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Official Interpretation of the "General Regulations."

The "General Regulations as to the Installation and Use of Electricity", of the Coal Mines Act, 1911, are remarkably clear and understandable in view of the complex and extensive subject with which they deal. Whilst everyone will concede that to be true in a broad sense, there are few mining electricians who will not agree also that when certain practical questions arise the Regulations cease to be of help and may even become quite confusing. It is hardly conceivable that in the framing of rules to cover the innumerable possibilities of electrical services in mines, there should be no ambiguity. The common limitations of the inability of the pen to record the finer shades of the mind of the writer will always, in works of this description, result in some reader missing or misapprehending the intention of the writer. So it is that some of those for whom these rules have been formulated as a compulsory guide may be so mentally elastic that they can with easy conscience stretch the wording away from its intention—to excuse themselves, to save expense, to shirk responsibility, and so on. There is not infrequently, under the cloak of the Rules, the serious thwarting by the management of the electrician's honest endeavour; the distraction caused by the superlative salesmen whose shoddy and unsuitable goods are forced into the pit because of his assurance that they so perfectly comply with the Rules, and are so very cheap.

Happily for the peace of mind of many mining electricians who have put the measure to the test, H.M. Electrical Inspector of Mines has always been approachable and most helpful in times of difficulty. He has made it one of his special cares to guide enquirers as to the true meaning and real intention of the Rules. Great indeed therefore will be the satisfaction felt by every mining engineer and manager now that the Electrical Inspector has prepared a studied series of Explanatory Notes on the Rules.

At the price of sixpence this book is within the reach of everybody. It is indispensable to every man who has anything to do with mining electrical work; in fact it would hardly be emphasising its importance to suggest that, like a motor-driving license, it should be subject to compulsory production by every mining electrical man on official request. In any case, the responsible mining electrician who will not take the trouble to make himself thoroughly familiar with the contents of this book, issued under Governmental Authority, must be so careless of his own interests as to be altogether foolish; and, in regard to any genuine interests he may claim to have in the welfare of his fellows, he deserves a much harder epithet.

We note with satisfaction that these Explanatory Notes are not to be reprinted without special consent. Even were we permitted to reproduce them in full, or as extensive excerpts, we would not feel inclined to do so; for we hold that the nature of the book and its easy price warrant every man having his own copy. Nor would we, by giving our readers a skimming of the cream, wittingly afford them an excuse for not spending sixpence on the full delectable measure.

In particular the lucid expression of the author deserves every recognition. Simple axiomatic sentences drive the truth home. Dipping in haphazard, for example, we find "Initial excellence of plant is of little avail if maintenance is neglected", "Maintenance implies regular inspection and systematic tests", (Definite periods for the frequency of tests and inspections, as well as the nature of those tests and inspections for the various types of apparatus, are given in full—a pointer which has long been sought by the mining electrician). Then again: "An assertion of competency by the person appointed does not absolve his superior of responsibility", "Supervision by an electrician requires effective and actual oversight on the spot".

We may in rounding off these brief notes cull one more of the many golden axioms: "Generally, however, the precautions to be taken are obvious and require nothing more than the application of common sense". Arising from which quotation we are impelled to a further tribute of praise and recommendation that this book is redolent of "common-sense".

The A.M.E.E. Convention.

"London: June 24th to 28th". Will all members of the A.M.E.E. mark now their calendars and pocket diaries accordingly—for the Annual Convention this year is officially booked for that place and period. The preparation of the programme is already so far advanced as to warrant its publication and the provisional details will be found under "A.M.E.E. Notices" in this issue. The London Branch, assisted by their virile offspring the Kent Sub-Branch, are to enjoy the privilege of hosts on this occasion and it is hoped they will be accorded the fitting reward of an overwhelming attendance of fellow-members from every part of the Kingdom.

As will be seen from the programme, though London is to be the centre of operations the field covered will extend from Chelmsford to Brighton. The five days of the Convention are well planned to give a maximum of instructional value served with, weather permitting, the goodly seasoning of an invigorating holiday. Time was, in deciding upon the place for the annual meeting, when London was ruled out. London was considered as a place having no collieries and beyond the national coal boundary; moreover it was thought to be too expensively remote from Scotland, South Wales, and Newcastle—the homes of great Branches of the Association. But London is still the world's commercial centre and it is the headquarters of vast national and international mining and electrical interests and concerns. Recently, and very important too so far as the A.M.E.E. Convention is concerned, the Kent coal-field has grown to be typical of the most modern development of electricity in coal-mining on a large scale and over a wide area.

The great national and political interests in coal and electricity have also, incidentally brought to London many engineering concerns and individuals who, though they may not hew coal or be makers of electricity, are directly associated with mining and electrical issues of great moment. The rapidly increasing strength of the A.M.E.E. in London may perhaps also be due in some measure to these developments in the Capital. The London Branch of the Association has shown remarkable progress during the past few years, and was able to constitute a Sub-Branch for the Kent coal-field which branch has also gone ahead with great activity from the very beginning.

In regard to the objection that a London Convention is an expensive proposition for those who hail from remote coal areas, we may be permitted to put forward the suggestion that the employer of the mining electrician would find it worth his while to encourage his man or men to attend this meeting; and the real encouragement is to defray his expenses and grant him a week's leave. The mining electrical man is often so placed that rarely has he the opportunity of conferring with his fellows from other far-away districts; of seeing the electrical work and methods at other collieries in other coal-fields; of inspecting, and hearing experts explain, the manufacture and performance of the latest types of plant and apparatus; of broadening his views and extending his knowledge in those directions which are directly to the advantage of the colliery whose best interests he is pledged to serve.

That we are right in the contention that visitors to these conventions do take them as seriously instructional is proved year-by-year. As the venue of the meeting moves into different centres so there are seen very many electrical men from the mines in the immediate locality, all keenly interested in the business and technical elements. Often, however, there is but a sparse sprinkling of visitors from distant centres—and the main reasons for this waste of a unique opportunity for valuable experience are expenses and leave of absence. We strongly recommend these points to the joint consideration of the employer and his mining electrician.

Coal Miners Insurance Scheme.

In co-operation with its 1500 employees a group life insurance scheme has been adopted by the Taff Merthyr Steam Coal Co., Ltd.

The scheme became effective on January 31st, the Company paying all premiums until February 15th, from which date the life insurance amounting to £100 for each employee who has joined, will be paid for jointly by workers and employer. The cost to the workers will be 3d. weekly, the Company agreeing to pay the entire cost of the insurance above that figure. There was not long to wait for a vivid illustration of what this insurance scheme means to the workers. On February 6th, while the Company was still bearing the entire cost, one of the employees died suddenly and the life insurance of £100 was paid to his widow the next day.

The life insurance is offered without medical examination and is available to every employee without regard to age, sex, or physical condition. In the event of total and permanent disability of a member of the scheme before age 60 the full amount of the insurance will be paid directly to the insured worker in 40 monthly instalments of £2 12s. 6d. each.

In case of death from any cause, while a member of the scheme, the £100 will be immediately paid to the beneficiary named by the member. In the event of a member terminating his employment for any cause, an individual policy for the same amount will be issued, without medical examination, at attained age and rates, if application for such policy is made within 31 days.

The members of the scheme are entitled, without cost or deduction of any kind, to the Visiting Nurse Service where provided by the Insurance Company. In cases of sickness or disability competent trained nurses will call at the insured employee's home, assist in carrying out the doctor's instructions and give any possible aid. The nurse will only call at the direct request of the insured member.

The life insurance and other benefits provided under this scheme in no way supersede or take the place in any way of Workmen's Compensation, benefits under the National Insurance Act, or any other present benefits, but are entirely in addition thereto.

The scheme has been placed with the Metropolitan Life Insurance Company of New York, which is a mutual company without shareholders, entirely owned by its policy holders.

Characteristic Curves and Efficiency of Dynamos and Motors.

F. MAWSON.

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

THE characteristic curves of a dynamo or motor show for any particular speed the relation between the varying quantities "current" and "electrical pressure." To obtain the characteristic curve for any machine, it should be run on normal load for about a quarter of an hour so as to allow it to attain a steady state of temperature, and to see that the bearings, etc., are functioning properly. A suitable ammeter is connected in the external circuit and a voltmeter coupled across the machine terminals. The speed should be maintained as near constant as possible and the readings of the ammeter and voltmeter taken for various loads up to about 50 per cent. overload. A good method of artificially loading a generator for purposes of tests is by means of a wooden trough or old barrel, and two moveable metal plates, immersed in the water, to which should be added a slight amount of salt or soda. The plates should be as far apart as possible at the beginning of the tests, and brought nearer together to increase the load.

A curve is then plotted showing the relation between the varying voltage and the current in the external circuit. This curve is called the external characteristic of the machine for that particular (normal) speed. It is usual to test the machine at the rated speed of rotation.

Series Dynamo.

The following results were obtained in a test on a small series dynamo, running at 1000 revolutions per minute. The resistance of the armature is 0.415 ohm, and the resistance of the series field windings 0.254 ohm. These resistances were measured by the volt drop test when the machine was warm.

(1) Amperes.	(2) Volts.	(3) Volts lost in armature and field coils.	(4) Total Volts.
0	5	0	5
5	44	3.34	43.34
10	90	6.69	96.69
15	107	10.03	117.03
20	115	13.38	128.38
25	118	16.72	134.72
30	117	20.07	137.07
35	114	23.41	137.41

Columns (1) and (2) are obtained direct from the readings of the instruments; Column (3) gives the volts lost in the armature and in the field coils and is obtained by the use of Ohm's Law, $E = IR$, where E is the voltage drop, I the current in amperes, and R the resistance in ohms.

The total internal resistance of the machine is $0.415 + 0.254 = 0.669$ ohms This multiplied by the current, Column (1), gives Column (3) for each set of readings. Column (4) is obtained by adding (2) and (3) together, and gives the total volts generated in the armature of the machine.

Two curves should now be plotted; first the external characteristic, which is obtained by plotting the amperes Column (1) horizontal, and the volts Column (2) vertical. The second or total characteristic curve is obtained by plotting to the same scale—Column (1) horizontal, and the total volts Column (4) vertical.

It will be observed that the voltage increases with the amperes up to a certain maximum and then falls. This is due to the increase of current in the series field and, therefore, an increase of flux through the pole pieces. A point is reached where the pole pieces become saturated; after that the flux does not increase at the same rate as the ampere turns, and hence the rate of increase of voltage falls off.

Shunt Dynamo.

The following are the results of a test on a 1.5 k.w. shunt generator running at 1000 r.p.m. An ammeter is coupled in the shunt field circuit in addition to the ammeter and voltmeter connections as in the previous test.

(1) External Amps.	(2) Volts.	(3) Shunt Amps.	(4) Volts lost in armature.	(5) Total Amps.	(6) Total Volts.
0	108	1.55	0.64	1.55	108.64
5	104	1.50	2.70	6.50	106.70
10	100	1.44	4.75	11.44	104.75
15	95	1.37	6.80	16.37	101.80
20	87	1.25	8.82	21.25	95.82
24	76	1.09	10.80	26.09	86.80
26	62	.89	11.14	26.89	73.14
26.4	55	.79	11.30	27.19	66.30
24	25	.36	10.05	24.36	35.05

Columns (1), (2), and (3) are obtained from the readings of the respective instruments. The resistance of the armature, measured as before, was 0.415 ohm. Column (4) is the volts lost in the armature and obtained by adding Columns (1) and (3) together and multiplying by 0.415. Column (5) is the addition of Columns (1) and (3); Column (6) is the addition of (2) and (4).

The curves should be plotted in exactly the same way as in the previous case. The first curve Column (1) horizontal, and Column (2) vertical, giving the external characteristic curve; the second curve, Column (5) horizontal, and Column (6) vertical, giving the total characteristic curve for the machine.

It will be noted that this curve is entirely different from the previous one, the voltage continuing to fall gradually for a time and then very rapidly; in fact, the curve turns back on itself. This is because the external resistance is small compared with the shunt resistance and, therefore, practically all the current is flowing through the external circuit, allowing the field to collapse, with a resulting drop in the voltage of the machine.

Compound Dynamo.

Tests on a 1.5 k.w. compound wound dynamo running at 1000 r.p.m., under similar conditions to the previous one gave the following results. The resistance were—armature 0.415 ohm, series field 0.083 ohm.

(1) *External Amps.*	(2) *External Volts.*	(3) *Shunt Amps.*	(4) *Total Amps.*	(5) *Volts lost in series coils and armature.*	(6) *Total Volts.*
0	115	1.65	1.65	0.82	115.82
5	115	1.65	6.65	3.31	118.31
10	113	1.63	11.63	5.80	118.80
15	109	1.57	16.57	8.25	117.25
20	103	1.48	21.48	10.80	113.80
25	90	1.29	26.29	13.10	103.10

The shunt field was connected to one armature terminal and to the end of the series field, that is, long shunt. If short shunt, it should be connected directly across the armature terminals.

The working out of the results is similar to the previous two cases except that for Column (5) the two resistances; that is, the armature and series field, should be added together and then multiplied by the figures in Column (4).

Example experiment:—volts lost in series coil and armature $= (0.415 + 0.083)\ 6.65 = 0.498 \times 6.65$
$= 3.31$ volts.

The curves should be plotted in exactly the same way as in the previous cases. It will be noted that the curve line is fairly level falling a little towards the outer end. Students should plot the curves very carefully.

Taking the case of a compound generator as follows: shunt field resistance 50 ohm, armature resistance 0.005 ohm, and the series coils resistance 0.002 ohm when generating 200 amperes at 500 volts:—

The total external volts generated is 500, and therefore the current in the shunt field will be, from Ohm's Law,

$$E = I_s R_s \text{ or } 500 = I_s \times 50$$
$$I_s = 10 \text{ amps.}$$

Thus the total volts generated in the armature will be $\{(200 + 10) \times (0.005 + 0.002)\} + 500$

i.e., total amps. $\times$ Resistance of armature and series coils $+$ external volts $= 210 \times 0.007 + 500 = 501.47$ volts.

The watts lost in the armature will be equal to the current squared multiplied by the resistance.

Ohm's Law—$E = IR$ and Watts $= IE$
therefore Watts $= I^2R$
that is $210^2 \times 0.005 = 220.5$ watts.

Watts lost in series coil $= 210^2 \times 0.002 = 88.2$ watts

Watts lost in the shunt coil can be obtained in two ways—from

Watts $=$ current $\times$ volts $= 10 \times 500 = 5000$ watts
or Watts $= I^2R = 10^2 \times 50 = 5000$ watts

In all the above cases no account has been taken of the voltage drop in the brushes themselves, and this may be quite appreciable. It is difficult to allow for this as it usually decreases with the current density and depends upon the brush pressure, etc.

EFFICIENCY OF DYNAMOS AND MOTORS.

In every machine there are certain unavoidable losses. These are, firstly, the losses due to shaft friction, friction of the brushes on the commutator, and the resistance due to friction of air and the moving parts: secondly losses due to the heating of the armature and field coils arising from their resistance to the passage of the current (this loss is calculated as in the above example): thirdly, the losses due to eddy currents and hysteresis.

The efficiencies are classed under three heads: Electrical Efficiency, Commercial Efficiency, and Mechanical Efficiency.

The Electrical Efficiency is found by dividing the watts in the external circuit by the total watts generated in the machine. The Commercial Efficiency by dividing the watts in the external circuit by the total power supplied to the machine in watts. The Mechanical Efficiency by dividing the total watts generated in the machine by the total input work expressed in watts. It therefore follows that the Mechanical Efficiency is equal to the Commercial Efficiency divided by the Electrical Efficiency.

Taking the case of the Series machine which has an armature resistance of 0.415 ohm, and a series winding resistance of 0.254 ohm; in experiment 5 the external volts are 115 and the current 20 amperes: then, the total watts in the external circuit is $115 \times 20 = 2300$ watts. Watts lost in the armature and series coils will be

$$20^2 (0.415 + 0.254) = 400 \times 0.669 = 267.6 \text{ watts}$$

$$\text{Electrical Efficiency} = \frac{2300}{2300 + 267.6} = \frac{2300}{2567.6}$$

$= 0.896$ or 89.6 per cent.

Taking the friction losses to be equal to ½ h.p.

Watts lost in friction $= \frac{1}{2} \times 746 = 373$ watts.

$$\text{Commercial Efficiency} = \frac{2300}{2300 + 267.6 + 373}$$

$$= \frac{2300}{2940.6} = 0.783 \text{ or } 78.3 \text{ per cent.}$$

$$\text{Mechanical Efficiency} = \frac{2300 + 267.6}{2300 + 267.6 + 373}$$

$$= \frac{2567.6}{2940.6} = 0.875 \text{ or } 87.5 \text{ per cent.}$$

This may also be obtained by $= \frac{78.3}{89.6} = 87.5$ per cent.

In the case of the shunt machine, armature resistance 0.415 ohm, shunt resistance 69.5 ohm, generating 20 amperes at 87 volts and a frictional resistance equal to half horse power.

Output $= 20 \times 87 = 1740$ watts.

$$\text{Current in Shunt} = \frac{87}{69.5} = 1.25 \text{ amperes.}$$

Watts lost in shunt $= 1.25^2 \times 69.5 = 109$ watts.

Watts lost in armature $= (20 + 1.25)^2 \times 0.45$
$= 21.25^2 \times 0.415 = 187$ watts.

Watts lost in friction $= \frac{1}{2} \times 746 = 373$ watts.

$$\text{Electrical Efficiency} = \frac{1740}{1740 + 187 + 109}$$

$$= \frac{1740}{2036} = 0.856 \text{ or } 85.6 \text{ per cent.}$$

$$\text{Commercial Efficiency} = \frac{1740}{1740 + 187 + 109 + 373}$$

$$= \frac{1740}{2409} = 0.722 \text{ or } 72.2 \text{ per cent.}$$

$$\text{Mechanical Efficiency} = \frac{72.2}{85.6} = 84.4 \text{ per cent.}$$

The compound dynamo generating 20 amperes at 103 volts, armature resistance 0.415 ohm, series winding 0.083 ohm, shunt resistance 69.5 ohm, and a frictional resistance equal to ½ h.p.

Output $= 20 \times 103 = 2060$ watts.

$$\text{Current in shunt} = \frac{103}{69.5} = 1.48 \text{ amps.}$$

Watts lost in shunt $= 1.48^2 \times 69.5 = 152$ watts.

Watts lost in armature and series coils
$= (20 + 1.48)^2 \times (0.415 + 0.083)$
$= 21.48^2 \times 0.498 = 229$ watts.

Watts lost in friction $= \frac{1}{2} \times 746 = 373$,

$$\text{Electrical Efficiency} = \frac{2060}{2060 + 152 + 229}$$

$$= \frac{2060}{2441} = 0.844 \text{ or } 84.4 \text{ per cent.}$$

$$\text{Commercial Efficiency} = \frac{2060}{2060 + 152 + 229 + 373}$$

$$= \frac{2060}{2814} = 0.733 \text{ or } 73.3 \text{ per cent.}$$

$$\text{Mechanical Efficiency} = \frac{73.3}{84.4} = 86.8 \text{ per cent.}$$

The testing of motors is a very similar operation excepting that some form of brake arrangement must be made to test the brake horse power given out by the shaft.

The Electrical Efficiency is equal to the electrical horse power spent in producing motion divided by the total electrical horse power supplied.

The Commercial Efficiency is the output measured at the brake divided by the total input horse power supplied.

The Mechanical Efficiency is the output measured at the brake divided by the electrical horse power producing motion.

Let E = the pressure of the supply at the terminals of the motor.
e = the back EMF of the motor.
I = current supplied to the motor.
W = power lost in friction, etc.
I_a = current in the armature and series coils.
I_s = current in the shunt coils.

In a Series Motor :—

$$\text{Electrical Efficiency} = \frac{Ie}{IE}$$ as the current is the same throughout $= \frac{e}{E}$

$$\text{Commercial Efficiency} = \frac{Ie - W}{IE}$$

$$\text{Mechanical Efficiency} = \frac{Ie - W}{Ie}$$

Shunt Motor :—

$$\text{Electrical Efficiency} = \frac{I_a e}{(I_a + I_s) E}$$

$$\text{Commercial Efficiency} = \frac{I_a e - W}{(I_a + I_s) E}$$

$$\text{Mechanical Efficiency} = \frac{I_a e - W}{I_a e}$$

Compound Motor :—

$$\text{Electrical Efficiency} = \frac{I_a e}{(I_a + I_s) E}$$

$$\text{Commercial Efficiency} = \frac{I_a e - W}{(I_a + I_s) E}$$

$$\text{Mechanical Efficiency} = \frac{I_a e - W}{I_a e}$$

Taking the case of a series motor with a back E.M.F. of 420 volts when supplied with 100 amperes at 450 volts and 1 horse power expended in friction.

$$\text{Electrical Efficiency} = \frac{420}{450} = 0.934 \text{ or } 93.4 \text{ per cent.}$$

$$\text{Commercial Efficiency} = \frac{100 \times 420 - 746}{100 \times 450}$$

$$= \frac{42000 - 746}{45000} = \frac{41254}{45000} = 0.916 \text{ or } 91.6 \text{ per cent.}$$

$$\text{Mechanical Efficiency} = \frac{41254}{100 \times 420} = \frac{41254}{42000}$$

$$= 0.98 \text{ or } 98 \text{ per cent.}$$

Total watts used = 450 × 100 = 45000

$$I^2 (R_a + R_m) = 100^2 \left(\frac{450-420}{100}\right) = 3000$$

Brake Horse Power =

$$\frac{450 \times 100 - 100^2\left(\frac{450-420}{100}\right) - 746}{746}$$

$$= \frac{41254}{746} = 55.3 \text{ horse power.}$$

NEW BOOKS.

H.M. STATIONERY OFFICE.

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

MINES DEPARTMENT.—THE USE OF CHAINS AND OTHER GEAR FOR HAULING AND LIFTING with Chart shewing temperatures and approximate colours for operations on mild steel and wrought iron, and with thirty-three figures shewing designs of hooks, links, bolts, shackles, etc. Prepared under the direction of H.M. Chief Inspector of Mines. Price 6d. nett.

This, the Mines Department Safety Pamphlet No. 6, has been prepared, under the direction of the Chief Inspector, with the object of presenting as concisely as possible detailed information (at present only available by reference to numerous text books and other publications) as to the best existing practice in design, conditions of use, and treatment of mine lifting and hauling gear other than ropes. Two papers recently published by the Safety in Mines Research Board contained detailed information and practical guidance respecting wire ropes for mining purposes. The present pamphlet deals with such important appliances as cage chains, tub couplings, detaching hooks, etc.

In addition to useful formulæ and data for calculating loads and factors of safety, it contains information of practical value in regard to the choice of materials for particular purposes, their adaptation for use, and their deterioration in service.

The Chief Inspector of Mines, in a foreword, appeals to all mine managers and other officials to study the book, and says that the careful application of the principles described will undoubtedly assist in the cause of safety.

As indicating the ground covered in some fifty pages the following Summary of Precautions which concludes the pamphlet will be useful and interesting.

(1) Chains and other appliances used for lifting purposes should be obtained from reliable manufacturers. Where life may be endangered by their failure, the quality of the material should be specified to British Standard or other high-class specification.

(2) In general, the equivalent dead load applied should not induce stresses beyond the yield stress. The extra cost of a larger size is small compared with the loss in case of failure.

(3) Area of wearing is as important as the stress. Avoid local high stresses by providing ample area of contact.

(4) A test certificate should be obtained showing the breaking load of samples of the finished article, and the elongation and reduction of area between the maximum equivalent dead load recommended and the breaking load.

(5) Every chain or appliance used on important work should be marked with an identifying number, and a record should be kept of the history of the appliance.

(6) The maximum load to be suspended from a chain, &c., having regard to the nature of loading, should be posted where it is accessible to the user.

(7) In addition to those examinations required by law, it is wise to have periodical expert examinations of important appliances.

(8) The heat treatment of the material should be given particular attention.

MINES DEPARTMENT.—GENERAL REGULATIONS AS TO THE INSTALLATION AND USE OF ELECTRICITY WITH EXPLANATORY NOTES by H.M. Electrical Inspector of Mines. Mines and Quarries Form No. 11. Price 6d. nett.

The Contents include: Part I. being the General Regulations for Below Ground and Above Ground; Part II. Explanatory Notres applicable to apparatus below ground and above ground (except as restricted by textual notes), and Explanatory Notes applicable to apparatus above ground only; Appendix I. excerpt from the Regulations of the Electricity Commissioners concerning Overhead Lines; Appendix II. the B.E.S.A. definitions of Flame-proof Enclosure; Appendix III. Signalling Circuits; also a complete Index to the subjects covered by the Memorandum of Explanatory Notes in Part II.

This being in the nature of an official interpretation of the "Regulations" makes instant appeal to every colliery engineer and mines manager. It is unique as a practical guide and safeguard. A leader in this issue presents other comments and urges every man directly interested in the electrical end of mining to make himself perfectly acquainted with this book of "golden advice."

The Wear and Tear of Superheaters.

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

THE advantages of superheated steam for colliery work are so great that it is not surprising large numbers of collieries have installed superheaters within recent years.

Like the boilers with which they work, superheaters suffer wear and tear from one cause or another as time goes on.

There are several causes of wear and tear, but the principal cause is overheating, which is liable to give rise to a number of troubles.

Modern superheaters are mostly constructed of mild steel. The strength of this material increases with temperature up to about 550° Fah., but it rapidly diminishes with further increase of temperature, the strength at 1200° Fah. being only about one-third of the maximum strength.

Now the conditions under which superheaters work are very severe. Thus the structure is placed directly in the path of furnace gases whose temperature is not usually less than 900° Fah., and in some cases as high as 1500° Fah.; the internal surfaces are not protected by water, but merely by steam, the temperature of which varies from approximately 350° Fah. at the inlet to usually not less than 500°, and in some cases as much as 700° or more, at the outlet. It may therefore be easily imagined that unless the conditions of working are maintained satisfactory, overheating may readily occur.

Heavy firing of the boilers, by producing unduly high furnace temperatures, not infrequently leads to overheating; and experience has shown that when the steam produced is highly superheated the trouble is very liable to present itself.

Perhaps the most common cause of overheating is the practice of passing the hot gases into the superheater chamber at times when there is no steam passing through the superheater.

A difficulty in this respect naturally occurs with the ordinary superheater when steam is being raised in the boilers. In the case of an independently-fired superheater, no difficulty arises because the firing of the superheater may be delayed until steam has been raised, but the case is different with the ordinary superheater which is placed in some part of the boiler setting.

The standard type of boiler at collieries is the Lancashire, and with this type the superheater is placed in the down-take, where the temperature of the gases is not very high. In such cases, it is not usually necessary to take any special measures to guard against overheating, because the water of condensation which has accumulated during the previous stoppage affords a certain amount of protection.

When, however, the gases are of very high temperature, some means of protecting the tubes when steam is being raised becomes absolutely necessary. One method of doing this is to provide a damper arrangement whereby the hot gases can be bye-passed at times when there is no steam passing through the superheater. The objection to this arrangement, however, is that the working parts of the damper arrangement soon become distorted by the heat, and so rendered more or less inoperative.

Another method of protecting the tubes is flooding the superheater. There are, however, certain objections to flooding. In the first place, unless all the water is effectively removed before the steam is passed through the superheater, there is considerable risk of water hammer being set up, a danger which is well-known to all concerned with steam plant. Another objection is that if the water contains scale-forming matter the internal surfaces of the tubes will sooner or later become coated with scale, when the tubes will be liable to suffer from the very trouble which the flooding is intended to prevent.

Serious deposits of scale in superheater tubes have in some cases been caused by priming in the boilers, in consequence of which large quantities of water have been carried over to the superheater. In one case the deposit was so heavy that some of the tubes were practically choked up. The affected tubes were badly burnt, a few of them being actually perforated.

One other cause of overheating may be mentioned, i.e., taking large quantities of saturated steam from the boiler, so that only a comparatively small amount is left for passing through the superheater, the result being that there is insufficient steam to carry the heat away fast enough to prevent overheating. It is a common practice to have a saturated steam connection on a boiler working in connection with a superheater: where this arrangement is in use, it is well to bear in mind the possibility of causing overheating in the superheater if too much steam be taken through the saturated steam connection.

The general effect of overheating in a superheater is to cause weakening of the metal, bulging of the tubes, oxidation and wasting, and in the case of welded tubes, possibly failure at the welds.

When the metal of which the tubes are constructed is raised to a sufficiently high temperature, it becomes weakened to such an extent that it is unable to resist the internal pressure, and the tubes are thus liable to bulge, and in serious cases rupture.

It is well known that mild steel when heated sufficiently and exposed to moisture oxidises and gradually wastes away, and these conditions obtain in the case of superheater tubes which are allowed to get overheated, since there is steam inside the tubes, and furnace gases containing moisture outside. Hence overheating may lead to both external and internal wasting.

It should be realised that superheater tubes are only thin, so that a slight amount of wasting may render them unsafe for the pressure. It is thus advisable to examine the tubes frequently for evidence of overheating or other troubles.

When overheating occurs the tubes are liable to become coated with a reddish coloured oxide on their external surfaces, and the discovery of such oxide should generally be regarded as an indication of overheating, and steps should be taken to find out the cause of the trouble. The affected tubes should be calipered at a number of places with the object of discovering if any appreciable amount of wasting has taken place. Indications of bulging should be looked for, and if any bulged tubes are discovered, they should be renewed immediately, because such tubes may fail at any time under the steam pressure.

Localised overheating frequently occurs through the accumulation of soot at certain parts of the superheater, notably about the ends of the tubes where these are expanded into the boxes.

This localised overheating is mostly met with in superheaters where the tubes are arranged horizontally, as in the case of water tube boilers; with the vertical tube arrangement, there is little tendency for soot to accumulate about the tube ends. The overheating is most likely to occur just after the plant has been shut down, for the soot constitutes a red hot mass, the heat from which cannot be readily carried away since there is no steam flow after shutting down.

A further objection to these soot accumulations is that they become damp during the periods when the plant is not working, and they are thus liable to cause external corrosion in the manner indicated by the accompanying diagram, Fig. 1.

External corrosion not infrequently occurs as a result of leakage at the tube ends. All leakages should, therefore, be staunched without delay by expanding the ends.

Internal corrosion in superheaters is comparatively rare. It is sometimes met with in the bends of the

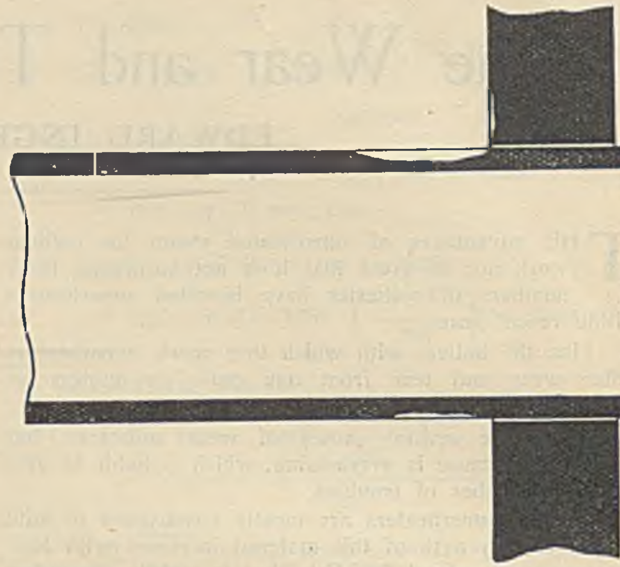

Fig. 1.

tubes, the result of accumulations of water there. Owing to the inaccessibility of the tubes, it is difficult to discover internal corrosion by visual inspection. Wasted parts can, however, be detected by careful hammer testing.

Most insurance companies advise occasional hydraulic testing of superheaters with the object of discovering seriously weakened tubes. There are some engineers who object to the hydraulic test on the ground that it may aggravate defects without revealing their existence, which is certainly a possibility. If, however, the test be applied judiciously, and if the test pressure be not greatly in excess of the normal working pressure, there is little doubt that it is of great use in discovering weak parts in inaccessible pressure vessels such as superheaters.

First-aid in Electrical Accidents.

The following extracts from *The Lancet* of February 8th last, are so valuable that they could with great advantage be distributed broadcast in every mine and factory.

It cannot be too widely known that electric shock hardly ever causes death outright. Dr. D. Pometta, principal medical officer of the Swiss Accident Insurance Institute, has recently given a useful resumé* of the various methods of treatment which will probably save the victim's life if applied promptly and patiently.

Such measures should be as familiar as the first-aid treatment of the common forms of poisoning, and the practitioner living in a district where accidents of this kind are particularly likely to happen will do well to have his apparatus packed in a special case ready to take up at a moment's notice. He should put aside all other work to answer the call to an electrical accident immediately, and should be prepared to stay by the patient for several hours. As soon as the victim has been removed from the danger zone, his mouth should be freed from dirt and any other obstacle to respiration, such as artificial teeth, and clothing should be removed from the upper part of the body, preferably cut off to save time. He should be kept warm with blankets and hot-water bottles or heated bricks, but zealous assistants must be warned of the danger of causing burns. The face and chest may be splashed with water, the limbs and cardiac region may be massaged, and cardiac and respiratory stimulants such as lobeline may be given subcutaneously; but none of these secondary requirements must delay or interrupt artificial respiration—the essential treatment—for more than a few seconds.

While pointing out that prompt and correct application is more important that the choice of any special form of artificial respiration, Pometta prefers the Sylvester method. Here he is in a minority, for most authorities agree with Prof. S. Jellinek† in recommending Schafer's method. He regards manual methods as better than mechanical, but says that apparatus may be useful to replace assistants when everyone is tired out.

Carbon dioxide is a valuable respiratory stimulant, and can be given from a soda-water syphon when no cylinder is available. The syphon is half emptied and a rubber tube is attached to its nozzle; it is then inverted and the fluid is blown out of the glass tube. Gas is admitted to the patient's air passages through one nostril while artificial respiration is maintained continuously.

Unless the patient's other injuries are so severe that he cannot possibly be alive, artificial respiration must be continued for at least five hours, and the absence of the sounds of heart or respiration or of the corneal reflex are no indication that he is dead.

* *Schweiz Med. Woch.*, 1930, iv., 82.

† See *The Lancet*, 1927, ii., 1001; 1928, ii., 314.

Proceedings of the Association of Mining Electrical Engineers.

SOUTH WALES BRANCH.

Elementary Principles of Electrical Measuring Instruments.

ROWLAND H. MORGAN.

(*Continued from page* 302.)

The Induction Type.

Induction instruments depend for their action upon the interaction between the fields of producing, or primary, currents and the opposing fields of currents induced in a movable element and are thus solely suitable for use on alternating current circuits.

Figure 23 illustrates an induction instrument which gives accurate results under all normal conditions. It is similar in principle to the rotating field induction motor. The combined effects of two magnetic fields produces a rotating field and a turning movement is established by the mutual reaction between this field and the fields of the currents induced in a closed cylindrically shaped secondary capable of movement. The effect of a rotating field is equivalent to that produced by a pair of magnet poles placed at opposite sides of a copper or aluminium cylinder with the magnet poles revolving round the cylinder. Referring to Figure 24 assume that at an instant the poles are as shown and that the poles are revolving clockwise. The same inductive action would obtain if the cylinder revolved anti-clockwise for the relative motion of field to cylinder would be identical. Such a movement would set up eddy currents in the cylinder under the pole as shown and oppose the relative motion as in the case of the eddy current brake previously explained. If now the field is rotating round the cylinder the opposition to the change will tend to cause the cylinder to rotate with the moving field.

The necessary rotating field can be set up by a combination of the fields produced by two currents which differ in phase by 90° and whose fields therefore are also in quadrature. Figure 25 gives two curves which may represent the fields produced by two alternating currents C_A and C_B of the same frequency and magnitude and which differ in phase by 90°.

From these curves the clock diagram given in Figure 26 may be obtained, in which the field due to the current C_A is represented as travelling along the horizontal line X_1 — X_2, increasing towards X_1 and decreasing towards X_2; the field due to the current C_B being similarly represented as travelling along the vertical line Y_1 — Y_2 increasing towards Y_1 and decreasing towards Y_2. When the field produced by C_A is at a maximum that of C_B is zero, so the resultant field will be along O — X_1 and have a strength comparable with the length of line O — A. As the field due to C_A decreases, the field due to C_B increases. Taking points A_1 and B_1 on the curves, the respective field strengths will be represented by the lengths O — A_1 and O — B_1 on the lines O — X_1 and O — Y_1 respectively. The combination of these two fields gives the resultant of O — R_1.

Repeating this process for the curve points A_2 and B_2, it is seen that the field of C_A has further decreased, giving O — A_2 and that of C_B still increased, giving O — B_2, from which the resultant O — R_2 is obtained. Another resultant, O — R_3, is produced by a further decrease in the field of C_A to A_3 and an increase in the field of C_B to B_3.

Next, taking the point where the field of C_B is a maximum and that of C_A zero, the resultant is given as O — R_4, that is, O — B. Developing this for the complete cycle gives further resultants of R_5, R_6, and so on, showing that the resultant field of two similar fields in quadrature is a rotating field with constant strength.

It can be similarly shown that if the fields are not in quadrature, are not equal, and do not follow a simple sine curve, a rotating field is still produced but the result will not be a constant rotating field but will depend upon the conditions obtaining in and between the component fields. The necessary fields having a phase displacement of about 90° are obtained for use in voltmeters and ammeters by splitting a phase by the introduction of much inductance in one portion of the phase whilst keeping the other portion very non-inductive or by utilising the field of a secondary winding which is almost in quadrature with the field of its primary winding.. In the case of a wattmeter an adjusting device is incorporated to attain the necessary phase difference in the respective fields.

Referring to Figure 23, which as illustrated is for service as a voltmeter, the windings A — A are in series with a high non-inductive resistance and the windings B — B in series with a choking coil so that the phase difference may be provided from which a rotating field is obtained which imparts motion to the aluminium cylinder. The cylinder is controlled by a spiral spring and its deflection will depend upon the resulting rotating field force of the two component fields and will promote a square law indication which however, can be evened out by shaping of the cylinder.

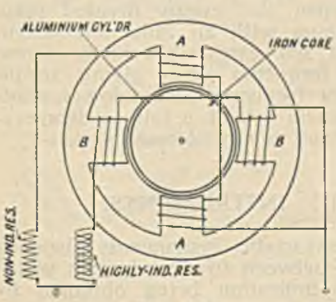

Fig. 23.

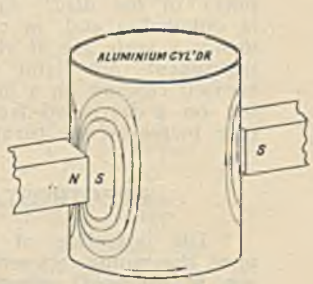

Fig. 24.

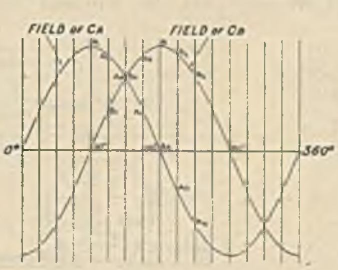

Fig. 25.

Fig. 26.

For an ammeter the coils would be wound with high section low inductance and small section high inductance coils respectively with one end of each pair of coils taken to the instruments terminals as in the voltmeter, and for a wattmeter one pair would be current coils and the other pair pressure coils. Damping may be obtained by the placing of the poles of a horse shoe or similar shaped permanent magnet near to a projecting part of the cylinder.

A development incorporating the transformer principle is shown in Figure 27. The main laminated iron core carries two windings, a primary and a secondary. The primary induces a current into the secondary and also provides a field across the aluminium cylinder, from pole to pole of the main laminations. Between the main poles is a permanently fixed cruciform core around which the cylinder is pivoted. On two polar projections of the core are mounted a winding energised by the secondary winding. The main field produced by the primary current will differ in phase from the field produced by the secondary on the core by almost 90° so giving rise to a rotating field. Motion of the cylinder is thus obtained in which the torque will be proportional to the square of the current, from which a more open and evenly divided indication may be obtained by suitably shaping the cylinder. The movement is spiral spring controlled and damped by a permanent magnet.

Frequency and temperature errors are corrected by a non-inductive shunt placed across the primary winding. A wattmeter on the same principle is shown in Figure 28. The main laminations carry the potential coil and the core the current coil. A compensating winding which is closed through a resistance is placed across the main laminations, the resistance being adjusted to obtain quadrature of the fields. The rotating field resulting produces a torque and the deflection is proportional to the power in the circuit. This class of instrument is very accurate and little affected by normal temperature and frequency variations.

A shaded pole instrument is shown in Figure 29. This consists of a rectangular laminated core carrying the energising coil of low resistance in an ammeter and of high resistance in a voltmeter. An aluminium disc's periphery is arranged to pass through a narrow gap in one side of the main laminations. Each pole face has one half surrounded by a shading ring of copper. On energising of the coil, the main field is divided up, one portion passes through the shaded part of the limb and the other through the unshaded part. That through the shaded portion lags behind the main field due to the eddy currents set up in the shading ring, and a moving or gliding field is thus produced passing from the unshaded to the shaded portion. This results in a torque being produced in the disc and the deflection will be proportional to the square of the current. Suitable shaping of the disc tends to promote a more even and openly divided scale. Such instruments as a class may have considerable frequency and temperature errors. A rise in the frequency strengthens the eddy currents and increases the torque, and a rise in temperature increases the resistance of the disc and so weakens the eddy currents and gives a lower torque. Whilst the use of a non-inductive and high temperature coefficient

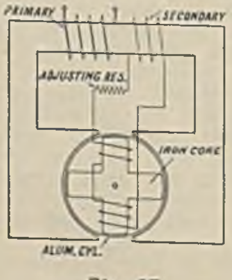

Fig. 27.

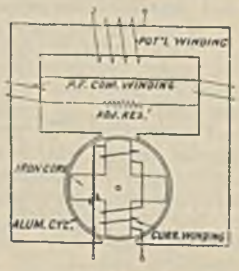

Fig. 28.

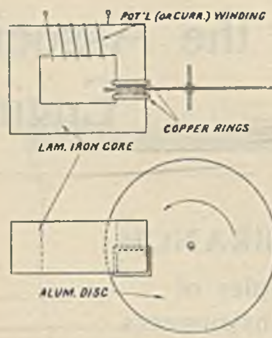

Fig. 29.

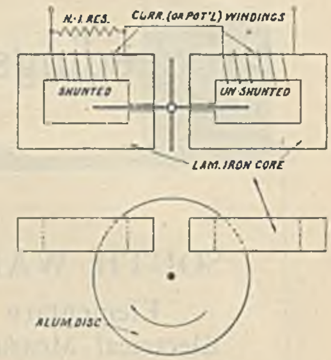

Fig. 30.

shunt on an ammeter reduces these errors, the result does not give great accuracy.

A development of this type which gives great freedom from both frequency and temperature error is shown Figure 30. Two distinct windings and laminations are used and the main current to one split into two parts with a phase difference of about 90° between by shunting one winding with a non-inductive resistance as given in Figure 31. With an increase of frequency the current in the shunted winding will decrease and its field weaken proportionally to the increase of the eddy currents, thus nullifying the change of frequency. The disc and shunt being of the same temperature coefficient material, an increase in temperature reduces the eddy currents in the disc in the same proportion that the current in the shunted winding, and therefore its field, increases due to an increase in the resistance of the shunt. The resulting indications give an almost straight line scale and are remarkably free from errors over a wide range.

The repulsion type of induction meter has a rectangular laminated iron core carrying a single winding whose construction depends upon whether the instrument be used as an ammeter or voltmeter. An aluminium disc is pivoted so that a portion of its periphery lies in a narrow gap in the main laminations, and the varying field in the gap induces eddy currents in the disc. These induced currents lag more than 90° behind the main current for the induced e.m.f. in the disc is 90° behind the originating current and the induced currents in the disc lag a certain amount behind their e.m.f., giving the induced currents a tendency to oppose the influence of the main current.

If the disc were symmetrical, the forces between the main field and the eddy currents would balance and no deflection would result. The disc is therefore shaped so that unequal paths are provided for the eddy currents by varying its surface area or its thickness. This difference in resistance gives the eddy currents on either side of the pole faces an uneven repulsion and the stronger eddy currents tend to move out of the main field and thus causes the disc to rotate so that the thick or wide portion leaves the gap. Control is provided by spiral spring or gravity and damping provided by sliding a permanent magnet over a point on the periphery of the disc. An open and evenly divided scale is obtainable and, in common with all induction instruments, a scale arc of about 300° can be provided. These instruments are liable to frequency error giving an increased reading on a higher frequency and a lower reading on a decreased frequency, whilst a fall in temperature increases the torque and a rise decreases it.

ELECTROSTATIC INSTRUMENTS.

The operation of electrostatic instruments depends upon the mutual attraction between two conductors which are at different potential, indication being obtained by permitting one conductor to be capable of movement.

Referring to Figure 32, should the movable vane and the fixed plates be respectively connected to two points at different potentials, the vane and plates become charged to this potential difference and the electrostatic attraction between them tends to draw the vane between the plates. The charge given to either is equal to the capacity multiplied by the potential difference, that is, the quantity is proportional to the potential difference. Consequently, the doubling of the potential difference doubles the charge on both vane and plates. As the force between two charged bodies is proportional to the product of the charges it follows that by doubling the charge on each, the force between is increased fourfold. Therefore, the force of attraction is proportional to the square of the potential difference, and promotes an unevenly divided scale. Furthermore, the permitting of the attraction to exert itself increases the electrostatic capacity, resulting in an increased charge and, consequently, attraction.

Various patterns following the principle outlined are obtainable; in some, the fixed and moving conductors are part cylindrical, and in others the moving system consists of many vanes arranged to travel between a correspondingly increased number of fixed plates. The use of a larger number of plates and vanes provides a greater deflecting force, enabling comparatively low pressures to be accurately measured.

As the attractive force for a given potential difference is the same and in the same direction, whether the vanes or plates have the higher potential, electrostatic instruments may be used on alternating or direct current, giving equal accuracy on both. As a considerable potential difference is, in general, necessary for their operation, they are confined chiefly for the measurement of pressure, but are in rare cases used as ammeters in conjunction with a transformer or shunt. The difficulty of obtaining other than small operating forces emphasises frictional errors. Increasing the deflecting force by minimising the clearance between the fixed and moving parts is attended by the danger of an increased pressure causing sparking between the plates and vanes. Damage from such sparking is usually guarded against by such devices as series resistances, range-varying condensers, fuses and spark gaps or liquid resistances which boil away under abnormal conditions and open the circuit. Electrostatic instruments are liable to be affected by adjacent electrified bodies, but are unaffected by external magnetic fields and have no frequency error. As their action does not entail the actual passing of current through them, they have no temperature error and a negligible consumption. For special work, such as battery testing, or where a constant pressure is essential such instruments are ideal, for they neither cause polarisation nor alter the potential difference. Some instruments are constructed so that the distance between the fixed and moving parts can be adjusted, thus giving a variable range.

HOT WIRE INSTRUMENTS.

Hot wire instruments of the expansion type depend for their operation upon the heating effect of a current and upon the expansion of an alloy when heated. The heating effect of a current is in proportion to the square of the current and the conductor's resistance. By using a conductor whose resistance does not alter with a change in temperature, the heating becomes proportional to the square of the current. If this zero temperature coefficient conductor be in the form of a uniform wire its expansion will be proportional to its heating. Thus the expansion of the wire conductor becomes proportional to the square of the current passing through it.

As the sag resulting from the elongation of the wire is greater than the actual increase in length it is customary to make use of this means of magnifying the elongation. Figure 33 illustrates simply the arrangement of a hot wire instrument in which increased indication is obtained through measurement of a two stage sag. In addition to the multiplication a more even scale is obtained than is offered by measuring the simple elongation which tends to follow a square law. The active wire, often of platinum silver, is stretched on the horizontal between two pillars A and B which in this case may be considered the terminals of the instrument. At a point C is attached one end of a phosphor bronze wire, its other end being insulated and anchored under tension at D. At a point E on the latter wire is attached a silk fibre which passes around the groved pulley F and thence to a flat steel spring G which keeps the whole arrangement taut. An increase in the length of the active wire is thus taken up eventually by the tension spring G in the course of which the pulley F revolves and carries with it a pointer which is attached rigidly to the pulley.

Instruments of this type are adaptable for use as ammeters and voltmeters and are suitable for use on either alternating or direct current circuits. When used as an ammeter a shunt is employed and the wire divided into two or four equal parts so that parallel paths are provided for the current and the potential difference across the instrument greatly reduced. It is essential that the temperature co-efficient of the shunt be identical with that of the active wire or the shunt to active wire resistance ratio will not be constant. Fig. 34 shows the splitting up of the wire into four parallel paths by means of connecting springs or thin silver foil attached to the points X, Y, and Z, X and Z being connected to one terminal and Y and the two ends of the active wire to the other terminal. When employed as a voltmeter a series resistance of low temperature coefficient is incorporated.

Variation in the length of wire due to change of temperature of the surrounding air has to be compensated for. In the type of instrument illustrated this is done by fixing the wire support pillars A and B on a common bedplate of such a material that its expansion, due to a given rise in temperature, will be equal to the expansion of the active wire. This method has a drawback in that the wire attains its new length much quicker than does the base plate. Another method of compensating for temperature variations is to use as the active wire one of two similar wires. One end of each is attached to a separate supporting pillar with the two other ends joined together to a flat steel spring. The one wire varies with change of temperature only, and is always kept under tension by the spring. The expansion of the active wire due to the passing of current is not taken up by the spring as the second wire remains at its normal length and so prevents

Fig. 31.

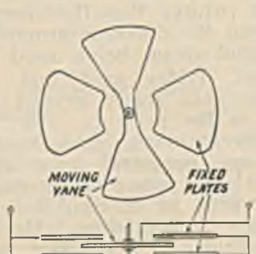

Fig. 32.

Fig. 33.

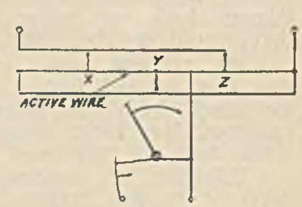

Fig. 34.

movement of the spring. Temperature variations, therefore, affect both wires and they are kept stretched in the same degree by the flat steel spring to which they are both anchored.

The continued pull on the moving system by the main tensioning spring may result in a slight variation of the position occupied by the pointer when no current is passing from elongation of the active wire, so a zero adjustment becomes necessary. This is usually incorporated in one of the active wire supports and may take the form of a screw, passing through the support, holding against the pressure of a small flat spring to which the active wire is coupled. Adjustment of the screw, which can be turned from the outside of the case, permits the spring to take up any incorrect sag.

The instruments are inclined to be sluggish in their action, due to the time taken by the wire in attaining the final temperature corresponding to a certain current. In spite of this it is customary to fit a damping device, usually of the eddy current type, the effect of which is really more useful in preventing a rapid return of the moving system to zero than in damping out working oscillations.

Such instruments are unaffected by stray magnetic fields and the lack of iron and shape of the active wire eliminates hysteresis and self induction errors. To obtain measurable elongation, the wire is highly loaded and liable to fuse on overload. The instruments have a relatively large power consumption and are of large overall dimensions. Their disadvantages outweigh their advantages for general application and consequently they are seldom now installed.

(*To be continued*).

WESTERN DISTRICT SUB-BRANCH.

The Problem of Peak Loads.*

Discussion.

THE CHAIRMAN (Mr. S. T. Richards) said they had had a most interesting and instructive paper from Mr. Hider, and were extremely indebted to him for his trouble. It was a great pleasure to them to welcome the Branch President, Mr. Hannah, a gentleman who has done a great deal of work to better the lot of the mining electrical engineer. He also welcomed one of their past Presidents in the person of Mr. Theodore Stretton, and another distinguished member of their Association, Mr. Haslam, now President of the Western Centre of the Institution of Electrical Engineers.

Mr. ISAACS said the author had covered a wide field dealing as he had with peak loads of seconds', minutes', and hours' durations and undoubtedly it was a problem to which more attention should be given. He suggested that Mr. Hider had looked at this problem too much from the narrow point of view of the combustion engineer instead of viewing the whole position. It might be that thermal storage systems were the economic solution in certain cases as things were at present, but it must not be lost sight of that all systems of energy storage had a running cost whether they were being called upon to supply peaks or not. The present trend seemed to indicate that in future peak loads would be thrown back on power stations of such a size that they would not be troubled by them.

Mr. HIDER—with reference to Mr. Isaacs' suggestion that he had looked on the problem of peak load too much from the point of view of the combustion engineer, Mr. Hider pointed out that he had discussed actual facts as they exist in power stations to-day.

Efficiency of combustion was not of primary importance in this matter, as Mr. Isaacs would be the first to agree that the matter related to the efficiency of utilisation of steam rather than to efficiency of generation.

He agreed with Mr. Isaacs entirely that it should not be lost sight of that the ideal position to aim at was 100% load factor. Even when that ideal was reached there would be many industrial concerns in which it would be more economical to generate their own power, simply because process steam was so related to power production that pass out turbines could be employed.

In his opinion, even though a super power station be operating on an extremely favourable load factor, current could not be supplied to such a works more cheaply than it could be generated at site.

In the ideal state to which all engineers were looking forward it must be remembered that 100% load factor will not be obtained without very heavy capital expenditure on lines, and heavy transmission losses not incurred under the present relatively inefficient system and the problem is still full of interesting problems and possible disappointments for those who are anticipating appreciable reduction in their power costs.

Mr. HASLAM congratulated Mr. Hider on his paper. He said he had been taking a certain amount of interest in the question of thermal storage lately, and this was the first time he had seen anything of any great value written in an unbiassed manner . In his paper, Mr. Hider had described, not so much a plant, or what is done by any one plant, as what can be looked for by an engineer giving serious attention to thermal storage. In criticising the Paper, he wanted it to be clearly understood that such criticism as he might offer was designed to obtain more information from Mr. Hider. Mr. Hider had studied a question and the diagrams and figures were all his own, and it was a great pity that it had to be given in the form of a lecture rather than as a published brochure.

He did not consider that the constant pressure accumulator does give a complete flywheel effect. He did not think any engineer would favourably consider the idea of putting a flywheel on which only half or quarter met the torque; that is what he considered the feed water accumulator does. He did not know whether Mr. Hider was seriously advocating that type, or merely describing it as a thing to be considered by engineers. He did not think that the feed water accumulator could deal with the loads in the way the variable pressure accumulator could. With the feed water storage it is only possible to store a certain amount of thermal energy, say, 20 to 25%. In industrial and generating station plants, the peak load rises some 50 to 100% above the average demand, and he did not think the feed water accumulator was capable of dealing with this peak load. One of the points emphasised by Mr. Hider, was the question of the time lag. It must be realised that when a demand comes for steam, the fireman starts to deal with it, and by the time the steam to meet it is available the peak load is off. He did not think the feed water accumulator would give the same instant supply of steam as is obtained from the variable pressure system.

Referring to Mr. Hider's remark that wet steam is obtained from steam storage, Mr. Haslam did not think this is the case, while if superheated steam is used, there is even less chance of it being wet. A proportion of the load is being taken with the superheated steam, which ensures that the steam is dry, how dry will depend on the different proportions of the superheated and saturated steam being used in that system.

Mr. Hider said that with the constant pressure system peak loads beyond a certain maximum entail a drop in the pressure. Mr. Haslam suggested that with a different system peak loads could be dealt with without any pressure drop at all. In the case of a 10,000 k.w. power station, the conditions were being dealt with by a combination of constant and variable pressure accumulators. He did not quite see the object of putting in a constant pressure system if the load calls for a variable pressure: to get any benefit from the constant pressure system it would be necessary to

*See *The Mining Electrical Engineer*, Jan. 1930, p. 257 and Feb. 1930, p. 303.

limit the capacity so as to get the constant pressure system to function.

With regard to the illustration Mr. Hider gave, of a load requiring 400 k.w. for 2 hours out of the 24, Mr. Haslam took it that he was assuming that it was a definite peak. If it was just an intermittent peak for 2 hours out of the 24, Mr. Haslam suggested that a Lancashire boiler could deal with that amount without putting in thermal storage. He thought a much better and more economical arrangement could be made without going in for thermal storage. Increase in boiler plant would not cost so much as thermal storage plant, and efficiency would not drop to any extent. He concluded by saying he was delighted to have been present to hear the admirable Paper.

Mr. HIDER, replying to Mr. Haslam, said he had taken some pains to avoid the introduction of controversial technical points, but was afraid that the string of queries raised by Mr. Haslam would compel him to enter into some detail as to the respective merits of the two systems of thermal storage referred to in the paper as peak load units.

It does really strike one in reading the series of questions put forward by Mr. Haslam that he has quite made up his mind that one system of thermal storage, i.e. the variable pressure has many advantages over the alternative system, i.e., the constant pressure system, as it will be noticed that each question and opinion is distinctly critical of the latter system. However, the object of any paper read before engineering societies is to elucidate the difficulties, and to ascertain the weaknesses of any proposed engineering project, and such a string of questions certainly opens up the way for a very full investigation.

In such a subject as thermal storage it hardly appears necessary to speculate on any phase. All the factors are easy to determine and there should be no difficulty in stating exactly what does occur under the two systems.

The most efficient way to deal with Mr. Haslam's points is to take each part separately, and it is found that such remarks and questions may be divided into eight phases as follows:—

(1) He did not consider that the constant pressure accumulator does give a complete flywheel effect.

(2) He did not think the feed water accumulator can deal with loads in the way the variable pressure accumulator can: it being only possible to store a certain amount of thermal energy, say 20 to 25%.

(3) In industrial plants peaks sometimes rise 50 to to 100% above average demand, and he did not think the feed water accumulator would deal with this peak load.

(4) Relative time lag: the variable pressure system is better in this respect.

(5) Mr. Haslam did not agree with the author on the adverse effect of the wet steam delivered by a variable pressure accumulator.

(6) Pressure drop: the variable pressure system will deal with peak loads without any pressure drop.

(7) Unable to see the advantages of a combined system.

(8) A criticism of Fig 8 in paper and a suggestion that such a load could be met better by installing a Lancashire Boiler.

In the opinion of the author the answers to the various points are as follows:—

(1) A flywheel must be so designed that it takes up energy not required for the external load and stores it to meet required increase on demand. Its weight must be such that the speed fluctuation be kept within desired limits. A flywheel that does not do this is badly designed as is also a thermal storage system which does not effectually store valley load steam for use at the peak load as required.

As Mr. Haslam has used the flywheel analogy, the author would ask him to bear in mind that the energy possessed by a flywheel depends on speed and mass and is expressed generally in feet pounds. It can deliver this energy as a very high torque for a very short time ,or a lesser torque for a longer time. How it does it depends entirely on the external load. In exactly the same way a thermal storage plant delivers its reserve power either as very high peaks of short duration, or lower peaks of longer duration, depending on the nature of the demand.

The author hopes to develop this phase in dealing with later phases of Mr. Haslam's remarks, but in passing this, he interprets this first query as suggesting that the variable pressure system of accumulation has a greater flywheel, i.e., storage effect, than the constant pressure system. It will be apparent to Mr. Haslam as the author develops the subject that he has formed entirely fallacious ideas on this matter.

(2) The author confesses his inability to follow the distinction which is made between steam storage and feed water storage, and would suggest that perhaps Mr Haslam had been rather mislead by terms used in trade literature. It is very necessary to see that the system referred to by Mr. Haslam as steam storage was an exactly identical process to that called feed water storage. Up to the storage point, i.e., the external vessel, the nett result of both systems is identical, namely, that there is a body of water stored outside the boiler proper, in which water the heat is stored which has not been demanded by the external load.

Is it not opportune to drop once and for all references to steam storage as against feed water storage, and also the terms total storage as against partial storage? Such terms are entirely misleading and not helpful to the development of a subject of vital importance to power plant engineers.

The essential difference between the two systems lies in the manner in which heat stored in the water is surrendered when required, and these features are fully discussed in the paper.

It is quite wrong to speak of the constant pressure accumulator as being able to meet peaks of 20 to 25% only. There is always a very small pressure drop which is necessary to work the regulator and this adds to the peak load capacity according to the water content of the system; and again, it has already been pointed out that it is fallacious and wrong to speak of peak loads in one dimension. Weight of steam and time are the factors to be employed, just in exactly the same way that with flywheel calculations, distance and force are involved.

(3) The author agreed with Mr. Haslam that peaks frequently occur of the order of 100% above average demand. As a matter of fact momentary peaks of far greater magnitude occur in some collieries. They are necessarily of very short duration and really a very small quantity of steam satisfies them. For instance, imagine a certain colliery load demanding on an average 100,000 lbs. of steam per hour and that peaks of five seconds duration occur of 200%,i.e., up to 300,000 lbs. per hour. This peak is satisfied with 277 lbs. of steam. A minute pressure drop in the system would liberate this, and the larger the content of the boiler, the smaller such pressure drop.

Mr. Haslam will notice that if these peaks be met by these means, i.e., the so called constant pressure system, the steam is available at boiler pressure and temperature, a vitally important feature in favour of this system.

(4) The author could not agee with Mr. Haslam that steam would be available without time lag in the one case, but with considerable time lag in the other case.

If cold feed water be cut off and hot delivered to a boiler and the firing rate maintained, the heat transfer from gas to water remains the same and increased output must immediately result. Reliable tests should be made to determine these matters. In his opinion appreciable delay must occur with the variable pressure system, owing to the arrangement of valves.

(5) The author was very sorry that he could not agree with Mr. Haslam. To preach the use of saturated steam in prime movers, was in his opinion, a retrograde step and slides were shown on the screen showing the greatly increased steam consumption of reciprocating engines when using low pressure saturated steam as compared with high pressure superheated steam (see Figs. 11 and 12).

Mr. Haslam had stressed the point that the variable pressure accumulator would meet peaks of very high magnitude, and such peak load steam under these conditions, would in the author's opinion be very wet.

As Mr. Haslam had pointed out, it should be boosted with superheated steam, but it must be remembered that such booster steam is taken from the h.p. main and must be debited accordingly.

(6) Mr. Haslam stated that with a different system peak loads may be handled without pressure drop. Assuming that by a different system he meant the variable pressure system, one must assume that what was meant was, that after the initial pressure drop had taken place, the low pressure was maintained at constant pressure. If his assumption is correct, the author agrees that with the variable pressure system a constant pressure could be kept in the low pressure main.

(7) The author was distinctly of the opinion that the combined system had many advantages and would undoubtedly be developed more extensively in the future.

(8) With regard to Mr. Haslam's criticism of Fig. 7 in the paper, the author had very carefully pointed out that that figure was purely imaginary and designed for the special purpose of illustrating the principle involved. Mr. Haslam will therefore agree that there is no need to discuss the alternative methods of meeting such a condition.

Generally, it will be seen that the author is in almost complete disagreement with every opinion put forward by Mr. Haslam, but is perfectly certain that Mr. Haslam is animated by a real desire to probe into the essential principles.

It has been necessary to deal at length with Mr. Haslam's remarks, and possibly such treatment may make it unnecessary to deal with the points raised by other speakers so fully, as much repition must occur.

It will be as well, however, to round off the reply to Mr. Haslam's many points by dealing with a practical example in a quantitative manner.

Consider a boiler normally evaporating 10,000 lbs. per hour at 200 lbs. pressure from feed water at 200 deg. F., and suppose that for one hour the steam demand falls to 9000 lbs. per hour whilst firing continues at the normal rate. There is then to be stored a quantity of heat equivalent to 1000 lbs. of steam.

Considering the "variable pressure" accumulator and assuming that its discharge pressure is 150 lbs. the absorption capacity is the difference between the heat content of water at 388 deg. F. (200 lbs.), and at 366.1 deg. F. (150 lbs.), i.e., 23.2 B.T.U.'s per lb. of water stored. Now the total heat of 1000 lbs. of steam at 200 lbs. from feed at 200 deg. F. is 1,031,200 B.T.U.'s. The quantity of water required to store 1000 lbs of steam is therefore approximately 44,500 lbs. or about 800 cubic feet.

The water stored in the "constant pressure" accumulator is heated in passing through the boiler from 200 deg. F. to 388 deg. F. (200 lbs. pressure) so that the heat absorbed is 193 B.T.U.'s per lb. of water and the quantity of water to store the heat equivalent of 1000 lbs. of steam is in this case 5,350 lbs. or roughly 100 cubic feet.

Thus it is seen that, under the conditions indicated, to store an equal quantity of heat the "variable pressure" accumulator must have eight times the capacity of the "constant pressure."

To return to Mr. Haslam's flywheel analogy it will be seen that for equal storage effect the variable pressure thermal flywheel must be eight times as heavy,

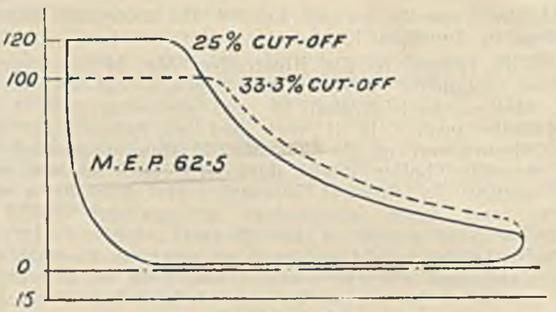

Fig. 11.

Suppose Cylinder 33" *dia.* × 48" *stroke* = *say* 24 *cu. ft.*

(a) *With admission pressure* 120 *and cut-off* 25%, *Steam per stroke* = 6 *cu.ft.* = 6 × .298 = 1.79 *lbs.*

(b) *With admission pressure* 100 *and cut-off* 33.3%, *Steam per stroke* = 8 *cu. ft.* = 8 × .256 = 2.05 *lbs.*

% *Increase in Steam Consumption due to Pressure Drop*

$$\textit{from } 120 \textit{ to } 100 \textit{ lbs.} = \frac{.26}{1.79} \times 100 = 14.5\%$$

i.e., costly, as that of a constant pressure thermal flywheel, which fact appears to be diametrically opposed to the views held by Mr. Haslam.

The conditions are more favourable to the variable pressure system lower down the pressure ranges, but it must be remembered that the "efficiency of utilisation" will fall considerably in those ranges. The pressure range chosen, i.e., 200 lbs. to 150 lbs., gives a low pressure steam which may be utilised fairly efficiently.

Mr. R. H. DAVIDGE said that peak loads were of long and short duration, and would have to be dealt with in different ways. He referred to instances in which turbines were loaded up and a small margin allowed between the necessary turbine stop valve pressure, and the boiler blow off pressure. This gave very small allowances for fluctuations of the load, and resulted in the boilers blowing off far too frequently. In such cases the load often returned suddenly, and any drop in pressure would necessitate some of the load being dropped. A drop in pressure would be necessary with a feed water accumulator. He thought that ample steam storage would be better to meet overloads of this type.

In cases where the fluctuations were of longer periods of duration and the drop in pressure was not important, he was of the opinion that the feed storage system was to be commended

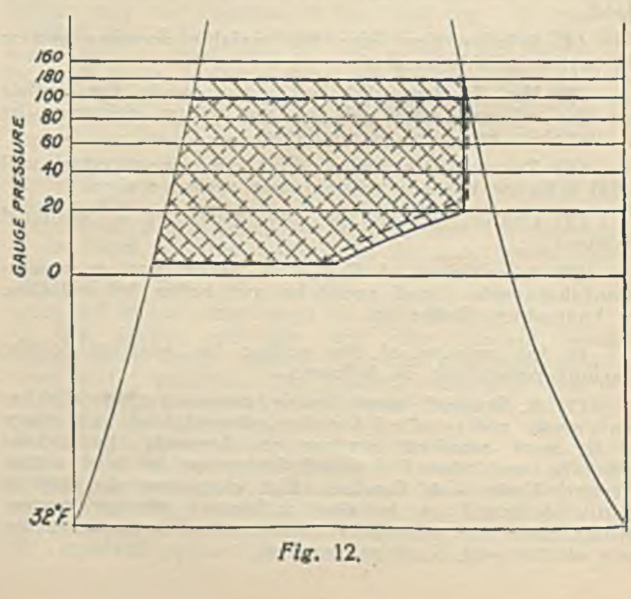

Fig. 12.

The amount of heat that could be stored by the high pressure feed water accumulator when used in conjunction with an economiser would be about 12½ per cent. of full load output. From this must be deducted radiation and pumping losses, therefore, as a means of increasing the boiler capacity, it would be reasonable to expect a maximum increase of 10 per cent.

He was also of the opinion that in the event of the accumulator being in operation for a fairly long period it would be necessary to by-pass some of the flue gases. This would entail a loss almost equal to the gain in the accumulator. He advocated steam storage with the automatic control of combustion.

Mr. HIDER thanked Mr. Davidge for his interesting comments and would refer him to Fig. 8 showing how the installation of an accumulator tends to prevent blowing off, which occurs without storage. For the conditions outlined by Mr. Davidge there was, in the opinion of the author, a complete solution in the constant pressure accumulator.

A small drop in pressure is necessary to operate with what Mr. Davidge describes as a feed water accumulator. Such pressure drop is negligible and is merely sufficient to operate the regulating valve.

As the author had pointed out in his reply to Mr. Haslam, sharp peaks may be met by a greater pressure drop. All these factors could be accurately determined and their probable effect definitely ascertained before action is taken.

Mr. Davidge thought that ample steam storage would be better to meet overloads of this type. If by steam storage Mr. Davidge meant the variable pressure system of accumulation, this merely emphasised the need for some systematic and ordered nomenclature.

Certainly in a normal power station it was exceedingly difficult to see how the variable pressure system of thermal storage could be introduced, owing to the fact that the steam delivered by such accumulator was at a very much lower pressure than such plant was designed for. This, of course, meant that special units must be installed.

Mr. Davidge stated that the amount of heat which could be stored by the high pressure feed water accumulator when used in conjunction with an economiser would be about 12½ per cent. of full load output, and gave it as his opinion that as a means of increasing boiler capacity it would be reasonable to expect a maximum of 10 per cent. The author would commend the several diagrams to Mr. Davidge's serious attention. In Figure 3 is shown the wonderful accumulator capacity Lancashire boilers. As is well known these boilers are looked on favourably for rolling mill and winding engine loads because of this feature.

The result of adding a constant pressure accumulator to water tube boilers is that, besides obtaining the increased efficiency of such units the accumulator capacity of Lancashire boilers is also retained.

Mr. Davidge's remarks emphasise the need of some greater accuracy in what is called pressure drop. Some engineers may have in mind a pressure drop of 20 lbs. per sq. inch, whereas a pressure drop of even 5 lbs. per sq. inch adds enormously to the output of any boiler plant. The water content of such boilers is of course the deciding factor.

With reference to Mr. Davidge's final paragraph, this was a vitally important matter and it is really extraordinary that experience has shown that the difficulties which Mr. Davidge anticipates do not occur. This is confirmed by the author's experience in a local tinplate works during the past month. In this works he has installed feed water heaters to take the exhaust steam from a generating set producing power for the auxiliaries. This had the effect of raising the inlet temperature to the economiser up to 160 deg. F. as against 70 deg. F. prior to the installation of the feed water heater. Before introducing the modifications a 100 deg. F. rise through the economiser was obtained, so that it was reasonable to expect a final temperature of about 250 deg. F. after the installation of the feed water heater. The economiser temperature has actually come down.

The whole phenomenon is bound up in the fact referred to in that part of the Paper in which it is pointed out that there are very reliable data to show that the efficiency of a boiler plant increases rapidly as the need for sensible heat is decreased. It will be necessary to refer again to this important matter in the replies to other speakers.

Mr. HANNAH said that the Western Branch of the Association was fortunate in having a number of very interesting papers this session and this one by Mr. Hider was particularly so. There was nothing very new in the principles of thermal storage, but until quite recently no one thought of applying the principles in a practical manner.

They were told a good many years ago that the Lancashire boiler had by reason of its water capacity one great advantage in meeting peak loads. After that the mixed pressure or exhaust steam turbine was introduced, together with a low pressure steam accumulator. This accumlator was identical in principle with one of those described by Mr. Hider, but worked only over a pressure range of 3 to 4 lbs.

He would have liked to have heard something from Mr. Hider with regard to the efficiency of thermal storage. There were other methods of storing energy, but they ware all inefficient. The electrical storage battery had an overall efficiency of less than 50 per cent. when allowance was made for the fact that current was not always required in the form in which it was stored. The hydraulic method of storing energy was also inefficient, largely owing to the relative inefficiency of all hydraulic machines.

He had wondered as to whether or not there was some other method of storing energy equally as simple as thermal storage which had not been aplied before and he suggested that possibly the gas engineers had partially solved the problem. Gas holders overcame the problem of peak load demands for gas, and the thermal efficiency of gas production was about 88 per cent. as compared with, say, 25 per cent. where the steam was involved. Would it not be possible to use gas in gas engines, in flash type boilers, or in gas turbines for meeting peak loads? It seemed to him that there might be room for working power stations and gas works side by side, as for certain questions involving the application of heat there was no question but that gas showed itself superior to thermal efficiency.

He repeated that the question of efficiency seemed the doubtful point in thermal storage and hoped that Mr. Hider would add to the value of his important and original paper by giving some figures on this point.

Mr. HIDER expressed his appreciation of Mr. Hannah's remarks, and said he evidently was in close touch with power plant developments. With regard to the efficiency of thermal storage, it was very difficult to ascertain the heat losses, but they may be taken as very small so far as the ratio of available heat to stored heat is concerned. The quality of the surrendered heat is a matter of vital importance so far as efficiency is concerned, and the overall efficiency would include an investigation into the efficiency of steam consuming units.

The author has in mind here the fact that undoubtedly the steam consumption of reciprocating engines will increase greatly if supplied with low pressure steam with little or no superheat. He was greatly interested in Mr. Hannah's suggestion that possibly the gas engineers had partially solved the problem of peak loads. He (the author) had always been of the opinion that power stations and gas works should be under one roof, as undoubtedly very high thermal efficiencies could be obtained by the use of gas in well designed engines working in conjunction with steam driven units carry ing the base load.

Mr. Hannah compared the efficiency of gas production with the efficiency of utilisation of steam. This comparison was not quite accurate. The thermal efficiency of a gas engine under normal conditions would be, say, 30 per cent. to 33 per cent. as against the suggested maximum of 25 per cent. where steam was involved. Very much higher thermal efficiencies could be obtained with gas engines carrying the peak load, if the exhaust gases from such gas engines were used to generate steam and the circulating water used as feed for the steam units. The question raised is an exceedingly important one and would require a great deal of space in which to deal with the matter fully.

Reverting to the question of efficiency there is much evidence to show that where a constant pressure accumulator is installed in conjunction with a boiler the efficiency of such boiler is increased appreciably.

As already pointed out in the reply to Mr. Haslam the use of low pressure wet steam is contrary to the trend of opinion in these matters, and this aspect requires very full consideration.

In conclusion, the author agrees with Mr. Hannah that the important question of thermal storage could be developed and a complete balance sheet for actual plant conditions worked out. Perhaps at a later date an opportunity will occur for a paper to be given along these lines.

Mr. VEATER—The difficulties of maintaining an adequate supply of steam at the working pressure, under conditions where the load is continually fluctuating is one which all engineers who have boiler plants under their control are fully conversant with. Time and again the relative merits of Lancashire and tubular boilers have been discussed. The argument for the Lancashire boilers always being the greater volume of steam storage, so that we find some Companies in laying out their boiler plants, comprise and instal both Lancashire and tubular boilers: the Lancashire acting as a reservoir for steam to meet the high peaks occasioned by a fluctuating load.

Mr. Hider in his paper has fully realised these difficulties as well as the high capital cost entailed in the laying down of a boiler plant which must primarily be of sufficient capacity to deal with the heaviest load; this load often being but a peak of short duration though of frequent occurrence. In cases of this kind, Mr. Hider has shown how, by the introduction of the steam accumulator with its "thermo-flywheel effect" the heaviest peak loads may be met, maintaining a constant even load on the boilers, with all the advantages of increased efficiency through regular firing and normal boiler setting, which is possible only with a constant load.

Mr. Veaton said he gathered from Mr. Hider's paper that his experience with the steam accumulator has chiefly been where it has been applied to rolling mills, and stations supplying steam for process work, etc. Although the load fluctuates considerably in these works, the demand is practically consistent throughout the 24 hours. He would like Mr. Hider to give some information regarding the installation of the accumulator to collieries, where the demand for steam during the working shift of eight hours forms a series of fluctuations and peaks due to the winding engines.

Assuming that the boiler plant of 50,000 lbs. per hour capacity for a new colliery, was being considered and laid out, would Mr. Hider embody in the layout an accumulator system? If so, would the benefits derived shew a saving over the extra capital expenditure involved to that of installing, say, a battery of Lancashire and tubular boilers, in so far that the fluctuation extends over eight hours only.

Mr. HIDER—Mr. Veater got right down to the gist of the matter in his remarks regarding the relative merits of Lancashire and tubular boilers. The argument for Lancashires is well defined in Fig. 2 in the paper which shows that it is possible to meet peaks of 100 per cent. because of the huge water content.

The author would emphasise the fact that it is not the volume of steam storage, but water storage in Lancashire boilers which allows them to meet peak loads so well. The constant pressure accumulator augments the water content of tubular boilers and thus creates in those units the ability to meet peak loads in exactly the same manner as does the Lancashire type of boiler.

With regard to Mr. Veater's request for information relative to the installation of accumulators in collieries; an accumulator of this type is installed at the Matthias Stinney Colliery near Essen. The capacity of the station, which consists of water tube boilers fired with pulverised fuel, is 200,000 lbs. of steam per hour. Winding engines are on the steam line, and in spite of the series of very sharp fluctuations the pressure curve is practically constant.

With regard to Mr. Veater's question relative to a boiler plant of 50,000 lbs. per hour the author is preparing some charts for the consideration of Mr. Veater, but at the time of writing these are not complete.

These charts show actual conditions at a colliery such as that referred to by Mr. Veater. The rated capacity of such a boiler plant would, of course, be closely related to the mean load as against the maximum load and thus there would be an appreciable reduction in capital expenditure on the primary units. However, all the factors can be definitely ascertained, and the author hopes to put before Mr. Veater his considered estimate of the assumed case refered to.

Mr. THEODORE STRETTON thanked the members for their very kind welcome and said he was always prepared to do anything he could for the Association. He had listened to Mr. Hider's Paper with a good deal of enjoyment, and when he had time to study it more closely it would doubtless prove even more enjoyable and instructive. With reference to the Railway Power Station referred to by Mr. Hider, he said it would be of great interest to them to know where that particular power station is situated. Mr. Hider had dealt fairly with the two systems, except that he had given far more information in connection with one than in connection with the other. He would like to have heard more in connection with the second system. As far as he had been able to learn, the variable pressure system had made tremendous headway recently, and it was proving its worth. With regard to the flywheel effect described, the value of this has not been fully realised either by power engineers or owners of works, and he quite agreed with Mr. Hider that to operate the average steam plant without a thermal flywheel was like running a gas engine without its flywheel.

Mr. HIDER said he regretted that he could not tell them where the railway power station was situated: the example quoted was abstracted from a German translation. To the author, however, it seemed to be more important to criticise and analyse the quantities referred to in the diagram dealing with that particular installation, and if Mr. Stretton would outline his difficulties in this matter, the author would do his best to offer solutions. With reference to Mr. Stretton's wish to hear more in connection with the second system of thermal storage, i.e. variable pressure, the author hoped that he would find it in his reply to Mr. Haslam, the information which he needed.

Sir ARTHUR WHITTEN BROWN thought the Branch was to be congratulated upon having inspired Mr. Hider to prepare such an interesting and provocative paper and he was sure that Mr. Hider would take their queries in good part. He said that the peak load problem was a very serious one, and as Mr. Hannah pointed out, the storage of electricity is usually impractical. The problem of peak loads as dealt with by Mr. Hider was likened to a cancer for which morphia is administered—it dulls the pain but leaves the disease—Mr. Hider would administer steam storage which helped the boilers, but leaves the peak load still there. He considered that it was starting at the wrong end to help boilers worth £1 to £1 10s. per k.w., and leave the generating and distributing equipment, worth £6 to £10 per k.w. unassisted.

The real problem is to remove the peaks from the load, and the Electricity Act 1926 is a powerful move in this direction, poviding base load stations at high load factor and auxiliary stations to deal with the peaks which then become very small by comparison. By the proper use of electrical thermal storage all peaks may be removed.

The day of the isolated steam plant which may justify accumulators is passing and we must look to the future. Process steam is used in many cases and this may be used as an argument for having local steam raising plant, but there is no magic in using steam. It is only for the purpose of appplying heat at a required point, and that can be done electrically. Although faced with the comparatively poor thermal efficiency of heat generated electrically, nevertheless it has great compensations in that it can be readily controlled, and there is no labour either in firing or ash handling. If steam is necessary, it can be generated electrically and by thermal storage, the electricity can be purchased at such hours that the load fills up the valleys, and very favourable rates may be obtained.

As an example of what can be done, he referred to *The Electrical Times* of October 24th, describing the electrically heated kilns in use in the Potteries, operating at high load factor, and thereby tending to level up the load on the generating station, and pointed out that there were at least eight Authorities in Great Britain prepared to sell current at ¼d. per unit for thermal storage at off-peak hours.

This filling up of the load curve is the true solution of the Peak Load problem, and anything which does not do this can only be considered as a palliative.

Mr. HIDER said with reference to Sir Arthur Whitten Brown's comparison of the treatment suggested being similar to the administering of Morphia to a patient suffering from Cancer, this analogy seemed to be a little incomplete. Sir Arthur must possess himself with patience. The ideal state must come gradually, but it is necessary to point out that the economies due to the Electricity Act of 1926 must be stated in comparison with the most efficient arrangement on existing plant. It frequently happens that what is really only an improvement of some really bad existing practice is credited with being a scientific advance based on the application of sound theory, and it is necessary to arrange the closest investigation of existing plant in order that it may operate at highest efficiency.

It is difficult to follow Sir Arthur into his electrical Utopia, but the immediate problem is to get the best out of existing plant.

Mr. MacSHEEHY said he was very glad Sir A. Whitten Brown had taken advantage of the broad scope the paper was evidently intended to cover, because the problem of peak loads affected the whole of any power system, and they as electrical engineers realised its bearing on the financial return on the distribution system. A load factor of 40 per cent. on a station might mean a load factor of 25 per cent. on the main feeders, 15 per cent. on distributors, and 5 per cent. or less on house services or individual circuits in the case of works' systems. It would therefore be most effective to tackle first the peak load problem at the consuming end of the system where an improvement in load factor assuming a normal diversity factor would improve conditions on the whole system.

The Supply Companies' attempts to do this accounted for the anomalies in charges already referred to where energy was sold at ¼d. per unit for high load factor service. He referred to thermal storage on small and large installations by means of storing heat in oil which afforded a means of larger storage per cubic foot than any other system he knew about.

In collieries they could often minimise the peak load effect on the whole system by the rearrangement of pumps and the provision of large sumps thus securing greater flexibility in their pumping periods.

In tinplate works where the nature of the rolls permitted, they endeavoured to get the works to run their cold rolls on two or three shifts instead of doing all the work on one shift, the two or three shift arrangement reducing capital charges and cheapening cost of generation.

The question of the peak load effect on boiler plant had taken up much of Mr. Hider's paper, and rightly so because means were readily available for definitely improving the boiler load factor and thereby improving their efficiency and reducing capital costs of a new plant.

He thought it a mistake to regard one manufacturer as committed to variable pressure accumulators and another committed to strictly constant pressure accumulation, since makers of the variable pressure accumulator also made constant pressure accumulators: in any case the term constant pressure should be regarded as a relative term since in many cases in which the big pressure drop between boilers and consumers, implied by the variable pressure system could not be applied a relatively small drop of 20 or 30 lbs. per sq. in. could be allowed for the sake of the advantages of accumulation at virtually constant pressure, the small pressure drop affording the means of dealing with the small peaks of high altitude which could not be satisfactorily met by a strictly constant pressure system.

He was interested in Mr. Hider's reference to the fact that by feeding hot water into a boiler the evaporation was affected to a greater extent than could be accounted for simply by the difference in temperature between the normal feed and the hot feed. He had noticed this characteristic of hot feed very definitely in the working of an installation of Druid Halpin thermal storage vessels connected to "Economic" boilers which he had had charge of twenty or so years ago: the increased evaporation consequent on using the stored hot water was about double that which could be accounted for simply by the increased feed water temperature.

Referring to economisers, he said that when a peak load came on under the Kiesselbach accumulator system the feed through the economiser would be slowed down and possibly stopped, with the result that the water temperature in the economiser would rise. He had come to the conclusion that this was not a serious impediment since it could be arranged that as soon as the temperature reached a predetermined point, say 300 deg. F., the feed pump could be automatically speeded up sufficiently to prevent this temperature being exceeded, and the boilers would receive a part of their feed at 300 deg. F., instead of the whole at, say, 370 deg. F., that only entailed the installation of a slightly larger accumulator system which by virtue of its bigger storage capacity, would yield more steam on its limited pressure drop and thus compensate for the portion of cooler water fed from the economiser.

Mr. HIDER said he was very glad that Mr. MacSheehy had found it convenient to be present, and he had contributed valuable technical matter to the subject of the paper. Much of Mr. MacSheehy's contribution required no comment.

The author had had many opportunities of collaborating with Mr. MacSheehy in this and many other power problems and much which was contained in the paper was due to such collaboration. He was glad to know that Mr. MacSheehy agreed with him that the careless reference to various types of accumulators was not good. With regard to the reference to feeding by hot water, the author suggests that this is a vitally important matter and its influence on boiler efficiency not generally appreciated. Mr. MacSheehy referred to definite experiments carried out by him with thermal storage vessels connected to Economic boilers, and pointed out that the increased evaporation consequent on used storage water was about double that which could be accounted for simply by the increased water temperature. The author would like to refer Mr. Davidge to this most important statement, as it emphasises the fact that the quantities referred to by that gentleman were not quite correct.

It may be of interest at this stage to refer to some experiments carried out by the late Sir William Anderson. Using a steam jacketted pan containing water in one experiment, 260 B.T.U.'s per sq. foot of heating surface per hour per degree difference in temperature between water and steam were transmitted through the plant when heating the water. Immediately the water began to boil this value increased to 606 B.T.U.'s. In a second experiment the amount rose from 368 B.T.U.'s to 660 B.T.U.'s. An increase of 80 per cent. These are really extraordinary figures and of special personal interest to the author, as he was apprenticed in the works of Sir William Anderson.

These experiments and Mr. MacSheehy's personal experience give a clue to the reason for the extraordinary case which the author has referred to in connection with a local works, i.e., that with increasing feed water temperature into the economiser, the gas temperature is not increased but tends to decrease. This, of course, can only be accounted for by an extraordinary increase in heat transmission in the boiler, thus cooling down the flue gases. The author was interested to notice Mr. MacSheehy's reference in his final paragraph to the economiser temperature under the constant pres-accumulator system.

Mr. J. W. DAVIDSON—The paper deals with a subject vital to all steel works engineers. In the plant with which he, Mr. Davidson, is concerned, the peak load problem is not similar to that with which power station engineers have to contend. The peaks are of very short duration, but of greater magnitude than those met with in central stations. As the author pointed out there is a very sound reason for the return of Lancashire boilers. Whilst many would much like to instal highly efficient modern water tube boilers, the limited water content of such is a drawback; and in order to meet the peaks it would be necessary to instal water tube boilers of very much higher rated capacity than with Lancashire boilers.

The system of thermal storage dealt with by Mr. Hider seems to afford the solution and he, Mr. Davidson, would have to begin to look into the question of concentrating the steam raising apparatus into one unit. Recently, he had had the opportunity of inspecting many plants in Germany which had been fitted with thermal storage of the type described by Mr. Hider in part of his paper. At a colliery near Essen connected with the Stinney's group they were making 200,000 lbs. of steam per hour with a series of water tube boilers fired by pulverised coal. Although three winding engines were operated by this battery of boilers, the pressure curve was absolutely constant. A remarkable feature about this plant was that one attendant was in charge of the whole of the operations, and for three shifts the wages expenditure on attendants would be of the order of £6 per week.

When it is realised that to generate this quantity of steam with Lancashire boilers we should have to instal twenty boilers (and there are steel works in Great Britain carrying this number of Lancashire boilers) it will be seen that the wages bill would be of the order of £90 per week instead of £6 in the German station referred to.

The whole question seems to open up a new line of thought, and engineers who are concerned with the prosperity of the steel works industry must look into these matters.

Mr. HIDER acknowledged the useful remarks of Mr. Davidson, who evidently had a very good grip of the importance of the subject of thermal storage. It was interesting to see that he remembered the essential features of the plant which he had inspected in company with the author at an important colliery near Essen.

Mr. T. S. RICHARDS said Mr. Hider had put his case forward very clearly on the steam side, but might have dealt a little more fully with the effects on the electrical side. The author had stated that power companies would seek and accept off-peak loads at rates considerably lower than those which it is necessary to charge for service coincident with the peak load, but in his, Mr. Richards', view that has not been so in the past. Taking the case of a colliery load, the form of load curve is known to all, the heaviest loading is naturally in the morning shift, whereas most Power Companies' peaks occur say, from three to seven in the afternoon for about three months in the year. The charges to that colliery, or any other colliery, is based on the amount of plant held idle or kept in reserve, and consequent standby losses, for such load. It is of vital importance that the time incident of all loads should be carefully considered. Most of the different industries follow a certain load curve regularly, and the charges for each industry should be made accordingly. Present-day charges are iniquitous, on the other hand reciprocity of suppplies has done a good deal to increase peak loads on one or other of the stations.

Mr. Hider had put the case for thermal storage very clearly, although he had only given instances relating to rolling mills and power work. There was, however, undoubtedly a field for this at collieries. One very often came across two or even three isolated boiler plants at collieries where if a central boiler plant were installed, and steam accumulators used, considerable saving and economy could be affected. As an instance of this Mr. Richards cited the case of one of the collieries he is connected with, where there is a central power station for compressed air and electricity, and two isolated batteries of Lancashire boilers. The central power station operates at a boiler pressure of 180 lbs. per sq. in. and the Lancashire boilers at 80 lbs. per sq. in. the latter supply steam for slant haulage engines developing 80 h.p. each. The haulage engines were in excellent condition and working very efficiently. To dispense with the Lancashire boilers was considered, as was also the electrification of these main slant haulage engines but on investigation it was decided, owing to capital cost and the additional electrical peaks, preferable to run a high pressure steam main from power station to these boilers, a distance of 300 yards, and converting one of the old Lancashire boilers into an accumulator of the variable pressure type. After a fair amount of experimenting with valves, etc. this scheme has now been put into commision permanently, with the result that the whole of the other boilers have been shut down, meaning a considerable saving in fuel, labour, etc. also minimising the peaks due to this load, and enabling better results to be obtained on the central station plant. This is only one instance of a very crude method. Still, it shows what can be done. Where there were five Lancashire boilers always in commission the consumption of steam after their closing down, with the accumulator in commission, is about 15,000 lbs. per hour. It should be stated that the capacity of the accumulator is on the small side, in fact only 50 per cent. of what it should be

The author stated that the system of meeting peak load by means of thermal storage is not so fully developed in this country as in Continental Countries. In the general press it was reported a few days ago that one of the Steam Accumulator Companies had under installation, or under construction, 58 systems—British Isles 32; Canada 11; United States 14; and India 1. Thirteen of the contracts in this country had been secured during the current year; it was further reported that in the Company's opinion 500 plants were immediately and urgently required in the industries of the British Isles.

The "constant pressure" system seemed to be the one more suitable for central station work as was shown by the author. Mr. Richards said he had read somewhere that the practical maximum steam capacity or "steam reserve" is on an average 5 to 50 times larger than the maximum steam reserve that can be obtained at a permissible pressure drop in the steam boilers with which they co-operate Would Mr. Hider say definitely whether that is so. If so, then there are vast possibilities for thermal storage.

Mr. HIDER, in replying to Mr. Richards, said it was abundantly clear that a more rational system of charges would have to be devised by Public Utility Companies, recognising of course, that in the limit, i.e., when peak loads have disappeared that this difficult problem would have solved itself. In the meantime some more rational method appeared to be necessary.

With regard to Mr. Richard's comments on the practical maximum steam capacity, the author would refer him to the diagrams in Fig. 8 which show a complete analysis of an actual plant. The rate of evaporation with and without the accumulator and with different pressure drops is clearly shown, and the author thinks fully answers the point raised by Mr. Richards.

WEST OF SCOTLAND BRANCH.

A meeting of this Branch was held in the Royal Technical College, Glasgow, on Wednesday, 15th January 1930 when a paper entitled "The Routine of the Electricians-in-Charge" was read by Mr. George Denholm. Mr. G. N. Holmes, the President, occupied the chair. In the absence of Mr. Gibb (Secretary), Mr. Brown read the minutes of the last meeting; they were approved and adopted. Apologies for absence from the Secretary and others were intimated.

The meeting unanimously agreed to accept the application for membership of Mr. Mair, Chief Electrical Engineer at the Summerlee Iron Company.

THE PRESIDENT, introducing Mr. George Denholm, said he was pleased to mention that Mr. Denholm had just passed the Association's Examination and gained a First Class pass; he was sure they would all congratulate Mr. Denholm upon his success.

Continuing, Mr. Holmes said that in preparing his paper Mr. Denholm's chief aim had been to interest the colliery electrician. He had made his paper as simple as possible, and it was hoped that after the reading of the paper many of the colliery electrical men present would take the opportunity of discussing the many important points raised.

Ⓟ The Routine of the Electrician-in-Charge.

GEORGE DENHOLM.

In our Association at the present time, the men we want to get into touch with most are the working colliery electricians and their assistants. To attract those men it is necessary to have the technical fare, which is read and discussed at our meetings, very liberally spiced with practical papers and discussions such as affect the colliery man, not only on occasion, but nearly all day and every day at the colliery. For this reason, if for no other, it may not be out of place to enlarge upon several points in the routine of the electrician-in-charge.

The duties of the electrician at a colliery are numerous and varied, and to perform those duties successfully, under conditions which are far removed from the ideal, efficient organisation and control are required. In addition to the general responsibility for the compliance with the regulations, certain specific duties are detailed in Reg. 131(c), and their routine performance should be recorded in writing with sufficient detail to serve as evidence of due performance. The regulation referred to requires—

"(1) that, the electrician shall be in daily attendance at the mine, and shall be responsible for the thorough examination of all apparatus (including the testing of earth conductors and metallic covering for continuity) as often as may be necessary to prevent danger; and

(2) the examination and testing of all new apparatus and of all apparatus re-erected in a new position in the mine, before it is put into service."

His responsibilities do not end there however, these being simply his duties for the compliance with the electrical regulations . The job he is really given is to apply electricity in its various forms to the safe and economic production of coal, and it is generally agreed that this is no mean problem.

In the bad old days, which we hope are rapidly nearing their end, the colliery electrician was regarded as a type of handy-man to whom one applied when the motor stopped, or when the light went out. This handy-man, often sadly lacking in electrical sense, then tried his skill—or his luck—to patch things up until they broke down again. This type of handy-man is, unfortunately, still in existence, although his days are certainly numbered.

The rapid growth of the application of electricity to mining in recent years very plainly calls for efficient maintenance as a necessity. The man who is in charge of the electrical department must, therefore, possess among other qualifications, the following:—

(1) A thorough understanding of the General Regulations as to the installation and use of electricity in mines, and also a fair knowledge of C.M.R.A. in general.

(2) Be able to make or check all tests or repairs made by his assistants of all apparatus under his control, and keep an up-to-date and systematic record of same.

(3) Be able to draft an intelligent specification for any type of apparatus or cable, etc., which may be required, and also to issue enquiries and accept tenders.

In dealing with these essential qualifications in the order mentioned, the first is self-explanatory and calls for little comment, viz.:

1.—*A thorough understanding of the General Regulations.*

Any person of ordinary intelligence who is conversant with the technical terms employed, can gain the requisite understanding of the General Regulations. The application of the Regulations, however, is another matter and requires continuous vigilance, diplomacy, and insistence. The electrician, being concerned more closely than any other official at the colliery with the electrical regulations must insist upon these regulations being carried out, not only by his own staff but all other officials—even his superiors—it being his duty to indicate to the management any infringement that may be reported to him or that may come to his notice during routine inspections and which he may not be in a position to rectify personally.

The average miner, or mine worker, still fails to a great extent to realise the assistance he receives or may receive from the use of electricity and still seems to have a vague apprehension that in the electrical engineer and his staff, he encounters a force whose object it is to electrify and mechanise the mines to his own (that is, the miner's) detriment. The miner, or mine worker, is therefore often not over careful in his dealings with any electrical apparatus that comes in his way. The minds of the electrician and of the miner would seem to work along vastly different channels. The electrician is usually of a creative turn of mind, while the miner is more of the destroyer. The nature of their respective occupations may explain this difference to a certain extent—the former being concerned with the repair and improvement of the plant under his care, and the latter being accustomed all his working life, to hewing, boring, and shooting out coal, which is in itself an operation of destruction rather than construction. A good deal of patience, tact and common sense is therefore required of the electrician to get the other man to see his point of view and to get him to come round to the electrician's way of thinking.

2.—*Checking Tests and Keeping Records.*

Under this heading comes the bulk of the work of the charge electrician. It may not be out of place here to point out that the Regulations do not require the man who signs the daily log to make the required tests personally, but it is a good thing if he makes as many tests as he possibly can, especially at the installation of new or re-erected apparatus. He can thereafter delegate to a reliable assistant the duty of taking any subsequent tests and can check them or compare them with his own figures. In addition to that, an occasional set of tests taken by himself will assure him that the tests are being properly carried out. If this is not done, conditions are bound to arise under which accidents and dangerous occurrences cannot be avoided, and surely we all want to be able to write a perfectly honest "None" under this heading in the daily log.

In order that this routine work may be carried out in a successful and orderly manner, some system of recording must be adopted (in addition to the daily log) which will show with a minimum amount of trouble the various tests, repairs, overhauls, and movements of pieces of apparatus from one place to another in the mine. Date and records of tests and repairs of motors for driving fixed apparatus, motors for portable apparatus, motor controls, armoured cables and trailing cables, should all be kept in separate books. Alternatively, the

MOTOR. No. 38.

Maker: White & Co. *H.P.*: 25 *Speed*: 960.
Type: S.R. (Flame-proof, No S.C. & B.R. Device).
Full Load Amps.: 32. *Maker's No.*: 9005/6.
Rotor Volts: 180. *Rotor Amps.*: 76. *Shaft Dia.*: 50 m/m.
Keyway: 15 m/m. × 6 m/m. deep.
Length of Free Shaft: 150 m/m.
Height (Feet to Shaft Centre): 270 m/m.
Length (Centre of Frame to end of Shaft): 450 m/m.

Driving.	Date Installed.	Date Withdrawn.	Reason for withdrawal.	Fitted with.	Starter Number.	Normal Load.
Force draft Fan on boilers	15.6.26	23.4.29	To be cleaned and re-bushed	Pulley 12"dia. × 9" face	16	25-28 Amps.

Fig. 1.

records, etc., could be arranged in the form of a card index. In either case it should be possible at any time on referring to these records, to ascertain (1) What motor is driving any item of plant at that particular time; (2) For how long it has been driving it; (3) What starter is employed; (4) the number, H.P., speed, and type of the motor, etc., and all other essential details.

An example of a data card or sheet is given in Fig. 1.

The information contained in Fig. 1 will in the event of breakdown, or withdrawal for cleaning or overhauling purposes, enable the electrician to tell at a glance what motor or motors he has available for replacement.

If these records are kept on cards, the history of a motor can be shown on the back of the card, or if kept in a book the particulars can be given on the left hand page, and the history of the motor on the right hand page. Such information as dates of renewals of bearing bushes, brushes, brush holders, turning up sliprings, commutators, and any repairs and subsequent tests can be recorded here. Comparisons of motor performances can be readily made in this way and also any recurring fault or peculiarity of individual motors will be quickly noted, such as a motor which may be hard on bushes for the driving end, or hard on brushes, or sliprings requiring attention frequently, or any other thing down to quite small details. Quite an interesting history, covering years of the life of a motor, can be recorded in a very small space.

Particulars and records of motor control panels and cables can be kept in a similar manner. An example of each is given in Fig. 2 and Fig. 3 respectively.

MOTOR CONTROL PANEL. No. 22.

Maker: Brown & Co. *H.P.*: 20. *Type*: Y
Maker's No.: 4371s.
Stator Amps.: 26 *Rotor Amps.*: — *Rotor Volts*: —
Incoming Cable: 19/.044" D.W.A. *Stator Cable*: 19/.044"
Rotor Cable: — *Interlock*: Mechanical. *Tappings*: —
Mounting: Floor. *Oil for Main Switch*: 5 galls.
Oil for Starter: 8 galls. *Overload Trip Setting*: 25% o.l.
Time Lag: 25 secs.

Motor.	*H.P.*	*Position.*	*Installed.*	*Withdrawn.*
45	18	No. 3 Dook Pump	14.12.25	28.8.28
21	15	No. 1 E.R. Haulage	6.1.29	

Fig. 2.

CABLE. *No. on Plan*: 17.

Size: 19/.044". *Cores*: 3. *Insulation*: V.I.R.
Sheathing: V. Bit. *Armour*: D.W.A.
Maker: Black & Co. *Length*: 215 yards.
Dia. over armours: $1\frac{3}{8}''$ *Dia. under armours*: $1\frac{1}{8}''$
Dia. overall: $1\frac{1}{2}''$. *Carrying Capacity*: 40 amperes.
Average load: 15 amps. *Maximum load*: 22 amps.

Leading from	*Leading to*	*Date Installed.*	*Date withdrawn.*
No. 1 E.R. Haulage Panel on No. 2 Distn. Board.	No. 1 E.R. Haulage Control Panel.	6.1.29	

Fig. 3.

It will be observed that the cable is identified by a number on the plan. This number will correspond with the number on the electrical plan kept at the colliery office as required by Regulation 120. The memorandum on this Regulation states:

"Although it is not compulsory to record on the plan the position of the cables, it is desirable that the run of all main cables should be shown with brief particulars of identification. As a matter of organisation a record of the cables in the mine is necessary, and for ready reference, the plan may be conveniently used to show for each cable the size and type, and the date of installation."

In addition to the plan at the office, however, the wise electrician has a copy of his own to which he can refer and keep up-to-date himself, as branch cables following rapidly advancing coal faces are shifted about a good deal and are usually omitted from the office plan.

By the adoption of the foregoing system of recording, several improvements may from time to time suggest themselves, all of which will make for higher efficiency. In addition to this the cost of maintenance of individual pieces of apparatus can be accurately calculated and performances of motors, switchgear, etc. followed quite clearly. Also when motors etc. become older in type, difficulty is sometimes experienced in obtaining spare parts because some manufacturers when altering standard types do so rather drastically, and when an old motor number is sent in to them with a request for spare parts, a long correspondence is entered into. The customer is often asked to state the type of motor, the probable date of purchase, and a host of other things, which tend to give the impression that the manufacturer would like to deny all knowledge of the machine.

One point here may be mentioned however, namely, the growing tendency among suppliers to substitute their own nameplates for those of the actual manufacturers. This further confuses matters and causes the maintenance man many an anxious time waiting for spares to wend their dilatory route through from the manufacturer to the colliery.

3.—*Specifications, Inquiries, and Tenders.*

Coming now to the third essential qualification, i.e., the ability "to draft intelligent specifications for apparatus and to issue inquiries and accept tenders." Having had experience on both the manufacturing and maintenance sides of the industry the author can fully sympathise with both parties. Generally speaking any manufacturer of repute can supply a suitable article, provided such article is clearly specified. A specification such as "Please supply one 60 h.p. haulage controller for use in a fiery mine," is really lamentable, but such a request is nevertheless met with. On the other hand, however, the manufacturer who supplies 75 h.p. motors with a cable gland capable of taking a $2\frac{1}{2}''$ dia. overall cable, and the said gland drawn up with two $\frac{3}{16}''$ brass bolts, does not deserve much sympathy.

In the matter of buying new plant, spares, etc., the average electrician-in-charge may argue that he has not very much say in the issuing of enquiries and selecting of tenders, but if he is aiming at keeping the cost of his department down to a minimum without impairing its efficiency, surely he is entitled to a voice in the spending of the money.

To be in a position to insist on this right he must, however, be able to convince his management that he is thoroughly competent in this part of his duties. When the management find that they have an electrician upon whom they can rely they will, as a rule, be only too pleased to listen and to be guided by him in things electrical.

The tenderfoot in the electrical market must proceed with great caution, and while first cost must in all cases be considered, maintenance costs must also receive their full share of consideration. It may be said that the dearest is not always the best, nor is the cheapest the worst, although generally the firm with the sensationally cheap article can hardly be expected to offer the quality offered by its higher-priced competitors. To start with, therefore, it might be prudent to pursue a judicious medium course. Naturally, mistakes can hardly be avoided on occasion, but if duly noted, they will often prove to be profitable, as it is almost entirely by experience that efficiency is acquired in this line.

In the first place, the specification must be carefully drawn up, every necessary detail being given fully and clearly. If the piece of apparatus is urgently required, obviously a slip-shod specification will mean considerable delay, endless correspondence, and of course, waste of time and money.

(a) *Enquiry for Motor.*

When enquiring for a motor the following data will be required:—

If a D.C. machine—The B.H.P.; Speed; Voltage of supply; Type of field winding; Rating; Type of enclosure (whether open or protected, enclosed ventilated or pipe ventilated, or totally enclosed); Type of machinery to be driven; Type and Dimension of cable supplying motor; manner in which it is to be connected to the cable box; any other accessories such as belt pulley, pinion, half-coupling, slide-rails, etc.

If an A.C. machine—The B.H.P.; Speed; Voltage and Frequency; Rating; Type of Enclosure; Type of Winding; Type of Machinery to be driven; Type of Starter to be used, and whether brush raising and short circuitting device is to be fitted, etc.

It is also a very important point to ask for a dimensional drawing, and to give guarantees of efficiency, power factor, slip, temperature rise at stated ratings and overload capacity, size of air-gap, size and type of bearings; rotor voltage and maximum rotor current.

A specification for a three-phase induction motor would read somewhat as follows:—

"One 60 b.h.p., 720 r.p.m., three-phase, induction motor, slipring type, continuous rating, enclosed ventilated, suitable for 500 volts, 50 period supply. The motor is to drive an endless rope haulage gear, and the sliprings are to be totally enclosed and flame-proof. A brush raising and short circuiting device is not required, but should be quoted for as an extra to be considered when your tender is received. The cable boxes of stator and rotor should be suitable for 19/.064" 3-core d.w.a., v.i.r. cores, v.bit. sheathed cable, $2\frac{1}{4}$" over armours and $1\frac{15}{16}$" under armours. Mechanical connections are to be fitted in the cable boxes as the motor has to be installed in a fiery mine. The motor must be fitted with a rawhide pinion having 20 teeth, $\frac{7}{8}$" pitch, the width being 5" between shrouds. A dimensional drawing should be enclosed with your tender, which should give the following guarantees:—

(1) Efficiency and power factor at full, three-quarter, and half load.

(2) Temperature rise after six hours run on full load.

(3) Overload capacity for two hours and momentarily. The type and dimensions of the bearings, air gap, rotor voltage, and maximum rotor amps. should also be stated."

When the manufacturer receives an enquiry such as the foregoing, the customer will have a reasonable chance of getting a speedy quotation and a price which can be considered final, not one which will require to be revised several times before a definite price can be obtained. As has been mentioned before, endless correspondence and waste of time is thus obviated.

(b) *Enquiry for Switch and Control Gear.*

If accuracy in detail is essential in motor specifications, it is even more so for switch and control gear, owing to the fact that switch and control gear is operated by semi-skilled and unskilled labour. It is obvious, therefore, that unless this type of apparatus is designed and installed properly it is a pretty hopeless job to try to maintain it in a safe condition and in compliance with the General Regulations. As the current is interrupted by the control gear the potential dangers which may arise, such as explosions, fires, burns, and shocks, are more likely to come from the switch gear than from other pieces of apparatus. All possible precautions should, therefore, be taken to ensure that only safe and reliable control gear is bought.

Taking as an example, if a circuit breaker and rotor starting resistance for controlling a slipring induction motor is required, the points of importance will be:—B.H.P. of motor; Voltage and Frequency; Rotor volts on open circuit and maximum rotor amps.; Percentage of full load torque to be exerted by the motor at starting; Number of starts per hour and minimum interval of time between two consecutive starts; Methods of interlocking circuit breaker and rotor starter; Number of overload trip coils to be fitted; Instruments; Size and type of cables, ingoing and outgoing, for stator and rotor; Type of mounting of switchgear (i.e., whether for floor or wall mounting).

A drawing is also required in this case giving the various dimensions, the temperature rise of the starter under specified conditions. It is also a good point to get makers to state the current densities of the various current carrying parts of the gear. Makers of repute will supply any amount of reliable and valuable information on request.

The following is an example of a Specification for Starting Panel:—

"One rotor starting panel to suit a 45 b.h.p., three-phase, 550 volt, 50 period, slipring induction motor, and comprising three-pole mining type oil-break switch, fitted with 3 overload trips, with adjustable time lags, no volt trip, loose handle, ammeter (reading 0-80 amps.), incoming and outgoing cable boxes arranged upon stands for floor mounting and mechanically interlocked with an oil-immersed resistance type rotor starter, capable of starting the motor against full load torque, six times per hour, with a minimum interval of two minutes between two consecutive starts. The open circuit rotor volts of the motor are 170 and the maximum rotor current is 130 amperes. The incoming and outgoing cables of the circuit breaker will be 3-core, v.bit., double wire armoured, and measure $2\frac{1}{8}$" over armours and $1\frac{3}{4}$" under armours. The incoming cable will enter horizontally at the right hand side of the breaker. The outgoing cable will leave by the left hand side also horizontally. The rotor cable will be of the same dimensions as the stator cable. All the above gear to be flame-proof and to comply with the requirements for switchgear operating in mines under conditions where Rule 132 applies. Tender should be accompanied by a dimensional outline drawing, and should state the current densities in the various current carrying parts, both fixed and moving, and also the temperature rise of the oil in the starter under the specified conditions."

(c) *Enquiry for Cables.*

Specifications for cable in mining work are in a great many cases looked upon as the essence of simplicity.

To a certain extent only is this true, for very little thought will bring home the fact that if it is essential to have satisfactory motor and switchgear, then it is equally essential to have suitable cable to ensure the success of the system as a whole.

Quite a number of items require consideration before an order is placed for a cable. Take for example the development of a new section which may be some distance from a distribution point. In the first place the likely ultimate load must be considered, and as this factor is fairly elastic it is good policy to err reasonably on the safe side. The information given to the electrician is sometimes of a very scrappy nature, often amounting to the bare facts that the section is being developed and that three coal cutters are to be installed. No mention is made of the extras in the way of auxiliary haulage, pumps, etc., which have a habit of crowding into a new section with alarming rapidity.

It may be argued, with an eye to first cost, that a certain size of cable may be installed to begin with, and later on a heavier cable may be installed. That may be good enough in theory but very often in practice the heavier cable is either long overdue or is never installed and the long-suffering first cable is left to carry on as long as it will, with detrimental effects to itself and everything it is feeding. It is, therefore, up to the electrician, with a view to future efficiency, to make a stand for an adequate cable in the first instance.

Another point which is sometimes lost sight of is to make sure that the cable comes to the colliery in lengths which can be conveniently handled, not only on the surface but in the position it has to occupy permanently. If the cable is supplied in convenient lengths a good job can be made of the installation and a great deal of unnecessary trouble is avoided, such as cutting the cable and reeling it on to smaller drums in order that it may be taken nearer to its destination.

The particulars required in a cable specification are: length; number of cores; particulars as to load, or alternatively sectional area of conductors; whether conductors are to be round or shaped; insulation of cores (V.I.R., V.Bit., Paper, etc.); sheathing around cores; armouring; serving or braiding; whether for shaft or roadway; if V.Bit. insulated, whether interstices are to be filled; if V.I.R. for medium pressure, whether 300, 600, or 2,500 megohm grade, and association or non-association quality voltage of supply; whether the cable must be in one length, or if not, what lengths can be allowed; maximum allowable size of drum (diameter over flanges and width overall); if shaft cable, state method of suspension.

The following may be taken as an example of a cable enquiry :—

"600 yards 19/.083", 3-core cable, the cores to be circular in cross section, V.I.R. insulated and V. Bitumen sheathed; double wire armoured, braided and compounded overall; 600 megohm grade, association quality, for 440 volts supply. The cable will be installed on a haulage roadway, and is to be supplied in three lengths of 200 yards each. The cable drum not to exceed 6' in diameter over flanges and 5' 6" in width overall.

The information accompanying tender should include the dimensions over and under the armouring and overall, also weight of cable and relative conductivity of armouring and conductor."

When issuing enquiries it is always essential, in order to avoid delays and supplementary enquiries, to ask the manufacturer to state earliest delivery, and also to make it clear that the quoted price is to include delivery f.o.r. to the station or colliery siding concerned.

Now as the primary object of this paper is to enable the colliery electrician, who may find himself in charge for the first time, to obtain speedy and complete control of the plant under his charge, such points as the standardisation of plant and electricity supply costs have been omitted. These points are receiving a great deal of attention at the present time, and are of so much importance to the progressive electrician in charge, that, in the opinion of the author, they could only be treated adequately in detail in separate papers.

Discussion.

THE PRESIDENT congratulated Mr. Denholm on his excellent paper, which showed that the author had succeeded in putting his subject in a lucid and simple manner to appeal to the colliery electrician. Mr. Holmes expressed some amusement at the author's remarks regarding the difference between the miner and the electrician. The miner's work, without speaking derogatively of it, is to destroy, while the electrician's is of the creative order rather than otherwise. With regard to Mr. Denholm's method of keeping records, the speaker was of the opinion that the card system would prove more efficient on account of its flexibility. It takes up very little room and much more information on the different items of plant can be inserted. Furthermore, it is very easily checked, and can be altered without upsetting the system in general.

Another point which Mr. Denholm had raised was in regard to the electrician's position when ordering, or when new plant was being installed. Undoubtedly that must be a subject for the manager. At the same time the speaker said he thought the electrician should be thoroughly conversant with any alterations about to take place, also any new plant to be installed; he should certainly be consulted when new plant is proposed, as there was often far too much haphazard ordering. Being concerned with the manufacturing side, Mr. Holmes appreciated Mr. Denholm's remarks regarding the data which is often sent out when enquiring for material and thought every manufacturer was up against a want of detail in many enquiries, and that frequently a great deal of time was lost in writing for fuller particulars before attempting to forward a quotation at all. Then in repeat orders going through, a good deal was also left to the imagination of the supplier, and if it were not that he is pretty familiar with the requirements there would be much useless apparatus going to the collieries. That complaint did not apply to collieries alone, but they are one of the worst culprits in that respect. The electrician of to-day, said Mr. Holmes, is a man possessing technical education and is always improving in this respect. He should, therefore, be fully capable, in most cases, of giving full details regarding his requirements. He would like to mention a little point brought up in regard to cables. The cabling costs of a colliery form possibly one of the highest factors of the whole plant. On the cable itself depends the continuity of operation and it requires very careful inspection. It is also very easy to put down a cable which looks as if it will carry the necessary load for the time being, but possibly is only a matter of weeks or, at most, months, before additional plant is installed. The cable is then required to carry more than its capacity. This simply means trouble; overheating takes place and ultimately results in breakdown. This point should always be very carefully considered and the correct size of cables put in at the beginning.

Mr. DIXON said there were one or two things in the paper where he was at variance with the author. For instance, in the reference to the electrician-in-charge and the issuing of orders for new plant. It was not quite clear as to whom is meant by the term electrician-in-charge in this sense and what he is going to issue. Mr. Denholme wants a good specification of plant from a man conversant with future developments, and yet says the primary object of the paper is "to enable the colliery electrician who may find himself in charge for the first time" etc., and then complains about the way this man is usually "in the dark." To Mr. Dixon it seemed that the man who is to issue enquiries or specifications for plant should be the one who, whether he happens to be the electrician in charge or not, is in touch with the management. He might be classed as a man on the management side rather than an electrician. He knew that in making this statement he threw himself open to sharp criticism, but he had seen too many amateur specifications of the practical electrician type and realised their danger.

It was not quite clear whether Mr. Denholm was talking about specifications or enquiries: he seemed to mix them up indiscriminately. In the enquiry for the motor, for instance, Mr. Denholm called it "Specification for Motor." "When enquiring for a motor the following data will be required." Later on, this is referred to: "When the manufacturer receives an enquiry such as the foregoing—." If he is specifying, as he says, for a 60 h.p. motor, then he ought to state his requirements regarding temperature rise and overload capacity and not merely ask for information. Mr. Dixon in concluding, said he was rather reluctant to criticise, but Mr. Denholm had generously invited it. He, Mr. Dixon, was in agreement with the author about records: it was very good where they are kept up-to-date, but one of the main troubles, where the plant is large, is that it is a man's job to keep the records. If they are not up-to-date they are of little use and in small plant the electrician is able to carry everything of consequence in his memory.

Mr. HOWAT referred to cabling, and Mr. Denholm's suggestion of numbering a cable on the plan: as he says, 17, or anything like that. In the case of a number of cables in a section which are to be cleared out and put away somewhere else, how is it possible to number those cables that are going to be rolled up by the miners? It would be very difficult to keep a hold of similar lengths of cable after they had been brought down to 50 yards or so, after the original cable had been cut. It became a very elaborate job to keep a record of all the cables where the plant is very extensive.

Mr. McCALLUM.—There is one point about the 60 h.p. motor mentioned. Mr. Denholm said there is no brush raising required for his motor which is to drive an endless rope haulage. Would the author give further details about the extension. In regard to the cards which Mr. Denholm suggested, Mr. McCallum said he had tried the cards for a matter of seven or eight years and had not got them to perfection yet. He always found a minute or two for keeping in touch with them but when he went to notify the people who are responsible for making the records, they, or the cards always disappeared. He was, however, still living in hope that he would get perfection yet: he was speaking more particularly about the records of motors of about 700 or 800 h.p.

Mr. STEVENSON.—The author said that it was his duty to report to the Management any infringement which may be reported to him, or which may come to his notice during routine inspections and which he may not be in a position to rectify: he, Mr. Stevenson, would recommend him to keep a record of such cases for, when troubles arise, it is wonderful how short memories can be.

Mr. Stevenson then recalled some of his experiences of enquiries giving vague, almost impossible particulars. One of them called for a cable to transmit several hundred h.p. at 500 volts to a distance of 800 yards with a drop of 2 per cent. voltage. Unfortunately it was an enquiry and not an open order. It is a great mistake when sending enquiries for cable prices to give the power to be transmitted and the distance, as the quotations received would all be for different sizes of copper, and the enquiry would have to be sent out again. Mr. Denholm appeared to appreciate this point, but in the specification for the control panel the sizes of the cables carrying the rotor current are not given. The manuturer, therefore, may supply the wrong size of socket.

It is to be noted that Mr. Denholm appears to be partial to V.I.R. V.B. sheathed cable. Whilst comment in regard to that might be getting outside the scope of the paper, it would be interesting if Mr. Denholm would give his reasons for preferring this type to the the ordinary V.B. sheathed type, which is much more commonly used.

Mr. BRASH said that despite any little detail omitted by the author in his specifications, there was no doubt the intelligence of the manufacturer would ensure the supply of what was required. The crux of the whole thing was: "When the colliery electrician arrives at conclusions concerning his requirements, which are based on practical experience, and takes care to have the same mentioned in his specifications, whether it be for motors, starting gear, joint boxes, or cables, does he get what he has specified?" Mr. Brash cited the case where a long cable was installed underground, and for a considerable length of time gave every satisfaction. During the course of development of the workings, probably not unforeseen, but not considered at the time the cable was installed, a demand was made for more power. The cable became overloaded, the core decentralised, and caused no end of trouble to the colliery electrician. Another point, not mentioned in the paper, but worthy of discussion is—when a colliery electrician installs a new piece of plant, say a haulage, who is responsible for the initiation of the person who has to work the machine, and by what standard shall one judge his qualifications? (See Rule 131a C.M.R.). A mistake in this respect can cause no end of trouble.

Mr. DAVID BROWN referred to the example of a specification for a motor starting panel, and asked whether Mr. Denholm preferred the mechanically interlocked type to the electrically interlocked type. In the mechanically interlocked type the rotor starter is usually locked with the circuit breaker in such a way that the rotor starter must be returned to the off position before the circuit breaker can be switched in. In such a case, the slipring brushes can be lifted, leaving the rotor short circuited, and the rotor starter in the off position; the circuit breaker can then be switched in. In that case the current ruptured in the breaker when it tripped would be about five times the motor current, whereas with an electrical interlock, in conjunction with both the rotor starter and the slip rings, the circuit breaker cannot be closed because the no-volt circuit of the circuit breaker is not complete until the brushes are down on the rings and the rotor stater in the off position.

Mr. DENHOLM (in reply).—The point mentioned by Mr. Holmes with regard to power factor when ordering cable, would certainly be essential.

Mr. Dixon asked who is meant by the electrician in charge. The electrician in charge is the official appointed under the electrical regulations to sign the daily log. His status may vary at different collieries, but he is the person who is actually responsible for the electrical apparatus at the colliery. With regard to Mr. Dixon's other point about the seeming indiscriminate use of the words "specification" and "enquiry," these two terms are very closely bound together, because on issuing an enquiry for a piece of apparatus, it has to be accompanied by a detailed specification. Otherwise the tender when finally received is almost sure to be for something quite different from that which the customer had in mind.

Concerning the question asked about the number of the cable on the electrical plan, he thought it could be followed quite well. The cable would not have the number actually attached to it. When a branch cable is installed between say, a distribution point and a coal-cutter gate-end box, it will be given a number. When an extension is put on, it will be recorded on the plan, with its length, but still with the same number. That is to say that several short lengths of cable of uniform cross section joined together would be considered one cable or branch circuit for purposes of identification.

Mr. McCallum evidently favours short circuiting and brush lifting devices on endless rope haulage motors, but the speaker's experience is that, given a good heavy slipring and suitable brush, there is as little trouble without a brush lifting device. Also, when the brushes are always down on the sliprings there is no danger of the attendant attempting to start up after a stoppage with the rotor short circuited and the brushes raised.

[Mr. McCallum here explained that he had no attendants on his endless rope haulage motors as they were remote control operated.]

The suggestion of Mr. Stevenson for a system of reporting infringements in writing to the manager is a good one. That very same point was discussed between the manager and the speaker not so long ago, and the suggestion came from the manager that when inspections were made, a written copy of any complaints should be supplied to him, and very satisfactory results have been obtained in this way.

Dealing with Mr. Stevenson's question as to why he preferred V.I.R. core and V.B. sheathed cable to V.B. core V.B. sheathed cable, Mr. Denholm said he found that in ordinary temperatures and fairly cool places, the former cable was slightly more flexible than the latter. Also when making off ends on a cable that has been re-installed several times, there was a tendency for the V.B. core insulation to break off and it had to be very carefully taped at the point where the core issues from the V.B. sheathing. In plain terms, more liberties can be taken with the V.I.R. core cable and it ages better.

Mr. Denholm agreed with Mr. Brown that electrical interlocks are more modern than mechanical, but thought the mechanical interlocks stood up better to abuse and being external to the apparatus, could be more easily inspected and even repaired without stopping the apparatus they control.

NORTH WESTERN BRANCH.

Annual Dinner.

The Annual Dinner of the North Western Branch was held at the Midland Hotel, Manchester, on Saturday, January 11th last. The Chair was occupied by Capt. I. Mackintosh, the President of the Branch. Amongst many distinguished guests present were, Capt. Walton-Brown, B.Sc., the President of the Association; Mr. T. E. Herbert, Chairman of the North Western Centre of the Institution of Electrical Engineers; and Mr. Noah Williams, the local Secretary of the Institution of Mining Engineers.

The Toast of "The King" was proposed by the Chairman, and duly honoured.

Mr. A. M. BELL, Immediate Past Branch President, in proposing the Toast of "Our Guests," said it was with very great pleasure that they particularly welcomed the President of the Association, Captain Walton-Brown. The Association was inaugurated in Manchester 21 years ago, the inaugural meeting being followed by a dinner; and they were proud to note that one of the original members of the working Committee of that day was still with them holding office as their Branch Treasurer. He referred to Mr. W. Bolton Shaw, who, he was very sorry to say, was unable to be present on account of sickness.

A retrospect of the position of electrical engineering as applied to mining, since the formation of the Association, proves most convincingly the tremendous advance which has been made, and no doubt much of the progress is due to the work of the Association of Mining Electrical Engineers, but they should not forget the great influence of the Coal Mines Act of 1911. While the Association acknowledges the valuable work of the Mines Department and of manufacturing firms, it was only right and proper that their President also should receive the honours which were his due. They wished to thank him cordially for his efforts in the work of the Association, and for upholding the traditions of his predecessors, one of whom, a member of this Branch, was there present, Mr. W. T. Anderson. The work of the Association demanded from the President much time and thought; his visit to them on that occasion was most valuable; it encouraged the Branch President and officers to continue the work they had undertaken with the assurance of the personal support of the Association's President.

Continuing, Mr. Bell remarked that for many years the mining industry had been subject to the criticism of Government and the public generally; but he would venture to suggest that the Association fulfilled its obligations to the public and to the industries of the country generally, by constant investigation of every means of winning coal by electrical power and thus reducing the production costs. The papers read at the various Branch meetings and printed in the monthly Journal, and the valuable technical articles also contributed to it, were evidence that this was a very live Association.

It is, however, but human to err, and so it was only fit and proper that their daily work should be subject to the supervision of an M.D., some person to prescribe a little corrective as may be necessary. That evening the "M.D." guest was Mr. W. J. Charlton, H.M. Divisional Inspector of Mines, to whom on behalf of the members of the Branch, Mr. Bell welcomed the opportunity of tendering their appreciation of his honouring them with his presence. As Divisional Inspector they would naturally expect him to have a very high O.H.M.S. value, offering resistance, reactance and impedance as his onerous duties may demand. The Annual Report of H.M. Electrical Inspector of Mines indicated that there was still room for improvement in the operation and maintenance of mining electrical plant, and he would assure Mr. Charlton that the Association was very much alive to the problems arising from time to time. Probably they could not accept and practise in their work and duties any higher standard than that which is practised in H.M. Inspectors' Department, and by mutual trust and confidence they hoped to attain the results the Department expected. Though sometimes one may be inclined to think the Regulations a little irksome, he, Mr. Bell, always believed the precautions called for were based on actual facts and experience, and the Association was always anxious to support any and every measure for the safety of the workers.

In putting the toast of "Our Guests," Mr. Bell coupled it with the names of Captain Walton-Brown, President of the Association, and Mr. W. J. Charlton, H.M. Divisional Inspector of Mines.

Capt. WALTON-BROWN.—It is the privilege of every President to visit every Branch during the course of his year of office, and it is a privilege which we all esteem very highly; because we are then able to meet again those friends whom we meet at Council meetings and, more important still, it enables us to see those members who are sufficiently interested in the President to come and meet him. We can then get in touch with the members of the Association all over the country, get to know them, see what they look for, and realise what good fellows they are.

That evenings entertainment seemed to him to be characteristic of mining men all over the world; they delighted in receiving guests and entertaining them, and he was sure the North Western Branch of the Association was not behind any other in that respect. Capt. Walton-Brown said he had not the knowledge of Manchester that he ought to have but he had just learned something. Though he had been probably twenty times to this city, that was the first occasion on which it had not rained. On the North East Coast they took a great interest in what happened in Manchester in the way of weather; in that North East country they suffered from the west wind which usually brought rain and that, they said, came from Manchester. The nice fine days were their own weather.

Capt. Walton-Brown, having remarked that he was speaking as a guest and not only as the President on behalf of the Association, said he felt he had freedom to digress a little. On the North East Coast they got a very large amount of their technical equipment from Manchester, the unfortunate thing, from their point of view, being that they were doing all the buying and Manchester was doing all the selling; they had no opportunity of pushing anything back in exchange.

There were other products of Manchester, to one of which Mr. Bell has already referred. That was the Association. It originated in that district. They might say also, he thought, that *The Mining Electrical Engineer*—that very excellent Journal which comes out every month—also arose in Manchester; but he was glad to say that the Editor of that excellent paper—he was sorry he was not able to be there that evening—received a good training on the North East Coast.

Capt. Walton-Brown then introduced one or two things about the coal trade, being careful to intimate that they were entirely his personal views and not those of the Association. He stood as a convinced advocate of a higher wages policy. He deplored the changes which were being made in the working hours in mines, for two reasons: One, that they will make the individual earnings smaller than they would otherwise be if the hours were maintained; and secondly, they would put a needless increase upon the price of coal. While there was that portion of the new proposals which one was inclined to oppose, there were a number of other proposals which, to his mind, could not fail to do good to the industry, and would be to their personal benefit. One always had the feeling that the policy of the coal trade in the past would have been an excellent one if it had been carried through by everybody. That was to say: to produce cheaply and to sell cheaply. But, unfortunately, since the War—and possibly before it—it had not been possible to get other trades, other industries, to follow the same lines. We had failed miserably as far as that was concerned. Other industries adopted a policy which no doubt had been to their own advantage, but the coal industry had always been left in the lurch; and one has the feeling that if some of the present proposals went through, and in particular some system of price maintenance without any other artificial restriction of production, there would be a change for the better; it would be possible to introduce into the coal trade the policy which has been so steadfastly pursued elsewhere, which in the long run would mean that instead of the wage being dependent upon the price of coal the price of coal would be dependent upon the wage. They could start off with the proposition of paying all officials and all men a reasonable and proper wage and translating that fact into the price at which coal should be sold. The consumers of this country should not complain if the coal industry is paying its men reasonable and proper rates of wages, and they should not expect to be able to buy coal at less than the cost price . The selling prices of coal have not increased to anything like the extent they have in other industries. The pressmen present would not object to his reminder of what we have the privilege of paying for our newspapers at the present time. Carrying the same principle into the coal trade, where coal was sold at 10s. pre-war, £1 might be a very excellent price to charge at the present time. The policy has been forced on the coal trade by the other industries, and we might even say by the policy of the Government itself. For instance the Government has been discussing the pre-war standard of Ministers' salaries and the fact that some of them struggle along with something like £2000 to £5000 a year. It is said to be obvious that something ought to be done to put those salaries on a reasonable basis. Nobody seems to mind that very much. At the Northumberland County Council they discussed a man's salary. It was £700 a year and it was found that someone in Yorkshire in a similar position was getting £900, so they put their man up to £900. In the same way when we are appointing a workman we could quite easily get a man to take a job, which is not a very important one, for £3 a week but the scale says that he must have 70s. and he gets 70s. They do not consider the question what the rates are, or what the taxes are, they pay the salary. Then they turn round and work out what the rates or taxes have to be. So, said Capt. Walton-Brown, I do not see why in the coal trade we should not do exactly the same thing and see that everybody under our banner is properly paid, and translate that into the price of coal.

Of course, one did not want to introduce politics into that meeting. Manchester had always been said to be the home of Free Trade but he, Capt. Walton-Brown, gathered that at the present time Manchester men were not quite so firmly convinced as they were in their early youth that the Free Trade policy still held good. However, speaking for the Association he saw them apparently as a very Protectionist body, and with a little explanation the members of the Association in Manchester would, he expected, be just as good Protectionists as those of any other Branch. What we have to do is to pay our tax. We have to pay the tax in the form of hard work, attending classes, reading books, private study and practical work. The result of paying that tax is that we have the privilege of going before the taxing officer—in the case of our Association it is Professor Statham—and supposing we pay a tax which satisfies him we in due course receive a receipt for that tax in the form of the Certificate of the Association.

The Council wished to draw the attention of all young men to this important certificate and to the examination, and hoped that they would come forward and assist successfully in increasing the membership. The Mines Department were not yet doing it, they may not do it for a year or two, but he, Capt. Walton-Brown was convinced that in due course of time, they would exact from the colliery electrician a definite qualification. It is up to the Association to supply the men, and he was quite sure that the Association could do so. He quite appreciated that the Association would be much more likely to supply the men when the rewards came more immediately in view.

All of them paid their taxes—income taxes and otherwise—he did not think anyone could sit for an examination and pay what he would call the tax without benefitting not only himself but also the standard of the industry and the brains of the country as a whole. The only thing to be careful of was not to get too clever. It was only when getting older that one came to realise not how much but how little one really knows. He would recount a story that is going the round of his district at the present moment. There was a very young mining inspector who had just passed his examination and of course knew everything. He was going down a pit. When he got in the cage one of the old-fashioned banksmen said to him, "If I was you I would take hold of the cross-bar." "Oh," he said, "It is quite all right. I am used to a pit." "You had better take hold of it," said the banksman. "I understand all about collieries, you leave me alone." "Well," the banksman said, "I still advise you to take hold of it, Sir." "No, I am not going to do it. I quite understand what I am doing." "Well," the banksman said, "You understand a very large number of things, but you do not know the bottom of that cage fell out three times last week." (Laughter)

In conclusion, Capt. Walton-Brown referred to the kind remarks by Mr. Bell in mentioning the name of Mr. Charlton: he was sure all in this territory looked upon the Inspectors as they did in the further North—as friends out to help and always willing to give the benefit of their experience. He must congratulate them upon having in Mr. Charlton a man of ability, perhaps particularly because he happened to come from the North East Coast.

Mr. W. J. CHARLTON having expressed his thanks said he had a personal note to put forward: that was not the first time he had appeared in Lancashire; he was there in the war years 1915 to 1917, and at that time was known as the Electrical Inspector of Mines. He was happy to be present as representing the Mines Department. As far as the Mines Department is concerned of course they welcome all the assistance that this Association gives, and look with a kindly eye upon all its endeavours, because it is out to do exactly what is wanted by the Mines Department, or by that branch of it with which he, Mr. Charlton, was connected. Their whole concern in that department was to have regard to the health and safety of the miner. Mr. Bell said the regulations were sometimes looked upon as being somewhat irritating but he believed everybody would agree they were very well founded and had been of tremendous service to the considered use of electricity in the coal mines.

Capt. Walton-Brown had mentioned the possibility that electricians in coal mines would have to be certificated. That, of course, was the keynote of all mining legislation in this country. The 1911 Mines Act started out with the requirement that the coal mine should be under the direct control of a person who had certain qualifications, a certain amount of knowledge. He did not think that was a very hard thing to require. As he had said the whole keynote of legislation in this country had been that there should be persons with a certain degree of knowledge to look after the welfare of the miner. Now that had been done with some effect: there was an important Mines Bill in 1872: in the decade 1873 to 1882 the death rate per thousand persons employed was: Underground, 2.57; Surface, 0.92; Total, 2.24. Last year, 1928, the mortality rate per thousand persons employed was: Underground, 1.18; Surface, 0.5; Total, 1.04. So we have made tremendous progress in decreasing the mortality rate in pits.

But look at it in another way. It is important we should look at it in another way because through the application of machinery—electrical machinery particularly—without doubt we did introduce a new form of risk. In the decade 1873 to 1882 the death rate per million tons of coal raised was 7.42. In 1928 it was 4.04.

Those figures do show that we are making steady progress. Incidentally, he would mention that in the previous day's paper the Chief Constables for Manchester and Salford gave their figures of the mortality due to accidents through vehicular traffic on the streets. In Manchester there were 83 fatal accidents and 83 deaths; in Salford there were 30 fatal accidents and 33 deaths—a total of 113 fatal accidents and 116 deaths. He could assure them that last year there were far fewer tragedies than that in all the collieries in the Lancashire district. Such figures gave one to think.

What he, Mr. Charlton, would emphasise was that the efforts of the Association were to increase the use of electricity in collieries, and the only way to ensure that that would be looked upon with approval by the public was to make certain that the use of electricity would be carried on safely. The whole object of the education of the coal miner was that the installation put in should be maintained in the proper manner. That was the essential point. It is the business of the electrical engineer at the colliery to see that the machinery is maintained in the proper condition. It is not much good the machinery being excellent unless it is maintained properly.

Mr. W. T. ANDERSON, in proposing the Toast of "Kindred Associations," recalled that when in Wigan the other day he had called on a very old friend of the Association, Mr. Heyes, who was saying, as was his regular habit some very kind things about somebody, and to justify which he recited some lines which so impressed Mr. Anderson that he had taken them down. They were in this wise:—

If with pleasure you are viewing, any work a man is doing,
If you like him or you love him, tell him now.
Don't withold your approbation 'till the parson makes oration
And he lies with snowy lilies on his brow.
For no matter how you shout it, he won't really care about it,
He won't care how many tears you may have shed.
If you think some praise is due him, now's the time to give it to him,
For he cannot read his tombstone when he's dead.

In proposing this toast and associating with it the names of his old friends, Mr. Herbert, the Chairman of the North Western Centre of the Institution of Electrical Engineers, and Mr. Noah Williams, the local Secretary of the Institution of Mining Engineers, Mr. Anderson said he would hold out that poetic sentiment as embodying in some way the feelings he could but imperfectly express. The kindred Institutions, of which most of them were members, were passing through difficult times. The state of some could be indicated by a little story. Two chaps started out in a jaunting car to get to Tralee. It seemed a very long drive and after going a considerable time they stopped and asked a native how far they were from Tralee. He said "Five Miles." After going two or three miles they asked another native. It was still about five miles. Then after a while they asked a third native and got the same answer. The jarvey turned round and said "Glory be! We're holding our own."

Mr. Anderson thought that represented the state of some of the Institutions to-day; but they were not down-hearted. It was perhaps apt that he had been called upon to propose this toast, because it was his privilege to be a member of one of those groups of engineers, round about 1913 and 1914, whose effort it was to try to make in Manchester a home for the engineering and technological institutions. That hope was frustrated by the avalanche of the War, but arising out of that effort the Engineers' Club did what was impossible in other directions and provided a place which had come to be accepted as the hub of engineering in this district.

The Management Committee of the Engineers Club was always particularly glad not only to entertain the distinguished members of the kindred Institutions but also their own Association, the A.M.E.E.

Mr. T. E. HERBERT in responding, expressed his pleasure and thanks for the hospitality and the opportunity of meeting brother electrical engineers: he need not remind them that the electrical engineer is the most important person in the world: the very structure of matter itself is electrical in origin, and therefore his remark was entirely justified. He had gathered from the remarks of previous speakers that it was their desire that the mining electrical engineer should maintain definitely his proper place in the profession of electrical engineering, and he sincerely hoped that that would always be the case. Cheap and unqualified labour be it professional or be it the labour of the hand, however cheap it may be, if it is inefficient, is about the most costly thing in the world. Anything therefore that could be done to raise the status of the electrical engineer was always in the best interests of the country.

Mr. Herbert mentioned that he was a member of the Institution of Professional Civil Servants, to which the Divisional Inspector of Mines belongs, and who have as their President a man who would certainly be well known very well to everyone present; he referred to Sir Richard Redmayne, who, in that connection might be said to lead all the professional civil servants in the kingdom in their fight for an adequate appreciation of the work which the professional civil servant does.

Referring to the general scope of the Association, Mr. Herbert said he was particularly delighted to realise that they were definitely pressing forward in the effort to reduce human effort to the minimum by employing machinery wherever possible. He had such an idea of the sanctity of human life, of human labour, that he did not think any operation ought to be performed by human labour which could be performed by a machine. There were certain cases where, owing to our financial system possibly—the high cost of money and so on—machines could not for the present be economically employed. The remedy, he thought, rested in the correction of those financial difficulties rather than in the pepetuation of human manual effort. He would commend that view to them: it was the duty of all to make the horrible jobs of life—and there were many horrible jobs—as tolerable as possible. He was pleased to know that was practically one of the ideals of the Association.

THE CHAIRMAN called upon Mr. Rooke Ainsworth to propose a vote of thanks to Mr. Bolton Shaw, branch treasurer, and to Mr. Vincent Heyes, branch secretary, for all the work they had done for the Branch, not only during the current session but also in the many years during which they have served so fully and voluntary in those respective offices.

Mr. R. AINSWORTH said it afforded him very great pleasure in expressing the thanks of the North Western Branch for the great work done by Mr. Bolton

Shaw as treasurer and by Mr. Vincent Heyes as secretary. He himself had been secretary of the Branch for several years so he knew the work involved in that office: but he did not think they all quite realised how exacting that work was. It called for persistent service in the interests of the Branch. Mr. Heyes had done that work excellently and had served the interests of the Branch through thick and thin for many years past. They could not too often express their thanks to him. Mr. Ainsworth said he looked upon Mr. Bolton Shaw as a stalwart of the Branch. He had done yeoman's work for the Association ever since its inception, and he looked forward to the day when they would see him take the presidential chair of the Association. He hoped that might be so at an early date.

Mr. V. HEYES suitably acknowledged the toast and regretted the absence of Mr. Bolton Shaw. At the risk of boring his audience he would bring forward that hardy annual question of attendances at meetings, and its psychological effects upon honorary secretaries. Prior to each meeting a paper has to be found, lecture room arranged, circulars printed, envelopes addressed, stamped and posted. At the meeting perhaps only 10 per cent. of the members attend. Now some secretaries might say that 90 per cent. of the paper, stamps, and labour was wasted, but he was not one of them. All the same, small attendances at meetings do tend to be disheartening; he trusted therefore that every member would make an effort to attend regularly. By so doing they helped each other, the Association as a whole, and the Branch; they would encourage the authors of papers, and last but not least, they would give the honorary secretary a little more work to do, for the Branch would most certainly grow.

LONDON BRANCH.

Oil-Filled Electric Cables.

R. E. HORLEY.

(*Paper read January 7th,* 1930.)

Just as the advance of civilisation has depended in a very great measure upon the development of better and quicker means of transport, so the ever-increasing application of electricity has depended to a very great extent upon better and cheaper methods of electrical transmission. The ability to generate large amounts of power is useless without the facilities for transmitting it to the places where it is required.

On the whole it may be said that the development of transmission systems, from the time when the introduction of the electric lamp created a serious demand for electricity has kept pace very well with the development of electric machinery and to-day the necessity for the transmission of the large blocks of power over considerable distances to satisfy the demands of industry causes no apprehension either from the point of view of safety, or reliability.

With the rapidly increasing demand for power, the attention of cable makers the world over, has been concentrated upon the problem of producing cables to work at very high voltages. The economical and operating advantages thereby obtainable are very considerable and include the saving of intermediate sub-stations, transformers, switchgear and attendance, the reduction in the number of cables required to carry a given load—a most important factor in congested streets —savings in synchronous condensers, increase in efficiency, improved regulation and improved stability of parallel operating of local plants with the outside source of power.

The Electricity Commissioners, in drawing up the National Grid Scheme, have come to the conclusion, all factors considered, that the most economical voltage for the transmission of the power required in this country is 132,000 volts. The primary lines are overhead

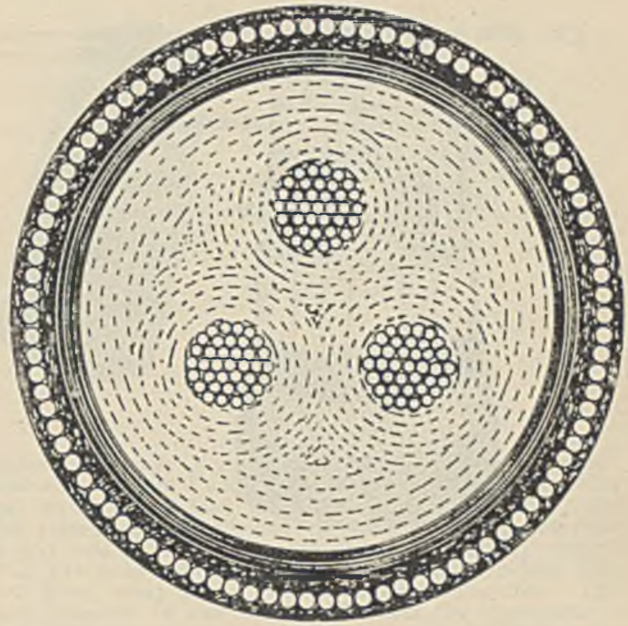

Fig. 1.

but the Commissioners were influenced in their decision by the possibility of being able to transmit power underground by cables at this pressure, since it is not always desirable or practicable to bring overhead lines at this high voltage into very congested areas. In America three-phase underground cable lines have been laid, carrying approximately 100,000 kilowatts at a pressure of 132,000 volts, resulting in very large savings in comparison with cables of 33,000 volts. Underground cable lines capable of transmitting 80,000 k.v.a. at 132,000 volts are at present being laid in London between Kidbrooke and Deptford, Wimbledon and Battersea.

To-day, underground cables may be manufactured for pressures as high as 220,000 volts, although only a few years ago the highest voltage considered practicable was 22,000. This remarkable increase in working pressures has been due to a better understanding of the phenomena taking place in super-tension cables; resulting in not only improved methods of manufacture but in more scientific designs of cable.

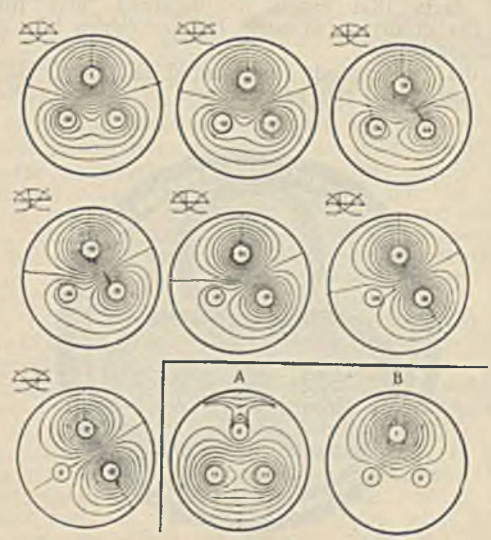

Fig. 2.

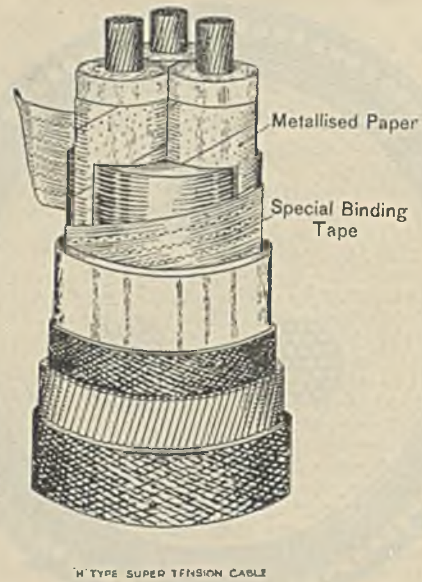

Fig. 3.

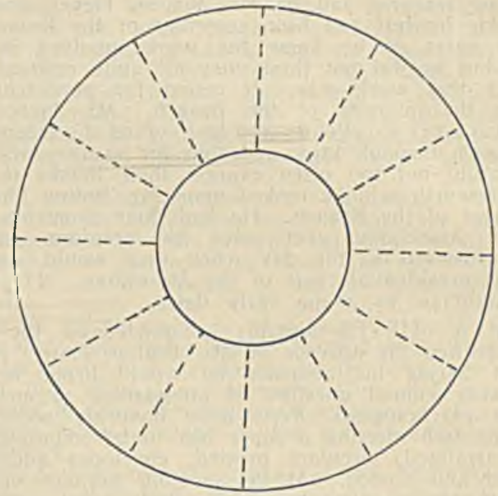

Fig. 5.

In order to understand the reasons which led to the introduction of the oil-filled cable, which constitutes a radical departure from the ordinary type of high-voltage cable, it will be helpful to consider certain phenomena occurring in normal type cables. Three-core cables of ordinary construction (Fig. 1 illustrates a 33 k.v. belted type) insulated with dried paper, impregnated with a very viscuous compound, gave for many years what seemed to be satisfactory service, in that actual breakdown was not so frequent as to be disturbing, at pressures up to 22,000 volts; so that, when the demand for power became such that a higher transmitting voltage was desirable, it was considered that cables of this type, but insulated for the higher pressures of 33,000 volts, would give equally satisfactory service. In Europe and America many cables for this pressure were manufactured and laid but after a time breakdown became very frequent; the reasons for failure were then so obscure that for a time many authorities abandoned the idea of transmitting power at such high pressures. In America the National Electric Light and Power Association appointed a special committee to investigate the causes of failure in these cables and their verdict, after analysing all the facts that could be obtained, was that the phenomena occurring in super-tension cables was not yet fully understood.

In 1912, Hochstadter attributed failure to tangential electric stresses in the paper layers of the core dielectric or in the fillings and great attention was given to the study of the electric field. It was then realised that in a three-core cable of normal design the direction and intensity of the field are constantly changing with the instantaneous voltage. The next illustration, Fig. 2, shews the field in a three-phase cable at different times in the period. The first seven diagrams shew the field as obtained by Emanueli and others, experimentally, for seven instants in the period at intervals of five degrees. The last two shew the field at two particular instants; the first corresponding to the case in which two conductors of the cable are connected together and the third to the lead sheath; the second, where two conductors are connected to the lead sheath and the other insulated. It will be seen from this diagram that the equipotential lines are not symmetrical and do not coincide with the surface of the insulation on the cores and belt; thus there is a tangential component and, as the dielectric strength of laminated insulated materials such as impregnated paper is much less along the surface than it is at right angles, the effective insulation of each core of a normal type three-phase cable is not so great as that of a single-core cable of equivalent size and in which the stresses are purely radial. These stresses become more important the higher the voltage at which the cable is operated.

Two types of three-core cable were then proposed, the Hochstadter or type "H" cable, Fig. 3, and the "S.L." or triple lead sheathed type, Fig. 4, which by being in effect three single-core cables laid up together removed the dangers due to tangential stresses since obviously the stress in a single-core cable is normal to the surface of the paper tapes as shewn in Fig. 5. Such cables have proved satisfactory in practice for pressures of the order of 30,000 volts, but for much higher pressures factors other than the direction of the stresses must be taken into account.

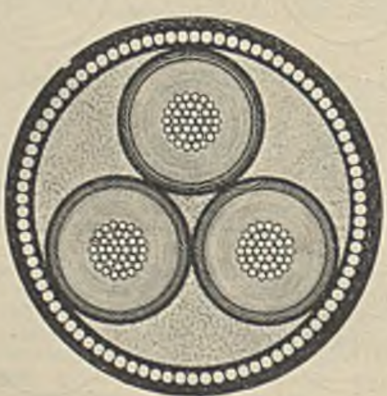

Fig. 4.

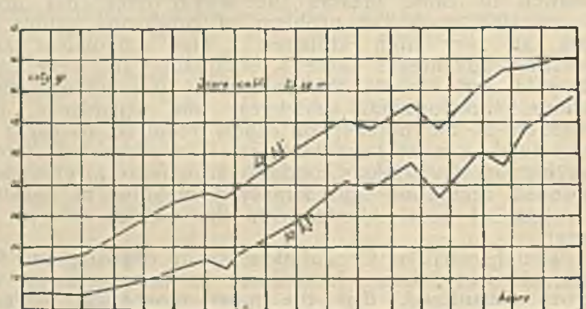

Fig. 6.

When a cable of normal construction and impregnated with the ordinary viscous compound is in service, the current heats up the cable. The comparatively large volume of compound held in the insulation expands as a result of the increased temperature and must find additional space for its accommodation. This occurs principally at the expense of the lead sheath which becomes distended. When the cable cools down during periods of lighter loading, the compound contracts, but the lead sheath does not contract with it, mainly owing to its inelasticity. Spaces are thus left between the lead sheath and cores. In time, compound drains out of the insulation into these spaces, resulting in the formation of voids within the cable insulation. If dielectric power factor tests are taken after the cable has been in operation for some time, the power factor is found to have increased, indicating change in the degree of impregnation of the insulation. The next illustration Fig. 6, due to Emanueli, shews an example of variation of power factor with time at 10 k.v. and 48 k.v. on a three-phase cable. This shews that the normal type cable although well impregnated in the factory does not remain well impregnated after being put into service. Now the loss of impregnation or formation of void has certain effects which shorten the cable life considerably.

A layer of gas or a void in a cable is in series with a composite dielectric of higher dielectric constant and, since the dielectric strength of a gas is proportional to its pressure, if there are voids in a cable electric breakdown of the voids will occur at a lower voltage than that required to produce breakdown in the rest of the insulation. It has been found by experiment that electric breakdown or discharge across voids or gas spaces in the cable results in the production of a waxy substance, the generation of gases including hydrogen, and the formation of water by chemical combination. The waxy substance has been found to have excellent insulating properties. The formation of water, however, is no doubt one of the chief causes of cable deterioration.

Again, the low mechanical pressure to which the dielectric is submitted, especially when the load is off, leads to a low dielectric strength and, consequently, possible breakdown. Besides this the gaseous films, especially when the mechanical pressure is low, are highly ionised and build up conductive laminæ, which produce distortion in the electrostatic field and stresses along the surface of the paper tapes. At high stresses it has also been found that gases migrate through the paper sheets under the action of the ionic bombardment, and build up an ionised path in the direction of the stress.

From what has been said, it is evident that the presence of ionised gas is highly undesirable in high tension cables. Some methods have been suggested to improve cables from this point of view. One method is based on the fact that if the mechanical pressure on the dielectric is sufficiently high, no ionisation occurs, and it has consequently been proposed to leave channels in the cable which may communicate with the atmosphere at the joints; but a more satisfactory method has been suggested, that of increasing the pressure over that of the atmosphere, using pumps or similar means. These methods, however, have been merely suggestions, and have never been developed. A great improvement in the behaviour of some cables has been obtained in America by filling the joints with a very fluid mineral oil, which can be supplied by reservoirs connected to the joint. The oil is sucked into the cable by vacuum produced by the cooling and contraction of the cable. The impregnation of the cable is consequently much improved. It is interesting to note, however, that the cable does not cease to absorb oil for a very long time. One of the reasons for this, is that the oil takes a very long time to reach the points of the cable far from the joint; but there is yet another reason which does not very greatly favour the system of feeding joints. The cable, when cold, absorbs the oil fed from the reservoir very slowly. The oil impregnates the points near the joint. When the cable is loaded and becomes heated, the compound expands but only a very small quantity of the oil mixed with the compound can return to the reservoir, this being due to the fact that the cable heats up quickly, and the return passage for the oil to the feeding reservoir is too small, the lead sheath is consequently stretched. This has been experimentally proved, and the lead tube has been burst by repeated temperature cycles. This high pressure is due to the fact that the compound is very viscous, and the size of the passage it has to move through is very restricted. In order to prevent the troubles here briefly outlined it will be readily understood that it is necessary to have:

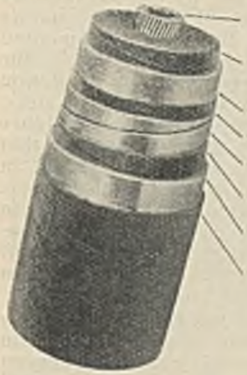

Fig. 7.

(1) A properly predetermined channel in the cable for the movement of the compound.

(2) A compound of suitable viscosity.

(3) A reinforcing of the lead sheath to prevent it becoming distended, and

(4) Feeding devices of suitable capacity arranged at predetermined intervals.

These points have been studied with great care in the design of the oil-filled cable system. In the oil-filled cable system single-core cables are used so that the stresses are radial. The impregnating medium is a mineral oil of low viscosity and the system is designed so that when the oil expands due to the increase in the cable temperature, the extra volume instead of distending the lead sheath, is accommodated by means of external reservoirs which return the oil to the cable when it contracts during periods of lighter loading. The cable is thus maintained full of oil under all working conditions.

The oil is fed into the cable through a central channel formed by stranding the conductors around a plain narrow metal strip so that a cavity is formed at the centre of the core (Fig. 7 illustrates a hollow core cable). This cavity is kept completely filled with oil by means of feeding tanks at a pressure which is maintained just above atmospheric pressure at all points in the cable.

In the manufacture of the cable the normal drying operation is only a preliminary drying and the impregnation of the paper is effected after the lead sheathing process. By this means much more perfect impregnation is possible because the vacuum that can be established in the lead covered core is more complete than can be established in the large impregnating tanks. As the tank in which the core is placed for the vacuum and impregnating operation is maintained at a temperature of 100 degs. C., the lead sheath must be perfectly sound or the vacuum cannot be established. This constitutes a check on the soundness of the lead sheath, impossible to obtain in the case of ordinary insulated cables.

The oil used for impregnating the cable is clarified by passing it through a centrifugal machine (Fig. 8), and degasified. The degasifying of the oil is a most important point as will be realised from what has been said about the effect of gaseous films in the cable dielectric.

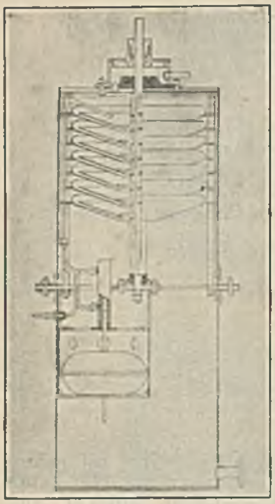

Fig. 8.

Owing to the preparatory treatment of the impregnating oil and the improved method of impregnating the cable, the stress per m.m. of insulation that can be used with safety, is about 50 per cent. higher than the maximum stress that may be safely employed in cables of ordinary construction. The thickness of dielectric in oil-filled cables is thus considerably less than that of normal type cables for an equivalent voltage.

Around the first sheath a reinforcing armour of plain brass tape is wrapped between two layers of impregnated cloth. This prevents the lead sheath from being stretched when subjected to increased pressure owing to the expansion of the oil, the total extra volume of oil flows instead along the central cavity and into the reservoir designed to accommodate it. The second lead sheath is applied to protect the tape against the chemical action of the ground. This gives a smooth surface for pulling into ducts, but where the cable is laid direct, a suitable waterproof covering is employed.

The special feeding tank which has been designed for dealing with the expanding or contracting oil is in effect a reservoir of certain capacity connected to the cable and placed at a height above it in order to obtain the necessary hydrostatic pressure as determined from calculations upon the profile of the line. It is essential, however, that the oil in the reservoir shall not be in contact with the surrounding air in order to maintain it in its degasified condition and, further, it must be kept practically at atmospheric pressure independent of the quantity of oil in the reservoir. These conditions have been fulfilled by constructing the reservoir in the form of flexible walled cells made of corrugated nickel plates, the number and size of cells depending upon the amount of oil required for the operating conditions in the cable at the particular point. The illustrartion, Fig. 9, shews a feeding tank consisting of nine cells, each with collapsible walls and connected in parallel to a common manifold (3); each cell is composed of a channel ring (2) at each side of which is soldered a corrugated nickel diaphragm (1) with retaining ring (4). The illustration, Fig. 9, shews a photograph of the parts used in this construction. The corrugation allows the plates to move under expansion or contraction. Two sizes of feeding cells or elements have been standardised, a certain number of these being paralleled togethed to form a tank. A number of tanks may be paralleled together by means of valves and manifolds to give the necessary volume of oil. The cells or feeding tanks are made of nickel because this metal will not become corroded by the atmosphere.

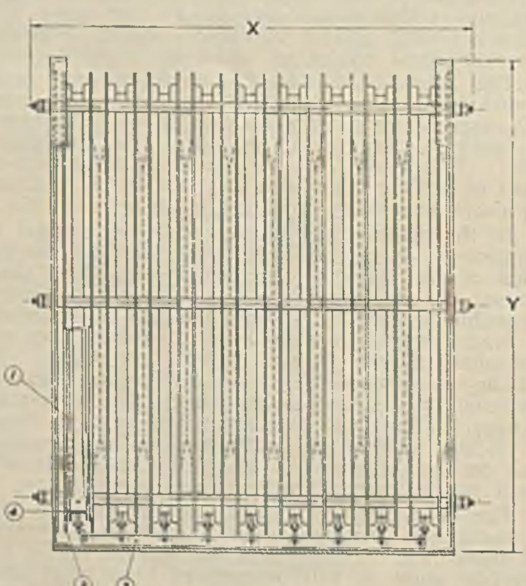

Fig. 9.

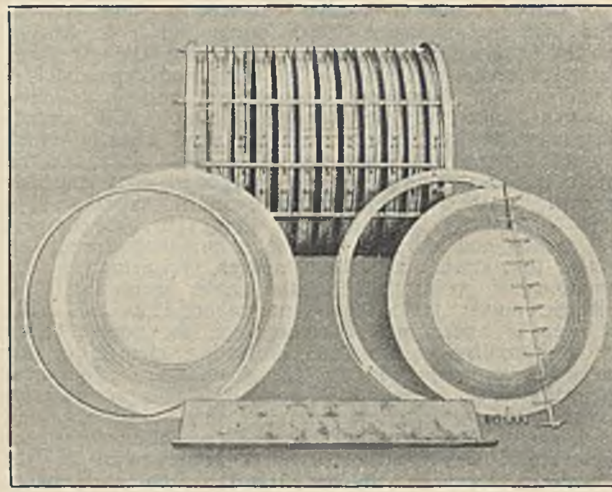

Fig. 10.

It has been determined that the pressure at any point within the cable must not be allowed to drop below atmospheric and it is evident that the length of cable that may be fed from one source in order that this condition shall be satisfied is limited. The length of section, however, may be considerably increased by installing a pressure tank, its function being to assist the feeding tank in providing accommodation for expanding oil and returning oil to the cable upon cooling. It differs in principle from the feeding tank in that it does not depend upon gravity for its action and consequently need not be placed at a height above the cable. A pressure tank consists of a certain number of collapsible gas tight cells, marked (1) in the Fig. 11, filled with gas under pressure contained in the tank (2), which is filled with oil. It will be seen that if the pressure tank is connected to the cable at a distance from the feeding tank, the oil in it, and the gas inside the cells, are subjected to the pressure corresponding to the static head of oil from the reservoir. When the cable cools down at a point distant from the feeding tank, but near the pressure tank, the pressure within the cable falls and the gas, therefore, enclosed in the collapsible cells of the pressure tank increases in volume and pushes out the oil from the tank into the cable. When the cable has finished cooling and steady conditions prevail, the feeding tank sends oil into the pressure tank and restores it to its initial condition. When the load is switched on the cable heats up and the oil expands. At a point in the cable remote from the feeding tank and near the pressure tank, the pressure in the oil rises. Oil is sent in both directions and causes the pressure in the pressure tank to increase. This accommodation of oil by the pressure tank reduces the rise in pressure which would have occurred due to the resistance of the flow of oil to the feeding tank. Details of the pressure tank are shewn in Fig. 12.

When the cable reaches its maximum temperature for the particular load, the pressure tank sends oil back along the hollow core into the feeding tank and its pressure falls to the initial static value. The action of

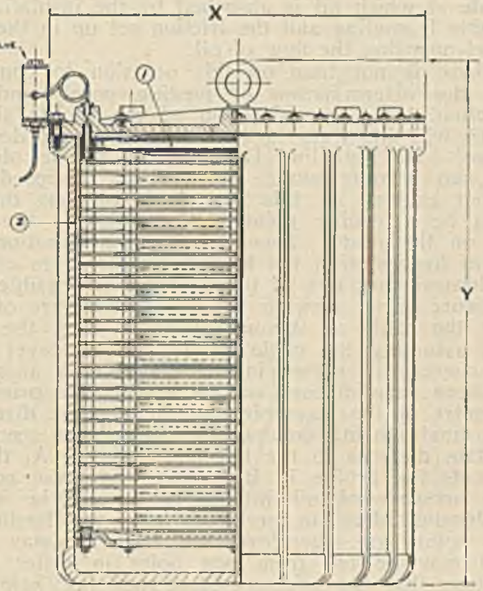

Fig. 11.

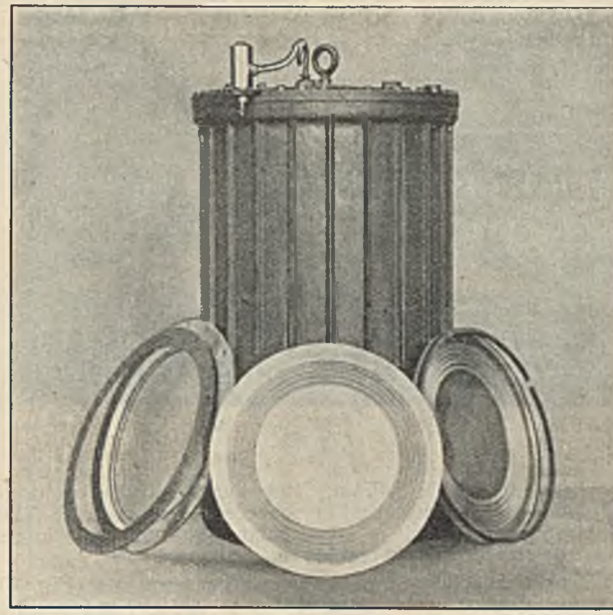

Fig. 12.

the pressure tank, therefore, is to reduce the pressure variation that occurs within the cable, and thus allow an increase in length of working section.

The dividing of the line into working sections is achieved by means of stop joints which connect electrically two sections of the cable and yet stop completely the oil communication between them and allow, if required, oil to be fed to either side of a section, independent of the other. A stop joint (Fig. 13) consists essentially of a cylindrical tank (1), filled with oil, which contains two inserted porcelain insulators (2), with terminal caps electrically connected by flexible coupling (3). The bases of the porcelain insulators are rigidly supported, one in each end of the tank. The two caps are screened by means of a metal shell (4), so as to obtain a good distribution of the electric field. The metal shell is insulated by means of impregnated paper (5). The tank portion of the stop joint, with insulators, caps, and insulation, is prepared, impregnated in the factory, and despatched to site, hermetically sealed. The ends of the cable are insulated in the field, provided with electrostatic control, fitted with specially designed spring contact plugs, and then slipped inside the insulators so that their connectors engage with the contact caps, the lead sheath of the cable then being wiped in position. Each end of the cable is impregnated under vacuum.

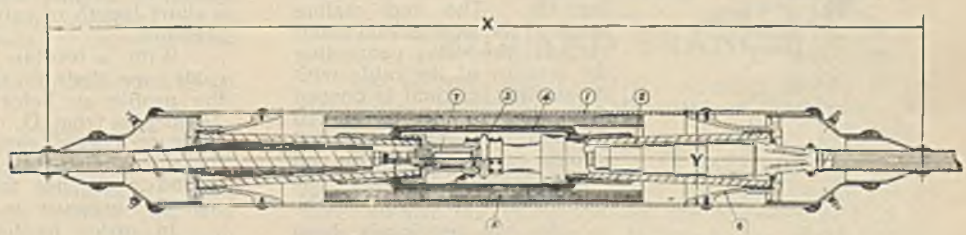

Fig. 13.

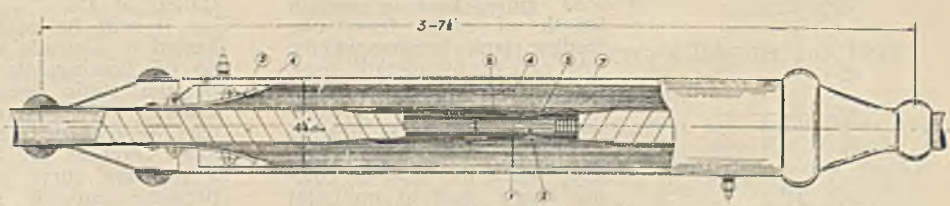

Fig. 14.

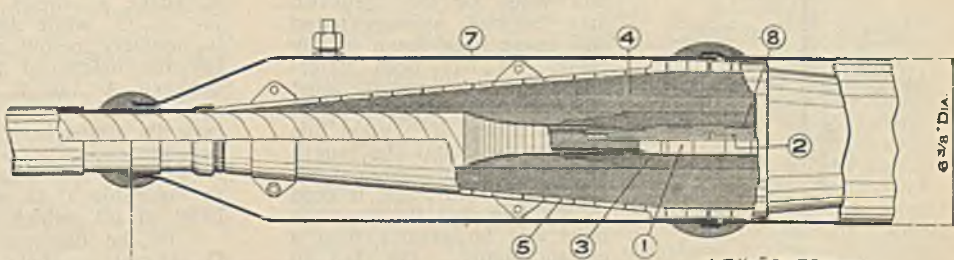

Fig. 15.

In the standard straight through joint for 66 k.v. and upwards (Fig. 14) the ferrule (1) is first insulated with a paper roll with tapered ends (3) to a diameter equal to the diameter of the cable insulation. The V gaps at the ends of the paper roll are filled in with strong narrow silk and paper tapes. A machine is used to apply the main insulation in the form of paper tapes similar to that used in the insulation of the cable. The ends of the main insulation (4) are tapered to fit into metal trumpets (5) which control the electrostatic field.

For 66 k.v. the joint is screened with a copper sheath (6) bonded at both ends to the cable lead, while for 132 k.v. and 220 k.v. joints (Fig. 15) the metal trumpet is extended to cover completely and screen the whole joint. The joints are enclosed in cylindrical copper sleeves (7) with conical ends plumbed to the inner lead

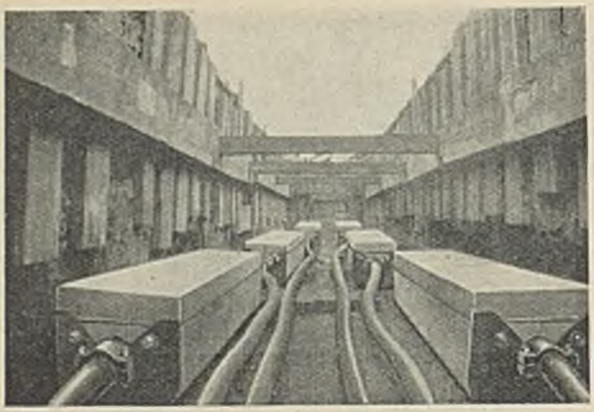

Fig. 16.

sheath of the cable . Finally, the joints may be enclosed in pits or individually in concrete containers. The illustration, Fig. 16, is of a joint bay with six joints constructed on 66 k.v. cables in London.

The connection of cable to sealing terminals (Fig. 17 is a sectional diagram of a 66 k.v. to 220 k.v. end sealing terminal) is made by means of copper ferrules (1). The ferrule is designed to act as a valve which on withdrawal of a steel pin connects the oil in the cable with the sealing terminal. The insulation of the cable at the end of the lead sheath is reinforced by means of a paper roll (2) and fitted with a metal electrostatic control (3). The prepared end is inserted into the end sealing terminal, and the ferrule fastened in position at top (4). The inner lead of the cable is plumbed to the bottom section of the base casting (5). The end sealing terminal is impregnated under vacuum, the valve connecting the interior of the cable with the sealing terminal is opened thus allowing oil to be fed through the sealing terminal into the cable. Finally, the end sealing terminal is fitted at the top with a covering shield.

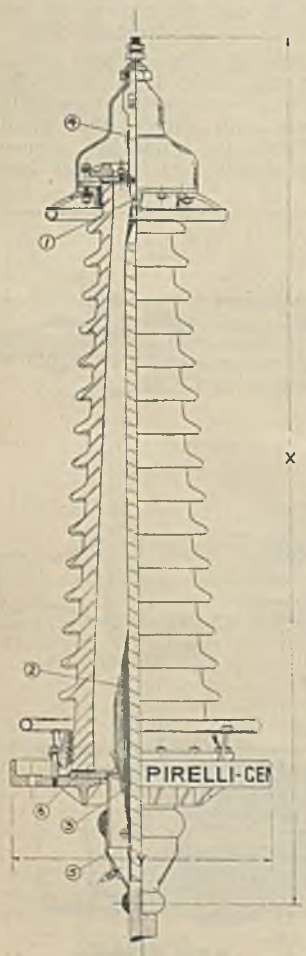

Fig. 17.

As has previously been stated it is not practicable to feed more than a certain length of cable from one feeding tank because in the first case the hydrostatic pressure would become too great at distant points of the cable when the cable was heating up, and secondly the pressure drop when the cable is cooling down must at no point be allowed to exceed a certain value or the dielectric may become unimpregnated and cause breakdown of the cable. It has been determined that the pressure must not fall below atmospheric at any point and it is upon this consideration that the length of section is determined although due attention is paid to the fact that the pressure must not be greater than a certain figure. The fall of pressure when the cable is cooling down depends upon the rate at which oil is absorbed by the insulation when the cable is cooling and the friction set up in the central channel opposing the flow of oil.

There is not time on this occasion to consider in detail the determination of feeding points and length of section, but a consideration of the profile shewn in Fig. 18 will illustrate how these points are decided in practice. The full line DAG is the profile plotted to scale and a route along which it is proposed to lay oil-filled cables. In this case it is obvious that there should be a feeding point at A, which is the highest point on the route. Now, from a consideration of the laws of hydrostatics, the load the cable is to carry and the physical constants of the cable, it is possible to plot a pressure curve shewing the fall of pressure of the oil inside the cable at various distances from the feeding point, assuming the cable to be laid on level ground. Such curves are shewn in the diagram as a, a_1 which have been superimposed on the profile, the origin being the centre of the reservoir and the positive direction of the ordinates being downwards. It will be seen that at a certain distance to the left and right of A, the curve a a_1 cuts the profile in B and C. At these points the static pressure of oil in the cable will be equal to the dynamic drop in pressure from the feeding tank, these points are, therefore, the farthest away from A which may be fed from one point in order that the condition that the pressure shall not fall below atmospheric is fulfilled.

Consider, however, the curve to the left of A. It is evident that the pressure of oil in the flat part of the curve would be at least equal to 33 metres head of oil, which would be far too great for safety. If we assume that the static pressure should never exceed 20 metres head, the section to the left of A must be divided into two sections by installing a stop joint at some convenient point about half-way down the slope between A and B and using another tank to supply the remainder of the line.

Suppose we place a stop joint and feeding tank at E. The head of oil immediately to the right of E will be about 18 metres, which is safe, and moreover the head decreases rapidly as we proceed towards A, so that only a short length of cable will be subject to any considerable pressure.

With a feeding tank at E, two metres above the cable, we find by superimposing our pressure curve on the profile as before we can feed as far as F, about 270 metres from D. The curves b and c are atmospheric pressure curves shewing an imaginary profile in which there is atmospheric pressure at all points. Since curves b and c do not fall below the actual profile we see that the pressure is nowhere less than atmospheric.

In order to feed the line from D to F without employing another feeding tank, a pressure tank is installed at D.

It will be realised that when the cable has been heated to a steady temperature, and there is consequently no oil flowing, the pressure in the pressure tank will be the static pressure at that point, which in this example is 17 metres head of oil. The pressure tank may be regarded therefore as another feed tank on the same level as the true feed tank at E. Superimposing a pressure curve as before, we obtain curve d. The pressure tank is now feeding half the section, i.e., 850 metres. With regard to the route to the right of A, curve a_1 shews that the feeding tank will feed as far as C, while the curve e shews that the pressure is nowhere below atmospheric. Of course, by increasing the height of the feeding tank at A, the distance between A and C might be increased, still satisfying the condition that the pressure should nowhere fall beneath atmospheric. The pressure, however, must not become excessive, as for example, if the feed tank at A were so raised so as to feed up to G, the pressure in the cable at G would be at least equal to 28 metres head of oil, which would be too great.

In the diagram a further feed tank is installed at G, 15 metres above the cable and the pressure curve f shews that it will feed to H. It is obvious that for this section the pressure will be well above atmos-

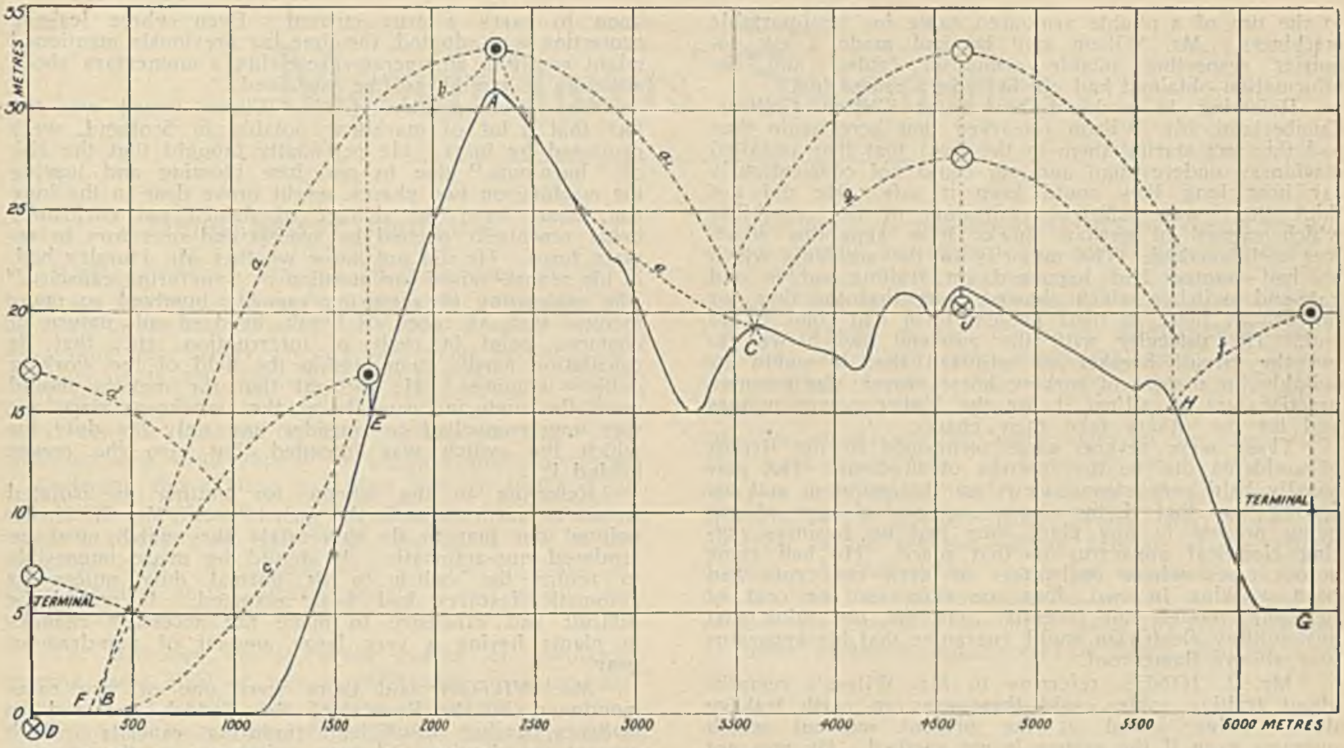

Fig. 18.

pheric at all points. A stop joint is placed at H, while calculations shew that the distance between C and H can also be fed from A without an additional feed tank, provided a pressure tank is placed at J.

The capacities of the feeding devices are arrived at from a consideration of the maximum changes in volume of oil in a section, due to heating and cooling, caused by rise and fall of the load. Seasonal changes of temperature must also be allowed for.

The size of the pressure tank is determined from two considerations:—

1. When the cable is cooling down. How much air imprisioned in the cells of the tank must there be so that its increase in volume between its normal static pressure and the minimum pressure required to send oil to the farthest point fed from the feeding tank will be equal to the volume of oil required by the length of line the pressure tank is feeding?

2. When the cable is heating up. How much air in the cells is required so that starting at the static pressure the tank can accommodate the excess oil due to expansion of oil in the cable without being compressed to a pressure higher than the safe maximum working pressure of the tank.

Whichever of these two calculations gives the higher result decides the size of the tank used.

There is not sufficient time to describe the methods adopted for the installation of the cable but, broadly, the principal is the taking of precaution to maintain the cable in a fully impregnated condition throughout the operations and to exclude air. When the installation is completed it is possible, by means of a simple physical test, to shew that the impregnation value is equal to, or better than, that obtained in the factory immediately after the factory impregnation.

Sufficient has been explained, however, to shew that in the oil-filled cable system the complex difficulties of the normal type high-voltage cable are swept away and the problem, instead of being an electrical one, becomes simply a question of hydrostatics, capable of solution by calculation, using well known laws.

With regard to the cost of the system, in spite of the expense involved in the oil feeding accessories, owing to the fact that it is possible to transmit much greater loads with safety, the total cost of an installation is less than that of a normal cable capable of transmitting the same amount of power.

MIDLAND BRANCH.

The monthly meeting of the Midland Branch of the Association took place in Mansfield on December 21st last, Mr. R. Wilson presiding.

An apology for non-attendance was received from Mr. L. G. F. Routledge, and the Chairman also stated that he had had a telegram from Mr. Grice—who was to have opened the discussion on the Report for 1928 of H.M. Electrical Inspector of Mines—to the effect that he was ill and unable to come. He, Mr. Wilson, thereupon opened the discussion.

H.M. Electrical Inspector's Report for 1928.

Discussion.

Mr. WILSON said there were two publications the colliery electrician ought to read, one the Journal of the Association, and the other, H.M. Inspector's Annual Report. They would benefit by the experience of others, and in the Report they usually had a record of "Things left undone which ought to have been done" etc.

One very alarming feature of the Report was the increased number of accidents due to the use of electricity in mines. We as the people interested and really responsible for the control and maintenance of electrical apparatus ought to be very seriously concerned about this increase. He believed there were about twenty-one accidents in the Report for 1928 on trailing cables and plugs, and he thought one of the lessons to be gained from that fact was how necessary it was that everybody concerned should make a really strenuous effort to improve the construction and design of trailing cables and plugs. These have to withstand very rough treatment, and as constructed to-day, will not stand up to this treatment. Mr. Horsley in his Report again refers to the use of a pliable armoured cable for semi-portable machinery. Mr. Wilson said he had made a few enquiries respecting pliable armoured cables, and the information obtained had not been very reassuring.

Referring to accident No. 9 at Clifton Colliery, Cumberland, Mr. Wilson remarked that here again they had this fact staring them in the face: that they installed machinery underground and yet could not concientiously say how long they could keep it safe. He did not think there was sufficient realisation of the possibility which existed of getting shocks from apparatus which was well earthed. The majority of the accidents which he had quoted had happened on trailing cables and gate-end switches which showed them that the time for the use of these in their present form had come to an end. The difficulty with the gate-end switch was to get the circuit breaker so adjusted that it would be suitable for motors of varying horse power; the common practice was to adjust it for the higher power motors and let the others take their chance.

There were several cases mentioned in the Report of accidents due to the ignition of firedamp. He, personally held very strong views on this question and his feeling was that if there was any real danger of gas being present in any place they had no business putting electrical apparatus in that place. He had come across cases where coalcutters or even conveyors had been working in two, four, or even six per cent of firedamp—though not recently. He did not think that any colliery electrician could guarantee that his apparatus was always flameproof.

Mr. J. JONES, referring to Mr. Wilson's remarks about trailing cables, said there was an earth leakage device being tested at the present moment which operates even if the system is not earthed. He was not prepared to give full details at the present moment, but it had been on test at a local colliery for the last twelve months. He would arrange for a paper to be given on the subject in the near future. He might say that they tested the apparatus with a live starling, and it tripped the breaker 10 times without injuring the bird. The apparatus could only be used on an unearthed neutral system.

He would like to ask Mr. Wilson whether the Report showed an increase in the number of accidents proportionate to the extension of the use of electrical apparatus underground.

Mr. WILSON.—In 1927 there were three fatal and eighteen non-fatal accidents, and in 1928 six fatal and twenty-five non-fatal, and they could safely say there had not been a corresponding increase in the use of electricity in that period.

Mr. C. D. WILKINSON said that theoretically there ought not to be any accidents since all apparatus should always be in good condition. All realised, however, the difficulty of keeping the plant in such condition, especially portable apparatus.

Trailing cables had proved a most fruitful source of accidents and even with the most up-to-date switchgear and systems of protection had still proved their weakness.

With regard to accidents due to the ignition of firedamp, it was well-known that only a very small amount of energy was required to ignite firedamp. A fault to earth on a trailer of the most up-to-date type, protected by switchgear and leakage devices of the modern type, was almost invariably accompanied by a flash, especially if the fault was caused through external damage. The fault must occur before the protective devices could operate, and there was always a time lag even with the most sensitive of these and a flash was usually set up during the interval between the origination of the fault and its clearance.

With regard to the accident in which a man had received a shock from gear which was apparently well earthed, one had to consider not only the percentage conductance but also the total impedance of the earthing system. It was possible, in the case of apparatus situated a long way in-bye on a system with earthed neutral, to obtain a considerable potential difference between the apparatus and earth if the earthing system were called upon to carry a large current. Even where leakage protection was adopted, the time lag previously mentioned might result in an operator receiving a momentary shock although it would not be sustained.

One other point that Mr. Wilson raised was the fact that a lot of machines, notably in Scotland, were protected by fuses. He personally thought that the risk of "burn-outs," due to one fuse blowing and leaving the machine on two phases, might prove dear in the long run, apart from the danger of flame-proof enclosures being repeatedly opened by semi-skilled operators to replace fuses. He did not know whether Mr. Horsley had, in his report, raised the question of "rupturing capacity." The calculation of rupturing capacity involved so many factors, such as speed of break, head of oil, nature of contacts, point in cycle of interruption, etc., that its calculation hardly came within the field of the working colliery engineer. He thought that the makers should mark the rupturing capacity on the switchgear since one was now compelled to consider, not only the duty for which the switch was intended, but also the power behind it.

Referring to the scheme for putting an isolated circuit to earth through the switch itself, Mr. Wilkinson pointed out that to do this safely the switch must be rendered non-automatic. It should be made impossible to return the switch to its normal duty unless its automatic features had been resumed. It would be difficult and expensive to make the necessary changes in plants having a very large amount of non-drawout gear.

Mr. WILSON said there were one or two cases mentioned in the Report of fires which occurred to switches having insufficient rupturing capacity. With respect to adapting old type switchgear to the requirements of the Inspector, this was a very difficult matter. Some of the drawout type gear could be easily adapted.

A SPEAKER asked whether any special type of trailing cable showed danger to life.

Mr. WILSON replied that it seemed to him that the type of cable which had not a metallic sheath on the phase cores was the one from which they could anticipate most trouble. Speaking from memory, there were two serious cases of accidents with trailers without metal sheaths. In one case the cab tyre had been penetrated by a piece of steel wire, and the man grasped the cable at this point (Accident No. 12). In another case (Accident No. 17) the cable had been penetrated by a piece of detonator wire about ⅞in. long.

Mr. J. W. Gibson and the A.M.E.E.

At the Council Meeting of the Association of Mining Electrical Engineers held in Preston on February 22nd last, Mr. J. W. Gibson, a Vice-President of the Association and a Past President of the London Branch, was unanimously nominated for the office of President of the Association for the Session 1930-31.

The invitation of the London Branch for the Annual Convention to be held in London was definitely accepted.

The Provisional Programme and Arrangements for the London Convention include:—

Assembly on Tuesday night, the 24th June—headquarters: St. Pancras Hotel, N.W. 1; Wednesday, June 25th: Visit to the Chelmsford Works of Crompton Parkinson, Marconi and Hoffman; Thursday, June 26th: Joining with the Kent Sub-Branch, a visit is to be made to Tilmanstone Colliery, near Dover; Friday, June 27th: Visit to the Works of Evershed & Vignoles Ltd., or the Metropolitan Electric Cable Co., Ltd.

A General Council Meeting will be held at the St. Pancras Hotel at 2-30 p.m. to be adjourned at 3-30 p.m., and resumed immediately after the termination of the Annual General Meeting which will open at 3-30 p.m. The Annual Dinner will be held in the evening of Friday at 8 p.m. in the St. Pancras Hotel.

On Saturday, June 28th, a visit will be paid to the works of Allen West & Co., Ltd., Brighton.

Manufacturers' Specialities.

Hand Safety Detector.

Mining electrical men and all those who are called upon to maintain and inspect electrical apparatus will be quick to see the advantage of having a handy "tool" for testing immediately whether any circuit electrical part is "alive or dead". Oswald Record and Company supply an indicator which, resembling a pencil box or ebony ruler, can be included in the working kit bag. The indicator is a stout ebonite or pertinax tube containing a condenser and a Neon gas glow tube in series. The glow tube serves as the current indicator; it is mounted inside a strong glass and visible through a slot in the enclosing case. A contact hook at one end and an earth terminal at the other complete a very simple and reliable instrument.

The detectors are in seven grades or standards, ranging from 1000 or less to 5000 volts maximum, and others up to 35,000 volts maximum, at prices varying approximately from £4 up to £12. The indicators for a maximum tension up to 5000 volts are supplied with one condenser cell, those up to 10,000 volts with two, and those up to 15,000 volts with three condensers of the same size and which are mounted in series. In such manner the length of the ebonite tube varies according to the working tension.

The enclosing tube is in two parts, a screwed cap covers the hook and indicator window end or, when in use, is screwed on the earth terminal end to form a hollow long handle. It will be noticed too that this useful safety appliance can very readily serve as a means of discharging live circuits—a feature which will appeal strongly to mining men.

Flame-proof Mining Controllers.

There are many distinctive features in the standard designs of Mavor and Coulson flame-proof controllers, which after many years of extensive use can be well considered in their present form as representing the best practice for safe underground service. Ranging in sizes up to 150 h.p. capacity, the controllers are built in a horizontal oil-immersed type and in a vertical air-break type.

Proportioned throughout on substantial and robust lines there are several particular details of design which may perhaps only be fully appreciated by the man who has to work with the plant. Whereas a hand-lever operation is all that is necessary for ease of working and strength of parts in the smaller sizes of the horizontal pattern, the larger sizes are fitted with a horizontal hand-wheel which gives an easier and more definite control over the heavier contact barrel. The barrel and contact fingers are fixed on the inside of the lid or cover so that on opening up and throwing back the cover all electrical parts and terminals are lifted out of the oil and are freely accessible. The cover is interlocked so that it cannot be opened unless the controller is off circuit. Another advantage of the hand-wheel type is that it permits of the controller being raised on a pedestal, which not only brings the wheel to a convenient body level for easy working, but which gives ample space for the easy bending entrance of cables into the glands on the lower sides of the controller. The hand-wheel, being of large diameter, affords the operator a definite "feel" and an off position stop prevents the controller being swung over from one direction to the reverse without pausing at the "off" position. Another detail, simple but necessary and effective, is that the cast-iron case has a well or depression running the length of the base inside, to retain carbon or other sediment and prevent it being churned into the oil.

Battery Traction Underground.

A further addition has recently been made to the fleet of electric mine locomotives used by the Coltness Iron Company. These locomotives are capable of hauling on the level, about 60 tons of pit tubs with plain bearings and about twice that weight of tubs equipped with roller bearings, at a speed of about six miles per hour. The driving power is supplied by D.P. Kathanode batteries which were selected for this purpose because of their ability to withstand heavy discharge rates. Two batteries are supplied with each locomotive so that whilst one is in use the other can be charged.

The batteries are mounted in removable battery boxes so that a discharged battery can be pushed off on to the charging platform and replaced with a fully charged battery, this process occupying only three or four minutes, including the disconnecting of the discharged battery and the connecting up of the new battery.

The locomotives are equipped with two 17 h.p., totally enclosed, series wound, railway type, 80-volt motors, each driving one axle of the locomotive through single reduction machine-cut spur gearing enclosed in an oil-tight gearcase. The motors will give a rated tractive effort at the locomotive wheels of about 2000 lbs. for one hour and a maximum tractive effort for starting of about 3600 lbs. The locomotives are each equipped with a series parallel controller, steel-tyred wheels, self-locking brakes, sanding devices on all four wheels, powerful headlights and an ampere hour meter to show the state of the discharge of the battery.

Diesel-Electric Locomotives.

The D.P. Battery Co., Ltd., have recently supplied two of their well-known Kathanode batteries of fifty cells, each having a capacity of 224 amp.-hrs. at the five-hour rate of discharge, for the starting and lighting of two 50 ton Diesel electric locomotives. These locomotives are for the North-Western Railway Company of India and they have been constructed throughout at the General Electrical Company's works in England.

Each locomotive weighs approximately 50 tons in working order. They are of the double bogie type, equipped with a 350 b.h.p. Beardmore high-speed Diesel engine, direct-coupled to a single bearing electric generator with overhung exciter. The generator supplies current to four traction motors mounted upon the bogie axles, control being effected by master controllers located in the driver's cabins at each end of the locomotive. The locomotives are designed to haul loads up to 100 tons at a maximum speed on the level of approximately 47 miles an hour and at correspondingly less speeds on gradients up to 1 in 50.

The batteries float across the exciter circuit and provide power for starting the engine and also a low tension supply of the lighting and control circuits. They are assembled in exceptionally strong ebonite containers of special design in order to allow for a free circulation of air round each cell, this practice being standard in the case of "Kathanode" batteries for use in hot climates.

LAMP CONTRACTS.

The Government of Northern Ireland, Ministry of Finance, Belfast, has placed a twelve month's contract for Siemens electric lamps, vacuum and gasfilled, and other materials.

The British Admiralty have also again placed a large contract with Messrs. Siemens for the supply of a large quantity of vacuum and gasfilled pearl lamps, also clear gasfilled lamps.

The General Electric Co., Ltd., also announce that they have been successful in securing a contract for some 308,000 Osram electric lamps from the Director of Navy Contracts of H.M. Admiralty. The whole of these lamps will be made at the Company's Works at Wembley and Hammersmith.

NEW ADDRESSES.

Tungsram Electric Lamp Works (Gt. Britain) Ltd., makers of Tungsram Electric Lamps and Tungsram Barium Radio Valves have recently transferred their Leeds branch into larger premises at Britannia House, 74 Wellington Street (Corner of Britannia Street). These new premises, which are conveniently situated near the centre of the town, became necessary, the old premises having been found too small to cope with the demand for the Company's products, the sales of both electric lamps and radio valves having increased enormously during the past few months.

S. Thomas Pemberton & Co., 8 Church Street, Colmore Row, Birmingham (Principal: S. T. Pemberton, M.I.E.E., A.M.I.Mech.E.), have been appointed to represent Bruce Peebles & Co., Ltd., Edinburgh, in the Midland Counties of England. Mr. Pemberton has for the last 28 years been the Representative of Electromotors Ltd. in the same district.

NEW CATALOGUES.

EVERSHED & VIGNOLES, Ltd., Acton Lane Works, Chiswick, London, W. 4.—The Midworth Distant Repeater, a system for transmitting information or controlling apparatus from a distance, is described in detail with many illustrations in this list, No. H-162.

BRITISH INSULATED CABLES Ltd., Prescot, Lancs.—This Company has issued an art publication describing with many photographs the work they have done in connection with the Central Scotland Electricity Scheme.

BRITISH ALUMINIUM Co., Ltd., Adelaide House, London, E.C. 4.—A handy little book gives with diagrams many hints for aluminium working. Electricians and amateur metal workers will find this useful.

A. REYROLLE & Co., Ltd., Hebburn-on-Tyne.—The Accessories Catalogue consists of a strong binder with a full set of illustrated lists of the smaller apparatus made by this Company. Being provided with interleaved index cards it is exceptionally convenient for daily reference by contractors and purchasers. Reyrolle Accessories include many types which are particularly suitable for mining work as for example, Plugs and Sockets.

MAVOR & COULSON, Ltd., 47 Broad Street, Mile End, Glasgow.—The M. & C. 16 inch gear for driving electric shaker conveyors is described in considerable detail in this colour illustrated pamphlet. The sectional drawings given are on a large scale and exceptionally clear.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway London, W.C. 2.—A number of new parts have been issued for incorporation in the standard G.E.C. binders. These include Section P 3, Direct Current Motors; Section X 8, Contactor Starters; Section X 10, Contactors, Relays, and Accessories.

Other G.E.C. publications received are Technical Descriptions Nos. 222, 231, 232, and 293, all of which deal respectively with various forms of G.E.C. Automatic Protective Gear, and which as usual are exceptionally complete with diagrams. A new edition of the G.E.C. Ironclad Switchgear Catalogue is still another recent issue.

BRUCE PEEBLES & Co., Ltd., Edinburgh.—The leaflet No. 172 is an interesting series of illustrations of the marine type dynamos and motors in which this firm has for so long specialised.

SIEMENS ELECTRIC LAMPS & SUPPLIES Ltd., 38-39 Upper Thames Street, London, E.C. 4.—Catalogue No. Z 130 is a compendious price list of Siemens low tension fuse and switchgear incorporating "Zed" fuses. There are several entirely new specialities included in this list which should be kept at hand by estimators and contractors.

CROMPTON PARKINSON Ltd., Bush House, Aldwych, London, W.C. 2.—Several new publications have been issued recently by this Company. Two handbooks dealing respectively with the installation and maintenance of D.C. motors and A.C. motors will be found extremely useful by working electricians, charge engineers and students. It is to be noted that these publications are marked with a price of 1/- and they are well worth it.

HEYES & Co., Ltd., Water-Heyes Electrical Works, Wigan.—Nos. 2, 3, and 4 of the "Wigan Review" a monthly circular published by this firm provides interesting reading and effective publicity.

GENT & Co., Ltd., Faraday Works, Leicester.—New editions of part of this Company's standard catalogue include: Section 1 b bells, indicators pushes and contacts, etc.; Section 2 b, electro-motor syrens.

BRITISH THOMSON-HOUSTON Co., Ltd., Rugby.—The descriptive list No. 2535 is a technical treatise concerning Helical Gearing in comparison with Straight Spur Gearing and in particular is to develop interest in the B.T.H. high speed helical gearing.

METROPOLITAN-VICKERS ELECTRICAL Co., Ltd., Trafford Park, Manchester.—The descriptive leaflet No. 39/1-1 deals fully with flame-proof induction motors for circuits up to 600 volts and up to 140 h.p. The list gives prices and also much useful data in regard to ratings and output, dimensions, etc.

Students and charge engineers who are interested in the efficient running of A.C. machines will be glad to read the Metropolitan-Vickers descriptive leaflet No. 40/1-4 which goes thoroughly into the technical considerations when determining the efficiencies of induction motors from test results.