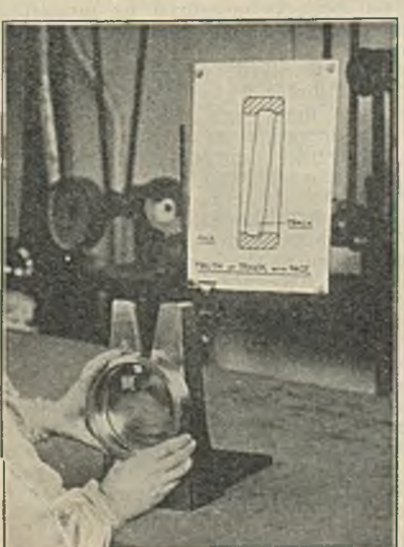


Fig. 5.—Testing Truth of Track with Face.

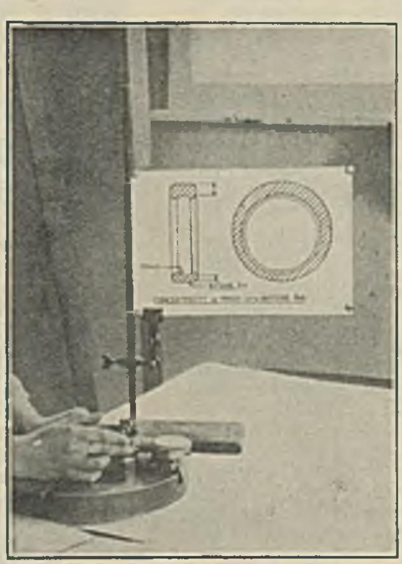


Fig. 6.—Testing Concentricity of Track with Outside Diameter.

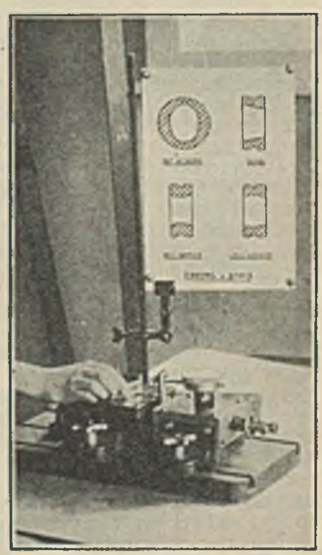


Fig. 7.—Testing the Bore.

discovering; in ordinary light and to the casual observer even in the "light box" these flaws are not discernible, but the highly-trained inspectors detect them immediately. This last defect is a particularly costly one, as all the operations have been put on the bearing and no steps can be taken to rectify and reclaim it. Further, it is a fault which in general engineering practice would have no influence whatever.

Grinding.

In this section is commenced a series of operations where low production costs are combined with the highest class of workmanship, where so-called semi-skilled labour carries out work of the closest accuracy. Sub-division of duties is necessarily well developed, and this accounts for the deftness and precision achieved. Scientific organisation and equipment design are factors which have been developed to the fullest extent to decrease the element commonly known as the "human factor" and to reduce both the handling time and the actual times of operations.

The first operation on standard ball bearings consists of facing both sides of rings (inners and outers) on Blanchard grinding machines, where the work is held down magnetically on a large revolving table, and the top face ground by a grinding wheel of hollow cylindrical form which removes the necessary amount from one face. After first facing, the rings are turned over and faced to the standard tolerance, 0.002 in., but a parallelism of approximately 0.0005 in. is required; this figure varying slightly with the diameter of the ring. The method of testing for width is exactly similar to that used in the turning operation.

The tolerances for outside diameters are: English sizes, 0.0005 in. all sizes; metric sizes, up to 75 mm. to 0.013 mm.; over 75 mm. to 0.020 mm.; above 150 mm. and including 420 mm. to 0.025 mm. The races are ground on the outside diameter in centreless grinders. The race tracks are ground on machines of a special design prepared by Ransome & Marles. The work head oscillates about an axis which passes through the centre of the circle forming the ball track. Several modifications have been embodied in the later machines to facilitate production and improve the product. One of these improvements consists of a wheel forming and truing attachment mounted on Ransome & Marles ball races. With this arrangement the necessary freedom of rotation, combined with an entire absence of slackness, is obtained. The ordinary type consists of a plain pin fitting in a plain hole which, no matter how good a fit, fails to give a suitable condition of wheel surface. A further modification is the method of gripping the ring for grinding. A tolerance of 0.0005 in. eccentricity is given, and until the device now in use was invented and patented, working to this tolerance was found to be particularly difficult and the scrap and rectification percentages were exceedingly high. However, the introduction of the present method of chucking has removed one of the chief causes of trouble met with in the manufacture of ball and roller bearings, and rings can be re-chucked in a few seconds sufficiently true to permit a cut of 0.0001 in. to be removed concentrically from the ball track.

Considering the fact that the tolerance on the outer diameter is 0.0005 in. and that work with this variation has to be handled without selective assembly, the difficulties to be met with when using standard equipment will be readily realised. A tolerance of 0.0002 in. eccentricity could be readily obtained by the improved method.

The rough grinding of the ball tracks is performed by a 46K wheel running at a speed of 4,000 to 5,000 feet per minute. Approximately 0.0002 in. is left on for the finishing operation, which is carried out with a special elastic wheel operating at a speed of 3,000 to 4,000 feet per minute. Soda water is used as a lubricant for the roughing operation, and machine oil is found necessary for finishing. Beeswax is occasionally supplied to the wheel to remove any trace of sharpness. Very little material is removed in this final grinding operation.

The tolerance on track diameters for the standard product is 0.002 in., and the gauging is performed as follows: A cage of balls is inserted inside the ring to be measured, and a plug having a taper of 0.010 in. per inch is inserted into the cage. Following the grinding of the ball tracks, examination of the following features takes place:—track diameter, track position in centre of width, track parallel with sides, roundness of track, formation of track, concentricity with outside diameter, and finish of track. All these features are tested for in exactly the same way as for the bearing in the soft state but to much closer limits.

The first grinding operation on the inner ring is the same as in the outer ring, viz.: facing. The limits are the same and the inspection is carried out in exactly the same manner. To grind the shaft hole the rings are roughly set by hand in special chucks which hold them lightly by means of spring tension, the jaws bearing on the front face. The wheel is brought to bear against the side of the hole, and the pressure quickly centralises the ring. A knurled knob at the rear of the spindle is gripped while the spindle is rotating, and the work is thus tightly secured for grinding. A few seconds only are necessary to perform the entire setting and gripping motion. By means of this apparatus, designed and made by Messrs. Ransome & Marles, the grinding allowances are reduced to a minimum. To facilitate the truing of the wheel, which must be done to finish each hole, a quick setting diamond holder is attached to each machine, and this fitting can be swung in and out of position instantly. The trial gauging for size is done by means of a taper plug tapering 0.010" per inch and carrying a mark which indicates the full nominal size. This is found to be the most convenient means of indicating to the operator the amount of material to remove, and also provides a convenient way of checking the hole for taper. The hole is finally checked by means of a parallel plug gauge. The features requiring inspection are size, out of round, taper, bell-mouth, and truth with face. The first four dimensions are inspected on a special fixture; the fixture has three pegs arranged to locate in the bore of the race and one of these which is diametrically opposite to a fixed peg is suitably connected to a minimeter; the third peg, at an angle of 90° to each of the others, is fixed and acts merely as a guide; the fixture is set to a standard ring, after which the parts to be tested are passed over the three pegs and slowly revolved, being supported on hardened parallel strips for the purpose; any errors in size and roundness are recorded on the indicator and the ring is then reversed and again revolved. As these measurements are not taken at the centre of the ring, any taper is immediately shewn up. A further check by plain cylindrical "go" and "no go" plugs is also carried out. Truth of face with the bore is measured by mounting the ring on a mandrel and running this on the true centres; an indicator is arranged on the face of the bearing and the mandrel revolved, when any error in truth is shewn up on the dial.

The grinding of the inner race of ball journals differs from the similar operation on the outer ring in that the formation of the track depends entirely on the form of the wheel, as the work head does not oscillate round the centre of the track circle as is the case in the outer ring tracking machine. The same wheel is used on both roughing and finishing operations. In this operation, to a greater extent than in the corresponding operation on the outer ring, the necessity for the ball-bearing diamond truing device is demonstrated. Absolute rigidity, combined with smoothness, are necessary in the swivelling action, and these can only be secured by such an accessory.

The test for concentricity of the inner track is carried out on a fixture in which the ring is revolved on a bush on which it is an easy fit, and a ball-pointed plunger, held down in the track by a fairly strong spring, operates the plunger of the clock; any variation in thickness from the bore to the bottom of the track is immediately detected. The limit here is the same as for outer rings.

The actual track diameter, roundness, centrality, and truth of track with face are measured: the final inspection is for finish which is carried out in the "light box."

This concludes all the machine operations on the bearings and their inspections, and the rings pass to the department known as the "Pairing-up" Department, where inners and outers of suitable track diameters are assembled together. Outer races are tracked in a series of diameters, the tolerance for each series being 0.002, and these outers are sized out in batches varying by 0.0001 in. by means of a long taper gauge.

It is usually found that the bulk of the parts in a batch are invariably grouped close together; the mean diameter of this group is chosen and (minus the ball diameter) given to the shops for the grinding of a balancing number of inners, the tolerance in this case being plus or minus 0.0005 in. These pass back to the Pairing-up Department, where they are graduated and assembled with suitable outers; the suitability of the fit, i.e., the amount of diametric clearance, is measured in a magnified form in a fixture indicating the lateral displacement possible between the inner and outer races.

With regard to roller bearing manufacture, the sequence of operations follows that of ball bearings very closely, and but little description is required. No lapping or polishing is permitted of Ransome & Marles roller bearing tracks, and the standard of workmanship and finish is very high. There is probably no other engineering product which demands such high-grade workmanship as ball or roller bearing tracks. Parallelism is required to be within 0.00005 in. to avoid a tendency to move endwise. On the question of track finish there is a considerable difference between the methods adopted by the various bearing manufacturers. The most common practice is to grind the track once and follow with a good scouring with No. 3 emery cloth, and there is every reason to assume that the majority of ball bearings used are made in this way; in fact, this method is also adopted to control the fit of races. In other words, the rings are ground so that, with the balls in position, they are tight, and the easing process is carried out by means of coarse emery cloth. This method might be styled the "Continental method" and is not generally carried out in this country—for obvious reasons. In general, the requirements of the engineering industry of this country, particularly in the case of the automobile industry, call for bearings of quieter and smoother running properties than can be made by this method, and the procedure adopted by Ransome & Marles Bearing Co., Ltd., is to attempt to grind all race tracks so that no lapping is necessary. Where polishing is necessary it is only of a trivial character, and no perceptible material is removed.

Passing from the Pairing-up Department, the components are dealt with in a department in which absolute cleanliness is maintained. All the air passing into this department is filtered through a special arrangement of filters, ensuring that the atmosphere is as free as possible from dust or other foreign matter which would prove injurious to the bearings. After the balls are placed between the races, the cages are next assembled and the rivets fitted, the heads of which are heated and formed in an electric rivetter.

After assembly all bearings are freed from dust and grit by means of a high-pressure air jet; air at 40 lbs. per square inch is blown against the balls, the inner race being held in the hand and the outer member allowed to revolve at a high rate of speed. Various washing methods have been tried, but nothing is found so effective as high-pressure air. The complete bearing is passed to the final inspection department, where it is inspected for rust and tried for run by hand; the "fit" is checked and marked on the bearing, the bore is tested again by "go" and "no go" plugs, and the outside diameter checked on a minimeter to the same limits as in the grindery, and the width also checked again. The assembled bearing is then mounted on a mandrel between centres, and the following features tested, using a dial indicator:—

(1) Truth of inner face with bore, by revolving the mandrel and placing the dial against the face.

(2) Truth of outer face with bore, by revolving the whole and holding the indicator against the outer face.

(3) Concentricity of outside diameter and bore, by revolving the whole and holding indicator against outside diameter.

(4) Concentricity of inner track and outside diameter by placing indicator in contact with outside diameter, holding outer stationary and revolving inner.

(5) Concentricity of outer track and outside diameter, by placing indicator in contact with outside diameter and revolving outer.

If the bearing passes all these tests satisfactorily it is again tested for run and noise, greased and packed ready for delivery.

CUMBERLAND SUB-BRANCH.

Miners' Safety Lamps, Past and Present.

J. GEORGE.

(*Paper read 14th March*, 1929).

We are taught that the first commandment registered was "Let there be light," and when light came chaos vanished. This commandment was given in the formation in space of this island we call the world. In the mining world, and to-day most of us are much concerned in this particular world, chaos does not exactly reign, but some of us are striving to bring into this "darkened sphere" light and more light, both in a spiritual and mental, and in a material way. The theme of this paper is not in the higher spiritual or intellectual realms, but in a lowly form of material light. When the mining world was in its Genesis and our early parents sought out "the black stone that burns," the primitive forms of light givers were called in to fill man's need of seeing in the dark. Open lights of many forms were used with much success until one day when the coal face had retreated inbye, it was found that the air "caught fire" and actually burned; another day the miniature mine of our early miners exploded and blew up.

Self preservation being a very early law of nature taught the pioneer pit men to look after their skins; they did so by utilising the skins of the denizens of the deep, the phosphorous of whose fish skins gave a little light whereby coal could be won with safety from fire risk.

This early and primitive method was but an indifferent success; the inventive genius of men brought out the flint mill, this consisting of a train of geared wheels driving a steel disc against a flint, thus causing considerable "open sparking" which, if it existed to-day, would not only cause gas or dust to explode but H.M. Inspectors as well.

George Stephenson, whose name must ever be associated with mine safety lamps, was developing a lamp which he believed would be a great boon to mines and miners. He was working on the principle that a light would not pass through a tube whose length was twice its diameter. Stephenson, however, found this law was only true under a certain set of circumstances, and that the law was not a hard and fast or established one. All the same, he established a form of safety lamp. The lamp in popular parlance of the mine was known as the "Geordie Lamp."

The honour of evolving or inventing the safety lamp goes to that great little Cornish chemist known as one of the greatest chemists of the age—Humphrey Davy. He had many discoveries to his name, but none have rendered more service to mankind generally than his miners' safety lamp, his great discovery being the use of a flame entirely enclosed by a copper wire gauze. The heated gases which entered the interior of the lamp were cooled down below ignition point by passing through and coming into contact with the wire gauze on their way to the outside atmosphere.

Davy invented the miners' safety lamp between the years 1813 and 1818—well over 100 years ago—and, while the safety lamp has been improved upon by very many men far too numerous to mention, conspicuous among those improvers being Dr. Clanny who introduced a glass into the lamp and thus improved the light given, suffice it to say that, save for the improvements and the better light given, the fundamental principle of Davy's invention still stands unaltered.

Forty years ago however Mr. Wood, late of Murton Colliery, Co. Durham, introduced into that colliery an electric safety lamp, a revolutionary change in mine lighting. Many shook their heads in derision at this bold departure from established rules, and for years this lone but brave effort to improve the light and lot of the miner went on generally unnoticed, unrecognised and unpraised.

Pits were growing larger, economy became more and more a factor in mine working, better light was demanded, and at last a prize was offered by the Home Office, now nearly twenty years ago, for the best electric safety lamp for use in mines, under certain conditions. The competition was thrown open to the world, and out of 200 competitors the first prize of £600 was won by the "Ceag" lamp, the next in turn being awarded £50. A new era in mine lighting had started, and to-day the user of safety lamps has numerous forms of miners' electric safety lamps to choose from.

The electric cell or accumulator supplied with a miners' safety lamp requires to be near perfection both mechanically and electrically—or should we say chemically, and we make bold to say that no other scientific implement gets the same rough treatment as this little lead generator.

(The author here proceeded to deal in a general way with the construction of electric safety lamps. Having outlined the electro-chemical principles of the lead-acid accumulator, he passed on to the subject of electrolytes).

Electrolytes.

In the author's opinion the best electrolyte—as an electrolyte for the lead-acid battery—is, and has always been, dilute sulphuric acid. But with electric safety lamps it is not a case merely of dealing with accumulators pure and simple. Makers of miners' safety lamps want to make the best accumulator, but they must first make the best safety lamp possible. In other words, the electrolyte used must be suitable for the safety lamp it is to be used in, rather than that the safety lamp should suit the electrolyte.

It was for these reasons that about ten years ago, because the destructive action of sulphuric acid on terminals and fittings was so great and the cost of upkeep so high, to say nothing of the discomfort of the miners using a raw acid lamp after it had been in use for some time, certain makers were determined to compound, if possible, a solid electrolyte.

A solid electrolyte was produced and experimented with for well over a year in a Scottish colliery in conjunction with the local electrician and later at the "Ceag" works, before it was put on the open market. In less than three years at 80% of the places where the makers' lamps were used raw acid gave way to the solid (gelatinous) electrolyte, not because it was a superior electrolyte but because it made a better and less costly safety lamp, the light of which was equally good and proved to be better near the end of the shift, for obvious reasons. After twelve years of experience with thousands of lamps, and at a great many different collieries, the author is more and more convinced that for a pit lamp we know of nothing better than the "solid" electrolyte.

(The author gave a brief description of the alkaline cell and compared its performance and electrical characteristics with those of the lead-acid cell).

The Incandescent Bulb.

Whilst Sir Humphrey Davy's name is commonly associated with the miners' oil safety lamp, rarely is his close connection with the electric lamp brought to mind. He it was who made the wonderful discovery of the first practical form of electric lighting away back in 1813, when he gave demonstrations before the Royal Institution of a "brilliant and dazzling light." It was, however, left to J. W. Swan in this country and T. A. Edison in America to bring in the carbon filament lamp. In later days metal filaments came in, and with these it was possible for the first time to have profitable mine lighting by electric hand lamps. The early attempts at Murton Colliery, referred to earlier, were made with carbon filament lamps.

The manufacture of bulbs for safety lamps for use in mines is a task for the specialist. The ordinary lamps for house and office lighting lead the life of an aristocrat compared with the life of the humble miners' lamp bulb. Can anyone imagine a more strenuous job for a delicate little bit of filament "housed" in a glass dome than the miners' lamp bulbs have to undergo? Surprising as it may seem, specialists have worked this bulb question out so effectively that we can now get quite as long burning hours out of this bulb as is commonly given by the standard patterns of house or office bulb.

Some people seem to imagine that an electric safety lamp simply means connecting any old cell up to any old bulb and you are right. That would give a light but it would not constitute a lamp, and especially a safety lamp. The changes can be rung more often on bulbs than on any other part of the lamp. The bulbs and the plates of the cell must be in harmony; a high amperage bulb will pull a cell to pieces and increase the cost a hundred fold. Beware of the man who is anxious to show you the brilliance of his lamp without going into other factors of the case. Over-run bulbs are all very well for sample lamps, but for work-a-day conditions they are to be avoided. It is well to remember too, at this juncture, that glare is not light, and *vice versa.*

Types of Lamps.

(The author described several types of modern "Ceag" lamps).

The salient features of the standard lamp are the safety fuse, which operates should the well-glass be broken, and the quick-action joints which are fitted at every place where it is possible to make use of them. For instance, a quarter turn will separate the lamp case from the top, and another quarter turn will dissemble the interior fittings. A quick-action lid is also fitted to the accumulator. The accumulator itself has circular concentric plates and solid electrolyte.

The pillarless lamp is similar in general design to the standard lamp but instead of having four protector rods in the dome, it has a bridle which carries a movable reflector, so that it is possible to concentrate the light on the working face and, if desired, to remove the reflector and have an all-round light.

The four-volt lamp consists of a light but strong aluminium casing which carries two standard type accumulators. This in itself is an important feature as it means that the good points of the circular accumulator are obtained and no additional spares need be carried. It is made in the form of a standard or pillarless lamp and, what has proved still more useful, a bull's eye lamp for conveyor runs.

The shaft lamp is another lamp in which the standard cell has been utilised, and this carries four cells which are automatically connected in series when the lid is pressed home. The lamp can be swivelled round in any direction.

There are many types of officials' lamps, such as the deputy lamp, which gives the alternatives of a narrow piercing beam or a wide beam for walking. The torch, the small bull's eye, and the lamp which surveyors use for signalling.

One very interesting lamp is the gas detector lamp which has been subjected to severe trials over th[illegible] years and is now put on the market as a sound w[illegible] able proposition. It consists of the old familiar and flame lamp mounted in a very compact and simple pec- on the top of the electric safety lamp, either of the standard or bull's eye type. The oil flame is ingen[illegible] ously lit by platinum wire operated from the lighting battery and the height of the flame is controlled very easily. This lamp has proved to be a very efficient means of detecting gas and, at the same time, gives the operator the advantage of a powerful electric light.

There are other lamps which might truly be described as offsprings of the miners' lamp, and which find common usage for examining the interior of petrol cans and barrels which have contained inflammable vapours or in other gaseous atmospheres.

The miners' cap lamp is the lamp favoured by the author as being the most efficient type. For years, especially in Scotland, there has been a strong demand for this type of lamp. It was known that with the ordinary type of lamp a lot of valuable light was being lost because the rays were shed in all directions when the eyes could only look in one direction at one time. The author firmly believes that the cap lamp is the miners' lamp of the future. America has 200,000 cap lamps at work, Canada believes this is the type of lamp that is wanted, the latest convert is Australia, South Wales is nibbling, Scotland has nearly seen the last of hand lamps, and yet England stands firm to her first love, a hand lamp. The author believes that one day—and that before long—economic pressure will force this country to discard at least 50% of the hand lamps and adopt the all-conquering cap lamp.

One may ask, why this sweeping assertion? The answer is because of the obvious better lighting effect and the generally greater utility of the cap lamp. Better lighting is of course an advantage, but better lighting with the same initial source, i.e., a two-volt battery, is an advantage demanding consideration. The special headpiece of the cap lamp having the switch attached to it, thus removing the switch away back from acid or acid fumes that may be given off, is an advantage that can best be discovered by actual users.

A large group of Scottish collieries, who have many hundreds of cap lamps working, have lent valuable assistance in the development of this head piece, and by the combined efforts of laboratory research and practice at the actual working places of the mine, a very reliable lamp has been produced.

A reflector for the new head piece has been evolved which gives a superior light; it collects up all the light given from the lamp and throws out a broad, pure beam, giving the desired illumination to the miners working with it and the minimum glare to any other person who may have to face it. In support of this claim it is interesting to mention that a large open-light pit, under no obligation to instal safety lamps, has installed 1,000 of these cap lamps.

The head-piece of the cap lamp is a fixture on the man's head, the head turns in unison with the desire of the man's eyes; that being so, no matter where the eyes seek to penetrate, the accommodating light from the head piece is there to light up the path. Such a natural combination of movements exists with no other form of safety lamp. With an ordinary hand safety lamp a worker has nearly always one hand to work with, the other being preoccupied holding his safety lamp: with the cap lamp, he has not only his two hands free to work with, but he has a natural beam of light lighting up the plane of vision sought by the eyes. Moreover, the cap lamp being attached to the workman's person is not subjected to the abuses the ordinary lamp gets.

SOUTH WALES BRANCH.

Visit to Works of Electric Construction Co., Ltd.

Favoured with ideal weather a representative group members of the South Wales Branch journeyed by from Cardiff to Wolverhampton on May 9th last. ough the good offices of Mr. W. J. H. Porter, the diff representative of the E.C.C., the members were ertained to luncheon by the Company and were duly shown over the works. The principal guests included Messrs. Theodore Stretton, A. C. McWhirter, T. S. Thomas, C. F. Freeborn, Dawson Thomas, W. A. Hutchings, and many others. The photographic group of the visitors and staff officials was taken on the bowling green of the "welfare" department by Mr. John Debreczeni; it is a creditable example of what a student member of the Branch can do as an amateur with a camera.

Mr. Dawson Thomas, Mr. Stretton, and others, thanked Mr. W. M. Furniss, Director and Manager of the Company, and the other members of the Staff for their extreme kindness and cordiality. The following very interesting and useful address was delivered by Mr. Furniss.

The E.C.C.

AN ADDRESS BY Mr. W. M. FURNISS.

This business was founded in 1882, in which year the late Thomas Parker came to Wolverhampton and entered into partnership with Bedford Elwell, who was then in business in Commercial Road, Wolverhampton, as the Patent Tip and Horse Shoe Company. An electrical department was established, the number of hands employed being three all told—Parker himself, a man and a boy. Parker was previously a moulder at Coalbrookdale, Shropshire, having been sent to work at this trade when nine years of age. His set of moulder's tools was a cherished possession of his widow until the time of her death about three years ago. The beginning of his interest in electrical matters was a visit to the Great Exhibition in London, for which the Coalbrookdale Company presented him with a ticket.

The illustrations Figures 1 and 2 show model dynamos constructed by Parker with his own hands during that period. These models, which are in the possession of his family, and are still in working order, undoubtedly represent the inception of the well-known Elwell-Parker dynamo and the beginning of the business now carried on by the Electric Construction Company, Ltd.

In the vestibule of the E.C.C. works is a casting which was used as an armature centre in one of Parker's actual machines. This casting is a remarkably piece of complicated moulding work; it was made by Parker himself and was rescued many years later by his son from a scrap heap at Coalbrookdale.

It is interesting to note that simultaneously with Planté, Parker discovered and utilised the value of concentrated nitric acid in facilitating the formation of the necessary oxide in secondary battery plates, and that the Solicitor-General divided the patent between the two inventors.

In 1889 the prospectus of the Electric Construction Corporation, Ltd., was issued, the directors including Sir Daniel Cooper, Bart., C.M.G. (the fairy-godfather of

Members of the South Wales Branch at the E.C.C. Works, Wolverhampton.

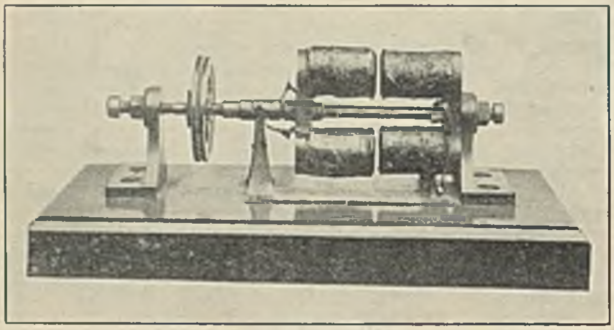


Fig. 1.—A dynamo made by Parker in the early "eighties."

the concern), Sir Henry C. Mance, C.I.E., Mr. John Irving Courtenay, Sir Douglas Fox and Mr. James Pender; the works director being Thomas Parker, and the engineer the equally well known J. E. H. Gordon. The Company embraced Elwell-Parker, Ltd., The Electrical Power Storage Co., Ltd., The Railway Electrical Contractors, Ltd., The Julien Patents for Electric Traction, and the Sprague Patents for Electric Traction and the Transmission of Power. In 1893 the present Company was formed, viz., The Electric Construction Company, Limited, with Sir Daniel Cooper as chairman, and the board included Mr. Emile Garcke, who was largely responsible for the reconstruction of the commercial side of the business.

Many of the early dynamos built by the Elwell-Parker Company are still in operation, and it is not an unusual thing for the E.C.C. to re-bar the commutator of a machine which has been in operation for 35 years or more.

The first dynamo was installed in Elwell-Parker's own works, and until quite recently it was in use at Bushbury as a motor driving a band saw in the Packing Department. Its historical value, however, was recognised, and it now indulges in a well-earned rest in the works' vestibule.

The photograph reproduced as Figure 3 illustrates an electric dog-cart, built in 1897. The then manager of the works was Mr. A. B. Blackburn, who was very fond of horses—hence the steering arrangement of reins. Another extraordinary feature was the operation of the controller by means of the sliding seat. It is said by an old employee who frequently drove the car that it operated quite satisfactorily when the manœuvre consisted of sliding the seat backwards, but not so well when it was necessary to pull it forward. This difficulty was

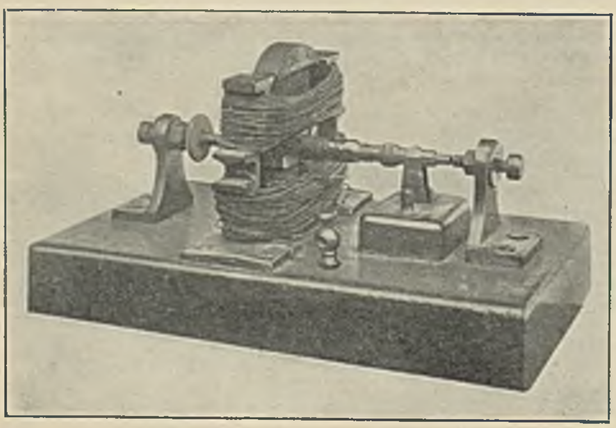


Fig. 2.—Another dynamo made by Parker about 50 *years ago.*

overcome by screwing down to the seat a wooden block shaped like half an egg. This rested between the driver's legs and thus became a key, the corresponding key-way being provided by the natural formation of the body!

The proper end of this vehicle should have been an honoured place in the South Kensington Museum, but unfortunately it was broken up. The motor, however, was retained intact and it is still doing service in driving the ash hoist in the boiler house at Bushbury Engineering Works.

The E.C.C. have been pioneers in most branches of electrical application, as for instance, dynamos installed underground in 1883 for electric lighting at Trafalgar Collieries, Forest of Dean, where later a Ward-Leonard system was installed which won the case for E.C.C. in an action brought in respect of the rolling mill plant at the works of Alfred Hickman, Ltd. Other early enterprises of the Company were: Slot System Tramways at Blackpool in 1884-1886; E.P.S. cells in 1877 for the submarine "Nautilus"; an Electric Accumulator Locomotive for Birmingham Tramways in 1889; overhead tramways for the South Staffordshire Company in 1893; and the Liverpool Overhead Railway also in 1893. Some

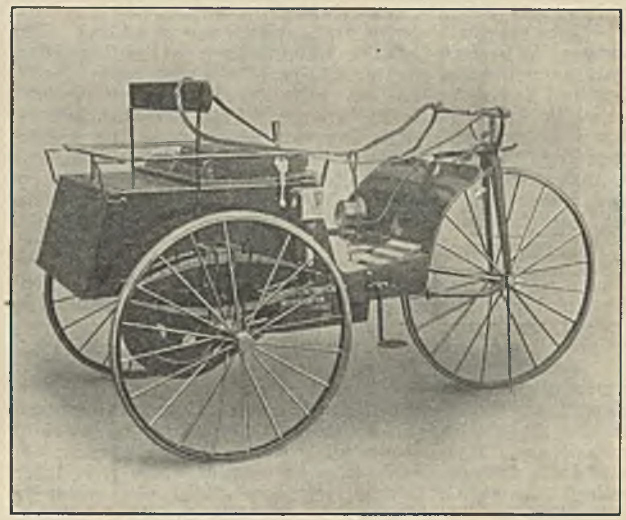


Fig. 3.—Parker's Electric Dogcart, built by him in 1897.

32 years ago the E.C.C. built for the Manchester Corporation the largest D.C. machine which had then been manufactured in this country, this generator being driven by a slow speed steam engine. Early traction installations included Halifax, Isle of Man, and the Surface Contact System at Melbourne, Australia. Pioneer high tension installations are represented by Sydenham Hill and Oxford—very early successful applications of high voltage D.C.—and a 10,000 volts, single-phase plant at Carlow. In 1894 were built for the London County Council Tramways (Greenwich Generating Station) four E.C.C. three-phase alternators each 3,000 K.W., 6,600 volts, 94 r.p.m.; these machines were 34 feet in diameter and were the largest electrical units built in this country up to that time.

It is interesting to note, as indicating the continuity which has been one of the characteristics of the business, that its first Works Manager was Mr. Richard Jones, his successor being his son, Mr. Harry Jones, who still fills the position, the service of father and son covering up to date a period of 47 years.

This brings us to the present day. As you will see the Works, I need hardly dilate upon what we are doing, but there are one or two points which I might emphasise. One is that we do practically everything ourselves; we make our own patterns; have our own iron and brass foundries; stamp our own core iron and prepare our own insulating materials. Also we test every machine that we build. Some of our competitors have done away with such tests. They do not state that this has been done in order to save money, but content themselves with the claim that their materials and methods of manufacture are of such superlative class that the possibility of breakdown is ruled out. Frankly the E.C.C. can make no such claim; even with the most rigid supervision the human element may be at fault, and even with the most careful selection of materials they may sometimes not turn out all that they appear or are claimed to be. We maintain, therefore, that although our percentage of breakdowns is extremely low, it is worth while to test in order to catch the one machine in a thousand that has some defect.

Amongst recent interesting contracts I may mention a Rolling Mill Plant for the Steel Co. of Scotland, which as you will see when you go round the works, is in course of despatch. This plant operates on the Ward-Leonard system and consists essentially of a 1400 H.P. mixed pressure turbine driving through reduction gear, a pair of generators, a flywheel and an auxiliary generator. The first named generators supply the current to the mill motor which has a normal capacity of 3000/5000 B.H.P. at 900 volts and a peak capacity of 7500 B.H.P., the speed being 55/110 r.p.m.

We have lately turned our attention to the manufacture of rotary converters, a large number of these machines having been supplied in various sizes during the past three or four years, including ten sets for Birmingham Corporation, ranging from 750 to 2000 K.W.; three 2000 K.W. and two 500 K.W. sets for Swindon to Messrs. Preece, Cardew & Rider's specification; two 1500 K.W. sets for Manchester Corporation; one 1500 K.W. and two 1000 K.W. sets for Glasgow Corporation, etc.

Coming to Mining Gear, which after all is what you are particularly interested in, I am sorry that we have not much work actually in the shops, for the simple but sufficient reason that colliery people are not at present in a position to place orders. Our plant, however, is well known in South Wales by reason of the work which we have carried out for Oakdale, Tredegar, Powell Duffryn, etc. In spite of the comparative slackness of this branch of our manufactures we do not cease to to advance in the matter of design, and we have lately had tested by Professor Statham at Leeds a flame and explosion proof slip-ring cover which not only fulfils the present official requirements but which we believe anticipates further regulations. Our patent flameproof vent for adding, as the necessary breather, to flameproof enclosures on motors and switchgear, has also been tested by Professor Statham with entirely satisfactory results.

SOUTH WALES BRANCH.

Three-Phase Induction Motors and their Control Systems.*

Discussion.

Major E. IVOR DAVID, in opening the discussion said the paper by Mr. Gregory was of the type they wanted—a short paper to induce a long discussion—with not too many points laid down dogmatically, but rather expressions of opinions from those who were using apparatus and plant as described in the Paper. There were many present who had troubles about control and starting gear and if they would only just express themselves the discussion would be of great value. He believed that to be the first time the double squirrel cage machine had been described in a paper before this Branch of the Association. Perhaps as one who introduced the first machine of that type in this district, and followed this up by others, he might say he was particularly interested in that part of the paper. The double squirrel cage winding attracted him from the very first, but unfortunately the British manufacturers did not take kindly to it. His firm had to go to Holland and they then found that the machines were not up to the required standard for underground work. They had trouble with the first machine which was 90 H.P. driving a pump. The British manufacturers eventually took it up and produced a machine to meet colliery requirements, and it was a first class job in every sense. Several pamphlets are now being published that manufacturers are making double wound machines with the rotors very much more robust than the earlier models. As said, the first machine installed was 90 H.P., but later the firm went up to 175 H.P. switched straight on to the line (driving a pump) at 3300 volts. Major David here warned users of these machines to be very careful with the oil rings to see that they were free and start easily. As was to be seen on the diagrams the machine gets up to speed in just under three seconds. Double winding machines are now made up to 1600 H.P.

With regard to star delta and auto transformer interlocks, the chief difficulty with all interlocks is that they do not get over the man who will tie the starter in the starting position and leave it there. He can still do that with the star delta starter, but there is not the same bad effect as with the auto transformer.

With regard to oil immersed and air break reversing switches, electricians started breaking circuits with air break switches, and then went to oil immersed and now were coming back to air break again. Reversing switches on haulages and winders have to stand up to a very large number of operations, and the air break was the better, particularly on heavy current. It was generally thought the oil was there to quench the arc, but in fact the oil intensifies the arc.

Regarding the controversy of the moving electrode, as one of the earliest advocates of these two types of controllers, Major David said he would like to hear other people's opinions.

There was one statement which the author made which he (Major David) thought was probably a slip. It was stated in the paper that the fan horse power varied as the square of the speed. This should be—the torque varies as the square, and the horse power as the cube of the speed

Mr. R. H. MORGAN—It is generally appreciated that the robustness, general reliability, and remarkable simplicity of the squirrel cage motor has done more, perhaps, than all else to popularise the electric drive during the past forty years. Its chief disadvantage, of taking a heavy starting current when switched straight on to the lines, has been mentioned. This drawback can be countered by the introduction of starting apparatus, which, however, destroys to some extent the delightful simplicity, and the author rightly advocates the overcoming of the starting problem without the introduction of trouble-promoting gear.

A comparison may be made between the construction, as affecting the probability of breakdown, of a slip-ring wound rotor and the squirrel cage bar rotor. Too often is the former type installed as a matter of course, without considering the installation of the more desirable simpler machine. The slip-ring machine has the disadvantage of slip-rings and brushes, both subject to wear, and, maybe, brush-lifting gear and short circuiting device which are often the root of the trouble. The least movement of the overhanging rotor end windings eventually leads to damaged insulation and absolute rigidity is difficult to obtain. Furthermore, positive rigidity of the windings in the slot is dependent upon the surrounding slot insulation which has a slightly flexible thickness. This does not obtain in the bar squirrel cage rotor and particularly in those in which the rotor end rings and bars are cast in solid. Following upon the consideration of such likely sources of trouble in the rotor, the fact must not be lost sight of

*See *The Mining Electrical Engineer*, July 1929, p. 22.

that oftentimes a rotor fault ultimately leads to a stator burn-out. These aspects are often not considered and the case for the squirrel cage motor is consequently neglected.

The efficiency and power factor of the squirrel cage motor are generally higher than those of a corresponding slip-ring motor, and a squirrel cage motor and auto-transformer starter are cheaper than a comparable slip-ring motor and starter. Far too little attention is paid to the efficiency of motors, the improvement of which is merely accepted whilst a reduction in generating costs is acclaimed and lauded disproportionally. This lack of attention to induction motors is promoted by the comparative ease of manufacture and their ready adaptability to mass production which warrants some firms producing such motors as a profitable but otherwise uninteresting, sideline.

The double squirrel cage motor is about 5% to 10% dearer than the standard squirrel cage motor, but this may be offset by conveniently using a star-delta starter instead of an auto-transformer starter.

The high starting torque obtained by the insertion of additional rotor resistance is clearly illustrated in crane and lift practice where a separate air cooled resistance is sometimes attached to the end of the rotor.

It is interesting to note that as long ago as 1900 a patent was granted to Hobart concerning an arrangement to obtain automatically a high rotor resistance at starting and a low running resistance by the use of "skin-effect." By using iron rotor conductors, a high effective rotor resistance is obtained at starting when the induced rotor currents have a high frequency. The lowering of the rotor current frequency at normal speed does not produce such a pronounced "skin-effect," and the desired change of effective resistance in the rotor is obtained automatically. The idea, however, is not practicable, because a necessarily high current density prevents an adequate "skin-effect" resistance increase and the high self induction, with the resulting reactance may counteract the benefit of increased resistance at starting.

It can be shown that the difference between the normal running rotor resistance and the increased rotor resistance to give good starting is really small, the chief point being to avoid an appreciable increase in rotor reactance.

The difficulty mentioned by the author regarding the supply of cooling water to inbye liquid starters is easily overcome by adopting the thermo syphon system for circulating the cooling water. No trouble has been experienced in using the system on haulages up to 300 H.P. Approximately 10 H.P. is continuously dissipated by a 24 cubic feet capacity tank, and the continuous dissipating capacity required, if unknown, can be assumed with safety to be (in cubic feet) three times the normal horse power of the motor.

The paper is indeed commendable and is particularly refreshing, coming as it does, from one so young. It is pleasing to find Mr. Gregory pursue an issue so often missed by mature members of the Profession.

Mr. J. F. SMITH—Mr. Gregory has confined his remarks on control gear for three-phase induction motors mainly to the rotor end. Switchgear for controlling squirrel cage and slip ring induction motors presents interesting problems, amongst which is the means necessary for preventing a switch opening on overload during start. With the star-delta switch method of starting it is common practice to arrange connections so that the overloaded coils are not in circuit until the delta connection is completed. Even with this device considerable time lag it necessary, as, since the current taken by a squirrel cage motor at start is proportional to the square of the reduction of the voltage used for starting, the current taken is considerably greater than normal full load current, but the period for which this normal current operates on the overload tripping device is shortened. Amongst other methods used is a mechanical device to render the overload trip inoperative during the starting period.

One of the most interesting overload protective devices for control of squirrel cage and other motors is the thermal type switch. This incorporates for the trip a bi-metal strip, through which passes the stator current or a portion thereof. Overload protection is provided for the motor, to prevent damage arising out of excessive heating of the motor and resultant detrioration of the insulation. It is obvious that time limit overload devices incorporating trip coils and dash pots or fuses can at best only approximate to the variations of load on a motor at start and during its running period.

These types of overload trips can make no allowance for the initial temperature of the motor which may already be high though not excessive, an overload of not sufficient duration to operate the trip increasing the temperature further. Again, a motor which has stopped due to operation of the overload trip can be started up again immediately by an attendant who has not taken the trouble to ascertain the extent of heating of the motor, and by repeatedly so doing raise the temperature of the motor to an abnormal degree. The makers of the thermal type of trip claim that the temperature of its bi-metal trip can be made to follow the temperature of the motor very closely.

There is no objection to running a motor with any degree of overload or repeated overloads, provided that an excessive motor temperature is not attained, and in fact there is some economy in so doing, by the relatively lower cost of a smaller size of motor for any particular job.

With reference to controllers for haulage purposes, the author stated that reversing switches become necessary in sizes above 200 H.P.: he (Mr. Smith) wondered whether Mr. Gregory meant that separate reversing switches become necessary at this size. Even for the lower sizes it would seem advisable that the reversing switch should be a separate piece of apparatus from the rotor controller, although controlled by the same lever. Controllers for both stator and rotor were sometimes self-contained in one tank. Would Mr. Gregory give his opinion on this, as it seemed to be asking for trouble to have, say, 3000 V. stator segments and rotor segments on the same barrel in the same tank, and with only a few inches of space between them.

Mr. H. PRITCHARD—The cooling of liquid controllers where fresh water is not available is now overcome by syphoning, or the better but slightly more expensive method of installing two tanks or sumps. One is fixed at a point just above the controller, which will give just the head required to produce the necessary flow, the discharge water from the controller is led to an open tank below a small drum pump chain driven from the haulage shafting, pumps the water back from the lower to the upper tank, while the haulage is running.

The prospective merits of air break and oil immersed reversing switches is a matter for local conditions, both giving good results. Major David in his paper on Electricity in Mines in 1924 gave some very interesting figures. He there stated that on a certain 1100 H.P. winder the maintenance costs with oil immersed reversing switches was £250 per annum, and the maintenance cost of the same winder after installing air break contactors was £150 per annum. The nett saving from the change would pay for a set of contactors within a few years. That, said Mr. Pritchard, would appear to settle the question as far as winders were concerned.

For large haulages below ground, the oil immersed reversing switch gives every satisfaction. Mr. Pritchard had in mind one of these reversing switches on a 150 H.P. haulage, in which the oil was changed at every 100,000 tons of coal hauled. There were two sizes of separate oil immersed reversing switches and liquid controllers now available for haulages from 300 H.P. down, made by Allen West & Co., the introduction of which was, he believed, credited to Major David.

The Double cage motors were undoubtedly a step in the right direction, said Mr. Pritchard, and when made totally enclosed, they would be seen universally used at the coal face. He knew of several now in use, in varying sizes, up to 175 H.P. all of which were switched direct on to the line, a method which would appeal to most of the members, since it did away with those expensive and troublesome auto transformer starter, or rotor starter, and brush lifting and short circuiting gear, which were the unavoidable necessity in larger machines.

The weir type liquid controller, which had been shewn on the slide, gave good service on many large A.C. winders, and was particularly suitable for sinking purposes where heavy loads were often handled at slow speeds; but for existing shafts with the winder motor designed for reverse current breaking, the dipper type controller appeared to have the preference.

Mr. W. A. HUTCHINGS—Squirrel cage motors were quite satisfactory for small machines, but with the large type machines, say, from 250 to 600 H.P. Mr. Hutchings said he would not consider squirrel cage motors satisfactory owing to auto starter transformer troubles such as had been pointed out by Major David. Although at the same time he would agree there was an appreciable improvement in the power factor of those motors. There were other things to be considered. He had been associated for the past 15 years with 600 H.P. pump motors, and on those pumps there were ordinary induction motors with short circuit slip rings and liquid starters, and he must say that they had been giving excellent results.

Mr. Gregory had mentioned controllers for haulage gear. That was a very vexed question. The author stated that from 200 H.P. to 300 H.P. haulages, liquid controllers should be installed. Mr. Hutchings could not quite agree with that: at the Colliery with which he was connected, there were a number of 100 H.P. haulages up to 300 H.P. haulages which had been working with liquid controllers for the past 15 years, and experience with those had been altogether satisfactory. The cost of maintenance of those liquid controllers was considerably lower in comparison with that of Oil Immersed controllers, and they were superior in regard to smooth starting. There was one important item connected with the controllers, i.e. the water supply in respect of broken pipes, this has been overcome by using the syphon arrangement.

Mr. Hutchings said he was hoping that within a short space of time the manufacturers would be able to offer a controller at a reasonable price for a 50 H.P. haulage, so as to do away with air cooled resistances. He believed that if the manufacturers would get down to this question more electricity would be used for haulages underground, which would greatly reduce the use of the uneconomic power of compressed air. Of course the manufacturers would have to pay more attention to the reversing switches for this type of controller, viz., the insulation, spacing and contacts.

Mr. H. T. GREGORY (in reply)—referring to the remark on the low reactance of the inner or running cage winding, said he agreed with Major David that it must have considerable reactance due to the position of this winding in the core, but what the paper really meant to convey was the lowering of the reactance of this winding by displacing the two cages, relative to each other in the core, as compared with rotors which have the two cage windings in the same slot placed above each other. Major David has corrected the slip made in the latter part of the paper, in that the horse power varies as the square of the speed which should have read, the horse power as the cube of the speed.

The motor referred to by Mr. Morgan was interesting, as it showed one of the many attempts to obtain a squirrel cage motor with the characteristics of a slip ring motor. Other designers like Mr. Hobart had constructed squirrel cage motors of various designs, but those designs do not appear to have been a commercial success.

Separate reversing switchgear becomes necessary for motors above 200 H.P., while in many cases it would be better to limit the controllers and metallic resistances to sizes below 150 H.P. Controllers with stator and rotor segments contained in the same tank were working satisfactorily on voltages up to 500 volts but for voltages above 500 volts the stator reversing segments should be contained in a separate tank.

Mr. J. B. HIGHAM in proposing the thanks of the meeting to Mr. Gregory, said it might be of interest to mention a new departure in the construction of high starting torque induction motors. This consisted of two stators, side by side, each with an identical winding; one rotor with the normal bars and shorting rings at each end, but with a central space occupied by a high resistance element connected to the middle of the rotor bars. The stator windings were so connected for starting that the rotor E.M.F.'s acted in opposition along each half of the rotor bar and the high resistance element was in circuit. When up to speed the stators were switched over to act on the bars as in an ordinary induction motor, the induced rotor E.M.F.'s acting in the same sense along each bar. The high resistance element was then out of the rotor circuit, or rather, inoperative, being connected to equi-potential points of the rotor bars. He had not yet seen one of these machines, and could not say whether they had proved themselves.

NORTH OF ENGLAND BRANCH.

The North of England Branch held their Annual Meeting in the Neville Hall, Newcastle-on-Tyne, on 11th May 1929, when the Branch President, Captain S. Walton-Brown, occupied the chair.

Mr. J. H. C. Brooking read a short paper, dealing with Colliery Cables, which was followed by a very interesting discussion.

Colliery Cables Considered.

J. H. C. BROOKING.

This brief paper deals with certain points in those types of cables used in collieries, that seem to need consideration. As in many other things, there are fashions in cables, and deviations from the prevailing fashion are "simply not done" in the best cables society. In approaching this matter the author is fortified as to the necessity of it by the dictum of his friend, Mr. C. J. Beaver, who, in his recent volume "Insulated Electric Cables" says:—

"There is very considerable room for improvement in all standard types of insulated cables, not only in the composition, form, and properties of materials, and methods of their application and protection, but also with regard to conditions of installation and maintenance of the finished cables. Moreover, the burden of such improvement must be shared between the designer and the user, if the evolution curve is to become steeper in accordance with the sharply accentuated requirements of the future regarding cheap power transmission and distribution."

"In other words, the general outlook in connection with the development of insulated cables should be such that research relating to production is not hampered by inflexibility of practice on the part of the user."

This extract, it will be noted, specially refers to the responsibility of the user in the matter of improvements in design; and in colliery work the conditions are so exceptional that it seems remarkable that cables are used which are at all in accordance with the standards of more normal places. It looks as if things are rather taken for granted; although, from the author's knowledge of certain colliery electrical engineers, it is not their fault that such designs have not been very violently altered in all directions. In any case, it seems to be a matter worth thinking over, and perhaps some of the suggestions contained in this paper may be improved upon, and other suggestions for improvements in design brought forward to stir up the inventive powers of British cablemakers.

We have come some way, however, since the first cables used in collieries had the following make up; double cotton covering over conductors, two layers of para strip, double cotton covering, hemp braided overall. Then came the vulcanised rubber insulation, for all purposes, with or without armouring. Very little of this class of cable is in use to-day, for main distribution at least. After these came vulcanised bitumen cables, and no type of cable has undergone so many changes in design and manufacture as this. It has certain advantages in as much that it can be handled very freely, and its ends are not easily affected by moisture, as is the case with paper insulated cables. Its disadvantages are low current rating, liability of the insulation to crack, and under certain fault conditions the production of inflammable gas from the cable. Later years have brought the compound insulated cables having various mixtures of rubber and bitumen compounds; they are certainly an improvement upon the ordinary bitumen cables, do not readily decentralise, and therefore can be run at high current densities.

Paper lead covered cables are now more generally used in collieries, and have many advantages over other classes of cable, namely, price, compactness, and reliability. They hold their own for general distribution and for extra high tension work there is nothing to beat them. The question of using shaped conductors for colliery underground distribution, is bad practice and failures are common, especially when the conductors are clover-leaf shaped, because they will not stand up against falls of roof without damaging the insulation.

As to trailing cables it now seems to be recognised that C.T.S. is the right material for protection, and it may be remembered that this successful type was first used by our neighbours, the Ashington Collieries, when all other trailing cable users approached fought shy of it and when most of the noble army of cablemakers derided it, then, and for some time afterwards. But there is a flaw in the design, that is sometimes fatal to its success, in regard to the corrupting influence of the large amount of sulphur (that is necessary for vulcanising cab tyre rubber) on the fine wires of the conductors used for its necessary flexibility. This is particularly the case where the copper braided earth shield is concerned, the tinning being worn away by the continual sliding of the braiding wires over one another; as the cable is repeatedly bent while at work, the braid is as the meat in the sandwich of the sulphur-laden layers of rubber that corrode it on both sides. This abrasive and corrosive effect causes lowered conductivity and, eventually, makes breaks in the flexible earth shield which are a source of danger when accidents happen on the farther side of the break. The defect is now becoming more appreciated and some makers are protecting the flexible copper braid by layers of more or less sulphur-proof material, such as cellulose; some are requisitioning other types of earth shield; some are using rubber without any sulphur, such as Pernax; and some are even doing without the earth shield on account of its uncertain life. This sulphur-corroding effect is accentuated on all conductors when moisture is allowed to come into contact with the rubber and copper as it takes up any free sulphur to form sulphuric acid and the copper is still more seriously affected. This, however, is the usual trouble with vulcanised rubber especially that containing a high percentage of sulphur; obviously one sure way to get over the difficulty is not to use vulcanised rubber, but to use a rubber compound which has no sulphur in its make-up.

After this general review, the cable may be considered in further detail, starting from its inside and going outwards:

Conductors.

As to material, copper cannot be beaten for conductivity, but for certain purposes, such as portable rubber cables, the use of steel wires either partly or wholly is worth considering where breakages in the conductors occur under excessive tension, when the more elastic rubber stretches, and leaves the conductors to take the full strain. Ordinary steel wire does not help much, and piano steel should be specified.

The lessened conductivity should not matter much, in comparison with the mechanical strength gained and the greater safety of the arrangement: and safety should be the keynote of all mining design. To this end a higher factor of safety is necessary than with cables used in ordinary situations, and greater safety usually lies in greater mechanical strength, even in electrical design.

The use of aluminum conductors is not likely to be so suitable for insulated cable, as for overhead work. Bronze wire is useful where fairly high conductivity allied with great strength is required. Also there are several other compounds of different metals worth considering for use where conductivity is not the most important point in a cable.

Insulation.

The three chief materials—rubber, bitumen, and paper, all have their backers for most situations in mines, and their respective limitations and advantages over each other are too well known to refer to here. In view, however, of the risks from mechanical damage that cables run in mines, it is rather a wonder that the standards of thickness are not greater for all types of insulation, especially for cables used in the more risky situations. This point has been appreciated in some cases, notably in regard to the "Cracore" improvement in guarding the conductors from multicores "Shorts", and some engineers improve on this design by having an extra layer of cab tyre around the cores of trailers, thus helping to protect against "Earths" also.

It is clear that wherever paper insulated lead covered cables can be used with safety and convenience there is little scope to improve their design, but there may be situations where the more expensive, but more mechanically strong, cambric insulated, lead covered type is to be preferred. This class of insulation is more used for machine insulation (without lead covering, of course) than for cables, but it may be worth keeping in mind for eventualities. Vulcanised bitumen is a material that varies rather more than other insulating materials, according to the ideas of the manufacturer. It is now apparently going out of fashion in this part of the country although it is still the vogue in Scotland.

An insulating material that is worth consideration in some cases is that known as "Pernax," which is a mixture of rubber and wax, and not being vulcanised there is no need for any sulphur in its constituents. Where there is trouble from sulphur this type is valuable. As a further indication of the scope of this material it may be noted that it is used for bird guards on overhead lines up to the highest voltages and so must be immune to climatic influences. The "Ite" materials are of fairly recent design and are mostly descended from C.T.S., which is itself an insulating material, though that is not supposed to be claimed by some of its makers for political reasons. These "Ites" are usually simple and effective for most colliery purposes.

Protection.

This part of the cable has been dealt with so variedly that there are few materials that have not been used. Designs, however, are much in line with standard cable practice and it is here that there is some chance of improvements being made, especially where the conditions for use are severe. Water, corrosive moisture, heat, foul air, falls of roof, runaway tubs, shifting haulage ropes, and in some cases several of these together need a special consideration when designing cables for use in their company. To go into details of some of the principal materials used:

Steel is excellent for tensile strength and abrasion resistance, but it corrodes in acid waters.

Fibrous materials, when well impregnated, protect for a time but eventually become soggy in water and are then easily worn out.

Lead is heavy and is attacked by certain corrosive moistures.

Cab tyre is flexible and not easily abraded but it can be damaged by sharp pointed materials with weight or impetus behind them.

This item of cable protection is one of the likeliest for consideration in regard to altering the design of cable the better to suit certain colliery conditions. There are sometimes combinations of mechanical, chemical, and electrical conditions that defy the standard materials used for cable coverings, and here is the opportunity to bring them to the light of day and to take counsel with this meeting as to the best way to get over such difficulties. The author would, therefore, invite suggestions from those present as to improvements in cable design, or even the necessity for improvements. No one should have better opportunity for the exercise of their critical and constructive faculties in this matter of cable improvements than colliery electrical engineers.

Discussion.

Mr. H. J. FISHER said he was sure everyone would have a warm welcome for Mr. Brooking, as being one of the Pioneers of the Association. Mr. Brooking had put in a great deal of hard work in its early days and been assiduous in helping its successful formation. Mr. Brooking had always paid a great deal of attention to the perfecting of mining cables. It was he who invented the cab tyre sheathing for trailing cables—one of the biggest improvements that have taken place in the design.

Referring to the question of the presence of sulphur in the insulation of cables, Mr. Fisher said he had found that sulphur does seriously affect the copper and is very detrimental to the fine strands of flexible conductors. He agreed with Mr. Brooking that it would be better first to cover the conductors with such a compound as "Pernax".

It seemed to be a custom now for most of the manufacturers to use bunched conductors instead of having rope stranded conductors for trailing cables.

The author had also mentioned an early form of insulation: that was very interesting because he, Mr. Fisher, still had about 100 yards of that cable left. It was originally designed by Mr. Llewellyn Atkinson, and it had an extendable core. The idea was that should a fall of stone occur which would fracture the cable, this core extended and prevented open sparking. That cable was pulled out about 15 years ago; it used to run D.C. cutters in the Margaret Pit, and the cable today was still in excellent condition—rubber and everything. It was laid on brown ware insulators.

Mr. G. RAW, in thanking Mr. Brooking, said the paper was a very excellent summary which would be exceedingly useful. He would like to ask whether the introduction of any type of stainless steel was a possible development.

Mr. H. ADAM asked Mr. Brooking if, in his experience of this "Pernax" type of insulation, the overheating of the cable had any effect on the "Pernax" after a period of time. Was there a tendency for it to get more brittle and thereby lend itself to the inlet of moisture should any flaws develop?

Mr. S. A. SIMON said he wondered whether Mr. Brooking had ever considered the question of current carrying capacity of trailing cables in relation to outside diameter. For coal cutters and similar work, it was important to keep the diameter small. If outer sheathing were reduced, it would lower the protection from mechanical damage—often with unhappy results—but the material of the outer covering may affect the current carrying capacity, and it would be interesting to know if any experiments had been carried out with the various types of covering mentioned in the paper, to ascertain which, if any, would stand up to higher temperature peaks than others, and particularly whether "Pernax" exhibits special merits in this respect. Mr. Brooking would appreciate that as light, flexible, and small cables are desirable at the coal face, the advantage would lie with a type of covering which would permit of a higher temperature—that is, of the use of smaller section of copper for a given duty. In this way, reduction in the diameter would be achieved without sacrificing mechanical protection.

Captain S. WALTON-BROWN asked Mr. Brooking as to what possibilities there were of manufacturing trailing cables in such a way that when the outer cab tyre covering became defective, it could be easily and economically replaced by another one. The interior was generally found to be more or less undamaged, although the outer part might be unserviceable; at present there did not seem to be any method of renewing it. He referred to a complete restoration when vulcanising had ceased to be of service.

Another question put by Capt. Walton-Brown was on similar lines to that of Mr. Simon. If the requirement be for a cable 800 ft. long for A.C. work which could be coiled and uncoiled repeatedly on a reel so as to work a locomotive, there seemed to be nothing available. It was a difficult problem to solve, owing to the bulk, but a flat type cable might be better. The requirement from the mining point of view was most necessary.

Mr. E. E. SHATFORD said he was in agreement with Mr. Brooking's remarks regarding the use of cables with shaped conductors for colliery distribution, and particularly so in the case of shaft cables. A cable with shaped conductors has not the mechanical strength of a similar cable with round conductors owing to lesser flexibility and the tortional stresses which are bound in when the shaped cores are laid up. The result being that unless the cable is very carefully handled during installation, distortion and damage may take place.

With regard to trailing cables, Mr. Brooking appeared to condemn flexible braiding under the sheath; unless the braiding is to be used in connection with leakage protection gear its use is likely to be a greater danger than a protection, as pointed out in Mr. Brooking's paper.

The use of increased thicknesses of sheathing and/or additional protections of hard cord lappings or braidings embedded in the outer sheathing was to be recommended and would certainly tend to increase the life of trailing cables.

Mr. BROOKING (in reply).—Mr. Raw asked would stainless steel get over the armour corrosion difficulty. There was no doubt it would do, but he, Mr. Brooking, happened to have gone into a case in regard to one colliery—where the protection of the cable down the shaft regularly disappeared—with th eidea of using stainless steel, and he was astonished to find what a large difference in cost there was.

Mr. Adam mentioned the possibility of overheating of Pernax, and asked would it be brittle: Mr. Brooking had never heard of any trouble from it, so must assume that people did not overheat Pernax, or, if so, it withstood the heating.

Mr. Simon asked for the best covering for reducing the size of the trailing cable so as to get the minimum size with the maximum amount of protection. That is a problem that has been discussed for many years. All sorts of things had been tried and Mr. Brooking could only think that C.T.S. was the most suitable material, but if the overall size had to be reduced—that is to say, the thickness of cab tyre—trouble from abrasion or damage to the outside should be anticipated, and therefore the trailing cables should be sent up out of the mine more frequently, for examination and repair. Greater thickness of cab tyre sheathing meant a longer period of the use of the cable in most situations, but not in all cases. It was one of those things where there were so many differences in situations and uses of the cable, and possibly in the arrangements for testing and repair, that it was not possible to say any one type of cable was suitable for every situation.

Mr. Hepburn mentioned that he found 7 or 8 m.m. difference in the diameters of armouring wires. That was an enormous variation and Mr. Brooking could only imagine that the armouring wires were not made in

Britain. Mr. Hepburn had also mentioned that he preferred braided finish. The trouble was that braiding could not be repaired; whereas should a lapping be pulled off, a piece of waterproof tape and lapped by hand, and a bit of tar deftly applied, made a repair of little difference from new cable. Braid cannot be replaced, but lapping can.

In regard to reinforced C.T.S. stopping splitting: there are two or three very good designs of this which are effective. As to the copper strand that was spiked through into the next core, there was no doubt that had been a faulty joint in the conductor, the parted wires had come adrift and one of the ends had gone right through the insulation.

Referring to the five-core mentioned by Mr. Hepburn, who said there should be no straight conductors: Several of the members present would easily remember what Mr. Williams devised in regard to dealing with five-core cable. Originally, the fifth core was put in as the centre, and that took all the strain, and broke very regularly. Mr. Williams arranged something that cured that fault by making it up in strand form, and when the cable is in tension gives a little in length and so does not get broken. Mr. Brooking said he thought the matter he mentioned, as to using piano steel wires, would help very much indeed where there were heavy strains. In that case, three piano steel wires and four copper wires of a slightly heavier size would give the necessary conductivity, and would not break. Piano steel was very useful in connection with the mechanical strength of trailing cables.

Mr. Shatford had said that he, Mr. Brooking, condemned flexible braid. That was not so; but he did condemn the design of cable in which the braid was subject to corrosion by excessive sulphur. Flexible copper braid is splendid by itself, but if it and sulphur get together, Heaven help the braid!

Mr. Shatford had suggested that C.T.S. cables should have thicker coverings, and Mr. Brooking agreed with him; where there was a great deal of abrasion, the extra thickness on the C.T.S. covering paid for itself in cost of repairs.

WARWICKSHIRE & SOUTH STAFFS. BRANCH.

Visit to the Coventry Colliery.

Mr. C. F. Jackson, the General Manager of the Warwickshire Coal Co., Ltd., invited the Branch to inspect the equipment of the Coventry Colliery, which was visited on March 16th. Mr. W. H. Cooper escorted the party and described the equipment installed and later read a paper—"Views of Insulated and Earthed A.C. Systems at Collieries"—to the members who assembled in the Company's Institute.

A short discussion ensued and, prior to to the termination of the meeting, Messrs. Hopley and English expressed on behalf of the Branch the pleasure derived from the courtesy of Mr. Jackson and the assistance of Mr. Cooper.

The Coventry Colliery is situated about three miles North-West of Coventry. The coal field covers about 5000 acres and there are two shafts each 21 ft. 6ins. diameter and 730 yards deep. The colliery has a designed capacity of one and a quarter million tons per annum. The steam plant includes seven boilers, at 160 lbs.

The winding engines are steam driven, 38 ins. diameter by 6 ft. stroke, with semi-conical drums, 14 ft. to 24 ft. diameter. They raise a starting load of 21 tons, consume 44 gallons of water per wind, and develop 2,500 horse power . Fifty men at a time are wound in each of the double deck three-tub cages. The winding engines at each shaft and the power plant are under one roof; the building is 239 ft. long and 54 ft. wide. The screening plant deals with 2,500 tons per eight-hour day.

The underground arrangements are chiefly driven electrically, no horses being employed; compressed air is used for heading purposes where gas may be found. Five years ago the existing generating plant consisted of two 750 K.W. mixed pressure turbo alternators, 2,750 volts, 50 cycles, and practically the whole of the current generated was used above ground, no electrically driven machinery having been used in the mine up to that time. To meet increasing demands for electricity due to speedy developments, both on surface and below ground, it became necessary and urgent to instal additional generating plant for this purpose.

These extensions consisted of two mixed pressure turbo alternators of 1000 K.W. and 2500 K.W. capacity each. Both these machines have their condenser pumps driven by H.T. three-phase A.C. slip ring induction motors, controlled by suitable switchgear erected near the machines. One interesting feature of the larger set is that, in the event of complete shut down, the sluice valve of condenser is operated by a 5 H.P. D.C. motor, supplied with current from an emergency steam lighting set.

In addition to some conversion and re-arrangement of existing panels, the main H.T. switchboards were extended to meet requirements, and Tirrell automatic voltage regulation for Nos. 3 and 4 generators were added.

The complete coal screening plant includes dust extraction equipments, driven in sections by eight 500 volt, three-phase A.C. slip ring induction motors, ranging in size from 10 to 40 H.P. each. The main ventilating fan was driven by high speed engines, but provision against breakdown had been made, as a temporary step, by the installation of a 225 H.P., H.T., A.C. motor, pending the completion of a duplicate electrically driven fan, which was at the time of the visit in course of erection.

The shaft cable was duplicated by the addition of 1000 yards of H.T. 3-core P.I., L.C., D.W.A. cable, size 0.15 square inch, laid between the power station and main distributing centre at the pit bottom. From this point energy is distributed through other substations and switchboards, inbye, to supply over forty three-phase A.C. motors at 500 volts. These are chiefly of the slip ring type, ranging in size between 25 H.P. and 60 H.P. each.

The main pumping plant is situated between the shafts, and consists of three throw pumps, driven through gearing by one H.T. motor 225 H.P. This pump deals with about 240 gallons per minute under the existing head of 2160 feet. This water had, previous to the electrification, to be wound up the upcast shaft daily in a large barrel by the winding engine.

Notes Regarding Insulated and Earthed A.C. Systems for Collieries.

W. H. COOPER.

The early days of the alternating current plant, in use at collieries, seldom brought one in touch with anything but the insulated system, and in some instances, very little automatic switchgear of any description was used for the purpose of protection. Nevertheless, it was possible to maintain all types of electrical apparatus in a state of safety from leakage or overloads. Reliability depended, however, too much upon the human element, but thanks to science, art of engineering, and practical experience, we now have a varied choice in the selection of switch and control gear, to suit the most difficult problems which may arise, in the application of electrical energy.

When considering extensions to plant, bearing in mind safety and reliability of service, there is the question of cost which is apt to cause some of the apparently less important parts of the equipment to take a second place. Take for example a substation, consisting of: power transformer, H.T. switchgear, and L.T. distributing switchgear.

(1) The first two items, naturally, take the lion's share of cost allocation.

(2) The L.T. distribution switchgear is apt to be the subject of a low tender.

Item (2), low tension switchgear, should have equal consideration, especially if it is required to operate on an earthed neutral system; then it should, however, be advisable to include leakage protection device of some description, in addition to the usual overload trip gear.

When the conditions of a mine call for flameproof apparatus, leakage protection devices which operate in the event of a slight fault current to earth, should become essential. On the other hand it is questionable whether earthed systems, unless equipped with firstclass and reliable leakage protection devices, can be regarded as being more safe than well-maintained insulated systems, owing to the heavy fault current, which may be likely to occur before the faulty circuit automatically becomes isolated.

Earthed systems, fitted with modern devices and adopted in a number of substations, etc., in various parts of a mine, appear to require some advance in both technical and practical training of the maintenance staff. By the time their knowledge has improved, it often happens that the most promising pupils leave the mining world for something better.

It is not an easy matter to introduce an earthed stystem, for instance, at a colliery power station where a number of alternators have already been installed, especially when two complete coal winding shifts have to be maintained and the load during the alternate shift is very heavy for pumping, etc.

If earthing the neutral be contemplated on the installation of additional generating sets, there occurs the difficulty and expense of fitting necessary apparatus to the existing equipments, which have apparently given every satisfaction.

It is preferable to instal earthed systems, fitted with complete leakage protection devices in new power stations, where additional outlay would be gradual, and electrical staff trained to grow with progressive plant. Insulated systems should, however, be regarded as highly safe and successful if kept in a good state of insulation and continuity, through periodic inspection, testing, etc.

Ideal installations will, in the author's opinion, be accomplished:

(1) When our Mines Departments are satisfied that perfection has been attained in the design of electrical apparatus suitable for use in mines.

(2) When our large engineering firms co-operate, to meet such requirements, by the standardisation on a commercial and economic scale, of suitable types of motors, switch and control gear, portable electric machines, etc., to suit every class of mine, whether their conditions call for flameproof equipments, or otherwise.

Hence one class, similar in a manner to the approved types of miners lamps, would leave no doubt or misunderstanding as to the suitability of any electrical apparatus required for use in mines. Thus the occasion to replace apparatus, to comply with other regulations, will not be anticipated. Should these views materialise, the author for one who is concerned with the responsibility of the safe application and maintenance of electricity in mines, would be satisfied.

Association of Mining Electrical Engineers. Examinations, 1929.

List of Successful Candidates.

Name.	*Branch.*	*Class.*
George Denholm	East of Scotland	First
John Black	North of England	Second
Herbert A. Fulton	Do.	Second
William Jeffrey	Do.	Second
Thomas Robson	Do.	First
Edward Rogers	Do.	Second
James Walton	Do.	Second
John Watts Wiffen	Do.	Honours
Harry Eames	Yorkshire	Second
William Percival Fielder	Do.	First
Robert Harold Howe	Do.	Second
Jesse Mann	Do.	Second
Fred. Faust	Midland	Second
Ernest Hawksley	Do.	First
Harold Wilkinson Randall	Do.	Second
Victor Wyness	Do.	Second
Basil James Burkle	South Wales	First
Cyril Edward Constable	Do.	Second
William Thomas Gay	Do.	Second
Ernest James Hilling	Do.	Second
Thomas William Wood	London	Second

Alfred Charles Evans of the South Wales Branch qualified at the Examinations for a Second Class Certificate, but this has been withheld owing to insufficient Practical Experience.

Association of Mining Electrical Engineers Examination Papers, 1929.

CERTIFICATE EXAMINATION.

1.—*Direct Current.*

(1) Six cells, each having a resistance of 0.5 ohms and an e.m.f of 1.5 volts, are joined in symmetrical arrangement of 2 sets in parallel and connected to a circuit with resistance of 7.5 ohms.

Find the current flowing through the circuit.

(2) Describe the methods of winding the armature coils of continuous current machines. Draw diagrams to illustrate your answer.

(3) Define the term "Insulation Resistance."

If the resistance of a copper conductor $1\frac{1}{2}$ miles long is found to be 0.2 ohms, what will be the cross-sectional area of the copper? Given that the specific resistance of copper is 0.668 microhms per inch cube.

(4) Explain how variations of load affect the speed of a series motor working at constant voltage.

A series wound dynamo gives an e.m.f. of 400 volts when running at a speed of 1,000 r.p.m. The machine takes 25 amperes when used as a motor, its output then being 10 H.P. Calculate its speed at this output.

(5) Draw the normal charge and discharge curves for a lead-acid accumulator. Enumerate some of the most important points to be considered in the treatment and care of a storage battery.

State briefly what causes the phenomenon known as "gassing" of a cell.

(6) Describe, with the aid of a diagram, a starter for a shunt motor and explain why such a starter is necessary.

(7) Define the term "Voltage Drop," with respect to a D.C. transmission line.

Show how the amount of heat generated in a conductor can be calculated.

The P.D. at the receiving end of a pair of feeder cables is 220 volts and the resistance of the cables is 0.5 ohm. If the feeders are delivering 44 kW., what is the amount of power put in at the generating station? What is the efficiency of transmission?

(8) A motor when undergoing a brake test takes 25 amperes at 450 volts, the speed of the motor being 660 r.p.m. If the motor is fitted with a brake pulley 18 inches in diameter and the pull on the rim of the pulley is 150 lbs., find:—

1. The Brake Horse Power, and
2. The Efficiency of the motor.

2.—*Alternating Current.*

(1) Define the terms:—"R.M.S. Amperes," "Form Factor" and "Frequency."

What is the form factor for a sine wave?

(2) State Lenz's law for inductive circuits. What is the practical unit of self-induction?

A coil has 300 turns and a current of one ampere flowing through the coil produces a flux of 8,000 lines. What is the coefficient of self-induction of the coil? If the coil is connected to mains supplying 16 amperes at 50 cycles and the resistance of the coil is one ohm, what must be the applied voltage?

(3) Explain the auto-transformer method of starting a squirrel-cage induction motor . Draw a diagram of the connections.

(4) A three-phase 440 volt motor develops 25 H.P. at 92 per cent. efficiency. If the power factor is 0.81, find the value of the line current and the current taken by each phase of the motor, the stator of which is mesh connected.

(5) Describe, with the aid of a diagram, the construction of an induction type wattmeter.

Draw also a diagram to show how it would be connected to a circuit.

(6) Describe the principle of a static transformer and explain what is meant by the "regulation" of a transformer.

A transformer has 315 primary turns and 21 secondary turns and its secondary output is 10 amperes at 100 volts. Find the voltage in the primary and the ratio of transformation, neglecting losses.

(7) Draw a diagram showing the electrical connections to an A.C. coalcutter and the various apparatus used in the circuit commencing at the shaft cable.

(8) The power supplied to a three-phase motor as given by two wattmeter readings is 264 k.w. If the sèparate readings of the wattmeters are in the ratio of 2 to 1, determine the angle of lag of the current and the power factor of the system.

If the power factor alters to 0.707, determine the new separate readings of the two wattmeters.

3.—*Electric Lighting and Signalling.*

(1) Describe, with the aid of a diagram, an electric bell designed to eliminate sparking at the trembler contacts.

What are the safety devices which can be incorporated in a signalling bell to render the breakflash at at the bare signalling wires incapable of igniting firedamp?

(2) State clearly the requirements of the Coal Mines Act with respect to electric lighting underground.

What type of switch would you instal to control a lighting circuit underground?

(3) Describe the construction of the lead-acid accumulator as used in the miner's electric hand lamp.

Explain the relative advantages and disadvantages of lead-acid and alkaline accumulators with respect to their use in electric hand lamps.

(4) State clearly the requirements of the Coal Mines Act with respect to shaft signalling apparatus.

Make a neat sketch showing a system of electrical signalling for a shaft, the winding being from two levels.

(5) Explain what is meant by the term "half-watt lamp." The annual cost of lighting a colliery plant is found to be £40 13s. 9d. If 200 lamps each giving 91 candlepower at a specific consumption of 0.66 watt per c.p. are lighted for 5 hours each day for 310 days per annum, what will be cost per unit for this lighting?

(6) Make a neat sketch to show how a relay would be connected in a mine bell circuit. Why is such a relay generally necessary?

(7) Define the terms "Mean Spherical Candle Power" and "Foot-Candle."

How would you express the efficiency of an electric lamp?

Draw a diagram showing how you would connect a lighting fitting so that it could be controlled from two separate points.

(8) A dynamo having an e.m.f. of 250 volts and an armature resistance of 0.25 ohm, is charging a battery of 100 accumulators, each having an e.m.f. of 2.2 volts and internal resistance of 0.001 ohm, through a regulating resistance of 0.25 ohm.

Find (a) the current generated by the dynamo, and
(b) the power wasted in the charging circuit.

State what type of dynamo you would use for such charging purposes and why.

4.—*Electrical Rules and Regulations, and Special Paper.*

(1) Define the terms "open sparking," "low-pressure," "medium pressure," and "authorised person," as laid down in the General Regulations.

What are the duties of an electrician under the General Regulations?

(2) Enumerate the restrictions imposed on the use of electricity in gassy mines.

Explain the various features of design to which you would pay special attention when examining a flameproof enclosure in use underground.

(3) State what precautions must be taken with respect to the protection of cables in order to conform with the General Regulations.

Describe briefly methods of supporting a cable in a shaft and in a haulage road.

(4) State the requirements of the General Regulations with regard to the provision of earthing conductors.

Describe, with the aid of a diagram, a simple method of testing the conductivity of an earthing system.

(5) An explosion of firedamp within a totally enclosed casing results in a high pressure being developed. Describe with the aid of diagrams two safe methods of releasing pressure from the casings of mining electrical apparatus.

State what you consider to be the best method of connecting a cable to the contacts of a gate-end circuit breaker.

(6) Describe, with the aid of a diagram, the construction of a "Megger" testing set and state for what purpose this instrument is used.

(7) It is required to instal an endless rope haulage haul 540 tons of coal per shift of six hours up an incline 660 yards long. The following details are available:—

Average gradient 1 in 5.
Weight of each tub 6 cwts.
Capacity of tubs 12 cwts.
Rope speed $2\frac{1}{2}$ miles per hour.
Weight of rope 10 lbs./fathom.
Co-efficient of Friction of tubs 1/50.
Co-efficient of Friction of rope 1/20.

Using these figures calculate the size of the required haulage motor.

(8) Describe the moving-coil type of voltmeter. How does this differ from the moving-coil ammeter?

A moving-coil instrument has a resistance of 5,000 ohms, and the constant of the instrument is such that 15 milli-amps give 150 divisions on the scale. What would be the deflection of the needle if a P.D. of 20 volts were applied to the terminals?

HONOURS EXAMINATION.

1.—*Direct Current.*

(1) Define the terms "Specific Resistance," "Insulation Resistance," and "Dielectric Strength."

A 50 H.P., 500 volt D.C. motor is supplied from a distributing centre 250 yards away. What must be the cross-sectional area of the cable if the loss in transmission is equal to 3% of the motor output? The efficiency of the motor is 85% and the specific resistance of copper may be taken as 0.66 microhms per inch cube.

(2) Describe and explain the object of the official tests on electric bells and relays for use underground in bare-wire signalling systems.

Discuss the problem which arises when two or more bells are connected in parallel on a bare-wire system and describe a method of overcoming the difficulty.

Indicate the disadvantages of a bare-wire system and describe an alternative system.

(3) Describe briefly the various ways in which the speed of a shunt wound motor can be varied.

A 50 H.P. 440 volt shunt motor is to be provided with a starter. Show how you would derive the necessary number of steps for the starter, to comply with the following conditions:—

(*a*) the maximum current taken during the starting period is not to exceed the full-load current by more than 50 per cent.

(*b*) the current on each step is assumed to fall to the full-load value before the starter is again moved. The resistance of the armature and leads may be taken as 0.05 ohm and the efficiency of the motor as 89%.

(4) Discuss the causes of sparking at the commutator brushes of a D.C. machine and the methods of eliminafting such sparking.

How and when are compensating windings used? Give the reason for building up armature cores by means of laminations.

(5) Show how you would calculate the B.H.P. of the driving motor of a mine ventilating fan.

Describe briefly the types of drive which can be used for a mine fan (*a*) when the speed remains constant, and (*b*) when it is necessary to vary the speed.

(6) Describe with the aid of a diagram the Ward-Leonard system of electric winding.

What is the object of using a fly-wheel in conjunction with such a system?

(7) What are the requirements of the General Regulations respecting the earthing of apparatus and conductors?

Sketch and describe a suitable earthing system for a plant having a capacity of 5,000 k.w. Give the principal dimensions and indicate the arrangement of the earth circuit.

2.—*Alternating Current.*

(1) A three-phase alternator supplies the following loads:—

(*a*) 25 k.w. at unity power factor for lighting.

(*b*) An induction motor of 100 H.P. output at 92% efficiency and 90% power factor.

(*c*) A number of small induction motors with a combined output of 50 H.P. at an average efficiency of 80% and power factor 75%.

If the three phases are balanced find the line current and the power factor of the combined load.

Voltage between lines is 220 volts.

(2) What conditions must be fulfilled before the paralleling switch of an alternator can be safely closed?

Describe, with the aid of a diagram, the construction and action of a synchroscope for high-voltage machines, and show by means of a second diagram how such synchronising gear would be arranged in the circuit.

(3) Define the terms "Power Factor" and "Load Factor."

If a power company's tariff takes no account of power factor what would be the general basis of such a tariff?

State what you consider to be the necessary items of a tariff which takes power factor into account.

(4) Describe, with the aid of a diagram, a method of installing a sinking pump in a shaft showing how the necessary equipment would be arranged.

State what type of motor you would use for the drive of a sinking pump, giving your reasons.

(5) Explain what is meant by the "regulation" of an alternator.

Why are special voltage regulators necessary with alternators?

Describe briefly the action of one type of voltage regulator. Illustrate your answer by means of a sketch.

(6) Draw a diagram showing the connections of a draw-out pillar switch with core-balance protection.

Describe the split-conductor system of feeder protection.

(7) A single-phase concentric cable (with the outer conductor *not* earthed) supplies current at a pressure of 2000 volts and a frequency of 50 cycles per second to a transformer.

If a break occurs between the end of the transformer and the outer conductor, and that end of the transformer becomes earthed, find the pressures produced across the transformer and between the outer conductor and earth.

For the purposes of the question assume:—

(*a*) Capacity between outer conductor and earth = 2.4 microfads.

(*b*) Transformer inductance = 8 henries.

(*c*) Resistance of transformer fault to earth (including resistance of windings, etc.) = 660 ohms.

Give an explanation of the phenomenon which this example indicates.

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.—REPORTS of H.M. Inspectors of Mines for the Year 1928. No. 4—North Midland Division, Report by Mr. J. R. Felton. Price 1s. nett.

BRITISH ENGINE BOILER & ELECTRICAL INSURANCE Co., Ltd.—TECHNICAL REPORT for 1928. Published by the Company at 24 Fennel Street, Manchester. Price 7s. 6d.

This is in effect an original and extremely valuable technical treatise on the use of welded joints for pressure work. In the introductory chapter it is pointed out that there is an increasing tendency to employ fusion welding in the production of pressure vessels, and the absence of any official rules or regulations in this country to guide design has resulted in a state of affairs which is unsatisfactory. So far as the Company is concerned there can be no question but that the rivetted joint is preferable to the welded joint, the actual efficiency of which depends so largely on the individual skill of the operator and the quality of the metal deposited.

At the same time, in view of the fact that welding is very often the most economic method of making a joint and that it is a convenient means of obtaining tightness, a welded joint is entitled to consideration as an approved form of construction for an unfired pressure vessel, provided that it is properly designed and constructed.

It has probably been the common experience of insurance companies to be invited to accept for insurance pressure vessels, of which it is impossible to see the inside surfaces of the joints or ascertain thicknesses without the plates being drilled. Although the application of hydrostatic pressure may reveal the existence of porosity in a weld, while a hammer test gives an indication of brittleness and unsoundness, these tests are insufficient for a determination of the safe working pressure where it is at all uncertain how the work has been carried out.

In the absence of recognised standards for construction makers have followed their own inclinations without knowledge of what any supervising authority must perforce deem necessary. The Company decided to enquire closely into the various processes of fusion welding, the influences affecting the production of good work, the strength of the most common forms of joint, and any other matters germane to the subject—the immediate object being to obtain sufficient knowledge on which to decide what constructions should be permitted for pressure vessels and what limitations, if any, should be set. The investigation, which has included the carrying out of many hundreds of mechanical tests, was limited in the main to the construction of vessels subject to air or gas pressure, and this book gives full details of the results together with recommendations.

RATIONALISATION FOR TIN, by A. P. L. Gordon. London: The Saint Catherine Press, Stamford St., S.E. Price 2s. nett.

In his Preface the author takes up the challenge that Rationalisation, on the economic side, could not profitably be applied to tin mining. This book shows that so far from such a policy being impossible, it is in fact easily realisable and industrially necessary. The chief task of Rationalisation is to free both producers and consumers from the risks of an uncertain market. The problem is being variously faced in many industries; but tin, most volatile of all commodity markets, is still unorganised. Supplies are regulated with scant regard to the world's requirements: in times of stress, when less tin is needed, failing prices impel producers to swell their output; producers, in the attempt to recoup their loss, only succeed in increasing the market's instability.

The difficulty presented by diversity of mining costs is apparent rather than real; if output-control effects a rise, not only in the price of tin per ton, but in the aggregate value of the total output, the benefit will be felt by both high and low cost producers. Since 1927, on a flourishing consumption, prices have fallen more than in proportion to the rise in output; conversely, restriction of supplies would achieve results more than proportionate to the sacrifice involved.

The scheme here put forward provides, it is claimed, an answer to the objections which have been urged against co-operative action. The recent formation of a Tin Producers' Association is an important step forward; but it provides in itself no solution for the industry's more pressing problems. Control of output is a necessity; but the mere restriction of present supplies even under the Association's auspices, would aggregate more evils than it would cure. A scheme of control must, to prove effective, be more ambitious in substance and more durable in form. It is to the finding of such a scheme that this analysis is addressed.

THE SOUTH INDIA MOTOR OWNER.—Bearing this title the First Number of a new illustrated monthly journal reaches us from Madras. It is altogether a commendable production combining sound technical advice with a leaven of humour which will certainly appeal to the motor owner of the Far East. Here are samples of the fare provided: Heat is as important as Speed in the life of pneumatic tyres; every car owner should practice Skidding and its Prevention; Empire Motor Spirit from palm trees; the Dimming Problem Solved; old ideas and present day comparisons; the Practical Side; the Commercial Owner—and so on. It is well produced in all respects and will undoubtedly "catch on."

SIR ISAAC PITMAN & SONS have published the fourth, and last, volume of the "Technical Dictionary of Engineering and Industrial Science in Seven Languages." The dictionary contains a most complete list of technical words, terms and phrases, with their equivalents in French, German, Spanish, Portugese, Italian and Russian, and will be found invaluable by firms having foreign connections and who aim at extending their foreign trade.

IMPORTANT RAILWAY CONTRACTS.

A feature of interest in connection with the electrification of the Manchester, South Junction and Altrincham Railway, contracts for which have recently been awarded by the G.C. and L. & N.W. Railways Joint Committee, is that the overhead contact wire system at 1,500 volts D.C. has been adopted. This is the first railway electrification to be carried out in Great Britain at this voltage, which is the higher of the two standard voltages recommended for railway electrification in this country. The British Thomson-Houston Co., Ltd., have been entrusted with the order for the complete substation plant, comprising switchgear, transformers, rotary converters, and control equipment, the latter being of the automatic type with remote control for one of the two substations. In each substation there will be six 750 Kw., 750 r.p.m., rotary converters, with transformers to take the incoming supply at 11,000 volts, three-phase, 50 cycles, from the Stretford District Electricity Board, the rotary converters being operated two in series. Although this is the first instance in Great Britain where rotary converters are operated two in series for railway work the British Thomson-Houston Company has manufactured a large number of such substation equipments for duty overseas, some of the automatic equipments most recently supplied being 5 sets for the New South Wales Government Railways and 26 sets for the Great Indian Peninsula Railway.

Manufacturers' Specialities.

The "Bridge-Meg" Resistance Tester.

To offer in one piece a reliable, handyweight portable means of testing the resistance of any circuit, insulation or apparatus commonly used in industrial and domestic practice will kindle the immediate interest of every electrician. Above all the mining electrical man will be exceptionally alive to its advantages. The illustration, Fig. 1, shows the new "Bridge-Meg" Resistance Tester, made by Evershed and Vignoles, Ltd.; it weighs less than 13lbs., and is self-sufficient for measuring resistance values ranging from 0.01 ohms to 100 megohms. It is when one sees the manufacture of these instruments that the secret of their success is revealed. To provide in a limited space a compact and sensitive mechanism which can safely be entrusted to a workman: to be carried about and dumped down for use anywhere in factory or mine, under cover or in the open air, demands the highest degree of design and skill in manufacture. The care given to every detail to ensure robust long service in the finished article was the outstanding impression gained during a recent tour through the Evershed works. To mention only a few features: the armatures of the solid little generators run on ground roller bearings, every pivot is ground to gauge, moving switch contacts are held evenly to their seats by spherical thrust, there are no flat springs to age nor contacts pressing sideways: and all these finest parts, as well as every part are made strictly to gauge of materials and metals tested regularly to mechanical and analytical standards. Processes such as grinding, tempering, annealing, and hardening, impregnating, bakelite moulding, wheel cutting, etc., are here effected as a fine art.

Every electrical man is familiar with the Meg Insulation tester, introduced in 1922 of the variable pressure pattern, and followed two years later by the constant pressure pattern for use where large electrostatic capacity in the cable or windings of machinery under test necessitates a constant testing voltage. The success obtained with the Meg Insulation Tester showed that there was a big demand for an insulation testing instrument which should be light, compact, and cheap. It showed, too, that the field of utility for the Meg did not overlap to any great extent that of the "Megger" Testing Set, no doubt for the reason that the Meg does not compete in the practical work-a-day sense with the more expensive and larger instrument. On account of the limitations imposed by its low weight and small size the Meg has one range only, and is not supplied either for testing at pressures higher than 500 volts or with scale maxima above 100 megohms.

The success of the "Meg" led the makers to believe that there was a similar opening for an instrument which should bear to the "Bridge-Megger" Set a similar relation to that which the "Meg" Insulation Tester does to the "Megger" Testing Set, and

Fig. 1.—The "Bridge-Meg" Resistance Tester.

this new instrument, known as the "Bridge-Meg" Resistance Tester, is the result.

The "Bridge-Meg" Resistance Tester is self-contained, not having an external Resistance Box like the "Bridge-Megger" Set. The change from the "Meg" setting (used for testing insulation) to the "Bridge" setting (used for measuring low resistances) is made by a turn of the Change-Over Switch without altering external connections. There are two external terminals only and no change of external connections is necessary when changing from "Meg" to "Bridge" or vice versa. This is a great convenience when a resistance which is expected to be of the order of megohms proves to be a few thousand ohms or less.

Fig. 2.

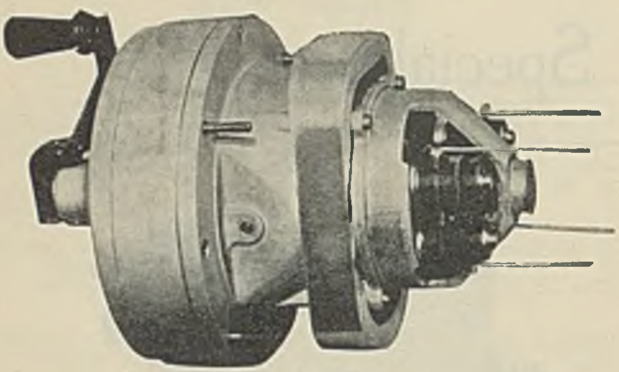


Fig. 3.—The Generator.

When testing insulation the instrument is used exactly like the Meg Insulation Tester: the terminals are connected to the resistance under test, the handle of the generator turned, and the value of the resistance read on the dial direct in megohms or ohms. The "Bridge-Meg" has one range only on the "Meg" setting, the scale being divided from 10,000 ohms to 100 megohms, and it is supplied for a testing pressure of 500 volts only. It corresponds in this to the "Meg" Insulation Tester, and contrasts with the "Bridge-Megger" Set, which may have higher ranges and higher operating voltages on the "Megger" Setting.

On its "Bridge" setting the new instrument is used like the "Bridge-Megger" Set on its "Bridge" setting. Balance is obtained by adjusting the resistances by means of the knobs on top of the case and the Ratio Switch. When balance is obtained the pointer stands at infinity on the dial, and the value of resistances is given by the figures under the windows on the top of the case multiplied or divided by the factor indicated by the Ratio Switch. The result is in ohms and decimals of an ohm.

Care has been taken in designing the "Bridge-Meg" to make every operation as simple as possible. There are no alternative methods of carrying out any measurement or making any setting. A test of insulation should not take more than from 5 to 10 seconds, and a Bridge measurement not more than from 15 to 30 seconds in normal circumstances.

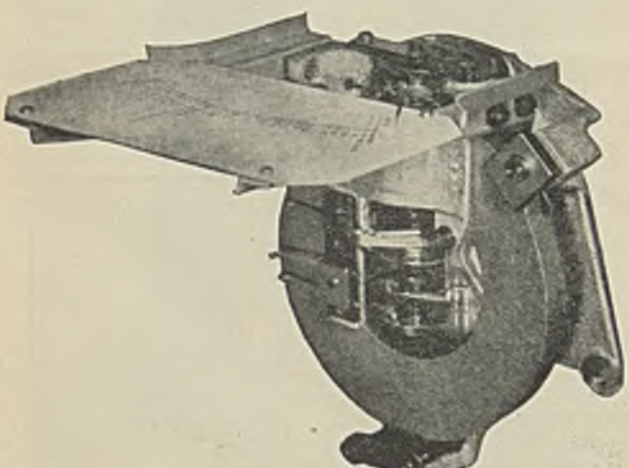


Fig. 4.—The Ohmmeter Movement.

The general design of the instrument and its easy portability are clearly shown in the illustrations, Figs. 1 and 2. The rectangular case of aluminium alloy, having a lid and base of moulded bakelite, encloses four separately assembled elements: a generator; an ohmmeter; a rheostat, or set of adjustable resistances; a "Bridge-Meg" change-over switch for changing from insulation to conductor measurements; and a ratio switch for use on the "Bridge" setting. When the resistance tester is laid down for use as in Fig 1, the generator handle is on the right, the terminals at the opposite end of the case, the adjustment knobs of the rheostat on the top under the user's hand, and the switches on the side facing him. The dial is on the top of the case, so that the scale is easily read while the adjustments are being made.

A system of guarded circuits is employed. Errors due to leakage over the surface of the instrument, which might otherwise arise when it is used in damp or dusty surroundings, are by this means eliminated.

The generator, Fig. 3, is similar to that used in the Meg Insulation Tester. It is a self-contained unit with two windings which are connected in series for tests of insulation, and in parallel for "Bridge" measurements, the voltage generated being 500 for "Meg" tests and about 250 for "Bridge" tests. The drive is transmitted from the turning handle to the armature through steel cut gears enclosed in an oil-tight casing. A free wheel interposed between handle and armature allows the latter to come to rest slowly when the handle is released, so that it is impossible to damage the generator by stopping it suddenly. A constant-speed clutch of simple design is also interposed between the handle and the armature shaft, so that the speed of the armature remains constant whatever the rate at which the handle is turned above the speed at which the clutch slips. The constant voltage developed is particularly important in tests of insulation where the circuit has an appreciable electrostatic capacity, and in the final adjustment of balance in a "Bridge" measurement.

The construction of the ohmmeter movement is shown in Fig. 4. The moving-coil element is mounted on an axle pivoted in spring-supported jewels carried in a cast aluminium frame, which also directly supports the dial plate. This arrangement ensures rigidity and accuracy. Connections are made through spirally wound ligaments which exert no appreciable control, so that the movement is to all intents and purposes free. Further, to ensure accuracy in case of any slight variation in these ligaments, an index adjuster is provided, operated by a small screw accesible from the outside of the case. This is a simple device, by means of which the field surrounding the pressure coil can be slightly distorted by movement of a small piece of soft iron: thus the index adjuster has no physical connection with the moving-coils, the control being entirely magnetic.

The change-over switch and the ratio switch are combined in one unit. The change-over switch is of the drum type, having fixed brushes sliding over a rotating drum which carries the contacts necessary to connect the

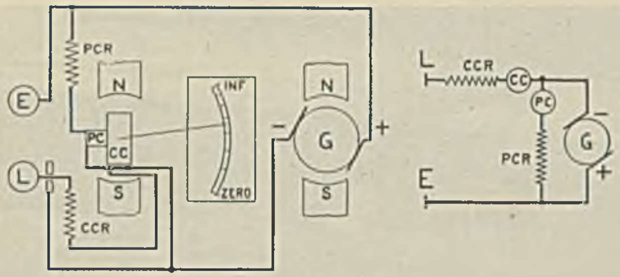


Fig. 5.—Diagram of "Meg" Setting (without the change-over switch)

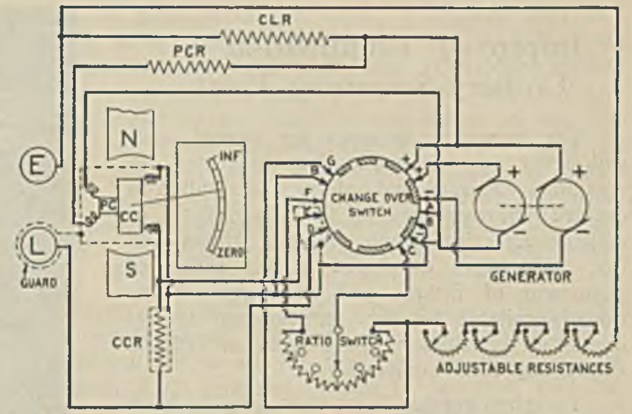


Fig. 7.—Diagram of "Meg" Setting (with the change-over switch)

brushes as required for the "Meg" and "Bridge" settings, respectively. The position of the switch is shown externally by engraving on the handle. The ratio switch is of the plate type, and has two arms sliding between two sets of studs. The ratio corresponding to a given setting is plainly indicated externally by engraving on the handle.

The adjustable resistances are of novel design, of very light weight and compact. There are four sets of these resistances: units, tens, hundreds and thousands, giving values from 1 to 9999, in steps of one unit. The value corresponding to a given setting of the dials can be read by numbers seen through small windows in the case.

Operating Principles.

The Bridge-Meg Resistance Tester is in effect two instruments, the connections forming an Ohmmeter on the "Meg" setting, and a Wheatstone Bridge on the "Bridge" setting. As an ohmmeter on the Meg setting there is the generator which supplies the current, and the direct reading ohmmeter movement which measures the unknown resistance, the arrangement being shown in Fig. 5. The movement has two coils—the current, or deflecting coil (CC in the diagrams), and a pressure, or control coil (PC in the diagrams)—mounted at right angles on a common shaft, and free to move in a magnetic field furnished by a permanent magnet of cobalt steel. These coils are so wound that when carrying current they tend to rotate in opposite directions, so that the final position of the movement represents a balance of the forces which they exert. The pressure coil is connected directly across the generator terminals (in series with a high resistance of fixed value), and therefore exerts a force proportional to the applied voltage. The current coil is connected, in series with the resistance under test, across the generator terminals and therefore exerts a force proportional to the current through the unknown resistance. When the unknown resistance is infinite, current will flow in the pressure coil circuit only, and the pressure coil will take up a position at right angles to the magnetic flux between the poles of the permanent magnet, a position at which the pointer attached to the movement will indicate "Infinity." When the unknown resistance is zero, the current passing in the current coil will deflect the movement in the opposite direction; and the forces are such that the pointer will come to rest opposite the point marked "Zero" on the scale. For any finite resistance a balance is obtained between the opposing forces of the current coil and the pressure coil in some intermediate position, which is determined by the ratio of the applied voltage to the current passing, that is, to the resistance under test. Since the final position of the pointer depends only on the resistance of the external circuit, the instrument is a true ohmmeter. The scale extends from 0 to Infinity, and is divided from 10,000 ohms to 100 megohms.

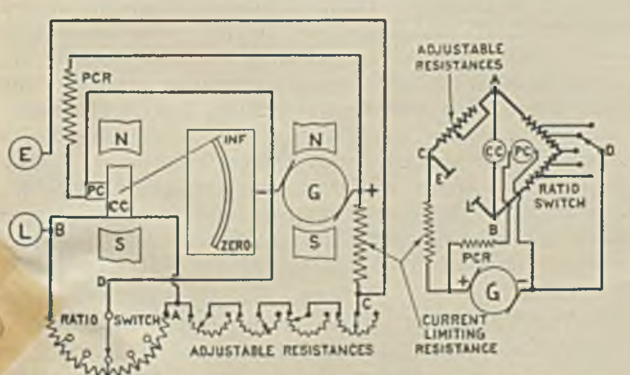


Fig. 6.—Diagram of "Bridge" Setting (without the change-over switch)

For the measurement of conductor resistances the change-over switch is set to "Bridge," and the instrument becomes a simple Wheatstone Bridge. The arrangement of connections can easily be followed out from the two parts of Fig. 6, in which the bridge points A, B, C, and D are correspondingly lettered. The two ratio arms and the rheostat form three arms of the bridge, which is completed by the resistance to be measured. The current coil of the ohmmeter, coupled in the mid-wire, serves as galvanometer; and the galvanometer control force is provided by the pressure coil which is independently supplied from the generator terminals. When no current passes in the current coil the force exerted by the pressure coil brings the moving system into the position in which the pointer reads "Infinity," as described above; so that the steady Infinity reading corresponds to a balanced condition of the bridge.

The diagram Fig. 7 shows the complete connections as for Meg testing. In this the connections of the change-over switch are included.

Improved Illumination of Colliery Screening Plant.

The increasing necessity for cleaner coals and better general illumination (to ensure the maximum efficiency and safety) has resulted in decided improvements in the illumination of colliery screening plant. Messrs. Heyes and Co., Ltd., have developed a full range of equipment of fittings and switchgear exceptionally suitable for this purpose and several important installations have been carried out embodying their equipment.

The photographic illustration, Fig. 2, shows a typical installation in which "The Wigan" "H" type pendant fittings are shown illuminating the picking belts. These fittings ensure a remarkably efficient system of illumination because, being arranged with the correct spacing factor, they provide an even illumination with the requisite cut-off angle, thereby ensuring an absence of glare. In addition the fittings are dust-proof and watertight, thus avoiding the expense and inconvenience of continued cleaning (with the exception of the outer surface of the glass) and deterioration in the reflecting medium. This style of fitting is also manufactured in a larger unit for general illuminating purposes. The well-known "Wigan" Prismatic Fitting is utilised for the lighting of the shakers and for narrow low passages, etc.; this fitting has been described fully in these columns and further comments are not necessary on this already well-known speciality. A full range of watertight switchgear is also included for the screen-lighting equipments, the single units being built up as switch panels, thereby economising in space and erection, and providing definite isolation points.

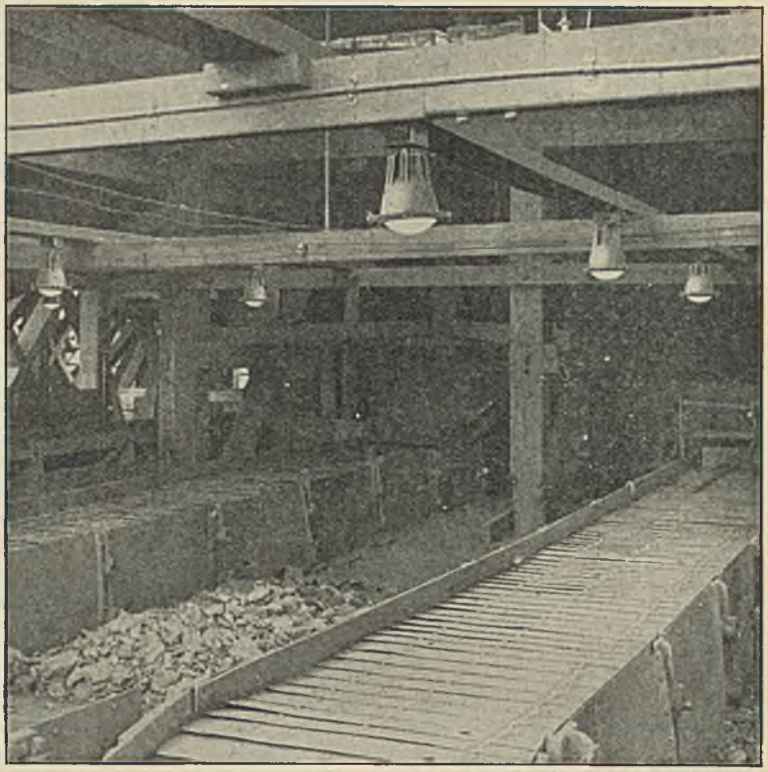


Fig. 2.

The diagram, Fig. 1, shows a plan of a typical installation, giving the various positions of the lighting units and feeding points. Messrs. Heyes and Co., Ltd., will be pleased to co-operate with anyone interested, and to forward samples for test purposes.

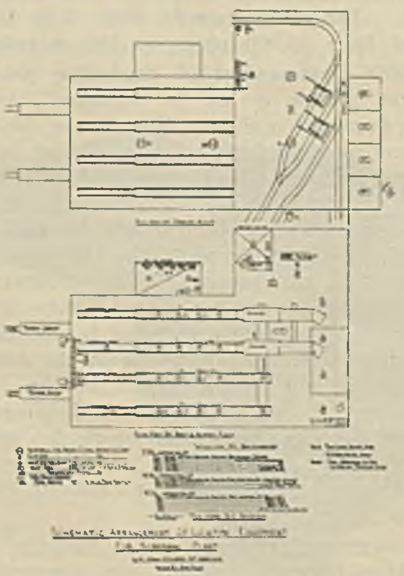


Fig. 1.

Exide and Chloride Accumulators.

On the occasion of a press visit to the works of the Chloride Electrical Storage Co., Ltd., on September 10th, Mr. D. P. Dunne, director of the Company, presided at the luncheon and, in extending a cordial welcome to the guests, referred in wittily-wise fashion to the amateur inventor of batteries. Public interest is frequently stirred by remarkable announcements in the press concerning some newly invented accumulator, for which claims are made calculated to give the new invention a marked and very desirable superiority over existing types. The claims are nearly always identical: the new accumulator has a much greater capacity and weighs less for the same bulk; has a higher efficiency; takes its charge quicker; has a longer life; can be short-circuited without damage; does not sulphate under any conditions; and has some special characteristic of construction not possessed by any other type.

The Chloride Company is the maker of the well-known Exide and Chloride Batteries and it makes accumulators of all sizes and designs for all purposes, from the pocket flashlamp battery to the giant accumulators for submarines and central power stations. It is, said

Mr. Dunne, the largest maker of accumulators in the British Empire, and it stands in line with the largest makers in the world. Its ramifications extend all over the world, and it makes nothing but accumulators. During forty years in business it has always had the reputation of being a progressive organisation.

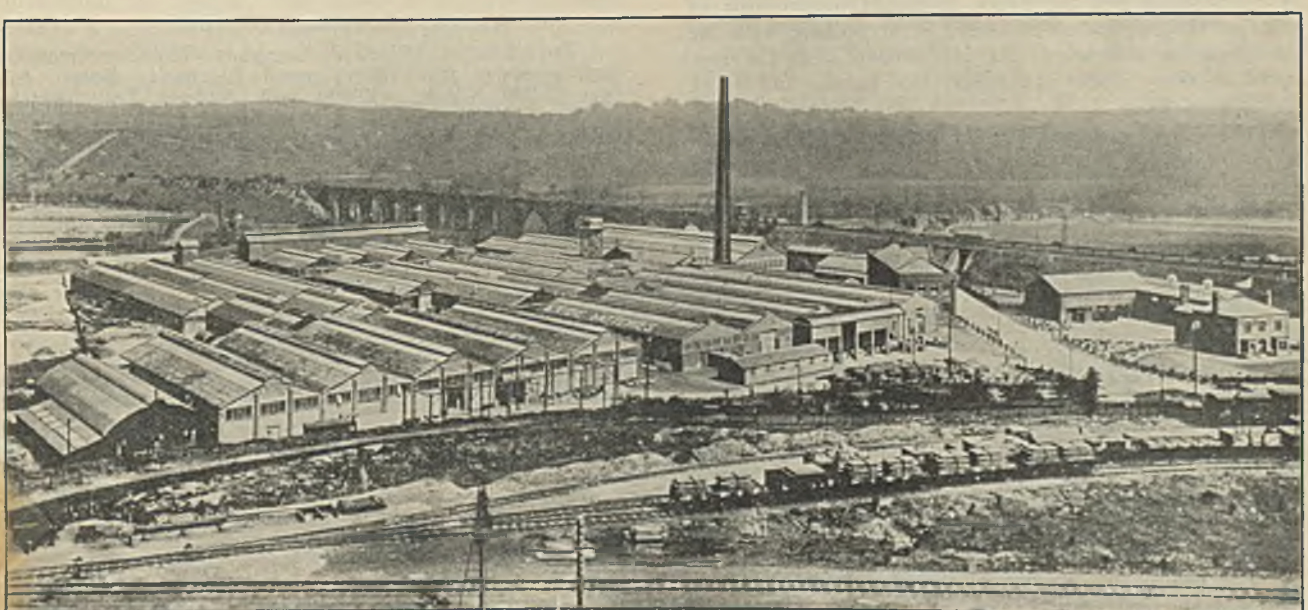
Any suggestion that the Chloride Company might have commercial cause to belittle an invention which did not belong to them is negatived by a consideration of their status in the industry and the hard facts of commercial practice. The position of the Company is such that the exploitation of an invention through their immense organisation would offer the greatest possible reward to an inventor. If his invention were taken up by Exide, the inventor need not raise or expend any capital, nor develop any organisation for its exploitation. His market would be ready-made, world-wide, and would have Exide behind it instead of against it. The Exide people could not afford to miss any invention worth having. On the contrary, Mr. Dunne emphasised that the continuance of their success depends upon the infusion into their body technical of new inventions as well as into their body commercial of new ideas and new energies. Evidence of this is afforded by the astonishing extent of their own research activities. They do not spend many thousands of pounds annually in seeking new inventions without wanting and valuing them. As a fact, Mr. Dunne stated that several inventions in the course of a year were brought before the Company by inventors. Unfortunately many were old ideas rehashed or rediscovered, some wholly impracticable commercially, some technically worthless, notwithstanding the inventor's honest pride. Very many of the wonder accumulators of recent years must have been offered to, or explored and rejected by, the Exide people during their forty years' activity.

From all of which it must not be implied that there have been no developments in the technique and production of batteries in late years. Everybody who uses batteries must appreciate the superiority of well-known makes over those of some years past. Developments and improvements are constantly being made; but they are brought about by the laborious application of long experience and highly developed skill, by purity of materials by test, trial, correction, and by the resources of widely capable production facilities. New discoveries and inventions, however promising, undergo a long and trying process of modifying and refining before they are deemed worthy to carry the stamp "Exide" on them.

There is no finality about accumulators. There may be an epoch-making invention some day. Exide are on the look-out for it all the time and through their organisation in all countries. There is, however, said Mr. Dunne, no sign of it yet. Claims founded upon a short series of tests are dubious. One may honestly deceive oneself by snap tests, especially if—as is too often the case—the life factor is omitted; and tests can be faked considerably. Nobody can be deceived by a full series of properly conducted tests and by the tests of actual performance during service life. The big public is the best judge, and the battery maker whose claims are well within his performance not alone substantiates his claims but earns public confidence and respect.

THE WORKS.

The works of the Company cover more than 37 acres in area, and afford direct employment to 2000 people, besides thousands in other industries who are kept occupied by the huge contracts for material placed by the Company. Large as they are, these works do not represent the full field of the Company's energies. There are branches in London, Manchester, Birmingham, Bristol, Glasgow, Dublin, Belfast, Bombay, Calcutta, Sydney, Christchurch, Capetown,, and Copenhagen—a world-wide organisation for distribution.



General View of the Chloride Battery Works.

Part of the Export Packing Department.

And beyond these immense ramifications is the vast enterprise of Exide Service. At all Exide Service Stations there are skilled men who have received training at the Company's works or overseas depots in the repair and maintenance of batteries; repairs to all makes of batteries are undertaken, and charges are on a fixed scale, uniform and moderate. There are over 600 in the British Isles, and more than 8000 Exide Service Stations distributed in all countries throughout the world.

Space prevents any reference in detail to the methods of manufacture and the finely developed organisation of a series of complicated processes in accordance with the most modern principles. As Mr. Dunne said, the products of these works are universally known and speak for themselves.

There are, however, certain notable features of the works which the battery does not tell its user. For example, the training of apprentices in any industry is of first interest to the public now-a-days. At these works a "trainees" scheme is in operation which gives youths entering the Company's service an opportunity of obtaining an all-round knowledge of the various branches of the Company's business, thus fitting them for positions of greater responsibility in later years. Youths of good education who have matriculated, enter under this scheme and move by steps of regular progression through the various departments of the offices and works. Their progress is carefully noted, and where a bent or flair for a particular type of work is evidenced, an effort is made to provide an opportunity for developing that talent. This scheme operates very successfully in keeping square pegs out of round holes.

The health and welfare of the workers is the Company's first consideration, and the measures adopted to this end go far beyond any regulations and requirements of government departments. A dental clinic is maintained, under the direction of a qualified dental surgeon and nurse. The terms for those under the age of 21 are, with one or two exceptions, free; for those over that age the charges are arranged on the lowest possible scale, and can be paid in small instalments. Other provisions for the workpeople's well-being include:—Sick Club, Annual Holiday with pay, Gifts to Women Employees on Marriage, Canteen and Kitchen (service of cooks, attendance, and cost of cooking borne by the Company), Library (sixpenny annual subscription), Recreation Club, Long Service Gifts—£100 for 25 years' service, Employees Benefit Fund, Pension Scheme (non-contributory), Evening Classes (with grants to students to cover, or towards, the necessary books). There is also a magazine, *The Chloride Chronicle,* with a circulation of 3500 copies.

The sports grounds provided for recreation include bowling green, four hard tennis courts, putting green, cricket ground, rugby football, association football, and hockey ground. Other pastimes fostered by the recreation club are angling, horticulture, swimming, and photography.

Elaborate precautions are taken against lead dust. All these safeguards are under the meticulous supervision of a resident doctor who was appointed by the Company at the end of 1927 to devote the whole of his time to the study of lead poisoning. The entire system is aided by blood examinations conducted periodically, by means of which any increase in the amount of lead absorption in the blood is detected immediately, long before there is any symptom or sign of trouble in the worker. In this way any defective process on which a man is employed is at once discovered, overhauled, and effective measures adopted before lead poisoning has had the opportunity to develop. These preventitive measures have proved so efficient that since the end of 1927 there have been no cases of lead poisoning at the Exide works.

LARGE TRANSFORMERS.

The English Electric Company have received a further order from the Central Electricity Board, for two 15,000 K.V.A., 132,000 volt, 3-phase Transformers for the Central Scotland Scheme, for installation at Saltcoates. The two units will each be provided with On-load Tap Changing Equipment, and will be similar to the four 15,000 K.V.A. and four 10,000 K.V.A. 3-phase units already supplied and on order. This makes a total of 130,000 K.V.A. of 3-phase Transformers being supplied by The English Electric Company, for this scheme.

PERSONAL

Consequent upon Messrs. Green & Jackson, of 12 Cherry Street, Birmingham, having dissolved partnership the agency for the sale of the electrical products of the Electro Mechanical Brake Co., Ltd., in the Midlands district is now held by Messrs. P. H. Jackson & Co., Newspaper House, 174 Corporation Street, Birmingham.

The Stirling Boiler Company Ltd. have recently appointed, as General Manager, Mr. George Summers, who has been associated with the Company for twenty-two years.

The Electric Construction Co., Ltd., have changed the Telephone Numbers of their London Office. The new numbers are Temple Bar 8306 and 8307.

The North-East Coast Exhibition.

A. REYROLLE & Co., Ltd.

(*Continued from page* 80).

132 *K.V. Condenser Insulator Bushings.*

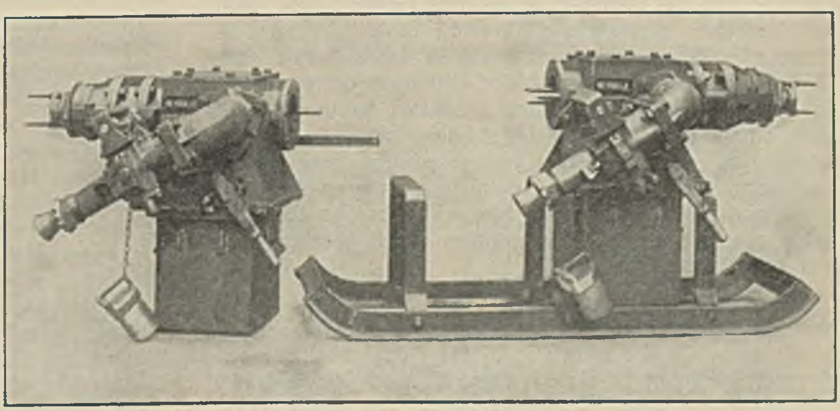
These bushings, as used in Reyrolle circuit-breakers for the British grid, serve as insulators for connections from the overhead lines to the circuit-breaker contacts. They are built up in four main parts: a bakelised paper condenser insulator, extending the full length of the bushing; two porcelain insulators, one at each end; and a current-transformer chamber clamped to the porcelains, in the middle of the bushing, and supporting them. The spaces between the bakelised paper and the outer porcelains are filled with insulating oil. The surface of each porcelain is corrugated to increase the path and that of the upper porcelains is shaped so as to make the bushing suitable for outdoor use. A current-transformer is housed in the transformer chamber and its secondary leads are brought out to terminals in a small oil-tight box at the side so that they are easily accessible and connections can be made to them without there being any need to interfere with the oil filling of the bushing itself. An oil-level indicator is fixed at the top of the bushing, which is at a height of about 13 feet when in use, and the form of the indicator is such that the level of the oil can be easily seen by anyone standing on the ground.

Large Metal-clad Draw-out Switchgear.

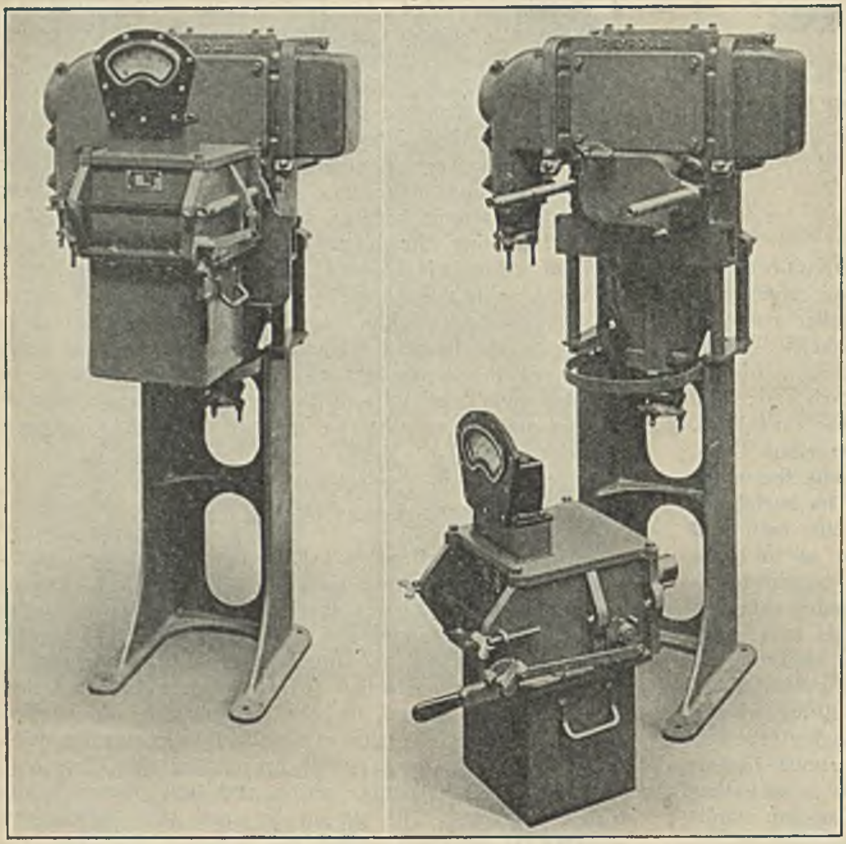
The exhibit includes one of these heavy-duty, duplicate bus-bar, metal-clad, horizontal, draw-out, switchgear panels, of the kind used in the sub-stations of many of the largest electrical power and supply companies throughout the world. The panel is suitable for controlling a circuit of 1,600 amperes at a pressure of 11,000 volts. The oil-immersed circuit breaker is arranged for direct manual operation but, as with all Reyrolle sub-station switchgear, arrangements can be made for remote mechanical operation through an adjacent wall or slate panel; or, alternatively, a solenoid or a small electric motor can be mounted on the circuit-breaker top-plate for electrical control from a remote panel or pedestal. The fixed back portion of the panel, comprising essentially two separate bus-bar chambers one above the other and a current-transformer chamber, has deeply recessed orifices with suitable insulators to separate the contact sockets. Corresponding self-aligning plug contacts are fitted to the moveable circuit breaker carriage and one set of removable plugs is supplied for fixing in either of the two upper tiers of the circuit breaker hood, which correspond to the two bus-bar chambers, so as to select a supply from one or other of the alternative bus-bars. The circuit breaker is supported on rollers, and a rack-and-pinion device is provided to facilitate its withdrawal and replacement. Locking-off doors are fitted to cover and prevent access to any live parts exposed by the withdrawal of the circuit breaker, and these operate automatically with the movement of the switch carriage. Simple mechanical interlocks are embodied to prevent incorrect sequence of operation, such as plugging the movable portion home with the circuit breaker closed, closing the circuit breaker before it is fully racked in, or withdrawing the circuit breaker from its working position while it is closed. The racking-in mechanism is provided with a locking bar which automatically locks the movable portion on the frame brackets when it is plugged right home and holds it securely in that position. All the connectors and bus-bars are enclosed in earthed metal casings and the spaces between the conductors and the casings run in solid with insulating compound.

Mining Type Oil-immersed Circuit Breakers.

Messrs. Reyrolle also exhibit two examples of small oil-immersed flame-proof circuit breakers with a current-carrying capacity of up to 100 amperes at 660 volts. One of these is adapted for either pillar mounting or wall mounting, and the other is mounted on skids so as to be easily portable. It is an interesting fact that the Certificate issued by the Department of Applied Science of the University of Sheffield in connection with flame-proof tests on a circuit breaker of this class was the first of its particular series, and thus possesses historical interest. The design is such that satisfactory working is obtained under the difficult conditions encountered in mines, and all the regulations made under the Coal Mines Act (1911) are complied with. The oil tank is of welded boiler plate and the circuit breaker is thus exceptionally well fitted to work under the severest conditions. Two or three series overload trip coils may be fitted and either inverse time limit dash-pots or tubes for instantaneous tripping may be included, each adjustable to give a wide tripping range. In the special case of controlling the supply to an A.C. squirrel-cage induction motor of a size suitable for switching direct on, a starting dash-pot may be fitted; it is so arranged that the operation of closing the circuit breaker lowers the trip-coil plungers and thus prevents tripping from taking



Two-panel Switchboard mounted on Skids; one Panel removed to show the Bus-bars.



3,300 *Volt*, 60 *Ampere, Three-phase, Flame-proof metal clad Switch Pillar.*

place under the influence of the heavy starting current. The plungers return gradually to their normal position while the motor is running up to speed and are ready for normal operation under running conditions. Adequate provision is made for earthing the metal enclosure of the circuit breaker, and a flame-proof ammeter can be fitted on the top of the enclosure when an indication of current is required.

In the pillar-mounting or wall-mounting type the dividing boxes are arranged so that the complete circuit breaker can be detached from them without any need to alter their position and thus the cables need not be unsealed. When the circuit breakers are mounted on a skid a very compact portable distribution centre is obtained, and 100-ampere plugs are fitted to the side of each circuit breaker to enable trailing cables to be connected up. A very useful feature of this gear is that one circuit breaker can be completely removed from the framework and the dividing box which carries the main cable can be transferred to another circuit breaker without unsealing the cable.

Particular care has been given to making the use of this gear safe. Interlocks make it impossible to remove any plug while the switch is in the "on" position, and the switch cannot be closed when the plug is withdrawn unless the cap provided to cover the orifice of the socket is screwed right home. This means that it is impossible for any live contacts to be exposed.

Flame-proof Metal-clad Draw-out Switchgear.

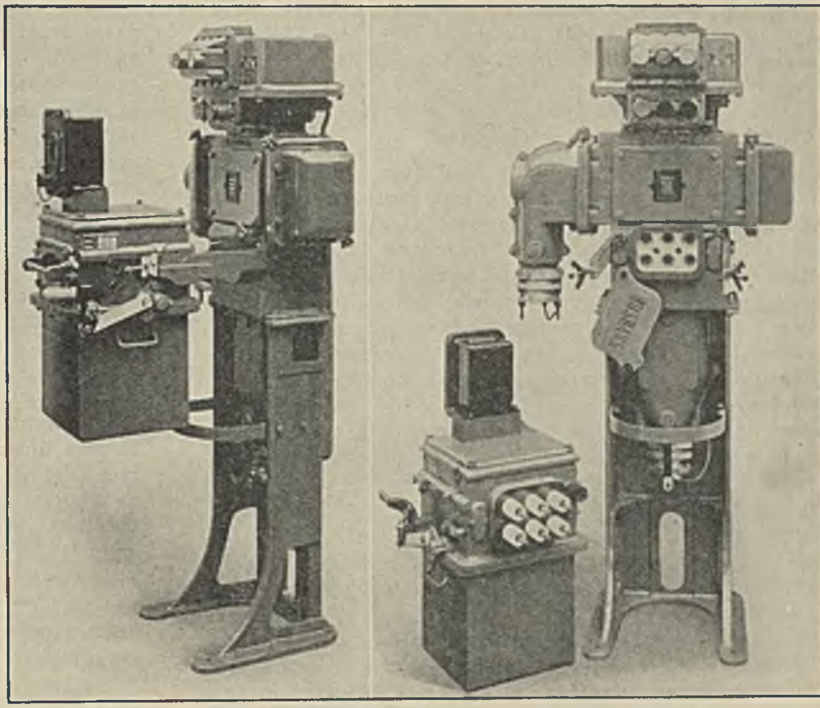
Other exhibits include a representative collection of the smaller switchgear manufactured specially for use in industry. Two of the metal-clad draw-out panels shown are provided with wide machined flanges at all essential points so that the enclosure is made flame-proof. The gear consists of a fixed portion and a removable portion. The fixed portion contains only well insulated connections, with the important consequence that there is nothing in it which is likely at any time to get out of order; the removable portion houses the current transformers, trip coils, and all other apparatus which might require attention, so that if adjustments are necessary they can be made safely on site or in the workshop. To isolate the circuit breaker it is only necessary to pull the removable portion along the slide bars provided for the purpose. This leaves the plug receptacles as the only accessible live parts. To prevent danger these are recessed deeply in porcelain insulators and a locking-off door provided with a padlock entirely screens these conductors and provides a safeguard for anyone working on the circuit. Simple mechanism is provided to prevent wrong operation, such as plugging in the removable portion when the switch is closed, or closing the switch before plugging the removable portion right home.

These circuit breakers are suitable for voltages up to 3,300, and have current ratings of 100 amperes, for the smaller types, up to 200 amperes for the larger. The moving contacts are of the laminated brush type fitted with renewable sparking pieces. Two or three instantaneous overload trips can be provided or, if required, a dash-pot giving an adjustable time lag may be fitted. The circuit breaker tank is of exceptionally heavy construction being built up of welded boiler plate steel and fitted with wide machined flanges which butt against similar flanges on the top-plate of the circuit breaker. On the top of the bus-bar chamber a potential transformer can be fitted and for ensuring the flame-proof isolation of this a very ingenious method has been developed. The H.T. fuses are mounted on holders screwed into the transformer housing. When any holder is unscrewed the circuit to the transformer is opened before the screwed portion of the holder disengages from the housing. Thus any sparking which might result takes place inside an enclosed metal casing. In order to ensure that no flame could reach the atmosphere a triple thread is employed instead of a single thread; this considerably increases the area of metal to metal contact and, in fact, performs a similar function to that of a wide machined joint.

A circuit breaker of the type exhibited has been tested by the University of Sheffield and a Certificate has been issued proving that it is safe to use in an explosive atmosphere. Only a single unit pillar is being exhibited, but any number of these can be mounted together to form a complete switchboard.

Plugs and Sockets for Domestic Uses.

A number of these plugs and sockets fitted to domestic irons are shown. These plugs and sockets comply with British Standard Specification No. 196—1927, which is for protected-type, two-pin plugs and sockets with earthing connections. Since this specification deals with 5-ampere, 15-ampere, and 30-ampere sizes, it marks an important stage in development, because it provides for metal-clad enclosure of these comparatively small plugs and sockets, and so introduces, for domestic apparatus, a safe connector for portable appliances. The earthing of the enclosure makes the plug and socket safe to handle and, further, prevents the possibility of shock from the framework of apparatus.



3,300 *Volt,* 200 *Ampere, Three-phase Flame-proof Mining Pillar.*

Fuses.

The Reyrolle standard self-aligning fuses are designed to comply with Home Office Regulations, and to be used on circuits working at pressures up to 660 volts. These fuses have a separate hand grip, and it is impossible for live metal to be inadvertently touched while they are being held. The fuse-wires are enclosed in asbestos tubes, fixed in separate chambers, and they cannot be encircled by a man's hand while a fuse is being inserted or removed. The fuses are built with self-aligning contacts, and are ventilated. The self-aligning contacts save time and trouble when the clips are being fitted to the supporting panels; they reduce the risk of cracked porcelains; and by reason of the exceptionally good contact they give, they promote the cool working of the fuses. This last-mentioned result is achieved the more easily because of the perfect ventilation, which keeps the porcelains cool, and the efficient contact which is obtained by the use of steel reinforcing springs inside the clip contacts. The design is such that the fuses are suitable for front or back connections; the handles and clips are interchangeable; and the range comprises standard sizes rated for 30, 60, 100, 200, 350, and 500 amperes. Each of these is capable of clearing short circuits at 660 volts.

Another interesting series of fuses is the range of heavy-duty cartridge fuses of 30, 60, and 100 amperes capacity, and a range of extra-heavy-duty cartridge fuses with capacities of 200, 350, and 500 amperes. The heavy-duty cartridges are suitable for fitting into the standard porcelain holders, and they are therefore especially serviceable in cases where the extension of generating plant has exceeded the safe limits of open type fuses.

CAMBRIDGE INSTRUMENT Co., Ltd.

This firm is exhibiting a representative collection of instruments for power stations and engineering works, including electrical CO_2 indicators and recorders, apparatus for recording the percentage of dissolved oxygen in boiler feed water, draught and pressure gauges, temperature measuring instruments, etc.

Boiler House Panel.

A striking feature of the exhibit is a panel of boiler-house instruments, comprising a 13in. Dial Illuminated CO_2 Indicator, a 13in. dial Index Thermometer for measuring the temperature of the exhaust gases, and a 13in. dial Draught Gauge. This panel, which is triangular in shape, thus includes the three essential instruments for the boiler house in one unit.

Indicating and Recording Thermometers.

Various patterns of Indicating Thermometers, of the mercury-in-steel type, with dials 8 inches and 13 inches in diameter are shown, and Recording Thermometers with charts $9\frac{1}{2}$ inches in diameter. Owing to their accuracy and their robust construction these instruments have proved particularly satisfactory for ship use.

Electrical Distance Thermometers.

These thermometers enable the temperatures in remote parts of a factory or works to be accurately observed on a single instrument, which can be placed in the most convenient position at any distance from the points where the temperatures are being taken. The instruments can have practically any range between —330° F. and +1000° F. (—200° C. and +540° C.). A 48-point indicator fitted with a robust metal case is included in the exhibit.

Electrical Instruments for Gas Analysis.

The illuminated dial CO_2 Indicator possesses many novel patented features which greatly facilitate the work of the stoker by enabling him to see at a glance the results he is obtaining. The dial is large and the figures distinct, while by using a novel method of dial illumination the CO_2 percentage is shown with exceptional clearness, and in such a manner that, except on rare occasions, it is unnecessary to read the actual percentage figure, since the general appearance of the dial at any moment gives a definite indication of the combustion conditions. The actual figure representing the CO_2 percentage is illuminated by a white light, while the pointer, in line with it, is illuminated by a green light if the percentage is increasing, and by a red light if it is decreasing. The position of the illuminated spot on the dial, combined with the colour of the pointer, enables the stoker to gather at a glance valuable information regarding the progress of combustion. The ease of reading is increased rather than diminished if the general lighting of the building is of the subdued order common to many boiler houses. The scale is graduated in CO_2 percentages, the range being 0 to 18 per cent. CO_2.

The working of the indicator is based upon the well-known Cambridge electrical method of CO_2 measurements, the instrument being connected up to a CO_2 meter or katharometer, soot filter, and aspirator in the usual way. An important departure from the ordinary design has been made, however, in order to ensure added robustness to the indicator itself. The galvanometer for the Wheatstone bridge circuit forms a separate unit which may be placed some distance away from the boiler plant. This galvanometer may be arranged to operate two, four or six indicators in an installation, being automatically connected up to each dial indicator (with its corresponding CO_2 meter) in turn by means of a master switch driven by a hot wire motor of patented design. The apparatus thus has the advantage that separate indicators of purely mechanical construction may be installed at each boiler, while the complete installation is entirely automatic in operation.

The Cambridge CO_2 and CO instruments shown are electrical in principle and contain no chemical absorbents or fragile glass work. The apparatus is robust and needs little attention. It comprises a CO meter panel connected to an indicator or a recorder, together with a CO_2 meter, soot filter and bubbler-aspirator. Current is supplied by a 4-volt accumulator. After passing through the soot filter, the flue gases are washed and cooled by passing through a bubbler which forms part of the aspirator, and are drawn past a CO_2 meter of the katharometer type. The CO_2 meter contains two identical spirals of platinum wire enclosed in separate cells in a metal block, one cell containing air saturated with water vapour, and the other being open to the flue gas. These spirals form two arms of a Wheastone bridge circuit. Changes in the percentages of CO_2 in the flue gas surrounding the one spiral cause changes in the conductivity of the gas and consequent changes in the galvanometer deflection. After passing the CO_2 meter, the gases are then directed into one cell of a second (CO) meter of similar design to the CO_2 meter and into a small electrically heated furnace, where any carbon monoxide present is converted into CO_2, and any hydrogen and methane is converted into CO_2 and water. The converted gases are finally passed through the second cell of the CO meter and back to the aspirator. The CO_2 meter, therefore, measures the increase in the CO_2 content of the gases caused by their passage through the furnace. This increase depends on the amounts of CO, hydrogen and methane originally present, and is shown on the indicator scale or on the recorder chart as a percentage of combustible gases. Since the gas passes in succession through both meters, only one soot filter is required. Both CO_2 and CO meters are connected to the indicator, which is fitted with two scales calibrated to give direct readings of CO_2 and CO percentages respectively, the standard ranges being 0-20 per cent. CO_2 and 0-10 per cent. CO. A two-way switch enables readings of either CO_2 or CO percentages to be obtained at will. If desired the indicator can also be connected to a thermo-couple in the flue, enabling the temperature, CO_2 per cent. and CO per cent. to be measured on one instrument. Single or multi-point indicating, recording, or combined indicating and recording outfits are made.

Particular attention is directed to the latest form of combined CO_2 meter and aspirator, which is here shown for the first time. The CO_2 meter is now combined together with a water-bubbler and aspirator to form a complete all-metal metering unit, which is so designed as to give accurate readings in widely varying boiler-house conditions, and is exceptionally robust and dependable.

A portable instrument for giving readings of CO_2 percentage and temperature at various positions in the flues is also included in the exhibit. This instrument is particularly useful for consulting and inspecting engineers, and for checking permanent installations in large power plants.

Cambridge Dissolved Oxygen Recorder.

This apparatus is a robust boiler-house instrument which records on a aclibrated chart the percentage of oxygen in boiler feed water, thus checking the working of de-aerators and enabling the corrosion of boiler tubes to be reduced to a minimum. Single or multipoint recording, indicating, or combined indicating and recording outfits are supplied, while the recorder can also be connected, if desired, to standard CO_2 and CO meters and to a thermo-couple placed in the boiler flues, thus obtaining on the one chart records of CO_2 and CO percentage and of the temperatures of the flue gases, in addition to the percentage of dissolved oxygen in the feed water.

Draught and Pressure Gauges.

The exhibit includes Dial Gauges with dials 7ins. and 13ins. in diameter for draught or pressure up to 20ins. of water. Three-dial Draught Gauges, Draught and Pressure Recorders for ranges up to 60ins. of water, and Pressure Recorders for ranges up to 2,000lbs. per sq. inch. The three-dial Draught Gauge has been designed for use in connection with modern balanced draught boiler plants. It provides in a compact and convenient form all the information regarding the air supply which is necessary for the efficient operation of the plant. The instrument comprises three separate gauge movements of the diaphragm type, mounted together in a rectangular metal case provided with three dials. The usual arrangement is for the upper dial to indicate the draught at the flue before entering the stack, the centre dial to show the pressure or vacuum in the grate, and the lower dial to indicate the pressure of the forced draught fan. The scales, which are 6ins. long, are usually calibrated for the ranges 0 to 2 inches of water draught, —2 to +2 inches of water pressure, and 0 to 6 inches of water pressure.

Among the Pressure Recorders exhibited is a circular chart model designed for low ranges down to 4ins. of water across the chart. This low pressure model is made in various standard ranges from 0 to 4 inches of water up to 0 to 2lbs. per sq. inch, draught or pressure. It is of similar appearance to the well-known Cambridge Recorders for higher pressures, and is fitted with a chart of the same dimensions, namely 9½ inches in diameter.

Combined Pressure and Temperature Recorder.

This instrument combines the mechanism of a pressure recorder with a mercury-in-steel thermograph. It may be used for steam, liquids or gases. It is fitted with two pens which record side by side on one chart, one pen being arranged to record the pressure while the other is moved in accordance with fluctuations in the temperature as measured by a mercury-in-steel bulb. The bulb is connected to the recorder by flexible capillary tubing which may be any length up to 50 inches. The instrument can be used for temperatures between —40° F. and +1000° F. (—40° C. and +540° C.), and for pressures or vacua between —50° and 2000lbs. per sq. inch. It is calibrated to cover only the working range, thus ensuring an open scale. The charts are 9½ inches in diameter.

Automatic Temperature Regulators.

The exhibit includes a hydrostatic type of regulator, designed for controlling the temperatures of tanks or chambers between the limits of —10° F. and +550° F. (—20° C. and +290° C.). The apparatus may be applied to control the flow of steam, gas, air, oil or water, and can be used in certain suitable cases instead of the electrical type of Cambridge regulator, an example of which is to be seen at the Exhibition applied to the control of a gas-fired furnace on the stand of the Newcastle and Gateshead Gas Co.

A valve in the steam supply (or other means of applying heat) is fitted with a diaphragm chamber, and is so arranged that when suitable water pressure is applied to the diaphragm the valve closes and the supply of heat is cut off. The water pressure is applied through a regulating device controlled by means of a vapour pressure thermometer of the dial type. This thermometer has a dial 4ins. in diameter, with a scale length of approximately 8¾ins. The graduations, which are in white figures on a black background, are clearly defined and easy to read. The bulb of the thermometer, which is exposed to the temperature to be controlled, is connected by capillary tubing to two pressure tubes in parallel, one of which is connected to the dial pointer (thus indicating the temperature), while the other tube is connected by a link to a pivoted lever which projects inside a chamber, and carries at its end two pads, which form valves at the ends of two pipes connecting the chamber to (a) the water supply, (b) an outlet for the waste water. A third pipe connects the chamber to the diaphragm valve in the steam supply pipe. When the temperature of the tank (or other device being controlled) is below the point at which it is to be regulated, the lever will take up a position such that the inlet or water supply pipe is closed, and the outlet pipe is open. There is consequently no water pressure on the diaphragm and the steam valve is open, thus allowing the supply of heat to pass to the tank. As the temperature rises the pressure tube is opened out, causing the lever to be tilted so as to close the outlet pipe, and if the temperature rises still further so that the critical point is passed, the inlet pipe is opened admitting the water to the diaphragm under pressure, and closing the steam valve. In practice, when the control temperature is reached the lever takes up a position such that both inlet and outlet pipes are practically closed. The diaphragm is thus held in such a way that the right amount of steam is constantly supplied and the valve will only be wide open or fully closed when sudden temperature changes have taken place. Provision is made whereby the temperature at which the regulator operates may be easily adjusted. This form of regulator can also be adapted to operate large valves requiring a considerable amount of power, in which case a modified form of valve control is provided.

Fuel Calorimeter.

The Rosenhain Calorimeter is a simple and accurate instrument for the determination of the calorific value of coal and liquid fuel. A sample of coal, or an absorption pellet soaked with the oil under test, is burned in a closed vessel under water. The design and the arrangement of the calorimeter vessel and the combustion chamber render the operation easy, rapid, and certain, and secures that all the heat generated by combustion is directly communicated to the water of the calorimeter.

Electrical Measuring Instruments.

A number of interesting electrical instruments are also exhibited, including two multi-range Thermionic Voltmeters; one, Pattern D, covers measurements to 4 volts and to 20 volts R.M.S., and has an effective resistance of about 0.5 megohm; the other, Pattern E, gives measurements of the peak and mean values of an alternating potential, and has ranges 0 to 350 volts peak, and 0 to 220 volts mean, corresponding to the values of a sinusoidal voltage of approximately 240 volts R.M.S.; the effective resistance is about 2 megohms. These instruments are robust and compact, and each requires only one external battery, for the valve filament circuit.

Other Cambridge electrical instruments shown include Electrometers, Unipivot Galvanometers and Testing Sets, Precision Galvanometers, Wheatstone Bridge and a Portable Outfit for the determination of Hydrogen-ion concentration in connection with electrometric chemical analysis.

E. N. MACKLEY & Co.

This firm, originally established in Newcastle, in 1914 acquired a five-acre site in Gateshead and has rapidly advanced in favour as manufacturers of pumping plant. The firm's products are distributed throughout the world and successfully compete with American and Continental manufacturers.

Among the many patented designs manufactured are multi-stage high lift turbine pumps delivering water at a high pressure, including 700 H.P. units as installed in waterworks, pumping stations, and in mines for unwatering and drainage, also in industrial undertakings where water has to be delivered at a high pressure. Patent pumps for use in quarries, tin mines, gold mines, etc., have been sent to South Africa and the East, also pumps dealing with a large volume of water at a low head. Patented pumps are manufactured for chemical works, sewage works, paper works, and gravel pumping where the water contains solids in suspension. Messrs. Mackley also manufacture reciprocating, piston and ram pumps.

Of recent contracts for colliery pumping duty may be mentioned the supply of a multi-stage pump to Messrs. Pease & Partners for one of their large collieries. This particular pump is an 8-stage 1500 gallons per minute 1100ft. head when running at a speed of 1180 r.p.m., and is driven by a 650 H.P. motor. Another interesting contract in hand is for a pump to the order of Londonderry Collieries. This pump is a 9in. ram × 18in. stroke three-throw mining type high lift ram pump capable of pumping 300 gallons per minute against a head of 1896ft.

A general view of the Stand at the Exhibition is shown in Fig. 1. The second illustration is of one of the most notable pieces shown: it is a turbine pump made to the order of a large firm in Scotland and is a duplicate of a set already supplied, capable of dealing with 1000 gallons per minute to a head of 1050ft. at 1450 revs. when driven by a 450 H.P. motor.

Fig. 1.—The Stand of E. N. Mackley & Co.

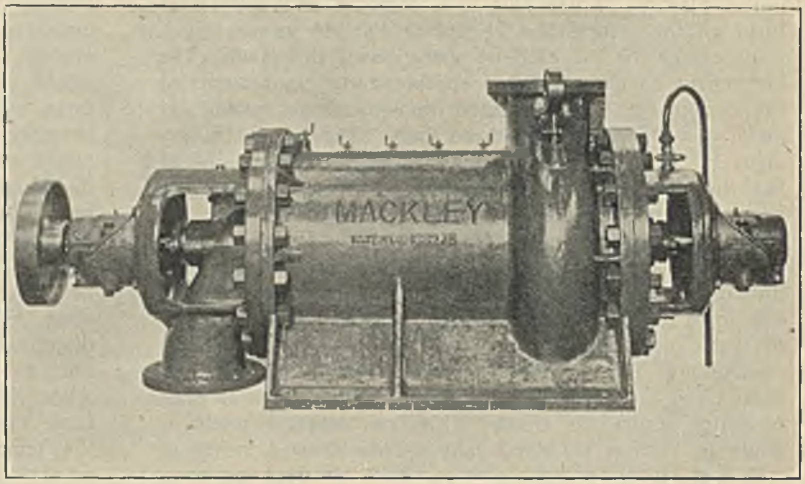


Fig. 2.—Turbine Pump, 450 *H.P.,* 1450 *R.P.M.*

Other exhibits of centrifugal and turbine pumps include: single stage centrifugals from 1in. to 6in. diameter of discharge for heads up to 100 feet; double-eye centrifugal pumps; and two-stage, split-casing pumps for heads up to 250 feet. There are also slurry and tailings pumps for lighter duty and heavier duty respectively.

Reciprocating pumps shown range from small hand driven types up to powerful three-throw sets for 300 gallons per minute against 350 feet head.

NEW CATALOGUES.

TUNGSRAM ELECTRIC LAMP WORKS (Great Britain) Ltd., 72 Oxford Street, London, W. 1.—The colour illustrated pocket price list gives essential details of the range of Tungsram Lamps standardised. Particular attention is directed to the Tungsram "D" Pearl Lamp for all general services, where a pleasing and effective light combined with a robust form of filament to withstand rough usage are necessary.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—The leaflet describes and, by means of several diagrams, explains the merits of a new series of Aerial Cable Unions.

BRUSH ELECTRICAL ENGINEERING Co., Ltd., Falcon Works, Loughborough.—This art catalogue deals in a very useful manner with Liquid Type Starters. Dimensions, weights and capacities are given.

GENERAL ELECTRIC Co.,, Ltd., Magnet House, Kingsway, London, W.C. 2.—The installation leaflet Collieries No. 6 is devoted to a very complete and illustrtated description of the G.E.C. electrical equipment installed at the Emlyn Anthracite Collieries.

Another similar technical leaflet, No. 9, describes in full the electrical equipment of new rolling mill of the Bromford Iron Co., Ltd., Oldbury.

GENT & Co., Ltd., Faraday Works, Leicester.—Section 4a of Book 7 describes the working principle and apparatus which make up the "Pul-syn-etic" system for the Unification of Workmen's Records—ensuring one uniform time at all clocking stations.

Section 5b deals similarly with the Staff Locator for calling or locating principals and officials in large works and business organisations.