The Mining Electrical Engineer.
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Only Sixpence!

The Annual Report for 1928 of H.M. Electrical Inspector of Mines, carries but a continuance of the unhappy sequence which year after year charges the mining man with gross negligence. It would, in very truth, almost appear that, for the sake of sixpence, ignorance shall prevail and lives and property be jeopardised. If some would demur that this is too blunt a way of putting things and that there is no need to make a fuss because the records of all the few inevitable fatalities of a year are packed together into one cover, let them read this report and learn that the majority of these accidents were plainly due to the deliberate neglect of established safe principles and the ignoring of advice and instruction which, for sixpence a year, has been available in these reports for years past. Also let them remember that it is only those cases of neglect which have culminated in serious accident which are here brought to general knowledge. Would it be unfair to say that these published as accomplished facts can only be a small proportion of the risks hazarded ?

It is not our intention to create alarm but we do seek to rouse the practical interest of everyone responsible. It is impossible to read chapter after chapter of tragedy directly attributable to carelessness—to slip-shod method, maintenance, supervision, and design—to a perpetuated apathetic ignorance—and keep silence. Furthermore, the safety of electricity in mines is essentially the care of this particular journal. Our efforts are centred upon helping to lead or drive the user and the maker of mining electrical gear into safe and knowledgeable channels so that the best of men shall have, and be entrusted with, the best plant.

In this, his latest, report, Mr. Horsley (H.M. Electrical Inspector of Mines) says "twenty per cent. of the accidents over a period of five years are attributed to defects of design, or misapplication; that is to say, to the use of equipment for a purpose for which it was unsuitable and never intended. The remedy for poor quality or unsuitable equipment rests with the purchaser. If price —initial cost—is the overriding determinant when selecting equipment, it is to be expected that quality will suffer. Initial outlay, although it cannot be ignored, is only part of the ultimate cost. The cost of upkeep and, what may be of much more serious consequence, the indirect cost of a breakdown of the apparatus, may entirely offset a difference in initial prices."

"While selling price is controlled to some extent by competition, it is determined ultimately by the scale of production."

"Two examples may be adduced, viz.: The British Standard Flame-proof Mining type plug and Trailing Cables."

"There is a British Standard Specification for plug and socket which ensures interchangeability as between plugs and sockets, from different manufacturers, and also prescribes certain standards of quality. These plugs are being manufactured in small quantities by different firms and while the design is intrinsically superior to the somewhat primitive plugs that they are steadily displacing, their cost is relatively high and this is probably due in no small measure to the scale of production."

"Trailing cables are manufactured in small quantities to many different specifications. The lengths into which the cable as manufactured is to be cut vary widely, although this may, and sometimes does, entail cutting to waste. Although the experience and high reputation of the cable makers maintain the intrinsic quality of material, there is wide and wholly unnecessary variety in the types that are manufactured. While the quality of the material is usually unimpeachable, the quality of the cable, as a working tool, varies between wide limits."

"My justification for referring to this question of quality—which is in the main an economic question—is that quality and reliability are to no small extent synonymous terms and that greater reliability tends to reduction of opportunities for accident."

In an analysis of the causes of the fifty-five non-fatal accidents notified there are shown only six classified as "unforeseeable." The others are respectively graded : defects of design, or misapplication, ten; Faults of maintenance, fifteen; Misuse or negligence, twenty-four. There were twenty-one accidents with trailing cables, and also eight accidents with trailing cable plugs. In consideration of the serious position: that this item of the equipment is alone responsible for about half the total of all electrical accidents, Mr. Horsley has written a separate section on the subject: an abstract of this part of the report is published on page 162 of this number.

The great value of this Annual Report is that it does not merely cite the cause and effect of accidents, but it gives explicit instructions as to how such accidents can be avoided. In the greater number of cases, pity 'tis, the preventive means are so very simple. That is why we emphasise that "only sixpence" stands between ignorance and much life-saving knowledge. It is inconceivable that they who read this report will fail to observe its teachings.

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.—REPORT of H.M. Electrical Inspector of Mines for the year 1928. J. A. Bernard Horsley. Price 6d. nett.

BRITISH STANDARD SPECIFICATIONS FOR COLLIERY REQUISITES.

No. 236-1929.—Flattened Strand Steel Wire Ropes for Colliery Winding Purposes.

No. 237-1929.—Flattened Strand Steel Wire Ropes for Colliery Haulage Purposes.

No. 238-1929.—Underground Lighting Fittings for Use in Mines.

British Engineering Standards Association, 28 Victoria Street, Westminster, London, S.W. 1. Price each, 2s. 2d. post free.

The Flattened Strand Rope Specifications, following the lines of the Round Strand Colliery Rope Specifications, already issued, contain clauses regulating the testing carried out in connection with the purchase of colliery haulage and winding ropes, tensile and torsion tests of the wire being specified both before and after the manufacture of the rope. After the issue of the round strand rope specifications it was felt desirable, in view of the large use of flattened strand ropes, mainly in South Wales and Lancashire, but to a certain extent in the other coalfields, to consider the preparation of flattened strand rope specifications. Examination showed that, although there was a large variety of constructions recommended for specific purposes, there were a number of constructions common to makers of flattened strand ropes not only in this country but in the United States and on the Continent. The difficulty in the way of the preparation of specifications lay in the fact that no agreement had been reached amongst manufacturers as to breaking strengths and weights. Standard tables have now been agreed with the makers and these are included in the Specifications.

The Underground Lighting Fittings Specification provides for fittings for use with British Standard Vacuum Tungsten Filament Lamps, with a minimum rating of 60 watts, and its main purpose is to ensure interchangeability of such parts as well glasses that require frequent replacement. The provisions in regard to interchangeability are also extended to cover the attachment of the cables so that with the new standard fittings quick replacement of damaged fittings will be facilitated.

For general guidance it will be well to note that the other British Standard Specifications for Colliery Requisites so far published are:—227-1926.—Steel Arches for use in Mines (Straight-sided and Horse-Shoe Arches); 229-1929.—Flame-Proof Enclosures for Electrical Apparatus and Tests for Flame-Proof Enclosures; 248-1926.—Light Rails and Fishplates for use in Mines; 279-1927.—Flame-Proof Type Plug and Socket, Heavy Duty; 291-1927.—Material for Colliery Tub Drawbars, Shackles and Couplings; 300-1927.—Round Strand Steel Wire Ropes for Colliery Winding Purposes [*Add.* April, 1929]; 322-1928.—Colliery Cage Main Shackles and Bridle Chains; 323-1928.—Colliery Rope Capels or Sockets for use in Hauling or Winding Men; 330-1929.—Round Strand Steel Wire Ropes for Colliery Haulage Purposes; 355-1929.—Mining Type Transformers [*Add.* May, 1929]. "*Add.*" signifies that an Addendum or Corrigendum is issued with this Specification. All are priced at 2s. 2d. each, post free.

THE PRACTICE OF SPECTRUM ANALYSIS with Hilger Instruments, including a Note on the various types of Emission Spectra, compiled by F. Twyman, F.Inst.P., F.R.S., Fourth Edition. Contributors are E. N. Da C. Andrade, D.Sc., Ph.D., F.Inst.P., Quain Professor of Physics in the University of London, University College, London; Samuel Judd Lewis, D.Sc., F.I.C., Ph.C., Consulting Chemist; D. M. Smith, A.R.C.S., B.Sc., M.Inst.Met., Spectroscopist to the British Non-Ferrous Metals Research Association, Birmingham; S. Barratt, B.Sc., Head of the Sceptroscopic Laboratory, University College, Gower Street, London; A. A. Fitch, A.R.C.S., B.Sc., Beit Scientific Research Fellow, Royal School of Mines, Imperial College of Science and Technology, South Kensington; J. W. Ryde, General Electrical Company's Research Laboratories, Wembley. Adam Hilger, Ltd.. 24 Rochester Place, Camden Place, London, N.W. 1. —Price 1s. 6d. nett.

Professor Andrade's contribution is a lucid and balanced statement concerning what modern atomic physics has at this date to say about the various types of emission spectra. Dr. S. Judd Lewis, who has for many years used spectroscopy in his daily work as consulting chemist, deals in a general way with the utility of spectrum analysis to the chemist, and supplies details of the methods of work which he has found most useful. Mr. D. M. Smith, who has been working for several years on the application of spectrum analysis to non-ferrous metallurgy, deals with metallurgical applications. Mr. Barratt reviews the recent methods of quantitative spectroscopic analysis, including his own. Mr. Fitch, who has been working on the applications of the spectrograph to mineralogy, adds some notes on this subject. Mr. Ryde, in whose hands spectrum analysis is in regular use at the Research Laboratories of the General Electric Co., Ltd., gives a description of the distinctive methods which he uses there, of the R.U. (*raies ultimes*) powder made by him at that Laboratory, and of the Exploded Wire method of spectrum analysis.

20,000 Volt Underground Mining Cables.

W. ELSDON-DEW and H. DENEHY.

(Abstract of Paper "The 20 k.v. Underground Transmission System at Crown Mines, Ltd." read before The South African Institute of Electrical Engineers, 25th July, 1929.)

(Continued from page 124.)

PROTECTION.

Reference has been made to the test sheath; this consists of a copper tape 0.010 in. thick, applied spirally under, but lightly insulated from, the lead sheath by 0.050 in. radial thickness impregnated paper, the insulation resistance of the test sheath to lead being of the order of 50 megohms per mile. The test sheath thus surrounds the three cores and, therefore, any external injury to the cable must entail damage to the test sheath before the main insulation is affected. By testing the insulation resistance of the thin dielectric between the test sheath and lead, a reliable indication will be obtained of the integrity of the lead sheath.

The detective panel arrangements for making this test are shown diagrammatically in the illustration, Fig. 2. The test sheath is normally connected to earth through the selector switch. During testing operations the selector switch disconnects the test sheath from earth and connects it to the four-way switch; in the second position of the latter switch the test sheath is connected to the 1,500 volt electrostatic voltmeter. If no high potential leakage exists from one of the conductors to the test sheath, the four-way switch is moved to the third position, thus putting the 500 volt voltmeter into circuit. By short-circuiting the series resistance through the push button, leakage readings up to 50 volts may be obtained. If no leakage exists, the final position of the four-way switch puts the direct reading testing set into circuit.

By this means a constant watch can be kept on the condition of the cable by allowing the dielectric to be explored without the necessity of isolating the cable, and slight damage may be detected in the initial stages without interrupting the service.

It will be noticed that the test sheath is here used purely for detection purposes, though Messrs. Glover, the makers of the cables, have patented a system whereby it may be used also for the purpose of fault isolation.

The fault isolation gear for this system received a considerable amount of study before the method presently described was adopted and, in order that reasons for this particular scheme may be appreciated, the following points should be borne in mind.

Switches on the 20 k.v. side exist only at the sending end, the cables being solidly connected to the step-down transformers. Isolation of one cable system is effected, therefore, by opening the 20 k.v. switch at the surface and the 2,000 volt switch on the secondary of the particular bank of transformers at the 29th level.

Another point is that each individual transformer is equipped with a Buchholz relay. This device is situated in the oil pipe connection between the conservator and the transformer tank, and its operation is a function of the velocity of any generated gases displacing a float and the consequential closing of the relay contacts. As gases may be generated by the breakdown of a transformer coil between turns, such a fault in its incipient stages involves neither an earth nor an overload. It is clear, therefore, that neither an earth leakage nor an overload relay would function until an advanced stage of the fault would result in a ground or a short circuit.

The simplest solution for the isolation of a fault, either in a cable or its bank of transformers, would be by the use of pilot cables, and thus cause the 20 k.v. sending end and the 2,000 volt receiving end switches to open simultaneously. Indeed the original schemes worked out by the engineers of the Victoria Falls and Transvaal Power Company and the cable makers involved the use of pilot cables, though the schemes differed in this respect, that whereas the former

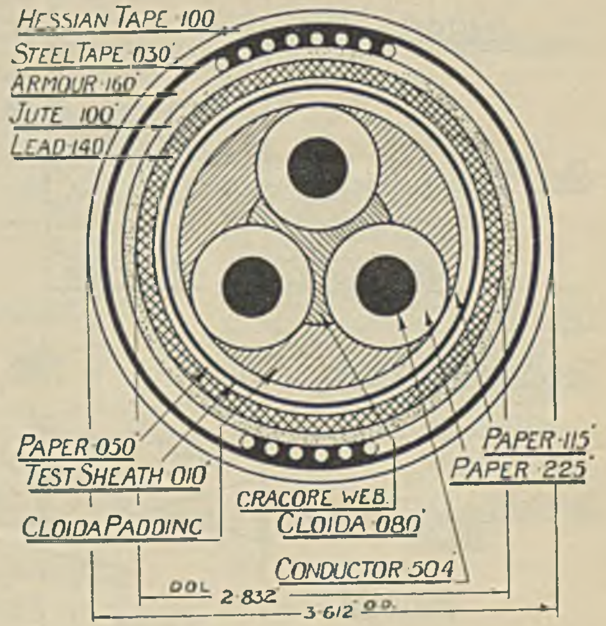

Fig. 1.—Section of the 0.5 sq. in., P.L.C., J.S., S.W.A., lapped with an open spiral of C.S. Tape, Hessian Taped, 22,000 volt Cable; Round Conductors (Earthed) with Glover's Patent Test Sheath.

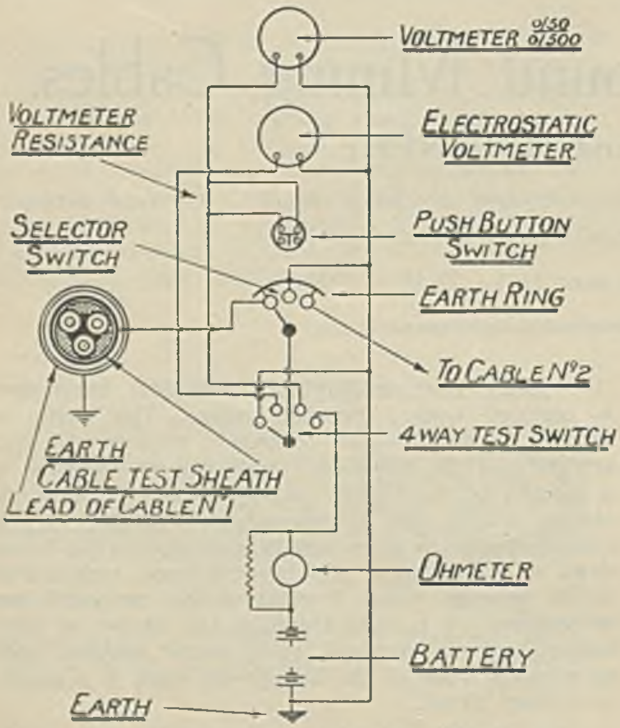

Fig. 2.—Connections of the Detector Panel.

consisted of overload and earth leakage relays at the sending end only, the latter was a differential one, involving differential and directional relays with the back-up protection of overloads and earth leakage relays as a second line of defence at the sending end.

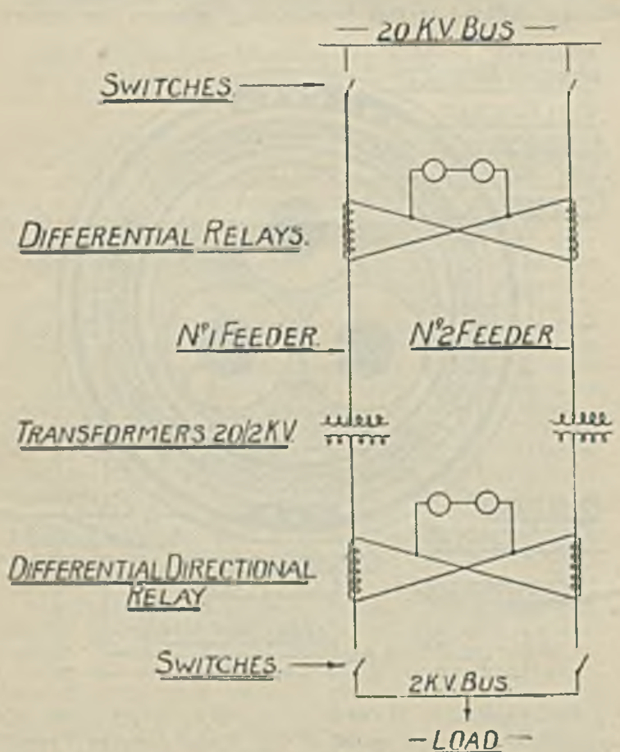

Fig. 3.—One-phase Diagram.

As the reason for pilot wires for the latter scheme may not be at once apparent, the following fundamental points during fault conditions, in a system of duplicate parallel feeders, are worthy of notice.

At the sending end the faulty feeder carries the heavier load, but the converse applies at the receiving end, i.e., the healthy feeder being the heavier loaded one.

The differential in load carried by the two feeders at the sending end is an arithmetical one, depending on the magnitude of the fault current. It attains its maximum value if the faulty feeder is isolated at the receiving end.

Conversely, the difference in load at the receiving end is an algebraic one, and may be arithmetically zero, but considerable algebraically. It attains its maximum value if the faulty feeder is isolated at the sending end. On the other hand, reversal in the faulty feeder can only occur when the fault current exceeds the load current.

Therefore, differential relays are required at the sending end, but differential directional relays are necessary at the receiving end; the former must isolate the more heavily loaded feeder whilst the latter must function on the lightly loaded one and must, moreover, take care of direction. Immediately the sending end switch of a faulty feeder opens, the healthy feeder becomes the more heavily loaded one, and unless steps are taken to prevent it, the relays on the healthy feeder would immediately afterwards trip out their own feeder as well, and thus shut down the whole plant. This is obviated by pallet auxiliary switches on each main switch, which, when the latter trips, cuts out the relay on the opposite feeder. This applies to the sending end only, as the direction of restraint of the receiving end relays keeps open the contacts for operating the healthy feeder.

The above outlines the functioning of differential and directional relays for duplicate parallel feeder protection when connected in the orthodox manner.

If we now introduce a Buchholz relay into the system under review and assume a leakage between turns of the same phase of a transformer, the faulty circuit is isolated from the receiving end only by the switch at this end opening, due to the action of the Buchholz relay. On the assumption that there are no pilot wires, the sending end switch on the faulty circuit will still remain closed; therefore, the healthy circuit becomes the more heavily loaded one and consequently trips, thus the whole service becomes interrupted.

It is now clear that if differential protection is required to cater for all fault conditions, the Buchholz relays must operate the sending end switches, i.e., pilot wires become a necessity.

As the successful discrimination of fault isolating gear is entirely dependent on pilot cables (where used), they should be protected from mechanical damage far more thoroughly than is possible underground in shafts and travelling ways, and for this reason they were undesirable for the system described in this paper.

The engineers of the Victoria Falls and Transvaal Power Company, Limited, solved the problem in a most ingenious way, which will be now described. In this scheme, which has been adopted, the differential directional relays for instantaneous operation and connected in the normal manner have been retained at the receiving end, as also the definite time overload and instantaneous earth leakage relays at the sending end. The differential relays at the sending end, however, have been arranged to operate conversely to the standard method; this means that the direction of operation of these relays is always to isolate the lightly loaded feeder. Thus the differential and directional relays at the receiving end, operate in the direction to isolate the feeder carrying the lighter load. A time lag is introduced in the sending end differential relays for reasons which will be presently explained.

Fig.. 3 is a single line diagram of the arrangement in which one phase only is shown, the potential circuit for the receiving end relays being omitted.

Under normal conditions, the opening of either of the switches, on a particular feeder causes that feeder to be completely isolated; by definition, this feeder thus becomes the "lightly" loaded one when either switch is opened. Thus, switching "off" may be performed from either end.

To switch "in", auxiliary switches (not shown in the diagram) interposed in the tripping circuits of the sending and receiving ends respectively are first opened, after which either of the main switches may be closed—telephone service being established between the two stations to facilitate switching operations, etc.

If any of the Buchholz relays should function on a high resistance fault (such as a breakdown between turns), the receiving end switch trips, followed by the tripping of the sending end switch of the feeder affected.

On the development of a single phase earth fault on one cable, that cable becomes the heavier loaded loaded one at the sending end; consequently the differential relay at that end tends to trip the wrong feeder, but before it can complete its cycle, the instantaneous earth leakage relay trips the faulty feeder and the differential relay resets. The functioning of the differential directional relays at the receiving end for earth faults is dependent solely on differential action, as the step-down transformers are insulated.

On the occurrence of a between-phase fault, the instantaneous differential directional relays would trip out the receiving end switch either on differential or directional action in accordance with the principles enunciated earlier in the paper. The time lag differential relays at the sending end would again tend to trip out the lightly loaded healthy feeder, but the definite time overload relay would function before the cycle could be completed.

It will be seen that the differential relays at the sending end are introduced purely for the purpose of

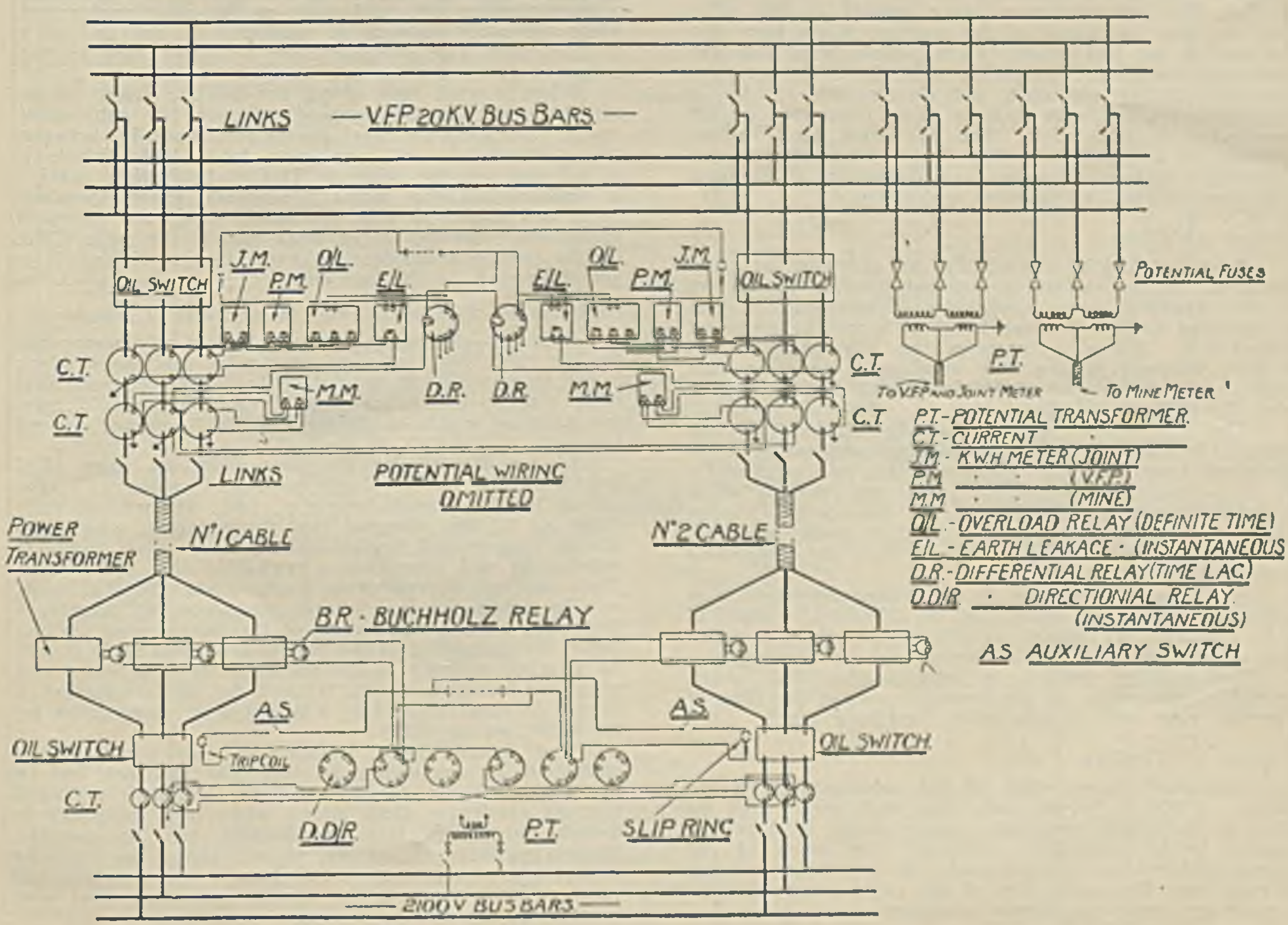

Fig. 4.—Diagram of the Protection and Metering Circuits for Two 20,000 volt Feeders: No. 14 Shaft, Crown Mines.

ensuring correct operation in the event of the Buchholz relays functioning and to facilitate switching "off" operations; they are, therefore, connected only in one phase and not three. The tendency for wrong operation on single phase earth faults thus only applies if such faults occur in the phase containing the differential relays.

Faults on the auxiliary feeders and 2,000 volt busbars are cleared by overload definite time trips on their respective panels, or by the overload definite time relays at the 20 k.v. sending end.

In conclusion, we wish to thank Mr. John Martin, chairman of the Central Mining & Investment Corporation, Limited, D. Samuel Evans, chairman of the Crown Mines, Limited, and Mr. J. Walton, general manager, Crown Mines, Limited, for their kind permission to read this paper to the Institute.

Mining Plugs and Trailing Cables.

(*Abstract from the Annual Report for* 1928 *of H.M. Electrical Inspector for Mines.*)

Accidents with Plugs.

In five of the accidents the plug was handled whilst it was "live" and out of the socket, or it was pulled out whilst "live" to avoid the trouble of switching off at the gate-end. In two instances this action was inadvertent; in two it was deliberate and unnecessary, and in one the plug was drawn in emergency.

There were four instances of visible arcing, due to failure of insulation, or to short-circuit arising from other causes, in the plug while it was inserted in the socket at a machine, at the coal face, and two other instances which occurred when the plug was withdrawn from the socket.

Accidents with Trailing Cables.

In five instances there were defects in the cable that the man in charge of the machine might have discovered if he had examined the cable with sufficient care and knowledge, assuming that the cable was not damaged during the shift, but if remedies are to be suggested for accidents such as those illustrated by the remainder, it is obvious that one must look further afield. In five instances there must have been "open sparking" that would have been dangerous if firedamp had been present in explosive proportions.

Design of Plugs.

It will hardly be denied that the common flat plug, pommell, or bat, as it is variously called, is not up to the standard, either electrically or mechanically, that is expected to-day of other parts of a colliery electrical installation. There is, however, an alternative in the British Standard Mining type plug, made in accordance with the requirements of British Standard Specification No. 279-1927.

The primary object of that Specification was to secure interchangeability between plug and socket when obtained from different manufacturers, but incidentally it is a requirement that the plug and socket, when properly assembled, shall form a "flame-proof" enclosure. Regarding this plug, it should be understood that in many of the details of the design the individual manufacturer has a free hand.

In the general design of the British Standard plug provision has been made for an effective mechanical interlock with the related switchgear and there is space for an electrical interlock, when such is desired.

The earthing contact, as between plug and socket, is not at the mercy of the operative, as in the case of the flat plug with a detachable "earthing pin."

Design of Trailing Cable.

Too much is expected of the manufacturer of the cable. While it is necessary that such cable shall be able to withstand inevitable rough usage it does not appear to be generally recognised that much of the injury suffered by trailing cables is avoidable, or that at any rate the useful life of the cable could be prolonged by more considerate treatment.

Trailing cable should not be coiled like a rope and then pulled out, because a half twist is thereby put into each turn and such twisting is most destructive in relation to the internal components of the cable. The surplus length should be coiled down, preferably upon a light and portable double bollard, in a figure of eight, for when so coiled, the half twists, being alternately right and left-handed, cancel out when the cable is drawn out from the coil. Of course, the cable might be coiled up on a drum, provided it is subsequently drawn out by revolving the drum.

Small incisions in the cab-tyre sheath should not be neglected and repairs should be properly vulcanised.

Effective testing is a difficulty at present, because the usual insulation test upon a dry cable with an ohmmeter does not discover incipient defects.

I have seen recently, at a Cable Maker's works, the application of an ordinary sparking coil (induction coil) for discovering and locating weak spots, such as punctures and incisions in trailing cables. The coil was capable of giving a ¼ inch spark in air. One terminal is connected to the conductors of the cable under test while the other terminal is connected to one end of a helix of stiff wire and the cable is drawn through the helix.

When a weak spot enters the helix, a spark passes and the spot can be marked at once for subsequent repair. Normally the spark passes (continuously) between two electrodes in an open glass tube placed where it is in view of the tester. This "observation spark" is extinguished the moment a spark passes between helix and cable, so that the attention of the tester is immediately directed to the weak spot in the cable. The test is speedy and does not harm the cable, and it is not dangerous to the operator.

Unarmoured Flexible Cable for Feeding Conveyors.

It is not a practical necessity to use an unarmoured flexible cable for conveyors or similar machinery which is not locomotive. It appears to have been assumed that there was no alternative type of cable that would meet the practical needs of the case. That, however, is not the fact, at any rate to-day.

In my Report for the year 1926, on page 17, I mentioned the use of pliable armoured cables with conveyors by the Consett Iron Co., Ltd., at three of their collieries. I am informed that those cables, which displaced unarmoured flexible cables, have given complete satisfaction and have cost a negligible sum for repairs. There are now several other similar installations at work.

To obtain the full security and economic advantage pertaining to the elimination of the unarmoured trailing cable, the armouring of the pliable armoured cable should be attached securely to the apparatus at each end. If a plug and socket coupling is used for the conductors it should be supplemented by a bolted or screwed union for the cable, as an entity.

The danger from handling a live plug can be countered by employing an electrical interlock but, if the plug is bolted to the apparatus and if it arranged that an electrician shall attend when it is necessary to detach the plug, this complication can be avoided. Moreover, there is no uncertainty about the earthing connection which is provided for in the simplest and most reliable way, via the pliable (stranded) steel wire armouring, by bolting the parts together.

Proceedings of the Association of Mining Electrical Engineers.

SOUTH WALES BRANCH.

Cotton in Engineering.

J. B. J. HIGHAM.

(*Paper read* 12*th October*, 1929.)

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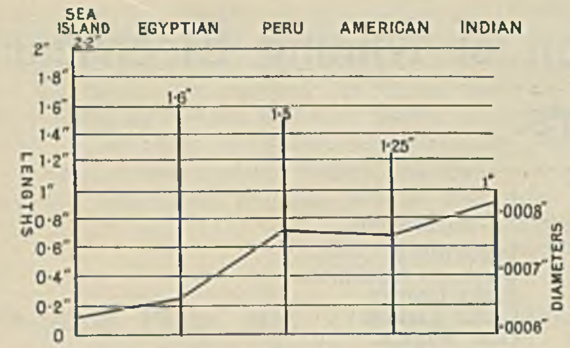


Fig. 1.

COTTON AND ITS MANUFACTURE.

The engineer possesses a knowledge of metals from the raw state through every process of production, but could he display the same familiarity with the process of cotton manufacture? Iron and steel, for example, have been associated for centuries with the science of engineering and a sound knowledge of them is considered essential. The application of fibrous materials, however, is comparatively modern, and the careful study of them has as yet been somewhat neglected.

In this section of the paper is described briefly the cultivation and manufacture of cotton from its raw state to yarns and fabrics. This is necessarily only an outline and for the benefit of those members who desire special information a bibliography has been added in the form of an Appendix.

Groups and Species of Cotton.

Cotton, a word derived from the Arabic *kutn, katan* or *kutun*, originally referred to Flax but is now used to denote the floss or down from the seeds of certain malvaceous plants (Mallows). Its generic name is *Gossypium* and it is therefore related to the English hollyhock, which it remotely resembles. The two groups of species generally recognised are as follows:—

I.—Old World or "Asiatic" Cottons.

(a) *Gossypium herbaceum.* Includes most of the Indian and Levant cottons and native types of Russian, Turkestan and Persia.

(b) *Gossypium arboreum,* or cotton tree, which includes the sacred tree cotton of India.

II.—Two Groups of "Non-Asiatic" Cottons.

(a) The Upland Group. *Gossypium hirsutum,* so called from the hairy character, in stem, leaves and seed. The American upland type is the chief representative. Indian Cambodia also belongs to this group.

(b) The Peruvian Group. *Gossypium Barbadense—maritimum* and *peruvianum*—includes Sea Islands, Egyptian, Peruvian and other cottons. Can be roughly distinguished as the "vine-leaf" cottons.

Chief Characteristics of the Cotton Plant.

The plant is generally of bushy form, growing about 3ft. to 6ft. high. The leaves are large, more or less deeply divided into three or five lobes, the form differing greatly in the different species and varieties. The flower also differs considerably; it resembles generally the flower of the hollyhock in shape but is more tubular and is surrounded by three large bracts or outside leaves. The boll or fruit varies in size from ¾in. to 1½in. in diameter, and is divided into from three to five *loculi,* each containing a "lock" of seven to nine seeds, to which the lint—the actual cotton itself—is attached.

The lint, with the exception of a small tuft or short fuzz at the point, can be completely detached from the seed of the Sea Islands and Egyptian cottons; these are known as "black" or "clean" seeds. In the American Upland and Indian varieties there are two kinds of hair, the actual cotton or "lint" about an inch in length and the other a short fuzz, which is only partially removed by the subsequent process of delinting. The delinting process removes what are known as "linters"; these seeds are known as "white" or "fuzzy."

The length, strength and fineness are the characteristic distinguishing marks of different varieties from the spinners point of view. Fig. 1 gives an idea of the average length of the various cottons and the cross curve serves to show the diameters. The strength depends upon the amount of cellulose in the cell wall of the fibre, and being of a varying quantity in all cottons and in any single fibre it is only possible to generalise. Sea Islands appear to be the weakest and Peruvian and Indian cottons the strongest. An average strength determined from 200 tests on Sakels (Egyptian) gave 5.85 grammes.

Cotton under the microscope is found to consist essentially of a single tube or cell closed at the outer end and growing from the surface of the seed. The tube consists of an outer skin, then a deposit of cellulose and an internal lining of endocrome or colouring matter. The cellulose wall is not uniform so that, when the cotton ripens and bursts, the fibres rapidly dry and collapse in an irregular twist, a valuable feature in cotton, inasmuch as it enables the fibres to offer frictional resistance to movement when in contact with each other. Fig. 2 indicates the usual appearance of cotton fibres and their cross section as seen under the microscope.

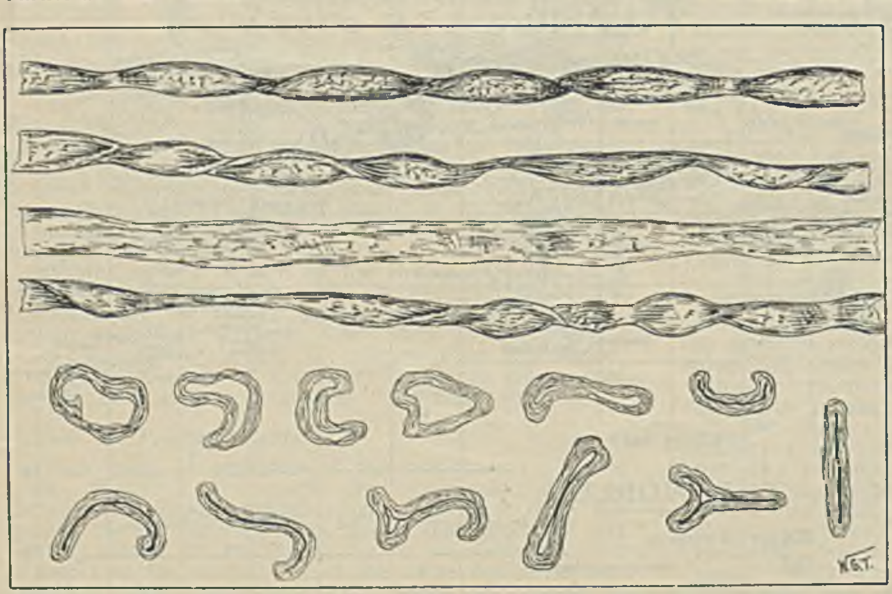


Fig. 2.

Limits of Cultivation.

The climate most suitable for the growth of cotton is subtropical from about 40°N. to 40°S. of the Equator, or better still, between the isothermal lines of 60°F. At one time it was a "monsoon" or rain crop, but now it is grown scientifically under irrigation in every cotton growing area. The Map herewith, indicates the chief of these areas, and in Fig. 3 arrows with small circles on tails indicate where varieties of cotton are grown, e.g., cottons from the American belt are grown in the Levant, W. Africa, China, Brazil, and Mexico.

Historical.

Fig. 3 serves to show the outstanding historical events, references to historical records and periods of development. India can be considered the cradle of the growing and spinning and weaving of cotton, but the Saracens, natives of Arabia, introduced the industry into Europe during the era of the Mohammedan conquest. In passing it is interesting to note that the manufacturers of Ferodo products were originally weavers of fustians, a coarse thick piled cotton cloth. The word fustian is from the Spanish "fustaneros"—cotton weavers—from the word "fuste" which denotes substance, so called because it gave substance to the thinner cloth or silk garment in which it was used as a lining.

Treatment.

(a) Prior to Shipment. The cotton after being picked is sent to the "gin" sheds where the fibre is removed from the seed by machines called gins. Two types of gin are in common use: the gin roller with doctor knife, a modification of the old "Churka" gin, or the American saw-type gin. Figs. 4, 5 and 6 illustrate these and are self-explanatory. As a result of the ginning process cotton fibre results in two forms—lint for spinning and linters or fuzz, largely used for the manufacture of nitro-cellulose, etc.

After ginning the lint is carried to a press by means of air currents or lattices, the former assisting greatly in the removal of dust and other foreign matter, and a preliminary compression and baling is done for local handling. Later a further compression is given; this is essential for economical storage and bunkering but necessitates a multiplication of processes before the cotton is ready for the actual spinning process. The pressing being of an intermittent nature, the bales when opened are found to consist of slabs of matted and entangled fibres containing many impurities.

Fig. 4.

Fig. 5.

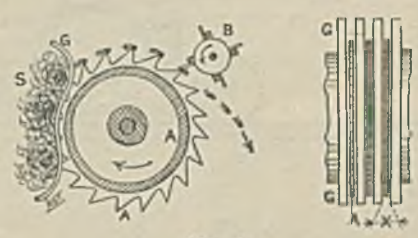


Fig. 6.

(b) At Mills Prior to Spinning. After breaking and stacking the bales the cotton is mixed as desired and transported to the opening machines where sand and soil, bits of leaves, seed scale, etc., are removed. In order to clean it efficiently the cotton should be opened, if possible, so as to separate every fibre from its fellow, hence a large number of entanglements have to be eliminated and, as the subsequent processes are arranged to deal with a certain range of fibre lengths, all short fibres should be removed during opening.

The cotton after this treatment is still a mass of loose fibres so that, simultaneously with, or subsequent to, the opening and cleaning, some kind of ordered arrangement of the fibres must result. The loose cotton is first formed into a fleece, its first ordered condition

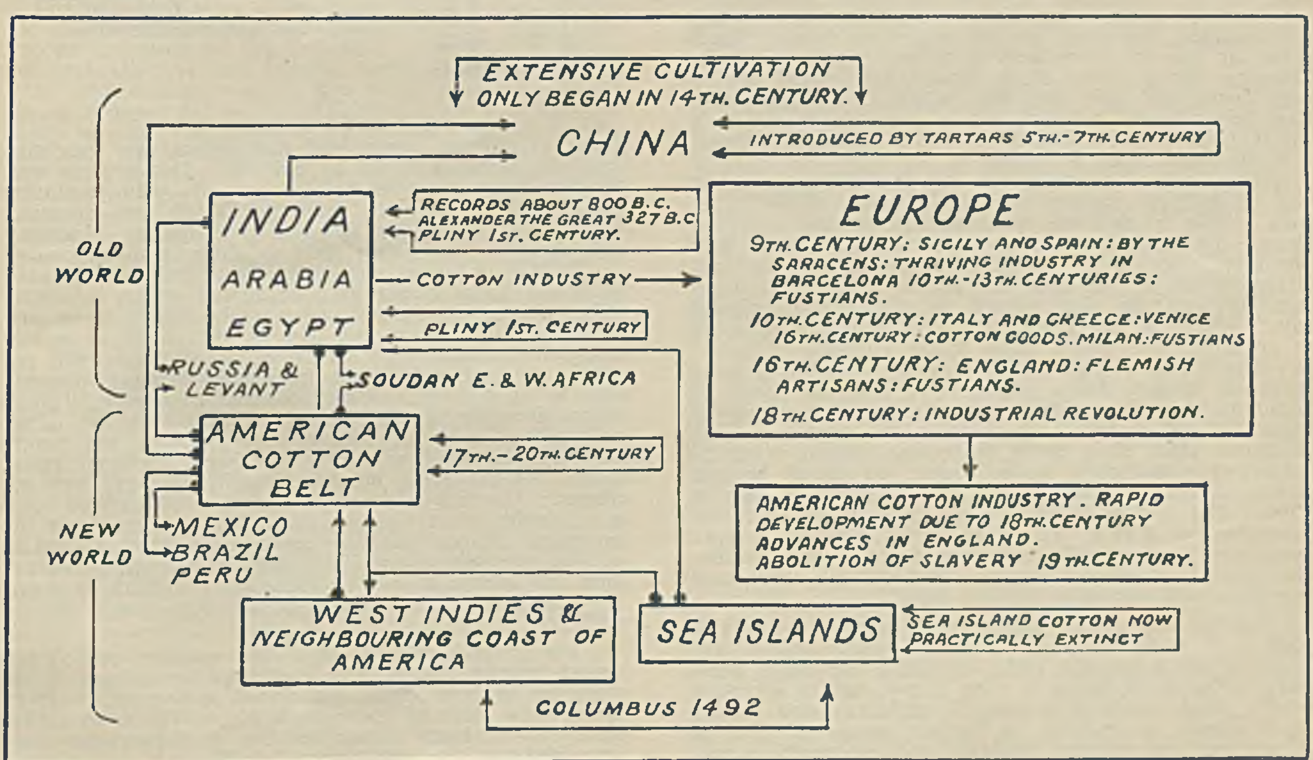


Fig. 3.

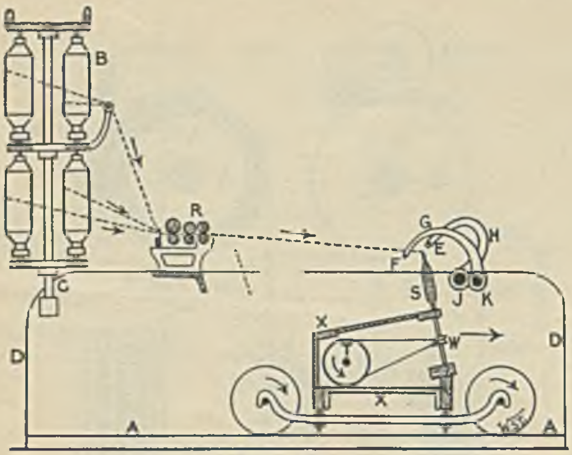


Fig. 7.

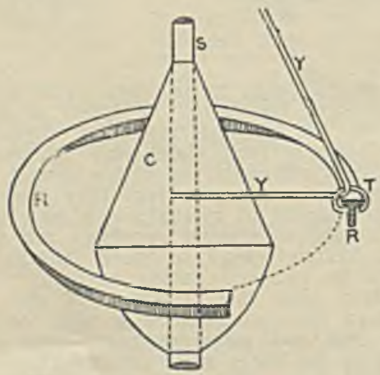


Fig. 8.

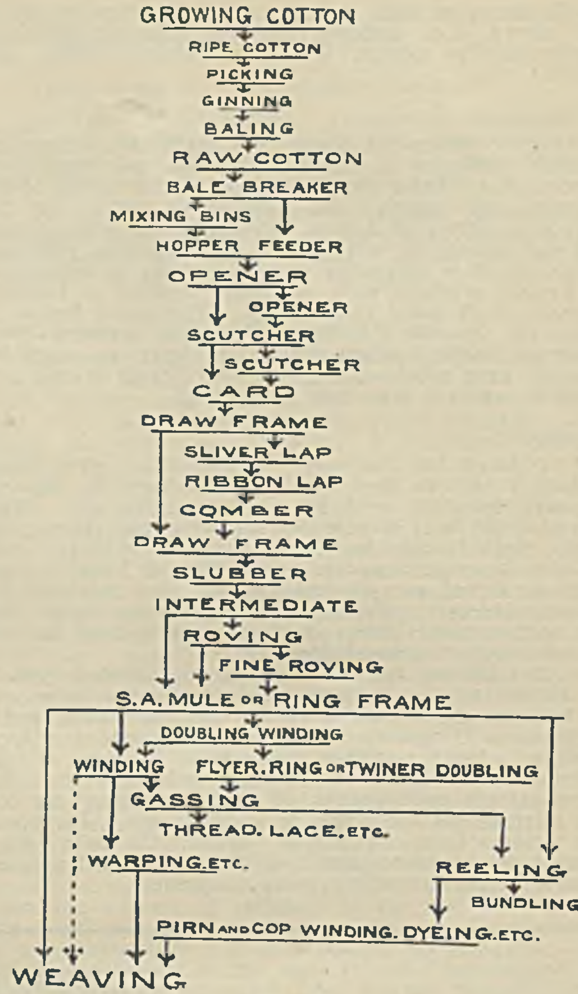


Fig. 9.

for spinning, the fleece is then rolled up into a "lap." This lap has to be reduced to a very small size by a drawing out process; it is opened and spread into a long, wide and very thin web, which is so thin that it can be gathered together into a rope form called a sliver. The sliver is drawn out into a gradually decreasing thickness called a roving.

The limit of drawing out any lap is soon reached and in order to continue the parallelisation of the fibres and obtain a uniform cross section several laps are drawn out simultaneously and combined, so as to give the same size lap for further drawing down. Six laps drawn down to one-sixth the section combine to form one lap with the same section as each of the original laps. When the fibres are parallelled and a uniform lap is produced it is drawn down to the roving.

The roving is still further drawn down but it is so weak in tension that a slight twist must be given in order to provide sufficient strength for the subsequent handling and drawing down prior to spinning. The machines which draw down the roving employ a modification of Arkwright's Water Frame, so called because it was driven by water power and patented by him in 1769. The cotton is handled in cans in the previous processes but it is wound on bobbins for roving, a more convenient method with such fine material, and because the roving machines employ bobbins all subsequent machines will naturally employ them.

(c) Spinning. The fundamental process is as follows: A mass of more or less tangled fibres are combed, which has the effect of laying the fibres parallel; a bunch of fibres is then drawn out to a certain length, after which it is twisted sufficiently and wound on a spindle or bobbin. A further supply of fibre is drawn out and treated similarly and eventually a continuous thread is made from the original mass of combed fibre. It will be appreciated that unless very carefully done the thread will not be uniform. This process was done in most countries by the peasants who employed the Distaff and Spindle, later by Distaff and Spinning Wheel, and to-day by Drawing and Roving Machines and either the Self-acting Mule or Ring Spinning Frame.

It may be asked why does the spinning of a mass of drawn fibres give a yarn or thread which is practically uniform in strength, whereas the drawn fibres are weak and lack uniformity? Briefly, the reason is as follows: the twisting of a length of drawn fibres will result in the section which is torsionally weakest commencing to twist first; as the torsional resistance of that section increases another section will take up the twist, and so on, until all sections have twisted and hence they will all have practically the same torsional resistance. At the same time the tensile strength has increased; the locking effect of a number of screwed rods in a bundle serves as an illustration of resistance to movement of one fibre of cotton over another, and it will be appreciated that if the bundle is given a twisted form like a rope it will be exceedingly difficult to move any single rod, the bundle acting very much like a solid rod.

The Self-Acting Mule.—This machine reproduces almost exactly the method employed for thousands of years by spinners using the distaff and spindle. It is the modern form of Crompton's Mule (1775), so called because it combined certain features of Hargreaves' spinning Jenny (1764) and Arkwright's Water Frame (1769) and performs three main operations—drawing out the roving supplied, spinning the drawn roving and winding on to a pirn or cop.

The roving is drawn between a series of rollers, an idea due to Paul (1735) and made practicable by Arkwright; the rollers are arranged in pairs, each pair arranged to run in contact under certain pressure and at the same peripheral speed. The rate at which each successive pair of rollers is run is increased so that the roving is gradually drawn out into a fine fleecy rove.

Each mule deals with a number of rovings, up to 1000 or more, and each roving is attached to a spindle which is inclined at a little more than 90 degs. to the roving. The spindles are arranged on a carriage which, with spindles rotating at a high speed (8,000—10,000 r.p.m.), runs out and spins the drawn roving. When the run out is complete the roving feed stops and while the carriage is stationary the spindles are reversed, then, with the aid of "faller" wires (Fig. 7—F and E) the few turns of open spiral at the top of each spindle is "backed-off." The backing-off completed, the carriage commences its inward run with spindles running as for spinning, and faller wire E performs an up and down motion, thus winding the spun thread on the spindle in the form of a conical spiral. The carriage having returned the whole process is repeated again; it will be seen that the spinning is an intermittent process like that employed with distaff and spindle.

The Ring-Frame.—A modern method of spinning which only came into extensive use after the introduction of electricity, the generation of which demanded prime-movers closely governed in order to avoid objectionable variations of voltage. A further impetus was given when the electric motor had been perfected. The quality of yarn produced by a Ring-frame is seriously affected with comparatively small variations of speed and a jerky drive causes innumerable breaks as well as irregular yarn. The Ring-frame can be considered to be a modern form of the old Italian spinning wheels which employed loose fliers.

Referring to Fig. 8, it will be seen that the spindles are arranged vertically and rotate in the centre of a horizontal ring, made of "Tee" section steel, over which is sprung a bent piece of steel wire called a flier. Above the spindle are situated the drawing rollers, which function as described for the S.A. Mule, and feed the roving out vertically over the spindle centre. Suppose the flier T is held stationary while the spindles rotate and the roving is being fed by the drawing rollers, then any tendency to wind the thread Y on the spindle at a greater rate than the roving is fed from the rollers will eventually cause the roving to snap; no twist is imparted to the roving either but, if the flier is free it will rotate round the ring in the same direction as the spindle rotates, the differential rotation will effect the correct amount of twist and winding simultaneously. The amount of twist which is imparted to the roving will depend upon the rate of rotation of the flier and this depends largely upon the weight of the flier used.

Summary.—The series of machines which perform all the operations mentioned are shown in sequence in Fig. 9. The order of the machines is indicated by arrows which give alternative methods, the selection depending on the kind or quality of yarn to be produced. The total number of spindles in Great Britain is approximately 63 millions, which includes quite 6 million doubling and waste cotton spindles.

(d) Weaving.—Even to-day there are a few places where the well-nigh universal art of weaving is unknown but where the art of making a perfect thread and netting it into fabrics is commonly practised. The interesting fact has been noted, that in such places rushes and similar growths are unknown. Now the use of rushes and the like for a rude floor covering in caves and dwellings might suggest to ingenious races the idea of weaving, since as a result of continuous movement the rushes would become interlaced and matted. Wall paintings at Bene Hason and Thebes in upper Egypt show the weaving of a rush or grass mat, and as these paintings are probably the most ancient in existence it certainly gives weight to the theory that weaving had some such origin.

The domestic system of spinning in England at the beginning of the eighteenth century was unable to supply the needs of the weavers, but the invention of spinning machinery quickly reversed this state of affairs despite the large demand for textile fabrics. The application of steam power to the loom and many improvements added to the loom itself equalised matters in the two industries. Watts' steam engine for cotton mills (1785) and Dr. Cartwright's first attempt at constructing a power loom (1786) were the first steps towards a revolution in the construction of looms. In rapid succession came power looms, notably those of Horrocks and Austin, and by the end of the eighteenth century, it was said, there were 20,000 power looms at work in Great Britain as compared with 250,000 hand looms. The number of power looms in Great Britain now in operation is approximately 800,000.

These early looms were mainly constructed of wood, but iron soon replaced this material and the loom has now become, except for the matter of working the shuttle, a very perfect automatic machine. An interesting point in regard to the working of the shuttle is that it is the catching and arresting of the shuttle which is the difficult operation, and this is still a source of many inventions and not yet perfectly done. The loom to-day with all its refinements still employs certain fundamental parts which were used in the earliest forms of loom employed thousands of years ago. The ancient Chinese draw-loom was the forerunner of the Jacquard with its wonderful mechanical devices for weaving intricate and beautiful patterns.

The quality of the product from the loom depends almost entirely upon the quality of the yarn supplied and therefore spinning has here been considered in greater detail than weaving. The fabrics from all looms consist of two essentials: the Warp, the threads which run from end to end of the fabric, and the Weft, Woof or filling, which is, with few exceptions, at right-angles to the warp. The to-and-fro motion of the shuttle is responsible for the formation of the weft, and mechanical contrivances known as heddles, or healds, are responsible for the opening of the warp to form the "Shed," in any desired sequence, in order to weave a given pattern.

The fundamental operations are three in number: first to divide the warp by lifting up certain threads and leaving others down to form the desired interlacing of the warp and weft; secondly, to throw the shuttle between these two sets of thread, leaving a line of weft in its track; and thirdly, to bring this line of weft up to the one which preceded it. These operations are termed "shedding," "picking," and "beating up."

A more modern loom for weaving tubular fabrics employs a continuously rotating shuttle which passes between selected warp threads arranged round a cylinder. The resultant fabric is sometimes slit longitudinally and a selvedge (self-edge) formed to prevent fraying.

The author wishes to acknowledge the courtesy of the following: Prof. J. A. Todd, Principal of the City School of Commerce, Liverpool, for permission to use the Map from "The World's Cotton Crops," published by A. & C. Black; Sir Isaac Pitman and Sons, Ltd., for the loan of the other illustrations which, with the exception of Fig. 3, are selected from "Cotton Spinning Machinery" by Wm. Scott Taggart.

APPLICATIONS.

These notes cannot be made exhaustive, owing to the fact that cotton is used for so many purposes in connection with engineering, but the author believes he has been able to include some of the chief applications and at the same time introduce some which are comparatively new. It is hoped, moreover, that the discussion will produce further knowledge of the behaviour of cotton, in one form or another, from the practical standpoint. It must be realised that apparatus and machines are designed to operate satisfactorily under certain conditions;

their limitations are well known, or should be known, by the *designers, the makers, and the users.* In compiling the information in this section of the paper an attempt has been made to keep outside the mass of facts to be found in engineering text books and papers and to avoid the mention of claims made by manufacturers as to the outstanding merits or performance of their products.

Electrical Insulation.

Cotton is used by the electrical engineer to a large extent for insulating purposes and in a variety of ways. It is an extremely useful and adaptable material for this work owing to its flexibility, good mechanical strength and ageing properties, and to its good electrical insulating characteristics when dry. Its chief limitations are, however, the maximum safe temperature at which it can be used continuously (viz., 90° C. to 100° C.), its hygroscopic and inflammable properties.

It is not often so used that it is subjected in the finished machine or product to very severe electrical and mechanical stresses in service, but these stresses are more generally met with during the application or use of the cotton material in manufacturing an insulation, and during the testing of the material when it is being or has been applied.

In the majority of cases the cotton, in such forms as thread, woven tapes or fabrics, is utilised more as a structural material and a reinforcement or support for other insulating material, e.g., micanite, rubber and varnishes. In nearly all cases, however, where cotton is employed some means has to be adopted either before during or after its application to dry out the cotton and to protect it so that moisture is not readily absorbed, this generally being done with varnishes.

The colour of the cotton products is not, as a rule, of any importance so it is general practice to utilise natural coloured unbleached materials, as these are preferable to those which have been bleached owing to the liability of residual chlorine products being present, which would be injurious to materials in contact with the cotton. In order to ensure the absence of deleterious chemicals, etc., from cotton insulations such as tapes and cloths, they are sometimes given scouring or other special treatments to remove such substances.

The following are some notes on the principal cotton products which are used for electrical insulation purposes.

Cotton Yarns.—A very extensive use of cotton yarns is made for the insulation, protective and ornamental coverings of wires and cables. Copper wires of circular, rectangular or other sections are covered with one, two, or three lappings of cotton yarns, and in some cases braided coverings of yarns are applied. These cotton covered wires are used for the conductors in all manner of coils and windings, and are sometimes subjected to severe mechanical pressures and abrasion, especially during winding. The electrical conditions are generally quite moderate and the cotton coverings are, as a rule, well dried and impregnated with moisture resisting insulating compound or varnish.

The outer coverings of flexible wires are generally braided cotton and are of various colours for ornamental or identification purposes. They are not of much use for insulation of the wires, but give some mechanical protection to the rubber or other insulation underneath.

Cotton is, to a small extent, used in the manufacture of asbestos papers and in the spinning and weaving of asbestos yarns, tapes and fabrics, all of which are used for electrical insulation purposes. The cotton is added to give increased mechanical strength to the asbestos products, in some asbestos tapes there being as much as 15% of cotton.

Cotton Thread.—Cotton thread is used for miscellaneous binding purposes and the requirements of this are only that it should have sufficient tensile strength, be reasonably uniform in thickness and not contain chemicals liable to be injurious to other insulations and copper wire.

Woven Cotton Tapes and Sleevings.—Cotton tapes are used almost universally for binding, insulating and protective purposes on bars, coils, connections, etc., where some protective varnish or other material is also applied to prevent absorption of moisture by the cotton. Tapes are made of thicknesses from .003in. to .020in. and in widths of ¼in. up to 2in. The thinner tapes are made from Egyptian cotton, the others being generally made of American cotton. Most of the tapes are plain weave, but some of the thicker tapes are of webbed or "herringbone" weaves to give more strength. The important features of insulating tapes are sufficient tensile strength to resist tensions involved in applying tapes, freedom from injurious and hygroscopic chemicals, and uniformity of structure and thickness.

A small amount of woven (braided or knitted) tubular cotton sleevings is used for covering connecting wires, etc., the material being used in the untreated state and also as the base for producing varnished cotton sleeving for similar purposes.

Cotton Fabrics.—Untreated. Thin cotton fabrics similar to cambrics are used for various insulation and protective purposes in coils and cables, in general their main function being to support and reinforce other insulations at awkward corners, bends, etc. They are also used as mechanical backing to flexible micanite tapes.

Cotton cloths thicker than cambrics are used sometimes for protection covers and for supporting insulation on windings which are subsequently varnish treated, and an important use of these fabrics is for the manufacture of synthetic resin bonded boards and mouldings, some of which are used for insulation purposes and large quantities for gear wheels.

Treated and Varnished fabrics of many thicknesses are those treated with various oils, japans, varnishes, shellac, rubber, bitumen, etc., to render them more moisture resistant or more adhesive, and in most cases better insulators; they are used for a large variety of insulating and protecting purposes according to their thickness, mechanical strength and the nature of the treating material. Typical uses are slot liner backings, protection caps of traction armatures, and insulation pieces for corners of coils, connections, etc. In many cases the treated fabrics are slit into strips or tapes, e.g., adhesive rubber and bitumen tapes.

The most widely known and used treated cotton fabric is the varnished cotton cloth, known often as Varnished Cambric, Empire Cloth, etc., which is made from a specially woven and finished cotton cloth treated with a varnish by a process which gives uniform well dried varnish films on both sides. This material is, perhaps, the most important and most interesting use of cotton for electrical insulation purposes, as a special fabric has had to be produced for this, which does not in itself perform the main function of an insulator, but is principally the carrier of the varnish films which are the real insulation.

The fabric for these varnished cloths is specially woven to facilitate uniform varnishing, and it is well "fired" or "singed" to remove as much nap as possible, this being necessary to ensure smooth varnish films, which is also facilitated by the filling and calendering of the fabric, giving uniform thickness and a smooth finish. The varnishing process is carried out by passing the fabric through a bath of varnish (usually a linseed oil and gum or bitumen varnish) and up through a vertical heated oven to dry the varnish films. Several treatments are given thus consecutively until good films are obtained.

The varnished cloth is either used in pieces of various sizes and shapes cut from the sheet cloth, or this is cut up into narrow strips or tapes. The larger proportion of this material is used in the form of reels of tapes so cut that the cotton threads are at an angle (e.g., 45 deg.) to the cut edges of the tape. This material is generally manufactured by one of two methods. The first is to cut the untreated fabric diagonally, at an angle (say 45 deg.) to the selvedge, into pieces, sew these together selvedge to selvedge and after varnishing the length of sewn material, cutting the roll of varnished cloth at right angles to the axis into narrow reels of tape. The other method is to use a tubular woven fabric (similar to pillow casing), cut into a helix at an angle (say 45 deg.) to the warp threads, and after being specially finished and calendered it is varnished in the piece and afterwards cut up into tape as in the previous method. This gives a tape without sewn joins but with the threads inclined to the cut edges; this kind being known as seamless bias cut tape.

These varnished cloths and varnished cloth tapes are used very extensively for all manner of insulating work such as for the insulation of armature conductors, connections, machine slots, bus-bars, field coils, cables, etc. The electrical conditions are generally severe where these materials are used, but the cotton itself is not relied upon for its insulating properties. Its important properties are mainly mechanical and physical as the cotton fabric imparts the required mechanical support for the varnish films, and as tension is employed in using the tapes a great deal depends upon the resilience of the fabric in preventing damage to the varnish films.

A few mechanical and electrical properties of typical untreated and treated cotton cloths are shown in Table I.

TABLE I.

Characteristics of Typical Untreated Cotton Cloths.

Material.	*Threads per inch.* Warp	Weft	*Thickness in mils.*	*Tensile Strength lbs. per inch Width.* Warp	Weft
Cotton Cambric ...	85	65	3—4	16	9
Cotton Duck	44	40	19—20	100	50
Calico	70	60	3—4	35	20

Characteristics of Varnished Cotton Cloths.

Material.	Thickness in inches.	Elec. Strength at 20°C. Minute Value v/mil.	Elec. Strength at 90°C. Minute Value v/mil.	Bursting Strength lbs./sq. in.	Tensile Strength lbs. per inch width. Warp.	Weft.
Black Varnished Cloth ...	.010	900	650	12	30	20
Yellow Varnished Cloth ...	.010	700	600	12	30	20

Fibre Brake Lining.

Brake lining of the Ferodo style is manufactured in thicknesses from ⅛in. to 1in., and in widths from 1in. to 18in. Linings ½in., ¾in. and 1in. thickness are largely used for heavy post brakes for winding engines, heavy haulages, etc. Thinner sizes are useful for the majority of lighter brakes. Ferodo fibre would be the ideal material for every type of friction brake or clutch but for its comparatively low heat limit. In no case should the temperature of the brake path exceed 200 deg. F. The coefficient of friction of Ferodo fibre, also specific wear value is higher than of any other fabric friction lining. The normal working value of the coefficient is 0.5, and this value is remarkably constant at constant temperature at any slipping speed and pressure (see Fig. 10) and falls only with temperatures above 180 deg. F. When slightly carbonised the value is 0.3, but this comparatively low value is never exhibited below 200 deg. F. Oil and water seriously affect the friction value, and since the fabric is designed to work dry, lubricants should be entirely excluded.

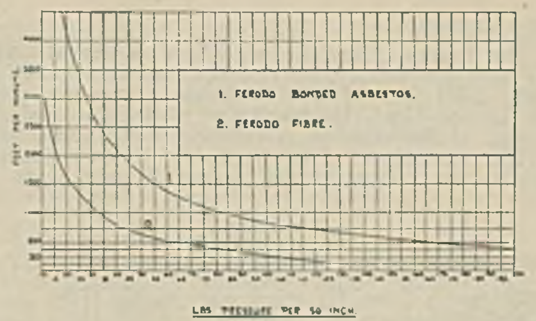


Fig. 11.—Permissible Pressures per sq. in. for Bonded Asbestos and Fibre Brake Linings at slipping speeds from 200 to 4500 ft. per min.

The specific wear value may be taken as 14 H.P. hours per gramme—that is, a piece of lining 1in. × 1in. × ½in. will absorb approximately 132 million foot lbs. of energy before it is worn entirely away. The generally recommended rate of work for Ferodo fibre is 13,200 foot lbs. of energy per square inch per minute (0.4 H.P. per sq. inch). From this figure, allowing u = 0.5, a suitable pressure can be arranged for any slipping speed up to 7,000ft. per minute, which is rarely exceeded in normal applications. The weight of the material is 19 grammes per cubic inch, from which the rate of wear of any given thickness may be calculated. Taking the above specific wear value and recommended rate of work it would require approximately 170 hours of braking to wear down ½in. thickness of lining. Continuous braking actually wears down ½in. thickness in 110 hours.

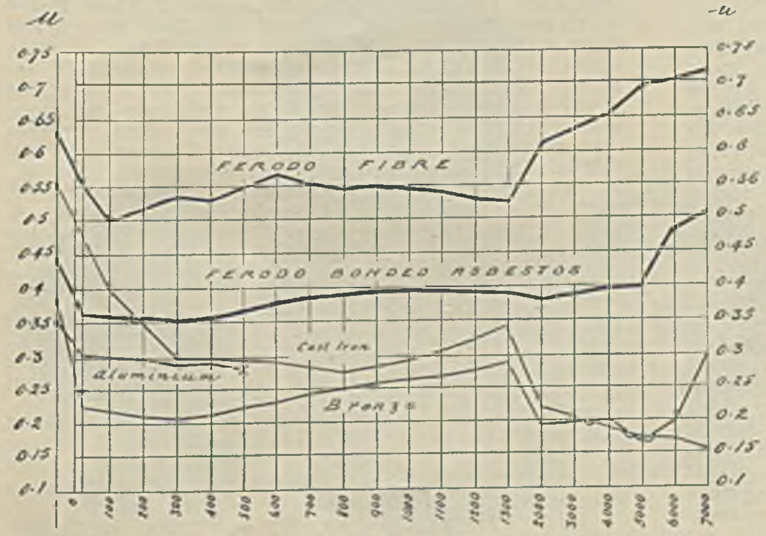


Fig. 10.—Speed, feet per min. Coefficient of Friction (M). Drum Temp. Max. with Cast Iron, 180°F. With other materials, 120°F.

Ferodo fibre will work against the softest steel, but should preferably not run against non-ferrous metal—cast iron is an excellent opposing surface.

Under normal friction duty (see Curve 2, Fig. 11) the stress which comes on to the material firmly fixed to a metal surface is negligible compared with its ultimate tensile strength, which may be taken roughly as 5,000 lbs. per square inch. For example, under a load of 100 lbs. per square inch the tensile stress would not be in excess of 75 lbs. per square inch—under compression no yield would be measureable up to 400 lbs. per square inch, so that the margin of safety in both directions is very great.

It should be mentioned here that many installations of this brake lining, intended for definite braking capacity, have been overloaded. Consequently the lining has become charred and the coefficient of friction reduced. The nett result is rapid wear and a large reduction in braking capacity. From the available data regarding a winding engine brake employing Ferodo fibre, it would appear that satisfactory service can be expected if the makers' recommendations are followed.

Clutch Linings.

The Ferodo Fibre Radial Weave is almost universally used for lining cone clutches, and is manufactured in ⅛in., 3/16in., ¼in. and 5/16in. thicknesses, in various widths from 1in. to 4½in. The coefficient of friction, wear factor, etc., is the same as given for Ferodo brake lining.

The particulars given in Table II. refer to two Wigglesworth clutches which employ Ferodo fibre.

TABLE II.

	No. 1.	*No.* 2.
Diameter	4ft.	4ft. 11in.
Running load	120 H.P.	220 H.P.
Starting load for a few seconds	300 H.P.	500 H.P.
R.P.M.	160	160
Material	Ferodo Fibre	Ferodo Fibre
No. of Pads	12	12
Size of Pad	23in. long × 4in. wide	25¼in. long × 4½in. wide
Thickness	⅜in.	½in.

From this data the following figures can be calculated:

	No. 1.	*No.* 2.
Tangential Effort at Clutch Rim—		
Running,	1990lbs.	2950lbs.
Starting,	4960lbs.	6700lbs.
Minimum Radial Press. on Rim, u = .5—		
Running,	3980lbs.	5900lbs.
Starting,	9820lbs.	13400lbs.
Minimum Press. on Pads—		
Running,	3.6lbs. sq. in.	4.35lbs. sq. in.
Starting,	9.0lbs. sq. in	10.0lbs. sq. in.
Slipping Speed at Start—		
	1630 F.P.M.	2000 F.P.M.
Permissible Press. (Curve 2, Fig. 11)—		
	20lbs. sq. in. approx.	15lbs. sq. in approx.

Gear Wheels.

These are made in three forms and supplied with spur, spiral, or bevel teeth and are made by The British Thomson-Houston Company.

(1) Fabroil Shrouded Gears consist of specially prepared cotton fibres compressed under hydraulic pressure of several tons per sq. inch of side surface, and held in compression by steel shrouds or side plates, threaded rivets passing entirely through the whole assembly, as shown in Fig .12. After the blanks are assembled and machined, they are impregnated with oil and again after the teeth are cut, rendering them impervious to moisture and proof against atmospheric changes. A further advantage of this process is that it assists tooth cutting, and also affords a measure of permanent lubrication for the gear teeth. In the construction of large gears having special hubs or bosses, it is necessary to use a metal centre and a separate Fabroil rim. The rim is forced on the centre and held by means of threaded studs passing half through the Fabroil rim and half through the metal centre (Fig. 13). They are made with or without metal bushes and to transmit up to 150 H.P. (Fig. 14).

(2) Fabroil A Moulded Gears, without Shrouds, are made from elements of specially woven textile fabric bonded together by a synthetic resin under enormous pressure into a hard homogeneous mass. The layers of fabric are interlaced in such a manner (Fig. 15) as to secure the maximum strength in the rim, at the same time providing a relatively thin web centre that blends perfectly with both rim and hub, thus making a well-proportioned and well-balanced gear. The whole of the elements after assembly are compressed to the desired shape in a steel mould which, being highly polished, imparts a very fine finish to the gear blank.

(3) Fabroil A Gears, without Shrouds, are machined from sheets or boards of Fabroil A material, which The

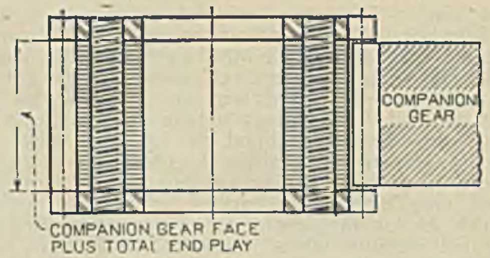


Fig. 12.

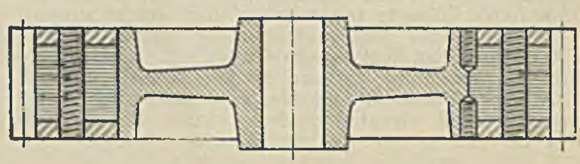


Fig. 13.

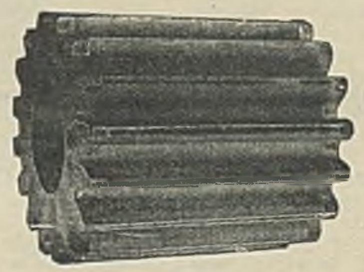


Fig. 14.

British Thomson-Houston Company have developed specially for this purpose. Small gears, such as are shown in Fig. 18, are usually machined in their entirety from the solid, whilst larger gears are often made in the form of rings and secured by means of rivets or screws to metal centres as shown in Fig. 18, and in diagrammatic form in Figs. 16 and 17.

Fabroil A Gear Board or sheet material is made as described in section 2. Those who wish to make their own gears can be supplied with Fabroil A Gear Board in various thicknesses up to and including 3in. When gears exceeding 3in. in width are required two or more layers of the material can be rivetted or screwed together to give the required width. Fabroil A Gear Board is easily worked by ordinary metal working tools, and is very often used for other mechanical purposes than gears when a non-metallic material superior to vulcanised fibre, wood, rawhide, etc., is required.

All three types of gear can be supplied with the teeth cut or in the form of blanks ready for tooth cutting. It should be remembered, however, when dealing with large gears as illustrated in Figs. 13, 16 and 17, that the teeth should not be cut until the Fabroil rim is mounted.

Bevel gear blanks (with shrouds) can be supplied if the pitch angle does not exceed 25 degrees and providing the diameter of the bore is not too large to enable the studs to be inserted. Bevel gear blanks (without shrouds) can be supplied for any pitch angle.

Fabroil gears should not be operated against uncut cast teeth or against any gears which have become badly worn. They should be lubricated with a thin dressing of vaseline and graphite or, alternatively, a good grade of machine oil may be used.

Figs. 19 and 20 show the application of Fabroil gears to a colliery haulage and a shaft turning lathe. Fabroil material being of an elastic nature it eliminates shock and vibration to a marked extent.

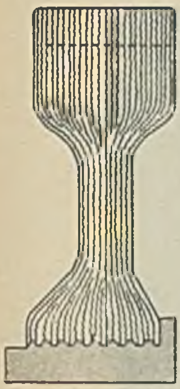


Fig. 15.

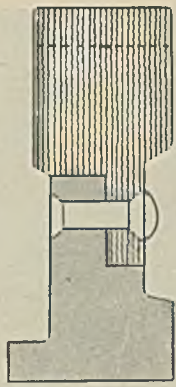


Fig. 16.

Fig. 17.

Belts and Ropes for Transmission of Power.

The results of research, which is being carried out by manufacturers, and others, will no doubt lead to a better understanding of some points which are not fully explained by present theory. It is doubtful whether it is air cushioning or centrifugal force which limits the power which a belt can transmit. At high speeds air cushioning plays a more important part in the way a belt functions than is the case with ropes.

Many high speed heavy duty drives employ cotton ropes. Fig. 21 illustrates a rolling mill drive in South Wales; the peak load is 4000 H.P. and it is transmitted by 42 2in. diameter ropes running at a velocity of 4700 f.p.m. This drive has operated satisfactorily for more than eight years despite the fact that it runs in a gritty and variable atmosphere close to a number of re-heating furnaces. Cotton ropes have often been adopted and have proved satisfactory when other transmission systems have failed.

Cotton ropes possess a high degree of resilience, hence they will smooth out fluctuations in power given by, or demanded from prime movers. The shock absorbing power of cotton ropes is due to hysteresis. With normal fluctuations of stress the energy absorbed will be comparatively small, but when the stress passes a certain value the energy absorbed will increase enormously. Ropes also exhibit remarkable powers of recovery after being overstrained, a property shown by many fibrous materials.

The space occupied by a rope drive for a given horse-power and speed is often less than that required by a belt, although for short centres the "Lenix" system of belt drive is undoubtedly more compact. Fig. 22 illustrates a belt and rope drive transmitting 75 H.P. and 80 H.P. respectively. The ropes cause less interference with lighting, a matter of importance in many cases

Truck Wheels and Castors.

The fabric in these wheels is cut in diagonal strips so that all wearing surfaces are on the ends of the threads of the cloth. When cut according to the desired pattern the strips of fabric are sewn together in blocks for convenience in handling. These are assembled in ring formation and then by hydraulic pressure compressed to approximately 50 per cent. of their original diameter. Into these solid fabric tyres steel centre plates and a flanged hub are forced under pressure, and the wheel or castor is then rivetted solidly together.

The advantages of these fabric wheels and castors in addition to their durability and silence, are their protection to finely finished floors, the fact that they are unaffected by high temperature and moisture, and their economy through long service. One of these tyres has been subjected to a test under a load of 400lbs. at a speed of five miles an hour in contact with a carborundum wheel, and no appreciable sign of wear could be observed after 400 miles. Fabric wheels will not chip or cut, and their cushioning qualities make them superior to metal wheels because they are less noisy and less destructive to all floor surfaces. These factors are of importance in many factories and offices and public buildings where the floors are made of concrete or finely finished mosaic tile. Where temperatures are high and floors are moist and greasy, fabric wheels have been found unaffected by conditions which often impair the service of other types of wheels.

Concrete Roads.

This interesting application may be useful in certain concrete construction where re-surfacing will eventually be needed or where there is a possibility of trenching for pipes, etc. The fabric employed has about six warp and weft threads per inch. This is placed between the concrete base course, which consists of a coarse aggregate with small cement and low water content, and the surface course which consists of a fine aggregate and a rich mix. The fabric in no way weakens the road structure but provides a horizontal cleavage plane. This allows easy removal of the surface course, without special or expensive appliances, by the application of a slitting pressure along the plane of the fabric.

The fabric is tamped into the top of the base course, and being pervious to mortar but practically impervious to coarse aggregate it allows full adhesion of the two courses. When the base course has been laid it is only necessary to go over the surface with the strike board once before tamping in the fabric. The top course is then laid and the surface finished. As the base course is not allowed to set before the top course is laid an excellent bond is obtained. The small aggregate in the top course allows of greater ease in manipulation, eliminates scaling and gives uniform wearing qualities.

When the top course is removed the base course exhibits a rough and granular texture, thus proivding a key for the new surface. The method of re-surfacing is as follows: The old base is first wet down, then spatter-dashed with a rich mortar; the spatter-dash drives out air and gives perfect contact. The top course is then placed in the usual manner. The surface of the

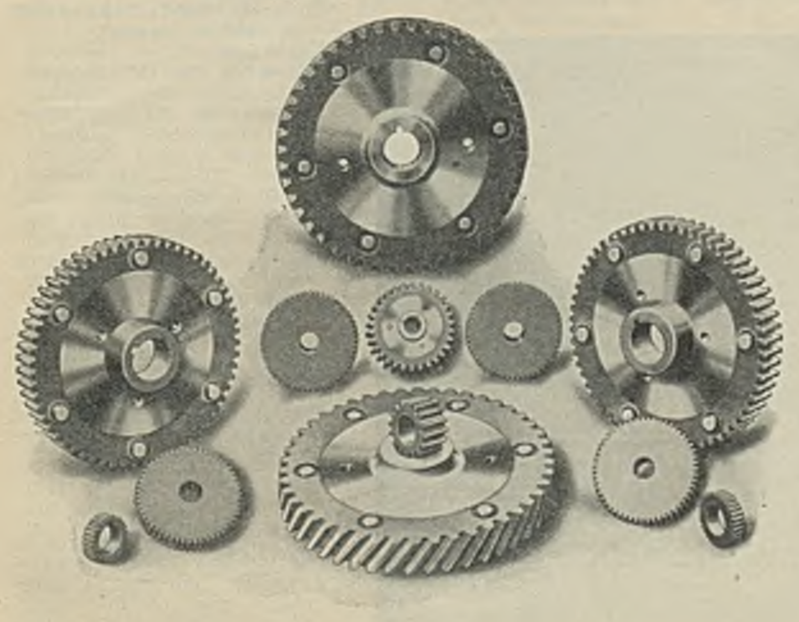


Fig. 18.

base course should be kept clean and free from oil drippings or other material which will affect the adhesion between the base and the new top course. Fig. 23 illustrates this application, which is marketed by the Sheet Concrete Pavement Corporation of America.

Light Roads.

The specially woven fabric used acts as a bond or reinforcement for a bituminous surface treatment applied to light roads. This fabric weighs 4.61 ounces per yard, being woven 36ins. wide and containing 3½ four-ply warp threads per inch and 7 four-ply weft threads per inch. The fabric is employed only along the shoulders of the road, the middle section being constructed and prepared in the same manner as the rest of the road except for the elimination of the cotton fabric. The whole treatment consists mainly of providing a waterproof surface to the road. The secret of the success lies mainly in the thorough preparation of the foundation. The cost is stated to be about £700 per mile.

The preparation of the road and bituminous treatment is as follows: The surface of the road is first scarified and brought up to the desired cross section and grade; it is then opened up to traffic to allow it to re-bond, the surface being kept smooth by scrapers or drags. After the surface has been thoroughly re-bonded it is closed to traffic and swept thoroughly to remove all dust and grit. A prime coat of one-quarter gallon per square yard of light tar is then applied. The next day, or after an interval of 24 hours, the cotton fabric is spread longitudinally along the shoulders of the treatment. This should be done while the tar is still sticky enough to hold the fabric in place. Approximately four-tenths of a gallon per square yard of hot asphaltic oil is then applied to the fabric and surface. The surface is then immediately covered with about 50lbs. per square yard of coarse sand or coarse sand and fine gravel or finely crushed limestone or granite. The road is ready for traffic immediately this covering has been applied.

Road Signs.

These are made of a heavy cotton fabric saturated with a specially made paint and backed with a rubber gum adhesive. This fabric can be obtained in lengths up to 50ft. and five, seven or ten inches wide. Letters in various sizes, either single or in four letter units, are similarly made. These strips and letters are laid rapidly, traffic is not disorganised, and at least three months' service is obtained under all traffic conditions. Perfect adhesion is obtained on all surfaces from asphalt, brick or blocks, to cobbles.

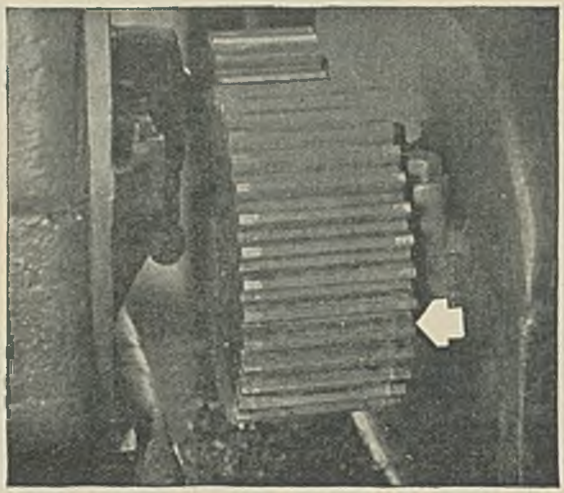


Fig. 20.—Fabroil Gear in operation for Seven Years. Effected considerable saving in time required to turn 20 to 29 in. shafts by eliminating wavy tool marks.

Waterproof Fabric.

This is used in the construction of bridges, tunnels and buildings. The cotton fabric for this purpose is impregnated with asphaltic compounds and laid in various thicknesses according to requirements. Thousands of yards were used in the Holland Tunnel, which connects New York City and New Jersey.

Other Applications.

The wide range of usefulness of cotton products is illustrated by the following list:—

Abrasive Bands and Sheets of Emery, Carborundum, etc.
Aeroplane Fabrics—wing and fuselage covering—doped.
Balloon Fabrics—gas cells and envelopes—rubberised.
Buffing Wheels.
Celluloid; Cellulose Paints, Varnishes and Lacquers.
Cement Bags.
Conveyor Bands—waterproof or rubber covered.
Explosives.
Filters in the Oil Industry.
Gaskets.
Hose—steam, air and water.
Insertions—rubber covered fabrics.
Motor Tyres—fabric and cord reinforcements.
Packing—against steam, air, water and oil.
Stair Treads—specially woven fabric.
Tarpaulins, etc.

Some of the above applications are so important and highly specialised, explosives and motor tyres for instance, that it would be impossible to deal with them in a paper of this nature.

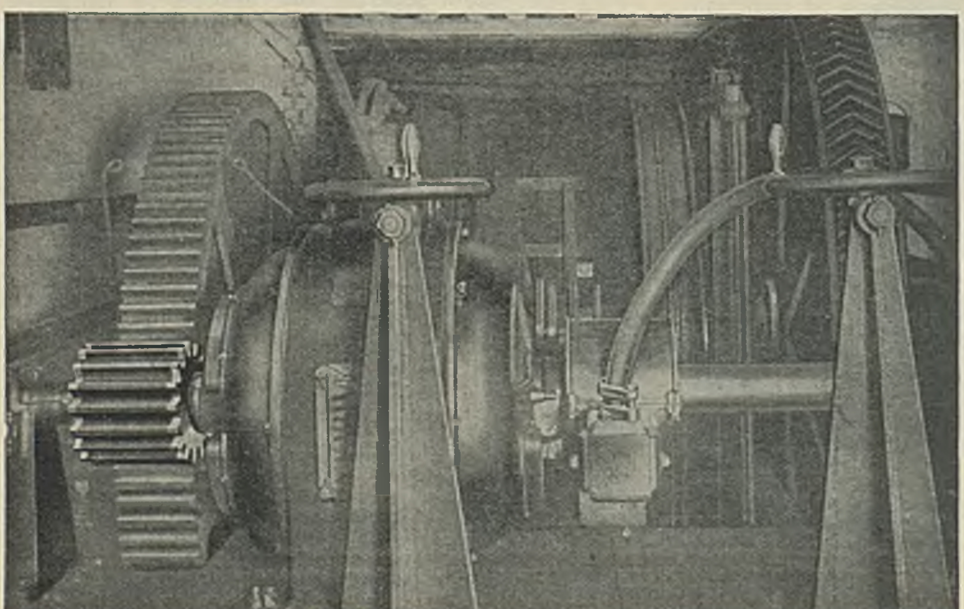


Fig. 19.

RESEARCH.

The value of research in any industry cannot be over-estimated, and this is particularly true of the cotton industry, but it would appear that so far research work has mainly been confined to the various problems

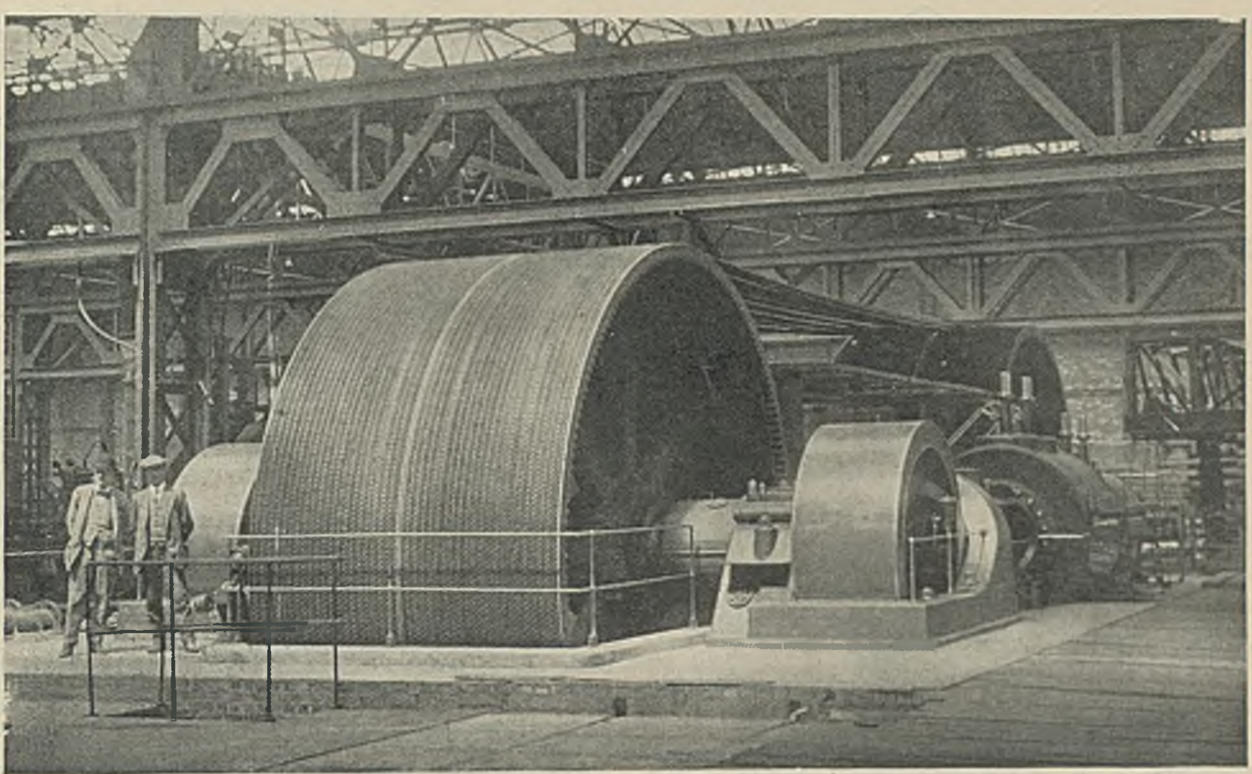


Fig. 21.

which have faced the grower and breeder of cotton. During the past 15 years comprehensive scientific and industrial research has been effected under the auspices of the Fine Cotton Spinners' and Doublers' Association. At the commencement it was clear that the farmer could never produce good quality cotton to order unless the spinner was able to explain exactly what was wanted. At the same time the spinner had no exact explanation to give the farmer. In plain words, the cotton industry was not as competent in the use of its raw material as were some other big industries. A broad outlook was adopted in this research and numerous investigations were commenced which did not immediately concern the industry. An outline of those investigations is to be found in Dr. W. Lawrence Balls' book, "Studies of Qualities in Cotton": they were so intricate and highly technical that it would be impossible to extract any salient fact. After reading the book one thing is evident, namely, that many problems of the cotton mill are the result of a condition of the raw material and therefore become problems for the farmer and breeder of cotton. It would be reasonable to suggest that some of the problems met with by the user of the finished product of the mill depend for their solution upon research in the industry and in many cases upon research in the field.

Within the last few years, however, a large amount of research has been carried out by the Air Ministry and others on various fabrics and yarns, including cotton, which will react on the manufacturing and growing of cotton sooner or later. The materials used for aircraft must be of the very best quality, which means, that not only must the raw material be good but the method of manufacture and any finishing process must be of such a nature as to give no cause for deterioration when the material is in commission. This research has dealt with matters relative to scouring, sizing, tensile strength and methods of testing, the effect of oil and ultra-violet light, etc. As a result of this work the user of cotton and such materials will have a guide or standard as to quality, based on scientific grounds and investigations and not on the judgment of "experts." Cotton for a shirt may possibly be assessed by the "look" and "feel"; the lint from the gins may be gauged near enough by pulling out a tuft with finger and thumb and laying on the coat sleeve; but eventually the microscope, the micrometer, the test-tube, X-rays and even special scientific tools are required to assist in judging. Despite all efforts to obtain detailed information relative to this branch of research the author has not as yet been able to glean much of value.

To return to research in the field. This will depend largely upon the problems confronting the particular area and these remarks will be confined to certain phases of research carried out in Egypt and America, because they are considered to be representative of research which has definitely led to the production of better cotton, and this undoubtedly concerns the user.

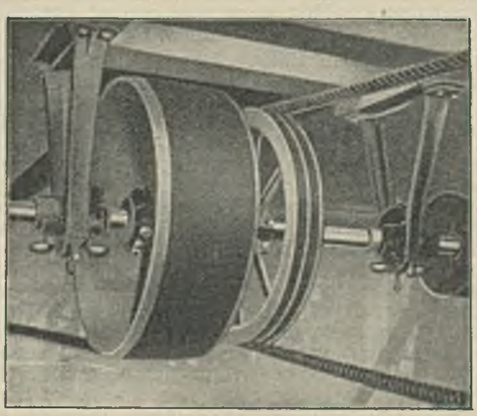


Fig. 22.

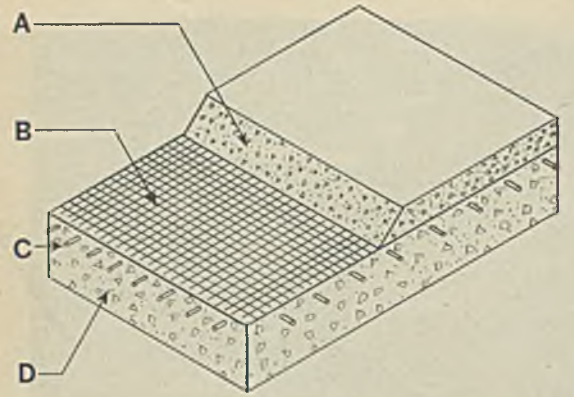


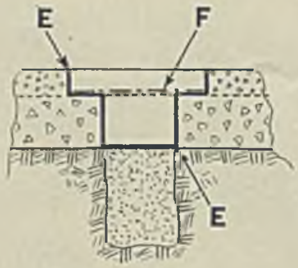
Fig. 23.—Sheet Concrete Method of Road Construction.

A.—*Top Course, Fine Aggregate and Rich Mixing.*

B.—*Cotton Cleavage Fabric Tamped in on top of Base Course.*

C.—*Reinforcement as required.*

D.—*Base Course, Large Aggregate: Small Cement and Low Water Mixing.*



Method of Replacing Cuts in Sheet Concrete.

Remove Concrete to line E.
Refill Trench.
Make good Base Course.
Place Fibre across Trench.
Lay Steel Reinforcement F *across Trench.*
Make good Top Course.
Top Course removed about 10 *ins. back from each side of cut in the base.*

In Egypt.

After the period 1895 to 1899, described as the "high-water mark of Egyptian cotton growing," slow but certain deterioration of the cotton crop commenced. The area under cultivation at that period was 1.1 millions of acres, and the yield per acre was about 540lbs. of lint. By 1916 the area under cultivation had reached nearly 1.7 millions of acres, but the increase in quantity of cotton was trivial despite the great increase in the amount of land, labour and water devoted to the crop. The ratio of cotton produced in 1916 to the amount in 1898 was in the ratio of 6.5 to 6.0. The incursion of a new insect pest, the pink boll-worm, first seen in Egypt in 1910 and causing damage locally on a commercial scale in 1912, somewhat obscured the issues involved in this remarkable phenomenon of yield deterioration.

Without entering too minutely into the details of the research, which commenced seriously in 1904, it may be said that irrigation without drainage was responsible for the deterioration more than any other factor. Through the foresight of Sir Colin Scott Moncieff, *irrigation and drainage* was rigidly insisted on, and carried out, during his control of the Egyptian Irrigation Service. His successors neglected the latter part of this important function, and many years of hard work were required to restore a balance. This work was carried out under the guidance of Sir Murdock Macdonald.

Dr. W. Lawrence Balls, who was then with the Khedivial Agricultural Society of Egypt, commenced research at the end of 1904, and early in 1906 he became interested in a suggestion made by Mr. J. R. Gibson, English Commissioner for the State Domains, who with his Chief Engineer M. Audebeau had been making observations and experiments on the basis of a working hypothesis which they had constructed, namely, that the rise in level of sub-soil water, or water-table, of the country in general, had caused a falling off in the yield of cotton. The extensive irrigation work carried out during the preceding decade had undoubtedly been responsible for the major portion of this rise, which amounted to as much as 6ft. in some areas. In the cultivable areas the sub-soil is largely gravel and sand and is covered by layers of sediment deposited by the Nile during flood; the water-table of these areas was known to be rising slowly at the rate of about five inches in every century, so that this phenominal rise of 6ft. was unquestionably due to irrigation.

It required years of patient experiment in the face of many adverse circumstances to prove ultimately that this suggested cause of the deterioration was correct. In the first place it became evident that the knowledge of the root function of plants was far from complete; gaps in existing knowledge had to be filled in before any serious attention could be given to the actual problem. The roots of such plants as cotton require Oxygen, and if only 8 ins. of a possible 4 ft. to 6 ft. depth of root system is immersed in stagnant water an immediate falling off in the rate of fruiting occurs. This immersion can be determined to within a day or two by close observation of the plant. To complicate matters, root interference, due to adjacent plants, had to be studied. Later, in 1909, a "Terrace Experiment" was laid out, which owing to accidental circumstances was not successful: following this, a "Strip Experiment" was laid out on a long strip of land having a sloping water-table; but proof of the injurious effect of a rising water-table was not fully demonstrated until 1914.

The manner of observation in the field having been very carefully thought out, bolling curves were plotted showing the number of bolls opening day by day. It was noticed that the time of arrival of cotton at Alexandria, which had been recorded year by year, was closely related to the time of fruiting but that the rate of arrival at Alexandria was dependent upon the conditions of market price, transport, etc. A study of these records showed that the time of average arrivals had been shifted backwards, which means that the bulk of the crop reached Alexandria sooner than it used to do. Arrival records were sifted, in order to allow for fluctuations due to price, etc., and plotted from the year 1906 and, by the simple device of compressing the arrival curve for successive weeks by a logarithmic scale a close similarity with the bolling curve became evident. The logarithmic compression compensated for the slowing down of arrivals as the market became full of cotton.

The arrival curves for several years prior to plant observation were treated in this manner, and the bolling curves for these years were arrived at by deduction from available agricultural information. When these pairs of curves were compared a close resemblance was again noticed and from a further study it appeared that the chief determinant for the form of arrival curve was *the actual rate of ripening of the cotton*; in consequence the Alexandria arrivals gave a first approximation to the form of the bolling curve. Hence, assuming that bolling curves of bygone crops had been restored by the Alexandria data, it was found that the maximum height of the curve, which is an index of the chemical and physical fertility of the soil, was as great in 1910 and 1913 as it was in 1898. The curves rise no sooner and no later than in the past.

The arrival curves with logarithmic compression show a definite cutting-off which agrees with the cutting-off effect of the time of rise of the water-table on the bolling curve. From these curves it appears that the cutting-off effect occurred in the thirty-eighth week in 1898 and in the twenty-sixth week in 1909 and 1916. Notice that the ratio of area cultivated in 1898 and 1916 is as 1.1 to 1.7, which is compensated for by the ratio of cutting-off at 26 weeks in 1916 to 38 weeks in 1898, which indicates that the main cause for the yield deterioration was water logging.

In America.

Ravages in the American cotton belt by various insect pests assumed such alarming proportions that skilled entomologists were called in and extensive and organised research was commenced. Despite all precautions the Boll-Weevil had affected nearly 85 per cent. of the crop in 1917, representing a loss of 4,550,000 bales of cotton valued at approximately £50,000,000. A remarkable fact to be noted is that under Boll-Weevil conditions and as a result of research, improved varieties of cotton were introduced yielding a more uniform staple and reduced susceptibility to damage from the many pests which invade the cotton areas. When all else fails, the only course to be adopted to combat these pests in the field is to spray or dust with insectides, which is often done by aeroplane; one plane can deal with as much as 1000 acres in a day.

It has been determined that the surest way of minimising the possibility of pests is to adopt proper cultural methods; the control of door-yard plants, weed destruction, fall cleaning of the fields, cotton free zones and the maintaining of surface mulch all assist the farmer by reducing the chances of pests being harboured; at the same time they assist the plant to fruit more uniformly and to yield heavier crops.

The introduction of pure strains of seed by careful selection from known varieties, most of which are hybrids, is not sufficient; the pure strain must be produced to meet demands year by year. It has been shown that the indiscriminate use of seeds from the gins, which may be dealing with cotton grown from pure seed, will, in the course of a few years produce a cotton with characteristics totally unlike the original and with a most irregular lint. In fact, only 2% of natural hybrids in a handful of pure strain seed can convert 30% of the individuals in that strain into rogues at the end of only three years.

The cotton breeder depends entirely on intensive and continued research in order to produce an ideal cotton from the standpoint of the spinner. One ideal is a uniform length of fibre, or staple, a result obtained by careful selection of plants for seed production. The selected plants are protected from cross-polenisation by bees and insects by covering each plant with a special screen, and the seed from these plants is sown in the following year, and so on, but soon the area required is so large that screens are impossible. A system of protection is employed to filter out the pollen from bees and insects by growing a belt of plants, about ten rows deep, round the 20 acres required for pure strain plants. The belts are of the same strain and all seeds from the belt are destined to be destroyed.

A Suggestion.

It has been stated that chemists may eventually be able to assist the cotton grower by the chemical control of the cellulose contents of the fibre. The cotton breeder specialist has doubts on this matter; having studied all aspects minutely for years he realises fully the natural difficulties of any strict chemical control. The growth of a plant depends so largely on local conditions, even within a small area, that chemical control even if successful would never be an economic proposition.

ADDENDUM.

Since completing the paper the author has had the opportunity of carrying out experiments to illustrate the Hysteresis exhibited by a cotton rope subjected to cyclic loading. Before commencing readings in order to obtain the Hysteresis loops shown in Fig. 24, the cyclic loading was repeated until the rising load/extension curve became constant. Practically no sub-permanent set was exhibited when this condition was obtained. From these loops it appears that the energy absorbed by the rope is given by the equation:—$E = Kp^2$, in which E is the hysteresis energy, p the maximum stress, and K a constant (Fig. 25).

When the rope had been given a week to recover from the foregoing experiment a number of loading cycles were applied rapidly to the rope and the extensions noted. Fig. 26 shows a number of the hysteresis loops thus obtained. The eleventh cycle was carried to a maximum of 70 lbs. and illustrates the increased hysteresis effect. The energy absorbed due to hysteresis with the normal range of stress is in the order of .1% of the energy transmitted.

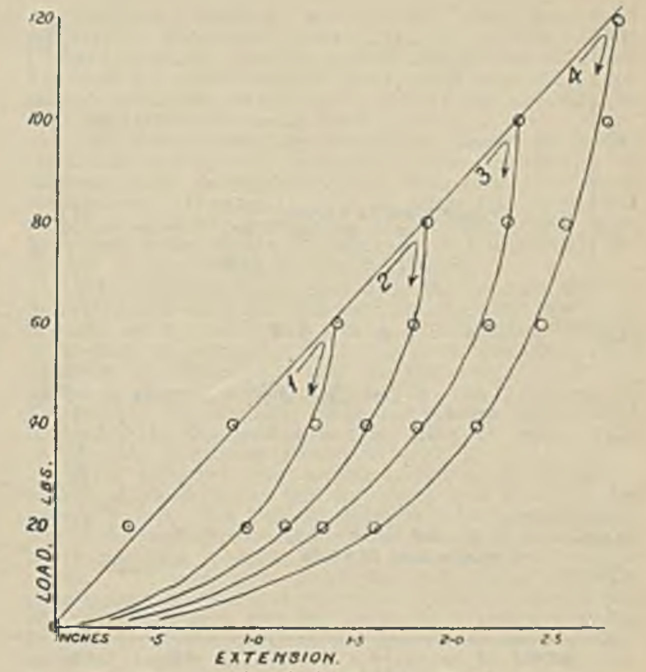


Fig. 24.—Energy absorbed due to Hysteresis proportional to Area of Loop. Stress proportional to Load. Cyclic Loading of Cotton Rope (lbs.)

1 0-60-0
2 0-80-0
3 0-100-0
4 0-120-0
Rope Dia. ...... ½ inch.

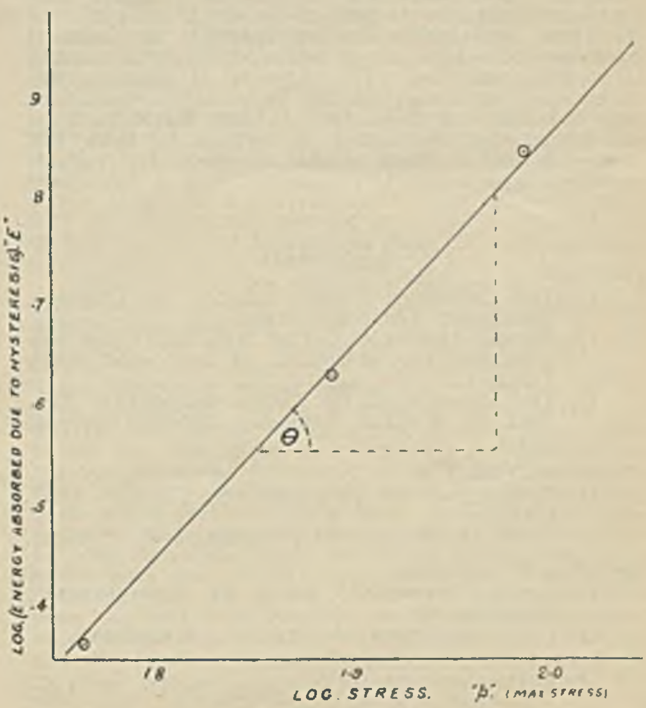


Fig. 25.—$\theta = 2$. $E \propto p^2$. $E = Kp^2$.

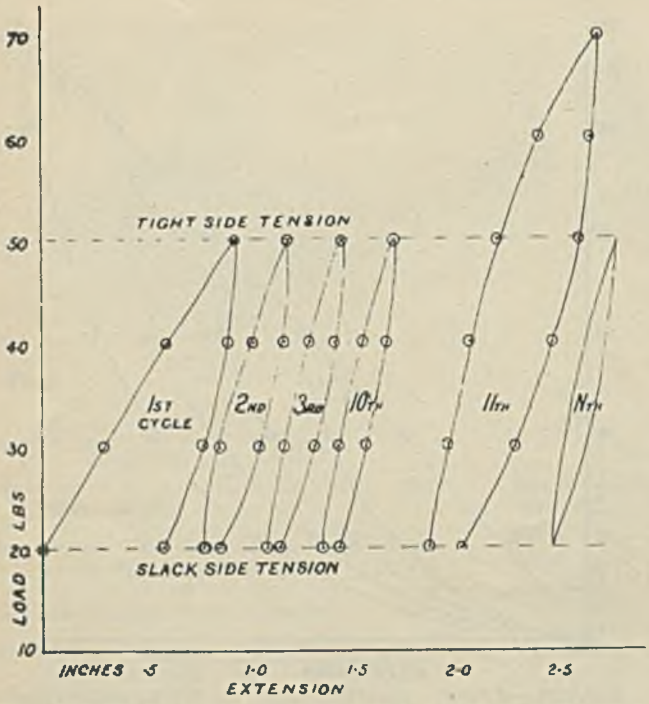


Fig. 26.—Hysteresis Loops for ½in. dia. Cotton Rope. The Loop for Normal Range of Loading would eventually become closed (Nth).

From a series of hysteresis loops obtained for ranges of stress considerably in excess of the normal, it appears that the hysteresis is proportional to the cube of the range of stress, i.e., $E = Kp^3$. If the hysteresis energy for a range of stress equal to four times the normal is calculated by interpolation, and if it is assumed that the load producing this stress is applied suddenly and maintained for about 0.015 seconds, i.e., representative of shock conditions, then the hysteresis energy may represent about 40% to 50% of the shock energy.

These experiments do not approach the practical conditions of a rope drive, because the rate of loading is comparatively low. The difficulty of obtaining any observations on a rope running under normal conditions with a velocity of from 1000 to 4000 F.P.M. will be appreciated, but the author is inclined to think that somewhat similar effects would be observed if suitable recording gear could be devised.

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SOUTH WALES BRANCH.

A General Meeting was held at the South Wales Institute of Engineers at Cardiff, on Saturday, the 7th September, 1929. Owing to the unavoidable absence of Mr. T. S. Thomas, the retiring branch president, Mr. Dawson Thomas temporarily took the chair. The minutes of the previous General Meeting having been read, confirmed, and signed, the following applications were accepted for membership:—Members: Messrs. Bert Parsons, William Stanley Richards, and Henry B. Smythe. Associate: Mr. Cyril Samuel Davies. Student: Mr. John James. Members of Western Sub-Branch: Messrs. Robert Atkinson, J. A. Findlay, and George Ernest Hider.

Presentation of Prizes and Certificates.

Mr. D. Farr Davies, Deputy Chairman, Monmouthshire and South Wales Coal Owners' Association, then presented awards as follows:—

Gold Medal awarded by the Association for the best Paper read before any Branch to Mr. S. B. Haslam, for his Paper, entitled "Modern Methods of Firing Steam Boilers with Special Reference to Pulverised Fuel."

Branch First Prize to Mr. F. E. Pring for his Paper, entitled "Coal Cutting Machines in Low Seams."

Certificates were presented to successful candidates at the 1929 Examinations: Mr. B. J. Burkle, First Class; Mr. W. T. Gay, Second Class.

Mr. Dawson Thomas having handed the Chair over to the incoming Branch President for the year 1929-1930, Mr. Hannah, the President, read his inaugural address.

Presidential Address.

W. W. HANNAH.

I am very proud of the honour you have done me in electing me to be your Chairman for the coming session. This is an Association of Mining Electrical Engineers, and your choice is due, I believe, to the fact that I am still actively and solely employed on the electrical side of mining work. The backbone of the Association in this district is largely formed of the representatives of the big engineering firms, and to them every credit is due for organising and maintaining this the largest branch of our Mining Electrical Engineers' organisation.

In this address I propose to review briefly some aspects of the present position with regard to the use of electricity in the mines of South Wales, and to touch on the ground covered by recent papers and discussions. If my interpretations and attempts to read between the lines are not good, if omissions are obvious and you note the omissions, you will still have been served with an attempt to review the position, and in that I find encouragement to proceed.

Before doing so, let me draw attention to the diverse nature of the mining electrical engineers' work. He is a specialist, or should be, in interpreting the Electrical Regulations of the Mines Act; he may have to be conversant with the planning, erection, extension, and maintenance of generating plant and extra high tension overhead lines between groups of collieries. He has to do with electrically-operated winding engines, air compressors, fans, pumps, haulage engines, conveyors, coalcutters, transforming stations, and the extensive transmission and distribution schemes necessary in connection with these diverse uses. There are, in addition, many side lines in miners' lamps, shaft signalling and underground signalling apparatus, and fairly extensive telephone installations. Often there are village and town lighting distribution schemes; and lastly, he must be conversant with the customs of the coalfield and of his own particular collieries.

It is not suggested that the average colliery electrician is called upon to plan out and lay down the items of plant enumerated, but it is very probable that at some time or other he will be involved in their maintenance. His value to his employers will be enhanced according to the understanding he has of the principles involved in their correct functioning and his ability to take a broad view and to form a balanced judgment of matters which are left to his discretion.

Review of Mining Electrical Work in South Wales.

In power generating work in South Wales, the paper read by the late Chairman in 1927, and the discussion which ensued thereon, emphasised the high load factor and the consequent low operating costs of colliery power stations: though it was particularly pointed out that there is still a large margin in colliery load curves suitable for municipal and other supplies.

It will be interesting to note the development of the Electricity Commissioners' plans for this area, and to observe whether some co-ordination between the private stations and the supply authorities will be possible. Collieries use power in bulk and it is of course essential that the supply shall be both cheap and reliable. The public authorities in the past have not been able to render such supplies; it ought to be possible in the future. The combination of colliery and municipal load and the utilisation of plant now held in reserve should tend to lower the cost per unit, and this would automatically create a demand for electricity.

It can be readily understood that in such a speculative business as the coal industry the less money that is spent on private colliery power stations, the less the capital risks to the coal owners. The ideal to which we ought to look forward, therefore, is the interlinking of the existing individual power stations so that their resources can be fully utilised, whilst future extensions would be carried out at one or the other of the bigger undertakings, not necessarily a colliery undertaking. This state of affairs would automatically come about if the Central Supply Authorities make their charges for current low enough in the first case to attract colliery consumers, and do not pursue the old policy of trying to extract from their first customers the whole of the wherewithal to extend their business.

A paper read by Mr. J. Smith in 1927 on the Cost of Electric Power Transmission gave us a very valuable corrective to too grandiose schemes of centralisation. The necessity still exists of drilling into the lay mind the fact that distribution costs in many circumstances can far outweigh generating costs. This paper and the one previously referred to, read in conjunction with each other, should enable one to form an opinion of the extent to which centralisation and interlinking can be economically carried out in South Wales.

On technical problems in generating work, two papers particularly stand out and demonstrate how well this our local branch has been served. I refer, in the first place to Major David's paper on The Protection of A.C. Systems against Short Circuits, and to the recent paper by Mr. Haslam on Pulverised Fuel. The Gold Medal awarded for each makes further comment unnecessary.

Coming to the use of electricity in mines, examples of collieries wholly electrically equipped are now numerous. In the bituminous areas of South Wales most of the minerals are let, and few new collieries will be sunk. The future problems, therefore, will chiefly be concerned with the conversion of older collieries to electrical drive. In this connection, battles still remain to be fought as to the direct use of steam in winding engines, fan engines, and air compressors, as against the use of electricity derived from large turbo driven alternators; but with the progress of time and the development of electrification schemes, whether by the Electricity Commissioners or by private firms through amalgamations, the use of electricity should grow. Indeed, this growth seems inevitable and therefore, in re-equipping the older mines due allowance for the coming of the all-electrical age should be made, even if under present conditions the use of reciprocating steam engines still appears feasible.

Electrical winding engines for the deep and moderately deep pits remain largely on the Ward Leonard principle, but as power stations have grown, flywheels for smoothing out peak loads have been dispensed with, and synchronous motors for driving the D.C. generators are being used.

The reciprocating air compressor driven by a synchronous motor still compares very favourably in efficiency with turbo-compressors except in very large installations. The capital cost of generating plant and electrically driven compressor is, however, higher than the direct steam driven compressor. A few remarks on the use of compressed air are made later.

Ventilation problems should be of particular interest to the mining electrical engineer through their similarity in many ways to electrical work. Unfortunately, we too often stop, or are stopped, at the motor coupling. The variation of efficiency of one or two per cent. in the motor is made much of, whereas the variation of efficiency in the fan and ventilating scheme generally is ignored. The synchronous motor, again, is largely used on fans for improving power factor.

With reference to pumping services, it is characteristic of South Wales that the steam coal measures are generally dry. The bulk of water is made at the points where the shafts pass through the upper measures, and heavy pumping is done only in close proximity to the shafts. The centrifugal pump has not a high efficiency compared with electrical standards, but the construction of water standages and the ability to transfer pumping to periods of low load at the generating stations have given us results with which we appear to be satisfied. We do not hear of many schemes for sealing the shafts by cementation to prevent the continuous use of power, but this is a complicated problem, rather outside the province of the mining electrical engineer. We are to have a paper on pumps in the coming session, which should be of exceptional interest.

In underground operations a gradual change is taking place. Many years ago, only outcrop coal was worked; then shallow pits for working small areas of coal were sunk. The easily got minerals are now largely exhausted, and our pits are in deeper measures. In consequence of the expense of sinking, wide areas of coal are worked from these deep pits. Even in connection with the shallower mines, centralisation schemes have been adopted to reduce handling costs, and again, larger areas of coal than hitherto are worked from these pits. Large outputs of coal have to be provided for in both cases.

The distribution of electricity underground, which some years ago could be at medium pressure, has now often of necessity to be at high pressure on account of the distances involved, and the large amounts of power which have to be transmitted inbye. Haulage planes have grown longer, and whereas earlier, one engine situated near the shaft bottom sufficed, it is now not uncommon to find that coal is handled by three or more haulages before arrival at the shaft bottom.

As the smaller and subsidiary haulages are the most numerous and situated furthest inbye, transforming and distribution substations have to be placed far in the workings, and their location in positions which will involve the least danger, and their equipment with protective devices to ensure interruption of current in the event of mishap, become necessary. To a certain extent the development of deep pits working large areas of coal has necessitated large roadways in order to pass the air currents at reasonable water gauges needed for these extensive workings, and to deal with the heavy traffic which obtains. These large roadways have automatically made safe the running out of electric cables for long distances. Again, the use of masonry and steel arches have also, up to a point, been conducive to the fairly extensive use of electricity at the bigger collieries. Near the coal face, however, whilst the mechanisation of work has made headway by the use of coal cutters and conveyors, and even the horse is being displaced by small haulages, compressed air appears to hold the field, and electricity is not playing a notable part in dusty and gassy mines.

What are the weaknesses of electricity? In haulage gears the small compressed air haulage, weight for weight, is superior in pull out power to the electrical haulage as usually constructed; its housing requirements are negligible, and it is simpler in use. The suggestion has been made at one of our discussions that the mechanical portions of our electrically operated haulages should be redesigned; squirrel cage motors with their simpler switching arrangements, friction clutches and variable speed gearing as used on motor cars, are surely possibilities worthy of attention. It is sometimes rather humiliating to see the A.C. electrical machine, on account of its lack of flexibility, flatly refuse the extra tram of coal, or jib at assisting in getting a journey back on the rails. There does appear to be need for reconstruction of the mechanical portions of such gears.

The foregoing, however, is one of the lesser evils, and can be surely overcome; it is the question of safety in using electricity inbye which is of prime importance. I have indicated how the processes of good modern mining make for safety on some of the main underground roads. If such roadways have been made secure for dealing adequately with heavy traffic, and if they have been designed for dealing with large volumes of air, then we have the first requisite for taking electricity into the workings.

The manufacturers, aided by the testing work of the Mines Department, appear to have done their share in giving us flame and explosion proof apparatus. It is still left to us, however, to guard against mishap to cables on roadways which cannot, for economic reasons, be made absolutely safe. Runaway journeys, falls of roof and sides, ground movements, all contribute their share of mishaps; but with all the sensitive devices at the disposal of the electrical engineer it should be ultimately possible so to protect such cables that whatever the nature of injury open sparking will not occur.

Technically therefore, there appears to be no insuperable difficulty to prevent electricity being taken practically right up to the coal faces, but there does remain to-day a very great objection to doing so. I refer to the abuse of the electrical apparatus. Workmen, and I include electricians, do not apparently understand that the pilfering or omission of studs, bolts, and nuts, from flameproof enclosures is equivalent to taking a naked light to that particular situation and leaving it there. The fireman or safety official does not consider it comes within the scope of his duties to note whether a cable is dangerously slung and liable to damage, and he pays no attention to the condition of electrical apparatus. Either a technically trained fireman must be evolved or the electrician-in-charge must be educated to test for gas, given wider powers, and be compelled daily to make routine examinations of mining conditions before machinery is worked and current switched on.

It has been instilled into the minds of underground workers that the safety lamp must be treated with respect; when every item of electrical apparatus is treated with the same respect, we shall have overcome one of the greatest obstacles to using electricity at the coal face.

It is an accepted fact that gas can be ignited by the heat generated by friction of moving parts. If the colliery manager is compelled to take action to maintain his ventilation so that gas will not be ignited by friction wherever mechanical power is used, then electricity will be equally safe in such situations.

Possibly we are already justified in saying therefore that electricity is not more dangerous than compressed air, but a great deal of prejudice will have to be overcome to convince people that this is so.

The displacing of compressed air by electricity is urgently required. I have in mind collieries which derive their power supply wholly from electrical sources. Winding engines, fans, pumps, and all the main underground haulages, and many subsidiary ones, are directly operated by electricity, and yet the air compressors used for small haulages, conveyor engines, and drills, account for 50% to 60% of the total power required for the pits. Compressed air will continue to be an expensive luxury, and it remains for us, as mining electrical engineers, to oust it and thus help to lessen colliery costs.

If only steam and air could be as accurately and cheaply measured as electricity, the figures obtained would lead to the extensive replacement by electrical drive.

We are to have a paper in the coming session on Maintenance of Colliery Plant; it is hoped that this well-worn subject will be given the prominence it deserves. It would be an admirable opportunity of discussing with the colliery managers certain aspects of the use of electricity below ground, in which we are all involved. A full and frank discussion of difficulties might bring us closer together in devising means of overcoming them. I look upon the question of adequate maintenance as being one of the chief factors in deciding whether electricity shall be used more extensively underground or not.

One other use of electricity deserves comment. The introduction of the common form of miners' electric lamp has not diminished the prevalence of Nystagmus. Cap lamps provide intensive light on the work that is being performed, and in the United States where such lamps are used, the number of Nystagmus cases is negligible. Experiments with cap lamps on a fairly large scale are being carried out in Great Britain, and developments in this direction can be expected.

We have heard little more of the suggestion thrown out by Professor Thornton in 1923 that coal face lighting by high frequency currents should be adopted, although this was shewn to be perfectly safe. Generally speaking, the position of face lighting is still unsatisfactory.

In concluding these remarks, it will not be inappropriate to talk about the work of this Association. The day has gone when the man who is practical with his hands only is fit to be in charge of a colliery with a large electrical plant. The complicated nature of modern devices, the innumerable uses to which elecelectricity is put at collieries, make it essential that brainwork also be expended. There is no easier method of keeping in touch with modern thought and practice than by listening to papers read by men who occupy similar positions to one's own. No other institution caters for the mining electrical engineer as this one does. I cannot think of any application of electricity to mining which is not by means of our journal, *The Mining Electrical Engineer*, brought to our notice.

It behoves us as colliery men, by attending these meetings and taking part in discussions, to help to keep this Association an institution which will be of benefit to ourselves and to the Coal Industry. If every member contented himself by reading the Journal in his own home, and took no other part in the work of the Association, there would ultimately be no papers or discussions to read. If on the other hand we can get together and encourage the outsider too to become a member, we shall by reason of our more complete knowledge of our work automatically obtain that higher status for our profession of Mining Electrical Engineers, which we all so much desire.

Mr. D. FARR DAVIES said he counted it a great honour to be present, more particularly because the objects of the Association were such that any man might feel proud of doing what he could to help its work forward. The objects of the Association were to promote the advancement of electrical science, and incidentally to ensure the safe application of electricity in mines. The greater the knowledge of electrical science, the greater the advancement towards safety in mines. He dare say many of the members, like himself, were inclined to complain that we have the most stringent electrical rules in the whole of the mining world, but he did not think any of them would be prepared to get up and say that they would like those rules to be less stringent. What we all had to bear in mind was that the rules follow the best practice, and not that the best practice follows the rules. Everything that is in those electrical rules had been prompted by improvement in mining science and electricity in past years, and if anyone complains, then he is not the pioneer but the laggard, and Mr. Davies was sure that could not be said about any of the members. They who, like himself, were responsible for the economics and expenses of mining were undoubtedly very much indebted to the Association for the assistance it had given, and would continue to give them in the years to come: assistance in the adoption of electrical science which is advancing by leaps and bounds every year in a manner which no colliery manager could hope to cope with. They had to rely on members of the Association and people of that kind. Mr. Farr Davies referred to the certificates which were to be awarded that night, and which were records of the high standard of electrical knowledge which the Association expected from its members. He was afraid there were many people who did not yet fully appreciate the value of those certificates. He did not know of any criterion by which the knowledge of the mining electrical aspirant could be judged, other than the certificates of the Association. They included first and second grades, also an honours grade. The honours grade was undoubtedly a grade in which a man required a great deal of technical knowledge, and for the first and second a considerable amount of knowledge was necessary. The Association was, therefore, an educative one; it encouraged papers on all aspects of mining electrical science.

It had occurred to him that they of the older age were very selfish. They had young people working for them and who did most of the work very often. If there was a paper to read they, the older men, often took the credit for it. He thought the better way would be to encourage young students to come forward by joining forces and combining with them in the reading of a paper. That would give juniors the start which they were afraid to take alone. He offered the suggestion to many of the older members.

He noticed it was not only the electrical side wholly with which the Association concerned itself because the Gold Medal which he had the pleasure of presenting to Mr. Haslam was awarded for a Paper on "Modern Methods of Firing Steam Boilers with Special Reference to Pulverised Fuel". That paper, which had undoubtedly received the well-deserved great recommendation, had gained the "Blue Riband" for the whole country. It was high credit to take the First Prize Award of a Branch, but to take the premier award for the whole country was the greatest honour of all, and he heartily congratulated Mr. Haslam upon his achievement.

Referring to the study of fuel, Mr. Farr Davies said that branch of research had made more advancement during the last ten years than in the previous 25 years. They would undoubtedly have two schools of thought, the chain grate stoker advocates and those favouring pulverised fuel. There were tremendous surveys going on over the whole country by the Fuel Research Board, the Mining Association of Great Britain, and various Universities, to get as much knowledge of the value of coal and to get out of it the greatest amount possible. They had all heard in that room many a time that those at the collieries had a lot to learn as to the efficiency of their boilers. Ten years ago it was considered that to get 60% efficiency was a great achievement, and that by using good coal. To-day things were never happy unless the figure was in the neighbourhood of 80% and using a coal of poor and inferior quality—coal which, burnt ten years ago, would not have given 30% in the boilers. Obviously there had been very great progress in that line.

In conclusion, Mr. Farr Davies expressed his thanks to them as an Association, first of all for the assistance which they give mining engineers in carrying out everyday duties, and also for asking him to present the Certificates and Prizes.

Mr. W. W. HANNAH (Branch President, in the Chair) proposed a hearty vote of thanks to Mr. D. Farr Davies. Everyone of them could not help but know that a gentleman in the position of Mr. D. Farr Davies must have made considerable sacrifices in honouring them by his presence. As an Association they worked primarily for their own good but that ultimately meant for the benefit of the coal owners and all connected with the industry.

Mr. IDRIS JONES seconded the vote of thanks to Mr. D. Farr Davies. He said that from Mr. Davies' opening remarks it would appear that he (Mr. Davies) evidently knew the mining electrical engineers at the collieries very well, and showed that he had the interests of the mining electrical engineer and this Association closely at heart. Might he venture to suggest that Mr. Davies would try and encourage a few more of the coal owners to attend some of the meetings. If they would only come to hear some of the Papers read he, Mr. Jones, was sure they would appreciate that every mining electrical engineer, of that Branch in particular, was out to try and help each and every member, as well as to improve his own knowledge of the work with which he was connected. Mr. Hannah had given them details of the various duties which the mining electrical engineer was called upon to perform. In Mr. Jones' opinion a man who had been for a large number of years on any modern electrical plant was qualified to go to any other type of plant and more than justify his existence.

Mr. D. FARR DAVIES.—Mr. Jones said that possibly the coal owners would appreciate the value of mining electrical engineers better if they came oftener to these meetings. Mr. Idris Jones would know quite well that he, Mr. Davies, was always on the administrative side, and could say that in his thirty years contact with the mining electrical engineer the standard of efficiency had grown infinitely higher than it was thirty years ago. Mr. Hannah in his excellent Address had referred to the advantage gained by both sides by greater co-operation between the municipal authorities and the collieries. He was very pleased to announce that his Company had come to an agreement with a large Power Company in South Wales whereby the Power Company would supply the Collieries during certain periods of the day and the Collieries would help the Supply Company to carry its peak load for other periods of the day—so that the advantages of co-operation were, in fact, beginning to be appreciated.

Mr. S. B. HASLAM, in proposing a vote of thanks to the Branch President for his excellent address, said each year it appeared they had almost reached the zenith of Presidential addresses, but the next one seemed to be better. Mr. Hannah had a very high standard to follow but he was sure they would all agree that he had well maintained if not actually improved on that standard. When reading the various Presidential Addresses of other branches published in the admirable journal of this Association, one was impressed by the sound common sense always contained in the addresses by the Presidents of this Branch. No doubt that was due to the fact that they were given by practical men, and the address they had heard that night was full of it. He was sure that it augered well for the coming session and under the leadership of Mr. Hannah they were assured of a very successful year.

Mr. A. C. MACWHIRTER, seconding the vote of thanks, said they all appreciated what Mr. Hannah had done for the past few years. He might be permitted to draw Mr. D. Farr Davies' attention to the fact that a few years ago it was with great difficulty that Mr. Hannah could be persuaded to speak at a meeting. Year by year he made progress in that respect and now he had been placed in the Chair. That was the process of promotion and encouragement in the South Wales Branch of the Association. They did the same with the youngsters, encouraged them to get on their feet and assisted them in every way. The Address they had just heard and the awards presented showed the standard of work done in the Branch.

WEST OF SCOTLAND BRANCH.

Visit to The Plean Colliery, Stirling.

On Saturday, September 14th last, through the courtesy of the Plean Colliery Co., Ltd., members of the Scottish Branches of the Association paid a joint visit to the Plean Colliery, near Stirling.

One of the most interesting features of the visit was the inspection of the Company's coking and by-product recovery plant worked in conjunction with the pit.

The visitors, numbering about fifty in all, were received by the Company's agent, Mr. Wilkie, and his staff, and under the guidance of Mr. Lanyon the mine manager, and Mr. Wright the coke works' manager, were conducted over the colliery and works.

Mr. G. N. HOLMES, the President of the West of Scotland Branch, at the conclusion of the visit proposed to the Plean Co.'s representatives a hearty vote of thanks on behalf of the Association and congratulated the Company on their very successful operations.

Mr. WILKIE, in replying, expressed on behalf of himself and his colleagues, his pleasure at having the opportunity of entertaining the members of the Scottish Branches, many of whom were old and personal friends.

His pleasure was greatly enhanced when he recalled his old connection with the Association, he having been at one time President of the Lothian Branch.

After the visit, the members adjourned to Stirling for tea, and were entertained during a short interval by Mr. Jas. Laird, with recitations, which were highly appreciated.

Thereafter the meeting settled down to business affairs and to hear the West of Scotland Branch Presidential Address by Mr. G. N. Holmes.

Presidential Address.

G. N. HOLMES.

At the end of 1918, and for a few subsequent years, this country was riding the summit of one of the greatest industrial waves of our time. New works were in the course of erection, older works had been enlarged and modernised, and altogether we were in a highly productive state. In addition to this the earning capacity of the nation had enormously increased and correspondingly the spending facilities of the people. Unfortunately the position was mainly artificial and it was not long before reaction, with its insidious influence, became not only threatening, but something approaching a national disaster. Throughout the world the industrial situation has changed and, while industries have increased the world over, the world markets have decreased. This situation has evolved owing to our Colonies and other countries establishing their own factories; they are not only supplying their own requirements but are now in a position to export much of the material they were in the habit of buying.

Our own key industries—coal, iron, shipbuilding and the general heavy section of engineering—had reached a crisis which only now appears to be resolving into stabilisation, and they are being slowly guided into channels where fresh outlets may be found for their resources.

To many people this position was merely an industrial crisis, but if we analyse the cause it would appear that some other force was at work, and it is suggested here that it could rightly be placed in the category of natural evolution.

Coal mining, in which we are so closely interested, has suffered longer and possibly more acutely than most industries; it is therefore more slow in its recovery and its position to-day must be attributed to the following causes:—

(1) The development of oil fuel for steam raising.

(2) The development of the internal combustion engine for road transport.

(3) The development of the Diesel engine for marine propulsion.

(4) The economic generation of electricity and its widely spread uses for industrial and domestic purposes.

(5) The loss of our export trade owing to high cost of production and transportation, and also to the highly competitive element due to the development of the Continental coal fields; and further, as a result of the war, to reparation coal.

It will be noted, therefore, that the present conditions cannot be attributed solely to any single factor but rather that they may be regarded as the result of a series of elemental causes which have taken the coal industry by surprise and found it unprepared.

These are not circumstances affecting an individual industry only, they are reflected throughout many of our manufacturing concerns whose survival and trade adjustments have been the outcome of necessity.

We have evidence of considerable research work being carried out in all directions to combat these altered conditions and a real endeavour is being made to maintain the services of our great coal resources, the possession of which placed Great Britain on its pinnacle of strength and made it the premier industrial country of the world.

There is no utterance of despair and a study of our achievements of the past is possibly one of the greatest hearteners we have. Therefore our watchword is "Progress," and to that end we all have the power to add our quota irrespective of the niche we fill. British initiative and the hereditary ability for solid work will win through.

For generations it would appear that the coal trade has lived in isolation, i.e., its only concern was the production and sale of coal as a finished commodity. It was not concerned with the valuable properties it contained and was quite prepared to give these gratis to the purchaser.

It had no concern regarding its economic use as a fuel; such detail was the work of the combustion and gas engineer, and in consequence coal was applied only to the large power plant which calculated its efficiency upon cubic feet, lbs. and horse power, while a vast proportion of the valuable contents was being poured out in smoke and otherwise deliberately wasted.

There is a feeling prevalent that the utilisation of coal is passing through a transitory stage. The economics caused by the more general use of cheap gas and electricity, the motive power of petrol and crude oils, have dislocated the demand for coal in its raw state and we are fast reaching a stage when raw coal will cease to be used as a primary fuel. Before this can take place, however, there will be a great deal of prejudice to break down, particularly in regard to fuels for domestic purposes. The solution to this is probably the elimination or a modification of the open fire and the introduction of central heating, or a more extensive use of electricity.

During the last few years scientists have been concentrating on the pre-heating and distillation of coal and their activities in this respect would appear as unconscious agents working in preparation for the changing conditions. The result of these scientific investigations may be summed up in the dual propositions of Low Temperature Carbonisation and Pulverised Coal, this latter being applied as a direct fuel. Individually both products are the result of entirely different processes though their ultimate aims are greater economy, and the elimination of waste.

The use of pulverised fuel in this country has not progressed very rapidly, but it is likely that the future will see considerable development. Experiments have been carried out regarding its application for steam raising in electrical generating stations with results that are encouraging. One of the latest achievements has been the fuelling of a Clyde built steamer with pulverised coal, which having run its trials satisfactorily, is at present completing its maiden voyage.

This is no innovation as the United States have already preceded us in this respect, but the interesting feature is the effect it might have in reinstating coal as a primary fuel for marine propulsion.

The British Admiralty is more than a little interested in this question; it is also no secret that more than one well known firm of boiler makers on the Clydeside is carrying out experiments and developing means by which powdered fuel may be utilised for boiler firing.

On the Continent pulverised fuel has made much more headway and is being extensively used, but this may be due to the force of necessity, because of the lower grade fuels available. There is, however, little reason why many of our boiler installations should not be adapted for powdered fuel, as considerable economy would accrue and it would thus be possible to find a market for much of the unsaleable coal that at present exists. There may be difficulties in the way of bulk handling of powdered fuel but no doubt, once the market is made, this question would solve itself.

It is possibly, however, towards Low Temperature Carbonisation that we must look for the real future of the industry. At present the process is in a purely speculative state, and it is still questionable whether our large coal resources can be pre-treated, or a stabilised market found for the resultant fuels and by-products.

By low temperature carbonisation our raw coal can be converted into a smokeless fuel or semi-coke, which may be directly marketable for domestic consumption, or for steam raising. It is not a far step before its adoption for these purposes becomes a recognised factor; and while there may be some dissension at first, the momentum of national requirement will rapidly sweep this aside.

The gas, oils and motor spirit by-products can all be put into commercial and industrial usefulness, and there is already an established market for these liquid fuels if they can be produced at a reasonable cost and in sufficient quantity.

Those of the members who were able to visit the Dunston Power Station at Newcastle during the Association's summer meeting, had the opportunity of seeing boiler plant operated not only by powdered fuel, but also by semi-coke obtained from ordinary Northumberland coal after pre-treatment. The system in operation was the Babcock Low Temperature Coal Distillation, combining the carbonisation of coal at low temperature with direct steam raising and the recovery of by-products from the fuel. One of the most notable features of this plant was the automatic action, coal being fed into the retort, distilled, and the coke product passed continuously to the stoker hoppers. The complete plant was operated by the boiler house staff without additional labour, but the recovery plant was separately housed and handled.

It is very gratifying to note that coal distillation is being carried out on a commercial basis in the Scottish industrial area, and the plant erected at Glenboig is probably the first to be put into operation with any real attempt to deal with the quantities required for a successful issue.

It is too early to visualise the financial attainments of these schemes, but scientifically they are a great advance in regard to the economic utilisation of our greatest national product, and should materially assist in opening up the new era of prosperity in the British coal industry.

The coal industry until the last decade existed upon the general demand for its product and possessed a universal market. It is now suddenly plunged into the same category as that of many other concerns of having to create a demand for its enormous output. How this can be attained is so great a problem as to be almost beyond conception, but seeing that the whole industry is being thoroughly reviewed and overhauled, there is more than a spark of hope that a solution will be found.

It is interesting here to refer to the Address by the President of the Association, published in *The Mining Electrical Engineer* for July. Captain Walton-Brown's address was one of great commonsense and threw a sidelight, which engineers are perhaps apt to overlook, on the whole situation and the extraordinary difficulties encountered in the coal industry—a careful and critical perusal of the Address would be advantageous to all members.

Captain Walton-Brown has not produced a solution, but he has referred to many issues which may become the basis for further exploration, and he is to be congratulated upon an address entailing much thought and investigation. It would appear that the industry in the past has devoted all its energy to production and spent little of its time and resources in scientific research or the production of new markets. The competitive element and struggle for existence forced most manufacturers to know their goods, to make them known and to make a demand for them. Coal distillation is likely to be a new industry and as such it should be very carefully considered whether it could economically form an integral part of the mines, or a subject for independent enterprise. Whichever step is taken the coal industry must not be found lacking in practical sympathy and wide outlook, and should be ready to foster every effort to the full limit of its power.

It is open to doubt whether much good could be obtained by advertising; certainly individual collieries would benefit by such means, but it is doubtful whether it would benefit the industry as a whole. Co-ordination and Rationalisation with a greater use of scientific knowledge regarding coal, its application, and its products is probably what is wanted and science may help in rejuvenating the industry as it has in creating entirely new ones.

While the question affects us only indirectly, in the event of reorganisation the coal industry may look upon our Association as an extremely interested ally. We may rest assured that the coal trade is energetically engaged in putting its house in order, and that ways and means for producing and marketing coal at an economic figure are being examined in detail. The whole question is having the closest attention of its members, many of whom are well known masters of industry. Notwithstanding these attributes we must not expect anything dramatic to occur, and it must of necessity be some time before anything like complete reorganisation takes place and the wheels run smoothly.

It is questionable if the coal trade can be compared with other industries which, with the growth of machinery and intensive production, have demanded more scientific organisation. It is, however, in the near future more than likely that the operation of the pits will be based on a higher technical plane and a larger executive staff will be employed. Statistics and graphical methods of computing output, costs, running operations, etc., will be more generally used, and by means of these records it will be possible to analyse at a glance the periodic working conditions of a pit. They would serve not only to indicate whether greater economy could be attained, but to act as a pointer to inefficient operation or undue losses.

The cutting down of labour charges may be one of the easiest methods of showing an apparent reduction in working costs, but it is doubtful whether that would be really economical. It must be remembered that the collieries are now highly mechanised, and that the amount of capital sunk in machinery alone represents no mean sum. In addition to this electricity is often the chief source of motive power, being in many cases taken from a public supply with special tariffs. The inefficient handling of these two factors alone may account for considerable losses in economic working, and may represent far greater charges than mere executive oncost. It is probably here that the more highly trained electrical engineer will prove of greater service to the management than hitherto.

The extended use of electricity in mining has placed a greater responsibility on the electrical staff, and is creating an increasing demand for men of wider experience qualified to hold the position of chief electrician, or electrical engineer.

To this end the Association of Mining Electrical Engineers has been steadily encouraging its members, and the creation of examinations and certificates of competency has been highly appreciated. There is one qualification arising out of these examinations, viz., that the holder of any Certificate has a proof of proficiency whilst the holder of an Honours Certificate possesses a testimony of high distinction. Work of a very high standard is expected and successful candidates may be considered competent within the correct meaning of the term "Electrical Engineer."

Here it might be permissible to make a digression and be excused of generalisation by a reference to some of the failings inherent in many men of mechanical aptitude, viz., the non-ability to express their views concisely and adequately when submitting reports or when sitting an examination. The prevalence of this handicap is also generally borne out by Professor Statham, the Association's chief examiner, who in his report mentions that mathematics and sketching are generally below the standard expected. The obvious suggestion, chiefly for the benefit of younger members, is that much more time should be given to cultivating these items. Machine drawing can be a pleasure, while elementary practical mathematics will carry an engineer a long way in most technical problems.

It cannot be too strongly urged that members attend more of our meetings, taking part in the discussions, or even submitting papers on their special subjects. These are valuable aids to personal education, and well worthy of the effort.

It may be truly said that in the past the colliery electrician was given little encouragement, but the future will perforce call for better trained men of executive ability. Every colliery electrician should be able to produce and be in possession of proper records of his plant, and it should be possible for an engineer to trace any piece of machinery, switch or switchgear by reference to plans. Data cards referring to details of performance and characteristics of individual machinery should be carefully filed; also power and other graphs of the general system should have their proper place in the natural order of things. Distribution plans giving sizes and grades of cables etc., should also be available, while an adequate system of keeping stock and spare parts is very necessary, and should form part of the electrical engineer's duties.

It becomes more apparent through the growth and complexity of the electrical equipment in the mines that the old haphazard ways which existed in many pits must be scrapped. Upon electricity depends the continuity of operation and consequently the output. In order that the service of electricity should be utilised to its fullest extent, that plant be properly proportioned for the work; that the lay-out is part of a pre-designed scheme and that the whole installation has a purpose and is not a mere incident, is the job of the technically trained man.

It is absolutely essential for the successful working of the industry that more use be made of this type of electrical engineer, and that he be given scope for his training and initiative; he must perforce be one of the inner circle when determining the advisability of a change, or additional plant; and without depriving the manager of primary responsibility, the electrical engineer should be endowed with departmental and executive powers utilising his specialised knowledge.

One can hardly over-emphasise the fact that the only way to save the Industry is the application of science, and the greater and more intensive use of machinery. By the comprehensive use of electricity, the speeding up of most operations should be possible. Signalling, winding, cutting, conveying, all come under this category, and within a short time the services of a bulk supply from the electrical grid should be available in most districts for this purpose.

Since the formation of a departmental committee by the Mines Department to consider the qualifications of the various officials engaged in mining operations, a good deal of discussion has centred round the question of compulsory certification of the electrical staff. As an Association interested in mining, and particularly so from the electrical point of view, we are concerned, should certificates become law, that our members should be properly represented on this committee, and steps are being taken in this direction. There are many who are of the opinion that the electrical engineer, or electrician, should be a recognised official of the pit and in that position should possess some form of certificate, qualifying him to act in that capacity.

The general use of electricity at the coal face and as a matter of fact, throughout the whole colliery, demands adequate knowledge and precaution for the safety of all other grades of men employed underground, and although electrical accidents are exceptionally few in comparison with the great volume of electrical plant in use, some of these might not have happened had there been better understanding. The fact of an electrician holding a certificate would give confidence to workmen unskilled in electrical matters, and they would carry out their work with greater assurance.

There is a strong feeling of suspicion regarding certificates on the part of many of the older men, but they have no need to be concerned. Admittedly these men could not now be expected to train specially for examination, but their past experience, gained in a hard school, would warrant the certificates being granted in their case—as has been usual in all similar cases in the past.

It is difficult to say if such a certificate would improve the status of the electrical engineer. Individual effort is the only way he can equip himself for advancement, and no Government Department will pave the way for him. Nor is it easy to define what qualification should form the basis of such a certificate, but it is more than likely that some term of apprenticeship would be served in conjunction with a reasonable technical training in the installation and maintenance of electrical plant underground.

Before closing this address it will be fitting to make some reference to the Association. It is a matter for congratulation that this year the Association has reached its majority. That it has survived the difficult years of the war and the more recent troublous times of the coal industry is testimony not only to its vitality, but to the activity of its various committees and members. The Association has grown in importance and is representative of colliery electrical engineering in every phase. Inaugurated when electricity was the exception rather than the rule in mining, it has been instrumental in bringing together all classes of engineers and technicians who, by discussion and interchange of thought and practice have greatly assisted in bringing mining electrical apparatus into the highly perfected state now existing.

Through its activities manufacturers have gained knowledge of underground requirements and have been able to design suitable machinery, etc., making electricity an economic, safe and reliable means of conveying and using power. In addition to this, much work has been done resulting in the standardisation of apparatus which, as time goes on, will be a universal benefit.

It is an interesting point that the A.M.E.E. is an independent Association and that its records prove that it has fulfilled its quota of usefulness in the highly specialised field of mining electrical engineering. Its official journal, "The Mining Electrical Engineer," is unique, being contributed to by men of wide experience and drawn from every class, professional, practical and technical. The publication of these articles is invaluable and the advantages accruing to the individual and the industry are self-evident.

In conclusion, as President of the Branch for the current year it is found necessary to urge members to regular attendance at meetings; surely members of the Scottish Branches cannot be so indifferent to their own interests that they can afford to let meeting after meeting go by without participating in them. Putting aside even the important point of personal interest or gain, regular attendance is surely only a matter of courtesy to the lecturers who, without doubt, must give much of their time to the preparation of papers of unusual merit, and who more willingly invite discussion on the subject matter. Moreover, in this part of a great industrial country there are many colliery electricians neglecting the opportunity of becoming members of an Association essentially vital to the interests of their daily work; all members should use their influence to recruit as many of these men as possible.

Whilst seemingly censuring absentees it is also fair to express a word of sincere appreciation to those members who have been the backbone of the meetings. A large attendance gives a heartiness to a meeting and an enthusiasm which is helpful all round.

By becoming a member of this Association there is a unique opportunity for self improvement. Self expression is difficult to acquire but it is only a matter of experience. The self confidence gained by the contribution of a paper or even the participation in a discussion at our meetings may make all the difference in a man's career. He has gained confidence, his outlook on life has broadened and he has developed his personality.

The membership of the West of Scotland Branch of the Association has fallen somewhat during the past few years, through adverse trade circumstances, but it is now fairly stabilised and showing a tendency to increase. The West of Scotland Branch may well be said to have played a leading and honourable part in the proceedings of the Association, and the call to every member is to maintain its traditions and work for its advancement.

Mr. BECKETT, in expressing thanks to Mr. Holmes for his very interesting address, said he had reviewed the difficulties which have beset our industry during the past years, and touched upon various schemes for overcoming them and enabling the industry to enter a new lease of life: as such there was much food for thought in the address, and in its printed form in "The Mining Electrical Engineer" it would repay careful study. They were all much indebted to Mr. Holmes and before putting the proposition formally to the meeting he would ask Mr. Reis of the East of Scotland Branch to second the motion.

Mr. REIS said he was very pleased to have had the opportunity of attending the meetings that day, and had very great pleasure in supporting Mr. Beckett's motion. They had always looked upon the West of Scotland Branch as a model on which other Branches could well base their activities, and he was sure that under Mr. Holmes the Branch would continue to progress.

Some of the questions raised by Mr. Holmes were distinctly controversial, and he would not refer to them; he could, however, express his entire agreement with Mr. Holmes' references to education, and he was very pleased to hear the remarks on that essential question.

Mr. PERRITT, of the Lothians Branch, thanked the West of Scotland for their invitation extended to his Branch, and had very much pleasure in associating himself with the remarks of Mr. Beckett and Mr. Reis, and supporting the resolution on behalf of his Branch.

Mr. HOLMES, replying, acknowledged the generous manner in which the speakers referred to his address, and the personal congratulations accorded him on his taking up the presidential chair for the year. Mr. Holmes welcomed the members of the East of Scotland and Lothian Branches and endorsed the mutual feelings of hearty co-operation which were the outcome of such joint meetings.

LOTHIANS BRANCH.

Presidential Address.

JAMES PERRITT.

(*Meeting held 26th October*, 1929.)

You have honoured me by electing me your president for the current year, an honour which, though I greatly appreciate it, rather reminds me of the story concerning the farmer who, in pursuit of an escaped bull, discovered the animal on the railway track with lowered horns awaiting an oncoming express train. "Go it,," cried the farmer. "I admire your pluck, but I despise your judgment." Like the farmer, I admire the pluck or the courage which led you to elect me as your president, but . . . . .

Our Association has done, and is doing, much to raise the status of the colliery electrician; it is not difficult to see the direction in which he is surely, if perhaps slowly, advancing. The Association, through its different branches, endeavours to educate the colliery electrician by the bringing together of men who are connected directly and indirectly with every phase of electrical practice in regard to mining. It therefore, behoves every member to keep abreast of the times by attending the meetings, by taking part freely in discussions; and to equip himself in every way thoroughly to understand his work, technically and practically.

The Branch Council strive to do much for the members of the branch by arranging papers and lectures which will appeal and educate. They also arrange visits to places of interest, which, besides offering information of value, are also entertaining. The papers, lectures, and visits are not decided upon merely to fill the syllabus, but only after very careful consideration.

Dealing with the papers which are read before the Branch, might I be allowed to express the hope that members will not hesitate to come forward with papers, or to open discussion on points of interest. After all, the work of the Branch is entirely dependent on the active interest of each individual member. Problems often crop up in the daily occupation which would provide excellent ground for discussion. Very often those little practical discussions prove of more value by serving to give a more lasting technical education than a very elaborate and "high-brow" paper.

While it is not intended to suggest that technical knowledge should become more important than practical training, it is to be emphasised that the colliery electrician should have sufficient theoretical knowledge to understand the working principles of electrical plant, its upkeep, and its repair. As the question of only certified men taking charge of the electrical plant at collieries might be enforced at any time, it is in the interests of all electricians to improve their technical knowledge as much as possible.

Some eighteen years ago the Association of Mining Electrical Engineers decided to award Certificates of Competency to all members who passed an Examination. Those certificates serve as a direct proof that the holders are competent men, and are recognised by colliery managers when selecting electricians.

The Report of H.M. Electrical Inspector of Mines for the year 1923 reads:—

"The Association of Mining Electrical Engineers, a Technical Society, with a view to fulfilling one of the primary objects with which it was formed, viz. :— 'To promote the general advancement of Electrical Science in its applications to the Industry of Mining,' holds voluntary examinations and issues certificates to those of its members who satisfy their examiners. These examinations point the way to the prescription of a definite standard of technical knowledge, the attainment of which must be to the ultimate advantage of the industry and of the Electricians themselves."

Some Practical Notes on D.C. and A.C. Windings.

This Paper, dealing with two distinct subjects, is presented with the object of furnishing repair men and practical electricians with some information as to the methods that are used in the winding or repairing of A.C. and D.C. machines. It is of necessity a purely practical and elementary study of the subject, principally intended to serve those whose duties are more closely concerned with the upkeep and repair of electrical plant in and around collieries.

Those to whom this Paper may appear somewhat too simple and commonplace will not complain because, after all, the main difference which exists between the technical individual and the practical repairman is that while the former must know *what* to do, the latter must know *how* to do it.

Electricians, when faced with the necessity of locating or repairing faults in A.C. or D.C. motors, and whose experience in this particular class of work has been somewhat limited, often find themselves wondering just what to do first. It is to assist those persons that this paper has been prepared.

The essential difference between a D.C. and A.C. Armature winding is that in D.C. the windings are placed on the rotating part of the machine while in A.C. they are placed on the stationary part; also, the direct-current winding requires a commutator to change the electro-motive-force produced in the armature conductors from an alternating to a continuous character, while in the alternating current winding no such rectifying of induced E.M.F. is called for and, therefore, instead of the coils or elements being connected to a commutator they can be connected directly together, with the resulting leads of the winding becoming the terminals of the machine.

The most common form of D.C. Armature winding is known as the two-layer drum type and is divided into two distinct types:—

1. Lap winding, which is a parallel or multiple circuit winding, and
2. Wave winding, a series or two circuit winding.

The distinguishing features of a lap winding are that the coil leads bend in towards the centre of the coil, the winding consists of as many circuits as there are field poles and there are also as many sets of brushes as poles. The coil leads in a lap winding are generally connected to adjacent commutator bars.

In the wave winding, however, the coil leads bend away from the centre of the coil; there are only two circuits, irrespective of the number of poles. It is known as a series or two-circuit winding owing to the fact that half of the conductors are connected in series and the two halves connected in parallel, thus giving only two current paths in parallel between brushes, no matter what the number of field poles may be. The wave winding is so called because of the zig-zag or wave path which the winding takes through the slots of the armature.

The distance between these paths in either lap or wave windings is known as the winding pitch or, core step, as it is sometimes called. This winding pitch represents the number of slots which lie between two similar points of two consecutive field poles. For example, if a 4-pole armature has 40 slots, the full winding pitch will be 40 divided by 4 = 10, and the coil will lie in slots 1 and 11.

Let us now consider an armature which is to be stripped and re-wound with a new set of coils. The process of stripping and re-winding may be outlined as follows:—

1. Stripping off old winding.
2. Cleaning slots and ends of core.
3. Overhauling and testing commutator.
4. Repairing commutator and fitting new commutator micas if necessary.
5. Making and taping new coils.
6. Insulating ends of core and cutting slot insulation.
7. Winding Armatures.
8. Testing out Winding.
9. Sweating Commutator.
10. Banding Armature.

Before stripping the armature it may save a good deal of time and trouble to mark the tooth on each side of the slot containing the top side of the coil with the letter T, denoting top; and the slot containing the bottom side of the coil with the letter B, denoting bottom. Trace out and mark the commutator bar or bars which received the lead or leads from the top portion of the coil marked T, and mark with one dot with a centre punch. Similarly mark the commutator bar or bars which receives the lead or leads from the bottom portion of the coil marked B, and mark with two dots.

Marking the core and commutator bars as suggested preserves the correct core and commutator pitches and saves much time when re-winding.

When stripping an armature the following particulars should be carefully noted:—

1. Number of Slots.
2. Number of Commutator Bars.
3. Number of Leads per Coil.
4. Number of Turns per Coil.
5. Size of Wire used and total Weight.
6. Core and Commutator Pitches.
7. Front and back Projections.

To remove the old windings from the core, lift up the top sides of coils equal to the core pitch, so that the bottom sides can be reached, and proceed to take out the coils one after the other.

One coil should be preserved in its original shape to use as a guide for winding new ones. There are several methods adopted in the making of armature coils but the shuttle method is, perhaps, the most simple. By this means the coil is wound with the required number of turns with both sides straight and is then pulled or spread to shape, either by hand or in a pulling machine. The coil should now be insulated and sleeving fitted over the leads, which should be cut to the approximate lengths, and the ends tinned.

The slot insulation should be cut so that it will extend about ½" past the end of the slots, and project about 1" above the slots. This forms a mechanical protection for the coils and serves as a guide through which the coils can be slid into place.

After the slots have been insulated, place one side of a coil in a slot and force it to the bottom with a hard wood drift or wedge a little narrower than the width of the slot. The other side of the coil (or top side) should be left out of the armature core for the present. Insert the bottom side of coil No. 2 in the next slot. Proceed in this manner until the top side of one coil is to be placed into the slot containing the bottom side of the first coil placed on the armature. This will be the first coil in which the top side can be placed in a slot over the bottom of coil No. 1.

When all the coils have been inserted, the top sides of the coils which were left out to allow the bottom sides to be fitted, can be placed in the slots. As the armature is being wound a good insulating strip should be placed in the slots between the top and bottom coils to insure that they are thoroughly insulated from each other.

To place the coil leads in the commutator, take the bottom leads of the coil lying in the slot marked B and place in the commutator bars marked with two dots. The remainder of the bottom leads can be connected in rotation. All the top leads should now be connected together with fuse wire, and with a test-lamp. A short circuit test should be taken; if found to be alright the leads should now be tested for rotation with the bottom leads, and the top leads of the coil lying in the slot marked T should be placed in the commutator bars marked with one dot. This done, all the remaining leads can now be fitted to the commutator bars.

The next operation is the soldering of the leads in the commutator. Great care should be taken that the solder does not fall or run down the back of the commutator to produce short circuits later on. To prevent damage to the conductors, acid fluxes should never at any time be used when soldering. A mixture of resin and methylated spirits is recommended instead.

If a drop of potential test between adjacent commutator bars and an insulation resistance test are satisfactory the armature can be rebanded and the windings stoved, to extract moisture, afterwards it should be dipped in good insulating varnish.

Some Common Troubles experienced in D.C. Windings.

A frequent source of armature winding trouble is short-circuits, either in or between coils. When an armature coil is wound with several turns of round wire it sometimes happens that one of the turns forming the coil becomes crossed over the other turns, perhaps when insulating the coil, or when fitting into the slot, and in order to force the winding down to an even depth, the turn of wire is pressed to such an extent that it cuts through the insulation of other turns and causes a short circuit between turns of the same coil. When this occurs, the resistance of the coil is reduced, more current is allowed to flow, which increases the temperature of the coil, and will eventually burn out the entire coil.

Another source of trouble is caused by short-circuits between coils which is often caused by oil soaking into the coils through leakage from the bearings, which together with the dust and other injurious deposits that in course of time work in between the windings, break down the insulation and cause an electrical leak between coils. Short-circuits also occur between top and bottom coil by reason of leads coming in contact with each other and are generally due to insufficient insulation having been inserted. Perhaps the most frequent cause of short-circuits in armature coils however, is faulty insulation between commutator segments.

The presence of short-circuits in an armature will generally be found by the abnormally heavy current required to start up the motor and after it is allowed to run for a very short time, the defective coil can usually be traced by the higher temperature which can be felt as compared with the others. The insulating compound on the coil may have softened or it may even have reached a temperature so high as to cause smoking.

If any doubt exists as to the exact location of the defective coil it can be readily found by submitting the armature to a drop of potential test. Another method of testing is with the aid of a small transformer or growler, using alternating current. By this means the windings are subjected to magnetic induction which induces an E.M.F. to flow through each individual coil in turn and will cause a current to flow in the coil which is short-circuited.

The principle of this method is that the magnetising or exciting coil on the growler acts as the primary winding of a transformer, while the armature coils coming under the influence of the magnetic field set up by the growler, act as the secondary. When a coil which is short-circuited passes through this magnetic field, a current will flow which magnetises the teeth on either side of the slot containing the defective coil and will therefore attract a small piece of sheet iron if held over the slot. The iron will also vibrate rapidly if held slightly away from the armature core.

If the armature is lap wound only one coil will generally be affected; but if wave wound with four poles, two coils will be affected; with six poles, three coils; with eight poles four coils; and so on.

An open circuit in an armature will cause severe sparking at the brushes when the motor is operating under load. If the machine is allowed to run for any length of time the commutator will be badly pitted between the segments to which the defective coil or coils are connected. For example, if a four pole armature has an open circuit the segments to which the leads are connected will pass a brush four times per revolution, each time it passes a vicious spark will take place. If the armature is revolving at 200 revs. per minute this spark will occur 200×4 or 800 times per minute. One can clearly understand, therefore, the reason why the commutator becomes so badly burnt.

Where the leads connect to the commutator is the most common and the most likely place to look for open circuits in an armature, as they are generally caused by poor soldiering. This condition serves to emphasise the fact that it is essential to see that all leads entering commutator segments be thoroughly cleaned and tinned.

The failure of the insulation in a D.C. winding to earth is another source of trouble. The weakest part in an armature winding, and where a number of breakdowns take place is at the corner of the slot, and is sometimes due to the straight sides of the coil that go into the slots not being long enough, resulting in the coils pressing too hard on the corners of the teeth.

The micanite vee rings often give trouble due to a deposit of carbonised dust being allowed to accumulate until it gradually causes a leakage to earth between the commutator and the shaft.

To locate an earthed coil in an armature, a test lamp should be used. The windings should be divided or broken up into sections, and each section tested. One end of the test leads should be placed on the armature shaft, after the winding has been opened at two points on opposite sides of the commutator. By applying the other end of the test lead to each of the sections in turn, one section will test clear. It is now known in which half of the winding the fault lies, and by the sibdividing of this half, and testing each time, the defective coil will be found.

Another method which can be used to locate an earthed coil is to short-circuit all the commutator bars by winding several turns of fuse wire around them. Next apply a source of direct current to the commutator and shaft. This completes a circuit from the commutator through the defective coil and out through the shaft, thus setting up a magnetic field around the conductors in this coil. By slowly moving a small piece of soft iron over the core the faulty coil can be located by means of its field attracting the iron.

When the leads of a coil are crossed and connected to the segments this will result in a reversed coil, and this is quickly found by noting the deflections on the milli-voltmeter when a current is passed through the windings. It can also be located by exploring with a compass needle from slot to slot which determines the direction of magnetism. When the needle is over the reversed coil, it will swing in an opposite direction, giving a very definite indication of the coil which is wrongly connected.

A.C. Windings.

The alternating current motor consists essentially of a stationary member called the "stator" and a rotating member called the "rotor." The rotor winding may be of the squirrel-cage type or of the wound-rotor type. The squirrel-cage type of rotor is mechanically simple, while being, perhaps, the most rugged and compact form of moving element to be found in any electric motor. Rectangular copper bars are usually fitted in the slots. End rings of either copper or brass are brased or welded to the bars, making a rotor cage, which is of one piece, without joints. The resistance of the rings, and consequently the characteristics of the motor depend upon both the width and thickness of the rings, and may be varied over a wide range by changing these dimensions.

Where it is necessary to start with small starting current a wound rotor is used; the ends of the windings being connected to slip rings. This makes it possible to connect an external resistance in series with the rotor winding when starting, after which the slip rings are usually short-circuited when the motor is running at maximum speed.

There are several methods adopted for winding the staror of an A.C. motor, but the usual method of connecting those windings are two, known either as a star or a delta connection. The star connection consists of the ends of the phases in a three phase winding being connected together, while the beginning of each phase forms the phase leads. In other words, A B and C which are the beginnig of each phase become phase leads, and A1 B1 and C1 connected together, are known as the star or neutral point.

In a delta connection the end of each phase is connected to the beginning of the next and the three phase leads are joined, one at each junction of the phases. In other words:—

A is connected to B1, B is connected to C1, and C is connected to A1.

In any three phase winding it is, therefore a simple matter to change from star to delta or *vice versa.*

There are several methods in use for the winding of A.C. motors, which are known as follows:—

1. Spiral or chain winding.
2. Bar or strap winding.
3. Basket or coil winding.
4. Former or diamond coil winding.

Each turn of wire in the first type of winding, the spiral winding is usually wound separately and by hand into a partially closed slot which has received the necessary slot insulation beforehand. Each turn or conductor is then formed to the required shape at each end of the stator core. The complete coil is wound in this manner. Each element in the complete coil should be thoroughly insulated with treated or empire and cotton tapes to ensure that there is no possibility of a short circuit taking place between the neighbouring elements. The bottom coil should also be thoroughly insulated from the top coils to prevent short circuits between phases.

In this type of winding a good deal of time is saved by winding each element or slot, with the full number of turns on a former, which is made to the correct size, and afterwards drop each wire or conductor into the slot separately one at a time. When placing the wire into the slot, care must be taken that each wire is lying parallel, without crossing, or some difficulty will be experienced in finding sufficient space in the slot to receive the total number of turns.

The needle winding is used where the slots are totally enclosed. It is generally adopted in stator windings where a somewhat heavy size of conductor is used. The slots in this case should each receive a suitable micanite or other insulating trough. The total number of turns per slot should be determined and a steel needle, equal in cross section to the overall size of the wire used, should be inserted in the trough, one needle for every turn of wire which the slot will receive. A suitable strip of insulating material, such as leatheroid, should be inserted between the adjacent layers of needles.

During the process of winding, a steel needle is pushed out as each turn is fed in, thus ensuring that each turn is lying neatly in the slot. When using a cotton-covered wire it is advisable to have it previously varnished with an electro-enamel varnish which prevents the cotton covering from fraying. As a further precaution the cotton covering should be well rubbed with paraffin wax.

Where floor space is limited, it is usual, after finding the total length of wire necessary to fill one slot completely, to roll one half of the wire into a coil. The other half is wound into the slots in a clockwise direction, while the half which was coiled is wound into the same slots in the opposite direction. This method is also suitable where there are two layers of turns per slot, the first half of the wire winds into the first layer of turns, while the second half winds the second layer. The starting and finishing ends are placed at the top of each slot on either side and are thus handily placed for making joints to adjacent slot windings.

When winding stators with the needle method, it will be found a great help to shape the turns, that is, to form the wire into the position it will occupy at the end of the core, before feeding it into the slot.

The stator for a large A.C. motor is usually wound with copper strap. The process of forming coils from this material is the same, whether each conductor consists of one bar or several bars, or straps in parallel. The copper strap is cut to the required length necessary to form a complete coil, and is bent at the middle around a pin thus forming a U shape with the sides slightly separated.

Where the strap is bent is known as the evolute of the coil. The U shaped strap should then be inserted into a former and held in position by a steel pin through the bend or evolute, while the sides are bent to conform to the shape of the former. The coil is now ready for insulating . Coils of several conductors can readily be made in the same manner by forming the individual conductors in a group, with a separator or distance piece equal to the thickness of the insulation, which will afterwards be wrapped on the bars, inserted between them. The group is shaped in exactly the same way, and each individual conductor insulated separately.

Bar windings having clips connecting top and bottom conductors at both sides of the stator are wound with two-piece coils which are formed from lengths of straight copper strap. The ends are shaped at a suitable angle to the straight or slot portion of the coil around two pins, spaced at a distance equal to a little more than the length of the stator core. After the coil is formed the ends are next bent into the required circular shape.

When the coil has been thoroughly insulated with treated tape or micanite, the next step is the actual winding of the stator. The straight part of the coil should be coated with a little paraffin wax and laid over the slot opening inside a leatheroid cell, with which the latter is lined. This cell should extend over the surface of the slot so that it may serve as a guide for the coil. A fibre or wooden drift should be used to drive the coil into the bottom of the slot.

The entire bottom coils should be inserted in this manner, followed by the top coils which are inserted later. After each slot is filled with a top and a bottom coil, the leatheroid cell may be folded over, and a retaining wedge, made from either hard wood or fibre is fitted over the full length of the slot. Care should be taken that a suitable insulating strip is always inserted between the top and bottom coils lying in the slot, and also the the end windings are thoroughly insulated between layers.

After all the coils have been placed in the core, their free ends should be connected together and an insusulation resistance test taken. A similar test should be taken between the different phases after the conductors have been connected into the proper phase groups.

The coils used for a basket coil type of winding are wound to a shape corresponding only approximately to their final shape. The essential feature when winding the coils is to be careful that they are correctly proportioned, so that no difficulty will be experienced when shaping, after placing in the stator slots, due to the coil being either too large or too small.

Basket coils are used with a one-coil per slot winding. This means that each side completely fills one slot, one end of the coil being shaped to drop below the bottom of the slot to allow the adjacent coil to pass over it, while the other side of the same coil remains on a level with or slightly below the surface of the core.

Suppose, for example, that a three-phase, four pole stator having 48 slots is to be wound, and that the core pitch is 1 in 12 (in slots). Mark two slots to serve as a guide in placing the coils with regard to their proper span or throw. Any slot may be taken as No. 1 and the other slot found by counting the throw in a clockwise direction.

In this case the bottom side of the coil is placed in slot No. 12. The slot is usually a partially closed one with only sufficient opening at the top to permit the wires or turns in the coil being threaded in one at a time. The slot insulation must now be cut and folded over while a retaining wedge is fitted over the slot. That part of the coil projecting beyond the slot should now be taped for about half its length on each side of the core, and afterwards shaped to drop below the bottom of the slot. The other side or top portion of the coil which goes into slot No. 1 remains out for the present.

In continuing the winding the top sides of slots Nos. 1, 3, 5, 7, and 9, should each remain out, since, in completing the winding, the bottom sides of other coils must be in place, with their ends shaped below the slots, before these portions can be inserted. When inserting the sixth coil into the stator core, it will be found that both sides of this coil can be threaded into their respective slots at the same time, while the ends can be both taped and shaped after the coil is inserted.

To give the winding a neat appearance it is particularly necessary that the tape should be applied as tightly as possible, otherwise the coil ends will have a tendency to become loose and baggy when the coil is shaped.

The process of dipping or shaping the bottom part of the coil below the bottom of the slot is also liable to pull the tape away from the laminations. With a little care this can be avoided.

The starting and finishing ends of each coil should be brought out in such a manner that the start of one coil faces the finish of the adjacent coil, thus making it convenient when connecting the windings. Each coil should be inserted in the same way as described, and the winding completed by placing each of the top parts of the coils which were left out, into their respective slots.

The former or diamond coil type of winding is suitable for either partially closed or open slots. The coil as the name implies is wound and shaped on a former, thus eliminating any further shaping after placing the coil in the stator slots as in the case of the basket winding. In this type of winding there is a bottom and a top side of different coils in every slot.

The main difference between the coils for a partially closed slot and an open slot winding is that the coils for the latter are wound, shaped, and insulated before being inserted into the slots, while the coils for the partially closed slot, although wound in much the same manner as the latter, must have each turn in the coil threaded separately into the opening at the top of the slot.

To explain this type of winding let us take for example a 72 slot, three-phase, four pole motor with a core pitch of 1.16; the winding will be divided into twelve groups of six coils, and as each adjacent six coils form different phases, the boundary coils, known sometimes as the phase coils must receive extra insulation at the ends, as these coils are subject to phase potential which is very much higher than the potential between any other adjacent coils.

In preparing to wind the stator, the slots forming the beginning of each group should be marked to indicate that they will receive the phase coils. The actual winding is started by placing the bottom side of the first coil in slot No. 16, the top side being left up or only placed temporarily in slot No. 1. The bottom sides of the next 14 coils should be inserted in rotation, thus making 15 coils lying as throw coils. The next coil should be placed in two slots, Nos. 16 and 31, and the other coils inserted in regular order, care being taken to see that the phase coils are inserted wherever indicated. To complete the winding the throw coils should be lifted, and after the bottom coils are in place, they should be re-inserted in the slots from which they were taken. The coils are usually held tightly in the slot by means of a retaining wedge fitted into grooves at the top of the slot.

When all the coils of the winding are in place, the next procedure is to connect them into groups; then, when the groups are connected into phases, the complete winding should be tested for break-down between phases, to earth, and for short-circuits between turns.

Perhaps at this point some brief general hints on connecting A.C. motors will be helpful. Using the same example, that is, a 72-coil, three-phase four pole winding, the first thing to do is to divide the number of coils by the number of groups. The number of groups is found by multiplying the number of phases by the number of poles. In this case the number of groups is 3×4 or 12 groups. Dividing 72 coils by 12 groups equals 6 coils, which means that the groups will all have 6 coils each.

In stators where a spiral or chain winding is used the different groups are readily distinguishable, but in the winding under discussion, the 6 coils per group should be counted off and connected in series. The groups per phase, however, may be connected in several ways; such as in parallel, in series, or in series-parallel, but the more common method, and also the least complicated, is the series connection.

For the purpose of making this clearly understood, imagine that each group is numbered 1 to 12. As each group will have a starting and finishing end, a beginning may be made in the connecting by making the starting end of group No. 1 a phase or line lead. The finishing end of this group should connect to the finishing end of group No. 4. The start of group 4 connects in turn to the start of group 7, while the finish of this group is connected to the finish of group 10. The other end or start of group 10 is known as the star or neutral lead of this particular phase.

Each of the groups of coils which have been connected in series belongs to the same phase, but are so connected as to be of opposite polarity. The two remaining phases are connected in a similar manner thus giving three-phase leads known as A, B, and C, and three star leads known as A1, B1, and C1. The latter may be connected together as the neutral point of the three-phase winding.

To check the connections, a piece of chalk may be used to mark the direction in which the current will flow through each phase. As a starting point, take any one of the phase leads, A, B, or C, and assume that the current is flowing in on this lead and check the direction through the whole phase, remembering that every fourth group should be passed through in an opposite direction. Check the other phases in the same manner, and if the chalked arrows, showing the direction of the current through the entire winding are facing in opposite directions between adjacent groups from a known starting point the connections may be considered correct.

For A.C. machines operating with high voltages it is usual to connect the winding in star because then the voltage from any one terminal to earth is less than the voltage between terminals, and is therefore less liable to breakdown to earth. Star and delta connected machines have advantages in special cases.

In the star winding the windings radiate from a common centre, but in a delta winding they are simply connected in series. In star connected machines the line voltage equals 1.73 times the phase voltage, whereas in delta connected machines the phase voltage equals the line voltage.

A fundamental consideration when checking the flow of current in a three-phase winding, is to imagine that when the current flows in the same direction in two of the phases, it flows in the opposite direction in the third phase.

Each of the three-phase leads should be taken from the winding at an electrical angle of 120 degs. apart. This is usually a separation of two poles.

The troubles occurring in an alternating current stator winding may be said to be in some respects, similar to those of a continuous current armature winding and most of the tests described for D.C. windings may be used in the testing of A.C. machines.

WESTERN SUB-BRANCH.

(Meeting held at the Royal Metal Exchange, Swansea, 12th October, 1929.)

Chairman's Address.

S. T. RICHARDS.

The usual subject for a Chairman's Address is one dealing with the trend of development of the particular industry, or phase of that industry, with which he is intimately connected. So much has been written and said concerning the trend of electrical development as applied to mining, that there is no need for me to add to it; it might not, perhaps, interest you to that extent, so to-night, I intend to deviate a little, and say a few words on how the Mining Electrical Engineer is keeping pace with progress in the use of electricity in and about the mines.

The other day I came across a leading article in one of the American engineering journals, and a paragraph therein attracted my particular attention. It was something to this effect "that there are probably few people who thoroughly realise the extent to which modern civilisation depends on Electricity—that servant of mankind who bids fair to become the "Deux ex Machina" for the whole world—and what the results would be if the sources of power were not as adequate, and as dependable, as they actually are."

In other words it is doubtful if there exists a true realisation of the burden of responsibility which rests upon the central electric station, or whether that understanding could be created without giving rise to the charge of sensationalism. Yet, among the peaceful arts, very little has been more sensational than the way in which those responsible for the generation and distribution of electric power, have met the demands made upon them by the increasing use of that power. I have no doubt, and I am sure you will all readily agree with me when I say that in no industry does the foregoing statement apply more forcibly than that of Coal Mining, and the personnel connected with the use of Electricity in Mines.

There is no need for me to introduce statistics, but the increase in the use of electricity in collieries is remarkable. The reports issued annually by the Mines Department, substantiate this. It is all the more remarkable in this industry, as the conditions met with are more severe and adverse to its use than in any other industry. One is amazed on looking back over the history of electricity in the coal mines, and how well the pace has been kept with the service requirements that have advanced with such leaps and bounds; by the installation of plant which very soon became obsolete, the substitution of more efficient plant, and the more economical methods of safe distribution. I use the word "safe" with a full realisation of its meaning, as the "safety phase" of the distribution and use of electricity underground is always the first consideration. I would draw your attention to the remarkable progress made in this direction. To attain the present state, considerable thought, research, designing, and of plain grinding hard work have been required. Discouragement, insecurity and uncertainty were always dogging the footsteps of the pioneers, and it is greatly to the credit of all concerned with the safe use of electricity in mines, that we are in the position we are to-day.

Accidents will happen with the best of people, either through misadventure or otherwise. Some are, perhaps, avoidable, and whilst they are to be deplored, yet I think, when compared with other industries using electricity, that the coal mines compare very favourably indeed. Still, our aim is towards the minimum "zero".

Once the use of electricity came to be fairly common in the mines, the period had arrived when it was thought, and no doubt it was found necessary, to introduce Rules and Regulations, and in 1902 a Departmental Committee was set up on behalf of the Home Office, to collect evidence and draw up a series of suggested rules. It has been my pleasure to read the minutes of this evidence, and I would commend its perusal to any member, and his time would be well spent.

The present Rules and Regulations you are all familiar with, or should be, and you have no doubt been responsible for the decrease in the number of electrical accidents; as well as for the zeal, care, and interest taken in the work by all concerned. The main trouble is not with the apparatus, but largely rests with the education of the man operating it. A great deal of investigation and research has taken place: The apparatus supplied is of an excellent standard: manufacturers have produced the goods: service requirements are admirably supplied and a co-operation exists amongst all concerned that has never existed before.

Again, as electricity became more and more established, the requirements, or the demands for the coal face became stiffer and stiffer. This meant that plants initially laid down were very soon unable to cope with the demand and quickly became hopelessly out of date. New conditions were being continually met with, some due to sheer necessity and others to that urge of finding what could be done to improve things. In the early days the object was principally to do the job. If there were inefficiencies, wasted hours of labour and waste products, they were not taken into any serious account. To-day, such slackness will not be tolerated.

The periods of depression in the coalfields have naturally made the coal industry a happy hunting ground for politicians and economists to practice their theories. One of their main planks has been and is "What can be done to lower the Cost of Production of the Article?" You are all fully conversant with the remedies proposed—re-organisation, nationalisation, and what not.

In all the series of investigations that have taken place, the question of Power Costs is an all important one whatever form it takes, whether in steam electricity, or compressed air and, as I stated in a previous paper before this Association, there are many collieries which are shut down and which, if cheap power had been available, would now be running profitably.

As it is my intention to give a Paper dealing with Power Costs later in the session, and therefore I will not enter into details this evening, but I do wish now to emphasise that the mining electrical engineer has contributed his share in the lowering of the cost of production to meet existing conditions. He has carried on with existing plant, maintained it, and at the same time had the utmost from it, having constantly in mind reliability, efficiency, and economy.

Collieries have often been accused (and not unjustly) of inefficiency and waste, but to-day the tendency is far otherwise. In collieries the plants are at a higher standard of efficiency than in many of the other industries, otherwise the collieries could never have survived. Considerable progress has been made in the conversion of coal into power, both from the point of view of improvement of the plant, and from its operation.

The Grouping of Collieries has taken place, which has lent itself admirably to the Centralisation of Power Supplies. Due advantage has been taken of this, reciprocity of supply with other industries and Power Companies has been brought about, with the result that power costs have decreased: and apart from that, the requirements of the industry have been met. All this progress has meant an exceedingly rapid change in practice and design in the generation of power, its control and distribution, so as to secure that essential continuity of service. Under the earlier systems this was taken care of only on the electrical side, but to-day precautions have to be taken, as one writer puts it "back to the coal pile". Allowances are also made to-day for future requirements: in other words, "very long views" have to be taken.

What has all this meant to the mining electrical engineer? It has demanded his constant vigilance and keen maintenance: he must be "adaptable", that is, he must meet all emergencies: he has to keep in touch with all up-to-date methods, and must be versed in the money side of his business, particularly the costs of the different spheres or matters under his control. Technicalities are on the increase, new problems and more advanced ones confront him, and with the growth in size of plant, practical considerations are much more complex: and, with it all, his responsibility for the safety of life and limb has increased.

The natural question to ask is what has this Association done, and what is it doing to assist the Mining Electrical Engineer in his work? Two of its main objects are:—

(1) The increasing of the Status of the Mining Electrical Engineer, and

(2) The advancement of Electrical Science as applied to Mining.

With reference to the former, this Association has been recognised by the Mining Association of Great Britain, Coalowners' Association, Coal-owners, Agents, and Managers, throughout the Coal-fields, Kindred Associations, and the Electrical Industry as a whole. It has proved of considerable value to manufacturers in the supply of suitable plant and material for use in and about the mines. The support given it by Members of H.M. Inspectorate is another instance.

The Association has now grown to be more than the "lusty infant" as my predecessor described it: and if the A.M.E.E. Certificate be recognised by the Home Office Authorities, then the status of the Mining Electrical Engineer will be further and greatly increased. Some might argue that the wages paid are far too low. As this Association is nothing in the nature of a Trade Union, that is beside the point, but the natural tendency is shown in the history of similar Associations, that matters in that direction ultimately adjust themselves.

With reference to the advancement of Electrical Science and the various meetings held during the Session, when papers containing valuable and useful material are given, it should be noted that the discussions are equally as important as the papers, if not more so. We all meet with our different problems, and therefore the subjects are viewed from many different angles. Take this Branch for example, in spite of many deletions, owing to members leaving the district and the failure to pay the annual subscriptions, the strength of membership of this Sub-Branch has been maintained, and now numbers 107. This proves that we are doing something.

The student is as welcome as the ordinary member: I would suggest that all colliery members endeavour to influence their juniors to join up. Last session very excellent papers were given by students, and they should be encouraged.

I wish to emphasise the value of the Journal of the Association, *The Mining Electrical Engineer*. It is worthy of a place of honour in any Engineer's Reference Library. The wealth of information to be obtained from this cannot be underestimated. It is compiled in such a manner that the men for whom it is intended, are able to understand it. It keeps one up-to-date with present day practice. As one writer in a Technical Journal stated the other day "*The Mining Electrical Engineer* is noted for its originality." This was in reply to a querist, and in referring the querist to the journal, he made the foregoing statement. I think, gentlemen, that the originality of the Papers before this Association, is the secret of the knowledge and the assistance obtained from it, in the solution of our practical difficulties.

Taking a survey of the papers to be read this session, each one of them is particularly interesting. There is the question of "Peak Loads and their Problems." This is undoubtedly a burning question, and a very troublesome one, and we are very fortunate indeed in having such an authority to give us his views on the matter.

Again, this year, we are to have somewhat of an innovation in a paper by a medical gentleman on First Aid, dealing with Accidents, etc., due to Electricity. This is a subject which your Committee thought would be of considerable assistance, and doubtless it will be, as the Author is a master-mind on his subject.

You will also have noted that we are to have a paper again from Mr. Horsley. I think we, as a Sub-Branch, have been very fortunate in securing Mr. Horsley's activity again, and it is to be hoped that the success of his last year's meeting will be eclipsed. His subject will, no doubt, be of very great interest to all concerned with the use of electricity in mines. The discussion on his 1928 Report will also be of very great interest and practical assistance.

There will also be, as stated earlier, an effort by myself on the Elucidation of Power Costs, which I trust, will be found useful: my experience is that it is not only the listener who benefits but more so the writer himself.

Our programme is altogether an attractive one and with your co-operation there is no reason why this session should not be successful and greatly to the benefit of all concerned.

I feel too that is desirable to draw your attention to the Certificates issued by our Association. Their unique value is beyond question, and it is to be regretted that there are not more candidates sitting for these examinations. Sooner or later the Certification of the Mining Electrical Engineer will be decided upon and the Certificate of this Association will stand in good stead. As a member of the Sub-Committee appointed for this Area, I can say that considerable progress is being made in this direction. The Certificates awarded by our Association to successful examination candidates are recognised as an important asset and recommendation.

The Examination Papers for 1929 are in the September number of *The Mining Electrical Engineer*. A prominent Examiner told me that he considered the questions set for these certificates to be of an exceptionally high standard, and the tests were well worthy of a place amongst the Technical Examinations of the country. It must be borne in mind that industry to-day puts considerable value on the technical man.

In conclusion, may I trust that these brief remarks have helped to prove that this Association has done, and is doing, something to be of assistance to the Mining Electrical Engineer. What the Association requires in return is your whole-hearted interest and co-operation. It is intended for you, the individual member, associate and student. It wants to help you technically and practically, and is at your service. All this can only be done by your faithful attendance, frank discussion and loyal support, then it can be truly said that the Mining Electrical Engineer, together with the Association of Mining Electrical Engineers has kept, and is keeping, fully in step with the progress of electricity, and the demands made upon it, as applied to the coal mining industry.

COUNCIL MEETING.

A meeting of the Council was held on Saturday, October 19th, 1929, in Preston. An Abstract of the Proceedings is as follows.

There were present: Capt. S. Walton-Brown, President, in the Chair; Mr. R. Holiday, Past President, Treasurer; Mr. A. B. Muirhead, Past President, Advisory Committee; Mr. D. Martin, Past President, Advisory Committee; Mr. T. Stretton, Past President, Advisory Committee; Mr. W. T. Anderson, Past President, Certification Committee; Mr. G. M. Harvey, Past President, Examinations Committee; Mr. F. Anslow, Past President, Publications Committee; Mr. J. W. Gibson, Vice-President, Examinations Committee; Mr. R. Wilson, Certification Committee; Mr. F. Beckett, Finance Committee; Mr. S. A. Simon, Papers Committee; Mr. G. Henderson, Papers Committee; Mr. J. R. Cowie, Prizes Committee; Mr. R. Ainsworth, Publications Committee; Mr. S. H. Morris, Publications Committee; Mr. J. Perritt, Lothians; Mr. J. Walker, Lothians; Mr. J. A. Brown, West of Scotland; Mr. G. N. Holmes, West of Scotland; Mr. R. Rogerson, West of Scotland; Mr. E. E. Shatford, North of England; Mr. G. Ward, North of England; Mr. I. Mackintosh, North Western; Mr. A. V. Heyes, North Western; Mr. F. H. Williamson, North Western; Mr. W. W. Hannah, South Wales; Mr. H. J. Norton, South Wales; Mr. E. D. C. Owens, South Wales; Mr. C. St. C. Saunders, Secretary.

Letters of apology for absence were received from Messrs. C. Augustus Carlow, Past President; G. Raw, Past President and Certification Committee; A. W. Williams, Advisory and Publications Committee; W. T. Mittell, Lothians; A. R. Hill, Cumberland Sub-Branch; F. Mawson, Yorkshire; T. H. Williams, Yorkshire; W. Bolton Shaw, North Western; A. Hulme, Warwickshire; W. G. Thompson, Warwickshire; A. C. MacWhirter, South Wales; Dawson Thomas, South Wales; and J. W. Robinson, London.

The Minutes of the Council Meeting held on July 5th, 1929, having been distributed, were confirmed and signed by the Chairman.

Finance.

Reports were submitted with regard to the Membership of the Association at June 30th, 1929, resignations, deletions, and transfers, the Bank Balances of the General and Publication Accounts, the Receipts and Disbursements, and Branch Balances.

Branches.

Mr. Gibson and Mr. Cowie, of the London Branch, reported the preliminary formation of a Sub-Branch at Dover, conditional upon permission being obtained from the General Council. Resolved that permission be given to form a Sub-Branch in the Dover district.

The Quarterly Reports of the Branches regarding Membership, Finance, and District Meetings, were communicated to the Meeting.

"The Mining Electrical Engineer."

Mr. Ainsworth reported upon the present position, which it was stated was quite satisfactory.

Examinations.

Mr. Harvey reported that the Examinations Committee had been re-drafting the Regulations with regard to the Candidates for Examinations. In regard to the Syllabus for the Examinations it was resolved that the Examinations Committee should further consider this matter, and submit proposals to the next Council Meeting, and that a draft of such proposals should be sent to the Branches for consideration. It was further resolved that the standard for next Year's Examinations should not be altered.

Qualifications of Colliery Officials. Departmental Committee.

Mr. Harvey reported upon his evidence given before the above-mentioned Committee, and a vote of thanks was unanimously passed to Mr. Harvey, Mr. Muirhead and Mr. Anslow for their services in this matter.

Next Annual Meeting.

Mr. Gibson conveyed an invitation from the London Branch that the next Annual Meeting should be held in London. It was resolved that the Annual Meeting in 1930 be held in London, and that the thanks of the Association be accorded to the London Branch for their kind invitation.

Educational Facilities.

Mr. Muirhead spoke upon the qualifications of Mining Electrical Engineers, and the probability of the Colliery Electricians having increased responsibilities placed upon them in future. The necessity for more comprehensive training both technical and practical is thus apparent, and by this means the status of the Electricians will probably be elevated.

Next Meeting of the Council.

Resolved that the next Meeting of the Council be held on February 22nd, 1930 at 9-30 a.m. at the Park Hotel, Preston.

MIDLAND BRANCH.

Smoking Concert.

The Winter Session of the Midland Branch was opened by a Smoking Concert at the Albert Hotel, Nottingham, on Saturday evening, November 2nd. Mr. R. Wilson (Branch President) was in the Chair, and was supported by Captain S. Walton-Brown, B.Sc., J.P. (President of the Association), Messrs. A. W. Williams, H. Cotton, O.B.E., and E. R. Hudson (Hon. Sec.).

Mr. R. WILSON, in opening the proceedings, extended a very hearty welcome to all present, and said he hoped that their attendance there that evening was a sign of their interest in the Association and the Midland Branch. They had commenced their session now for several years with a meeting of this description, and were again fortunate in having with them the President of the Association. He had had the pleasure of meeting Captain Walton-Brown this last summer at the annual conference, and had an opportunity of inspecting the all-electric Seghill Colliery with which that gentleman was connected. There were no boilers at Seghill, and they had adopted electricity throughout. He had come to the conclusion that the destinies of the Association were this year in very capable hands, and had great pleasure in calling upon Captain Walton-Brown to favour them with an address.

Captain S. WALTON-BROWN (President of the Association) said that one of the pleasantest features he had found hitherto in his work for the Association was that he had been able to make a large number of new friends amongst the members of the Council, and he now hoped that, as the result of his visits to the Branches, he would be able to make a friend of every member. All technical men lived on and learnt from technical friendships. There were many people working at neighbouring collieries and existing as though a high wall divided them. The Association broke down such walls and gave them a common meeting ground, and an opportunity to appreciate each other's good qualities. The Midland Branch was the first he was visiting during his presidency, and from the stories he had been told about Nottingham men he was really anxious to see what they were like.

He had received numerous letters from members in different branches setting out amongst other things their aspirations and hopes. He had formed the opinion that there were two main groups in the Association. The first included the keen fellows anxious to qualify themselves fully and to climb right up the ladder of life but, in cases, somewhat disappointed because they were not progressing as speedily as they desired. He assured the latter that there were times in the lives of all successful men when they were similarly placed and counselled them to exercise patience and further improve their knowledge until the right niche offers itself.

The second group, equally valuable in their own way, but not so ambitious were more desirous of better general conditions in their present status. To both he would say that on a silver article we usually look for the Hall-mark and we could not complain if employers ask that we in our turn should produce the Hall-mark of our Association—that is its Certificate. The mining industry keeps calling for good men and, although at times it may be difficult to link up the best men with the best jobs, the existence of our Certificate should render it simpler for employers to discharge this duty equitably.

Mr. WILSON then called on the President to present Association certificates to the following:—Mr. Ernest Hawksley, first class; Mr. Harold W. Randall, second class. Two others had passed in the second class, but as they had already secured second class certificates further certificates were not issued.

Mr. H. COTTON, in proposing the toast of "The President", said it gave him great pleasure in undertaking this duty. It was a privilege for them to have Captain Walton-Brown with them, and from what little he personally knew of the Council they were very careful in selecting capable men for the position of President. Captain Walton-Brown had had a very extensive experience of colliery work, and was connected with Seghill Colliery, an old colliery which had been rejuvenated and turned into an all-electric colliery; for that reason, if for no other, he would be able to lead the Association in the way it should go.

Mr. Cotton said that what appealed to him personally even more than the President's experience was the fact that he looked upon his fellow-men as human beings, who needed sympathy, and took a great interest in welfare work. So many men in his position were apt to treat their employees as machines. Personally, since he had become a member of this Association, he had found it the means of meeting many men interested in the application of electricity to mining, and believed that he had benefitted considerably by mixing with them and exchanging views. He would like to bring to Captain Walton-Brown's notice one point, which was the question of Electrical Examinations. There had been recently several editorials in The Mining Electrical Engineer on this subject, commenting on the few young men coming forward to sit for the examinations, and he would like the President to bring before the Committee the desirability of doing everything possible to popularise these examinations.

He, Mr. Cotton, had a visit recently from a Government Inspector, who said that people up and down the country were apt to grumble at the lack of facilities of education for diplomas and degrees they wanted to obtain. If anyone wanted to go to educational institutions and be prepared for some particular examination there must be a fairly large demand for such preparation, and they would then be provided. They had various courses at the University for the various electrical examinations and these covered fairly widely the requirements, but he felt that if more candidates would come forward and ask for special courses these could be provided.

The question of studying for examinations could be looked at in two ways, the gaining of certificates and diplomas in themselves a worthy object, but there was a much larger matter, and that was that the preparation for an examination was in itself worth while; a man has to study, and for that reason is so much the better man. We believe that in the future these certificates will be much more valuable, and from that it follows that candidates will have to work for them.

Captain WALTON-BROWN, in replying to the toast, expressed his gratitude for the manner in which they had received Mr. Cotton's proposition. They could rest assured that he had taken careful note of Mr. Cotton's remarks regarding examinations and would see they were advanced in the proper quarters. He had always been in favour of examinations because, after all, life in many respects is a continuous series of such tests. Every new problem in our daily work was an examination of a kind and the man who consistently produced the right answers and, as a consequence, results which benefitted his employers, generally also collected such prizes as were available.

Mr. R. WILSON said he wished to speak for a few moments on a matter which was seriously concerning the Branch Council, namely, the slight decrease in membership. From enquiries he had made, he had come to the conclusion that there were two chief reasons for this; first the economic condition of the mining industry, and secondly, it was suggested that the Association was not improving the status of its members as much as ought to be done. Dealing with the first reason, he quite agreed that the economic condition of many of those who have been, or ought to be, active members of the Association, was deplorable, but he ventured to suggest that these men should very seriously consider whether they could afford to be disconnected from it. Surely if there was a time when it was necessary as it were, to take stock of one's economic value, it was when times were bad, because it was obvious that only those who are the best equipped could hope to "carry on" or "win through" and he claimed that one of the best methods of increasing one's own economic value, of obtaining the best equipment, was by taking the fullest opportunity of the advantages that this Association had to offer. After all, the weekly cost was little more than the price of a packet of cheap cigarettes.

The second cause indicated was rather involved, because it came, not only from those who are or who have been members of this Association, but from those not directly connected with it. The amount of benefit to be derived, the amount of work that can be done, by either this or any other Association, is proportionate to the number of live and active members possessed by that Association, and if this statement be true, then the obvious action of those who are not satisfied with the progress made, is to join and help on with the work, and not take up the selfish attitude of waiting until the spadework is done before coming in. Many of them were aware that the Government has set up a Departmental Committee to investigate the whole question of the qualifications of colliery officials, and the Association has submitted a statement to that Committee, and representatives have given oral evidence. Of course one cannot state what the findings of that Committee will be, but speaking as an interested party without any claims to inside knowledge, he believed that some improvement was bound to result. In conclusion, he would like to quote a paragraph from an address given by the first President of the Association, Mr. Maurice, just twenty years ago—"remember that the Association cannot do other than reflect the collective character and ability of its members. If they are careless or apathetic so will the work of the Association be carelessly or half-heartedly done." That is as true to-day as it was twenty years ago.

Mr. L. G. F. ROUTLEDGE proposed "The Visitors," to which Mr. Hopley and Mr. Farmer responded. An excellent musical programme was provided by Messrs. Percival and Syms.

NEW CATALOGUES.

TURNER BROS. ASBESTOS Co., Ltd., Rochdale.—A series of well illustrated pamphlets give valuable information concerning "Sindanyo" insulating boards, etc.

GENERAL ELECTRIC Co., Ltd., Magnet House, Kingsway, London, W.C. 2.—Revised edition of the X and Y section of the G.E.C. main catalogue gives up-to-date particulars of ironclad switchgear, fuses, distribution boards, etc. It is fitted with the usual metallic clip for fixing into the bound volume of catalogues.

Installation leaflet, Miscellaneous, No. 7, is a comprehensive illustrated description of the electrical equipment of the Shropshire Beet Sugar Factory. This installation is of exceptional interest, the whole process from the raw beet to the sugar output being electrically operated. In all there are some 150 "Witton" electric motors in use.

Various leaflets indicate that the new electric light fittings introduced by the G.E.C. show remarkable improvement over older patterns.

RECORD ELECTRICAL Co., Ltd., Broadheath, Manchester.—Two interesting folders direct attention respectively to the Company's "Cirscale" measuring instruments and also portable electrical measuring instruments.

MIDLAND ELECTRIC MANUFACTURING Co., Ltd., Barford Street, Birmingham.—The latest illustrated list of switch and fuse gear issued by the M.E.M. Co., is exceptionally complete and contains also much useful technical information concerning lighting and power circuits.

ROYAL INSURANCE Co., Ltd., 1 North John Street, Liverpool.—Motorists will be pleased to know that, on application, this Company will send them a wall card giving valuable hints for the protection of motor cars, etc., during the frosty weather.

THE CLARMAC ENGINEERING Co., Ltd., 48 Payne Street, Port Dundas, Glasgow.—A colour printed booklet shows several lines of industrial switchboards, including mining boards, made by this Company.

DORMAN & SMITH Ltd., Manchester.—A folder containing an interesting series of leaflets dealing with this Company's switchgear, fittings, and electrical indicating devices.

Manufacturers' Specialities.

Underground Circuit Breaker and Cable Coupling.

The two photographs reproduced here show respectively a flameproof air-break circuit breaker and an armoured cable coupling. They were taken in a Midland Colliery to show these appliances in actual service. The circuit breaker and the cable coupling were of standard types made by George Ellison Ltd., whose photographer succeeded in getting the pictures, with the help of the colliery engineer who went to some trouble in rigging up a temporary lighting circuit to illuminate the breaker and grouped several miners' lamps around the cable coupling. Two of the miners' lamps appear in the second picture and it is interesting from a photographer's point of view that the halation which might have resulted from these lamps being in front of the camera, was overcome because the exposure of the negative was necessarily a long one.

The circuit breaker is the standard Ellison magnetic blow-out air-break type enclosed in a welded steel flameproof box on skids for use at the colliery gate end, where a trailing cable connection is required for operating coal cutters, conveyors and loaders.

The supply cable to the circuit breaker is fitted with a detachable sealed end which is bolted to an adaptor on the breaker and connected to its terminals by means of removable links. When the mine working necessitates a move forward, the cable is detached and the breaker dragged to the new position. The sealed end of the cable then forms half a coupling and a new length of cable with its ends similarly prepared is laid in place with one end attached to the breaker and the other end bolted up and linked to the cable which was laid up to the old position.

The two cable ends thus form a workmanlike joint when the cover, which is provided, is bolted over the links and the two halves of the coupling are bonded to secure the electrical continuity of the cable armouring. This cable end coupling is an Ellison patent and is already used in many mines where it is appreciated that the device saves time and labour and does not require the use of a blow lamp or liquid bitumen to make and seal the joint.

Peebles-Brown Boveri Mercury-Arc Rectifiers.

Messrs. Bruce Peebles & Co., Ltd., Edinburgh, have been granted by Messrs. Brown Boveri & Co., Ltd., Baden, Switzerland, the sole licence for the manufacture and sale in Great Britain of the well-known Mercury-Arc Rectifiers, with which the name of the latter firm is so intimately associated.

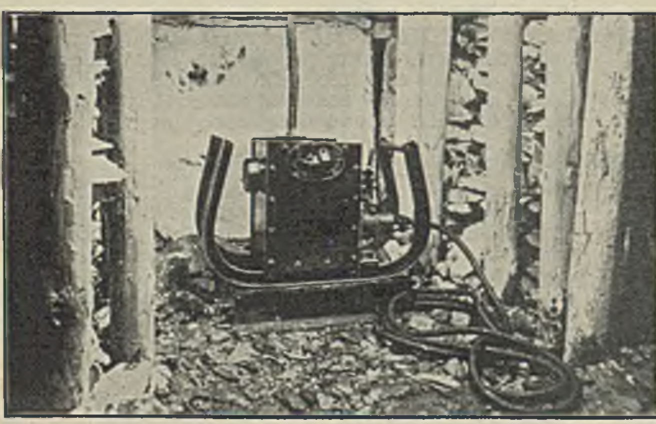
The Acme of Efficiency.

With a fuel consumption of 1.33 lbs. of coal per unit generated, and a thermal efficiency of 21.35 per cent., the Padiham Power Station of the Lancashire Electric Power Company takes premier place in the Electricity Commissioners' Report for the year ending 31st March, 1929. This achievement is the more remarkable as Padiham comes in the "50-100 million units generated" group of power stations, there being two groups with higher outputs, namely "100-200 million" and "over 200 million" units. Thus, Padiham ranks as the most efficient power station in Great Britain, irrespective of size and output.

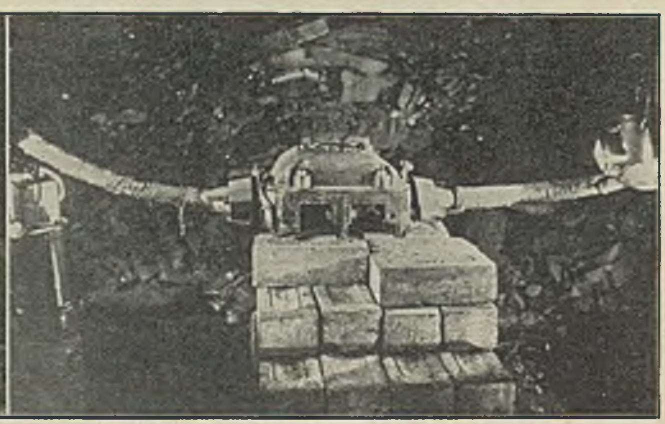
The actual figures of this plant for the Commissioners' year, ending 31st March, 1929, are:—

Total number of units generated 67,043,877; Units generated by latest B.T.H. 15,625 k.w. C.M.R. turbo-alternator 59,925,000 (practically 90 per cent. of the total output of the station); Number of running hours during the year 6057; Average load on the machine 9893 k.w.

It is early to predict the results which will be obtained at the L.E.P. Company's new super station at Kearsley, the load on the first B.T.H. 32,000 k.w. C.M.R. turbo-alternator having hitherto not exceeded 20,000 k.w., but the figures given here are such as to justify expectations of still better results. The whole of the electrical equipment at both Padiham and Kearsley power stations was supplied by the British Thomson-Houston Co., Ltd.



Circuit Breaker.



Cable Coupling.