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Imagination and Energy.

The virtues of imagination and energy in regard to promoting industrial prosperity were proclaimed by the Prince of Wales in his address when opening the North East Coast Exhibition on the 14th of this month. In the presence of some 50,000 people the Prince reviewed the recent industrial situation of the district; happily he was able, after sympathetic reference to the distress which had for so long prevailed, to indicate that a definite improvement had set in. During the past few months steadily increasing business in iron and steel, in shipbuilding and in coal held out the sure hope of a return to continuous prosperity. In particular the Prince commended the courage and wisdom of the people who could, when trade was bad and the outlook so disheartening, boldly launch the large and costly advertisement of a great Exhibition planned to make a powerful international appeal. We would again commend to every business man the argument which we have so often put forward by quoting from the Prince's speech: "Times of depression often find a business community loth to spend money on advertising itself and its wares, although logically that is the moment when a little bold advertisement is needed." So it was that in his peroration the Prince aptly summarised the situation by declaring that "The Exhibition is, in fact, the challenge of the North East Coast, and an announcement to the whole world that the great shop of this industrial district is still open, is determined to carry on, and is prepared to meet all orders with the highest traditions of a not unworthy past."

Mining Research College.

Prior to the inaugural ceremony at the Exhibition the Prince of Wales, at the request of Lord Grey of Falloden, President of the College, was pleased to open an extension of the Armstrong College of the Durham University. A handsome new building has been provided and equipped for the express purpose of mining research. It is interesting to note that three-fifths of the cost has been provided as a gift from the Miners' Welfare Fund, £20,000 out of the funds of the Central Committee, and £10,000 from the local Northumberland Miners' Welfare Committee. On this occasion too the speech of the Prince was characteristic. Keenly full of personal sympathy he was yet helpful and encouraging in his clear exposition of the right way to progress as shown by lessons of the past. Such extended educational facilities as were afforded by colleges of this description were not only a sure means of promoting industrial progress but they were the avenue open to every worker by which he could free himself from the monotony of his normal life. The industrial utility of this college of research is beyond dispute: faced with an acute economic condition showing an extremely fine margin in regard to costs and prices and aggravated moreover by hard competition from overseas, the British mining industry must needs look up to science and research for its main support. Scientific knowledge and training of all engaged in the industry whether as practical workers or as staff men are essential.

Decide Now.

It is just as well to take this opportunity of reminding members of the Association of Mining Electrical Engineers that they must now make a quick decision as to whether they will attend The Annual Conference which will be held in Newcastle during the first week in July. It is not a simple matter and it takes much time to organise a good programme which shall run successfully and smoothly through its course. Therefore to help those enthusiastic friends who are wrestling with the dozen and one troublesome details, each member is asked to make up his mind at once and, if he feels that he would like to join in the festive reunion, pass his name forward right away to the local organising secretary.

There are some members who never intentionally miss these "annuals," and there are others who have never attended. Of those who never attend there may be a few particularly unfortunate men who by adverse circumstances cannot get away, much as they might wish to do so. It would, however, be safe to venture the opinion that the large majority of the stay-aways do not appreciate the advantages to themselves and to their Association which these conferences offer. For everyone attending there is the unique opportunity of widening the circle of friends engaged in similar interests; a broader outlook on the general conditions, trend of progress, and popular opinions and notions is inevitably acquired as a natural result of taking part in these conferences where men of higher and lower stations in the industry hailing from all parts of the country meet in friendly holiday mood. Each one of the visitors attends the A.M.E.E. Annual with that as his primary and particular object—for unlike some other technical annual conferences the A.M.E.E. does not introduce the reading or discussion of technical papers on these occasions. Visits to selected notable places of interest and charm may be said to be the only orthodox "educational" features of the round of festivities.

The great advantage accruing to the Association as a whole is by way of advertisement. The activities and usefulness of the Association, its virility and its prestige are exhibited and enhanced—and happily they are acknowledged by Civic and Public Authorities, leaders of industry, and in the influential circles of the places visited. The wind-up of a busy session, during which the sixteen branches spread over the Kingdom have been closely studying and debating the means to progress, is thus fittingly celebrated on the occasion of the election of the new officers. The past year is reviewed and the new year with its prospects is viewed with the optimism and enthusiasm of one refreshed by holiday after a hard spell.

The programme of this year's conference, which is published under the A.M.E.E. Notices in this issue, indicates that it is to be exceptionally interesting and typical of all that such a programme should be. To secure the promised advantageous results for individual and association it is only now necessary to make the gathering as numerous and representative as possible. Every member is urged to help himself and his Association to the good fare here offered in a most palatable form.

North East Coast Exhibition Notes.

It is pleasing to be able to record that when, on the 14th inst., H.R.H. The Prince of Wales declared open the great North East Coast Exhibition, the 75,000 persons who that day passed through the turnstiles saw and enjoyed what is unusual upon such inaugural occasions, namely a great Exhibition complete and ready for inspection in every department and detail.

Some idea of the extent of this undertaking can be gathered from a simple statement of the main attractions that have been provided: the Palace of Engineering with its 100,000 square feet of floor area; the Palace of Industry, larger still by 60,000 square feet; the Palace of Arts; the Lake, with boating and other sports facilities; the Artisans' and Women's Pavilions; the Garden Club; the "Evening World" and "Chronicle" Pavilions; the Festival Hall; the Carillon Tower, with bells lent by the New Zealand Government; the Pavilion of the British Empire Marketing Board; the Algerian Village; the Amusement Park with its Giant Racer and its Water Chute.

It is in the Festival Hall that the Annual Council and General Meetings of the A.M.E.E. will take place.

Unusual care has been devoted to the illumination of the Exhibition Grounds, and to those electrical men who have cause to be interested in "lighting" features, it will be noticeable how decided is the advancement that has been made in the comparatively few years which have passed since the "Wembley" days.

The name Swan will be for ever linked with electric lighting. Sir Joseph Swan, the pioneer worker in electrical science and discoverer of the incandescent filament lamp, was a Newcastle man. It is therefore not surprising to find that the Electric Lamp Manufacturers' Association have made an exceptionally great effort to provide an exhibit of all that is best and most beautiful with the modern masterpieces of lamp construction, all of which still depend upon the basic principles crudely established by Swan.

The exhibit takes the form of a separate building embodying a central hall—"the hall of light"—and two outer rooms. The lighting of the ceiling and upper walls of the hall is of particular interest as indicating the decorative possibilities of the new architectural lighting. This lighting system takes the form of lighting fittings actually designed with and built into the structure.

In a leading article *The Times* hails this exhibition as an indication that this country is now learning to overcome that instinctive shyness which has often been held by the superficial observer to be a form of pride, and that we are at last coming forward boldly with sound, colour and every other attractive means, compelling the world to take notice of our products. In particular the part here played by the Empire Marketing Board is singled out for exceptional praise. Quoting from *The Times*' eulogistic article: "Great Britain can do a great deal of business in the family; and the more business done in the family the better equipped will each member of it be to do business with the outer world. From the point of view, therefore, not only of the promoter of exhibitions as composite works of advertisement, but also of all who work and hope for the prosperity of the Empire, it is a capital advantage that the Empire Marketing Board should understand so well as it does the importance of attractive publicity. A deep psychological effect can be produced by 'the right playful quality'—by that touch of gaiety which proves more shrewdly than anything else that bad times and lean years are not to be allowed to bring low spirits and an apologetic demeanour. The man, or the people, who can work hard, and at the same time give proof of enjoyment of the work and of pride in its results, is irresistible; and of this mingled determination and gaiety the North East Coast Exhibition in general and the Empire Marketing Board Pavilion in particular are signs to be warmly welcomed."

When a Dynamo Fails to Excite.

F. MAWSON.

(This is the third of a series of Articles intended more particularly to help Students and Junior Engineers).

(Continued from page 320).

ONE of the most troublesome causes of the failure to excite of a dynamo is that due to loss of residual magnetism. Dynamos generally retain sufficient magnetism, after running for test for long periods at the makers' works under normal conditions, to start up again easily after re-erection, but occasionally trouble is experienced through this cause.

Loss of magnetism may usually be attributed to one of the following reasons:—

(1) The dynamo may during erection or at some previous handling or running, have experienced excessive vibration; the obvious lesson here is that a machine should always be provided with a solid foundation.

(2) It may be too near another dynamo, so that when the latter is running fully excited, there may be stray lines of force passing through the magnetic circuit of the idle dynamo in the wrong direction, thus destroying its residual magnetism. This is not a common fault, especially in modern machines, but it does occur occasionally with some of the older types of dynamo.

(3) The dynamo field may have been excited in the wrong direction. This can very easily occur when machines are run in parallel and the equaliser connections are insufficient. The current from one machine will pass through the series coil of the other in the opposite direction to that in which the current from the machine itself would flow. This can only occur in the case of compound-wound machines, as in the case of shunt-wound machines the current in the respective field windings will always be in the same direction in every machine, whether derived from the machine itself or from the other machine or line.

(4) Loss of residual magnetism may result from a reversal of the field or armature connections. Ordinarily, when the armature is rotated, a small E.M.F. is induced in the armature, which tends to send a current through the shunt-field coil, and so build up from the residual magnetism. If the field or the armature connections have been reversed, the exciting current will flow in the wrong direction in the shunt field, and instead of building up the field, will have a demagnetising effect. Should the direction of rotation be reversed, the induced E.M.F. is reversed and it is then necessary to change either the field or armature connections.

When a dynamo has lost its residual magnetism, the pole pieces will have little or no attraction for a piece of soft iron. Also, a compass needle held near each of the pole shoes will not indicate a definite polarity, that is, the same field magnet will attract both ends of the needle.

Series dynamos seldom lose so much of their residual magnetism that they fail to excite their fields when the terminals are short-circuited. Therefore when a compound-wound machine refuses to excite with its shunt coil connected, the excitation can often be effected by disconnecting the shunt coil and short circuiting the armature and series coils through a light fuse.

In the case of a shunt dynamo, the field excitation may be started by rotating the brushes back from the neutral or normal position and short-circuiting the armature through one or two sections of a variable resistance, having an ammeter fixed in the circuit. As the dynamo begins to give current, resistance may be gradually put into the circuit until the dynamo is fully excited. Should the brushes be set ahead of the neutral position, that is, rotated in the direction of rotation, there will be a demagnetising effect. Care should be taken in the case of a shunt machine to avoid inductance in the shunt coils. The field circuit should be so arranged that when broken the field coils are shunted with a discharge resistance.

Where the dynamo has separate excitation there should be no difficulty if one of the brushes be disconnected or lifted and the main switch put in as if the machine was being put into service; the current will then flow from the bus-bars in the correct direction. If current from another dynamo cannot be obtained, several cells of an ordinary battery should be tried, the field coil and cells being connected in series. If this fails, the operation should be repeated with all the connections reversed, as it is quite possible that the first time the battery was applied, the battery magnetising current was opposed to the residual magnetism. If these methods fail, the series coils should be connected in parallel, so as to obtain the least resistance possible, put this combination of parallel coils in series with the armature through a light fuse, and then run the armature at a speed considerably higher than normal.

A shunt or compound dynamo will not excite if the shunt field circuit is open. This may be caused by a break either in the shunt windings or in the shunt regulator; these can be easily tested for continuity by a battery and bell, or a battery and galvanometer. First the regulator or rheostat should be tested, then the shunt windings. If the fault proves to be in the shunt windings they should then be tested individually.

Sometimes a dynamo fails to excite through a bad contact, such as a shunt wire loosely connected or a dirty commutator. It is necessary always to bear in mind that the E.M.F. generated when a dynamo is first started is always very small, and even a partial break may prevent the machine from building up its excitation. Thus, all the connections should be made secure, the commutator and brushes cleaned, and the brushes should make good contact with the commutator surface.

Short circuits between the armature terminals will cause a shunt dynamo to fail to excite, or to lose its excitation. With a series or compound dynamo, a short circuit in the line will increase the excitation as a large current flows through the series windings. A short circuit in the field windings of either a series or a shunt dynamo will prevent excitation, nor will a compound machine excite if there be a short in the shunt coil, and the series coil be at the same time on open circuit.

Short circuits within the dynamo itself very often show themselves, and the first thing to be found out is whether the short is within or outside the dynamo. If the dynamo excites its field when the main switch is open, and fails to do so when closed, the fault may be assumed to be outside the machine.

NEW BOOKS.

ELECTRICITY APPLIED TO MINING: H. Cotton, M.B.E., M.Sc., A.M.I.E.E. London: Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, W.C. 2. Price 35s. nett.

The first portion of the book deals with generation, transmission, and distribution, and the author states that he does not make any particular claim to originality for these chapters; the treatment is, however, very sound and has the necessary bias to mining practice to justify inclusion in a work devoted to mining electrical engineering. There are also several important matters included which the writer does not recollect having seen in other books, e.g., the effect of capacity in the sensitiveness of an electrostatic leakage indicator, and the theory of the Course-Rosebourne protective system—to mention only two of these.

The chapters on the Power Supply and on the Generation give a very clear exposition of what is at the present time a very important engineering problem, namely the conservation of fuel, and the attainment of the maximum possible economy.

In the Transmission and Distribution chapters there are useful tables of cable data, some of them extracted from an article which appeared in *The Mining Electrical Engineer*; the author has made the most effective use of these by giving fully worked numerical examples to indicate how the tables are to be practically applied.

The second part of the book will probably be found the most interesting by mining electrical engineers actually engaged in mines, since it deals with the applications of electricity to mining problems, and the author is certainly justified in claiming that the treatment here is largely original. The first mining application considered is the drive of a ventilating fan, a difficult subject which is treated very fully and with great lucidity; it is a debatable point whether speed control of the fan is justifiable or not, and the author's treatment of this problem will be read with interest, especially in view of the fact that many of his published papers show that he has made a thorough study of speed control.

The sections dealing with electric drives of air compressors and of pumps give much valuable information; here again speed control is considered in detail, and in the case of compressors there is the development of a useful expression for comparing the efficiencies of intermittent and continuous running. These are followed by chapters on haulages and winders, the different systems of haulage are considered very thoroughly and comparisons are emphasised and explained by fully worked out examples. Control gear is also considered in detail, there being many diagrams of connections and also formulæ by which the rating of controllers for the different kinds of duty can be calculated.

The section dealing with the rating of haulage motors is particularly sound, the author not being afraid of making use of advanced mathematics where necessary, and it is pleasing to see that locomotive haulage is not neglected. The chapter on winding commences with a discussion of the influence of the drum profile on the shape of the power diagram. This is followed by descriptions of the A.C. and Ward-Lennard systems of electric drive; these two systems are compared with one another, but it would have been an advantage if steam and electric drives had been more fully compared, especially in regard to the factors influencing the choice of either one or the other. In the section dealing with the A.C. drive of main winders the difficult subject of electric braking is clearly explained.

The remaining chapters deal with coal cutting and conveying, underground lighting, flameproof apparatus; these call for little comment excepting to note that they are well done. Perhaps a more complete review of the methods of protection for portable plant, a subject which calls for very close consideration on the part of mining electrical engineers, might have been given with advantage.

It will be gathered, however, from these notes, that Mr. Cotton's book will be of considerable value to all who are interested in the application of electricity to mining, and if there is any pointed criticism to make it is that the author did not complete his work by including a chapter on the subject of signalling; that could well be included in future editions. As it is, the book appears to be by far the most comprehensive treatise on the subject so far written.—A.W.W.

STANDARD MINING TYPE TRANSFORMERS.

The British Engineering Standards Association has just issued a British Standard Specification for Mining Type Transformers, this being the first of a series of specifications that are in the course of preparation for mining electrical apparatus by the Colliery Section.

This specification applies to Oil-Immersed Naturally Cooled Transformers primarily for use underground in collieries and, while no stipulation is made on flameproofness as an essential requirement, it includes the necessary constructional provisions to satisfy the requirements of the Coal Mines Acts underground in collieries. The provisions of B.S. Specification No. 171 Electrical Performance of Transformers for Power and Lighting, are embodied.

Maximum overall dimensions for three sizes of transformers, 100 K.V.A., 200 K.V.A. and 300 K.V.A., have been included in order to assist colliery managers and engineers in the installation of transformers underground.

The Colliery Electrical Section have also in the course of preparation Specifications for Mining Type Motors and Generators, Flameproof Switches and Circuit Breakers, Miners' Hand Lamp Bulks, Underground Lighting Fittings and Cable Glands and Sealing Boxes.

Copies of the new specification (No. 355-1929) can be obtained from the British Engineering Standards Association, Publications Department, 28 Victoria Street, London, S.W. 1, price 2s. 2d. post free.

Proceedings of the Association of Mining Electrical Engineers.

WEST OF SCOTLAND BRANCH.

Ball and Roller Bearings.*

Discussion.

Mr. WILLIAMSON indicated that for general purposes about collieries ball bearings were not much used until more elaborate machinery was introduced. With electric generators and motors highest efficiency was sought, and ball bearings came in with them; but with other plant that worked at collieries, such as the haulage arrangements, ball bearings had never been much used. There are several reasons for that difference. With small outputs and small loads the point is of very little importance, but with heavy outputs then it is necessary to take full advantage of all possible efficiency. That would be ensured by ball bearings, but there are difficulties which arise with the introduction of ball bearings for mining machinery. One of these is the cost and another is the construction of plant to which the bearings are to be applied: for example, a hutch may itself cost less than the ball bearings to fit it. There is the behaviour of the bearing in connection with spragging; it adds considerable weight to a 5 cwt. hutch, for example. With heavy loads these arguments disappear to a certain extent, because there is a more elaborate form of hutch or wagon, and it might pay to have ball bearings because of the higher efficiency gained with the greater output or weight carried.

Mr. Williamson said that some time ago he had questioned a manager about the difference in efficiency, and he had learned that in a dipping road the horse could bring out three hutches on ball bearings where it could only bring out two before. Round about Hamilton the tubs do not carry more than about 10, 12 or 13 cwts., but in one case in the Hamilton district there was at one time as much as 25 and 30 cwts. carried by the hutch. Ball bearings would have been of use there. In one case the cost of the ball bearings per tub was £6 10s., and that was practically the cost of the tub itself. It was a fairly well constructed tub of iron and steel plates, and it was quite an ordinary construction. On one occasion on visiting that particular colliery, Mr. Williamson saw one of the tubs lying on the surface. It had been smashed by accident and the bearings were all destroyed. The manager said the bearings were useless, but when asked if he did not consider that an objection to ball bearings, he replied that the occasional smash was a very small item in comparison to the higher efficiency and the benefit of using the better form of bearing. He had no idea of giving up the use of these bearings in the colliery tubs.

Fans usually worked under the conditions where ball and roller bearings would show to advantage, especially so in the case of the heavier fans and the high speed fans.

Mr. R. C. ANDERSON.—The design and manufacture of ball and roller bearings has always been and always will be a matter for the specialist. These bearings are eminently suited for easy fitting, and generally speaking the results obtained from their judicious use leave nothing to be desired.

At one point in his paper the author stated that only the outer race of the locating bearing should be locked. If a locating bearing such as an ordinary ball bearing or a universal roller bearing be used at one end of any shaft and a plain cylindrical roller bearing at the other end, then there seemed to be no reason why the outer race of the latter bearing should not also be locked. Locking the outer races of ball or roller bearings must prevent any wear in the casing supporting the race, and the speaker failed to see why with such an arrangement as indicated, locking of the outer race would do any harm. To his mind lack of definite instructions or giving instructions which in practice were difficult to carry out meant future trouble. Simply to give an instruction to provide small clearance is hardly definite, but to state lock the outer races, using the correct type of bearings, can only admit of one interpretation. Coming to the application of roller bearings to the crank pins of engines, in the example given the bearings were applied to an engine in a textile factory. Here was the case of an engine more or less uniformly loaded, but in a winding engine the loading is entirely different, rising to a maximum during the acceleration period. In fitting roller bearings to such an engine would the peak load determine the size of bearing to be used, or would roller bearings stand high overloads for short intervals without likelihood of trouble? It would be interesting to have an illustration of the type of roller used on haulage equipments in South Africa. Perhaps the author might consider having such an illustration embodied in the paper when printed.

The figures given by the author in connection with ball or roller bearing fitted tubs as compared with ordinary tubs, showing the pull-to-load ratio, were worthy of close attention. Only by such figures could properly be emphasised the great importance of reducing friction to the minimum. In one part of the paper it was stated that the pull-to-load ratio was as 1 to 35 for plain bearings and for anti-friction bearings 1 to 84, the draw-bar-pull ratios being 1 to 46 and 1 to 84 respectively. The speaker did not quite understand the 1 to 46 ratio. Why should this vary as compared with the pull-to-load ratio of 1 to 35?

Ball and roller bearings would come more and more into use in the future. Simple and easy to fit, yet compact and exceedingly reliable, to his mind they were ideal. Unfortunately the first cost was too often the deciding factor against their use, whereas reliability, economy in running and ease in renewing were overlooked.

Mr. JAMES ANDERSON said he thought the last speaker had misunderstood him about the locking of the outer rings of bearings, or else he had very kindly drawn his attention to a point which had not been made quite clear. With cylindrical roller bearings all the outer races must be bound, but with ball bearings or self-aligning roller bearings one outer race can be bound, the others must be free.

Mr. D. MacLEAY regretted that the author had altogether neglected screening plant. The tendency in England, more than in Scotland, was to substitute roller or ball bearings in all the bearings of screening plants. This has been gone into very carefully by some collieries, and it had been proved that there would be considerable savings by installing ball or roller bearings.

It was rather unfortunate for ball bearings that in Scotland they had been the pioneers in fitting ball bearings to pit tubs; in some cases they had not been altogether satisfactory.

Mr. JAMES ANDERSON, in reply to Mr. MacLeay, said he thought the trouble with ball and roller bearings on pit tubs had been that, as in everything else, they had to learn by experience, and while the early stages of pit tubs with ball bearings may not have been

*See *The Mining Electrical Engineer*, April 1929, p. 331

altogether satisfactory, he would remind them that ball bearings are not now advocated for pit tubs. Roller bearings are suitable because they can take a great deal more shock load, to which pit tubs are subjected, than can ball bearings. Another of the troubles with ball bearings on tubs was the protection, and in protecting an anti-friction bearing to exclude dirt and water; experience in other fields does not help in regard to collieries. The protection which is quite satisfactory in a grinding mill would not be satisfactory in a paper mill; it was only after, unfortunately, a certain amount of trial and perhaps error that the protection problem for collieries was solved. The protection at first was in the form of a felt washer, and it was found not to exclude a gritty material like coal dust when water is present. The felt was ground away, the bearings laid open for penetration of dirt, and failure ensued. To protect pit tub bearings it is necessary to provide labyrinth protection so that dirt may be excluded, and as the grease works out it washes away any dirt which may lie about the labyrinth.

Mr. DIXON.—Mr. Anderson in his paper compared the co-efficients of friction. First he compared unlubricated bearings with plain lubricated bearings, and showed one to be five times as efficient as the other; that figure indicated a poor specimen of a lubricated bearing. Then he compared that with the ball and roller bearing and showed the improvement to be fifty times. It would appear as if Mr. Anderson had taken the best of the ball and roller bearings and not the best of the others. There are some very fine ordinary lubricated bearings, for example, those of flywheel sets with flood or forced lubrication. He, Mr. Dixon, had in mind a 12-ton flywheel which with only the weight of a penny hung on the rim, would start to revolve. He doubted whether much better than that could be got with ball or roller bearings.

The author had said that this ball and roller question was of very great importance where current is paid for on a maximum demand basis. There did not seem to be much of consequence in that point, as the usual starting period of motors (with the exception of winding motors) is so short that it has no appreciable effect on maximum demand. He would agree with Mr. Anderson in advocating the application of ball and roller bearings to machines like rotary converters; though the statement that the majority of good motor manufacturers fitted these bearings as standard was rather too sweeping, and certainly more so in regard to pumps. As a matter of fact he, Mr. Dixon, had had fourteen tenders for pumps looked out at random that day, and found that eleven pumps were offered with plain bearings and three with ball or roller bearings.

One of the disadvantages in connection with ball and roller bearings appeared to be that little warning is given when anything is going wrong; and when ball bearings failed it meant total stoppage. There was a greater factor of safety with plain bearings.

Mr. Anderson had stressed the point about accurate information being given as to the loads, because ball bearings were designed to carry certain loads. A previous speaker had mentioned the difficulty of gauging possible loads on mining machinery, and it would seem that unless the ball or roller bearings were of ample size the same reliability as with ordinary bearings could not be assured.

In concluding, Mr. Dixon said he was not antagonistic to ball and roller bearings, but thought that the field for their application was not quite so wide as one might be led to think from listening to this paper.

Mr. JOHN GEORGE said he considered one of the items of special interest to colliery managers was the question of ball bearings for tubs. Every attention was paid to haulage engines and to the bearings thereof and to get the best efficiency from haulage engines, yet there had been laxity in considering the work the haulage engines had to do. The other end of the string had been neglected. Personally he would agree to have ball bearings on every tub irrespective of its size, as a reduction in friction of the load to be dragged must necessarily lead to a reduction in cost both of haulage engines or initial source of power, and of the initial expense and running expense both of the haulage engine and the tubs themselves. He would even have the rollers and wheels of the haulage roads fitted with roller bearings. An example in mind was the Mary Pit of the Fife Coal Company, which is going over to roller bearings. He would, however, not agree with the author that roller bearings were best for fans. He would not have roller bearings there, because the first consideration was safety; he must have the safest and most reliable bearing. He could afford to lose just a little energy there in the hope of gaining the greater degree of safety.

Mr. T. T. D. GEESIN.—From the practical point of application of ball and roller bearings Mr. Anderson in his reply to one of the speakers mentioned the use of the felt washer and how it wore down and allowed water to get into the bearing. Another objection which he, the speaker, had found in the practical application to electrical machinery was the form of oxidation which was set up at the face of the felt washer with the consequent friction. To overcome that objection they had machined out the bearing caps with grooves just clear of the shaft and packed between the bearing and the laps with a high melting point grease, a method which was found most satisfactory. For dusty situations such as in colliery work, naturally the labyrinth passage was the correct thing to fit. Mr. R. C. Anderson had spoken about the locking of the outer race: Mr. Geesin thought that that question had been settled a long time ago; the reason for the push fit, as the author had made quite clear, was to allow for a slight creepage in the outer race. With regard to the question of fitting lock-nuts to shafts, would the author give his opinion as a specialist in ball bearings as to whether a lock-nut was absolutely essential? He had said that the inner race should be a tapping fit on the shaft, and yet many manufacturers of electrical machinery put in the inner races without any lock-nut whatever. Mr. Geesin would like to know if that were becoming the general practice.

On the question of lubrication, is it or is it not essential to fit lubricators? This seemed to be a thing that had raised a tremendous amount of controversy within recent years where ball or roller bearings are used. The theory was that a ball or roller bearing should require no lubrication, only a film of oil or grease being necessary to prevent pitting of the balls and races. On the one hand we find from big textile manufacturers that they had considerable trouble with ball bearings on the spindles of spinning machinery, and they eventually decided to leave off the lubricators and simply pack the bearings with suitable lubricant. They adopted this practice two years ago, and they now report that their troubles in the application of ball bearings to spindles are less than a half of one per cent. since that took place. On the other hand, if one happens to design and send out an electric motor without a lubricator, in nine cases out of ten back comes a complaint, the question asked being: Who is to take the caps off every six months to lubricate the bearing? Would the author give some further information on these points.

Mr. JAMES ANDERSON said he might reply to Mr. Geesin at once. First of all with regard to the locking. The position is that the technical department of his, Mr. Anderson's firm, do not favour fitting inner races without a lock-nut; but at standardisation meetings at which all the ball-bearing people were present and a great many of the electrical people, it was practically insisted upon that for certain applications on small armatures it was necessary from the point of cost to fit the bearings on to the shaft without any locking device, and in consequence certain fits have been recommended by the ball-bearing manufacturers to conform to the motor manufacturers' desires; so that, under certain conditions, all the manufacturers are quite open to agree to that practice, although he personally did not care for it.

With regard to lubrication he was very strongly of the opinion that it is better not to fit lubricators. A lubricator is fitted to a motor, the cup is filled up and some ignorant man comes along and squeezes the thing right down, and the lubricant goes through the protection device and gets into the windings and causes trouble. Some other ignorant man comes along and sees that the cup is empty and he fills it up and screws it down again, and so the game goes on. It was very much better in his opinion in certain classes of machinery, such as electric motors, to take the cap off once in six months, but not any more often than that, and fill up with fresh grease. As a matter of fact, the recommendation now for line shafting is that no plummer blocks be fitted with lubricators, but that the caps be taken off and the grease replenished.

Mr. FRANK BECKETT (Chairman) said he was not in entire agreement with the author of the paper about the locking of bearings. In some cases it was unavoidable; all races could not be definitely locked, but for long lines of shafting it was better to have a ball bearing to fit the shaft together with a roller bearing. No matter how carefully the outer races of a bearing are fitted, unless it is locked there will be a certain amount of creep, and with that creep there must be a certain amount of wearing of the outer race, or of both races. He considered that in the design of any machine embodying ball or roller bearings the design should be such, if possible, as to permit of all races being locked, both inner and outer, if the best results were to be obtained. The author had referred to the use of roller bearings for winding engines and haulage gears, but though a strong advocate of ball and roller bearings, the speaker found that certainly at the present time the capital cost was prohibitive, particularly in the present condition of the coal industry.

Mr. Beckett said he quite agreed with the author's remarks on the disadvantage of roller bearings which embodied split races in their design, or which permitted the rollers to run direct on the shaft. Nor did he care for the taper roller bearing which needed such very careful adjustment. Referring to the author's advice on the method of fitting ball and roller bearings, it was noticed that he recommended where two or more bearings were in line that one outer race only be locked in its housing, the remainder being left with clearance to allow for expansion and contraction or slight inaccuracies in the machinery. Whilst that was certainly necessary in the case of ball bearings, Mr. Beckett considered the best results were obtained if one bearing only was of the ball type, the remainder being plain roller type with all outer races locked. No matter how carefully an outer race was fitted, if it were not locked in its housing there was bound to be a creep, with gradual wear of the housing race and consequent slackness and rattle. The use of ball bearings only, fitted in the way suggested by Mr. Anderson, had been discarded by most motor manufacturers, and the use of a ball bearing at one end and a roller bearing at the other end adopted, with both outer races locked.

In Mr. Beckett's opinion the design of any machines embodying ball and roller bearings should if possible be such as to permit of all races being definitely locked, both inner and outer races, if the best results were to be obtained: he knew, however, that that was sometimes impossible at the present rate of development.

The author had referred to the use of roller bearings for winding engines and haulage gears, but except in the case of quite small machines, where ball and roller bearings have already been successfully employed, the increased cost of fitting them is prohibitive.

Referring to dust excluding devices, Mr. Beckett's experience had led him to discard entirely the use of felt washers; he had found the method effective only when new.

One of the difficulties with which plant manufacturers were faced was the absence of really definite information in the bearing makers' lists as to the load capacity of ball and roller bearings. Most sizes are standardised, all makers working to these standards, and as they were all necessarily using approximately the same grade of materials and the same treatment of those materials, it was reasonable to expect that the loading capacities of the bearings of different makers would be approximately the same. The lists, however, quote very varying capacities.

Some firms give what they call a safe load, others a basic load to be used with a constant depending on the hours of life expected from the bearings. Those factors were all based on continuous running which very rarely obtains in practice. No figures were obtainable for intermittent loading with long periods of rest, such as when a machine was idle for at least one shift per day. There was no question that a bearing which has periods of rest will run satisfactorily for a very much greater number of hours than one which had to run continuously week in, week out.

Mr. JAMES ANDERSON, in reply, said that the point raised had been dealt with fully in a paper by a Mr. Macaulay, who wrote the handbook on Ball and Roller Bearings for the Institute of Automobile Engineers, and also by, he thought, Mr. Palmgren before the same Institution. The formula for intermittent working was so elaborate that he was afraid the majority of engineers, with the exception perhaps of a few more closely interested people like Mr. Beckett's firm, would have nothing to do with it. They would say, "This is far too complicated; we cannot be bothered with it." The result was that a simple formula was first of all expounded by Professor Stribeck, who investigated ball and roller bearings, and within certain limits that formula still obtained. Mr. Anderson had recently made up a little table comparing Professor Stribeck's formula and safe carrying capacities and basic loads under the two conditions mentioned by Mr. Beckett, and he had found that taking the safe working load given by one particular firm they showed a graph comparing their safe working load with Professor Stribeck's formula, and their safe working load was in excess of Professor Stribeck's formula. The formula dealt with by Mr. Macaulay in the paper referred to was a safe measure of arriving at the loads which a bearing could take, and it depended upon this factor. If a bearing be run under a particular load for 100 hours, failure will ensue in about 93 per cent. of cases. That was taken as a basis. Halving the load at those revolutions gives double the time of the bearing running, that is to say 200 hours' running; but if after that the factor be altered and the load set at 1.5, then the run is for 1,500 hours; 2 gives 4,000 hours; 2.5 gives 10,000 hours; 3 gives 20,000 hours and 4 gives 60,000 hours continuous working. Of course, it is known that if the load is not running continuously the stresses in the metal become relieved and a longer period is got, but the manufacturers give these safe factors for the reason that they do not want failures. If it is said that a bearing will run for 4,000 hours the maker does not want the customer to come at 3,999 hours and say, "Your bearing has not run as long as you said it would." The makers must retain a margin: they give these load tables, working instructions, and indicate what the user may expect. Where there is a discrepancy between the different manufacturers the only thing to do is, it would appear, to pin faith to one or the other.

LONDON BRANCH.

Visit to the Beckton Gas Works.

A meeting of the London Branch took the form of an outing to the Gas Light and Coke Company's Works at Beckton on Saturday afternoon, the 23rd March.

About thirty members including Mr. F. Anslow, the President of the Association, and Mr. T. Stretton, Past President, were present.

After a thorough inspection of the works, the Company very kindly provided tea for the party.

The Branch President, Mr. J. W. Robinson, in a short speech proposed a vote of thanks to the Company which was seconded by Mr. F. Anslow.

The vote of thanks was carried with acclamation.

A brief speech in reply was made by Mr. Rogers on behalf of the Company.

CUMBERLAND SUB-BRANCH.

Modern Practice in the Design and Operation of Coal Cutting Machines in Great Britain.

FORREST S. ANDERSON, B.Sc.

(*Paper read 22nd February,* 1929).

The development of machines for the mechanical getting of coal has a history which is not widely known, but it is one which reveals, above all else, the dogged perseverance of the British race. At this present stage of advanced development it is difficult to realise many of the early stumbling blocks encountered; the problems to be solved were very real and at times the task seemed well nigh hopeless as mining engineers struggled with mechanical, and at a later stage with electrical, details. The practical application of coal-cutting machines dates from about 1860, and it is interesting to note that the types of machines which are meeting with the greatest success to-day are those which apply the principles early adopted by the pioneers. The chain, disc and bar are the chief modern types, and all of these were practically applied during last century. The modern product, however, embodies many new ideas suggested by practical experience or made possible by the use of new engineering tools and methods in manufacture, so that we now have machines giving consistent and reliable service under conditions which were formerly thought to be totally unsuitable for machine mining.

From the purely mining aspect also, much progress has been made, for example, with regard to such questions as roof control and lay-out of faces in order to get the best results. In addition, the developments with regard to conveyor practice, the high labour costs, and the fact that many of the larger seams have been worked out, have increased the sphere of economic application of coal-cutting machines.

It is illuminating to note the increase in the percentage of machine cut coal during the last 27 years. In 1900 only 1.4% of the total output of coal in Britain was machine cut. In 1910 this figure was up to 6%, in 1920 it was 13%, and in 1927 it was 23%. These figures, however, give only a partial indication of the progress made since; if Scotland alone be considered, it is found that, in 1927, 56% of the total output was machine cut coal and, along with this figure, it is significant to direct attention to the fact that Scotland has easily the largest output per man employed.

Modern Types of Coal-cutting Machines.

As already mentioned, the chain, disc and bar patterns are the chief modern types of coal cutting machines, and the statistics show that of these the chain machines at work outnumber the total of disc and bar machines combined. In this connection it is interesting to note the reversal in order of popularity of the types during the present century:—

In 1900 there were 160 disc; 18 bar; and 4 chain machines.

In 1927 there were 863 disc; 740 bar; and 3,209 chain machines.

Within the last few years there has been a decline in the numbers of disc and bar machines, but the number of chain machines has continued to rise rapidly. In spite of this, however, it should be borne in mind that the bar and disc machines have still their own special spheres of usefulness and although the scope of the chain machine has, owing to improvements in design and construction, been greatly extended within recent years, it cannot yet tackle every coal cutting proposition in the most economical way. It may therefore be of some advantage to review briefly some of the outstanding characteristics of the three types.

The Disc Machine.

The disc machine can still cut harder material than any other type and, under suitable conditions will cut a higher yardage per shift in a stiff holing than any of its rivals. Nevertheless, it has several more or less serious limitations. Under a bad roof, for example, the space required to be kept open at the face, due to the breadth of the machine, becomes rather a serious problem and there is also the necessity of continually withdrawing and re-setting timber while the machine is in motion. This practice is not desirable under any conditions. The disc machine also requires stables to be made for it at the ends of the run; it is limited as regards depth of undercut; it is not suitable for undercutting friable seams, and it is not readily flitted or transported.

The Bar Machine.

The bar machine is specially suitable for undercutting very friable seams and possesses some advantages when cutting in troubled ground, but it is not suitable for hard holings and also has the disadvantages due to its breadth.

The Chain Machine.

The chain machine has several unique advantages. It is the narrowest type and this is a feature of great importance in longwall working. In some cases this dimension is as low as 2ft., so that under most conditions the line timber does not require to be touched once it is set, and if working in conjunction with conveyors, these may be shifted up while the machine is still cutting. The chain machine produces the roundest holings and is the most effective as regards cleaning the holings out of the cut. It will cut hard material or undercut a moderately friable seam; it is suitable for longwall or heading work; it can be conveniently arranged to cut at practically any position desired in the seam; it will jib into its cut under power; it is readily flitted, turned and transported, and in general is undoubtedly the most versatile and easily handled of all the types. Chain machines will be dealt with in more detail later.

Motive Power.

In the days of the very early machines, compressed air was the only power used and it was not until 1885 that we have any record of electricity being actually applied to coal cutting machines. Compressed air continued to have the greater application until about 1904, but since that date the popularity of the electric machine has so greatly increased that at the present time about 70% of the total machines in the bar, chain and disc classes are driven by electricity. It is worth noting, however, that although there has been a steady increase in this percentage during recent years, the increment has been very slight. In 1918, for example, electrical machines formed 67.7% of the total, whereas in 1927 they formed 71.5% of the total. Against this has to be placed the fact that in 1918 only 12% of the coal output was got by coal cutting, whereas in 1927 23% was got by coal cutting. It should also be mentioned that in Scotland, where about 56% of the total output is machine cut, 97% of that amount is got by electric machines. The figures quoted show that in spite of the undoubted superiority of electricity in many ways for coal cutting work, there is still a strong party in England who uphold the use of compressed air. The electrical installation is admittedly the more economical, but it is chiefly on the question of safety that differences of opinion arise.

Compressed air has few potential dangers and some spheres of special usefulness; also in many of the older pits where large compressed air plants are already in existence, the cost of changing over to electricity becomes a very serious item. From the purely mining point of view there is this aspect that, as time goes on, we will probably be forced to develop seams at greater depths and in some districts these workings will be very hot. In such cases the use of compressed air plant will possibly be an advantage.

Turning now to electricity, there is no gainsaying that it may be a source of danger but, so far as coal cutters are concerned it is noteworthy that, according to the reports of H.M. Electrical Inspector of Mines, during the ten years from 1918 to 1927 inclusive, there were only three fatal accidents due directly to the use of electricity which involved coal cutting machines. The auxiliary gear appears to be the greatest source of trouble, but endeavours are being continually made to improve such gear and these efforts are meeting with considerable success. Most of the designs and arrangements suggested, both with regard to switchgear and trailing cables, have been widely discussed and it will be sufficient here merely to mention such items as the increasing use of circuit breakers for gate-end control, the Williams-Rowley system of earth circuit protection, the employment of earth leakage protection devices, and the variety of types of trailing cable which are at present being experimented with. There will always remain, however, the very important question of maintenance and, in addition, the necessity of keeping a close supervision on the operation of the gear, as some machinemen display a complete lack of even an elementary knowledge of the grave dangers involved in certain actions.

If the question be now considered from the machine operator's point of view, it will be found that where both types have been experienced, the electric model is generally the favourite. With the compressed air machine there is usually the necessity of handling a cumbersome hose which is usually in a fairly short length so that it has to be changed over to a number of pipe connections during the shift. There is also the bogey of shortage of air which, although not an essential feature, is a very common one. On the other hand, where the pressure is good, there may be trouble due to freezing when the machine is hard pressed, especially in the cooler pits. The compressed air machine also is, if anything, noisier than the electric model and there is generally a haze hanging round due to the exhaust. The trailing cable for the electric machine is much more easily handled than the hose for the compressed air machine and is usually of a length sufficient to serve the whole of a longwall face. The electric switch control is not generally so readily mastered by a novice as the simple air valve operation, but an intelligent man is usually not very long in mastering it. The modern compressed air machine is certainly a great improvement on the older models but, if anything, the electric type is preferred by the operators.

Types of Motor.

With regard to the types of motor employed on modern coal cutters there are many distinct departures from early practice. Originally the compressed air motors were all of the reciprocating type, but the double helical gear turbine is now almost universally employed. The reasons for this change are to be found in the greater simplicity and robustness of construction of the turbine, in the lower maintenance cost, and in the smaller overall dimensions required for a given horse power.

With regard to the electric machines, direct current was principally employed for many years, but of recent years alternating current has come so much into vogue that by far the greater number of machines now being installed operate off the latter supply. Alternating current has many advantages as regards generation and distribution, but probably the increased application of the squirrel cage motor for coal cutter work, consequent upon the rise to prominence of the chain machine, has also had some effect. This type of motor is simple and robust; it has no rubbing electrical contacts; it has the smallest overall dimension for a given horse power, and it is the cheapest to manufacture. The switch is generally of the star delta type, but in some cases the motor is thrown straight on to the line so that the switch also is simple both in construction and operation. The comparatively low starting torque of the squirrel cage motor is an objection to its more extensive use, but this does not militate seriously against its use for machines of the chain or bar type. With disc machines, however, it is customary to use a slip-ring A.C. motor in order to get the higher starting torque.

When direct current is employed, the chain machine motor is either shunt or compound wound, and the bar machine is generally shunt wound. The disc machine on the other hand is either compound or series wound, since with this class of coal cutter a high starting torque is desirable and at the same time there is not so much risk of overspeeding.

When considering the question of electric motors for coal cutters it should always be realised that these have to be designed and manufactured to meet specially arduous conditions and are not in any way comparable with the ordinary commercial type. Size is a limiting factor; they have to be totally enclosed; the case has to be extra heavy to withstand severe stresses; they have to meet a fluctuating load; withstand repeated switching; and be capable of giving reliable service when working in a humid atmosphere. To meet these conditions great care has to be exercised in design and manufacture, only the highest quality materials may be used, and it is now customary in the best machines to impregnate thoroughly all windings with special insulating and water resisting varnish. The impregnating process requires special plant and is fairly expensive, but it is very effective and has proved itself to be a true economy in the long run.

Chain Coal-cutters.

In view of the supremacy of the chain machine at the present time, it is desirable to consider this type in more detail, with special reference to the longwall class in the first instance (see Fig. 1).

Longwall Machines.

These machines are usually constructed on the unit principle, that is to say the assembly consists of a few units, each of which is complete in itself. The general practice is to employ three units: the motor; the gearhead, which is fixed to one end of the motor; and the haulage gearcase, which is fitted to the other end of the motor. The great value of the unit construction lies in the fact that, in the event of a major mishap, the unit affected may be readily taken off and replaced by a spare or, if that be not available, the unit alone can be taken to the surface and the damage put right in the engineer's shop.

The Motor.

The design is generally such that an A.C. electric motor, a D.C. electric motor, or a compressed air motor may be employed or interchanged, and so the motors have to be designed to run at the same speed or else a simple provision is made for gearing to correct the difference. The electric motors generally run at from 720 revs. per minute in the larger sized machines, to 1450 r.p.m. in the smaller sizes. The low speed motor saves the use of some high speed gearing and also simplifies the design of the D.C. machine, for it must be remembered that most coal cutter electric motors are of the reversible type. When it comes to the question

Fig. 1.—A 17in. Longwall Chain Machine. (Anderson, Boyes & Co., Ltd.).

of the smaller sized machines it becomes imperative to increase their speed in order to get the desired H.P. without making them unduly long.

As already stated, the compressed air motors are generally of the double helical gear turbine type and the rotors run at a speed of from about 1500 r.p.m. to 2000 r.p.m. This type of motor, of course, can only run in one direction and so entails the use of a reversing gear, but since the two rotors revolve in opposite directions, the reverse is usually obtained by the use of a simple selective device which allows the drive to be taken from either the one rotor or the other as desired.

The Gearhead.

The gearhead houses the reduction gearing between the motor and cutting chain driving sprocket, and also carries the jib. In most cases provision is made so that, when desired, the cutting chain may be put out of action. The jib support is designed to allow the jib to swing through an angle of 180 deg. or more so that the cut may be made on either side of the machine. In some cases special gear is used for slewing the jib into the cut but, as a rule, this is done by the haulage chain or rope.

The Jib.

The length of jib commonly employed varies from 4ft. to 8ft. depending on conditions, but 4ft. to 5ft. might be taken as the usual length for longwall work, and 6ft. to 7ft. for heading work. These figures make it evident that the jib should be as light as possible, and yet it must be of sufficient strength to withstand the severe stresses imposed upon it. So far as the detail design of the jib is concerned, there is one point to be mentioned and that is the type of guide provided at the outboard end of the jib for the cutting chain. In some cases a sprocket wheel is employed at this point, while in others a simple slipper block is used, and there is occasionally some controversy as to which is the better arrangement. In the opinion of the author both methods have their advantages, and the deciding factors are really the length of jib and the conditions under which it has to be used. With the longer jibs a sprocket end is a distinct advantage for starting up, and also when the holing material is of a gritty nature. The advantages of the sprocket end are obvious, but it should also be borne in mind that, so far as the bearing is concerned, the sprocket is working under extremely adverse conditions and unless proper attention is given the load will be increased instead of diminished. With reasonable care, however, very little trouble will be experienced with a well designed bearing. The solid end, on the other hand, is cheaper to manufacture. It requires the minimum of attention, and in practice has been found to give satisfactory service under a wide variety of conditions.

The Cutting Chain.

The cutting chain is one of the most important parts of this type of machine, and it was chiefly with this element that troubles were experienced in the initial stages. The size of the chain is limited; it has to withstand very severe stresses due to sudden shocks, and at the same time it has to possess high wearing qualities. The problem of the early designers was therefore a difficult one but, due to the great advances in metallurgical science in recent years and the improved methods of manufacture which have been devised, cutting chains can now be produced which will give very reliable service under the most exacting conditions. The general practice is to build the chain up of a number of different types of pick-holders which hold the picks at different angles so as to distribute the cutting points over the breadth of the cut. By this design one type of pick suits every holder. The question of the number of cutting points to employ and the sequence of the different pick-holders in the chain is one which has to be decided by the holing conditions, but the five-point and the seven-point chains are the two most commonly used.

The Gearcase.

The gearcase houses the reduction gearing for the haulage, which may be either by chain or rope. It is customary to provide both a low speed or speeds for cutting and a high speed for flitting, and it is good practice to incorporate a friction clutch which will limit the pull that may be put on the hauling medium. With rope haulage machines a ratchet feed is usually employed for cutting, so that by operating a cam plate four or five different cutting speeds may be obtained. The chain haulage machines are usually provided with a continuous feed which is adjusted by means of interchangeable gear wheels to give the feed best suited to the particular conditions. The cutting speeds are usually within a range of from 1ft. to 3ft. per minute, and the flitting speed about 20ft. per minute. There have been many controversies as to whether chain or rope haulage is the better and, as in most of these questions, much can be said on both sides. Briefly stated, the variable cutting speed on rope haulage machines is claimed as a great advantage, but while this is the case in certain circumstances, the author has not found that this claim has been substantiated under most every-day working conditions. Where the nature of the holing varies greatly or the workings are wet and dirty, the rope haulage machine has a strong claim but, in general, the chain haulage is preferable as being more versatile and also more pleasant for the operator to work with; while there is an advantage in the average holing in having the rate of travel predetermined.

In General.

With modern machines the cases of the various units should be heavy section steel castings so that they may stand up to the severest conditions without damage. The gearing is contained in oil-tight cases; ball and roller bearings are largely employed; careful provision is made for the lubrication of all gear wheels and bearings while, at the same time, special precautions are taken to prevent oil leaking into the motor. In a well designed machine the exterior is smooth so that there are no sharp corners or edges to injure the operators, no projections to catch the line timber and pull it out, and all the controls are conveniently placed and readily operated.

So far as electric machines are concerned these should be of flameproof construction, safety usually being obtained by the use of wide machine faced joints. In this connection might be mentioned the recent adoption of the British Engineering Standards Association flameproof plug and socket for coal-cutters, which is now being used to a considerable extent with very satisfactory results.

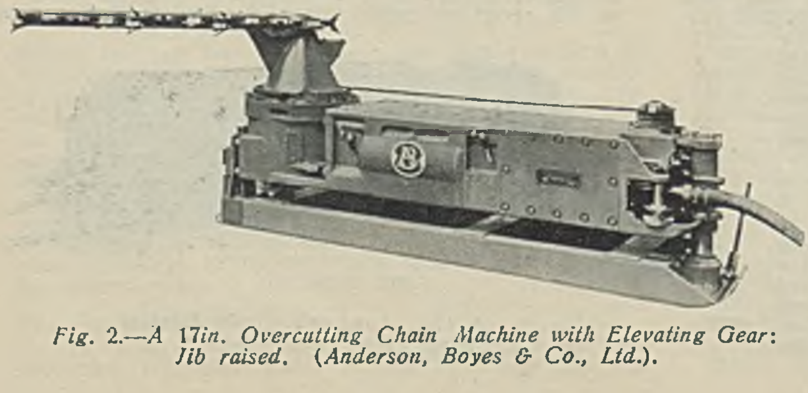


Fig. 2.—A 17in. Overcutting Chain Machine with Elevating Gear: Jib raised. (Anderson, Boyes & Co., Ltd.).

Undercutters and Overcutters.

The most common type of longwall chain machine is the one which cuts at floor level, and this machine gives the greatest satisfaction under most conditions. In some cases it is desired to cut out a dirt band in the seam in order that the coal may be got clean and, as a rule, the chain machine can be readily adapted for this work. Where the band occurs within about 12ins. from the floor, the usual practice is simply to fit an under-carriage to the standard machine, but if the band is higher, the machine is generally arranged for overcutting. There is no hard and fast rule on this question as, in addition to the position of the band, there are usually other factors which affect the case.

There is one case of overcutting which deserves special mention, and that is when the machine is cutting at the top of the coal or immediately above and the conditions are such that the machine is forming its own roof. This is an operation that can only be carried out under fairly good roof conditions since it is not possible to put bars up; and, in addition, the machine must be so designed that it can be lowered from its normal cutting position (see Fig. 2) when the machine has to be flitted for any reason; as, for example, when turning at the end of the run. There are many points which might be discussed in connection with overcutting, but there is one aspect which it is necessary to emphasise, and that is that before adopting a holing position away from floor level very great care should be taken to make sure that the parting at the floor is good and that the coal will lift readily.

Lay-out of Faces.

With regard to the lay-out of faces, this is generally governed by the particular method of working adopted. In Scotland, the practice is to work with a relatively short length of face which is cut and filled off every 24 hours. In certain parts of England long faces, say about 500 or 600 yards long, are employed and these are cut and filled off about every week only. There are some points to be raised in favour of this latter system, but in the main the balance of the benefit is probably in favour of the unit face; which method, with the increased adoption of face conveyors, is coming more rapidly into vogue. In addition, where face conveying has been introduced it often has the effect of limiting the length of face and so the amount required to be cut by the machine in a shift.

In many cases this limitation has proved to be a distinct economy as, in certain quarters there is a tendency to lay-out so much ground that the machine is pushed to the absolute limit to get through. The inevitable result is that more often than not the operators have to be paid overtime, they have no time to give proper attention to lubrication and minor adjustments and so the machine gets into bad condition; and in the event of serious delay, due to face conditions or mechanical trouble, a whole day's output may be lost.

It cannot be too strongly emphasised that where intensive mining methods are employed, a large measure of the success of the system depends on the timeous completion of each of the individual operations and so the truest economy will be obtained if a reasonable time margin is allowed. The cutting capacity of chain machines is really a question of particular conditions, but 90 yards per shift might be taken as an average figure.

Heading Machines.

In addition to longwall work the chain machine is also used for driving headings. There are two main classes for this work, the shortwall machine and the arcwall machine.

Shortwall Machine.

The true shortwall machine differs from the longwall type in that the jib is permanently fixed in the straight forward position. This design can be arranged to give a very short machine, and chain haulage is generally adopted as being the more convenient for this class of work. The method of using the shortwall machine is to sump in at one side, draw the machine broadside on across the place, and then draw back out, squaring off the side. A place can be cut in this manner in about half-an-hour under fairly good conditions, but a considerable time is spent flitting from place to place although, when much flitting has to be done, a power propelled bogie may be employed if the gradient is suitable. Shortwall machines have never had a great vogue in this country and, with the increasing success now being obtained from arcwall machines, it is unlikely that they will be much used. Where an arcwall machine is unsuitable it is common practice to instal one of the standard longwall machines, which has been designed to do heading work in addition, and this machine has proved itself very suitable for this class of work.

Arcwall Machine.

The arcwall machine has usually the same principal features as the longwall machine except that it is mounted on wheels, and remains mounted when cutting, and a drive is provided from the machine to the track wheels. The place is cut by slewing the jib from one side to the other, so that the maximum width of place is decided by the length of jib employed, but a narrower place may be driven with the same jib by modifying the method of cutting. The great advantage of keeping the machine mounted all the time is obvious but, if full use has to be made of it, the machine must be designed so that all operations can be easily and conveniently controlled, and the component parts must be capable of standing up to really arduous work.

The chief factors which limit the use of arcwall machines are the grade of the workings and the cutting position desired. So far as the grade is concerned, this is really a question of flitting, but up to about 1 in 9 there is practically no difficulty, and many arcwall machines are giving very satisfactory service flitting unassisted on steeper grades than that. Where the grade exceeds about 1 in 7 it becomes necessary to make special provision for going up and coming down the steep parts. With regard to the cutting position, some machines are very limited in their range, but others can be adapted to hole at practically any height except at or very close to floor level. As a rule it is found that the best results can be obtained when the holing position is more than 6ins. above rail level, but this is largely a question of conditions and, if special provision is made for raising the jib sufficiently clear of the rails when flitting, satisfactory results can be obtained holing nearer the floor (see Fig. 3). It will be readily understood that one of the essential factors in this class of work is that the track must be on a solid bottom and well laid.

The principal sphere of the arcwall machine is for driving the narrow places in pillar and stall workings, but the scope of its work is now being widened and many colliery companies are finding that it is an

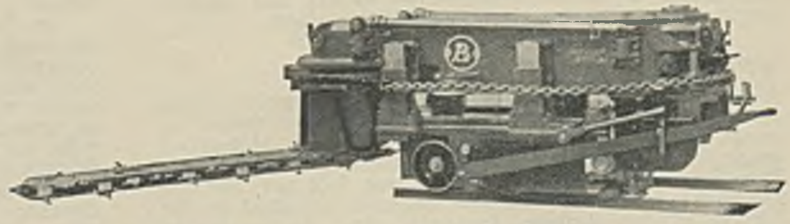


Fig. 3.—An Arcwall Electric Chain Machine with Elevating Gear: Jib raised. (Anderson, Boyes & Co., Ltd.).

economic investment for doing development work alone. It permits of a new seam being developed in the quickest possible manner; it makes the longwall retreating system a more attractive proposition; and, where an area of coal has to be left in to prevent surface subsidence, a certain percentage of it may be worked at an economic rate even in the case of thin seams. The cutting capacity of the arcwall machine is really a question of conditions, but from about ten to twelve places per shift might be expected with a well planned lay-out and under average conditions.

Although this paper does not by any means exhaust the subject, the longwall and arcwall types of chain machine have been dealt with in more detail than any of the others, because it would appear certain that in the immediate future they will be the chief types of coal cutting machines to be employed in this country. Coal-cutting machines are becoming more largely adopted throughout the British coal-fields every year, and at the present time particularly are proving their worth as real cost reducers.

WEST OF SCOTLAND BRANCH.

Pumping Lay-Out and Practice.

H. T. COLLINSWOOD.

(*Paper read 12th December*, 1928).

The development of the turbine centrifugal pump to its present pitch of simplicity and reliability is without doubt due in great measure to an endeavour to meet one of the most serious problems which face the mining engineer: the flooding of underground workings. It is very natural perhaps that, so far as the mining engineer is concerned, the theoretical principles "are honoured more in the breach than in the observance," and it is not perhaps until troubles and difficulties arise that deeper interest is aroused. In this paper the author wishes to indicate some of the points which, if they do not receive due attention, may give rise to trouble and disappointment. In the first place it will perhaps be useful to comment on the first stage in the installation of a pumping set, namely the enquiry. To ensure the minimum of correspondence it is well that every endeavour be made to give all the necessary information, particularly with regard to the proposed pipework. In mining work, the situation often demands awkward arrangements which may affect the performance adversely if not taken into account in the initial stages. A specimen Enquiry Sheet is shown below and if, when enquiring, the various items there covered are attended to, there should be no fear of vexatious correspondence and delay.

Every pump set before despatch is tested to full capacity to ensure that it is in every respect up to specification and entirely capable of the duty. If, when the pump is installed, the desired results are not obtained the first step is obviously to ascertain in what way the running conditions are different from those on test. In nine cases out of ten the answer will be found to be unsuitable pipe-work; and, moreover, of these nine causes it is no exaggeration to say that suction troubles would be found responsible for eight.

Suction Lift.

As regards the total suction lift, the turbine pump suffers from the same disability as all other forms, in being limited to a theoretical maximum of 34 feet of water: the height of the water barometer at sea level. This figure suffers a reduction of one foot per 100 feet above sea level. In addition the head absorbed in the friction of the strainer, foot-valve, and suction piping must be allowed for. In short, the maximum effective static lift should not exceed 15 feet to 18 feet. If the water dealt with be warm, even this figure is impracticable on account of the increased vapour pressure. The Table I. gives the maximum suction lifts (static and friction) for various temperatures, which should not be exceeded.

TABLE I.

Temp. of Water Deg. F.	*Max. Suction Lift: Feet.*
100	18
125	12
150	8
160	4
170	0
180	— 2
190	— 4
200	— 7
212	— 10

It is therefore clear that the suction pipe must be as short as possible, and of ample section if the best results are to be obtained. The fact that the pump is supplied with, say, a 7in. suction branch does not of necessity fix the diameter of the suction piping. The branch diameter has been fixed by the designer to suit the conditions local to the pump, and it is very good practice to fit an expanding distance piece connecting with a suction pipe an inch or two larger. This taper piece should not be too short, a maximum total angle of slope being 14 degs. When fitting such a taper piece care should be taken that no part of the suction piping rises above the level of the suction flange, similarly, care must be taken that the suction pipe rises all the way to the pump, avoiding air pockets. If an air pocket is unavoidable, then a pipe must be arranged connecting the pocket with the suction side of the first impeller, in that way avoiding an air lock: Figs. 1 and 2.

In a case where two pumps are arranged on a common suction pipe, similar pipe connections will be necessary in order to avoid air locks in the T-pieces when the pumps are working singly: Fig. 3.

Probably one of the best known principles of hydraulics is the law of stream line or non-sinuous flow, upon which practically all calculations on flow are based. Despite this, however, it is very common to observe a pump connected to its suction pipe by a sharp right angle elbow, which must produce anything but a stream line effect. This too, in face of the fact that the conditions at the suction of the pump are most sensitive in relation to the efficiency. It is most desirable that a fairly long length, say 8 to 10 diameters of straight pipe, should be connected to the suction flange before a bend is introduced: Fig. 4.

Unfortunately in many cases it is really impossible to accommodate such a straight pipe, and accordingly in the patented "Spiroglide" pump a dividing septum or rib is cast in the suction branch in order to promote non-sinuous flow, and to nullify so far as possible the effect of a bend close to the pump.

In this connection a noteworthy fact arises in that, with a given direction of rotation, different results are obtained according to which side of the pump the suction branch is arranged on. As a rule it is therefore in the purchaser's interest to try to accommodate the maker's standard branch positions, if at all possible, rather than call for some possibly disadvantageous modification.

In the case of a suction main otherwise satisfactory, the most frequent cause of trouble is air leakage. The design of practically all turbine pumps is such that the shaft gland at the suction end is under suction pressure and it is thus subject to air leakage. This is obviated by fitting a pipe from the delivery side of the first stage to a space in the middle of the gland packing. In order that this pipe should be fully effective, it ought to have a cross section equal to twice the area of the clearance between the shaft and the sleeve in which it runs. In the event of a new sealing-pipe having to be fitted on site, care should be taken that it is of ample area.

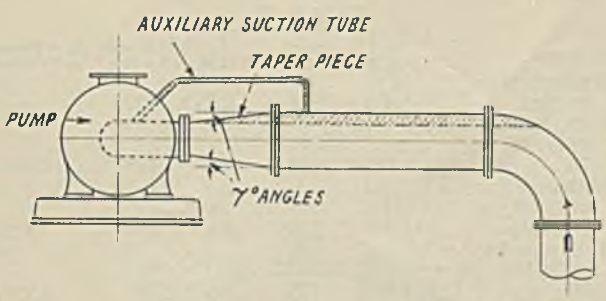


Fig. 1.—Air Lock avoided by use of Auxiliary Suction Tube.

Air leakage into the suction main itself is often very difficult to trace. It may be detected by allowing the pressure of the delivery column to come on to the suction pipe by means of a bye-pass on the reflux valve; or by actually looking for leakage, while the pump is running, by means of a naked candle flame—a method usually impossible under modern mining regulations.

It is poor policy to utilise old and worn piping for the suction main and if priming is to be effected by a bye-pass from the rising main, the suction piping must be capable of withstanding the full delivery pressure.

The use of a sluice valve on the suction side is really most undesirable, and in cases in which such a valve is fitted, e.g., boiler feed pumps, it should not be used for throttling but should be kept fully open while the pump is working.

The foot valve is a unit in the suction system which ought to receive considerable attention. The strainer should have perforations equivalent to at least twice the area of the valve inlet, in order to reduce friction to a minimum, and to provide against partial choking. It is a mistake to fit the foot valve above water "for accessibility," since air will be trapped beneath the valve, and will cause the pump to lose its water. There should always be 2ft. of water over the foot valve at the very least. Since the foot valve is the most inaccessible part of the whole system, reliability is the prime consideration. To this end, a design embodying a minimum of parts and rubbing surfaces is desirable, e.g., the mushroom type, either with a guiding stem or, as shown in the sketches, Fig. 5, with simply a steel disc carrying a rubber ring which beds on an inserted gun-metal seating, the disc being guided by ribs cast in the valve body. Another extremely simple and effective form, though rather expensive, is the ball type of foot valve, Fig. 6. The ball consists of a hard wood core covered with "cab-tyre" rubber, and bedding on a gun-metal seating. The motion of the ball in an upward direction is limited by suitable ribs in the body. With such types failure is scarcely conceivable, and the symmetry of the internal arrangements reduces friction to a minimum.

Priming.

In priming a pump, a watertight foot valve is of course essential, whether the pump be charged from a separate supply by means of the tundish, or by a bye-pass from the rising main. Where necessary, a small

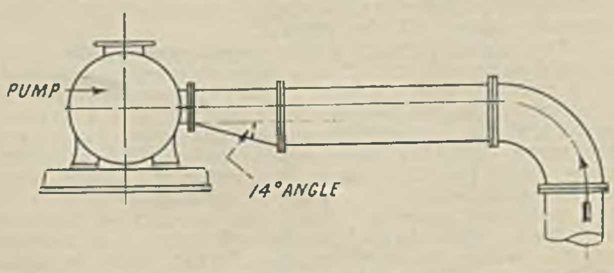


Fig. 2.—Air Lock avoided by use of Straight-sided Taper.

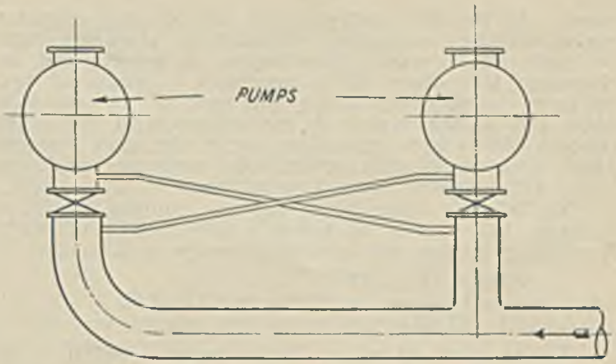


Fig. 3.—Avoidance of Air Lock when one pump is working.

air pump may be installed to exhaust the suction pipe of air. Various types of exhausters have been evolved on the ejector principle. One of the most effective is the Seaborne Interceptor, Fig. 7. This consists essentially of a tank of suitable capacity having a flange top and bottom. The top of the tank is connected to the suction pipe, while at the bottom a connection is made to the suction branch of the pump. To start up, it is only necessary to fill the interceptor with water, and on starting the pump a partial vacuum is formed in the top of the tank, causing water to rise in the suction pipe and flow into the interceptor. In falling, this water carries with it entrained air, a cone arrangement being provided inside the tank on the ejector principle. This continues until all the air has been passed through the pump in minute bubbles. This arrangement is particularly useful in dealing with sewage, petrol, etc., which are liable to give off gas, and if necessary, it can be used without any valves in the system whatsoever.

Delivery Main.

The delivery piping, while much less prone to trouble, should be carefully selected. If too small a pipe is fitted, the head lost in the friction will be excessive, and will necessitate a higher pressure at the

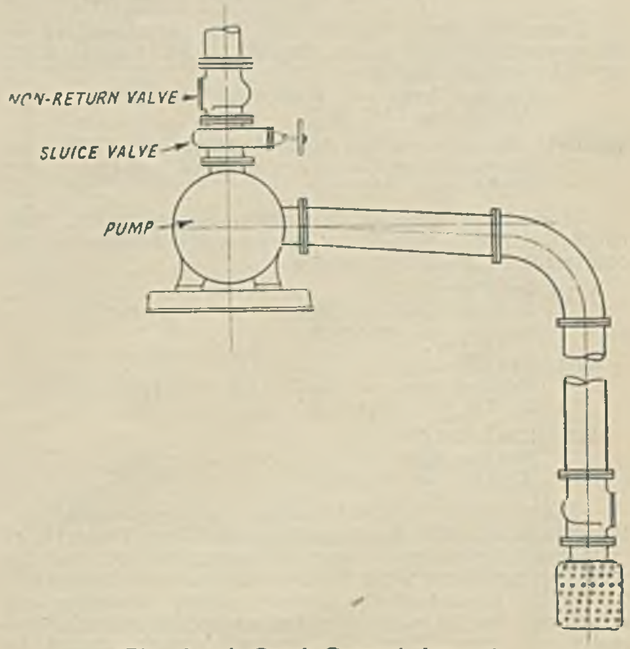


Fig. 4.—A Good General Lay-out.

pump. At the other extreme, the use of large diameter piping may be prohibitive. In addition, allowance must be made for increasing pipe-friction as growth and incrustation take place. It is necessary to work out two or three alternatives, taking the cost of the pumping plant and of the piping in conjunction with any other factors. As regards expansion pieces, the same remarks apply here as in the suction side, and too sudden a taper will certainly cause loss of head.

To take an example at random, suppose we have to raise 1000 g.p.m. of water a total height of 500ft. Neglecting friction the power necessary is

$$\frac{1000 \times 10 \times 500}{33,000} \text{ H.P., or } 151 \text{ H.P.}$$

Taking first of all a 7in. diameter pipe, it is of course necessary to allow for the friction of the various fittings, which can be found from the friction chart, Fig. 8, together with the following data:—

Box's formula for Friction-Head is:

$$H = \frac{\text{Length (ins.)}}{\text{Dia. (ins.)}} \times \frac{1}{32} \times \frac{V^2}{2g} \text{ Feet.}$$

Loss of Head in Fittings, expressed as Length of Piping to be added to the measured length in feet:—

Foot Valve and Strainer	50	feet.
Sluice Valve, full open	3	„
Round Elbow	15	„
Reflux Valve, flat type	10	„
Reflux Valve, globe type	30	„
Bend, radius 3-5 diars.	5	„
Sharp Elbow or Tee	30	„

$$\text{W.H.P.} = \frac{\text{G.P.M.} \times \text{Ft. Hd. (total)}}{33,000}$$

$$\text{B.H.P.} = \frac{\text{W.H.P.}}{\text{Pump Efficiency}}$$

Total lift	500	feet.
Foot valve, etc.	50	„
Sluice valve	3	„
Reflux valve	10	„
Four bends	60	„
Horizontal length	17	„
	640	feet.

From the chart, the friction loss corresponding to the passage of 1000 g.p.m. through a 7in. pipe is 8.1ft. per 100 feet of piping.

Friction head = 6.40 × 8.1 = 52ft.
W.H.P. = 167 H.P.

Taking a 9in. pipe with a loss of 2.25ft. per 100ft. run,

Friction head = 6.4 × 2.25 = 14.4ft.
W.H.P. = 156 H.P.

If we now suppose that the pump is 2000ft. "inbye," the result will be to increase the friction to the equivalent of 2640ft. of piping.

WITH 7IN. PIPE:

Friction head = 26.4 × 8.1 = 206ft.
W.H.P. = 214 H.P.

WITH 10IN. PIPE:

Friction head = 26.4 × 1.4 = 37ft.
W.H.P. = 163 H.P.

WITH 12IN. PIPE:

Friction head = 26.4 × .5 = 13.2ft.
W.H.P. = 156 H.P.

These results, which all attain the same result, viz., the raising of 1000 g.p.m., are tabulated in Table II.

These figures make clear the importance of studying well the conditions before choosing the pipe diameter.

In the lay-out of the delivery piping advantage can sometimes be taken of the syphon effect, though normally not more than 70% syphonic return should be counted on. The most usual example of this is in the case of condenser circulating water systems, where cooling water is drawn from and discharged through the same stream or reservoir.

TABLE II.

	G.P.M.	Head ft.	W.H.P.	B H.P. with eff.=75%	% of Power to Friction.
Without pipe friction	1000	500	151	202	—
With pipe friction of 640ft. of 7in. pipe	1000	569	167	223	10.5%
With pipe friction of 640ft. of 9in. pipe	1000	519	156	208	3%
With pipe friction of 2640ft. of 7in. pipe	1000	775	214	286	4.2%
With pipe friction of 2640ft. of 10in. pipe	1000	549	163	218	8%
With pipe friction of 2640ft. of 12in. pipe	1000	517	156	208	- 3%

Water Hammer.

With a long delivery pipe, trouble is sometimes experienced from water hammer. Protection can be obtained by fitting a relief valve at the danger points. The reflux valve should generally be fitted on the side of the sluice valve remote from the pump, in order that both pump and sluice valve may be protected from a bad surge, since reflux valves are nowadays quite reliable.

If for any cause, such as the failure of the power supply, a bearing seizure, or even the sudden closing of a valve, the column of water is suddenly brought to rest the kinetic energy stored in the moving column is suddenly converted into a pressure or impulsive force, sometimes of many tons. The destructive effect of such a surge is often very severe, and in addition, in the case of a long horizontal pipe, a periodic sway of the whole pipe line may occur. This is due, in say the case of a valve closing, to the following. The water next the closed valve is suddenly brought to rest and its pressure rises. This wave of pressure travels to the open end of the pipe. Here, since there is a difference in pressure between the water and the atmosphere, the water will flow out. A wave of velocity will now travel back along the pipe to the valve, and these alternate waves of pressure and velocity in turn set up sway. The effect is sometimes accentuated by the opening and closing of the non-return valve. In this connection, in shutting down, the sluice valve should always be closed before the motor is tripped out, so that the water column is gradually brought to rest. By this means, the shock caused by the sudden closing of the reflux valve is avoided.

Pump Characteristics.

One of the most interesting and useful facts relative to the centrifugal pump is that for any given speed of rotation the maximum pressure which can be developed is a definite and fixed figure. This is perhaps better understood by referring to what is known as the "characteristic curve" of the pump.

The characteristic of a centrifugal pump is the curve of head developed drawn to a base of quantity delivered. In a typical curve, at zero delivery, a certain head is developed. As the delivery increases there is a gradual and slight rise in pressure up to a maximum figure, and the curve thereafter falls more rapidly. The efficiency curve, when plotted, gives the optimum normal duty at the point where the head is approximately 90% of the maximum possible. Since the product of delivery and head, when divided by the efficiency, is a measure of the water horse power, the B.H.P. curve is easily plotted From this latter curve a very interesting fact arises. Whereas the power taken with the valve closed

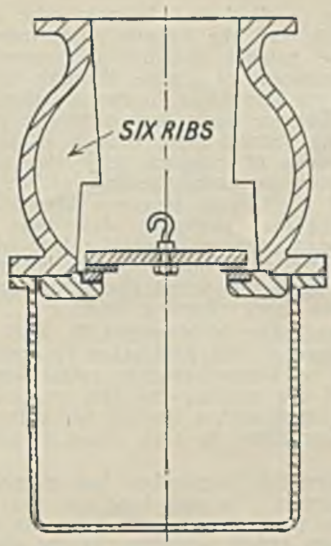


Fig. 5.—Foot Valve, mushroom type, without stem.

is only 35% of the normal full load, the maximum overload which can come on the motor is only 15%, since the power curve begins to fall away beyond this point. Thus, while no excessive or dangerous perssure can be developed, neither is there any danger of serious overload.

One important point arises where induction motor drive is installed. The speed of such a motor, as is well known, varies appreciably with the load, the percentage variation being known as the "slip." The head developed by a centrifugal pump varies as the square of the speed, and consequently the effect of the "slip" is to accentuate the downward drop of the characteristic. It will be realised, therefore, that it is most important that both pump and motor should be designed with special reference to each other, and care taken that the "nett characteristic" of both pump and motor is suitable for the duty.

Boiler-Feed Pumps.

The installation of turbine pumps for boiler feeding calls for special care in the choice of characteristic. The ordinary "hump-back" characteristic is unsuitable for boiler-feeding, for at least three reasons. Suppose a feed pump to be operating on the rising part of the characteristic. Should the demand fall, the reduction in output involves an immediate reduction in the pressure

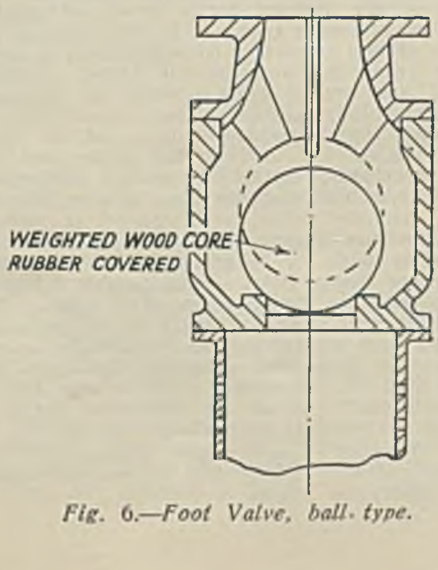


Fig. 6.—Foot Valve, ball type.

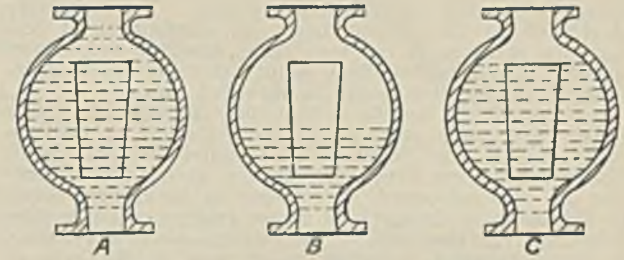


Fig. 7.—Seaborne Interceptor. A, *before starting*; B, *vacuum forming and water entering*; C, *charged for normal running.*

at the pump, and there is consequently a surge back to the pump from the feed range. This surge may be so severe as to amount to water-hammer.

Secondly, suppose two pumps to be running in parallel still on the rising part of the characteristic. It is impossible to ensure that both pumps have exactly similar characteristics, although both curves may pass through the same normal duty point. The pump having the slightly higher characteristic will answer to any increase in demand before the other. This increase in delivery automatically increases the pressure developed by this pump, and the mean pressure of the feed range rises. The second pump is now delivering against an increased pressure, which causes a fall in the quantity delivered. This involves a decrease in the pressure developed by the second pump which further aggravates the condition, until finally one pump is taking all the load, while the other ceases delivery altogether. If, however, the pumps had been operating on the falling part of the curve, the pump first answering the demand would decrease its pressure, which would automatically cause the second pump to take its share.

In the third place, suppose a pump to be operating at the peak of the hump-back, and it is desired to

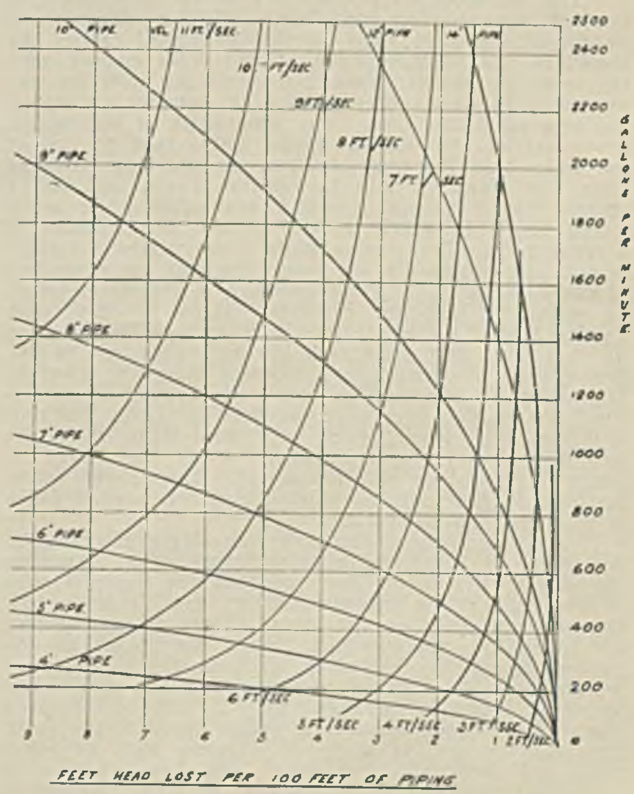


Fig. 8.—Friction Head Lost per 100 *feet of average Piping: based on Box's Formula.*

bring a second pump into action. The pressure developed by the second pump on starting up is less than the pressure at the feed range however and, consequently, it will not deliver until either its speed is increased, or the first pump is throttled down.

It is clear, therefore, that the characteristic of a boiler feed pump must be of the "stable" or continuously falling type, without any hump-back whatsoever. These conclusions have been arrived at on the assumption of constant speed of rotation as in electric drive. If the pump is driven by a steam turbine, an automatic pressure regulator will be necessary, since a variation in speed causes a variation in pressure in the ratio of the square. Such a regulator must be sensitive to variation of pressure in the feed main, so that it can open out or throttle the turbine with the demand, and must also be capable of stopping the pump in the event of a burst main.

Design and Construction.

It might perhaps be of interest at this stage to say something about the most important feature of the hydraulic design, namely, the impeller and guide vanes. The angle of the impellor vane at the inlet to the impeller is designed so that the water on entry is picked up without shock. The actual direction of flow into the impeller is, within limits, a matter of conjecture, but if the absolute direction of flow is assumed to be radial, it is a simple matter to draw a triangle of velocities and thus obtain the correct angle.

The outlet angle of the impeller determines to a great extent the characteristic of the pump and also the angle of the guide vane. To avoid shock, it is of course necessary to arrange the guide vane at the same angle as that of the absolute velocity of the water leaving the impeller. This angle is obtained from the velocity triangle for the outlet from the impeller.

In the course of manufacture, these details receive special attention, the guide vanes being carefully machined to template, so that the accuracy of the angles is assured.

The patented "Spiroglide" type of construction is one of the simplest and most effective designs yet developed. A steel shaft suitably keywayed carries the impellers, the shaft being protected from contact with the water by bronze sleeves. Commencing with the suction end, the end cover carries an outside bearing of the ring lubricated type. The main body of the suction cover carries the suction flange and serves to convey the water into the first impeller. A cast iron "closing plate" is spigotted into the suction cover, and has a central "eye" provided with a renewable white metal "neck ring" in which the eye of the first impeller is a running fit. The closing plate itself carries a further spigot, into which fits the pump chamber corresponding to the first impeller. This chamber is a casting, inside of which the impeller revolves. It is provided with "guide ports" to receive the water as it is thrown from the impeller, and conveys it through passages to the next stage. The requisite number of stages to give the head required can thus be spigotted together in succession, the whole being held together by girdle bolts of 60,000lbs. high tensile steel. The final stage discharges into the delivery cover, which carries the flange to which the discharge pipe is coupled. The delivery cover carries a further unit, the balance chamber, beyond which is the outer pump bearing.

In all multi-stage pumps having single entry impellers there is considerable axial thrust. On examining the section it will be observed that the external area of the impeller on the suction or "eye" side is considerably less than on the other. There is consequently the cumulative out-of-balance thrust, due to all the impellers, acting on the pump shaft in the direction of the suction end. This is overcome by means of a simple hydraulic balancing arrangement. It will be observed that in the balance chamber is a disc keyed to the shaft. This balance disc is made of stainless steel or other hard and incorrodible material, and bears against a renewable cast iron plate. Water at high pressure is permitted to leak between the shaft and the long water bearing, and thence between the faces of the renewable plate and the balance disc, into the balance chamber. The balance chamber is connected with the atmosphere by means of a pipe, through which the leakage water flows, amounting to two or three gallons per minute. The balance water may either be led to a drain or back to the suction pipe, though in the latter case if the pump is kept running with the delivery valve closed there may be undue heating of the water in the pump. should the thrust increase, the balance disc is pulled close to the renewable plate thus reducing the flow. The mean pressure over the face of the balance disc consequently rises until balance is established. If on the other hand the thrust decreases, the mean pressure falls, once more effecting balance.

An external pipe is arranged to lead water at the delivery pressure of the first stage, to seal the suction gland, a pair of bronze spacing rings being placed in the middle of the packing for this purpose. The suction cover is fitted with a tundish for priming purposes, a pet-cock being fitted to each stage to release the imprisoned air.

The "Spiroglide" chamber has some special and interesting features. In this type the water is received into the guide ports which lead it in the correct curve to the maximum radius permitted by the diameter of the casing. The fullest possible diffusion is thus obtained. The curve then continues, the radius of the passage continuously decreasing and its cross-section increasing. The curve, however, is not a plain curve, but has a pitch like a screw, which is such that by the time the water has described the curve and is at the radius of the eye of the next impeller, it has moved axially forward, and is in fact on the point of entering the "eye." By this means, the water flows from the impeller of one stage without shock, follows a continuous curve, and is received by the next impeller without any sudden change in direction. Such an arrangement yields the utmost possible conversion of kinetic energy to pressure, with beneficial results to the efficiency and general performance.

It will be appreciated that this type of construction is an extremely flexible and simple one and, all the parts being standard, it is only necessary to build up the requisite number of stages, which are strongly bound together by stout girdle bolts of 60,000lbs. high tensile steel, to meet any condition of head. Naturally, the manufacturing methods adopted are most up-to-date and carefully studied, and the limits of accuracy are very fine indeed. Absolute interchangeability and accuracy of fit are thus ensured.

Turbine versus Reciprocating Pumps.

At this stage it might perhaps be of interest to make a comparison between the turbine pump and the reciprocating type. In the first place, a study of the characteristics of the turbine pump shows advantages not possessed by any other type. It is impossible to produce a pressure greater than that corresponding to the speed, as shown from the form of the curve, obviating all danger of line breaks when a valve on the discharge line is accidentally closed. The capacity/horse-power curve shows that a sudden closing of the discharge valve will reduce the load on the motor and that the maximum overload is within the control of the designer The efficiency is high, ranging from 55% to 84% in some cases.

Since the size of any pump for a given duty varies approximately with its speed, it follows that the high speed turbine pump is at a considerable advantage as compared with the slow reciprocating type. There is consequently great saving in space by the installation of the turbine type of pump, and incidentally, a considerable saving in first cost. Roughly speaking, the first cost of a high lift centrifugal pump is one third of that of a displacement pump for the same duty, and the floor space occupied is only about one fourth.

The following figures show comparative costs of electrically operated turbine and reciprocating pumps for a typical hydraulic station:—

TABLE III.

USEFUL INFORMATION.

Pump Efficiency $= \frac{\text{W.H.P.}}{\text{B.H.P.}}$ B.H.P. $= \frac{\text{W.H.P.}}{\text{Efficiency}}$

B.H.P. of D.C. motor $= \frac{\text{Volts} \times \text{Amps.} \times 1.34 \times \text{Efficiency}}{1000}$

B.H.P. of 3-phase motor $= \frac{\text{Volts} \times \text{Amps.} \times \text{Power Factor} \times 1.34 \times 1.732 \times \text{Efficiency}}{1000}$

1 K.W. = 1.34 H.P.; 1 H.P. = .746 K.W.; 1 H.P. = 33,000 foot lbs. per minute.

Water Horse Power $= \frac{\text{G.P.M.} \times \text{Head in feet}}{3{,}300}$

FLOW DATA.

Velocity feet per sec. $= \frac{\text{G.P.M.}}{2.6 \times \text{area of pipe (sq. inches)}}$

Approximate Head Loss per 100ft. run $= \frac{6V^2}{D}$ V, Vel. ft./sec.; D, diam. inches.

For measurements up to 50,000 G.P.H. the 90° Notch is the most suitable.

H = height of water in inches above bottom of notch
G.P.M. = $2H \times H^2$

For quantities above 50,000 G.P.H. the Rectangular Weir is most suitable.

G.P.M. = $2 \times H \times H \times L$
L = width of weir in inches = O 2H

1 Imperial Gallon of water	= 277.27 cub. ins. = 10lbs. = 4.53 litres.
1 Cubic Foot of water	= 6.23 imp. galls. = 62.35lbs. = 28.375 litres.
1 Litre of water	= .22 imp. galls. = 61 cub. ins. = .0353 cub. feet.
1 Ton of water	= 1 cub. metre; 1 Kilo of water = 2,204lbs.
1 Pound per sq. in.	= 2.3 feet head.
1 Foot head	= .434lb. per sq. inch = 1.135 × vacuum in inches.

Thickness of cast iron pipe: $T = \frac{D \times P}{2S}$

D = internal diameter in inches.
P = pressure lbs. per square inch.
S = Safe stress in C.I. (1500lbs. per sq. inch).
T = thickness in inches.

	Turbine Pump.	*Recip. Pump.*
Interest on capital outlay	3.3	9.1
Depreciation	3.3	9.1
Cost of power	74.6	66.6
Maintenance and repairs	0.7	2.9
Oil, packing, etc.	0.7	1.4
Attendance	6.4	10.9
	89.0	100.0

In the case of the centrifugal pump, the operation is perfectly smooth, and since there is an absence of valves there is freedom from water hammer and shock. The installation of relief valves and air vessels is therefore, as a rule, unnecessary.

Only in cases where a small quantity of water is required at high pressure, does the reciprocating pump show any advantage, and the fields in which the turbine pump does not give complete satisfaction are increasingly narrower as further developments take place.

Sinking Pumps.

A type of pump which is of great interest to the mining engineer is the sinking or unwatering set. For this purpose the pump and motor are rigidly attached to a framework of girder construction fitted with a pulley by which the unit may be lowered into the shaft. The motor is of the drip proof type, or it may be totally enclosed. For large powers high tension windings are usually fitted. Since the pump is hanging vertically, special thrust arrangements are necessary. In the case of sinking pumps dealing with gritty water no balance disc is used, all the thrust being taken on a Michell bearing. Dewatering pumps dealing with comparatively clean water are fitted with a balance disc in conjunction with a special floating coupling which is arranged to take the thrust at starting until the pump pressure builds up and the balance disc becomes operative. To facilitate dismantling and assembly in the vertical position, the stages are generally bolted together by small bolts in suitable lugs, in addition to girder bolts.

In the case of a sinking pump the head at which the pump begins to operate is very much less than the final head. This difficulty is overcome by building the pump with the full number of stages; but at first one or two of the final stages are replaced by "dummy" chambers. As the de-watering progresses, these stages can be replaced, the pump thus operating with maximum efficiency all the time, with a corresponding economy in power.

TABLE IV.

Estimate Data Sheet. Centrifugal Pumps.

Name and Address of Enquirer.

Number of Pumps. Horizontal. Vertical. Sinking. Borehole. Boiler-feed.

Site of Delivery or Erection.

Purpose for which Pump is required. Continuous or Intermittent.

Desired Duty. Imperial Gallons per minute. Cubic Metres per minute.

Total height from suction level to discharge level.

Feet—or pressure required at discharge branch, lbs./in.^{2}

If discharging into closed system, state maximum pressure, lbs./in.^{2}

Height from lowest water level to pump house floor. If this is variable, the limits should be given.

Piping—Length, number of bends and general arrangement of Suction and Delivery Pipes; also maximum quantity of water for which delivery piping has to be used when other pumps working simultaneously are discharging through the same pipe. Is Syphonic working possible? (A rough arrangement sketch is an advantage).

Liquid to be pumped. Has it corrosive properties or suspended matter?

State nature of solids, etc. (A chemical analysis is an advantage).

Temperature of liquid, F°. Is pump ever liable to freeze?

Drive.—Belt or Rope. Diameter, width and exact number of revs. of driving pulley

Direct-coupled. Is quotation to include for driving unit?

If electric drive, A.C. or D.C. Voltage, periodicity, phases.

Type of control desired.

Is site damp, wet, dusty or fiery?

If direct-coupled to steam-engine or turbine give steam pressure and dryness fraction or superheat, and whether condensing or non-condensing, giving back-pressure in either case.

Are there special difficulties in transport or erection?

Give maximum admissible weight.

Is skilled erection to be included?

In the case of a sinking pump installed at Betteshanger Colliery, Kent, satisfactory working was obtained even when dealing with water containing up to 33⅓% of Kent green sand.

Borehole Pumps.

With regard to borehole pumps there are really two classes of these. Those for use in boreholes where the diameter is somewhat restricted are of special design in order to keep the overall diameter low, while in the case of deep wells where more room is available, they are of more standard type. So far as the arrangements of the piping and shafting are concerned, there is practically no difference between the two. In the latest design of borehole pump there are several novel features. The borehole pump itself, as a rule, only develops sufficient head to bring the required quantity to the surface. A booster pump is installed at the surface to lift the water to wherever required, should there be a considerable lift from the surface to the reservoir.

The chambers of the borehole pump referred to are of the "Spiroglide" type, modified in such a way as to reduce the diameter and increase the axial length, but retaining the highly effective features of smooth and uniform flow. The pump is hung from the rising main, which is composed of uniform lengths of steel piping. Up the centre of the main runs the shaft connecting the driving motor at the surface with the pump at the bottom of the borehole. The shaft is supported at each joint in the piping by a bearing, the housing of which is "sandwiched" between each length of pipe. The bearing is built up of strips of carefully selected lignum vitæ, carried in a bronze shell, which in turn is keyed in the sandwich housing. The shaft is made in as many sections as there are lengths of pipe, each length being joined up by an accurately machined, quick-disengaging, coned muff-coupling, which is positively locked on the shaft. A bronze sleeve is lightly shrunk to the part of the shaft forming the bearing.

If the water dealt with is gritty, the wear of the sandwich bearings may be severe. Consequently, in such cases, the shaft is enclosed in an inner tube, down which is circulated part of the delivery water, passed through a highly efficient filter.

At the surface a cast steel stool supports the weight of the stationary parts, viz., the piping and pump chambers, etc., and also the booster pump, where this is fitted. About 2½ft. higher, a second stool carries a Michell thrust bearings, which supports the weight of the rotating part, that is, the shafting and impellers. Variations of these arrangements are frequently made, one stool sometimes carrying the whole weight. The drive is effected either by D.C. or A.C. electric motor, or through bevel gearing from an oil engine.

A very simple and effective joint has been devised for the internal tube. Means are taken to allow for the stretch in the main pipe, and any tendency for leakage to occur from the rising main into the inner tube is prevented. Once the pump has been put into operation the only attention necessary is to see that the oil level of the Michell shaft does not fall, which should not occur for some months.

If the level in the borehole is at all variable, a depth indicator is necessary to guard against the possibility of the pump running dry—a disastrous contingency. One of the simplest types of depth indicators requires a small copper tube to be run down the borehole. The pressure necessary to force all the water out of this tube is then a direct measure of the water level, a small air pump and pressure gauge being provided for the purpose.

The manufacture of such a pump calls for extreme accuracy, as will be appreciated when it is realised that the problem is to finish some 300/400 feet of pipe work and shafting, so that when coupled up the alignment of the pump shall be absolutely correct. The elimination of vibration is effected by balancing the rotors of pumps and motor to within close limits on a dynamic balancing machine.

Other Applications.

There are many other applications of centrifugal pumps, all governed by the same principles. In the case of pumps for coal washery duty the difficulty is to prevent excessive wear of the internal parts. The design of such pumps involves the prevention of eddies, and the passages are made as simple as possible, so that with low water velocity the abrasive action of the material being handled is reduced to a minimum. The material used for the casings, etc., is carefully selected chilled or white iron.

For condenser extraction duty the chief difficulties lie in the prevention of air leakage, and in the method of getting the water efficiently under control in the eye of the impeller. As the duty is usually fairly small, a single entry pump of the overhung type without balance holes in the boss is adopted. With this arrangement there is only one gland, and this is under delivery pressure. In the case of larger volumes, two impellers may be placed in one casing, arranged with the suction eyes facing each other. In this way end thrust is eliminated and both glands are under pressure.

In conclusion, it ought perhaps to be stated that with a subject of such interest and having so many fascinating ramifications, some difficulty has been experienced in deciding upon those which should be included and those which should be left out. In such a short paper it is of course impossible to give a very full treatment, and there is the danger, in attempting to cover too wide a range, of falling into the diffuse. It is hoped, however, that any of the aspects of the subject, theoretical or practical, upon which further information is desired will be brought up in the course of the discussion. Finally, acknowledgments are due to the Harland Engineering Company for the use of the illustrations and technical details.

Discussion.

Mr. LAIRD.—In referring to the subject of delivery mains Mr. Collinswood said, "on the other extreme the use of large diameter piping may be prohibitive." Why should that be so? In the case where a battery of pumps say for maximum demand reasons was placed on the electrical side and at some periods one pump only is delivering to the rising main, which is large enough and common to say four pumps, would the author say that the pump would be inefficient because of the large diameter of the delivery main? Mr. Laird said he had an instance in mind where the pipes, 30ins. diameter, originally belonging to an old type of beam engine multiple rain, were used for a 1000 galls. per minute pump, and the pump had done excellent work for many years with a three-ram 1000 galls. per minute pump discharging into the same delivery main.

He deplored the admission that it was necessary to put dummies in where head is gradually increased, as in sinking or unwatering. A steam pump was much superior in that case, as in many such situations it would be impossible to spare time to make the changes. At what would the author put the time necessary to change by removing a dummy and fitting an impeller in a 2000 to 3000 g.p.m. unwatering job? Would a second or spare pump be necessary with a slip ring motor connected to a turbine pump? Mr. Laird said he would like the author to give an explanation of the adjustment of the Michell thrust and its relation to balance valve opening. Was the hardened collar of the thrust hard against a shoulder and suitable washers of various thicknesses used for this purpose, or was this position fixed once and for all on the pump leaving the test bed? He thought the author ought to give some "don'ts" in regard to delivery pipe lay-out such as right angle ties and square bends. He would also like Mr. Collinswood's opinion on very long suction pipes, as many times mining men had to face such conditions very quickly.

Mr. COLLINSWOOD, in answer to Mr. Laird, said the large diameter delivery piping may be prohibitive simply on account of cost. If a battery of pumps, say four, were designed to work on a common delivery pipe assuming that the head necessary when the four pumps were working was 100% and that the static head was 50%, in other words, that 50% of the work of the pumps was done by overcoming friction in the common main: obviously then when one pump only was working the quantity flowing through that pipe would be only one quarter of that finally required; the friction would only be one-sixteenth of the 50%. So that the total head when one pump was working would be approximately 55% as compared with its ultimate full load duty of 100%. Therefore, the pump would either have to be throttled to bring it back to something near its maximum efficiency or if it were allowed to work against a full open valve it would tend to deliver more water and work at a lower efficiency point.

Mr. LAIRD.—Is it not a disadvantage to throttle down?

Mr. COLLINSWOOD.—Not at all, excepting that it is a waste of power. It simply means wasting power across the valve; the valve being used to choke down the head, the power is expended in creating heat in the valve, the heat being of course carried away with the cold water.

As regards the question of fitting dummy stages in the pump in the shaft, the head required on the pump at the commencement may be only one-third of that ultimately required. The pump could be allowed to work at full open valve with a tendency to increase the quantity delivered. That means to say that the pump would be working at an inefficient point of the characteristic. The same remark applies, that it might be better to throttle back. But to throttle back is to waste power: obviously the best thing to do is to take out some of the impellers and by that means save considerable power, and the saving in power would pay for the little delay in taking the pump adrift and putting back the active stages.

Mr. LAIRD.—In those cases where the growth of water was really enormous by the time the pump stage was removed and changed, the water would be running over the mouth of the pit.

Mr. COLLINSWOOD said he quite realised it was working under great difficulties to replace dummy stages in a wet shaft, but of course if the actual fitters at the pit were asked to do the job it would probably take a long time, whereas men used to handling these pumps could replace the impellers in a very short time; they were used to handling vertical pumps, which was quite a different proposition from handling horizontal pumps.

Mr. LAIRD said he would refer to an experience he had had recently. They were dealing with something like 600 gallons of water a minute and had a burst of water up to about 3000 galls. per minute. He was fixed with three definite pumps at the pit bottom, and had to deal with a definite quantity. He lost two hours in putting in a Michell thrust and found it was not up against any collar at all and he had to adjust that in parts where it was quite impossible to do any engineering. He wished to know exactly what the clearance was in the Michell thrust when the balance disc was hard home.

Mr. COLLINSWOOD replied that there was a rigid body, which was the Michell thrust, coupled to a moving body which was the balance disc. The two simply would not work together. The arrangement usually adopted was to make one or other carry the load, usually the balance disc, and to leave a clearance between the pads and the slipper of the Michell bearing. Consequently the Michell bearing did no work at all. That seemed to be the experience Mr. Laird had come across.

(Mr. Laird here resorted to the blackboard, and he and Mr. Collinswood arrived at the means whereby the difficulty of Mr. Laird was overcome).

Mr. LAIRD dealt further with the emergency he had described, which meant pumping 3000 gallons when he had only 600 gallons to deal with normally. One of the motors was a D.C. and the other two were A.C.

He was able to isolate the particular line on an alternator and raised the frequency almost ten cycles on the A.C. pump, and on the D.C. pump he put a shunt regulator into the shunt field and split it and thus increased the speed and the output of the pump.

Mr. COLLINSWOOD, referring to the suggestion by Mr. Laird asking for some "Don'ts" in delivery pipe lay-out, such as right angle ties and square bends, said he could supply figures as to the loss in head caused by faulty lay-out. It was obviously always against good practice to have bends on the delivery side and even more so on the suction side.

In regard to the query concerning very long suction pipes, Mr. Collinswood said he had often had to face such conditions. In one case the suction pipe was 90 yards long, and the client was very surprised when the pump would not work. On applying a suction gauge it indicated up to 29½ inches. Still the client could not quite see why the pump would not lift. The suction was eventually reduced slightly and, helped by a high barometer, the pump was made to work. Under conditions of that kind the faintest trace of air leak causes the pump to lose its water. Although in the paper it was stated that not more than 15ft. to 18ft. suction lift was desirable, he had in mind quite a few pumps that were working with 26ft. and 27ft. That, however, was a practice to be avoided whenever possible; it was really asking for trouble.

SOUTH WALES BRANCH.

At the meeting of this Branch, held in Cardiff on January 19th last, Mr. T. S. Thomas occupied the chair. In the absence of the Hon. Secretary the previous minutes were read by Mr. Theodore Stretton; they were adopted and signed.

The following applications for membership were confirmed: Member—Mr. Walter Oakley Vicary of Crumlin; Associate—Mr. John Franic Thomas, of Cardiff; Student—Mr. David Basil Gillett Thornton, of Llanbradach. New members of the Western Sub-Branch elected were: Members—Messrs. Richard Adrian Gower, of Ystalyfera, and William John Morris, of Pontardulais; Associate—Mr. John Williams, of Lower Cwmtwrch.

Mr. F. E. Pring then read his paper entitled "Coal Cutting Machines in Low Seams," which was fully illustrated by lantern slides.

The Chairman opened the discussion, and he was followed by Messrs. R. H. Morgan, W. W. Hannah, J. B. J. Higham, Dawson Thomas, Jas. Jones and J. H. Bates. Mr. Pring suitably replied.

A hearty vote of thanks to Mr. Pring for his interesting and practical paper was proposed by Mr. S. B. Haslam and seconded by Mr. C. F. Freeborn.

(P) Coal Cutting in Low Seams.

F. E. PRING.

Coal cutting in low seams differs widely from cutting in seams of greater thickness; roof trouble is usually a drawback and there is the disadvantage of the men being in a stooping position while working.

Many really good coal cutting machines do not give maximum efficiency because:—

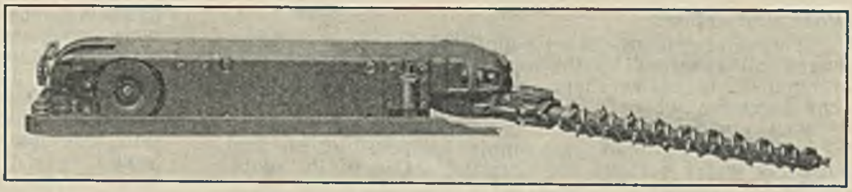


Fig. 1.—A Bar Machine on Skids.

(1) They are not properly prepared for cutting before the cut is begun.

(2) They are not properly handled during the cut.

(3) They are not always left in the best position when the cut is finished.

(4) Not sufficient time and care is taken for the examination of oil, and for loose bolts and nuts, before starting.

The modern coal cutters are usually of 30 to 50 H.P. and are seldom over-loaded, except when using blunt picks or, as in the case of the chain machine, when the jib gets jammed through the weight of coal.

Cutter Picks.

A good machine man accustomed to his machine and the ground he cuts, should know when to change his picks. But, as is often the case, even when he knows his picks are blunt, and he has a few yards to go to his pull, he carries on irrespective of the extra load he gives his motor and the strain he puts on his machine.

Cutter picks should always be sharpened by an experienced blacksmith, and tempered in oil, otherwise they are liable to snap off or blunt easily (see types of picks).

Where there are a number of machines at work, it pays to have an experienced man to overhaul them and keep them in order, to ensure prompt starting.

Typical Machines.

Fig. No. 1 shows a bar machine on skids. This particular machine gives very satisfactory results. It has an advantage over other types when cutting under the coal, such as in fire-clay or hard stone. When encountering balls of mine the bar takes the easiest course, cuts itself clear of the impediment, and rises in the coal. The bar can then be withdrawn and the picks changed. Those types of machines which do not do this incur delay in cutting out the jib or disc, before the work can again proceed. The author has six sets of

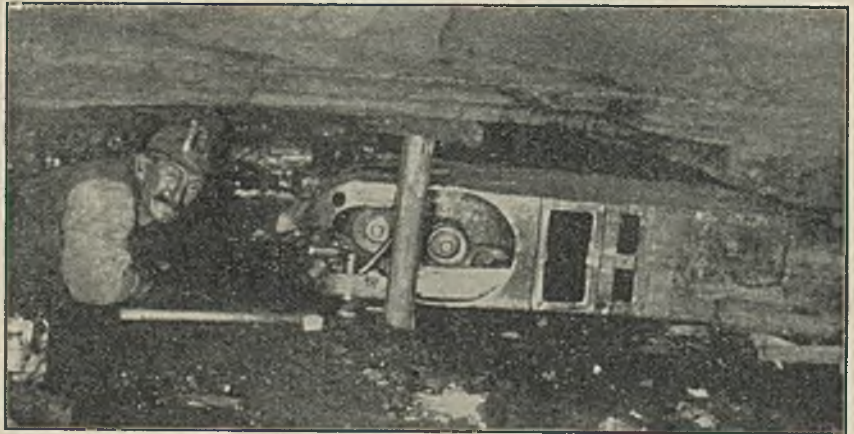


Fig. 2.—A D.C. Machine in a 16in. Seam.

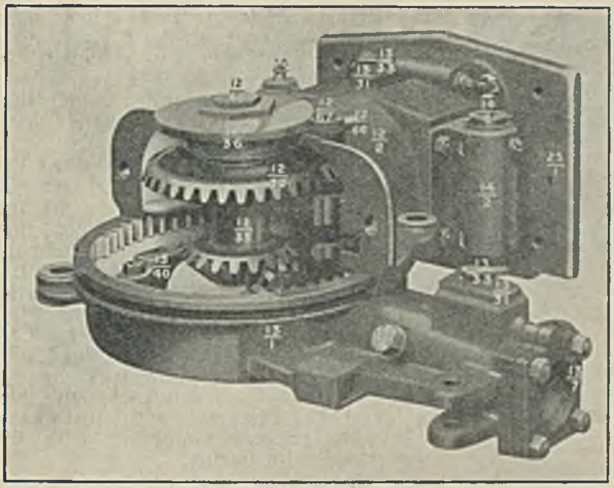


Fig. 3.—Machine Gear Head opened.

these machines, 20 years old, and up to a short time ago they were in use and gave good results.

Fig. 2 shows a "baby" D.C. machine, cutting a seam of 16ins. on the long-wall system. The machine is here seen facing a road, and the illustration affords a good idea of what happens when a breakdown occurs between two roads. In most cases the machine has to be drawn out to the nearest road for repairs.

The illustration Fig. 3 shows the gear head open for inspection; whilst Fig. 4 shows a machine cutting through a fault. In the latter particular note should be taken of the method of propping.

Holing.

Most machines to-day hole in the fire-clay or hard stone; this method means a great saving and, of course, adds to the output. Holing in the coal, apart from the loss in output, has the disadvantage of spreading coal dust throughout the colliery, which is a source of danger. The author believes that some attachment might be fixed over the cutter to prevent the dust rising.

Fig. 5 shows the bar entering the coal. The old method of doing this was with a ratchet handle; very hard work for the man, and usually taking him about 15 minutes. With the newer machines this is done with the power. Once the bar is in position the cut proceeds at the rate of a yard per minute, providing roof trouble and timber do not interfere. As pointed out, the illustration Fig. 5 shows the bar entering the coal, and it does so in nearly every case at one or the other end of the face.

The necessity for ventilating these fast ends of machine faces has caused the Mines Department to issue a leaflet No. 31, November 12th, 1928, pointing out the danger in explosions of fire damp not only in seams which are fiery but also in seams which are considered free from fire damp. The leaflet also points out defects in the electrical apparatus: (1) imperfection of design; (2) lack of proper maintenance.

During the years 1914 to 1927 inclusive, there were twenty-eight instances of ignition of fire damp by open sparking. In the majority of these cases serious and obvious defects were found in the enclosure of the working electrical parts. One of the commonest defects is the loss or omission of screws from cover plates, whereby an opening is left into the switch box or some equally dangerous part of the apparatus.

Plugs and Terminal Gear.

Automatic interlocks to prevent the withdrawal of the plug while the power is on at the machine end and the gate-end panel, are not universal, and are sometimes inoperative. Few of the commoner type of plugs in use can be regarded as flame-proof, even with such an interlock.

The Chief Inspector of Mines suggests the following:—

(a) No unbottomed screw holes through the walls of the enclosure.

(b) Some device such as a washer or lock-nut to check the tendency of screws to work loose under vibration.

(c) No unshielded projecting bolt heads; nor, in cases of movable machinery, projecting edges of cover plates which may be caught or displaced.

(d) No drain plug holes or other similar openings so placed that they cannot be readily inspected.

(e) No connecting passages between separate parts of the enclosure.

(f) A terminal box for the external connections, outside the flame-proof enclosure.

(g) A flame-proof plug and socket coupling such as the B.E.S.A. type.

The leaflet also adds that these requirements should be definitely specified by mine owners in ordering all new equipment.

Alteration in design to the terminal box, both on the machine and the gate-end, is much overdue, and calls for better facilities and easy inspection when fixed in position. In the old type, and before the earthing system of to-day was in force, the terminal box consisted simply of its terminals fixed to a slate base, with no provision for earthing other than an external connection, such as securing the armour wire of the cable to a bolt. The pommel or connecting plug was attached and held in position by a pin.

The introduction of the three-pin plug and terminal box, now in general use, improved things from a safety point of view, inasmuch as the earthing pin makes first contact. The contact pins are made of split brass and fit into sockets of the pommel. These split pins easily

Fig. 4.—Machine cutting through a Fault.

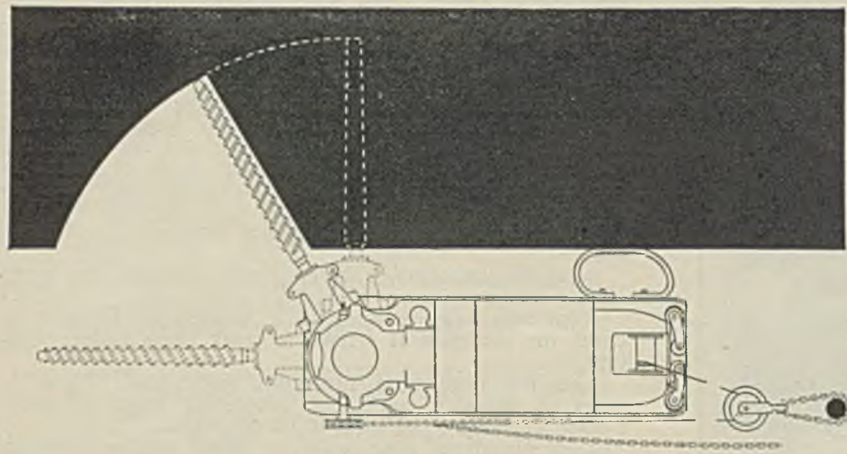


Fig. 5.—Bar Machine entering the coal.

close under vibration; they are connected and disconnected twice during each shift and, if not examined and kept well opened, the vibration of the machine while working soon brings about a set closing with resultant partial contact and sparking to the extent of burning the pin points.

The construction of the present style of terminal box, both on the machine and at the gate end, prevents inspection when it is once fixed in position, therefore it is a matter of guesswork whether good contact is made and maintained.

The earth connection should be attached outside the terminal box, where it could be easily inspected, so as to avoid possible accident should the machine break down to earth. With a coal cutter which gets so much rough handling, and where the only thing that counts is coal output, the earthing of the machine is the chief safety factor.

Illustration Fig. 6 shows a modern type of gate-end switch and fuse box; the incoming terminals are protected from possible contact by a bolted cover. The mechanical interlock prevents access to the fuses except when the switch is in the off position. These gate-end switches and fuses are in common use with coal cutters, and there is something to be said for and against them.

(1) They are somewhat unreliable.
(2) Their fusing point changes while in use.
(3) They give off much heat.

They are unreliable because so much depends on the type of fuse holder, the length of bridge, and the cooling facilities of the casing: so that the value given in a table of fuse wires can only be taken as true under certain limiting conditions.

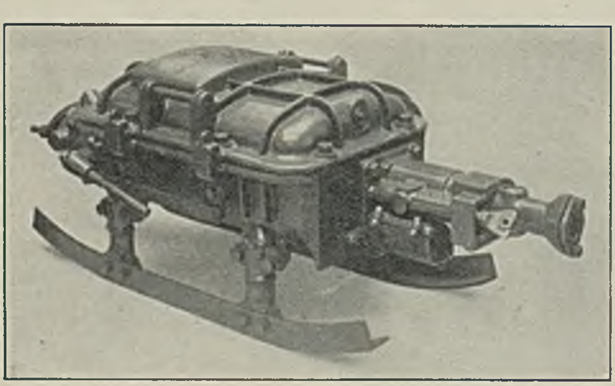


Fig. 6.—Gate-end Switch and Fuse Box.

If a fuse is carrying a load near its rated capacity, it must work hot; and if cold, it offers no safeguard to the coal cutter. If it is maintained hot the copper deteriorates so far that it will fuse at a much smaller load than its original rated capacity.

The constant working heat of the fuses had a very bad effect on the insulation of the fuse box, and the fuse holders are often so hot that they cannot be handled with the bare hand. Again, there is the temptation to the machineman to increase the size of the fuses if they blow too often, and to save himself work. Circuit breaker gears with overload and no-volt coils, with time lags, are to be preferred to switch-fuses, and they should be equipped with locks and keys to prevent tampering with the overload adjustments.

The no-volt coil is of importance as, in the case of D.P. switch and fuses, it often happens when the main breaker comes out, that the machineman is slow in switching off. Consequently the full voltage against full load is put on to the motor, the bar being fast in the coal. It is usual, however, to avoid this by allowing one or two minutes before re-switching in. The no-volt coil on a circuit breaker, of course, would deal with this liability to trouble. It could also be made as a means of stopping the machine from the bar end by means of a tapper-switch or button. The author does not know whether this method is being employed from the bar end of the machine, but under existing conditions, should the man at the bar wish the machine stopped, he either has to wave his light, or call to the machineman. This is not always effective, and a tapper as suggested would overcome the difficulty.

Fig. 7 illustrates a 100 amp. 660 volt, oil-break, flame-proof gate-end switch fitted with an incoming detachable cable dividing box on the left hand of the switch, and an outgoing 100 amp. B.E.S.A. plug and socket mechanically and electrically interlocked with the switch handle. This view shows the switch arranged for right-hand use.

Fig. 8 shows a 100 amp. B.E.S.A. plug and socket with the plug shown separately, and with the protecting cap partially screwed into the socket portion.

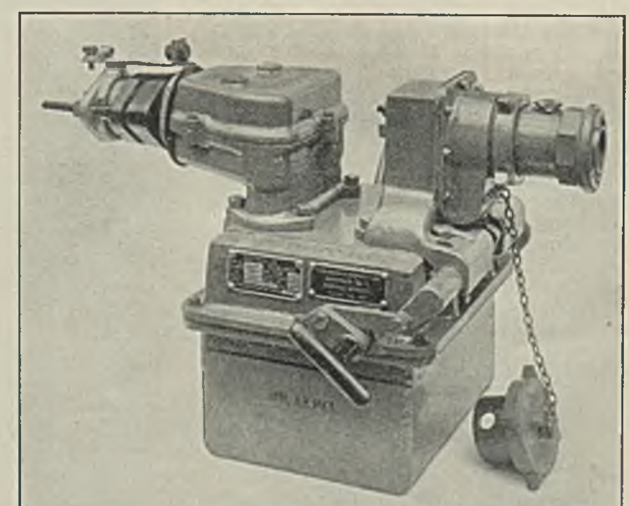


Fig. 7.—Gate-end Switch with Plug and Socket mechanically and electrically interlocked.

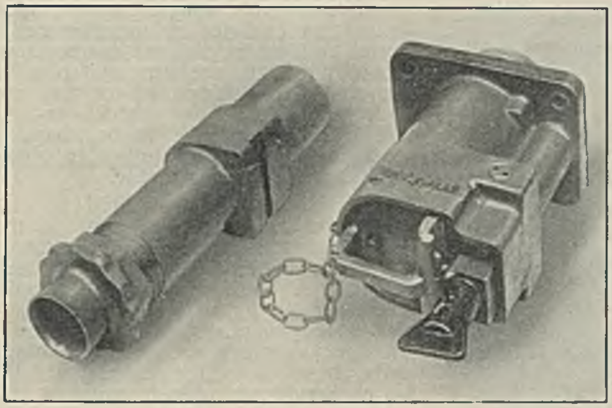


Fig. 8.—Standard Plug and Socket.

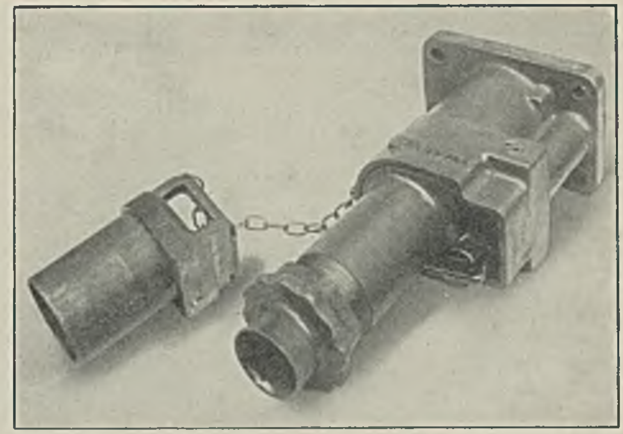


Fig. 9.—Standard Plug and Socket.

Fig. 9 is of a B.E.S.A. plug and socket with the plug inserted into the socket and the cap removed.

The illustration, Fig. 10, is of a mothergate switchboard comprising three 60 amp. units, each provided with an oil-break circuit breaker and an outgoing 60 amp. plug and socket, mechanically interlocked with the switch handle.

Fig. 11 shows a chain machine used in longwall cutting. This type of machine gives good results cutting in the coal. The fault with these machines and some other types, apart from their cutting capabilities, is the difficulty experienced in renewing spare parts when the machine is at the face. For instance, assuming it breaks down between two roads and there is only three or four inches between the top of the machine and a faulty roof. Ten minutes work would get it going again, but that cannot be done without first taking the machine apart. The machine has therefore to be pulled out by hand to a suitable place.

One of the faults with the chain machine is the jib becoming fast from the weight of coal after the cut. This is most noticeable in thick seams, and where too deep a cut has been taken. It is not always an advantage to take a very deep cut unless the coal can be cleared, and the face left in shape for the machine on the following shift. Bunches left have to be taken out before the machine gets by, causing delay and loss in output.

Fig. 12 shows another view of a chain machine cutting a face.

At the end of each shift trailing cables should be coiled up near the gate-end, as a protection from damage, and not be allowed to remain attached to the machine as is sometimes the case.

Cables.

Most mining men have their own opinions as to the best type of cables to use according to the conditions which vary in different collieries. In collieries of thin seams, more especially where temperature and conditions vary over distances of 200 yards, more or less, the utmost care must be taken in selecting a cable suitable. It is of importance to instal the cable in as long lengths as possible, to omit the use of joint boxes, and in doing so consideration has to be given, before ordering, to the size of drum which will clear the roof in-bye. Also by having proper brick insets installed ready for your joint boxes, much time is saved.

Twin D.W.A. cables, of course, are to be preferred where there is space enough to instal them, and also where there is little risk of them being disturbed. In low seams this class of cable can easily be adopted to feed the sub-stations nearest the coal cutters. From the sub-stations in-bye in most cases there are difficulties such as heat and water, with varying temperature. Again, a difficulty is the varying distance between the rail and the sides to which the cable is secured. This latter is of much concern to the electrician when laying his cable, and also while in use. It is obvious that if

Trailing Cables.

Flexible trailing cables as used with coal cutters are entirely in a class by themselves. The risks attendant on them are well known. They should be protected by the toughest suitable materials, usually some form of cab-tyre. When a cable of this class is damaged and the cab-tyre cut, even only enough to expose the insulated cores, it should at once be sent out to the surface, and properly vulcanised. Under abnormal conditions, such as exists in low seams, the life of trailing cables is short.

For some years past the author has used cab-tyre cables, with two layers of tape over the same, and then spirally wire armoured, the wire armour being of such a nature as to ensure flexibility and also prolong the life of the cable. The wire armour, of course, is connected to the earth core of the cable at both pommels.

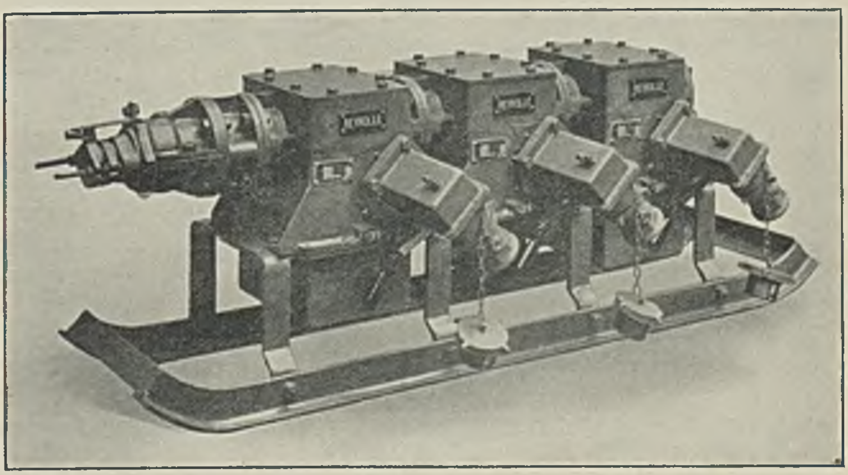


Fig. 10.—Mothergate Switchboard of three 60 amp. units with Plugs and Sockets.

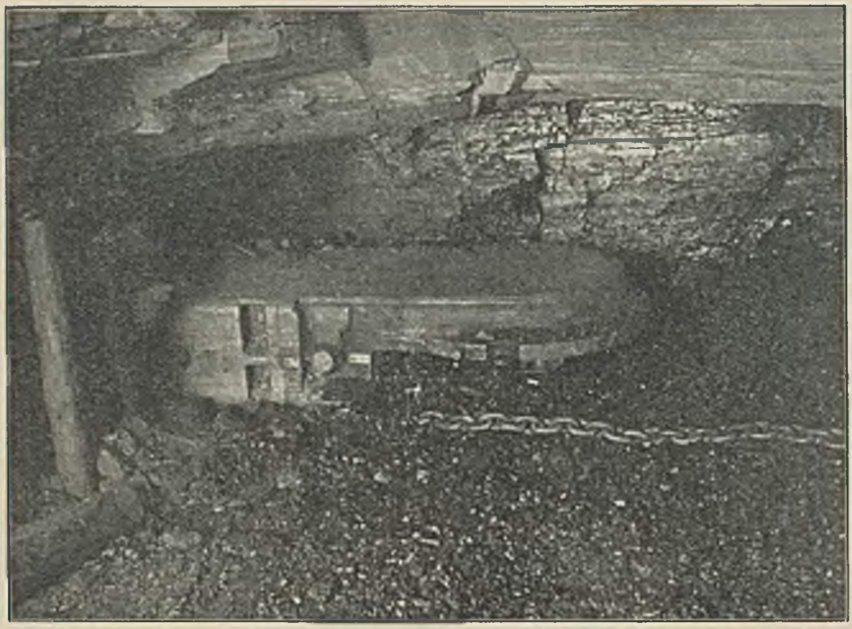


Fig. 11.—Chain Machine in Longwall Cutting.

Bitumen cables, which are graded by voltage and not by megohm resistance, and where the pit temperature is not too high, are very suitable for use on main headings, where they are little disturbed. For cables in-bye, and where they have to be changed from one heading to another so often, V.I.R. is the most suitable.

In regard to the method of suspension of cables, this depends on the nature of the roadway and whether the same is timbered or not. Where the road is timbered the cable should be suspended by means of tarred canvas slings supported by wire hooks. The hooks, which are hung on stout nails driven into the timber, should be of ample strength to support the cable, but weak enough to yield in the event of any material falling on the cable. This is, of course, desirable in the event of a fall.

All suspenders should be fixed in position before the cable is taken in, one end of the suspender being left free. It then only remains for the men handling the cable to lift it into position and hook up the free end of the suspender. This method greatly facilitates the installation of long lengths of cable.

there be only 8ins. or 12ins. between the rail and cable, it does not allow of any slack. The remedy is to have a suitable place cut out of the side to allow a number of extra coils being left. Another item to be considered is the renewal of timber after the cable has been installed. This work has to be followed up closely to prevent the repair man forcing the cable (often by a bar) to meet the new timber and thereby straining the cores. Under these and other conditions the author has found it most suitable to use two single-core cables in preference to twin conductors. This because the cores of a twin cable being already twisted together, they are more liable to damage than are two single cores under the same installing conditions. Of course with single core cables there is the extra bonding to contend with, and which entails extra maintenance.

Cable passing through brattice sheets should be enclosed in split porcelain or earthenware tubes, as a prevention from fire in the event of a blow-out on the cable.

Jointing.

The jointing of cables should in all cases be made by means of a joint box, and carried out by a competent man, as too much care cannot be given to this class of work. It is advisable to employ link boxes where possible: this enables the testing of sections of the cable. The link boxes, which offer such an advantage for section testing, are however a source of danger when they can be opened up by merely removing nuts and bolts, when the power is on. This risk can be obviated by attaching a locking device, the key of which would be kept at the sub-station controlling that particular section.

Fig. 12.—Chain Machine in operation.

Earthing.

Fig. 13 shows an auxiliary earth plate in a sump hole. Earthing, which forms such an important part in the electrical system, should be given the utmost attention. The use of tinned copper tape and clips on the steel armour wires are quite alright, but they should be examined often to prevent them becoming slack and dirty. A good method as an addition, apart from the bonding of armour wires, is the jointing up of old cables, and connecting them to all sub-stations with earth plates in sump holes where possible.

Where there is enough of this cable it should be taken to the gate-ends, and linked up with the earth core of the trailing cable. This earth cable should be laid on the ground, and as near as possible to the side, tappings being taken off say every 100 yards, to the armour of the feeders in-bye. The system is therefore protected should the feeders by any chance become severed by a fall or other cause.

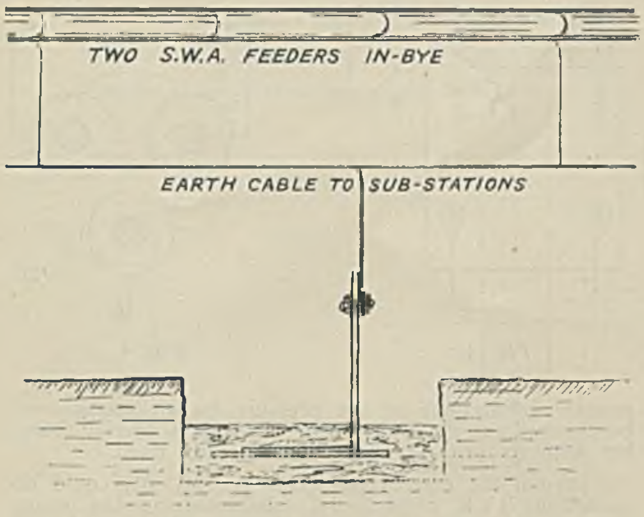


Fig. 13.—Method of Earthing.

Coal Cutting in U.S.A.

Coal cutting in America by electric coal cutters even twenty years ago was done on a more extensive scale than it now is in this country. In the U.S.A. at that time there were sometimes as many as twenty machines in one colliery, with coal seams 12ft. thick and upwards.

These machines work on the stall system making a cut of 4ft. to 6ft. When the author was in America he noticed that they did not observe any hard and fast rules and regulations, such as there are here under the Coal Mines Acts. There was no question of wire armoured cables and flame-proof switchgear, etc. Even the control switches on the machines were of the open type. Earthing was a secondary consideration, and as regards the locomotive haulage, which pulled 60 tubs to the pit bottom from an inside parting, current was collected from a bare overhead trolley wire which was attached to the timber, with the track rail as return. The costs of coal getting from the electrical point of view were small compared with ours.

NORTH OF ENGLAND BRANCH.

The Testing of Switchboard Instruments, Relays and Transformers.

GEORGE TILSTONE.

(*Paper read 9th February*, 1929).

This short paper is compiled to deal with a number of points which repeatedly arise on site in connection with Polyphase Instruments, Relays, etc., and their associated Transformers. Certain difficulties are frequently met with which occasion inconvenience and, at times, an expense disproportionate to the value of the instruments, etc., involved. Many of these difficulties could speedily be overcome when tackled with a knowledge of fundamental principles.

It is important to note in the beginning that all the points discussed herein have arisen in connection with colliery plant. They are such as have cropped up when extensions to existing switchboards were carried out, or when additional relays or protective gear were added to existing boards.

In some cases additions may be undertaken by the colliery engineers themselves, and although they may have stated their requirements to the instrument suppliers fully and accurately, these troublesome points for one reason or another recur.

The chief troubles arise in connection with Power Factor Indicators, Synchronisers and Polyphase Meters. In some cases it may be found that the maker's diagram of connections cannot be used directly as it stands; e.g., the maker may show a meter operating from transformers in the red and blue phases, while on site the only phases in which the transformer can be fitted may be red and yellow. Although every possible care has been taken, the new Power Factor Indicator may read in the wrong quadrant through no fault of its own. Then comes the temptation to start changing wires about until the indicator reads approximately what one thinks it ought to read. When the instrument has nine terminals there is plenty of scope for changing connections, often with unsatisfactory results.

In order to grasp the fundamental principles involved, let us consider what conditions have to be fulfilled before a single phase or a polyphase instrument, or a synchroniser, etc., can operate correctly:—

(1) Where current or pressure transformers are employed these must obviously be of the correct ratio for which the instrument is calibrated, according to information on the dial.

(2) The relative polarities between the current and pressure coils must be correct.

(3) The phase relationship between the current and pressure coils must be correct (where the instrument has both kinds of coils).

(4) In some cases the phase rotation of the voltages and currents of the instrument must be as stated by the maker.

Relative Polarity.

In order to understand this thoroughly we must be able to state the "polarity" of a transformer: i.e., the instantaneous direction of the secondary voltage or current with respect to the primary supply.

The present B.E.S.A. markings of T_0, T_1 (primary) and T_0 and T_1 (each in a circle) secondary will be familiar to all. The actual meaning of the markings is often obscure. In Figure No. 1 a current transformer marked in this way is shown. If we consider the current at a given instant as entering the primary terminal T_0, then the corresponding secondary current is leaving T_0 (circle). It is useful to remember that the instantaneous direction of the secondary current is the same as it would be if it were possible (on grounds of safety) to connect the two T_0 terminals with a piece of wire. (Figure No. 2). In some cases the physical arrangement of the terminals does correspond to the electrical relationship; in others it may not do so.

The checking of the polarity of an instrument transformer is a simple matter necessitating only a dry cell and a polarised D.C. voltmeter connected as in Figure No. 3. At the moment of closing switch S the voltmeter should show a forward kick. Other polarity markings are often found, e.g., P_1, P_2, S_1, S_2; Ll, Mm, etc., but the meaning is the same.

Phase Relationship.

This is easily checked by inspection. The only point here is that where several secondary circuits are taken through any one meter it is important to know with certainty the corresponding "in" and "out" terminals.

Phase Rotation.

The maker generally specifies the required phase rotation, i.e., R.Y.B. reaching their respective maximum values in that order. In most cases, the phase rotation of a system will already be known. Cases often occur where definite knowledge of the phase rotation has not been required prior to some extension.

The easiest way of verifying the phase rotation is by means of the small instrument resembling a crude form of three-phase induction motor. The disc or rotor

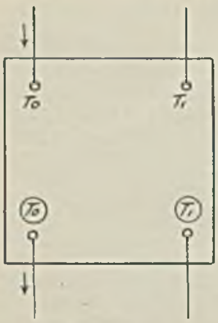


Fig. 1.

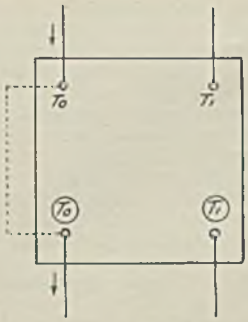


Fig. 2.

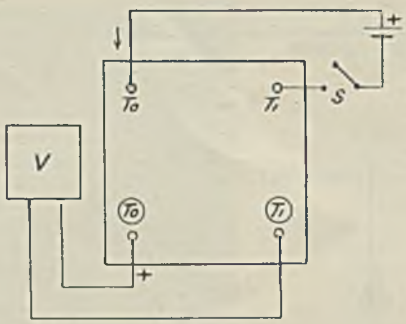


Fig. 3.

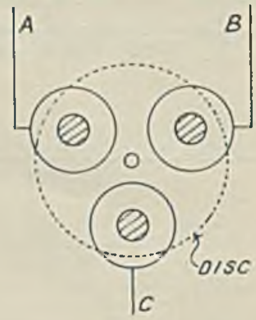


Fig. 4.

is marked with an arrow indicating directly the order in which the phases arrive at their maximum; if this is not available a very rough but serviceable one may be arranged as follows.

Three no-volt coils standing vertically at the three corners of an equilateral triangle are connected as in Figure No. 4. A piece of iron sheet forms a common base for the three. A disc of copper is suspended by a piece of thread at its centre and hung so that the disc lies in a horizontal plane over the plungers of the coils. The three phases of which the rotation is required are brought to the terminals A, B, C.

The disc will tend to rotate in the direction of the rotating field, i.e., in the direction indicating the sequence. Note here that phase rotation might be indicated in three different ways, e.g., A B C, B C A, C A B, for standard rotation; or A C B, B A C, C B A, for non-standard rotation.

This is of importance in transposing a maker's diagram to suit some special conditions.

Still taking the power factor meter as typical of the instrument with numerous connections, let us now take what we will suppose is a maker's diagram and transpose it to suit some special conditions.

Figure No. 5 shows the terminals and marking of a balanced load power factor indicator. The meter is connected exactly as per maker's diagram.

Supposing it is found on investigation that the phase rotation of the system is non-standard, i.e., B Y R, it will be necessary to modify the connections to the meter to make it read correctly for non-standard rotation. The primary connections of the pressure transformer cannot be changed, as the transformer is inside a special chamber with its primary connections already fixed.

(1) On the current terminals M_1, M_2, M_3 could be connected B Y R respectively, this satisfying the phase rotation point. This would require that on terminals V_2 and V_3 must be put the voltage between the yellow and red phases. This voltage is not available, so this combination will not do. The necessary phase relationship previously mentioned cannot be supplied.

(2) Now suppose on the current terminals M_1, M_2, M_3 are connected Y R B respectively. This would require the voltage between R and B respectively, applying to V_2 and V_3. Again this voltage is not available, and although we have fulfilled the condition re phase rotation, the phase relationship condition is not got and the combination cannot be used.

(3) On terminals M_1, M_2, M_3 are now connected R B Y respectively. This means that the voltage between B and Y phases respectively must be applied to V_2 and V_3. This voltage is available. The modified connections will now appear as in Figure No. 6. The meter should now indicate correctly.

Referring again to Figs. 5 and 6, suppose the current transformers can only be mounted with T_1 towards the supply station; then it will be necessary to change the polarity of each current element to get the correct indication.

Thus by going over the whole ground carefully it has been shown how the re-connecting may be reasoned out on paper before touching the meter connections.

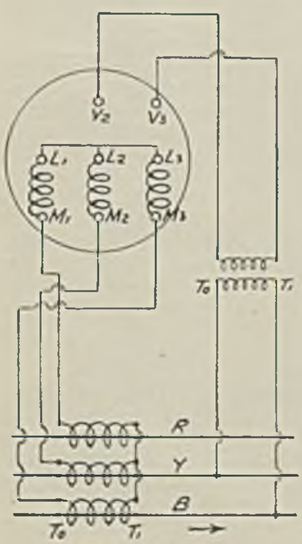


Fig. 5.

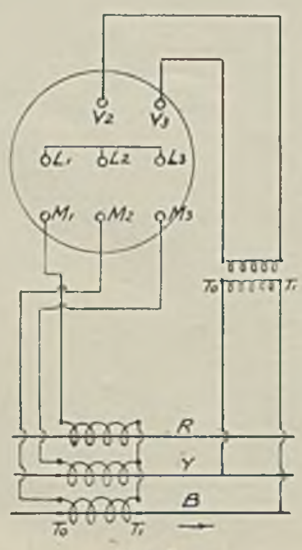


Fig. 6.

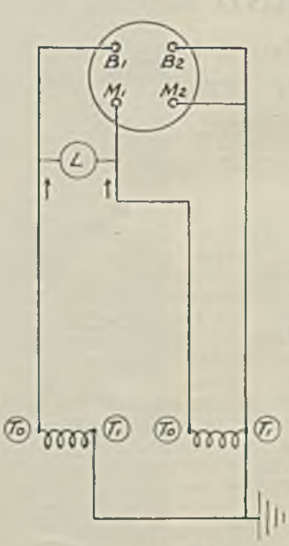


Fig. 7.

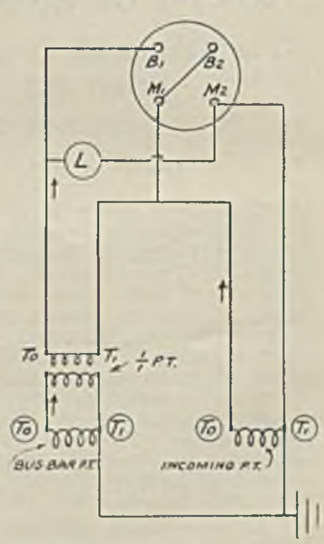


Fig. 8.

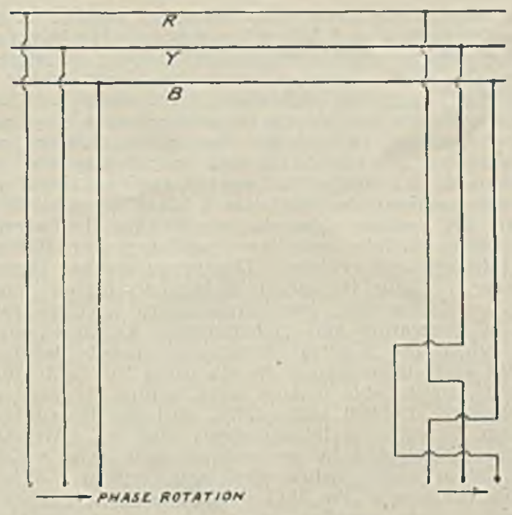


Fig. 9.

Synchronisers.

It will now be useful to see how a knowledge of transformers, polarities, etc., may be applied to synchronisers. Suppose it is the case of a synchroniser with an indicating lamp or lamps arranged to synchronise "dark," and it is wished to re-arrange the circuits so that the lamps are "bright" at synchronising.

The skeleton diagram for "dark" synchronising is shown in Figure No. 7. The change to "light" necessitates an additional pressure transformer of, say 1/1 ratio. (See Figure No. 8). In Figures 7 and 8 the instantaneous directions of the voltages from bus-bars and incoming machine are indicated by arrows.

Before leaving the subject it is desirable to mention that, in the case of parallel feeders, though the indication of a phase rotation meter may show the phase rotation at the far (unparalled) end to be the same for the two feeders, it must not be accepted as sufficient evidence that coupling switches at the remote end may be closed. Figure No. 9 shows that the phase rotation meter would indicate standard rotation in each case, but a dead short would ensue on closing the coupling switches.

The author concludes with the hope that, brief as is this paper, he has covered sufficient ground to enable more involved connections for protective gear and the like to be tackled. At the same time he would emphasise that when connecting up portable testing transformers and instruments it is of vital importance to take into account the polarity markings of all the apparatus. This particularly applies when using two single phase watt-meters to measure three-phase power, especially in cases where neither the direction of the power nor its power factor are known, e.g., in interconnecting cables, etc.

Discussion.

Mr. H. J. FISHER (in the chair) expressed high appreciation of Mr. Tilstone's very practical paper. Wattmeter and power factor meter diagrams were always interesting, and no doubt many of the members present would have questions to ask. The author had described a little gadget for indicating phase rotation; another very simple one which anyone could make for himself is shown in Fig. 10. All the tackle required is an A.C. 200 volt shunt coil D and four lamps arranged as shown in the diagram, for finding the phase rotation on 500 volt circuits; 250 volt lamps will be used at L_1, L_2, L_3 and L_4. Leads are connected to terminals A, B and C from the supply then, if the lamps connected to terminal A glow brighter than those connected to terminal C, the phase sequence is from left to right A, B, C. If, on the other hand, the lamps connected to C

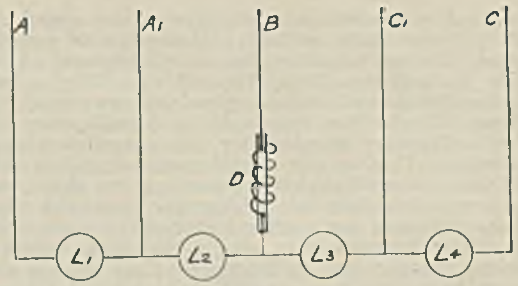


Fig. 10.

glow brighter, then the phase sequence is C, B, A. The extra terminals A and C are for testing phase sequence on 200 volt and 100 volt supplies, in which case suitable lamps must be used. Mr. Fisher said he had found this simple arrangement very useful indeed.

Mr. S. A. SIMON said he had often experienced difficulty owing to lack of agreement between the instrument diagram and the switchboard diagram, or between the terminal markings on the actual instrument and those shown on the diagram, and more care might have been exercised by some switchboard manufacturers in this respect. In the case of centre zero wattmeters and four-quadrant power factor indicators, there was seldom any indication of the direction of flow of power, so that if such instruments were used on interconnecting feeders it was not evident whether power was flowing in or out.

He was pleased that Mr. Tilstone had mentioned the necessity of testing out parallel feeders, not only for correct phase rotation but also for identity of phases. Serious results, more especially with higher pressure systems, might accrue through the neglect of this precaution.

Mr. R. G. MILBURN.—Would Mr. Tilstone further explain the method of connecting a standard marked meter on to a system which was already coloured or marked, but where the colouring or marking was not the usual standard arrangement.

Mr. A. HEPBURN.—In laying out any scheme of three-phase instrument connections it was first absolutely essential to provide for a correct phase sequence. This was usually indicated by the well known colour scheme. If however the colours, to which Mr. Milburn had made reference, did not agree with the phase sequence, then they were useless and misleading so far as instrument connections were concerned. It therefore became necessary first to determine, or check, the cyclic order as indicated by the respective colours before attempting to make new connections or to check those in existence.

Reference had been made to the term "leading phase," and it might be of service to note that where the sequence of phase rotation and colouring were standard, then R leads on Y, while Y leads on B, and B leads on R, and so on, so that B is the leading phase where current transformers are inserted for use only in the B and R phases, respectively. It might here be well to note that current transformers should not be left in circuit with open secondary winding, as might well obtain when instruments were taken out of such circuits for repair, etc.

The lecturer had pointed out the importance of "polarity" in the case of current and potential transformers in instrument circuits and explained simple methods for its determination, particularly in the case of older units not marked to B.E.S.A. standard. It would appear usual to maintain the instrument connections to potential transformers in the same order of polarity, irrespective of incoming or outgoing power, and to effect any required reversal by altering the current transformer secondary connections to meet the respective conditions.

More attention should be paid by those in charge of colliery equipment to ensure compliance with B.E.S.A. conventions so far as phase sequence, colouring of phases, and instrument connections were concerned. Diagrams of connections, suitably coloured with respect to the phases, were most helpful to electricians who had to wire up instrument circuits, and especially so where conventional coloured secondary wiring was used.

Some standardised method of identification could with advantage be adopted for the potential wiring of instruments. The current transformer secondary wiring should be coloured strictly according to phase, while the external braiding of wiring for potential circuits could be indicated by a strand or two of some conventional colour interwoven to give a two-colour effect with the prime phase colour in evidence. Care should always be taken to "earth" permanently one end of the secondary windings of both current and potential transformers in service.

For the benefit of the younger members, it might be advisable to point out that they would ultimately be well repaid for any time spent in the study of the principles of operation and connections of instruments in general use, especially those for use on three-phase systems. No useful purpose was served by trial and error methods when applied to such instruments, and those members having difficulties in this direction would be well advised to consult some of the older men who would endeavour to solve their problems if given the opportunity.

Mr. TILSTONE (in reply).—The device described by Mr. Fisher was both useful and interesting: Mr. Fisher was no doubt aware that this device was sometimes made up with a condenser instead of a choke coil. When the instrument had not been in use for some time, the tester was apt to forget the meaning of its indication. With the phase rotation meter that was not possible, as an arrow on the disc shows in unmistaking fashion the actual phase rotation, the arrow passing the terminals in the order of their maximum. For this reason he preferred the rotating indicator.

Mr. Simon's points were quite interesting, but the object of these notes was to enable the transposition of makers' diagrams, more or less. Instruments did not always come from the same manufacturer, for obvious reasons. By proper study of the maker's diagram, he did not think there would be found great difficulties in transposing them. Admittedly, complications did arise sometimes, but he thought they could always turn the diagrams round.

If a power factor meter were connected up in standard fashion, it would be reading above the diameter when power was flowing in the normal direction.

In regard to indicating wattmeters in general, if the voltage and current be applied to the instrument terminals as shown in the maker's diagram, and if the power be in the direction shown on the maker's diagram, the pointer would then be on the right-hand side of the scale. True, it would be an advantage if the dials were marked in that way.

Replying to Mr. Milburn, if the phases were already coloured R Y B, it would then be possible to say whether the phase rotation of these phases was standard or non-standard, according to the indication of a phase rotation meter. Reference to Figures 5 and 6 would show how to transpose the maker's diagram.

Joint Meeting of the Scottish Branches.

(Held in Glasgow, 26th January, 1929).

The Relative Merits of High Tension and Low Tension for Underground Services in Mines.

Discussion.

Mr. A. F. STEVENSON (West of Scotland Branch), who opened the proceedings, said that the experiment of a "discussion" meeting last session was so successful that it was decided to repeat it. That meeting proved that there were many members capable of carrying on an interesting and informing debate. He had suggested the subject of this discussion as one of interest to the whole of the members, and one about which there might be stimulating differences of opinion. The circumstances of a colliery electrical engineer's employment, the isolation and lack of the competitive element, render him liable to get into a rut and just "carry on" as he has done in the past. The supply engineer is in a very different position: he works in a blaze of publicity and, though his concern has no competition, he personally has plenty, as his costs are published for the whole world to see and criticise. The result is that these men are ever pushing the plant makers to higher temperatures and pressures, ever striving to save a few per cent. in generation and distribution. As an example of that, when the Central Electrical Board decided on 132,000 volts transmission they pushed the cable makers. Although some cable makers were willing to have a shot at supplying 132,000 volt cables, still the Board thought it would be safer to let somebody else try. Mr. Stevenson then illustrated by an example how even a Government Department pushed the manufacturer. When he was in the works the P.O. engineers had a nasty trick of raising their specification to the best results obtained in the test room, their idea being to push the cable maker till his abnormally good became his normal. In self-defence the makers were driven to faking the test figures of abnormally good cables so as to make them just comply with the specification, otherwise there would have been trouble ahead. Those P.O. engineers were animated with the right spirit: plant makers need sympathy and encouragement when they bring out something new, but they also need pushing. Everybody needs it at one time or another. The speaker thought it better not to take just what the manufacturers offer. They should be pressed to offer something just a little bit better.

When mining electrical work began 100 volts D.C. was adopted as nothing else was available. As the makers grew more expert the pressure rose to 500 volts D.C., and stopped there, due to commutator limitations. Then A.C. came along and we changed over to that system at the same old pressure, and there most of us have stuck, although the main reason for stopping at 500 volts is no longer there. Many large collieries have been using 3,300 volts underground for years. Perhaps they too have stuck, and might now be using 6,600 volts with advantage. For transmission the higher pressures have obvious advantages. A .03 three-core V.B., s.w.a. 3300 volt cable will transmit as much power as a .2 cable at 500 volts, but the cost is £635 per 1000 yards less. At the same time, while the drop in pressure is the same in amount in the H.T. cable, the percentage drop is only one-sixth of that in the L.T. cable.

Mr. Stevenson said there was no need to enlarge on this advantage, especially in keeping down starting currents. As far as reliability is concerned, from his own experience and the experience of others, he could confidently say that there is nothing in it between 3300 volt and 500 volt V.B. cables made by the same firm or by firms of good repute. He thought, too, that the same would apply to switchgear, motors and so forth at 3300 or even 6600 volts; but he must let the makers and users of the plant speak for themselves. He had been informed that 3300 volt motors can be made very satisfactorily down to 30 horse power, and some makers would be pleased to make them at 6600 volts: that being so, high tension below ground could be quite satisfactorily used not only for transmission to the bottom of the shaft, but also in-bye actually to the motors themselves without crippling the job by making expensive sub-stations containing transformers and the necessary switchgear.

With regard to switchgear, it was to be noted that switchgear makers very often charge about twice as much for 3300 volt gear as they do for 500 volt gear to transmit the same current. It would be found that the case and current carrying powers were apparently all the same, and almost the only difference made is to put dividers in between contacts. He felt quite sure that if the ability shown in buying general items were applied to switchgears the 3300 volt switchgear would be got at practically the same price as 500 volt gear. In regard to the motors he could not say, but in any case the figure given showing a saving of over £600 on 1000 yards shows that in a place where current has to be carried a couple of miles very considerable savings can be made by the use of 3300 volts, and in addition, the copper being so much smaller only half as many joints are needed. As a cable maker he hated joints, especially when they are made under the conditions obtaining in a colliery.

Mr. ARTHUR DIXON (West of Scotland Branch).—In this district most of the pits are shallow and small and therefore suited to low tension, so naturally most of the present electrical installations are developments from small beginnings at low voltages. A colliery undertaking, so far as electricity supply underground is concerned, requires treating in the same way as an ordinary supply company's distribution: that is, the voltage which should be chosen is correctly determined by the loads and the distances to be transmitted, so that if the ultimate development of the system is known generally as to horse power and distances, it can be decided from the purely economical point of view whether it is a case for high tension or low tension. From a surface point of view, the same factors come in, the economics, capital expenditure, and losses.

There are, however, the special conditions which prevail underground. For high tension, which in an ordinary mine will be from 2000 volts to 6000 volts, Mr. Dixon said his personal preference was for paper cables with plumbed joints, and these joints want properly doing. There is no great difficulty in naked light pits, but in fiery mines it is not so easy, even in the main airways, and it is prohibited within a certain distance of the face. An incidental advantage is that if a high tension installation is put in it must be well done: he could not help noticing the conditions that low or medium tension gear has to put up with underground. He knew from experience, not so much in this district as in others where high tension is extensively used underground, that the high tension installation is well and carefully installed, and being high tension it is given a good deal more respect and is kept in good condition. The installations referred to are exceedingly satisfactory and give less expenditure on copper losses and on maintenance. Of course, low tension has to be taken to the coal face, owing to the limit of power imposed by the regulations for high tension and the difficulty of obtaining small high tension motors sufficiently strong mechanically. His opinions were that where there is considerable horse power underground, totalling 300 horse power or more; where there are long roads and a good roof; and where the conditions are reasonably dry, then adopt high tension.

Mr. JOHN FINDLAY (Lothians Branch), said there were two points raised by the previous speakers to which he would like to refer. In the first case, he was very much interested to hear that manufacturers are now prepared to consider the 60 horse power 3300 volt motor on to a pump down to 30 horse power. One point which concerned him very much to begin with was the question: What is high tension and what is low tension? It is defined in electrical regulations as low pressure and a medium pressure of 600 volts. He, for one, would never think of saying that 3000 volts was high pressure. Mr. Dixon had referred to the fact that in this part of the country most of the mines were old mines: well, if the electricity was properly laid in they would have to get away from that idea altogether. At the present time, or rather six months ago, he, Mr. Findlay, had put in a mile of high tension cable in a mine 50 years old, simply because the plant was there with a high tension installation. Mr. Dixon had also referred to the fact that cable for 2000 to 6000 volts should be paper cable. In one colliery Mr. Findlay had put cable a mile and a half long under conditions by no means dry, and that was between five and six years ago. That cable had never given a minute's trouble in the six years; some people were apt to look rather askance at high tension because it is difficult to make a satisfactory joint. Pursuing that point still further, on the question of 500 volts to-day, if it were impossible five years ago to make, is it not likely within the next five years that you might get a 10 or 15 horse power high tension motor? To him it seemed to be but a natural development. From the safety point of view he could not see any reason why 3000 volts should be any more dangerous than 500; statistics tended to prove that 100 volts is just as dangerous and causes as many accidents as 6000 volts.

Mr. G. N. HOLMES (West of Scotland Branch).—Whichever way we treat this subject we are always faced with the extraordinary conditions prevailing underground, and while these may be bad in many mines, they will be worse in others. Pit water, humidity and moisture-laden atmoshperes, especially in the return airways and upcast shafts, play havoc with all classes of apparatus, cables, etc., and it is often very difficult to maintain anything like a reasonable protection to the gear employed. Under such conditions it may be advisable to play for safety, even though the efficiency is lowered and initial costs are higher. The reason for a colliery being in operation is its output in coal, and in this respect it is dependent upon the continuous running of all plant and its freedom from breakdown. We have in these facts alone perhaps the strongest case for low tension supply; that is, for pressures up to 600 volts. It should not be difficult to insulate, and maintain an adequate insulation throughout any low tension system, but because the system is low tension there is a possible tendency to treat it with contempt. Use is therefore made of much inferior apparatus and material, with ultimate high costs of production due to frequent stoppage of the mine.

In the smaller mines undoubtedly A.C. low tension three-phase supply is the ideal system, but its efficiency depends upon its quality and manner of installation, and in this respect the electrical engineer should be mainly responsible. The limit of low tension supply is reached when the I^2R losses and voltage drop has become uneconomic owing to extended roadways and in-bye plant. It may also be mentioned here that many of the motor failures are due to an excessive fall in voltage, causing over-heating and its consequent troubles.

In dealing with high tension supply it would be safe to hazard that there is greater immunity from breakdowns, not because the apparatus may be better designed—there are just as good designs to be had for low tension gear—but because it is installed with greater respect. It is a fact, nevertheless, that nicer discrimination is used when selecting the apparatus to be used, and it would be just as well for the colliery working with the low tension system to realise the old adage, "What is sauce for the goose is sauce for the gander." and probably benefit from it.

We have reached the stage when 3300 volts is, comparatively speaking, no longer high tension but a perfectly normal working pressure for everyday use. It may be considered, therefore, that this meeting is irrelevant, but the mere fact that we have met to-day is suggestive of the progress being made regarding the possibilities for high tension currents for underground working.

It may be fairly said that mixed pressure, that is, low tension and high tension, is not only desirable but necessary for reasonably large mines if economic working is to be attained, and there is no doubt that pressures of 3300 volts form the best basis for general distribution.

As previously mentioned, when low tension current is being used on workings some distance from the surface, the most troublesome element we have to deal with is pressure drop. To remedy this we have three alternatives, viz.: to increase the size of conductors; instal boosting transformers; or resort to high tension feeders, transforming down at suitable points for the low pressure supply. Obviously the third arrangement will appeal to most engineers on account of its elasticity. Not only can it be utilised for point feeding, but high tension pressure at 3300 volts is very suitable for motors of 100 H.P. or over, as may be used for pumping and main haulages. In-bye sub-stations can be constructed at suitable points, but attention must be given to efficient ventilation, and the free circulation of air around the transformer. If possible, provision should be made for inspection and repairs, and it is usual to sink a pit wherein the transformer tank may be completely lowered, thus allowing head-room for the withdrawal of the core. Special portable transformers are now being constructed for mining work and fitted with wheels suitable for the haulage way. By these means they can be readily removed to the shaft for repairs or overhauls. These transformers are of the air-cooled type, and should be fitted with plus and minus tappings on both sides. They are generally delta-connected on the high tension side and star-connected on the low pressure side, with the neutral point available for earthing.

The sub-station should contain the necessary control switches, and these should be of the iron-clad oil break type, fitted with the usual protective gear, and should furthermore have clearly marked upon them the apparatus, or section controlled. Cleanliness, good lighting and telephonic communication should not be overlooked as part of the ideal sub-station.

The question of cables will present no greater difficulty than the rest of the apparatus. For the high tension supply, paper-insulated and lead-covered and wire-armoured cables are recommended, provided that the roadways are suitable. Such cables are highly reliable, but care must be exercised when making off to joint boxes, etc., to which special glands should be fitted to ensure continuity and earthing of both lead and armouring. Boxes must be compound-filled to prevent the access of moisture, or condensation.

There is a point arising out of these mixed pressure systems due to the greater cross-sectional area of L.T. cables, and it would appear that the armouring of the H.T. cables would not provide sufficient conductivity to meet the Coal Mines Act, which calls for 50 per cent. conductivity of one of the cores. In order to deal effectively with this, the neutral point of the in-bye transformer is attached to supplementary earths as well as the armouring of both sides of the system.

Mr. Stevenson mentioned in his remarks that there was no reason to stick at L.T. supplies, but he seemed to have overlooked the fact that low pressures are more or less necessary at the coal face, and for operating the smaller machines. It is perfectly economical to use 440 or 600 volts for such working. In regard to the high tension cables, Mr. Stevenson mentioned the very large saving there is to be obtained from these. When taking a considerable supply any distance underground, say 900 yards or more, it is perfectly feasible to use H.T. and transform there for further distribution. In many cases there is no machinery or tappings taken off feeders 1000 yards underground, and in such cases point feeding is simple.

Mr. Dixon has raised the point about new collieries taking high tension supply, but he would find that it is almost necessary to start the development of a new colliery with a low tension supply. When the ordinary sinking work is being carried out, a L.T. supply is very often laid down specially to deal with this work; also for some distance in-bye low tension supply is possibly handier for the preliminary working. When heavier power say for pumps, etc., is required, then a H.T. supply becomes superior.

Mr. Holmes then referred to his recent paper on "Electrical Conductors," in which he particularly mentioned that V.I.R. cable with bitumen worming and sheathing formed one of the best classes for mining work. There is room for further development for a cable of this class, although it has not been seriously taken up by the mining industry so far.

He could hardly agree with Mr. Findlay in his remark on 100 volts being just as dangerous as 3300 volts. Admittedly the man receives a shock, but it depends largely on his physical condition, and also on the manner he receives the shock whether it is fatal. Frequently he is saturated with water; in such cases 100 volts may easily be fatal. At the same time if he received a 3000 volt shock under similar conditions there would be absolutely no hope for him at all, whereas from a low pressure shock there would be some chance of his resuscitation. He agreed with Mr. Findlay that we are reaching a stage where 3300 volts will be a very common pressure, and if we compare this with the 132,000 volts which is now being transmitted in this country, there is little room left for argument that 3300 volts is E.H.T. We are, however, governed meantime in the use of H.T. by the size and horse-power of available motors, but if the motor manufacturers come in line with something suitable it would lead to a very much wider field for H.T. supply.

Mr. FINDLAY explained that his remarks on 100 volts being as safe as 3000 volts were with reference to Government statistics, which proved it. He sought to emphasise the fact that 3000 volts is just as safe, because there is more care taken in that case, as statistics prove.

THE CHAIRMAN (Mr. Frank Beckett, West of Scotland Branch).—The question of the use of H.T. depends very largely on the efficiency of installation. It is necessary to have a great deal more care expended on it than is expended in a great many cases on the lower voltage. He believed, as Mr. Findlay had said, that the use of higher voltage is very largely a question of natural development. We started with 100, and we gradually came up to 500. As the manufacturers get more technical information about their manufactures they can improve them, and the voltage gradually increases. Mr. Holmes had spoken of the use of mixed pressures. As things are at present there is no question that mixed pressures must be used. There must be low tension for small motors, the limitation being made by the motor manufacturers, apart from the Home Office Regulations. The motor manufacturers at present are not able to make very small motors for high tension, that is in sizes less than about 50 horse-power.

Mr. Holmes seemed to pin his faith to paper cables, but a little later on made out that the V.I.R. cable, bitumen wormed and sheathed, was even better. Perhaps he would explain.

Mr. HOLMES.—Paper cables for underground working, or any other working for that matter, are good by reason of the great stability of paper as a dielectric The objection to paper cables underground appears to be not to the cable itself so much as to the coupling up of the joint boxes and the necessity of carrying fluid compound underground. Another possible objection to paper insulated cable is the greater weight to handle. V.I.R. cable bitumen wormed and sheathed is better than the ordinary vulcanised bitumen cable which is in every-day use. The possible use of bitumen cable is due to it being acid-resisting, and as pit water is slightly acidulated it has proved its usefulness in this respect. It will not, however, stand anything like the mechanical handling that rubber insulated cable will, owing to the internal friction of the conductors themselves and the centre layers of the bitumen. Rubber insulated cables are extremely useful from that point of view, and have proved themselves of great value. A further advantage of the rubber insulated and bitumen wormed and sheathed cable is that it will meet both conditions of pit water which may be found: that is, rubber will resist slightly alkaline solutions while the bitumen will withstand acidulated solutions. Mr. Holmes said he did not seek to put the V.I.R. bitumen cable forward as a competitive cable against paper, but where objection is raised to the handling of the heavier lead covered paper cable, then rubber insulated bitumen wormed and sheathed cable will provide an excellent job.

With regard to the point raised about high tension at the coal face, he did not think that the Home Office would admit of it at the present moment, but as those rules are amended there will be an opportunity for coal cutter and motor manufacturers to consider the idea further, and possibly develop on those lines.

"INTERESTING NEWCASTLE"

This excellent little Cameo of British History as perpetuated in the main ways and by-ways of the ancient city of Newcastle, will be generally appreciated, especially by those Members of the Association of Mining Electrical Engineers who attend this year's Conference, and for whom this little guide has been prepared. It is issued as a loose supplement so that it can conveniently be carried to Newcastle and applied to its intended service as a guide.—*Editor, M.E.E.*

ALL roads lead to the North East Coast Exhibition in these days, but for once in a while why not choose a more devious and less familiar route? There is so very much of interest to be seen here and there in this old City, even in the brief space of the two short hours we can well spare in which to take a look around.

One could hardly conceive of a more appropriate position for the statue which greets our eyes as we leave the Central Station Hotel. Here, a grimy reminder of the immortal Northumbrian engineer, stands J. G. Lough's "Stephenson" Memorial: a dark, dusty gentleman who turns his back moodily upon the bustle and clamour which throngs the entrance to the station but a few yards behind him. Stephenson's birthplace—a humble cottage at Wylam, a few miles to the West—is still to be seen.

We turn and pass down Neville Street and, via Collingwood Street, to St. Nicholas Square where, at the door of the Cathedral, we make our first halt.

The Church of St. Nicholas has been the Cathedral of the Diocese of Newcastle since 1882. but for eight centuries before that the Church has been, as it continues to be, the Mother Church of Newcastle-upon-Tyne. The steeple, for sheer magnificance of aspect and intricacy of craftsmanship, is without rival in the North.

The early history of the Cathedral is hidden in obscurity, though tradition speaks of a rough erection, on the site of the present building, shortly after the departure of the Romans from Northumbria. Reference is also found to a Church founded here in the reign of William Rufus, but destroyed in 1216. The present Cathedral was, however, not finished until 1350, since when it has obviously undergone numerous changes and alterations.

It is the beautiful steeple, an addition to the original tower, which at once rivets our attention. Robert de Rhodes, an eminent Newcastle lawyer and M.P., is generally accredited with having provided the wherewithal for its construction in 1430, and, high in the vault round the bell-hole inside the Cathedral is the inscription, "Orate pro anima Roberti Rodes." There are several imitations of this architectural feat, the best known of which are St. Giles, Edinburgh; the Church at Linlithgow and the College Tower at Aberdeen. All, however, fall short of the original.

Such a conspicuous landmark could not fail to attract hostile attention in the turbulent days of Northern warfare, and numberless stories are related in connection with the history of the steeple. The following, probably true, is undoubtedly the most interesting.

In 1644, during the Civil War, the Scots, who were besieging Newcastle threatened to bombard the steeple if the keys of the town were not at once delivered up by the Mayor, Sir John Marley. Not for a moment dismayed, this shrewd Northumbrian replied by lodging the chief Scottish prisoners in the steeple, where they spent their time during the siege. "Not so much as a shot was fired at St. Nicholas Cathedral," relate chroniclers of the period.

We have just time for a brief inspection of the interior of the Cathedral, which will prove of interest. We enter by the North door. Against the wall on our right is the oak panelled War Memorial, designed by Mr. W. H. Wood. The ancient marble Font, said to be the gift of Rhodes' niece, is noteworthy mainly for the beauty of the 16th century oak covering. For those who wish a tour of the North Aisle, the new Vestries, the Library and the Lady Chapel will afford an hour of interest. We will leave again by the South Porch, finding ourselves at the top of The Side.

On our left the street known as The Side clatters steeply downhill. It still preserves many of those curious and picturesque old "overhanging" houses, which date back to the time of Elizabeth. In a brick house at the head of this street on the left hand side, Lord Collingwood was born on September 26th, 1750. It has now been demolished and Milburn House extends over its site. It was up The Side that coaches from the South used to make their entry into the town after crossing the old Tyne Bridge, which stood where the Swing Bridge stands to-day. Here also is Amen Corner, where once stood the workshop of Thomas Bewick, the famed wood-engraver. A tablet marks the spot, and, hidden away in a niche, there is to be found an admirable bust of the great artist.

The Black Gate, gloomy and strangely out of its environment amid modern conditions, stands quietly on our left. Here one expects to see the mailed Borderer gripping impatient sword ere hasting North: vigilant Northumbrian, dour and stern, watching from its shadows: eerie flares, guttering lanthorn . . . .

. . . And one feels strangely disappointed to see but a whistling errand lad stroll lazily forth from its blackness.

This example of early English architecture was formerly the main entrance to the Castle, and is believed to have been built by Henry III. in 1247. Its original aspect has been greatly altered by restoration, and there is now no trace either of the former double portcullis or drawbridge. The rooms inside are used by the Society of Antiquarians in Newcastle as a museum and, for a small charge, we may inspect the numerous Roman remains therein. Frankly, it is disappointing, and we may pass without regret to the Keep itself.

The present structure is the work of Henry II. and, commenced in 1172, was completed in 1177. Entrance is obtained by an external staircase on the East side over the fore building, which contains the interesting old Chapel (once separate from the Castle itself). For parties of three or more a nominal charge is made for admission, and Brewis' Guide, obtainable for a few pence from the Caretaker, is a remarkably good investment. After a tour of the interior of the Castle we must not fail to clamber up the ill-lit and broken stairway to the roof and battlements. These, unfortunately, are modern and do not even reproduce the original. The sundial, in the centre of the roof, is of interest. It was brought from Carville Hall, near Wallsend (a few miles down the river) and bears the date 1667. On the higher portion of the face is the motto: "Time tide doth waste, therefore make haste, we shall . . ." Add the word "dial" to complete the rather weak pun, "die-all."

Northwards we see, at our feet, the Black Gate and, beyond, St. Nicholas' steeple in all its grandeur. Eastwards rises the renaissance Church of All Saints; to the South the "coaly Tyne" and Gateshead. For a moment we will disregard the new Tyne Bridge and devote our attention to the High Level, which lies below. This bridge, a mighty monument to its designer, Robert Stephenson, was commenced upon the proposal of Hudson, the early railway "king," in 1846 and completed in 1849. The railway line was opened for traffic on August 15th of that year, and the lower roadway on February 4th, 1850. In the haze beyond is the Redheugh Bridge, the work of Sir Thomas Bouch, engineer of the ill-starred Tay Bridge.

Quitting the Castle we turn left into Castle Garth. The dark, sombre building before us is The Moothall, County Court of Northumberland. We cross the cobblestones to the Castle Stairs, and commence the descent.

There are few who know of the antiquarian interest in these cracked, paved stairs. As we make our way cautiously down our attention is attracted mainly by the quaint old shops tucked snugly away in the whitewashed walls which hem us in, wherefrom issues the monotonous "tap-tap-tap" of the cobbler, so that many are apt to miss by far the most interesting feature of the stairs. After descending two short flights of steps we pass through a low arched passageway. The oblique direction of the passage is noteworthy; this postern is the oldest remaining fragment of the Castle and is the same to-day as when it was built—probably by one Robert Curthose.

We are now into Sandhill. Opposite is the Swing Bridge and Coroner's Court and, a few yards further on, the Guild Hall and Exchange. We turn sharply to our left and pause before a picturesque old many-windowed house, which stands shabbily forgotten opposite the Exchange. This was formerly the residence of Aubone Surtees, Esq., the Banker, and it was from one of these lower casements that his daughter, Betty, eloped on November 18th, 1772, with a Mr. John Scott, afterwards to become Earl of Eldon, Lord Chancellor of England. A few doors to the East is another old mansion, No. 33, Sandhill, said to have been the residence of the ill-fated Lord Derwentwater.

We now cross the road to the Quayside. Above towers the stately New Tyne Bridge, which we are to visit shortly. A short walk brings us to the Customs house and, directly past that, Trinity Chare. A visit to the Chapel and Hall of Trinity House—at any time but Saturday afternoon and Sunday—may prove to be the most interesting visit of the day. Here, in the entrance hall itself are displayed various curiosities: models of a full rigged line of battle ship "Ville de Paris" (on board which Admiral Collingwood died), made by French prisoners at Porstmouth out of beef-bones; an Esquimaux canoe; charges of grapeshot; a Russian musket picked up in Sebastopol Bay, and many other exhibits of interest; but more interesting than all are the Board Room, erected in 1721, and the Chapel, with its black oak pews and its ceiling modelled to represent the underside of the deck of an old man-o'-war.

We may retrace our steps past the ancient almhouses to the Quayside once more. For those who so desire, a walk along the Quayside brings them to Sandgate, immortalised in the famous "Keel Row" song:—

"As I cam' thro' Sandgate
I heard a lassie sing,
Oh, well may the Keel Row
That my laddie's in."

"INTERESTING NEWCASTLE."

1.—*The Side.*
2.—*The Stevenson Monument.*
3.—*The Black Gate.*
4.—*The Castle.*
5.—*The War Memorial.*
6.—*The Exhibition Entrance.*
7.—*The New Tyne Bridge (from the Castle Battlements).*

Disillusion, however, awaits the visitor to Sandgate, for Sandgate as it is and Sandgate as imagined by the thousands who delight in the lilting Tyneside melody are vastly different. At one time, when it stood amid green fields, with a sandy beach and a limpid River Tyne before it, there is no doubt but that it was a pleasant locality enough. But to-day it is an ugly avenue of grimy warehouses, sordid and forbidding. It was in Sandgate that, on May 30th, 1742, John Wesley commenced his ministrations "among the poorest and most contemptible part of the town." Sandgate appears to have lived up to its reputation, for in his journal we find the following:—

"So much drunkenness, cursing and swearing, even from the mouths of little children, do I never remember to have seen or heard in so short a compass of time."

Back again beneath the Tyne Bridge, we ascend by means of the "halfpenny" lift to the bridge itself. This wonderful structure, the longest single span bridge in the British Isles, was opened on October 10th last year by their Majesties the King and Queen.

Our path now lies up Pilgrim Street, which, as its name implies, was the popular route taken by the early pilgrims on their way to the little chapel at Jesmond, and a turn to the left down Mosley Street brings us to Grey Street, Grainger's masterpiece, the finest thoroughfare in Newcastle. Ascending towards the Grey's monument—accessible to the agile for a small sum—which monument was erected in honour of Charles, Earl Grey of Howick, Prime Minister of England, and is an appreciation of his strenuous work in connection with the abolition of slavery—we pass the Theatre Royal on the right and, in Market Street, the bank which stands on the site of the house in which Charles I. was imprisoned for a period during the Civil War. Once more to the right and up Northumberland Street. Pause outside the Church of St. Thomas the Martyr to gaze at the wonderful sculptured relief "The Response," one of the most beautiful war memorials in England.

We must leave the Hancock Museum on our right, and Armstrong College on the left, for our two hours are gone. Exhibition Road takes us to our Mecca and our "betters"—who attend at Council Meetings whilst we enjoy ourselves—will expect us to be prompt for luncheon.

THE CHAIRMAN asked Mr. Holmes whether, with paper cables, he held the opinion that there was no necessity for lead joints? The office of lead joints is to make the cable watertight, and he, Mr. Beckett, did not think there was a mechanical coupling to couple the lead on to the box and give a perfectly watertight joint.

Mr. HOLMES in reply said there was some degree of truth in that, but it should not be allowed to worry them very much. There are several boxes on the market in which a mechanical lead joint can be made, and which practically seals up the lead and completes its continuity. Possibly one of the easiest ways to meet a condition like that is to make a specially prepared gland in which shredded lead is filled in, and which can be closed up mechanically in the form of a stuffing box. Mr. Holmes said he understood that such a box would meet the jointing requirements; but so far as the watertightness of the box was concerned the lead sheathing of the cable was generally taken inside the box itself through the gland and made off there. The essential point was to see that the box was completely filled with compound, and so it would be almost impossible for any moisture to find access to the joint.

Mr. STEVENSON, commenting upon the remarks of Mr. Holmes as to the properties of the combined V.I.R. and V.B. cable, wondered whether Mr. Holmes would be quite prepared to see his cable lose its V.B. sheath in alkaline waters. Mr. Stevenson said he personally would be distinctly nervous as to the continuity of service of such a cable.

Mr. DIXON.—There seems to be some doubt about the question of small horse power motors on high tension. The regulations are quite clear; they will not allow any smaller motors than 20 horse-power on high tension, but the manufacturers have a limit much higher than that. Mr. Findlay showed this in his reference to a 90 horse-power, 3000 volts motor. Mr. Dixon said he knew of a case, going back some years, where manufacturers would not quote for a 60 horse-power motor on 2000 volts, but that was for high speed pumps. The question of speed certainly entered into it: it was a question of mechanical strength of conductors. Small motors for these high voltages can be made, but they would have to be artificially strengthened to the detriment of efficiency and price.

Mr. W. HENDRIE (East of Scotland Branch), said it occurred to him that in the discussion regarding motors they were overlooking the question of high tension trailing cables at the face. Having got the motor makers to provide high tension motors for face machines it would be necessary to introduce a cable just as suitable for high tension for the motor as for other purposes.

Mr. W. McCALLUM said he could not see any advantage in taking H.T. in-bye, as the motors there are of low horse power in comparison to the motors found in the pit bottoms of most collieries, where all the heavy pumping, haulage, etc., is done. It is there that H.T. could with advantage be applied to these motors, which are usually of 50 H.P. or more. It is a consideration taking from a medium pressure supply the power for these motors, as it involves a cable of large cross-sectional area in comparison to an H.T. cable capable of carrying the same power.

The only case which in his opinion justifies the taking of H.T. any further than the pit bottom is where a very considerable distance has to be travelled before the first motor on that particular line of cable is encountered. High tension could then with advantage be applied and greatly reduce the C^2R losses. As a particular case in point in a colliery under my supervision there is a distance underground of 1400 yards from the pit bottom to the first motor on a certain medium pressure cable carrying 200 amps. In the near future that cable will most certainly become overloaded, unless it is replaced with a medium pressure cable of greater cross section. That would be very costly, whereas a H.T. cable could be installed at a greatly reduced cost as far as the first motor, and the pressure there transformed down. This would also cut out the volts drop which would take place in the medium pressure cable.

Mr. Stevenson had mentioned that at present the Regulations prevent an underground motor under 30 H.P. being put to work directly off high tension supply; the percentage of mine motors under this H.P. is about 80% of the total. This section of the Coal Mine Acts would require to be altered before any great advantage could be obtained by taking H.T. in-bye.

Concerning Mr. Findlay's statement that he could not obtain (several years ago) a motor of 90 H.P. to work direct off a H.T. supply for the purpose of driving an underground pump, Mr. McCallum quoted one particular case where a surface motor of 30 H.P. had been working for a peried of twelve years off a 3000 volt supply.

One of the speakers had mentioned that the cost of oil-immersed switchgear for a H.T. job cost more than the gear of the same capacity in a medium pressure system. Mr. McCallum had not found that to be so at a certain colliery; there the prices for a H.T. shaft cable with necessary switchgear (including a transformer to step down to medium pressure again in the pit bottom) and a medium pressure cable with switchgear were exactly similar. The length of the cable was 500 feet, and the current capacity 400 amps. at 500 volts.

Mr. JAMES BRASH (West of Scotland Branch) said it would be of interest to pass on a remark in respect of the efficiency of the electrical colliery engineer. It had been advanced that one reason why low tension is being kept in use is because the colliery engineer can go about his work in a slip-shod fashion, and if he were to discharge his duties faithfully the high tension would be introduced if the regulations would permit it. That seemed to be the trend of thought which prompted the remarks of the various speakers. The idea of Mr. Holmes seemed to him to be the most correct, namely, that mixed pressure is a necessity in the lower seams of Lanarkshire at the present time. In the case of those who may wish to introduce 3000 volts into the coal-cutter in a 16in. place he, Mr. Brash, would have no objections to it—he would stand by and learn.

The Housing of 66,000 Volt Switchgear.

A large contract covering the supply of 66,000 volt switchgear has been placed with the British Thomson-Houston Co., Ltd., by the Central Electricity Board for the South-East England Electricity Scheme. This switchgear is of the "indoor-outdoor" type and each oil immersed circuit breaker is rated at 600 amperes, with a rupturing capacity of 1,500,000 K.V.A. at 66,000 volts.

The buildings to house the switchgear have three floors, the two upper being glazed and provided with access facilities at each end, the lower being unenclosed but having a retaining wall from end to end. The circuit breakers are to be placed on either side of this wall, the bus-bars and bus-bar isolating switches being in the two enclosed floors above.

All bus-bars are in duplicate on each side, one set being enclosed on the first floor and the other set on the second. Oil filled bushings of special construction are used where the connections pass through the floor of the top chamber, these bushings also taking the clip contacts of the bus-bar isolating switches for the first floor bus-bars. In most instances copper tube is to be used for the connections, and all isolating switches are remote operated from ground level, a comprehensive system of interlocks preventing access both to the bus-bar and isolating switch chamber unless all associated details have been made dead. In addition, the interlocking devices are so designed that maintenance men can check the operation of isolators with safety in switch chambers which have been made dead for this purpose, special sequence interlocks being provided to meet this condition.

Manufacturers' Specialities.

An Electric Quarry.

A general view of the Blackford Quarry of the Midlothian County Council is shown in Fig. 1: the plant was originally driven by two gas engines of 80 H.P. and 40 H.P., and these have now been discarded and electric motors installed throughout. An electric supply is taken from the Edinburgh Corporation at 6600 volts three-phase 50 cycles, and received in a sub-station at the quarry, where the pressure is reduced to 400 volts by means of a 400 K.V.A. Bruce Peebles transformer.

The contract for the motors was placed with Bruce Peebles, through their agents, Messrs. Mitchell, Graham & Son, Ltd., of Edinburgh, who carried out the whole of the electrical installation work. The complete quarry plant was designed and supplied by Messrs. H. R. Marsden, Ltd.

The first operation in quarrying road material, which is the staple product of this quarry, is the breaking up of rock. This is done by suitable methods of drilling and blasting, the broken material being roughly separated by hand and graded into two sizes of over and under five inches. This material is then transferred to light narrow gauge rail wagons, and taken to the inclined haulage road, where an endless rope haulage transports the wagons to the feeding platform. The haulage, which is illustrated in Fig. 2, is driven by a Peebles 16 B.H.P. 712 r.p.m. protected type squirrel cage induction motor.

There are two hoppers situated at the side of the track on the feeding platform, and when the wagons come abreast of these, the contents are tipped into them, the large material going to the primary crusher and the small to the shaker feed. The empty wagons are then run on to return rails, and automatically return to the quarry face.

The shaker feed is of the reciprocating type, its function being to receive the small material in bulk from the wagons and feed it evenly to No. 1 conveyor. The shaker is driven by a Peebles 10 B.H.P. 945 r.p.m. enclosed ventilated type slip-ring induction motor, the whole equipment being mounted on an elevated platform in the same house as that in which the haulage is installed (see Fig. 2).

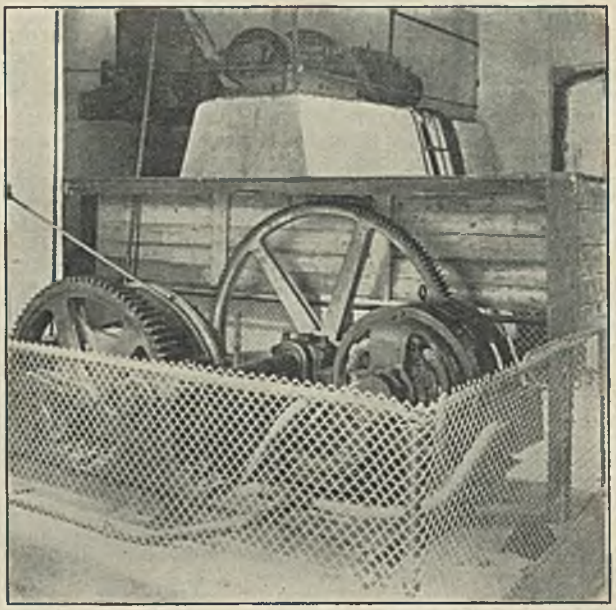


Fig. 2.—Endless Rope Haulage and Shaker Feed.

The Blake-Marsden primary crusher has jaws and side plates of manganese steel. It is a massive piece of machinery, capable of reducing the material to five inches at the rate of 85 tons per hour when running at a speed of 300 r.p.m. Two heavy fly-wheels ensure steady operation of the crusher, which is driven by a Peebles 85 B.H.P. 972 r.p.m. enclosed ventilated type slip-ring induction motor.

The No. 1 belt conveyor collects the output of the primary crusher and shaker feed and transports it to the secondary crushing plant shown in Fig. 3. The con-

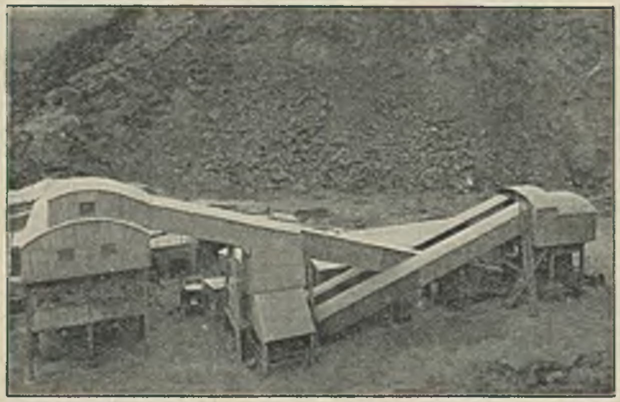


Fig. 1.—The Blackford Quarry.

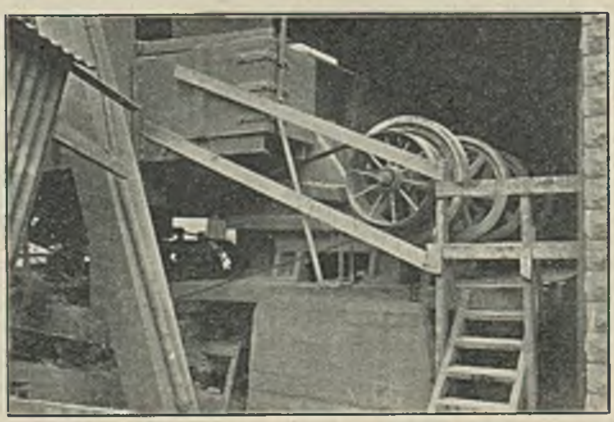


Fig. 3.—Secondary Crushing Plant.

veyor, a section of which may be seen in the illustration, is 30 inches wide, with 80 feet centres, and is supported by idlers of the five-pulley type designed to give the correct contour to the troughed belt.

To prevent any "tramp iron" from the quarry passing through and possibly damaging the secondary crushers, a magnetic pulley is installed at the head of the conveyor. This special pulley takes the place of the ordinary conveyor head pulley; it is energised at 220 volts by a Peebles 3.5 K.W. squirrel cage induction motor generator set, situated in the same house as the 85 B.H.P. 972 r.p.m. slip-ring motor which operates the above conveyor and the four Blake-Marsden stone breakers. These breakers form the secondary crushing plant, each machine having an output of 12 tons per hour, and reducing the material to 2½ inches and under.

The breakers are arranged in pairs so that the output from each pair is collected by two belt conveyors (Nos. 2 and 3) each 18 inches wide, with 105 feet centres, and transported to the chippings plant.

The chippings plant consists of two cylindrical primary screens and two crushers. Each screen is 4 feet in diameter and 15 feet 3 inches in length, and is made up of several sections perforated with different sizes of holes for suitably grading the stone. The graded material automatically passes through collecting hoppers into the crushers, the rejects being fed to a Blake-Marsden granulator, and the smaller material to a disc crusher. Incidentally, the smaller material may be passed either to the disc crusher or to the No. 4 conveyor, or both, as required. The granulator, when set to crush to one inch and under, has an output of approximately 10 tons per hour when running at 280 r.p.m. The complete chippings plant and Nos. 2 and 3 conveyors are driven by a Peebles 85 B.H.P. motor similar in every respect to the one previously mentioned.

The crushed material from both machines is collected by the conveyor, which is 24 inches wide by 170 feet centres, and carried to the feed hopper situated over the main grading and tar-macadam plant.

On reaching the main grading plant, the material passes to two cylindrical screens, each 4 feet in diameter and 35½ feet in length. These screens and the No. 4 conveyor are driven by a Peebles 50 B.H.P. 967 r.p.m. slip-ring motor. The screens are fitted with suitably perforated sections and are situated above two storage bunkers of ferro-concrete, a bunker being under each screen. The bunkers, which have a total capacity of 800 tons, are divided into compartments corresponding to each size of graded material, each compartment being provided with sliding trap doors over the loading dock. Any size of material can thus be transferred direct to the wagons.

The tar-macadam plant is fed by means of belt conveyors running longitudinally under each bunker. It consists of two tar mixers of the double paddle type, each with eight paddle arms fitted with manganese steel tips; the sides of the mixing chambers are provided with wearing plates of the same material. A tar tank situated above the mixing chambers is fitted with a control valve and spraying pipes, and the proportions of the mixture, as well as the mixing time, can be easily adjusted, all the controls being most conveniently placed and in view of the operator. The mixers are arranged at a suitable height over the roadway so that

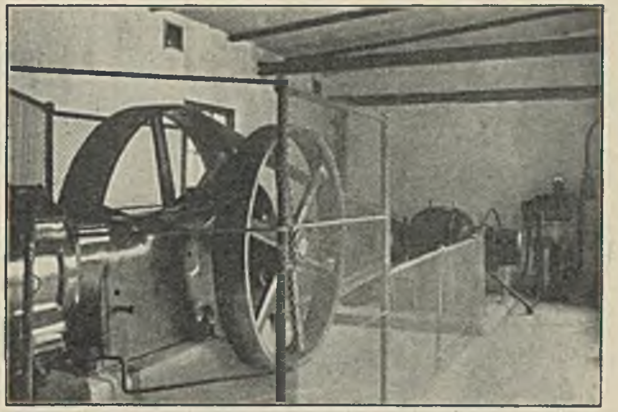


Fig. 4.—Electrically Driven Air Compressor.

the "batches" may be dropped straight into the wagons. The discharge is very rapid, as the bottom discharge doors occupy the full width of the machines.

This plant and the machine tools in the fitting shop are driven by a Peebles 25 B.H.P. 965 r.p.m. slip-ring motor. The advantage of having a central plant where tar-macadam can be prepared and delivered to the site of operations in the right condition for use will be readily appreciated.

Fig. 4 illustrates a Peebles 85 B.H.P. 970 r.p.m. enclosed ventilated slip-ring motor driving an Ingersoll-Rand air compressor for supplying compressed air to the rock drills.

A central electrical distribution station situated adjacent to the transformer house contains an oil-immersed unit type distribution switchboard to which the low tension side of the transformer is directly connected. As will be seen from Fig. 5, the switchboard consists of four units, the largest of which controls the incoming supply from the transformer, and the three smaller ones the feeder circuits. The unit controlling the incoming supply consists of a 450 amp. triple pole oil-immersed circuit breaker provided with three overload releases, time lags, no-volt release, ammeter and leakage indicator. The three out-going feeder circuits are each controlled by a 200 amp. triple pole oil-immersed circuit breaker surmounted by an ammeter and fitted with three overload and one no-volt releases with time lags. The overload releases are provided with padlocked dust-proof covers.

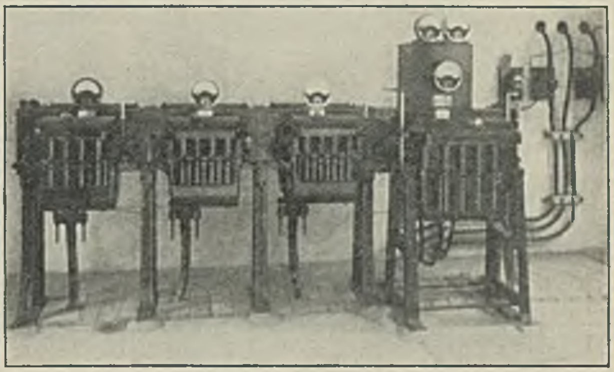


Fig. 5.—Central Distribution Switchboard.

Three-core paper insulated, lead covered and wire armoured cable is used throughout, all switchboards and control gear being provided with the necessary cable boxes for its accommodation. The feeder cables leading from the distribution station are laid in trenches where necessary, and cleated on wood to the walls of the buildings where convenient.

These cables terminate in unit mining type distribution panels, each of which consists of three single pole, Home Office pattern fuses with unbreakable handles, triple pole quick break isolating switches, and busbar chamber; the fuses and switches are interlocked so that the doors cannot be opened when the switches are closed.

The circuit cables are led from these boards to the various motor control panels and motors. The motors are controlled by triple pole oil-immersed circuit breakers mechanically interlocked with oil-cooled rotor starters.

Spare ways have been left on the boards where possible extensions are contemplated, and the distribution boards are arranged to facilitate future extensions. All the switch-gear is electrically bonded to the earth system and complies with the Mining Regulations in this respect.

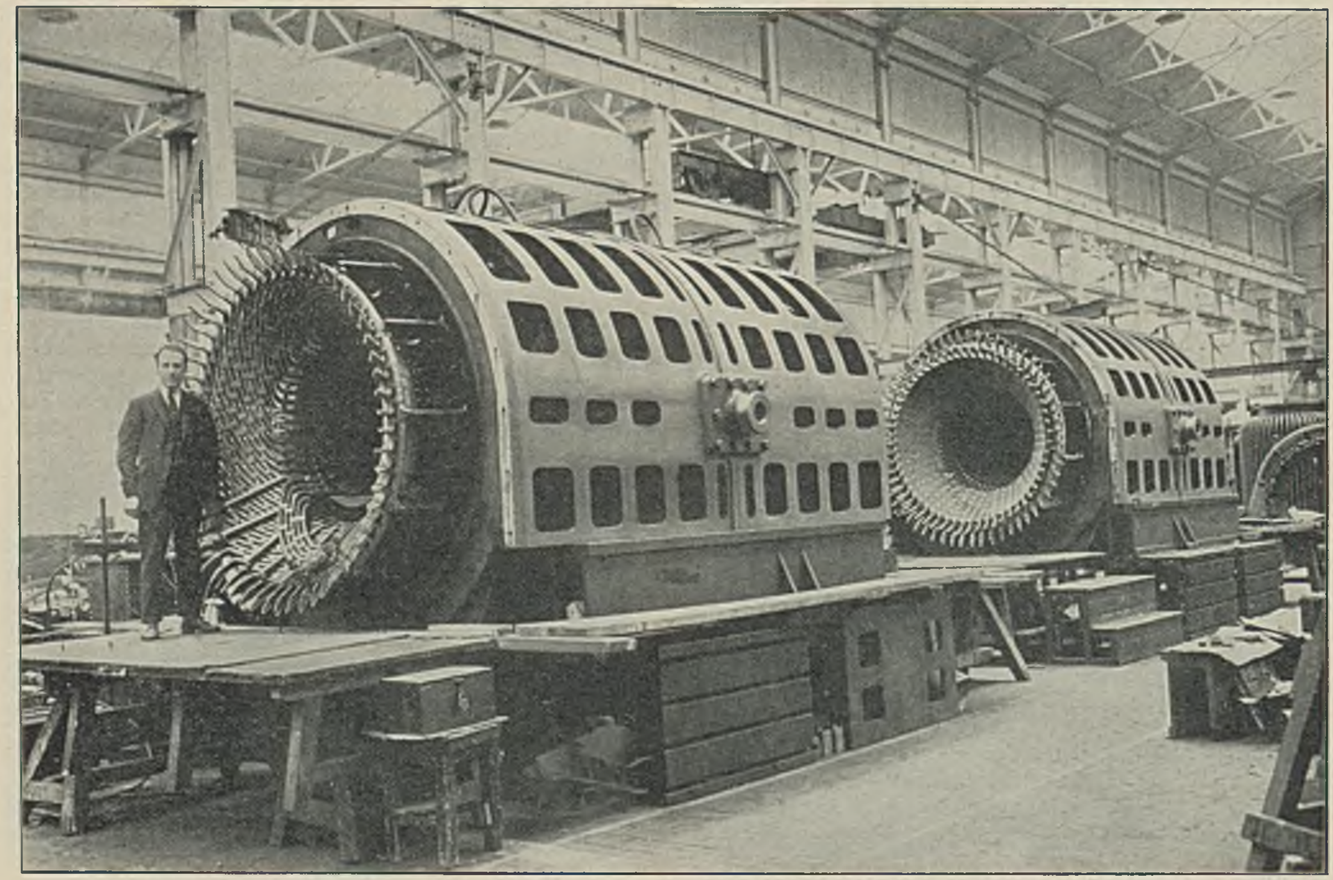
The general system of distribution has been to group the motors in sections and to feed each section with one feeder, this arrangement being found the most convenient in view of the layout of the buildings.

All the motors with their control gear are housed in separate chambers so as to protect them from stone dust, the drives being taken through the walls by means of belts. The complete electrical installation complies fully with the Coal Mines Regulations.

69,000 K.V.A. of Turbo-Alternators.

The accompanying illustration provides an interesting indication of present activity in the building of power station units of large size. Both of the alternator stators are for complete 3,000 r.p.m. steam turbine and alternator sets in course of manufacture at the Rugby and Stafford Works of The English Electric Company. The stator in the foreground is for the 37,500 K.V.A. set which is being constructed for West Ham to the specification of Mr. F. W. Purse, the Chief Electrical Engineer to the Corporation. The turbine for this set will have a high-pressure cylinder and two low-pressure cylinders exhausting into a single-body "English Electric" condenser, which will be the largest of its type so far produced at Rugby, with a weight of some 100 tons.

The second stator is for the 31,250 K.V.A. turbo set under construction by the same Company for Leicester Corporation to the specification of the Chief Electrical Engineer, Mr. John Mould. It is also interesting



A 37,500 K.V.A. and a 31,350 K.V.A. Turbo-Alternators under construction.

to note that an "English Electric" set practically identical with the latter mentioned was recently ordered by Sheffield Corporation, under the advice of Mr. S. E. Feddon, before he relinquished the post of Chief Engineer and Manager to take up his appointment on the Mid-East England Scheme of the Central Board.

A.C. Gate-End Circuit Breaker.

The new A.C. Automatic Gate-end Circuit Breaker introduced by Mavor & Coulson, Ltd., exhibits many features of novel construction and special design to meet colliery conditions. In designing this circuit breaker, the common and more orthodox construction was ignored and the result has been to provide an equipment which it is believed will appeal to and be appreciated by those with first hand knowledge of gate end conditions, and who are responsible for the use and maintenance of gate-end circuit breakers and rely on their good service.

The equipment is not a mere adaptation of an ordinary feeder oil switch, arranged in the most economical manner to be in some degree movable, but it has been devised as a gate-end equipment from the beginning. Though price was to some extent held to be a secondary consideration, by studied detail design and adequate manufacturing facilities the new gear is available at prices comparable with those of gate-end circuit breakers of the usual pattern.

The gate-end circuit breaker is of 100 amps. capacity and suitable for medium pressure systems. It is of the automatic oil immersed type and flameproof in construction, having wide machined joints to the oil chamber, thus conforming to Regulation No. 132, and suitable for service in fiery mines.

The general construction is illustrated in Fig. 1. It will be seen that the equipment is skid mounted. The breaker unit is arranged to be lifted out of the tank, and thus the working height is less than would be the case if space had to be allowed for tank lowering; also the centre of gravity is kept low and the equipment can be flitted with more ease and safety.

Accessibility is ensured by the provision of suitable disconnectors, the breaker unit can be lifted out and supported on the tank for inspection and adjustment in a convenient position and without the collection of dirt. Moreover, the provision of disconnectors avoids the disturbance in any way of the permanent armoured cable or plug connections. Fig. 2 shows the gate-end circuit breaker open ready for disconnecting, and Fig. 3 shows the breaker unit withdrawn and supported on the tank for inspection.

If the overhaul required is such as cannot conveniently be carried out at the gate-end, the breaker unit can be removed to bank, the cover of the equipment being closed, and padlocked. There is no need to dig out sealing compound and disconnect armoured cable.

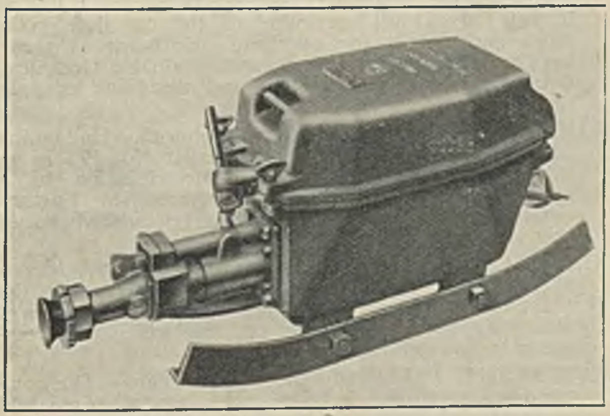


Fig. 1.

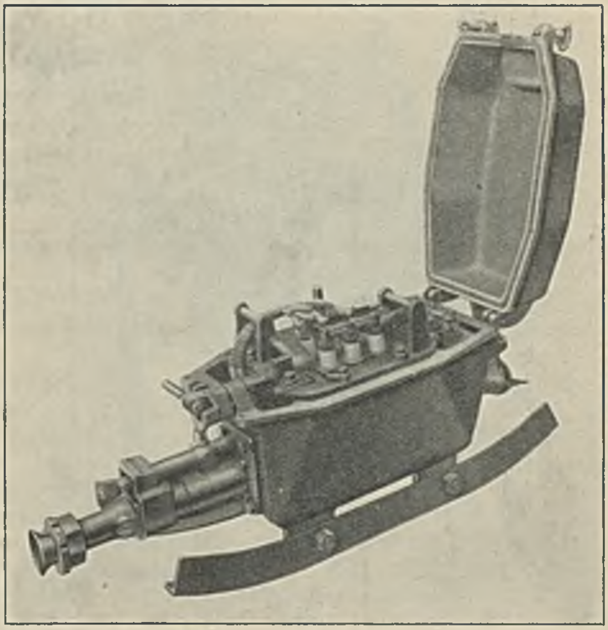


Fig. 2.

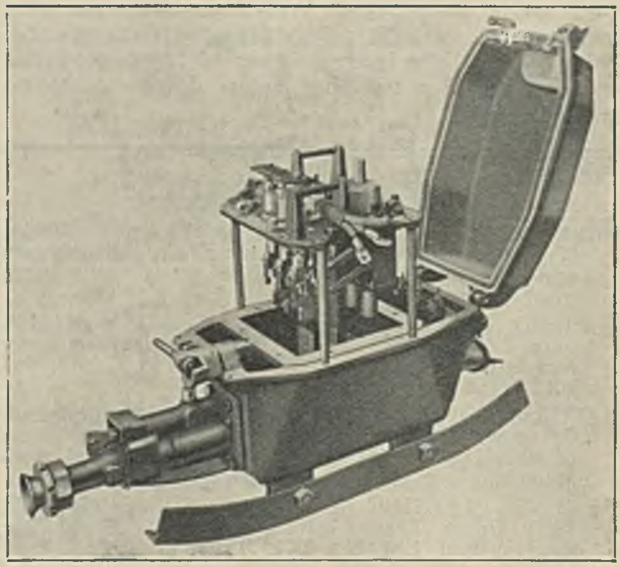


Fig. 3.

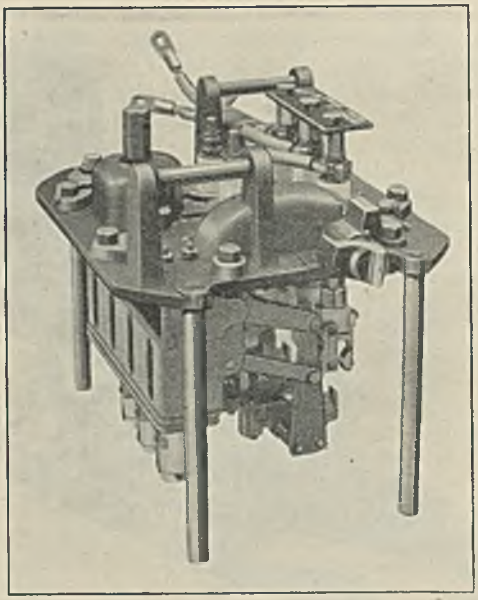


Fig. 4.

The breaker units are interchangeable and spares of these can be stocked instead of complete gate-end circuit breakers, as is the usual custom. Again, a breaker unit of lower rating can be substituted for a larger one if required. The breaker unit is shown in Fig. 4.

The gate-end circuit breaker can be supplied with two or three overload trips and no-volt trip can also be fitted if required. Leakage protection can be provided by the incorporation of core balance transformer with suitable trip. Either the makers' standard flat type plug or their design of B.E.S.A. plug can be fitted as desired.

As will be seen from Fig. 4, which shows the removable breaker unit, the mechanism is of sound construction, and a special feature is the type of contact employed. These contacts are of the controller finger type, spring loaded, with heavy renewable tips. The contact bar is of solid copper of heavy wedge section. This substantial construction allows of the circuit breaker being used for switching motors directly on to the line if necessary.

NEW CATALOGUES.

HEYES & Co., Ltd., Water Heyes Electrical Works, Wigan.—An interesting folder directs attention to particular features of the "Wigan" switchgear made by this firm.

ENFIELD CABLE WORKS, Ltd., 296/302 High Holborn, London, W.C. 1.—Two pocket price lists cover respectively "Enfield" V.I.R. Wires and Cables, and V.I.R. and pure rubber Flexibles.

MAVOR & COULSON, Ltd., 47 Broad Street, Mile End, Glasgow.—Details, general specification, and prices of the Gate End Switches, flameproof and non-automatic, are given in the Price List No. 46/4.

SIEMENS ELECTRIC LAMPS & SUPPLIES, Ltd., 38/39 Upper Thames Street, London, E.C. 4.—The Electric Fan List No. 201 is an illustrated Price List including electric fans for every situation and purpose.

BRITISH ALUMINIUM Co., Ltd., Adelaide House, King William Street, London, E.C. 4.—A series of loose-leaf data sheets for insertion in the "Aluminium Facts and Figures" handbook include:—

Two sheets of amplified tables of the properties of stranded aluminium and steel-cored aluminium conductors, revised in conjunction with the British Engineering Standards Association.

A new data sheet on expanded aluminium sheets. The metal in this form makes up into economical framing, backgrounds and screening, and a variety of light structural uses.

METRO-VICK SUPPLIES, Ltd., Trafford Park, Manchester.—The colour-printed folder No. 1450/5 gives many illustrations of the "Cadillac" Portable Electric Blower and its use in practice. Hundreds of these machines are in regular service in factories and works in this country. Particular attention is directed to the fact that the power of the latest type has been raised by about 30 per cent. and its efficiency as a universal factory cleaner thereby increased.

RELAY AUTOMATIC TELEPHONE Co., Ltd., Marconi House, London, W.C. 2.—"The Relay Recorder," number II., May issue, is as interesting and amusing in letter and sketch as ever. Work done for the B.B.C. and for Japan, in the way of automatic telephones are particular subjects selected for comment.

CAMBRIDGE INSTRUMENT Co., Ltd., 45 Grosvenor Place, London, S.W. 1.—An illustrated card gives general details and an illustration of the use of the Cambridge Optical Pyrometer.

LANCASHIRE DYNAMO & MOTOR Co., Ltd., Trafford Park, Manchester.—A leaflet summarises the history and activities of this Company and its associated companies.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2.—In sending forward several additional sheets for adding to the G.E.C. Blue Catalogue the Company advises that though the demand for the original catalogue has been very heavy there are still a few remaining.

The Aldwych House Automatic Motor Converter Sub-station, completely equipped by the G.E.C., is fully described in the illustrated leaflet No. 18. Other publications deal with the highly special features of Church Lighting, a branch of work in which the G.E.C. have been notably successful.

The G.E.C. "Magnet" Lampholders of metal, bakelite and porcelain patterns are the subject of a very complete bound catalogue.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancashire.—"Copperweld" wires and stranded wires are tough steel cores with a covering of pure electrolytic copper. Their characteristics and merits are discussed in a useful way in this folder.

"Pole Line Materials" published by the B.I. Co. is not only a full catalogue of the complete main items and details for overhead line work as made by the firm, but it gives much valuable technical data concerning the erection and designing of pole lines.

BRUCE PEEBLES & Co., Ltd., Edinburgh.—Under the title "A Modern Quarry," the leaflet No. 171 is an interesting description of the electrification of a quarry turning out road making material. Further details of the installation are given elsewhere in this issue.

GENT & Co., Ltd., Faraday Works, Leicester.—A broadsheet and a catalogue deal respectively with the "Tangent" Mining Specialities and with the Power Bells, Signalling Apparatus, etc., for which this Company is so well known.

WATERTIGHT FITTINGS, Ltd., Chesterfield.—The compendious catalogue includes many weather-proof and underground fittings of particular interest to mining and colliery men.