The Mining Electrical Engineer.

OFFICIAL JOURNAL OF THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS.
EDITED BY E. DINSDALE PHILLIPS.

Vol. X. FEBRUARY, 1930. No. 113.

Impressions of "The Fair."

Our interests are centred in the Birmingham section—the heavy section—of the British Industries Fair. This is the eleventh of the series and it is the largest ever, with its area of 450,000 square feet under one roof and its four miles of exhibit display. Vast must be the selling power of this triumph of organisation and one cannot be too lavish in praising those progressive men who are responsible for bringing a great national ideal to this full fruition.

At the same time and, we hasten to say, without feeling the least shade of dissatisfaction with work so obviously and thoroughly well done, the mining electrical man passing through the fair must feel some degree of disappointment. The heavy sections of electrical and of mining machinery are not exhibited; here and there a few examples can be sifted out by a discriminating eye, but there is not the forceful display of an "exhibition" of that particular class of goods. Perhaps this scarcity may be because the makers of large units of modern power plant consider that their wares could not be shown excepting at such a heavy cost and inconvenience as would outweigh any possible gain in return. We can hardly accept that view as a sufficient excuse for them not taking a prominent part, nor do we believe that the makers of such plant are in any way less progressive or more slow to seize any and every trade bringing opportunity which may offer. There are effective ways and means of "exhibiting" even the heaviest engineering works without transporting complete plants. Those ways are well known and often used. Yet, there must be some reason or other why they have not as yet been freely used at these Fairs. It may be that in the course of perusing these impressions possible causes of these defections will occur to the reader.

The minds of those whose first interests are bound up in the coal industry are led into serious vein by the numerous examples of plant and appliances telling of the advance of oil at the expense of coal. The market demand for oil engines has apparently driven all our old established builders of steam engines to concentrate on the construction of oil engines. Here are oil engine exhibits bearing the names of practically every famous builder of high speed steam sets. There are oil and petrol driven excavators, electric generators, pumps, locomotives, ships' plants, etc. Machines and machinery for the getting, handling, preparation, grading and refining of coal are conspicuous, to the mining man, by their absence. Even mining electrical gear is subsidiary in the few cases where it is included in a variety of industrial electrical equipments.

It is with mixed feelings that the mining electrical man views the extensive "gas section" which occupies 37,500 square feet. A gas boom augurs well for the coal mining part of his interests, but he is concerned also with the threat to the electrical side. He, however, may take some consolation from the fact that the "electrical section" covers 55,000 square feet and is thus larger in area than the gas section.

There are in all one thousand exhibitors and they include 300 classified under "hardware, ironmongery and brassfoundry." The great predominance of Birmingham wares prompts one to consider whether this "British" Industries Fair is quite correctly named—so long as it is permanently stationed in Birmingham. True, this is professedly a branch of the Fair, the only other branch being in London, but to all intents and purposes it is Birmingham's own show. Nor would we have ourselves misunderstood as guilty of complaining that the great city of the Midlands has taken to itself a national asset. On the contrary, every credit is due to her for making the most of an excellent institution available at hand. The great Continental Fairs after which this Fair is modelled, or which at any rate largely inspired its creation, are expressly intended for the development of the industries of particular cities and their localities. It was inevitable that the institution of the Birmingham Fair would be overwhelmingly to the advantage of the neighbourhood, and the great and successful labours of the Birmingham Chamber of Commerce have automatically resulted in immense benefits for their city. So, when mentally viewing this aspect of the Fair, arises the question whether it would be practicable for our other great industrial centres, guided by their respective Chambers of Commerce, to organise branches of the National Fair; or whether the Provincial Section should change its location each succeeding year and thus in turn occupy three or four suitable centres in regular sequence. Against any suggestion of this kind we know that usually the first objection to be advanced is always that there are no suitable buildings available: but it must be noted that there are many great shows organised for but a few days' run in canvas housings—and wonderfully successful they are.

Perhaps after all it would be best to concentrate every effort upon extending the scope of the Birmingham Fair. In the Fair held in 1926 there were 400 exhibitors in a building of 185,000 square feet; to-day, as said, there are 1000 firms in 450,000 square feet, and in all there are 45 acres of land available for expansion. Forceful and persistent publicity throughout the world, again aided this year by a Government Grant of £25,000, has established the Birmingham Fair as an annual rendezvous for buyers from all countries. It is sincerely to be hoped, therefore, that this well-founded permanent market place of British Industry will be much more greatly used by manufacturers and producers throughout the home country. In heavy engineering; in power and transport; in mining; in shipbuilding, in iron, steel and metallurgical works this country still retains the premier position for all that is best in regard to quality of output and modern in process and practice. When the great firms in those staple industries neglect this Fair, which is designed to represent British Industry, and which the world at large is encouraged to accept as such, they not only miss the opportunity of big business but their absence year after year must inevitably tend to dull the brilliance of the reputation they have for so long enjoyed in overseas lands.

Aeroplanes and Mining.

Since aeroplanes were first used in the Rouyn mining boom in Canada some six years ago, for regular passenger and freight service, they have come to be recognised as a necessity in certain mining areas. Interesting particulars of some of these developments were given by Mr. F. E. Conway Lupton in a recent issue of *The Empire Mail*. It was in the midsummer of 1927 that Western Canada Airways inaugurated a regular air mail in the Central Manitoba mining area; by October, 1927, they had six 'planes, and by June, 1928, 31 'planes were in operation. In 1928, Mr. John Hammell extended the idea and formed the Northern Aerial Minerals Exploration, Ltd., which company uses the aeroplane for mineral exploration purposes. There are five main bases, and numerous supply depots and caches of petrol and stores along the flying routes, which cover the best part of Northern Canada.

At present, prospecting work is carried on mainly in the summer. In the winter, all necessary overhauling work is done on the 'planes. Moreover, the machines are kept busy, carrying supplies to claims found during the season before, establishing caches for the following summer's work and making reconnaissance flights. The value of aerial transportation of supplies, etc., is particularly apparent during the annual freeze-up. During this period, which usually begins about the first of November, the floats on the 'planes are removed and replaced by runners for landing on snow and ice.

According to recent information from Canada, aircraft of 1000 h.p. to act as "mother-'planes" for the smaller machines are a posibility, either next season or during the following year. The principal utility of these 1000 h.p. "mother-'planes is in the establishment of petrol caches and in the transportation of instruments and supplies, and occasionally large bodies of prospectors, leaving the smaller six-men machines free for scouting and cruising and for depositing prospectors in favourable localities.

In 1928, prospecting was organised in single 'plane expeditions; last year machines were sent out in pairs except on short flights, and later in the autumn three-'plane expeditions were planned. The maximum cruising range is believed to be 600 miles in one "hop," but more progress can be made by increasing the number of petrol caches, some of which are from 400 to 600 miles apart. Intervals of 100 miles are the ideal now aimed at, and more wireless stations are required in the north country, at a distance say, of from 300 to 400 miles apart.

The prospecting organisations have been greatly impressed with the value of aerial photography. Already it is being employed extensively by the builders of railways and power transmission lines. In one recent case, in connection with the building of a power transmission line, a survey was made at a cost of $2,000 by air photography which would have cost $100,000 by the older methods.

Every time a 'plane goes out on an exploratory expedition aerial photographs are taken and these are then sent to headquarters, where they are fitted together and used in conjunction with the prospector's reports, to make up large geological maps of the various mineralised areas.

In South Africa, a scheme is under consideration for policing Namaqualand, the largest diamond field, from the air. Aeroplanes are used to convey diamonds from the Namaqualand district to Capetown, and are also being considered for the transport of platinum, as this industry becomes established on a larger production basis.

Speaking at a general meeting, the chairman of the Crown Mines, Ltd., said that he estimated that a saving of £100,000 would have been effected by the gold mining companies on the Rand if the export of gold overseas had been by air instead of surface transport.

In Mexico, aeroplanes are used to take the bullion from the gold mines at Guadalajara to Mexico City and to bring back cash for the pay roll.

A Fairchild machine has recently been purchased to connect the Treadwell-Yukon Mine in the Yukon Territory with the coast.

In Europe to-day almost all the gold is transported by air in preference to railways and steamers. It is simpler, quicker, cheaper and less risky. The insurance rate is much lower when gold is transported by air, as there is less risk of theft.

The aerial transport of uncut diamonds between London and Amsterdam has been the practice for many years.

The Principles of D.C. Motors.

F. MAWSON.

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

SO far as the electrical features of the direct current motor are concerned, they are almost identical with those of the direct current generator. Such differences as occur are chiefly mechanical. The force exerted between the magnetic field and the armature conductors of a motor is in the same direction as the motion of the armature: in a generator the force acts just in the opposite direction. In a generator, mechanical force is applied to the armature and the armature conductors are forced to cut across the magnetic field. The e.m.f. generated causes current to flow through the armature conductors and this current reacts on the field in such a way as to oppose the motion of the armature. The more current the generator is called upon to supply, the greater is the drag between the armature and the field, and consequently the more work the driving engine or mechanism has to do. In the case of a motor, the greater the load applied to the shaft, the greater must be the reaction of the armature and the greater must be the amount of current drawn from the supply main.

Counter or Back E.M.F.

Owing to the fact that the motor e.m.f. is exerted to oppose the current in the armature conductors, it is commonly spoken of as the "Counter" or "Back" e.m.f. of the motor. The existence of the back e.m.f. is not a drawback to the operation of the motor merely because it tends to prevent current flowing in the armature, the creation of the back e.m.f. is essential to the operation of the motor. In the case of the generator a reaction against the driving force exists, which the engine has to overcome; in the motor the turning effect exerted on the armature conductors by the magnetic field produces and assists the motion, and the reaction which exists is known as the back e.m.f. which is opposed to the potential difference of the supply circuit. If the motor be prevented from turning, there will then be no back e.m.f. because the armature conductors do not cut across the field, and the current which would flow through the armature windings would only be limited by Ohm's Law and would therefore be equal to the applied e.m.f. divided by the resistance of the armature. Since the resistance of the armature is usually very low, the current with a stationary armature would be so large as to heat the armature conductors and perhaps burn them out. In addition, the motor would be doing no useful work because the armature is fixed, and therefore all the energy supplied would be expended idly in heating the armature. If the armature were to be released, it would at once run up to speed and the current would decrease to a much smaller value owing to the opposing or back e.m.f. created. A steady speed would be attained when the back e.m.f. of the motor becomes nearly equal to the potential difference at the motor terminals, and the current flowing would be just sufficient to furnish the force required to maintain the speed.

Effect of Load.

If the rotation of the motor be checked by some form of load, the first effect would be to lower the speed of rotation of the motor, with the result that the back e.m.f. would be decreased. The terminal voltage remaining constant, the effective back voltage in the armature windings being decreased, a greater current would flow in the armature, with a corresponding increase in speed until a balance for that particular load is obtained.

Let e = back e.m.f.
,, V = line voltage.
,, I = current in armature.

$$\text{Then } I = \frac{V - e}{R}$$

From the above it follows that the current flowing into the armature will increase with additional load which causes a decrease in speed and back e.m.f. of the motor. The safe limit of load which can be put on a motor is determined by the temperature rise, caused by the heating effect of the current and the sparking of the commutator.

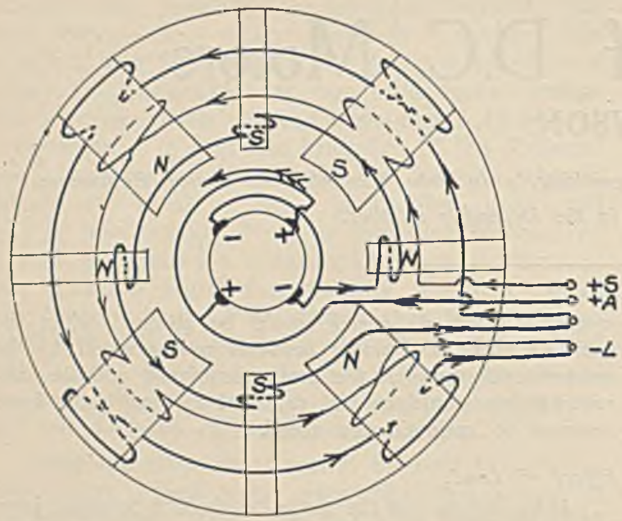
Shunt Wound Motors.

A direct current motor with a shunt field is identical, from an electrical point of view, with a shunt wound dynamo, when supplied with current at constant voltage it will run at nearly constant speed whatever the load put on it, up to full load. At this point the full current allowed for in the design of the machine is being taken with the maximum allowable temperature rise.

A shunt wound motor will give a fairly good starting effort if the field be fully excited before the current is switched on to the armature, though it should not be used to start up suddenly on full load.

Series Wound Motors.

The series wound motor is used almost exclusively for traction and for crane driving purposes. It gives a very strong starting torque and is thus useful for rapid starting against full load. If the load becomes light, the speed increases to a higher value; the speed drops as the load increases, and this machine is therefore a variable speed motor. Since the field coils are in series with the armature the strength of



the field excitation depends on the current flowing through the motor. The torque exerted by the motor is proportional both to the strength of the armature current and the strength of the magnetic field. If there be a large load on the motor shaft and current is allowed to flow into the series-coupled armature and field at starting, both effects combine to make the starting effort of the machine especially strong. On the other hand, with no load on the motor shaft a weak current flowing into the armature and field will cause the machine to race: with no load the machine will, if not checked, race up to a sufficiently high speed to damage the machine. The machine should therefore, be always under hand control, with a variable controlling series resistance in the circuit.

Compound Wound Motors.

These are electrically equivalent to the compound wound dynamo, with or without interpoles. The compound motor combines to a certain extent the advantages of both series and shunt wound motors. It may possess almost as constant a speed under varying loads as the latter, and has to some extent the powerful torque of the series wound motor. If the magnetising force of the series coils adds itself to that of the shunt coils, the motor gives a better starting torque than the plain shunt wound motor. Such a motor is called an accumulative compound wound machine, and that is the usual method of winding a compound motor.

Instead of connecting up the exciting coils so that the shunt and series assist each other in their magnetising effects, the series coil may be reversed and connected so as to oppose the shunt field. The polarity of the poles is not then reversed, but the strength of the field is varied by the differential action of the coils. The object here is to secure constant speed at varying loads: but this arrangement is not widely used because it is found that a well designed shunt wound motor will have sufficiently constant speed for all practical varying load purposes. This connecting of the series and shunt field windings in opposition is termed differential compound, and with this type of motor it is usual to arrange for a cut-out of the series field until the motor has run up to speed.

The use of interpoles is exactly the same as in the case of a generator, but the sequence is exactly opposite; that is to say, whereas in a generator the armature coils pass from a S main pole to a N interpole, in a motor they pass from a S main pole to a S interpole as shown in the diagram which illustrates the windings of a compound wound interpole machine.

Overseas Contracts.

Included in recent orders received by the British Thomson-Houston Co., Ltd., Rugby, for electrical plant destined for duty overseas is one from the High Commissioner for India (Consulting Engineers, Messrs. Preece, Cardew & Rider) for four large water wheel driven alternator sets to be used in the Shanan Power Station in connection with the Uhl River Hydro-Electric Scheme. Each alternator will be driven by a water wheel and will have an output of 12,000 k.w., the rating being 13,333 k.v.a., 0.9 power factor, 11,000 volts, three-phase, 50 cycles, 428⅓ r.p.m. Each set will be provided with direct-coupled exciters arranged for automatic voltage regulation.

For the supply of electric power to the mines of Messrs. North Broken Hill, Ltd., Broken Hill South, Ltd., and the Zinc Corporation, Ltd., Australia, a particularly notable central power station is projected, and orders have been placed with the British Thomson-Houston Co. Ltd., on behalf of Messrs. Australian Ore and Metal Pty. Ltd., for the six 2500 k.v.a. alternators and the whole of the switchgear. Messrs. Robert Bruce & Sons are acting as inspecting engineers for this equipment, which is the largest wherein Diesel engines are used as prime movers ever installed in the world at one time. The six alternators are each rated 2500 k.v.a., 0.8 power factor, 6900/7200 volts, three-phase, 40 cycles, with neutral earthed, and will run at 160 r.p.m. They are of the protected type, and the stators and rotors are split on the horizontal diameter.

The rotors, which are of cast iron, are designed to give sufficient flywheel effect to ensure an engine cyclic irregularity not exceeding 1/250 without the use of any additional flywheel. The stator frames are built up of fabricated construction. They will be mounted direct on the engine crank shafts, there being an outer bearing between each alternator and its overhung 110 volt exciter.

Included in the B.T.H. switchgear is a control board with high tension cubicles mounted beneath the switchboard gallery, the oil circuit breakers contained in these cubicles being remote electrically operated. In addition there is a low tension switchboard. The total number of the panels is thirty-six without allowing for the automatic Tirrill voltage regulator panels, which bring the total to forty-five, while the high tension remote control cubicles number eighteen. Protection is given to the alternators by circulating current protective gear and field suppression equipment.

In addition to the foregoing, the British Thomson-Houston Company has received orders for outdoor type transformers required in connection with the electrification scheme. Of these transformers, seven are three-phase units each of 750 k.v.a., 6900/575 volts, 40 cycles rating, and eleven are single-phase units of 833 k.v.a.

Personal.

Mr. S. Nichols, who has been for some years Manager of the Middlesbrough Office of the British Thomson-Houston Company, Ltd., is now relinquishing this position and becoming Manager of this Company's Liverpool Office at 27-29 Stanley Street, Liverpool.

Mr. A. D. Mackinnon, for many years a member of the Company's Glasgow Office staff, has been appointed Manager of the Company's Middlesbrough Office.

Proceedings of the Association of Mining Electrical Engineers.

LONDON BRANCH.

Chimney Dust Problems.

J. W. GIBSON.

(*Continued from page* 267.)

CENTRIFUGAL COLLECTORS.

Centrifugal collectors, as their name implies, make use of the principle of centrifugal force to obtain the separation of the constituents of the dust-laden gases. Typical instances of the application of the same principle are familiar in the form of cream separators, oil cleansers and the dehydrating centrifugals. In these applications it is found convenient to cause the containing vessel to rotate, but with gas centrifugal cleansers it is usually found that, on account of size, the gases are given a circular motion, whilst the container remains stationary.

The necessary circular motion is given to the gases either by admitting them tangentially into a circular or volute casing or by employing guide-vanes. Whichever method is adopted, the circular motion causes the heavier portion of the uncleansed gases, i.e., the dust, to travel to the periphery, where it is collected, whilst in due course the cleansed gas leaves the collector through a suitable opening in the centre.

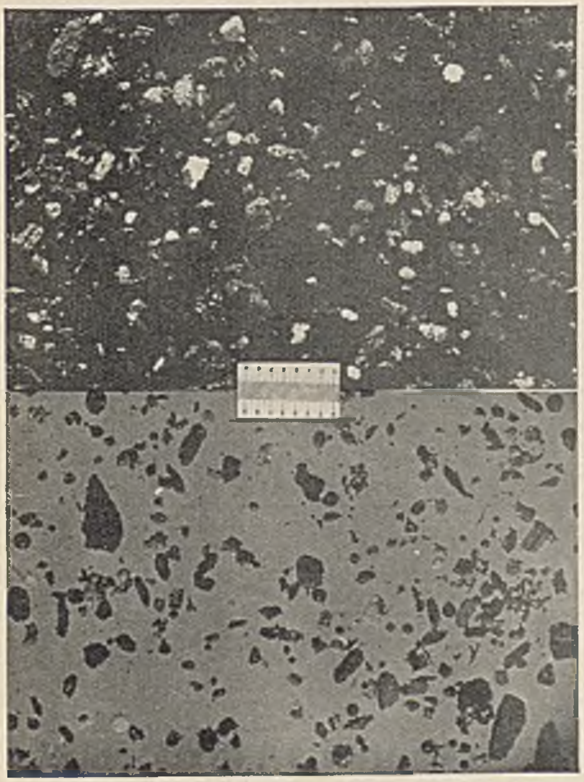


Fig. 1.—Ungraded dust from Stoker-fired Water-tube boiler; photographed against light and dark background. The numbered divisions on the scales in each case are equal to 0.1 *millimetre.*

The most familiar type of centrifugal collector is the cyclone, but unfortunately in the types commonly employed it cannot be considered very reliable or consistent in action.

The firm with which the author is connected has carried out very extensive research and evolved a collector of this type in which the objections to the cyclone have been overcome. Tests are continually being run with different types of dust, and efficiencies of 85 to 90 per cent. on a model some 20 feet high are by no means uncommon, whilst on a smaller model it is the exception rather than the rule to get an efficiency less than 90 per cent.

The collector may be used either on the suction or on the discharge side of the fan, as may be found to be the more convenient, but preference should be given to the application on the suction side if possible, not owing to difference in efficiency, but to the fact that if used on the suction side of the fan the gases entering the fan have already been cleansed and the life of the fan is prolonged on account of reduced erosion.

This latter point, i.e., erosion, has been receiving most serious attention both here and in America. The tendency of modern boiler practice is all in the way of increased draught requirements, and this entails higher periphery speeds and higher fan gas-outlet velocities. It is inevitable, therefore, that the scouring action of the dust in the gases should be a grave menace to the fan on a modern boiler.

Fig. 2.—Ungraded dust from Stoker-fired Water-tube boiler; photographed against light and dark background.

With an up-to-date boiler design, water gauges of the order of 7 inches and temperatures of 250 deg. F. are by no means uncommon, whilst on occasion water gauges as high as 11 inches, or even 12 inches, are met with. A water gauge of 7 inches at a temperature of 250 deg. F. would imply a peripheral speed of the fan wheel of about 10,000 feet per minute, whilst the dust-laden gases will leave the wheel at a considerably higher velocity than this.

When it is remembered that a good grinding speed for a carborundum wheel is 6,000 feet per minute, it will be appreciated that the question of fan erosion presents a very real problem.

The main object levelled at the cyclonic or direct type collector is the amount of space which it occupies and many designs have been evolved with the idea of obtaining similar results with an apparatus taking less space. One of the most successful and least difficult to apply is a type of collector which consists of two parts, a primary and a secondary. The primary is formed by building a volute around the chimney. When the dust-laden gases pass through this circuit the dust is thrown out by centrifugal force and concentrates at the periphery, where a projecting lip skims off the heavy concentration, together with a sufficient quantity of waste gas to keep the dust in suspension, and passes the mixture into the secondary circuit, where it is separated; the dust falls into the dust receiver and the waste gases pass back to the main circuit.

It will be noticed in this design that a portion of the gas is shunted into a secondary circuit, and on this account the name "shunt" is adopted. Two types of collector are made, the main difference being that one is installed on the suction side and the other upon the discharge side of the fan: being named respectively "shunt suction" and "shunt pressure" collectors.

It is suggested that the requirements for a perfect collector would be as follow:—

(1) It should be capable of dealing with the dust in the gases over a wide range of boiler loads.

(2) It should be capable of dealing with dust of various sizes, the finer the better.

(3) It should be capable of dealing effectively with a wide range of dust concentrations, so as to cover the difference in concentration corresponding to light load on one hand and soot blowing on the other.

Needless to say, the collector that will perfectly fulfil all these conditions has yet to be invented, and the best that can be done is to select a type that will most nearly fulfil the desired conditions, or, alternatively, to select two types to act in conjunction with one another, the combined characteristics of which will more nearly approach the ideal.

It has previously been stated that in order to deal with sulphur fumes washing will probably be resorted to, so it may be anticipated that the trend of research will be in the direction of a dry filter of the centrifugal type to extract the bulk of the dust, and a washer primarily to handle the sulphur fumes, but capable of reducing the residue of the dust escaping from the centrifugal collector.

In the light of what has been said in regard to erosion, and the inherent difficulties attending washing, it is probable that the collector will be placed before the fan and the washer after it.

It will be of interest to give some particulars of the quantities which have to be handled by the collectors installed on boiler plants. In the case of a battery of boilers fired with coke-breeze, the amount of dust collected was 17 tons per week, which corresponded to 0.68 per cent. of the total weight of fuel fired, whilst in the case of another plant burning a mixture of dust and slack from a coal-washery, the amount of dust collected from the waste-gases was 450 pounds per hour, or 8.1 per cent. of the total weight of coal fired.

In a powdered coal installation the boiler was rated at 80 tons evaporation per hour. On test with a load of 72 tons evaporation per hour, the amount of dust collected was 1,185 pounds per hour, or 6.96 per cent. of the total coal fired; whilst at another test, also at 72 tons evaporation, the dust collected amounted to 1,940 pounds per hour, or 11.72 per cent. of the total coal burned.

A trial, to include soot blowing, was also run on this boiler. The load upon the boiler at this time was 50 tons evaporation, and prior to the actual period of soot blowing the dust collected was at the rate of 915 pounds per hour. The actual operation of soot blowing lasted 17 minutes, but the dust came down so rapidly that difficulty was experienced in coping with it. The collector was fitted with a dust receiver in permanent connection with the collector, and the dust was drawn off by a screw-conveyor at the bottom of the receiver for weighing purposes. Just prior to soot blowing the receiver was empty but, owing to the rate at which the dust came down at soot blowing, it was 40 minutes before the receiver again could be emptied.

Assuming that the process of combustion in the boiler continued to deliver dust to the collector at the same rate as prior to soot blowing, 1,445 pounds of dust were brought down in 17 minutes owing to soot blowing alone, whilst the total amount brought down in this period would be 1,705 pounds.

This, it will be seen, is a conservative estimate, since the dust would commence to build up again in the boiler passes at the termination of soot blowing, so that in reality the quantity of dust delivered to the collector from the termination of soot blowing to the end of the period of weighing would be less than the the average rate before soot blowing. A rough approximation of the volume of the waste-gases during this time would be 63,000 cubic feet per minute, so that the dust concentration during the period of soot blowing amounted to the extraordinary figure of 11.13 grains per cubic foot of gas.

A long series of tests at this power station gave the dust concentration in the waste-gases under ordinary working conditions as varying between 3.45 and 1.79 grains per cubic foot, with an average of 2.53 grains per cubic foot. This example is of particular interest as illustrating the necessity for a dust-collecting apparatus to be capable of dealing with the really heavy dust concentrations.

In the very early stages of experience, it was noted that with the different kinds of dust different efficiencies were obtained, even with the same apparatus. The reason for these differences in behaviour is not yet fully understood, although an examination of dusts through a microscope gives ample ground for thought.

The author does not propose to propound a theory but will content himself by showing a few microphotographs of various dusts which in the ordinary course of business have from time to time been collected (Figs. 1 to 8). These dusts have been graded on D.I.N. or Tyler sieves, i.e., German or American, and each group of illustrations shows the various grades of the same dust, whilst in some cases the dusts have been photographed without grading.

The dusts have been illumined, for photographic purposes, by oblique lighting, so that when viewed against a black background it is rather difficult to distinguish with certainty the carbonaceous particles from the incombustibles, as under this lighting both have a lustre. In some cases, therefore, the dusts have been photographed against a white background, but here the difficulty is to preserve the image of some of the particles of incombustibles, which have the appearance of clear glass. Unfortunately, photography, being monochrome, fails to show the true values of the different particles of the dust.

When viewed through a microscope, a fairly wide range of colours in the incombustibles will be observed, a faint yellow to a deep brown, whilst some of the incombustible particles are colourless and transparent, and others have a pearl-like lustre.

The carbonaceous particles may be divided into three classes:—

(1) Particles of the raw coal which apparently have been carried over unchanged. These, as might be expected, are comparatively rare.

(2) Particles of coke.

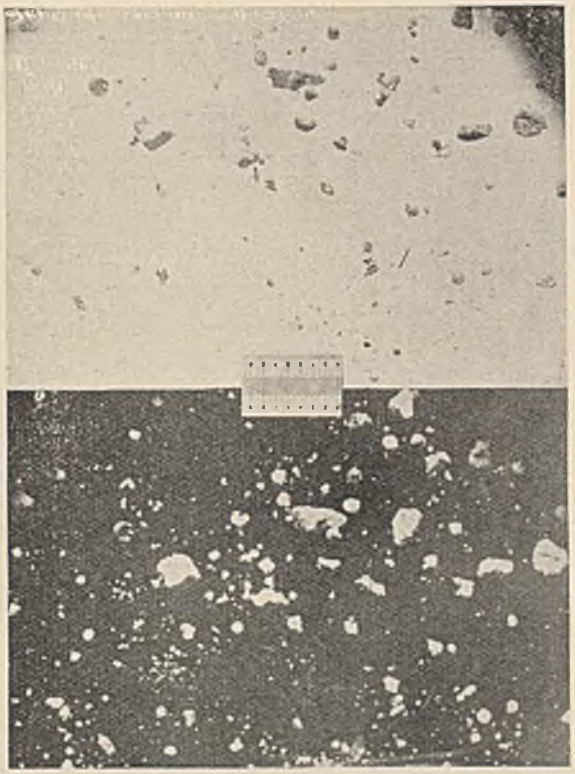


Fig. 3.—Ungraded dust from Pulverised-fuel-fired Water-tube boiler fitted with Fishtail burners; photographed against light and dark background.

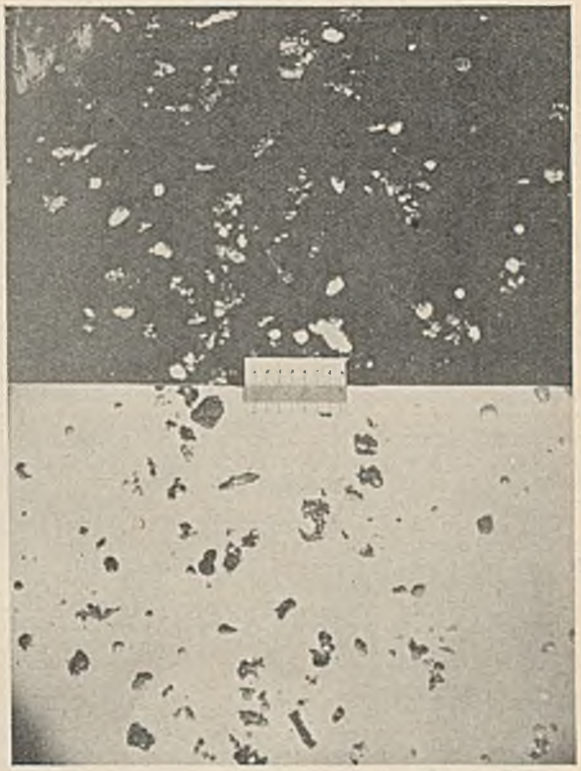


Fig. 5.—Ungraded dust from Pulverised-fuel-fired Water-tube boiler fitted with Fishtail burners; photographed against light and dark background.

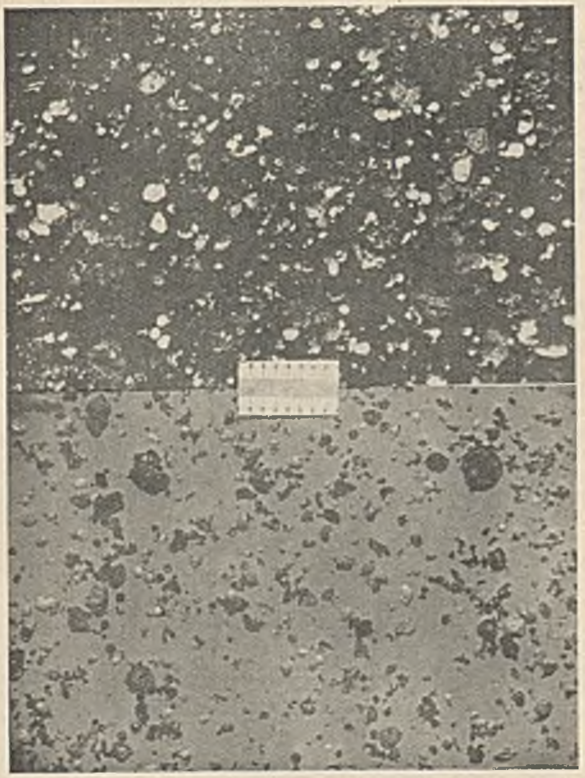


Fig. 4.—Ungraded dust from Pulverised-fuel-fired Water-tube boiler fitted with Calumet burners; photographed against light and dark background.

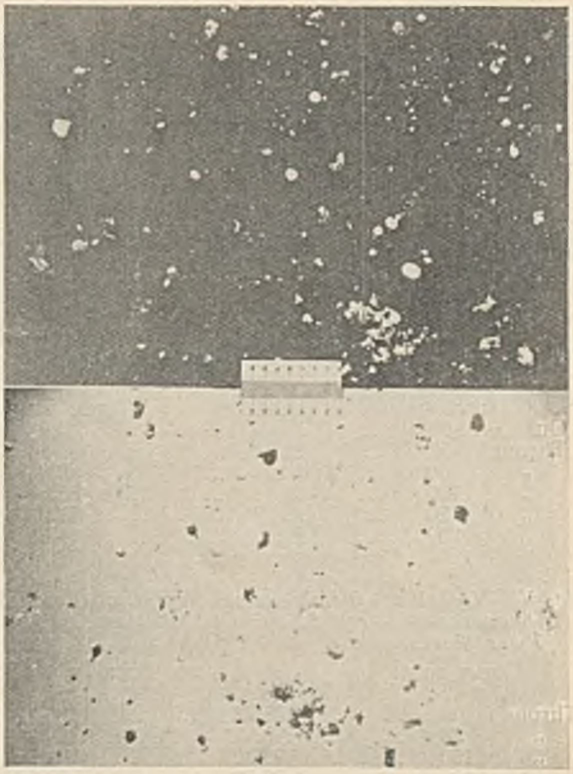


Fig. 6.—Ungraded dust from Pulverised-fuel-fired Water-tube boiler fitted with Turbulent burners; photographed against light and dark background.

(3) Particles of the fuel in a spongy condition, and in most fantastic shapes. This class gives the impression that the particles of fuel were in a state of distillation when carried over to the cooler passes of the boiler, where the temperature was not sufficiently high for the process to be completed. In fact, particles have been observed where the tarry matter was in a process of exuding from the particle when the chilling prevented the process being completed.

The particles of incombustibles also offer an interesting study. Some are fairly crystalline in structure, with sharp angles and corners: others are irregular fused masses with well-rounded corners; whilst particularly with the dusts from pulverised-fuel-fired boilers fitted with turbulent burners, a large number of spherical particles will be observed. These are found to be hollow, with very thin walls.

It will be appreciated that such particles offer considerable resistance to separation, either by centrifugal means or by wetting; and, since a comparatively light blow would fracture them into smaller particles with sharp edges, they provide a ready source of abrasive powder, which may account for the heavy erosive action noted with some dusts.

This paper will be concluded with a few typical grading analyses of dusts that have been obtained from collectors at various times (Tables I. to VIII).

Table I.—*Nechell's (Birmingham), Water-tube Boilers, Chain Grates, S.S. Collector, Tyler Sieves.*

SIEVE MESH.		PER CENT.
On	60	0.73
Through	60	99.27
„	80	95.86
„	100	94.00
„	120	93.22
„	200	64.62

Coal-slack dust and coke breeze.

Table II.—*Barking, Water-tube Boiler, Powdered-fuel-fired, S.P. Collector, D.I.N. Sieves.*

SIEVE MESH.		PER CENT.
On	1600	0.62
Through	1600	99.24
„	3600	97.61
„	6400	95.38
„	10000	93.85

Table III.—*Lot's Road, Water-tube Boilers, Chain Grates, S.P. Collector, D.I.N. Sieves.*

SIEVE MESH.		PER CENT.
On	1600	13.5
Through	1600	86.5
„	3600	75.0
„	6400	62.1
„	10000	48.0

Table IV.—*Central Electric, Water-tube Boilers, Chain Grates, S.P. Collectors, Tyler Sieves.*

SIEVE MESH.		PER CENT.
On	60	4.9
Through	60	95.1
„	80	90.0
„	100	85.3
„	120	77.0
„	200	16.85

Coal, washed peas.

Table V.—*Nechell's (Birmingham), Water-tube Boilers, Powdered-fuel-fired S.S. & D. Collectors in Series, Tyler Sieves.*

SIEVE MESH.		PER CENT. S.S.	PER CENT. D.
Through	60	99.72	100
„	80	96.62	99.94
„	100	93.36	99.72
„	120	92.70	99.64
„	150	85.30	99.0
„	200	72.22	96.96

Table VI.—*Klingenberg Water-tube Boilers, Powdered-fuel-fired, D Collector, Tyler Sieves.*

SIEVE MESH.		PER CENT.
On	90	0.72
Through	90	98.82
„	120	97.86
„	150	96.70
„	200	90.95
„	320	78.76
	Lost...	0.46

Table VII.—*Shoreditch. Water-tube Boilers. Chain Grates, D Collector, Tyler Sieves.*

SIEVE MESH.		PER CENT.
On	60	19.75
Through	60	80.25
„	80	60.5
„	100	59.6
„	120	58.8
„	200	36.0

Coal—75% Whitwick Slack.
25% Scotch Washed.

Table VIII.—*Beckton Gas Works. Water-tube Boilers, Chain Grates, D. Collector, Tyler Sieves.*

SIEVE MESH.		PER CENT.
On	60	40.6
Through	60	59.4
„	80	54.6
„	100	42.2
„	120	36.7
„	200	16.35

No attempt has been made to obtain samples either of exceptional fineness or showing any special features. The tables show that in some cases the dust is extremely fine. This, as might be antipicated, is more particularly the case with the dust from pulverized-fuel fired boilers.

These gradings are of dusts that have actually been caught by a collector, so that the percentage of fine dust in the dust offered to the collector will undoubtedly be greater. In one case an attempt was made with a special apparatus to entrap the dust in the gases passing to the chimney from a collector, and it was found that 99.6 per cent. passed through the 200-inch mesh sieve.

Figs. 9 to 14 illustrate the typical appearance of the various sizes of dust from a boiler fired with pulverised fuel where the burners are of the fish-tail type. Fig. 9 shows the dust remaining on the 1600 D.I.N. sieve i.e., no particle can be less than 150 microns or 0.15 mm. diameter. It will be noticed that the majority of the particles are partly distilled coal which, due to distillation, is usually in most fantastic shapes. In the Fig. II. grey particles can be seen, which are probably coke, whilst the white particle would probably be a fused mass of the incombustibles.

In Fig. 10 it will be noticed that the white particles predominate. These are the fused incombustibles. Smaller particles of partly distilled coal and coke will also be noticed. The dust shown in this figure was that remaining on 3,600 D.I.N. sieve, after having passed the 1600 D.I.N. sieve, the equivalent diameter of the particles must be between 150 and 100 micron, i.e., 0.15 and 0.10 m.m.

Fig. 11 represents that portion of the dust which, having passed the 3,600 D.I.N. sieve, is retained by the 6,400 D.I.N. sieve. The equivalent diameter of the particles will, therefore, be 100 and 75 micron, i.e., 0.10 and 0.075 m.m. In addition to the white spherical particles a number of black round particles will also be seen. These, as well as a number of the white particles will be found to consist of a thin shell of the incombustible matter only—the centre being hollow. It will be appreciated that these particles are so light that they will float on water, and as they can be easily fractured they provide a ready supply of sharp-edged powder, which may give trouble in the fans due to erosion.

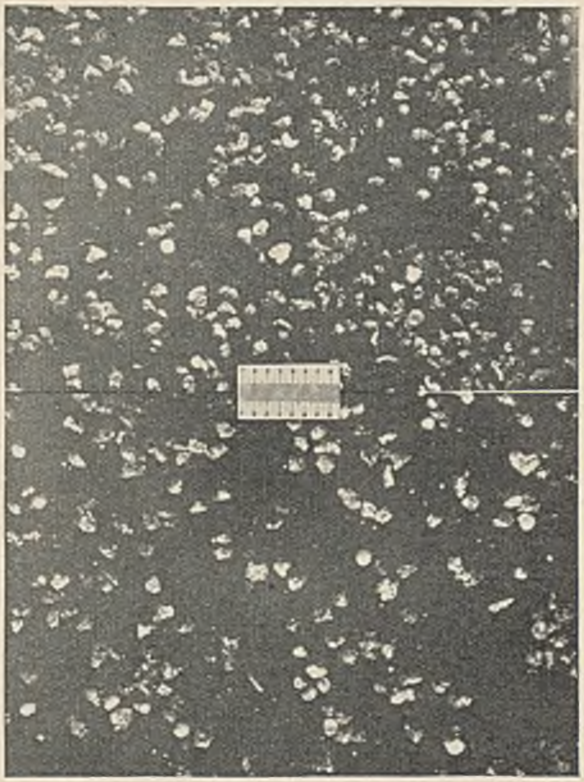


Fig. 7.—Graded dust from Pulverised-fuel-fired Water-tube boiler fitted with Fishtail burners; (a) remaining on 60 D.I.N. *sieve; (b) remaining on* 80 D.I.N. *sieve.*

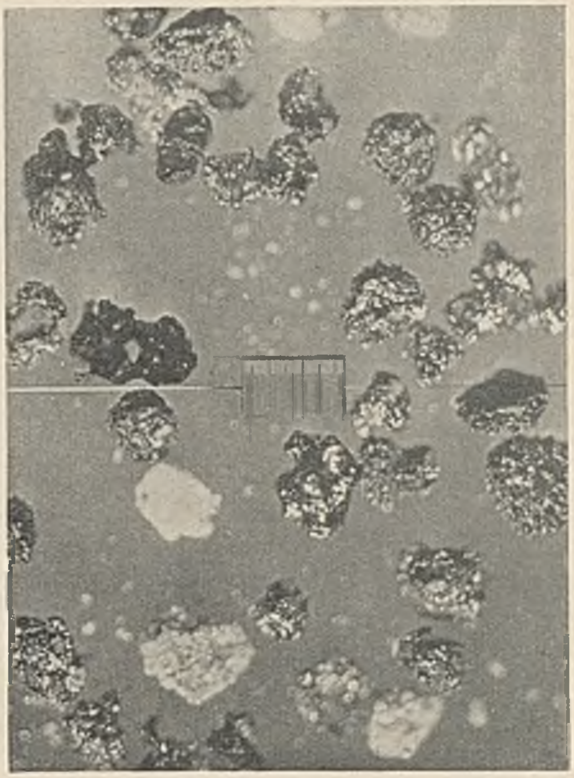


Fig. 9.—Dust from Water-tube boiler fired with pulverised fuel, Fishtail burner, remaining on 1600 D.I.N. *sieve. Scale* 1 *division* = 0.1 *m.m.*

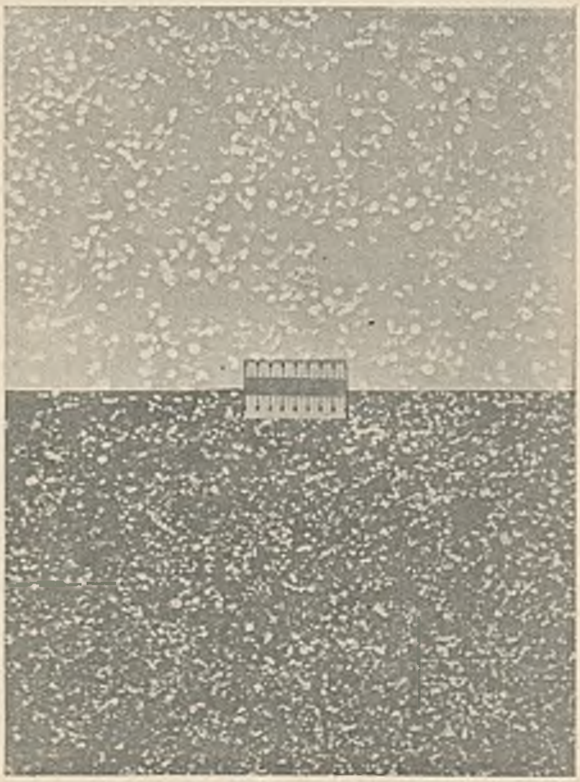


Fig. 8.—Graded dust from Pulverised-fuel-fired Water-tube boiler fitted with Fishtail burners; (a) remaining on 100 D.I.N. *sieve; (b) passing through* 100 D.I.N. *sieve.*

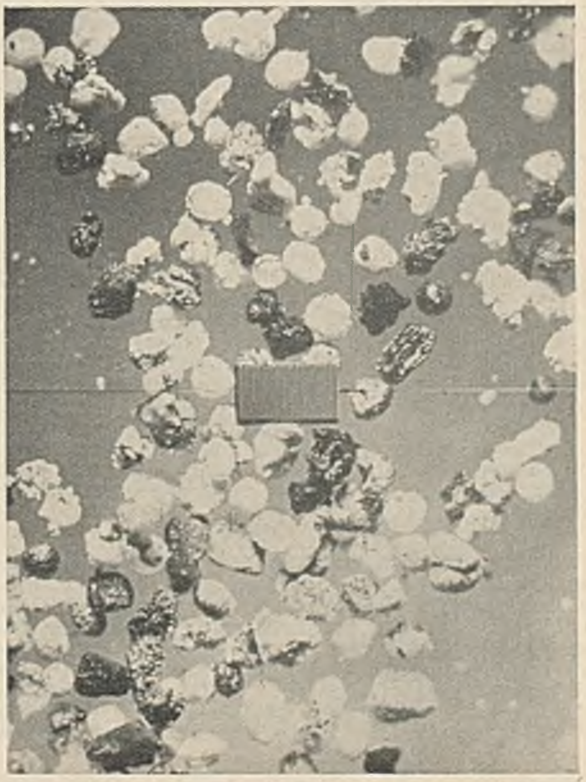


Fig. 10.—Dust caught by Collector from Water-tube boiler fired with Pulverised fuel, Fishtail burner, remaining on 3600 D.I.N. *sieve. Scale* 1 *division* = 0.01 *m.m.*

Fig. 12 represents the dust passing the 6,400 D.I.N. sieve, but retained by the 10,000 D.I.N. sieve. The equivalent diameter of the particles therefore, lies between the limits of 75 and 60 microns, i.e., 0.075 and 0.060 m.m. Here, in addition to the white and black spherical particles, already referred to, a considerable number of sharp edged solid particles will be noticed.

Fig. 13 represents that portion of the dust which passed the 10,000 D.I.N. sieve, i.e., no particle is larger than 60 microns or 0.060 m.m. diameter. By comparing the size of some of the grains with the scale shown in the centre of the print, it will be noticed that a large proportion are considerably less than 10 microns. Whilst the particles are small it will be noticed that many are sharp edged and therefore capable of considerable erosive action.

Fig. 14 illustrates the dust which escaped from the collector. This was photographed to a considerably larger scale than the remainder of the figures, but even to the increased scale it will be noticed that some particles are so minute as to be almost invisible. The larger masses are groups of separate particles which cohere due to moisture when once the dust has cooled, and are afterwards most difficult to separate for the purpose of photography. As this solid matter leaves the boiler, however, each grain is separate. No particle of the dust is larger than 10 microns whilst the preponderance is very much finer. Even though the particles are so minute it will be noticed that many have the appearance of being hollow. The quantity of solid matter escaping with the waste gases was quite small and only amounted to 0.299 grains per cubic foot.

Discussion.

Mr. WALLACE said he had had experience of the four methods mentioned in the paper of extracting dust from flue gases, and his experience was exactly in accordance with that of Mr. Gibson. He had found that centrifugal methods were very efficient, except during the soot-blowing period. The makers of soot-blowers usually gave instructions that the correct method of operation was to start from the furnace and move forward to the chimney, but he considered that if the process were carried out in the opposite way the collector might have a lighter task, because when blowing into the furnace it disturbed the material between the furnace and the chamber, whereas if the process were carried out in the opposite direction the material could be taken off practically in slices, and the collector would be better able to deal with it. He asked for Mr. Gibson's views on that matter.

Mr. H. M. MORGANS (Past Branch President), referring to a statement in the paper that dust would settle in still air with increasing velocity, said he presumed there was a limiting velocity. With regard to sieves, he expressed regret that recourse had to be made to the German D.I.N. sieve and the American Tyler sieve, these being presumably more suitable than any English make.

He asked what was the speed of travel of the air in the cone separator. One would imagine that it must be very slow, in order to allow the dust to settle, but the tube was so small that turbulence might be expected.

Mr. GIBSON said there was sound common sense behind the suggestion made by Mr. Wallace, that better results would be obtained in soot blowing if the operation were carried out in the direction opposite to that usually followed; the dust concentrations would be more even. If soot blowers were used only once in 24 hours there was a tremendous amount of dust to be removed during the period of blowing. Tests showed that concentration could vary between half a grain and 15 grains per cubic foot and collector efficiency was practically the same over this range.

In reply to Mr. Morgans—Particles which come under the definition of dust, i.e., 10 microns and over, would settle in still air with increasing velocity, within the limits of a settling chamber. The velocity of entry into a dust collector was only a little higher than ordinary flue velocity and this velocity was practically constant through the D type collector; there might be a small increase of velocity at the bottom of the smaller cone.

Colonel WALTER BRIDGES, referring to the microphotographs of samples of dust obtained from the Lott's Road power station, asked whether those samples were taken from the dust collector or from the dust which was emitted into the air.

Mr. GIBSON replied that the samples were taken from the dust caught in the collector, and that the dust emitted from the chimneys would be very much finer.

Replying to further questions by Colonel Bridges, he said that some collectors had been fitted at Lott's Road, and others had yet to be fitted. He did not know what was the efficiency of those fitted, but he imagined it would be somewhere in the neighbourhood of 85 or 90 per cent.

Colonel BRIDGES asked how much of the dust from the boilers—of the fine dust as well as the clinker—was actually caught.

Mr. GIBSON replied that 85 per cent. was quite a common efficiency on stoker-fired boilers. At Lott's Road there was a collector on each of eight boilers, and eight tons of dust was collected per day from those eight boilers. Another eight collectors were being installed.

Colonel BRIDGES said there was a good deal of dust getting into his house, which was at Chelsea, and he supposed that that came from the boilers which were not yet fitted with the up-to-date separators. It appeared however, from Mr. Gibson's statements, that there were hopes of improvement. With regard to the micro-photographs of dust from powdered fuel-fired boilers, he asked if the globular particles were fused silica, and said he gathered there were none in the dust from ordinary stoker-fired boilers.

Mr. GIBSON replied that the particles referred to were principally silica bubbles, and that there were very few of them in the dust from stoker-fired boilers.

Colonel BRIDGES said he had had experience of their occurrence in connection with pulverised fuel fired rotary kilns.

Mr. GIBSON said he would not expect to find them in the form of silica from rotary kilns.

Colonel BRIDGES suggested that in the case of the powdered fuel plant the silica bubbles were probably blown from the refractory surfaces of the combustion chamber.

Mr. GIBSON disagreed. He pointed out that the fuel was delivered to a turbulent burner, the air for combustion being admitted with the fuel; therefore, there was a hot zone in which the temperature was sufficient to fuse the impurities and burn off practically all the carbon. (He exhibited samples of the ash obtained from the same coal when burned in a turbulent burner and a fishtail burner respectively, to illustrate the difference between the two, and added that the ash obtained from the coal burned by the turbulent burner was extremely difficult to deal with by water.)

Colonel BRIDGES asked what was the highest efficiency he had ever obtained in the removal of dust at any power station.

Mr. GIBSON caused some amusement by replying that the highest figure he had obtained was 128%. He explained how that was due to the fact that furnace adhesions which had been storing up for three or four days had come down during the test, so that the amount of dust and ash collected was increased thereby. In one of the tests carried out at a German power station the efficiency recorded was 83.6%. The remaining 16.4% which escaped, was so very fine as to be more of the nature of smoke, and its specific gravity was so low that it could not be caught by centrifugal force. (He exhibited some dust samples containing some of

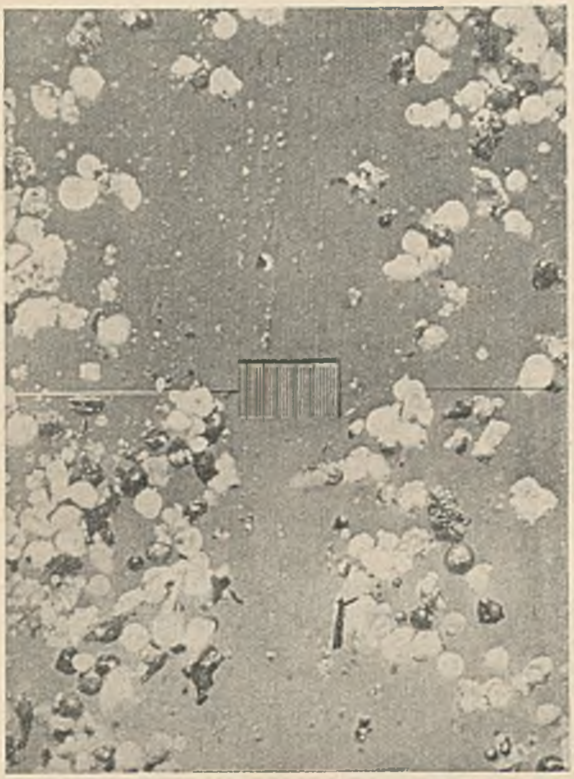


Fig. 11.—Dust caught by Collector from Water-tube boiler fired with Pulverised fuel, Fishtail burner, remaining on 6400 D.I.N. *sieve. Scale* 1 *division* = 0.01 *m.m.*

Fig. 13.—Dust caught by Collector from Water-tube boiler fired with Pulverised fuel, Fishtail burner, passing through 10,000 D.I.N. *sieve. Scale* 1 *division* = 0.01 *m.m.*

Fig. 12.—Dust caught by Collector from Water-tube boiler fired with Pulverised fuel, Fishtail burner, remaining on 10,000 D.I.N. *sieve. Scale* 1 *division* = 0.01 *m.m.*

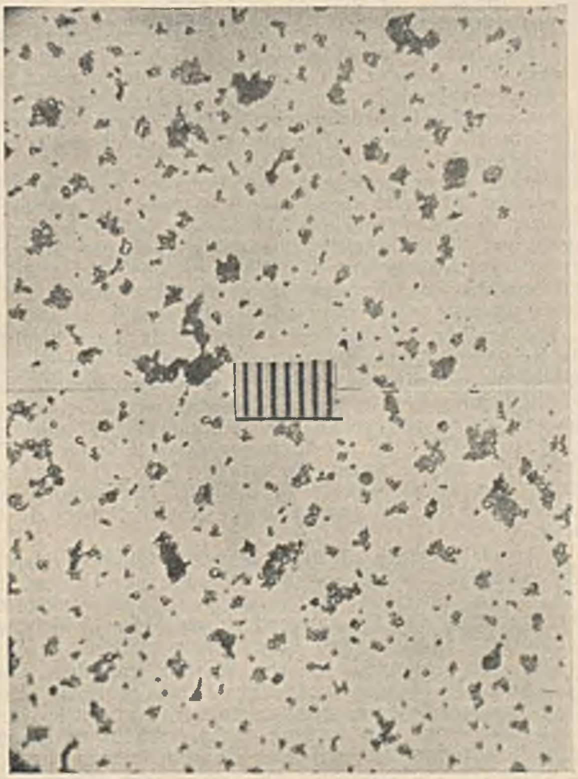


Fig. 14.—Dust passing Collector from Water-tube boiler fired with Pulverised fuel, Fishtail burner. Scale 1 *division* = 0.01 *m.m.*

this very fine dust, pointing out that these very fine particles had been caught only because they were in combination with bigger particles; otherwise they would have escaped altogether.

Mr. J. B CLARKE said that soot blowers fitted to boilers created a nuisance, and although cyclone collectors worked perfectly satisfactorily during the normal working of a boiler, there was generally some discharge from the chimney during the period of soot blowing. He had experience of various makes of cyclones, all of which were working satisfactorily. Commenting upon the variation in the working efficiencies of cyclone separators this seemed to be due, to a large extent, to the varying ash content and fineness of the coal used, but in special cases efficiencies up to 86% were quite common.

Dealing with the fineness of pulverised fuel ground in a Raymond Mill, he said 80% of the pulverised coal passed through a 100 mesh sieve, 63% went through a 200 mesh sieve and 46% through a 300 mesh sieve. The resulting grit extracted from the boiler flue gases by a washing process such as he had installed revealed the fact that 97.8% of a sample of the grit collected passed through a 300 mesh sieve, i.e., 90,000 apertures per square inch. This explained the necessity for using grit arresters to prevent the discharge of grit particles to the atmosphere

He had carried out experiments on a boiler of 6,500 sq. ft. H.S. evaporating 40,000 lbs. of water per hour, fired by chain grate stokers, but when fired with pulverised fuel the steaming capacity of the boiler was raised to 60,000 lbs. of steam per hour. The combustion chamber was a large one of 6,600 cu. ft. capacity, and the amount of coal used per hour was about three tons, approximately one pound of coal per hour per cu. ft. of combustion chamber space. With this large chamber the combustion of the coal was so complete that there was practically no carbon found in the ash. The steaming results obtained with coal of 12,000 B.Th.U's. per pound of fuel was 1.6 lbs. of coal per unit of electricity generated. That was a good figure, showing an overall thermal efficiency of the plant of 17.7%.

The ash content of the low grade coal first used was 14%, but he considered it advisable, however, to use coal with a lower ash content. Bearing in mind that the gases evolved by the consumption of one ton of coal amounted to approximately 1,000,000 cu. ft., one could appreciate the volume of gases to be dealt with in a large station.

During a run consuming 400 tons of coal (with an ash content of 8%), there were 32 tons of ash to be accounted for, and considerable success in the collecting of grit was achieved with a washing appliance in series after a cyclone separator. The cyclone extracted a great quantity of the grit from the flue gases, but a greater quantity was collected by the washer.

The washer consisted of a tank, 30 ft. long by 10 ft. wide by 20 ft. high, and contained 100 water sprays, each capable of distributing 1½ gals. of water per minute, but satisfactory results were obtained when using only ½ gal. of water per spray per minute, *i.e.*, 50 gals. per minute, or 3,000 gals. per hour for the whole tank. The boiler flue gases were discharged from the induced draught fan at a velocity of 3,400 ft. per minute, and reduced to 5 ft. per second while passing through the washer.

A special feature of the washer was that no baffles were introduced which would impede the flow of the gases. This obviated the necessity of increasing the power required for the induced draught fan, which was an important consideration in a power station.

The grit collected by the washer contained very little carbon. It was not slimy, but perfectly clean and of uniform texture, grey in colour, and settled very quickly when run into settling tanks. About two hours was sufficient for the grit to settle sufficiently for the free water to be drawn off, and the sludge dumped into lorries under the settling tank, so that there was no labour required in handling the grit.

With regard to the action of the sulphurous acid on steel-work, he pointed out that unless the steel plates were properly protected they would not last long. In early experiments the pipe-work had fallen to pieces after about six weeks' use due to corrosion set up by the sulphur, and that seemed to be more or less a common experience. Consequently all metal parts in contact with the gases were now lined or covered with lead. There was also corrosion of the discharge pipes leading the effluent to the settling tanks. These were now displaced by wood troughing, which had proved eminently satisfactory.

Mr. GIBSON pointed out that the ash content of the coal used was 7%, so that the concentration of grit was much lower than that which had to be dealt with in the average power station. The lowest ash content he had in mind when writing the paper was about 12%, and one of the dusts he had illustrated was obtained from coal containing 28% of ash. A gas velocity of from 250 to 300 ft. per minute through a spray chamber was very satisfactory for dealing with low concentrations. He supposed the corrosion difficulties had been overcome by lead lining.

Mr. CLARKE agreed.

Mr. GIBSON said that at Chicago it had been found necessary to line the cast-iron pipes with crepe rubber; the pipes would not otherwise stand up to the work on account of acid corrosion. Discussing the period of contact of the water and the dust particles in the gases, he said that in most cases where sprays were applied in chimneys the period of contact between the dust particles and the spray was something less than one second, and that was absolutely inadequate for complete hydration.

Mr. CLARKE said that the grit problem could not be overcome successfully by half measures. It must be dealt with systematically and in plant of large dimensions, and it was waste of money to try to deal with it in a small way.

Mr. W. N. C. CLINCH who, in view of the observations of an earlier speaker, prefaced his remarks by stating that they were made without prejudice, stated that he had considerable difficulties in dealing with grit. He had tried water washing—not only for flue dust, but also for pulverised coal dust—filtering by bag filters, and, at one of the stations of his Company they were about to put to work a Lodge-Cotterell electrical arrester.

It seemed to him that we were forced to adopt these various methods of dust collection because we had not overcome the trouble at the source. In other words, there was much to be said for reducing the ash content of the fuel before it passed from the combustion chamber, and it appeared strange that in this country very little progress had been made in that respect. Difficulty might be met with certain coals, but the majority of English fuels had an ash fusion temperature which permitted the ash to be slagged in the combustion chamber, with a consequent reduction in the ash content of the flue gases.

The added advantage of this process would be the tendency of the ash particles to fuse together, resulting in an aggregate which could be handled by the cyclonic separator in an efficient manner.

Commenting on the remarks made by Mr. Clarke concerning a boiler having an evaporative capacity of 40,000 lbs. per hour, he said that he believed a mistake had been made, and that the figure of 17.7% was not the efficiency of the boiler but the thermal efficiency of the station.

With regard to the washing tank mentioned by Mr. Clarke, he pointed out that if that method of washing were adopted in a large station of, say, 50,000 kilowatts capacity or more, with 10 or 12 boilers of equivalent capacity, a large area would be needed for these tanks. He held no brief for any particular collector but, having gone so far in designing the big chambers, the electrical device instead of the water sprays could be used, as the velocity of the gas, being brought down to 5 ft. per second, was one at which the electrical precipitators were most effective.

Water washing had its disadvantages because one had to face the difficulty of decanting as the dust removed from flue gases did not all precipitate in the settling tank. He had carried out an experiment with a settling tank in which the dust was supposed to collect at the bottom, and the water be decanted from the top and used again for the gas washing. By coincidence the $C.O._2$ content of the gases was increased at the time the tank was installed, and as a result, after operating for 12 hours, the grit in the water was not only precipitated, but some was floating. The floating matter formed to a depth of three of four inches, and was practically white, whereas the deposited material was dark grey. It became apparent, therefore, that the only place from which the water could be taken was about half-way up the tank on the outfall side. This indicated one of the difficulties which always would be experienced at inland power stations where water had to be used over and over again. Another interesting result had been found, and that was that the water was alkaline, as also was the dust collected. The damage to the pipe-work was generally not due to corrosion, but to erosion owing to the abrasive action of the dust.

To his mind there was definite advantage in using any device which did not set up increased back pressure against the induced draught fans. The cost of providing the additional power required for an increased back pressure of 2 in. W.G. over the period of a year was considerable. He was not sure if it did not pay to instal a device which presented practically no back pressure rather than one which put heavier duty on the induced draught fans, even though the capital cost of the former might at first sight be greater. There was also a very great need for arranging collectors on the suction side of the induced draught fans, and so far, existing collecting apparatus did not appear to be as efficient when arranged in this manner. The necessity of considering this point was that with one plant it was not unusual to have to reblade the fans every three months.

He had used bag filters to prevent the discharge of coal dust into the atmosphere and had found that provided the gas temperature was maintained well above the dew-point, they were remarkably effective. Some years ago he had used bag filters which had to be shaken in order to release the dust collected. More recently, however, a novel device had been introduced. The bags were arranged in compartments, and a scavenging air fan was provided. Every half-minute or so a compartment was shut off and a quantity of air, which had already been filtered, was blown through in the reverse direction so that the dust collected on the bag was dropped into a receptacle at the bottom. This was quite effective, but whether or not it could be installed in a chimney he was not prepared to say. In his opinion it would not be a satisfactory arrangement.

With regard to the laboratory tests taken to ascertain the efficiency of the grit collectors he did not believe that these presented the same condition as is obtained in practice, and he said that there were some electrical phenomena which caused the dust in the gases to be dis-associated during the passage from the boiler to the chimney, whereas in a laboratory the dust had already been collected, and although sieve tests gave remarkably fine grading it did not ensure that the particles when applied to the experimental plant were not adhering.

Mr. GIBSON said he would be glad to demonstrate to Mr. Clinch the manner in which tests could be carried out on a practical scale, using a full-size collector, with about 30 h.p. drive at the fan: Mr. Clinch could carry out tests for himself on any dust he wished to use. An efficiency of 86% had been obtained under those conditions, using the finest dust obtainable—of —which 93.8% would pass through a 10,000 mesh per square centimetre sieve. In these tests, however, they could not yet reproduce hot gas conditions.

At Bow Road they had taken the trouble to build a second chimney around the existing one (the outer chimney was closed at the top) so that the waste gases had to pass down the annular space between the chimneys. In the receptacle at the bottom, where the flow of gas changed from the downward to the upward direction, there was a small deposit each day and very little dust passed away to the atmosphere. The efficiency worked out at 94.94%.

With regard to the collection of dust from gases travelling at a velocity of 5 ft. per second he agreed that that was a suitable velocity for electrical precipitators under normal working conditions but if the electrical precipitator was called upon to deal with concentrations such as those resulting from soot blowing they would find that the collecting efficiency would rapidly fall.

Mr. J. EAMES, discussing erosion, said it had been found that gunmetal valves, used by cement manufacturers for filling cement into bags, which valves contained tortuous passages through which the cement passed, wore out usually in about three months. On one occasion, however, some worn valves were patched with babbit metal, and experience had shown that this lasted about three times as long as the gunmetal. He suggested, therefore, that it might be advantageous to use such metal, or perhaps rubber, for covering suction fans used to draw in grit-laden air. It was his experience that when a water gauge of 3½ in. was reached, erosion commenced, and as the water gauge increased, the erosion increased, not in direct ratio, or even as the square or cube, but as the fifth power. That was important, bearing in mind that in some cases in London we were budgeting for 8 in. water gauge.

Mr. J. W. ROBINSON (Branch President) referring to the author's comments on powdered fuel firing, said that whilst powdered fuel could be shown as advantageous in certain cases, its indiscriminate application was not justified, and he felt that many people who had installed it in this country shared this view. One feature of its development was the incentive it had had given stoker manufacturers to improve their design.

SOUTH WALES BRANCH.

At the general meeting held at the School of Mines, Treforest, on October 12th, 1929, Mr. W. W. Hannah occupied the Chair. After the minutes of the previous general meeting held at Cardiff were read, confirmed and signed, it was announced that Mr. W. D. Wooley, General Manager of The Tredegar Iron & Coal Co. Ltd., had consented to become a Patron Member.

Mr. J. B. J. Higham read his Paper entitled "Cotton in Engineering," which was profusely illustrated with lantern slides and, at the end of the meeting, Mr. Higham showed a series of cinematograph films illustrating growth, handling, transport, and various applications of cotton.

Cotton in Engineering.*

Discussion.

Mr. W. W. HANNAH commended Mr. Higham on his excellent address. He had put in a considerable amount of work to produce a lecture of that kind and the way in which he had delivered it showed him to be a master of his subject. He, Mr. Hannah, was not very competent to criticize the general ground covered, but he would like to refer to one of the applications of cotton. As mining men they often came across cotton, chiefly as insulation in electrical machinery and in which case the cotton was used as the carrier of the insulating varnish or oil. It was characteristic of insulating mediums that they

*See *The Mining Electrical Engineer*, Nov. 1929, p. 163

gradually aged or perished presumably with cotton due to evaporation of the insulating varnish or oil by the application of heat. It would be of interest to them all to have a brief description of what actually did take place during the ageing process.

Mr. C. F. FREEBORN referring to the subject of road construction, said that, in England, this particular use of cotton had not found great favour, principally because the grading of the top surface received greater attention, and thus no great advantage was to be gained by its complete replacement when the road was repaired. It is customary in England, to remove the upper, or fine layer of the top surface only, when doing repair, and as this consists, on first class roads, of a finely sifted metal with the voids filled with residual bitumen, the same can be easily burned off as a general rule. Although, originally, tar could be used with some sucess in roadmaking, the present-day product has had so many by-products removed that it is comparatively poor, and so its use is avoided as far as possible.

Mr. Higham had dealt very thoroughly with the use of cotton in insulation, but he, Mr. Freeborn, would like to amplify the author's reference to treated fabrics by mentioning the extensive development that has taken place in this direction. Messrs. Whitely have produced a refined form of cotton which, after being subjected to a special process, constitutes one of the finest forms of insulation yet discovered; this substance is called Elephantide. Last May and June *The Electrician* described the manufacture of Elephantide and kindred materials in which the sheets etc. are built up from a number of layers of fibrous material pressed together under special conditions of heat, moisture etc.; the mixing of the various kinds of pulp decides the actual dielectric strength and the life as an insulation; and with pulps of wood, jute, hemp, and linen, cotton pulp compares very favourably, especially as regards ageing. A representative value of the dielectric strength of Elephantide is 100,000 volts for one minute on a sheet ⅛ inch thick at 90 deg. C., after having been dried for 48 hours and saturated with oil for 48 hours at the same temperature: this represents 770 volts per mil. Elephantide is being used largely on the 132 kv transformers on the British Grid. Cotton fibre thus prepared, is used extensively for slot wedges, field coil spool flanges, and especially for the insulation pieces of the third rail in electrical traction.

The selection of cotton as the basis of Elephantide was decided upon as a result of much research work at Trafford Park, and every other class of fibre was tried before cotton was finally chosen; the unique ageing properties of cotton under the influence of heat have definitely established its superiority. Recent experiments have shown that the insulating properties of cotton can be greatly improved by subjecting the material to a process of water boiling.

An article relating to the ageing of cotton appeared recently in *The Electrician*: there is no doubt that much variation occurs in the ageing properties of the different kinds of cotton, and tests tend to support the opinion that Egyptian cotton is better than American. In a recent test made upon such cloth no material difference was found at 100 deg. C. but a distinct variation was noted after an ageing of 60 hours at 180 deg. C.; the test, made upon a material of 0.037 inches thickness and having a tensile strength of 130 pounds per inch width, consisted of folding it back on itself six times in opposite directions. Cotton would appear to be the only material capable of withstanding this excessive ageing temperature.

It is, of course, impossible, as Mr. Higham said, to deal with every side of the subject, but it was surprising to note that the Paper did not include a reference to the work of the British Cotton Research Association Laboratories at Shirley Institute, Manchester, which are responsible for a very large section of the research work on cotton.

Mr. IDRIS JONES referred to the several more common uses of cotton in electrical and power services. In regard to power transmission he considered the cotton rope to be one of the finest, smoothest and most pliable of silent drives; Mr. Higham's remarks on the question of brake lining, and the figures he gave of the actual wear per brake horse power, for electrical winders and haulages, explain why it was that some of the brake linings on high speed winders have a much shorter life than one might ordinarily expect.

Mr. THEODORE STRETTON said he would briefly refer to one or two matters. The first was the very interesting point regarding the ageing of the cotton. In connection with rubber cables, and he was particularly refering to tough rubber cables, there was, he understood, an artificial ageing test carried out by passing an electric current through a wire coiled round the cable. It occurred to him that it might be possible to test cotton which is to be used for insulating purposes in much the same way.

Another point was in connection with the use of cotton driving ropes. The high efficiency and other advantages of this type of drive, as compared with the many other forms of drive were well known, yet the use of cotton ropes for this purpose was only very limited, and in fact seemed to be decreasing. He had often wondered why that should be so.

Mr. S. B. HASLAM said it would perhaps be interesting to members to know that some of the original and most primitive forms of gins as illustrated by the author are still in constant use in Egypt to-day. He had seen several of the type where there is a large horizontal stone about 10/12 inches deep. The family from grandparents to youngest grandchild sit round this stone ginning the seed with primitive knives made of stone and shaped to an edge. The ubiquitous donkey connected to the centre of the stone by means of a wooden arm walks round the outside of the family party and so rotates the stone. Unfortunately some ardent bootlegger of ancient day discovered that the seeds from which they removed the fibre contained an oil and so a portion of the stone was hollowed out near the centre and the seeds thrown in and crushed. The residue was allowed to ferment and with an added amount of some very raw spirit a very potent and satisfying drink was made at little expense.

He had been rather interested in the author's remarks about cotton ropes, and gathered that there was practically no permanent stretch and that when once the original stretch was taken out anything further was only temporary and subject to atmospheric conditions or due to shock or mechanical stress. Perhaps Mr. Higham would elaborate that point and say whether that was the case or whether a rope stretched during use would recover when stationary and take no permanent stretch.

Mr. J. B. J. HIGHAM (in reply) As expected, the use of cotton for insulating purposes is of greater interest to electrical engineers than any other application. He wished to thank Mr. Freeborn for the most useful information and data regarding the product of Elephantide and for bringing representative samples of the material. The researches at Trafford Park had, Mr. Higham believed, established the superiority of cotton as an insulating medium or carrier, if correctly treated during manufacture. In that particular product a suitable combination of cotton with other ingredients and certain oil produced an insulation superior to any other form of insulation of a similar nature.

With regard to the ageing of insulations employing a cotton basis, there are a number of factors which affect the useful life and the treatment the fabric or pulp receives during manufacture is important. The moisture content of the cotton fibre, or any fibre composed largely of cellulose, affects the physical and electrical properties considerably. Fairly abrupt changes in conductivity occur at certain percentages of relative humidity. This was probably true in respect to the pulp. The physical properties of the pulp would probably be entirely different from that of the fibre, owing to the almost complete destruction, by chemical and mechanical treatment of the individual fibre. In so far as the cotton fibre was concerned, it was well known that cotton spinning required a fairly close adjustment of humidity in order that the cotton hair may withstand successfully the mechanical strains imposed during the various processes.

There appeared to be three distinct phases of relative humidity which gave well defined characteristics; some overlapping occurs, but an analysis suggests the following:—

Relative Humidity.	*Characteristics.*
0-15% phase	Chemical Hydration
40-90% phase	Absorption
Above 90%	Coarse capilliary phenomena

The curves relative to conductivity, stiffness to bending and torsional resistance, plotted to a base of relative humidity, show distinct hysteresis loops. The conductivity is greater for a given relative humidity when the fibre is being dried than when wetted. Another interesting effect is that the cotton fibre undergoes a change in temperature when the humidity of the air in its vicinity changes. Complete removal of moisture by de-hydrating the cotton only very slightly increases the electrical resistance, and therefore it would appear to be unnecessary completely to dry the fibre before impregnating it with insulating varnish or other medium. The varnish has to be carefully selected; some varnishes and such like materials are subject to chemical change or decomposition, developing acid characteristics, which will ruin the fibre or pulp base and cause corrosion of conductors.

The cotton has its mechanical strength somewhat reduced as a result of the drying-out process, but in so far as it effects the ageing this will be of minor importance. The troubles due to evaporation and hardening of the varnishes, with consequent loss of flexibility and insulating property, are not so noticeable in products manufactured to-day as was the case some years ago. The superiority of sheets and boards which employ a cotton base is definitely established, particularly when used in transformer construction. It may interest Mr. Freeborn to know that when the author commenced to collect information on the subject of the uses of cotton, the first people to be questioned were the research departments of the various Cotton Associations, amongst these the Shirley Institute. The information asked for in particular was that having some bearing on engineering applications, also for references to possible sources of information.

The result was distinctly disappointing, for, although much must have been done in these research departments which might be of value to the engineer concerned with the manufacture and the critical user of cotton for various purposes, no information was directly obtained. The reason for this, the author suggests, is that those responsible for the research are concerned with the problems of the cotton mill or cotton grower, and fail to see any possible connection with engineering applications. The engineer, given the opportunity, will generally spot or make use of any information which he can fish out.

The same trouble exists between the rubber research departments and some users of rubber. A paper read before the Aeronautical Association a few years ago on "Shock Absorbers" made this quite clear; in that case much research had been done, but was not directly available to the user. The suggestion made by Mr. Stretton for an artificial ageing test was interesting, and would possibly give comparative results which could be interpreted, by reference to some standard, into a measure of useful life under well-defined conditions of use.

The author was pleased to hear that Mr. Idris Jones considered that rope drives had many advantages over belt drives. In this connection Mr. Stretton had pointed out that the use of rope drives seemed to be decreasing. That may be true in respect of their application to colliery drives, but in other industries, in the milling and cotton and woollen mills, for instance, they still hold the field. Peculiarly enough, rope drives were often installed when all other methods had failed to stand up to the severe conditions imposed. The details of primitive gins still largely used by the Egyptian natives given by Mr. Haslam, were most interesting, but it would appear from literature published within the last few years, that the American saw gin is finding favour.

From experiments made by the author on cotton ropes it would appear ,as Mr. Haslam supposed, that once the initial stretch is taken up, as is done in practice, any further stretch, due to shock or the like, is generally temporary—in time the sub-permanent set, exhibited immediately the excessive stretch is removed, will vanish, *i.e.*, the rope recovers. This recovery is very noticeable when a rope drive is shut down for a considerable time and the ropes left standing. Unless bearings are carefully watched when the drive is re-started, hot necks will result. This can be obviated by "blocking" the ropes *after* shutting down; i.e., barring in a chock of wood under the ropes on the large rope wheel—the chock should be nicely rounded off to prevent crushing of strands at the edges of the chock. A new rope, after being put into service and running for some time, will never fully recover its original length, but the "run-in" off-duty length will remain practically constant if the rope is of ample capacity for the duty required and if the splicing is good.

In conclusion the author wishes to thank the various speakers for their expressions of thanks and congratulations, and also for the way in which the paper has been received by everyone. To single out for thanks any particular firm would be invidious, and this opportunity is taken to thank all who have supplied information for their kindness in so doing.

DONCASTER SUB-BRANCH.

H.M. Electrical Inspector of Mines Report for 1928.

Discussion.

(*Meeting held* 30*th November*, 1929.)

Mr. WADESON.—This report is exceptionally valueable to people concerned with electrical equipment in mines. It shews that the number of mines working has decreased from the previous year and so has the number using electricity, but the horse power of motors in use has increased.

Fifteen fatal accidents associated with electricity occurred, of which eleven were directly due to electric shock, and four from fires started electrically. Four of the eleven persons directly concerned were qualified electricians, three of whom were carrying out work on main swetch-gear and H.T. work, and the accidents would not have happened had precautions been taken to earth the switch or circuit.

In the first instance an electrician at Plymouth Colliery, Derby, accidentally touched a live terminal. The system was three-phase at 520 volts with the neutral point earthed, so that the single-phase "shock" pressure was about 300 volts.

In the second case a timberer accidentally struck a live trailing cable with his pick; the system being three-phase at 600 volts, the neutral point being earthed, so that the single-phase "shock" pressure was approximately 350 volts.

In the third accident a conveyor man received a shock owing to the fact that some broken strands of the wire rope he was pulling had pierced the sheathing of a trailing cable, and the rope was charged electrically. The system in this case was three-phase at 440 volts and the neutral point was earthed. The trailing cable was of the usual type and appeared to be in good working condition.

In the fourth case, temporary connections had been made to try-out a portable drill, which was working at 125 volts, three-phase.

In the fifth, an electrician was cleaning a truck type switch panel when, it would appear, he slipped backwards into the cubicle and so came into contact accidentally with live parts which, according to the medical evidence, must have caused instant death. The system was three-phase at 3,300 volts.

In the sixth an assistant electrician cleaning insulators on a transformer chamber came into contact with, or induced a discharge from, the live terminals of a circuit housed in the same chamber. The system was three-phase at 23,000 volts.

In the seventh, two men were moving a shaker conveyor at the coal face whilst a coal cutting machine was at work. Actually they were sliding a section of the conveyor pan, which was upside down, diagonally across the live trailing cable. The right-angled sharp edges of the pan cut through the rubber sheath and insulation of the cable, and made electrical contact with the live conductors. The electrical system was three-phase at 550 volts, the neutral point being earthed.

In the eighth, a gate-end loader had been used during one shift and, after all coal had been removed, a Sylvester was attached to the loader to pull it back. There was an unarmoured flexible cable lying on the ground which carried the current to the loader and, when the machine had been withdrawn about 14 feet, one of the wheels passed over this cable, with the result that the Sylvester and rails became alive. The system was three-phase at 550 volts, the neutral point being earthed. The earthing system appeared to be in order, but no fuses were blown.

In the ninth case a lad was cleaning out a tipping bogie when an overhead line conductor broke and fell on him. The lighting circuit was connected between two phases of a three-phase transformer, designed to reduce pressure from 2,750 volts to 220 volts. The measured pressure on the secondary ranged from 240 volts to 250 volts; the neutral point of the L.P. system was not earthed, so that he received a shock at a pressure considerably above the single-phase voltage, which would have been at 140-144 volts.

In the tenth, a miner pushed a tub over an unarmoured flexible cable that had been suspended across the track on nails driven into the props on each side of the track, with the result that the sheath and insulation were split, and the tub or the rails, or both, became "live." The system was three-phase at 500 volts, and the neutral point was not earthed.

In the eleventh, an electrician was moving some insulated cables on a wall behind the main switch-board in the power hour. It appears that the man gave instructions for the "juice" to be cut off at 9 o'clock, and he actually started work at 8.40, twenty minutes before he knew the supply was to have been cut off. It seems as though he must have slipped on the ladder, and clutched at the live cable to save himself. The circuit was part of a three-phase 3,300 volt system, the neutral point being earthed.

The twelfth case was one of explosion. A coal cutting machine had been overhauled, and it seems that enclosure of the electrical parts had been left in an unsatisfactory condition.

In the thirteenth case it is thought that a fall of roof had taken place, had pulled on a trailing cable and when the plug was dragged from the socket with the load on it caused an arc, and this ignited an accumulation of firedamp. The system was three-phase at 500 volts.

The fourteenth case was the result of an explosion due to the arcing of contact tubes on a coal cutting machine. It appears that the arcing was due to the breakdown of the bushing insulator, the system being D.C. at 500 volts.

The fifteenth case was presumably owing to the fact that a non-flameproof switch was being used in a district where gas had been accumulated. There was evidence that an arc had been struck at some time between phases at or above the level of the oil.

Altogether there were fifty-five non-fatal accidents and dangerous occurences, and in analysing these it will be found that the major portion were the result of negligence. The case of the explosion of switch-gear at the Windsor Colliery, Glamorgan, raises a technical matter. The report states that this is a three-phase system with earthed neutral, operating at 3,300 volts between phases. It was fed through four 2,000 K.W. transformers in parallel from a generating station controlled by a switch of 50,000 K.W., and at the bottom a switch was installed of 25,000 K.W. From the switchboard there was a branch circuit to a haulage motor controlled by a switch of 15,000 K.W. capacity. It appears that a fault occurred on the stator reversing contacts of the controller of the haulage motor, and that in attempting to clear this fault the branch circuit breaker at the pit bottom had developed an internal short circuit which destroyed the tank and set the oil on fire; thus causing the explosion, with the result that the pit was shut down for a considerable period.

In many collieries it will be found that the switches installed have a rupturing capacity that is far too small for the connected system.

There was also the question of trailing cables and plugs. As regards trailing cables, perhaps Mr. Roper would be able to give some useful information, but he Mr. Wadeson, believed the general opinion would be that the "Firflex" type of trailing cable is usually the best for the work mining trailing cables have to do.

The next point which required attention was that relating to the question of taking adequate precautions before men start to work. It was commonly known that to save time men often did minor repairs with the "juice" on, but it was never worth the risk, and the best precaution every time was to make the gear "dead."

The Inspector, in his report, stated that automatic starters for coal cutting machines and subsidiary apparatus were coming into use. The Association had a paper on such apparatus some time ago. Mr. Wadeson said that in his opinion the remote control gear was not satisfactory. There was also the tendency for the powers-that-be in spending money for the gear in collieries to keep down the first cost. That tendency ought not to have free sway, as experience proved it was always better to pay a little more and get additional safety.

Mr. WILLIAMS said that Mr. Wadeson had covered the ground very fully, and he would like to appeal to all to read and study this Report; and to each chief electrician that he hand a copy of this report to each of his men. The Inspector pointed out the necessity for taking more care, and particularly in regard to using of coal face machinery, which was probably the most dangerous machinery in the pit.

There was one accident mentioned in the report due to an O.I. switch of non-flameproof design being actually put to work where gas was.

The Inspector also reported on the electrocution of three pit ponies. The report says that there was a faulty earthing system, and the leakage current was distributed along the rails and through the ground, with the result that there was a sufficient potential difference to kill ponies 700 yards away in another seam. It should be borne in mind that horses are very susceptible to shock, and it does not take a great deal to kill them; but as the Inspector points out, this accident drew attention to the importance of systematic testing of the earthing circuit.

There was one other point in this record which particularly interested Mr. Williams, and that was the peculiar accident which occurred at a pit where a trailing cable was pierced by fragments from a shot firing cable; it was surprising to learn that the wire of a shot firing cable could be pushed through the sheathing of the trailing cable.

Mr. MANN said that last year the Mines Department issued a circular recommending a certain way of earthing cables from switch-gear, and he would like to suggest that the system advocated therein was wrong.

Mr. WHITEHOUSE believed Mr. Mann was referring to the circular issued by the Mines Department which gave a sketch of switch-gear fitted with this apparatus, and the earthing was an extension of the contacts. To him also that appeared to be a dangerous piece of apparatus if not used properly.

Mr. J. JONES.—Is earthing not required in a draw-out switch

Mr. WHITEHOUSE.—No.

Mr. WADESON.—This arises out of the Inspector's recommendation last year (1927).

Mr. WILLIAMS was of the opinion that none of the fatal accidents last year would have been prevented even if the Inspector's recommendations had been carried out.

Mr. WADESON.—Except the man working on the cable before the circuit was made "dead."

Mr. WHITEHOUSE.—But it must be borne in mind that this man was killed by a circuit alongside that which he was working on.

Mr. F. MANN said he held it to be a duty of the man in charge to see that the circuit was "dead" before he sent men on the job. At a colliery the electrical engineer was the man held responsible for the circuit being "dead" before work was started.

Mr. RAYNOR.—So is the man in charge.

Mr. PILKINGTON.—But the man in charge can be given a lock and key and is in a position to see that the switches are safely locked out before he starts.

Mr. WADESON said that the point was that the electrical engineer of the colliery accepts the responsibility for the plant under his control, but if he employed competent men to do the work he was absolved from blame if they did not carry out his instructions, unless it could be proved that he was negligent.

A MEMBER asked whether it was necessary to have a special type of lock. If not, he would appreciate any comment as to what would be best.

Mr. WHITEHOUSE.—Any lock would do so long as it served the purpose; personally he would recommend a "Yale" or some such pattern. So far as he knew there was not a lock made that could not be picked. If a switch is locked out, surely that should be sufficient indication that the switch must not be tampered with.

Mr. BLUNT.—Is it necessary to have special locks for each switch: is it necessary, say, if you have 300 switches on the job to have one lock for each switch

Mr. WADESON.—If padlocks are used, probably about half or one dozen locks about the place would be sufficient; for, after all, it is not likely to require more than a dozen circuits locked off at any one time.

Mr. DIXON said he would like to know what ought to be done when a man received a telephone message instructing him to make a circuit alive.

Mr. WHITEHOUSE replied that he was disposed to answer that question off-hand. Details of that kind should be agreed by the staff. Personally he did not think a man would be right in closing a circuit on telephone request.

Mr. WADESON said it seemed to him purely a matter of organisation.

Mr. MORRIS agreed that it was a matter of organisation, but in practice many circuits had to be made alive on receipt of telephone messages. Probably a system of written authority would be best and safest for that purpose, but circumstances would control the situation.

He would like to ask Mr. Wadeson if he thought limiting Reactances for heavy circuits, such as a pit circuit, were a good engineering proposition.

Mr. WADESON said he would recommend them without hesitation: certainly they were a paying proposition, as they were less expensive than changing the switch-gear.

Mr. WHITEHOUSE, in closing the discussion, earnestly recommended that all electricians at collieries should read and study the report.

AYRSHIRE SUB-BRANCH.

A meeting of the Ayrshire Branch was held in the Station Hotel, Kilmarnock, on Saturday, 21st December. Mr. T. M. McGlashan, Branch President, presided over a good attendance of members.

Mr. W. W. Morgan read the following paper:

Electric Arc Welding for Colliery Boilers and Machinery.

W. W. MORGAN.

It is not to be expected that all the uses to which the electric welding process can be put, are known generally. Even those who are engaged wholly in this work do not by any means know the full extent of its utility, and every now and again are faced with fresh problems just as are those engaged in any other branch of the engineering. This paper will, therefore, by giving a brief summary of the history and uses of electric welding, serve to make members more familiar with the process up to date, and those who have not so far had occasion to make use of the process, may perhaps be in a better position to recognise a welding proposition when it arises.

History of Welding and the Kjellberg System.

The term electric welding embraces several types of welds which are used for different purposes, but this paper is confined solely to electric arc welding. About the year 1860 the first attempts at electric welding of metals were made by an Englishman named Wilde, but these were apparently not attended by any appreciable success.

The Thomson Process of resistance welding was introduced about 1885, and although very useful for quite a number of jobs, it was not found applicable to general repairs.

Attention was later turned to the utilisation of the heat of the electric arc and the first to achieve any degree of success was a Russian engineer named Bernardos. This man used a carbon pencil to form an arc with the subject and the metal to be added was fused by the heat of the arc. The Bernados Process, however, had a number of disadvantages, the principal ones being that no provision was made to prevent contamination of the weld by carbon. The heat also was very great introducing the danger of burning the the weld or causing distortion. Carbon arc welding is quite extensively used in certain industries and metal can be deposited quickly by this process. The quality of the metal, however, although good enough for certain particular classes of work, is not good enough for the work which is commonly called for to-day. The Bernardos Process still being unsatisfactory another Russian engineer named Slavianoff made some progress by substituting a steel or iron electrode, this being fused with the subject by the heat of the arc. Most of the defects of the carbon weld, however, were still there, and there was still room for great improvement.

At this stage, O. Kjellberg, of Gothenburg, started experiments, and by the year 1902 his process was brought to such a stage of perfection that he was able to carry out important boiler repairs. He overcame the difficulties mentioned previously by employing a steel electrode having a sheath or cover which had normally non-conducting qualities. This sheath among other things had the effect of protecting the fused metal from oxidation and enabling the deposited metal to become practically equal in strength and other physical characteristics to the subject being welded. It also reduces the temperature of the arc to little more than melting point of steel and thus practically eliminates the risk of burning the metal. The addition of this cover also enables the welder to control the arc so that the metal is deposited exactly where it is required, Working, therefore, on the Kjellberg principle, we can to-day weld vertically, horizontally, or directly from underneath; added to this the work can now proceed very rapidly, with the result that the applications are almost unlimited. It goes without question that the modern success of electric arc welding generally is due to the use of the covered metal electrode for which Kjellberg was responsible. He was awarded the Gold Medal by the Swedish Academy of Engineering Science, in recognition of his contribution in the field of electric arc welding.

Plant and Electrodes.

A great deal of time and thought has been expended in designing and producing a generator suitable for welding, and to-day we find quite a number of firms marketing welding generators. The modern generator can be driven direct coupled to a motor, belt driven, or coupled direct to a petrol engine. It is a very robust machine totally enclosed and possesses the unique feature of requiring no switchgear or instruments, the whole regulation being done by means of a single hand-wheel. This gives all the regulation required when using the smallest or largest electrodes within the capacity of the machine.

Many firms make the mistake of using a generator which is too small. Owing to the trying conditions under which welding is carried out, namely, the full load being constantly thrown on and off, a welding generator should have, preferably, a considerable reserve of power.

There are various types of electrodes available. For welding on boilers, tanks, pressure vessels, building up worn shafting, and, say, welding of a general nature, there are five kinds of rods with different characteristics. The welds from these rods give a tensile strength of 23 to 30 tons per sq. in., with a Brinell hardness number ranging from 120 to 150. One rod specially worthy of mention, is the rod giving approximately 27 tons tensile strength. This rod does not necessitate hammering or scaling while the welding operation is being carried out, no matter how many layers are being laid on. Some rods on the market require a considerable amount of scaling and this means a big difference in welding time and also in the result. This particular rod is specially good for pressure work, and for the manufacture of pipes, etc. All these rods are suitable for welding cast steel, but if harder material is required another rod giving this quality is available. The weld can be so made that only a grinding operation will dress it.

Rods for welding brass, bronze and copper, can also be supplied, so that it can be readily seen there is great scope in almost any works establishment for the use of this process.

Regarding the operator, or welder, while it may at first sight appear that all that is required is a steady hand, there is more in it than that. A man with a few week's training will be able to tackle small odd jobs, say, on repitition work, but to make an expert welder fit to tackle important work, often in difficult and confined spaces, men require to be put through a very thorough training. They graduate out in various classes of work under close supervision, and are encouraged towards a sense of responsibility. The importance of this will be appreciated when one comes to consider, say, vessels putting to sea with perhaps 10 or 12 combustion chamber back-end plates welded in position and every one must be relied upon.

TYPICAL REPAIRS.

Boilers are continually being examined by Board of Trade and Insurance Company Inspectors, and when the inspectors come across any part of the boiler which is wasted and reduced in thickness and coming within the range of danger their report contains a recommendation to have this attended to. It is now admitted that the most economical and the quickest method of general repairs of this character is to reinforce the wasted parts by welding. This even proves in many cases to be almost the only possible way. Thus new metal equal to the original can be added and the particular part becomes as good as when new.

An example of this is to be found in the case of manhole doors on a marine boiler. Through time the flanged part of the aperture becomes wasted and the face of the joint becomes thin, causing leakage. Reinforcing by welding in the only cure here.

The only way to renew the back-end plate of the combustion chamber of this type is to insert the new back in two or three parts, welding horizontally and vertically where the parts butt. This is quite common practice now. Leaking landing seams, cracks, wasted rivets, can all be successfully treated and the results guaranteed.

Repairs properly carried out by this process are accepted by all the various authorities. Regarding the safety of this means of repair, it can be said that the welders have never yet been held in any way responsible for or contributing to any boiler explosion in spite of the fact that the Company with which the author is connected have carried out some tens of thousand boiler repairs by these methods.

In a similar manner tanks and all kinds of steel vessels may be repaired generally without need for removing any fittings attached. There are a great number of mild steel parts often replaced by new when a welding repair would be speedier and more economical. Take shafting worn at journals, this can be built up again and then re-turned and finished to the original size. If $\frac{1}{16}$ in. is required to be added there is no need to turn the shaft down before welding: the new metal is welded on to the worn part and cleans up beautifully and without sign of any hardness. A recent job of this kind was to build up two journals of a sugar machine crusher shaft. These were 15 in. diameter, 17 in. long, and were worn away $\frac{1}{2}$ in. in diameter. This was made up by welding, machined easily and made a sound, clean job.

Cast steel is another good subject and many castings are saved by welding. Blow holes can be filled up, tears in castings can be cut out and welded: it will be appreciated that a casting weighing perhaps several tons is worth saving. Wearing surfaces of cast steel parts become worn in course of time and these can be built up: an electrode giving the desired hardness can be used and the wearing surface brought back to the original, the work being carried out in place if convenient.

It is not so well known that cast iron can in most cases be welded but many thousands of castings large and small have been saved by us by this method of welding. Taking proper precautions and using proper electrodes, a casting either preheated or cold will weld just as easily as a mild steel plate. Trouble caused by expansion and contraction can in most cases be overcome by preheating. Such a weld can be machined and, if properly carried out, will withstand the required pressure. When preheating is not possible or necessary, the weld can be carried out using either cast iron rods or mild steel rods, whichever is suitable for the particular case.

Bronze, brass and copper castings in many cases can also be welded, and in each of these, preheating is essential. All the various steels are welded with success from the softest mild steel to carbon steels, nickel or manganese steels or cast steel. Soft metal can be deposited, easily chipped, filed or machined, or hand metal deposited (manganese steel) which can only be ground.

The following are a few of the typical jobs carried out for coal mining concern: building up worn teeth and replacing the worn race in the centre of the wheel; welding up broken parts of a coal cutter bedplate damaged by explosion; building up corroded part of a cast iron pump casting, in place, at the bottom of pit shaft; welding up broken winding engine connecting rod broken clean through at the fork end; worn armature shafts built up and re-machined,

WELDING IN DESIGN.

An outstanding example of electric welding considered in design is the Hawthorn Wyber boiler and is worthy of special mention. In view of the continued sucess with repair work it was decided by Hawthorn, Leslie & Co., Ltd., to construct a new marine boiler with most of the joints welded instead of riveted. The boiler was specially designed and the construction very much simplified by employing welded in place of riveted joints. The flanging of the end plates, a difficult and expensive operation, was altogether dispensed with; so also was the flanging for the combustion chamber joints. The saving in coal consumption alone in the plate-heating furnace for levelling and annealing the flanged-end plates, was estimated at about 20 tons. In this size of boiler when riveted joints are used, there are 290 rivet holes 15/16 in. diameter to be drilled through the double ply of plate at each end of the shell, the holes have to be countersunk and the riveting done by hand. All this work is of course dispensed with in the welded boiler. The main particulars of this boiler are: Internal diameter, 15 ft. 6 in.; mean length 11 ft. 6 in.; three corrugated furnaces with outside diameter of 4 ft. 2½ in.; working pressure, 180 lbs. per sq. in.; hydraulic test pressure 360 lbs. per sq. in.

As regards the actual welding of the first of these boilers, preliminary trials were carried out in the first place and after these trials the work was entrusted to the Anglo-Swedish Electric Welding Company. There was in all, a total length of about 500 ft. of welding to be done, and this was carried out so successfully that the boiler was absolutely tight the first time it was tested to 360 lbs. per sq. in.—i.e., double the working pressure—without touching up of any kind being required, either during the tests or after prolonged steaming. The boiler has now been under steam at Hawthorn Leslie's works for about nine years and has never given the slightest trouble. It has been approved by Lloyd's Register of Shipping, the British Corporation, and Bureau Veritas.

There are many parts being bolted and riveted up to-day which, if considered in design, would be welded, and wherein welding would prove to be a much more convenient method and in the end more economical. In structural work this will become the regular procedure, for instead of weakening the section by drilling holes, the section will be left at its original and will have in addition the added strength of the welding.

TESTS.

Tensile Tests.

The strength of the eight test pieces varied from 27.5 to 29.9 tons per sq. in., and in every case the break was away from the weld. Elongations were measured on 8 in., and ranged from 16.3 to 21.0%, which is a very satisfactory degree of ductility.

Modulus of Elasticity.

Careful determinations were made on two pieces of wholly welded deposited metal, and the value of the modulus of elasticity was found to be 13,100 tons per sq. in., or very nearly the same as that of ordinary steel plate in good condition.

Micro-Structure.

Through 100 magnifications it was revealed that the plate welded was not injured in any way by the heat of the welding process. The grain of the metal was unusually uniform in grain.

Alternating Stresses or Fatigue Tests.

Twelve welded joints were subjected to stresses varying from 6½ tons to 13 tons; the majority of them withstood 5,000,000 reversals of the stresses without a break It should here be noted that another well known process of arc welding was tested under the same conditions and most of the pieces broke long before they had reached 1,000,000 alternations of the stresses on 7 tons per sq. in., the best result obtained being one of only about 2,000,000. Ordinary working conditions require metal with ability to withstand fatigue and this is very good proof of the Anglo-Swedish method of welding being able to do so.

Torsion Test.

A bar of metal composed of metal deposited by welding only was turned and prepared for the torsion test. The length of the piece was 100 times the diameter. It was held at one end and twisted through 360 deg. 28.9 times before it fractured. The Royal Naval College report stated that the nature of the fracture showed sound metal even at the weakest zone.

Cold Bending and Impact Tests.

Tests proved the elastic limit of welded metal to be usually higher than that of ordinary mild steel. Impact tests on large plates, two blows from a falling weight of 2 cwts. on ¼ in. welded plate, and 4 cwts. on ½ in. plate left the welds uncracked and unbroken.

Discussion.

THE CHAIRMAN—Discussion on the relative merits of oxy-acetylene and electric welding crops up periodically. It cannot be denied that under certain conditions and limitations both serve a very useful purpose in nearly all spheres of engineering. The adverse criticism we sometimes hear is nearly always traceable to the fact that some repair has been undertaken by a novice or unskilled man with only the haziest knowledge of the principles of welding and with a very rudimentary knowledge of strains and stresses. Personally, he, Mr. McGlashan, was an advocate of both methods, but only when assured that the work would be done by a fully qualified and experienced operator. An operator may be sufficiently skilled to weld, say, an open tank quite successfully, but the same operator possibly would be hopeless with a repair to a boiler or small cylindrical vessel where the inner edge of the weld could not be seen or examined. Only the most experienced men, who fully realise their responsibilities, should be allowed to do work where the inner edge of the weld is hidden. He was against the welding of small air-receivers, cylinders or tanks likely to be used under air or steam pressure, unless it was possible to inspect the inside of the weld. Grave risks attended the working of such vessels whether the pressure be high or low. It was all very well to say the hydraulic test would expose any weakness, but the hydraulic test would not counteract the breathing action and its effects on a flanged dished end plate. The welding of plates subject to what might be termed "panting actions" was a doubtful practice. Electric welding could be employed to effect boiler repairs, but it should only be done under close supervision and by experts well up in strains and stresses: that was the secret of all sucessful boiler repair work.

Mr. McGlashan, continuing, said he had seen marvellous repairs carried out on cast iron work by electric welding at a fraction of the cost it would have taken to get a new casting, and it was a pity that dependable firms should have to suffer through the defects and failures of other firms which undertook repairs neither suitable nor safe for the welding method of repair.

Mr MITCHELL said cast iron weldings were the biggest difficulty. He had had two or three crude oil engines with fractures at the exhaust pockets, and he had never yet been able to get them successfully welded.

Mr. MORGAN said they had done a lot of that class of work very successfully. Taking ¾ in. material the weld was made at about 80 volts and 200 amps. Other systems have various voltages, but sometimes he thought the correct electrodes were not being used. A quite successful weld should be made of ¾ in. material His company used cutting tools which get right to the end of the crack: the man with a chisel does not, and unless the crack is got out the weld cannot be a success.

Mr. PAIRMAN referred to some tests mentioned by Mr. Morgan, in which the plates gave way before the weld did. The welding ought not to give way before the plate. That was just as bad a defect as the welding giving way first.

Mr. MORGAN replied that Mr. Pairman's point was good. The same thing applied in regard to the pipe weld. Those tests were only carried out by Lloyds at Greenwich to ascertain the strength of the weld. It did not mean that all the welds were stronger than the plates. They were special and peculiar tests. In the case, say, of welding a flange on to a pipe, with the small section of metal in the pipe and the heavy section on the flange, there was unequal expansion of the metals and thus it became necessary to have a weld of low tensile strength to allow for expansion on the weld.

Mr. GARVEN.—In cast iron we have found that when a break occurred at the weld a part of the cast iron was adhering to the weld, so it was not really the weld that broke. The same thing happened to the crank shaft of a pump. That crank shaft broke two or three times until we reduced the pressure on it. Though it never broke at the weld, he would not say that the weld being there had not something to do with its breaking.

Mr. McGLASHAN said the welding of a piece of cast iron was one of the trickiest thing: and until recently he had thought it could not be done successfully but he had seen a wonderful repair carried out by Mr. Morgan two months ago.

Mr. W. MORRISON.—Welding is all right up to a point, but there is difficulty in generally recommending it. Welding is decided upon for a certain repair, then along comes the welder with his appliances and he does more damage than he set out to repair. Take, for example, a cross pipe: after it has been welded it is shown by the hydraulic test that there is more water getting out than there was before: one experience of that kind means the finish of welding repairs. Mr. Morgan's company may do the job in a thorough and scientific way, but the insurance company does not stipulate who is to do the welding. It is the man who makes the weld purely and simply that matters, and so it is that the insurance companies do not recommend it at all. Until there can be a surer guarantee regarding people who take on the job, there is not likely to be any change in that attitude.

Mr. MORGAN then referred to a welding job on a rather big vessel: some corrosion had taken place on the rudder post. The corrosion was about half an inch deep, but there was no question of getting a new rudder post: the existing one had to go back on the ship. Lloyds were agreeable to welding, but the Board of Trade were against it, so the rudder post went back into the ship as it was, with all its defects. Thus the difficulties were not confined to boiler people alone. It was really up to the people in various works to force the hands of the insurance folk and the Board of Trade and to get them to approve of welding.

Mr. PAIRMAN.—What about Mr. Garven's experience with the pump shaft?

Mr. GARVEN replied that he had never examined the shaft himself, but an engineer said it did not break at the weld. It was successfully welded but had to carry too much stress for the shaft to stand: it broke through overloading. The pump was running with a very small pipe, and the head on the pump was too great until the size of the pipe was increased and the pressure reduced.

Mr. MITCHELL.—Is welding ever done over the top of rivets?

Mr. MORGAN.—That is a particularly common practice now, but it is not a good one.

Mr. KIRKWOOD.—Sometimes on a locomotive stay there are two or three fractures and they weld over it.

Mr. MORGAN.—Unfortunately we have often to do just as we are told: if a boilermaker comes along and tells us to weld over a stay we have to do it.

Mr. MORRISON.—That is just the trouble. The welders weld over the top of a stay and it seems quite nice and tight, but in six months' time the insurance people come along and tell them to take out the stay and of course the welders are at once blamed.

Mr. McGLASHAN said if he were getting a welding job done he would insist on getting all the surrounding rivets taken out. Electric welding could not be done without affecting the surrounding rivets. There was so much heat.

Mr. MORGAN agreed that the heat of welding did disturb the rivets, but his welders removed them whenever they could get at them. On a ship with eight boilers they had carried out welding to the extent of £500, practically all welding over rivets and so on.

A MEMBER pointed out that those boilers were under the care of engineers, certificated men, whereas colliery boilers were under the care of firemen.

Mr. MORGAN remarked that, however, may be, some ships' boilers under the care of certificated men were not kept nearly so well as colliery boilers.

Mr. MacCALLUM—Is the molecular structure of the metal destroyed when welding?

Mr. MORGAN replied that he had raised that point in connection with the Greenwich tests. The only way to test that effect was by microscope.

Mr. MacCALLUM said that in this Branch they had discussed the molecular theory and Mr. Baird had made extensive tests on a shaft and found that the molecules in a steel bar could be righted by passing an electric current through it.

Mr. MORRISON—would Mr. Morgan agree that the success of welding depends mainly on the human element or on the electricity? Would he say that anyone outside his own Company could make welds successfully, supposing they used his Company's plant?

Mr. MORGAN replied in the negative, but agreed that the man making the weld had to be trained thoroughly first. His company had undertaken the training of men for fims who did their own welding. All his Company's welders serve their time as boilermakers, and when they are journeymen they are put on as chippers and stand by watching the men who are welding. During that time they often get a duplicating or repetition job in welding and they are eventually put on as welders proper.

Mr. GARVEN said there was undoubtedly great scope for welding but he believed certain jobs were often welded which ought not to be done, such as, making up a casting which should really be scrapped and renewed.

Mr. MORGAN concluded by mentioning that the Company retained their welders. The youngest welder in their employ had been with them sixteen years, and thus they had absolute faith in their men. Mr. McGlashan had spoken about the risk of not being able to see the inside of the weld: these men realised the trouble and danger in that better than anybody else and they were always out to see that no job was ever a failure.

SOUTH WALES BRANCH.

Elementary Principles of Electrical Measuring Instruments.

ROWLAND H. MORGAN.

This paper aims at explaining, without attempting to be highly technical, the electrical operation of some of the various principles incorporated in commercial instruments. It is hoped that the contents will be of service, in particular, to the young and practical, who, as a rule have at their disposal neither a collection of literature in various forms nor the opportunity of investigation in practice.

ELECTRICAL PRINCIPLES.

The practical measurement of electricity depends in principle upon any one of its several effects, of which we shall consider the electromagnetic, the electrostatic, and the thermal effects. The advantage with regard to measurement which these effects, the electromagnetic one in particular, give electricity over other sciences is remarkable, yet infrequently appreciated. Before considering the application of these manifestations for certain duties let us deal briefly with items of general association with measuring instruments.

The heavy currents and high pressures obtaining in practice have led to the adoption of means whereby the measurement of a definite proportion of the whole amount is arranged to indicate truly the total. Such means avoid the necessity of manufacturing instruments requiring considerable insulation, resistance and heavy section conductors, and furthermore permit of standardisation of the essential portions of instruments in that one particular unit for measuring a certain fixed amount may be used to indicate varying quantities by the use of a ratio unit whose numerical ratio will depend upon the magnitude of the original quantity. To accomplish this reduction transformers, shunts, resistances and, sometimes, condensers may be utilised depending upon conditions.

Instrument transformers are precisely similar in fundamentals to power transformers. For use in conjunction with instruments, transformers fall under two general headings, current transformers and potential transformers.

A current transformer's primary winding is of exceedingly low resistance, with but one or two turns comprising the coil, which is connected in series with the main circuit and carries the main current; the secondary winding has a larger number of turns to give the desired conversion. The connections of an ammeter served by a current transformer are given in Fig. 1.

The primary winding of a potential transformer consists of a coil composed of a large number of turns, has an exceedingly high resistance, and is connected in parallel with the main circuit with the full line pressure across its terminals. The secondary winding has a smaller number of turns comparable with the transformation required. Fig. 2 gives the connections of a potential transformer and its voltmeter.

Instrument transformers have a comparatively small power capacity, the standard ratings being 15 and 40 volt-amperes for current transformers and 15, 50, and 200 volt-amperes for potential transformers, the size being chosen according to the specific duty involved. The ratio of a current transformer, that is, the comparison between the values of the main or primary current and the instrument or secondary current, is arranged so that the secondary current at rated output is 5 amperes. Should the normal full load of the primary current be 800 amperes then the current transformer adaptable will be one having a ratio of 800/5 amperes, or if the primary be 2000 amperes then the suitable ratio will be 2000/5 amperes.

This same value of the current on the instrument side of all current transformers permits the use of identical instruments, but with a suitably marked scale, to indicate greatly varying ranges of current in the main circuit.

In potential transformers the ratio or comparison between the line or primary pressure and the instrument or secondary pressure is arranged so that when the rated primary pressure is applied the secondary pressure will be 110 volts. According to the line pressure we then have ratios such as 3300/110 volts and 6600/110 volts, and so benefit in standardisation from the similar secondary or instrument pressure.

As the fundamental necessity for the operation of a transformer is a varying field, the resultant effect of which gives the secondary supply, it is apparent that instrument transformers may be utilised with alternating current circuits only. There are many important issues worthy of attention in and arising from instrument transformers but such will not be pursued here. Full details of ratios, capacities, permissible errors, etc., of both current and potential transformers will be found in the standard specification for instrument transformers issued by the British Engineering Standards Association.

A shunt is a definitely rated low resistance unit placed in series in a main circuit so that a small drop of potential takes place across the shunt in direct proportion to the current passing. Across the ends of the shunt is connected the instrument circuit through which a current also passes whose magnitude will depend upon the potential drop across the shunt and thus upon the main current. Shunts have a large field of application and are invaluable for direct current measurement. By them the magnitudes of large currents are revealed by measuring a small portion of the current, and, with other advantages, enable the use of desirable instruments whose construction does not allow them to carry any but the smallest currents. They contribute to standardisation and afford a convenient way of making an instrument multi-range. Shunts are generally constructed of negligible temperature coefficient metal, that is, metal whose resistance does not vary appreciably with the change of temperature, for a variation in the shunt's resistance would interfere with the definite relationship existing between the current in the shunt and the current in the instrument.

Consider the case where it is desired to measure a current which is in excess of the current which may be measured by the instrument alone, the instrument for the occasion being termed an ammeter. Fig. 3 gives the connections of a shunt and ammeter, reference to which will simplify the following calculation to find the suitable resistance value of a shunt. Assume that when used alone the ammeter will measure up to C_A amperes and that it has a resistance of R_A ohms. Let E volts be the potential difference across the ammeter and shunt, and C_S amperes the current through the shunt. To enable the measurement of a main current of C_M amperes, a shunt with a resistance of R_S ohms is required. The current through the shunt will be equal to the pressure drop across the shunt divided by the resistance of the shunt, thus:—

$$C_S = \frac{E}{R_S} \text{ from which } R_S = \frac{E}{C_S} \quad \text{......................(1)}$$

The main current is equal to the sum of the shunt current and the ammeter current, the shunt and ammeter being parallel circuits, that is:—

$$C_M = C_S + C_A \text{ from which } C_S = C_M - C_A \text{...(2)}$$

Incorporating this value of C_S in formula (1) gives:—

$$R_S = \frac{E}{C_M - C_A} \quad \text{.......................................(3)}$$

Referring to the ammeter, the full scale deflection value is equal to the potential difference divided by the resistance of the ammeter, as follows:—

$$C_A = \frac{E}{R_A} \text{ from which } E = C_A \times R_A \quad \text{............(4)}$$

Substituting this value of E in formula (3) gives:—

$$R_S = \frac{C_A \times R_A}{C_M - C_A}$$

For example, consider an ammeter having a resistance of 1 ohm and in which $\frac{1}{10}$ ampere will give full scale deflection. It is desired to measure a main current of 10 amperes with the aid of a shunt, then the value of the shunt resistance will be:—

$$R_S = \frac{\frac{1}{10} \times 1}{10 - \frac{1}{10}} = \frac{\frac{1}{10}}{\frac{99}{10}} = \frac{1}{99} \text{ ohm.}$$

Similarly, if it is required to measure 50 amperes with the same ammeter, the value of a suitable shunt will be:—

$$R_S = \frac{\frac{1}{10} \times 1}{50 - \frac{1}{10}} = \frac{\frac{1}{10}}{\frac{499}{10}} = \frac{1}{499} \text{ ohm.}$$

These examples do not take into consideration the resistance of the leads between the shunt and the ammeter which it is assumed is negligible. Should the leads be long and have a comparatively high resistance, the value of the leads resistance should be taken into account.

The availability of current transformers lessens the use of shunts for alternating current work although they are adaptable. With a non-inductive shunt the ammeter reading will vary with a change of frequency, a lower reading obtaining with a higher frequency, due to the self-induction of the ammeter coil, so that accuracy is only obtained at a certain fixed frequency. This variation in the ratio of ammeter to shunt due to frequency change may be overcome by rendering the shunt slightly inductive so that its ratio of inductance to resistance (time constant) is similar to that of the ammeter coil.

A resistance used to alter the range of an instrument is of a high value and connected across the mains in series with the instrument concerned, so that the total potential drop takes place across both instrument and resistance, the drop in each being in proportion to its resistance. The value of the series resistance will depend upon the line pressure and is in each case of such a value that the pressure drop across the particular instrument is constant. Change of temperature error is countered by making the series resistance of such a metal as manganin which has a negligible temperature coefficient. The connections of a resistance in series with an instrument are given in Fig. 4, the instrument being now referred to as a voltmeter. The value of an appropriate resistance is arrived at as follows.

As the resistance and voltmeter are in series, the potential difference across the mains, E_M volts, is equal to the sum of the pressure drops across the resistance, E_R volts, and across the voltmeter, E_V volts, that is:—

$$E_M = E_R + E_V \quad \ldots\ldots\ldots\ldots(1)$$

The potential drop across the voltmeter alone is equal to the current in the voltmeter, C_V amperes, multiplied by the resistance of the voltmeter and similarly with the series resistance, thus:—

$$E_V = C_V \times R_V \quad \ldots\ldots\ldots\ldots(2)$$

$$\text{and } E_R = C_V \times R_R \quad \ldots\ldots\ldots\ldots(3)$$

Incorporating these values in formula (1) gives:—

$$E_M = C_V \times R_R + C_V \times R_V$$

$$\text{from which } R_R = \frac{E_M}{C_V} - R_V \quad \ldots\ldots\ldots(4)$$

The current through the voltmeter, as obtained from formula (2) is:—

$$C_V = \frac{E_V}{R_V}$$

Substitute this value of C_V in formula (4) and the following is obtained:—

$$R_R = \frac{E_M}{\frac{E_V}{R_V}} - R_V \text{ which after conversion gives}$$

$$R_R = \frac{E_M \times R_V}{E_V} - R_V.$$

Let it be assumed that the voltmeter has a resistance of 1 ohm and that when alone will measure up to $\frac{1}{10}$ volt. If the voltmeter is required to measure up to 100 volts, the value of the required series resistance will be:—

$$R_R = \frac{100 \times 1}{\frac{1}{10}} - 1 = 1000 - 1 = 999 \text{ ohms.}$$

Similarly, if the same voltmeter is required to measure 250 volts, the series resistance value will be:—

$$R_R = \frac{250 \times 1}{\frac{1}{10}} - 1 = 2500 - 1 = 2499 \text{ ohms.}$$

For medium and lower pressures, series resistances are often used in alternating current circuits, but for such it is essential that they be wound non-inductively. For higher pressures, potential transformers are generally found more adaptable.

Condensers may be used as range multipliers with voltmeters of the electrostatic type. A number of condensers are connected in series and placed across the mains. If the condensers are of equal capacity, the difference of potential across each condenser is the potential difference between the mains divided by the number of condensers in series. An electrostatic voltmeter connected across one condenser will therefore indicate some ratio of the total potential difference and by multiplication or suitably marking the scale, the total line pressure is obtained. Such an arrangement is depicted in Fig. 5. In this case the voltmeter would measure actually 2500 volts if the line pressure was 10,000 volts. In order to maintain the correct ratio it is essential that the capacity of the voltmeter be very small compared with the capacity of each condenser. The range of electrostatic voltmeters may also be extended by connecting them in series with condensers in which case the total potential difference divides between them inversely as their capacity and is suitable for set combinations only.

The inconvenient method of varying the range of gravity controlled instruments by alteration of the controlling force by an exchange of weights is seldom now practiced. There are various other methods of range variation adaptable for different instruments which do not call for the use of accessories as distinct from the instrument construction itself.

MECHANICAL PRINCIPLES.

Before considering in some detail the various types of indicating instruments it would be well to deal briefly with the more common requirements of such instruments as a class as distinct from the actual electrical operation.

Each instrument has to be fitted with means to enable the current passing through it to provide a moving action which in turn permits indication of the quantity of the flow in a convenient manner. Indication is generally obtained by attaching a pointer to the moving system so that the movements of the latter cause the pointer to run along a suitably marked indicating scale. Normally, the passing of current through the instrument causes the moving parts to take up some position between the two extreme points of zero and maximum deflection.

In order that the deflection may be proportional to the deflecting force, a controlling force which opposes and controls the deflecting force is necessary. The energising of the instrument causes the moving parts to take up some temporary position of equilibrium, at which position the deflecting and controlling forces are equal, the deflecting force tending to deflect further the moving parts, whilst the controlling force tends to return the moving system back to the zero position. The more common controlling forces utilised are the force of gravitation, with which the torque is proportional to the sine of the angle of deflection, and the torsion of a spiral spring, with which

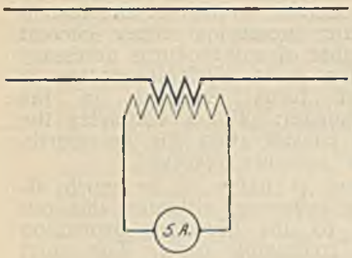


Fig. 1.

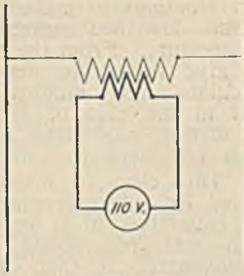


Fig. 2.

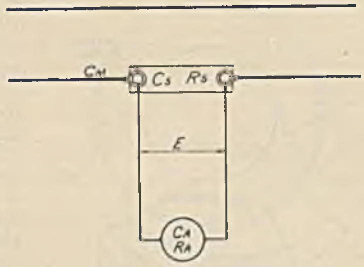


Fig. 3

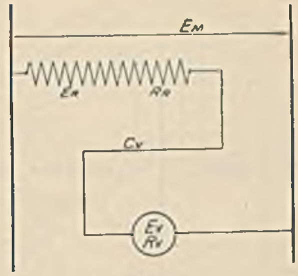


Fig. 4.

the torque is proportional to the angle of deflection. The system of control does therefore affect the form of the indicating scale.

Magnetic control is sometimes used. With spiral spring control it is customary to utilize two springs, generally one on each end of the moving systems spindle, and set in opposite directions so that one spring coils up when the other uncoils. Expansion or contraction of the springs caused by temperature variation is thus neutralised and no deflection of the moving system results from the variation in the length of the springs themselves. When such control is used with instruments having a moving coil the springs are available for conducting the current into and out of the moving coil.

The imparting to the moving system of an impulse due to a change in the magnitude of the current flowing through the instrument tends to promote oscillation. The general undesirability of such oscillation has led to the introduction of various means of damping, aiming at a "dead beat" indication. The more general attainment of damping is either through the agency of eddy currents, the viscosity of liquids, or air friction.

The eddy current damper consists usually of an aluminium disc so connected to the moving system of the instrument that a portion of the periphery rotates between the poles of a permanent magnet when the instruments moving system operates. Fig. 6 explains the operation of the damper. The action of the disc cutting the magnet field of the permanent magnet induces eddy currents in the disc, and, in compliance with Lenz's Law, such induced currents oppose the motion producing them, and consequently retard the disc and moving system. As this damping arrangement depends upon a magnetic effect it is more suitable for adoption in electrostatic and hot-wire instruments than in those types where the eddy current magnet may have an adverse effect if the magnet strength varies.

A simple damping arrangement is that afforded by immersing a light disc or wire spiral, which is attached to the moving system, in a liquid. Oil is generally used and the viscosity of the liquid prevents the rapid turning of the disc or spiral and so damps out the oscillation.

An air damping device of simple design consists of a fixed air chamber, in which a piston is arranged to travel with very small clearance. The chamber is sealed at one end and, the piston being connected to the instruments moving system, oscillation is hindered by either a compressing or suctioning action of the piston on the air in the chamber. Figure 7 illustrates this particular type of air damper; various other forms are in use.

Should the disposition of the moving parts not give balance about the spindle, balance must be attained by the addition of a counterpoise, which often takes the form of a threaded extended arm on which small weights are screwed.

It is essential that the weight of the moving parts and friction be reduced to a minimum in order that indication may be obtained with the least expenditure of power, for the power necessary to impart movement is proportional to the weight and friction of the moving system. Such lightness of movement is attained, amongst other methods, by using aluminium where possible, using a minimum of iron and by providing jewel bearings for spindle settings.

A B.E.S.A. standard specification dealing with indicating instruments gives particulars of other detailed requirements.

ELECTROMAGNETIC INSTRUMENTS.

This class consists of the moving iron type, the moving coil type, the dynamo-meter type and the induction type.

The Moving Iron Type.

The action of the moving iron type depends upon the effect of a magnetic field, produced by a stationary current carrying coil, upon a piece, or pieces, of soft iron, the resulting movement of which is arranged to provide the necessary indication. The moving iron type embraces several distinctive patterns, the principle of which it will be well to consider individually.

An elementary example of the repulsion type of the moving soft iron class is shewn in Figure 8. The coil

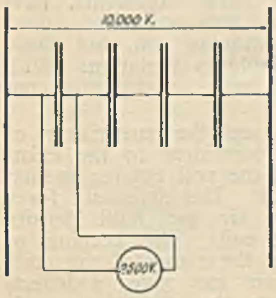


Fig. 5.

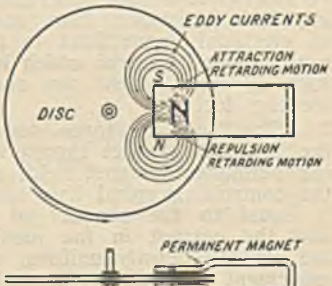


Fig. 6.

Fig. 7.

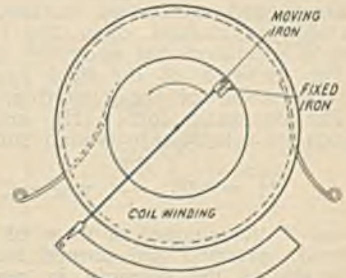


Fig. 8.

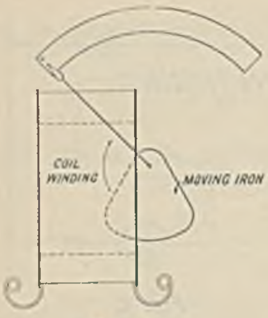


Fig. 9.

Fig. 10.

is wound on an insulated and non-magnetic bobbin. Set axially inside the coil are two pieces of soft iron, one fixed and the other capable of movement, the latter being attached to a suitably pivoted spindle set concentric with the bobbin. Whilst no current passes through the coil the two pieces of soft iron lie parallel to and near each other, with the pointer lying on the scale's zero mark. On the passing of current through the coil the two pieces of soft iron become magnetised, by the solenoid's magnetic field, so that each piece has similar polarity at the same ends. Repulsion between the now magnetised soft iron pieces results, and the piece capable of movement is repelled thereby causing the pointer to move along the scale. At any point, the force of repulsion is approximately proportional to the square of the current in the coil, for each soft iron piece is similarly magnetised, but the torque will not be similarly proportional as the distance between the moving and fixed soft iron pieces increases with the deflection. By using shaped iron pieces, and considering the type of control, it is possible to obtain an evenly or irregularly divided scale to choice.

That the strength of a solenoid's magnetic field is strongest and most uniform at the solenoid's centre is made use of in the instrument shewn in Fig. 9. A piece of soft iron is attached to a spindle, which also carries an indicating pointer. The energising of the coil results in the attraction of the soft iron piece towards the centre of the coil by an amount proportional to the current.

Another example of the moving soft iron class is shewn in Fig. 10. The action of this instrument depends upon the fact that although the magnetic field inside a solenoid is strongest and most uniform at the solenoid's centre, at the ends of the solenoid the field is strongest near the winding due to the leakage of lines through the sides. Thus a long piece of soft iron suspended inside the solenoid tends to move outwards to the winding, on the coil being energised. The illustration shews a curved thin soft iron plate, extending the length of the solenoid, which is fixed horizontally slightly to the side of the solenoid's centre. The movement of the plate causes rotation of the spindle, which also carries a pointer, by an amount dependant upon the field, and thus upon the current.

Moving iron instruments are suitable for use on direct and alternating current circuits for the motion does not depend upon the direction of the magnetic field produced, but upon the strength of the field alone. The strength of the field produced depends upon the construction of the operating coil for a given current. The magnetic force (H) inside and parallel to the axis of a uniformly wound coil or solenoid, is:—

$H = 1.25 \frac{CT}{l}$, where C is the current in amperes and T the number of turns of wire (these two are generally grouped and termed the ampere-turns) and l the length of the solenoid in centimetres. Similar dimensioned coils with various values of C and T but with their products equal have the same magnetising force. It is possible, therefore, by adopting different coil windings to make the moving system of the instruments described suitable for measuring either current or pressure. From the number of ampere-turns necessary to give full scale deflection it is a simple matter to calculate the number of turns required on the coil in the case of an ammeter. For a voltmeter the calculation must take into consideration the necessarily high resistance to suit the pressure involved.

This class of instrument is liable to be much affected by external magnetic influence, although this can be countered to a degree by the diverting protection of a soft iron shield or containing case. The chief disadvantage is that of hysteresis which results in a decreasing current indicating more than the same current indicates whilst ascending. The use of a small amount of well annealed soft iron makes this and eddy currents faults less prominent. In the attraction type the deflection is almost proportional to the current when the moving iron is saturated. Up to saturation point the deflection is proportional to the pole strength of the iron and the strength of the coils field so that a small mass of very soft iron also promotes an open and evenly divided scale.

Change of temperature error in the case of a voltmeter is often met by using a comparitively low resistance coil of copper wire with a series high resistance of extremely low temperature coefficient alloy, in which case the change in resistance of the copper coil with variation in temperature is so small when compared with the total resistance that it is negligible.

The winding of a series resistance non-inductively reduces frequency error on alternating current circuits, for then the inductance of the coil is small when compared with the total resistance of coils and series resistance. Without correction an instrument that has been calibrated with direct current will tend to indicate less than the true value when used with alternating current, but instruments are at present available which give equal accuracy on direct current and alternating current at all ordinary frequencies.

A coil consisting of two or three distinct windings or with tappings taken off a common coil are multi-range obtaining means sometimes adopted with moving iron ammeters.

The Moving Coil Type.

This type of instrument depends for its action upon the rotative force exerted upon a current carrying coil whilst the coil is in a magnetic field. Generally the instrument chiefly consists of a coil of fine wire so pivoted that it lies in a strong magnetic field provided by a stationary permanent magnet. Fig. 11 illustrates the general construction of a typical moving coil instrument. A permanent magnet fitted with soft iron cylindrically bored pole pieces has in its centre a permanently fixed soft iron core with a small air gap between the pole pieces and the core. In this air gap the moving coil is pivoted so that it is capable of rotating to a degree dependant upon the design of the particular instrument. The moving coil is generally fitted with two hair springs, one at each coil end. These provide the controlling force and also serve as electrical connections to the moving coil. In very low resistance instruments silver ligaments, having less resistance than springs are sometimes used as electrical connections to the moving coil, but these exert a small control which is liable to variation. With such an arrangement one spring may provide the controlling force.

The lines of force set up on the energising of the coil tend to set themselves coincident to the existing permanent magnet field, and the coil rotates against the controlling spiral hair springs. The deflecting force is equal to the product of the air gap field density and the current in the moving coil. The keeping of the air gap density uniform over the range of the coils movement by utilising a small air gap gives a deflecting force directly proportional to the current promoting an open and evenly divided scale. The moving coil is generally wound upon a light metal frame and a damping action is obtained through the agency of the eddy currents induced in the frame.

A serviceable development of the moving coil type is that in which a flat circular pole shoe is interleaved between two plates having opposite polarity to that of the centre pole shoe, thus forming two air gaps which are geometrically and magnetically in parallel. The active conductors of the coil are those lying parallel to the pointer and not those at right angles as is generally the case. The coil on functioning may attain an angular motion up to 300°, its motion being only limited by the narrow neck supporting the centre pole shoe. The disposition of the pole pieces provides an astatic magnetic system with consequent freedom from external magnetic influences. Damping is effected by eddy currents in the metal former upon which the moving coil is wound.

The necessarily delicate construction and operation of the moving coil and its connecting conductors permit only the use of very small currents. The instrument may be used as either a voltmeter or an ammeter, but it is necessary to employ a shunt when any but extremely small currents are involved.

The limiting of the mass of the moving coil and temperature variations are generally overcome by placing a high resistance of negligible temperature coefficient in series with the moving coil when the instrument is required to serve as a voltmeter. The easy attainment of this dual use with the same movement will be evident from the calculations previously given when dealing with the general use of shunts and series resistances.

Moving coil instruments are suitable for direct current circuits only as the direction of the current flow decides the rotational direction of the moving system. The number of ampere-turns required is small, due to the intense magnetic field, and enables the use of a light moving system, giving sensitiveness and a small watt consumption. Hysteresis errors are entirely absent and the instruments very "dead beat." The possible drawbacks to moving coil instruments as a class are the effect of time upon the hair-springs and permanent magnet, the influence of external fields and temperature change in ammeters.

The Dynamometer Type.

Dynamometer instruments are similar to the moving coil instruments previously described, except that the permanent magnet is replaced by a stationary coil which usually surrounds the moving coil. The instrument in its simple form is depicted in Figure 12. This consists of a fixed rectangular coil and a moving coil fitted on a spindle so that it is capable of rotating inside the fixed coil. The customary controlling force is that provided by spiral hair-springs, which also serve to convey the current into and out of the moving coil. The energising of the coils causes each one to set up

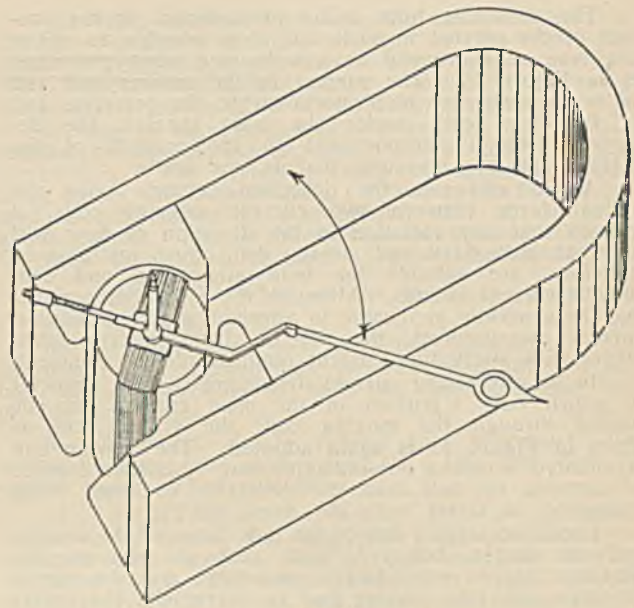


Fig. 11.

lines of force which are at right angles to the plane of each respective coil. The mutual reaction between the two fields causes the moving coil to rotate so that its field may be in line with or parallel to the lines of force of the fixed coil. The intensity of each field is proportional to the ampere-turns of its respective coil and, as the force between two fields depends directly upon the product of the two fields strength, the deflecting force is proportional to the product of the current in each coil, for in both the number of turns is constant.

In ammeters of this type for the measurement of very small currents, the fixed and moving coils are connected in series. The necessity of restricting the mass of the moving coil leads to the introduction of a shunt when larger currents are involved, so that only a portion of the main current is passed through the moving coil as shewn in Figure 13. The current in the moving coil being proportional to the current in the fixed coil, that is, the main current, the deflection is proportional to the square of the current, tending to promote an unevenly divided scale.

Figure 14 depicts the connections of a voltmeter. The current in both coils being proportional to the potential difference of the mains, the deflection will be proportional to the square of the voltage and again tends to an unevenly divided scale. An additional series high resistance of manganine or similar material is incorporated.

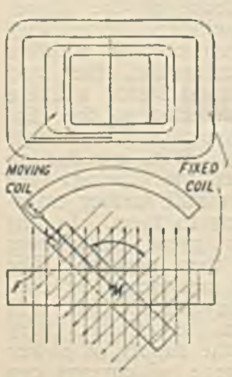


Fig. 12.

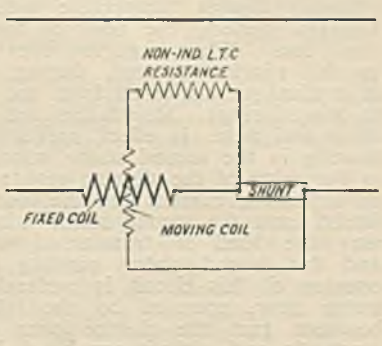


Fig. 13.

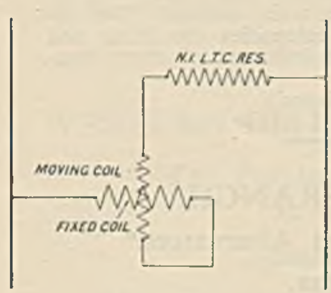


Fig. 14.

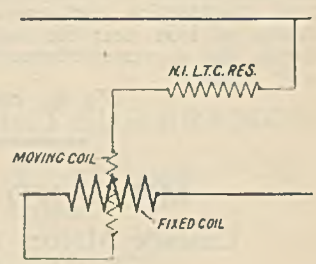


Fig 15.

The deflecting force being proportional to the product of the current in each coil, it is possible to utilise this type of instrument as a wattmeter when connected as in Figure 15. The current in the moving coil and its series resistance is proportional to the pressure, and as the fixed coil carries the main current, the deflective force is proportional to the product of the current and the pressure, that is, the watts.

As in all cases the deflection depends upon the mutual force between two current carrying coils, it follows that any variation in the direction of flow will influence both fixed and moving coil. Such instruments, therefore, are suitable for both alternating and continuous current circuits. Although the foregoing remarks may be generally applicable to alternating and continuous current measurement, the use of dynamometer instruments with alternating current requires further comment.

In an alternating current dynamometer type ammeter in which only a portion of the main current may be passed through the moving coil, the arrangement as given in Figure 13 is again adopted. The moving coil is shunted across a non-inductive low resistance capable of carrying the full load, the resistance or shunt being connected in series with the fixed coil.

Frequency errors due to the inductance of the moving coil are liable, however, with such an arrangement. To meet this a non-inductive resistance may be placed in series with the moving coil to overwhelm the inductance and so render the circuit almost non-inductive, or the error may be countered by making the time constant of the shunt equal to that of the moving coil. The value of the shunt will be such that the potential difference is sufficient to send enough current through the moving coil and its series resistance to give full scale deflection. The series resistance of the shunted circuit will be of a low temperature co-efficient material. Similar correctional precautions are taken in dynamometer type voltmeters and wattmeters for use on alternating current circuits. As the deflection in all cases is proportional to the product of the fields produced by the fixed and moving coils, the deflection in the case of a wattmeter is directly proportional to the actual power in watts, as by multiplying the instantaneous values of the current and the pressure the true, and not the apparent, watts are obtained for an inductive load.

Dynamometer instruments are generally used as wattmeters in alternating current circuits as the moving coil type for continuous current and the moving iron and induction types for alternating current are cheaper and as suitable for service as ammeters and voltmeters. As a rule they are constructed with an absence of iron so that they may not be greatly affected by frequency hysteresis and eddy current errors, and may be equally accurate on alternating and direct current if designed with care. Shielding is generally necessary to prevent interference from external magnetic fields. The tendency of electrostatic attraction arising from difference in potential between the fixed and moving coils makes it undesirable to take high pressures direct to the instrument. The majority of dynamometer instruments are constructed with an absence of iron near the coils but instruments are available which incorporate iron in their construction and operate with success. The inclusion of iron near the coils intensifies the fields and shields the movement from the influence of stray magnetic fields.

(*To be continued.*)

MIDLAND BRANCH.

Cascade Motors and Alternators.*

Discussion.

Mr. R. WILSON said he thought all would agree that Mr. Hunt had done remarkably well to cover the ground in so short a space of time. He personally, was struck with the variety of uses to which these machines were particularly applicable. It was a machine very suitable for driving a fan. At one of the collieries with which he was connected they had one of these machines, of about 400 h.p., and whilst he could not be too definite he believed it ran for continuous periods of about six months. There were no sliprings, and consequently not a deal to go wrong with it. He was interested in the application of these machines for haulage. He did not know whether there were any examples in this country of their application to deep winding, and would like to be informed on this point.

Mr. H. COTTON said he was very pleased to have heard Mr. Hunt, and to express his appreciation of that gentleman's ingenuity in developing what must be one of the most remarkable machines on the market. He thought the cascade motor was most interesting and a most satisfactory method of control. Mr. Hunt had pointed out that the single winding was called upon to perform so many functions; it had to carry currents of two different frequencies. It was essential that the two fields should not be mutually inductive. Another essential was that there should be no unbalanced magnetic forces.

Mr. Cotton said he did not know anything about the price of the machine, and the price did not concern them so much as performance. He presumed that most of those present were more particularly interested in colliery work. Mr. Hunt mentioned the application of cascade motors to electric winding. He had certainly made out a very good case for this motor in several cases, and had given papers which had been published in various Journals. He would like to ask Mr. Hunt whether he would regard it as suitable for an extremely large winder, for example Harworth Colliery, or some of the large South African mines. Would there be any surge of current in changing over; possibly there may be with a very large machine of that kind?

It had a very good application for driving a mine fan; the power falls off very considerably as the speed is reduced and it was possible to make the motor to run at two speeds. One item with regard to a fan, the torque must be very good to get up speed very quickly, which appears to be a disadvantage in the use of a salient pole machine. He presumed the cascade motor could be used for power factor regulation. For intermittent control the cascade motor would be as good as any. It could be useful with main and tail haulage, the control was much superior, and a creeping speed of constant torque could be reached. In the same way the possibility of getting a uniform creeping speed would also be very valuable for electric winding, especially when a shaft had to be examined.

Mr. HUNT.—For the driving of large winding engines, the Ward-Leonard system is probably the most suitable. The cascade system is very efficient for small and medium sizes of winders up to about 600 to 1000 B.H.P. Tests obtained from cascade winding engines having an R.M.S. rating of 600 B.H.P. gave overall efficiency figures comparable with those of the Ward-Leonard system, the cost of the winders being very much less. When changing over from cascade coupling to the slipring control, during acceleration, the load is gradually transferred from the second stator winding to the sliprings. Resistances are connected to the sliprings and these, in effect, partially bye-pass the currents flowing in the second stator winding. With a reduction in the value of the slipring resistances, the sliprings take an increasing current and the load is still further transferred from the second stator winding to them. In this way the load is transferred with great smoothness and the second stator winding is then opened. The opening of this circuit is preferably performed by contactor gear, operated by the falling current. It will be seen that the change over can be effected very gradually and without any break in the supply of power from the mains, consequently no surge of current can result.

* See *The Mining Electrical Engineer*, Dec. 1929, Jan. 1930

With regard to fan drives, the first cascade synchronous motor made was direct-coupled, by a rigid coupling, to a colliery fan and started without the slightest difficulty and with a power factor, during starting, of about 0.9. The full load output was 450 B.H.P. Motors of this type have been built for leading power factors as low as 0.4 for power factor correction.

For driving pumps, two- and three-speed motors have been supplied with simple control gear for automatic starting and stopping.

Mr. NORTHCOTT said there were two questions which had occurred to him; he was not quite clear whether a single speed motor without sliprings could be made for more than one speed.

Mr. HUNT.—A motor having a short-circuited rotor runs at only one efficient speed but, by resistances connected to the stator tappings, the speed can be controlled down to 2% of full speed.

Two or three speeds are obtainable by the use of three sliprings.

Mr. NORTHCOTT.—Taking fifty cycles, is there more than one speed?

Mr. HUNT.—With 50 cycle supply, motors can be built for cascade speeds of 500, 333, 250, 200, 166, 143 r.p.m. and so on, the total number of poles being a multiple of 6.

The highest speed for which a two-speed motor can be built, for 50 cycles, is 50% greater than the cascade speed, and for three-speed motors three times cascade speed.

Mr. NORTHCOTT.—When driving compressors with two or three speed motors, how is the control gear arranged for starting up? For instance, would it always be started up on the bottom speed, and as the demand for air grew would it come up to second speed and then on to top speed and would it drop in the same manner, by automatic control?

Mr. HUNT.—Yes, that is the case, preferably by contactor gear. If only two speeds are required it is possible with a high voltage machine to change the speed without any switching in the stator circuit.

Mr. WILSON asked Mr. Hunt to explain what there was about a self-paralleling alternator which allowed it to be switched in without anything much happening and when there was current on the bus bars. In the old days that could not be done.

Mr. HUNT.—Mr. Cotton has already given the principle reason why the behaviour of these alternators differs so widely from that of ordinary synchronous machines the fact that they are mainly induction generators. To be precise two-thirds induction and one-third synchronous machines. It has also to be remembered that the whole of the stator windings is available for damping purposes.

Mr. PIDCOCK said he would like to enquire respecting the difference in power factor as regards the different speeds, and if the air gap has been altered.

Mr. HUNT.—An example will best reply to this question. A three-speed motor, wound for 10, 20, and 30 poles, has corresponding power factors of 0.93, 0.87, and 0.74. The air gaps of these motors are of normal length.

Mr. NORTHCOTT, referring to Mr. Hunt's remarks about cascade alternators explaining the damping effects due to the parallel action, asked why could not the same effect be got with heavy damping grids?

In regard to the use of cascade motors for winders would he explain when it was an advantage to use a cascade motor instead of an ordinary slipring machine.

Mr. HUNT.—Heavy damping grids could not produce the same effects.

The main difference between the cascade alternator and the ordinary machine is that in the first the power is generated in two stages, one induction and the other synchronous, whilst in the ordinary alternator the power is generated in one synchronous stage.

Coming to the question of winders, the only saving effected by the cascade system is in the losses during acceleration. The system is only of advantage when these losses are considerable, i.e., when the time occupied in accelerating is a substantial part of the total winding time. This is irrespective of the reduction in the peak load which is often of great importance.

Mr. HUDSON.—What are the particular advantages of the cascade alternator?

Mr. HUNT.—Its self-paralleling properties. In addition it has a completely short-circuited rotor winding, having two bars in half the slots and one bar in the remainder.

Mr. WYNESS.—Is the control gear as robust, and would it stand the rough usage in a pit; and does it require more skilled attention?

Mr. HUNT.—Cascade motors driving haulages, pumps, compressors, fans and other machines found in collieries have been in regular and successful service for many years. The control gear is as robust as that for other types of motors and requires no more skilled attention. The motors themselves are very much more robust than slipring motors which, in many places, they have replaced.

Mr. F. SMITH.—In a colliery we have two turbo-alternators, each of 500 k.w., and both are run for the day shift. It is proposed to put in an electric winder at an outlying shaft. We dont want to run the two turbines during the night shift; would the use of a two-speed cascade motor, for the winder, enable us to shut down one turbine during the night shift.

Mr. HUNT.—That would be a very good application. The winder could be arranged for full speed or two-thirds, and if the lesser speed was sufficient for the night shift one turbine could be shut down.

Mr. GRICE.—It was stated that the short circuit current was roughly twice full load current. Would the short circuit current on a fault be less than from an ordinary generator?

Mr. HUNT.—Yes, much less.

Mr. GRICE.—That would mean gaining economy in the rupturing capacity of the switchgear.

A SPEAKER.—Could the cascade system be applied to a coalcutter of, say, 30-50 h.p.?

Mr. H. COTTON here pointed out that the cascade motor would not be suitable for a coalcutter, because of the limitations imposed on the design by the restricted space available.

Mr. H. COTTON proposed a vote of thanks to Mr. Hunt. Mr. W. Wyness seconded, and Mr. Hunt briefly responded.

WESTERN DISTRICT SUB-BRANCH.

The Problem of Peak Loads.

G. E. HIDER.

(*Continued from page* 260)

The general principle of thermal storage as a means of meeting peak loads has now been considered briefly. The economic advantage of applying either one or the other system is a question which can only be considered in relation to individual conditions and requirements.

Before proceeding to discuss other means of meeting peak loads it will be useful to take an actual plant and to discuss the ability of that plant to meet peak loads, and then to determine the effect of adding an accumulator of the type which has just been discussed.

A diagram of the arrangement of the plant is shewn in Fig. 5. The relative quantities are given in the illustration Fig. 6, but in view of the importance of the conclusions, these are repeated in Table V. The function of such systems has been dealt with firstly, because the principles are not so well known as the generally accepted "Primary" method of dealing with peaks. The whole question is one of elementary thermodynamics and for peak loads of certain magnitude the principles must receive the full consideration of engineers.

Let us now consider another type of peak load which clearly demands investigation along other lines in order to determine the true economic solution which, after all, is the true engineer's solution. Fig. 7 is purely an imaginary diagram, designed for the special purpose of illustrating the principle already discussed and to extend the discussion into alternative spheres.

Assume that the prime movers require 20 lbs. of steam per k.w. hour. Throughout 22 hours the steam must be supplied at 4,000 lbs. per hour, and for 2 hours at 8,000 lbs. per hour, making a total in the 24 hours of 104,000 lbs., which corresponds with an average of 4,333 lbs. per hour. The number of electrical units generated in 24 hours will be 5,200 and the average load 216.66 K.W.

If now we speed up the rate of firing of the boiler to correspond with an evaporation of 4,333 lbs. per hour instead of 4,000 lbs. per hour required by the 200 K.W. load, we have available for storage 333 lbs. of steam per hour for 22 hours, or its equivalent, so that at the end of this period we have stored 7,326 lbs. of steam, or equivalent heat, to meet the 2 hours' peak. This would be discharged at the rate of 3,666 lbs. per hour. The similarity between the functions of a steam accumulator and a flywheel will be apparent.

Some important facts emerge from the consideration of such an elementary curve as Fig. 7. It will at once be appreciated that a two-hour load, double that existing throughout the rest of the day, will just double the gross capital charges, if the load be met by bringing into commission a duplicate plant. Whether the capital charges imposed by such a load as that depicted may be greatly reduced by the installation of some system of thermal storage, as apart from peak load units, would

TABLE V.

Data Relating to Curves Shewn in Fig. 6.

Three Water Tube Boilers—

Working Pressure: 205 lbs. Gauge.
Rated Evaporation: each 27,000 lbs. per hour.
Water Content: each 850 cub. ft.
= Total—137,000 lbs.

Accumulator Capacity—

2550 cub. ft. = 137,000 lbs.

The three boilers work to meet a normal steam demand of 50,000 lbs. per hour, total from feed at 160° F. with very heavy sudden peak demands occurring for short intervals (see Fig. 7) making the average equal to 55,000 lbs. per hour.

With the accumulator, a constant rate of firing is maintained corresponding to 55,000 lbs. per hour from feed at 160° F. when feed is supplied from the accumulator at, say, 385° F. Evaporation due to rate of firing increases to 70,000 lbs. per hour.

Analysis of Automatic Release of Steam due to Pressure Drop.

	Pressure Drop P_1 to P_2 Lbs. Gauge	*Steam Temperature at P_1 & P_2 Deg. F.*	*Heat Released From Water B.T.U.'s*	*Latent Heat at P_2 B.T.U.'s*	*Evaporation Due to Press Drop Lbs.*	*Rate of Evap'n if Drop Occurs in 1 Minute Lbs./Hour*	*Rate of Evaporation Due to Firing Lbs./Hour*	*Total Rate of Evap'n During Peak Demand Lbs./Hour*
With Accumulator	205-200	390-388.0	580,000	838.2	692	41,500	70,000	111,500
	205-195	-386.0	1,160,000	840.2	1380	83,000	70,000	153,000
	205-190	-383.9	1,770,000	842.1	2100	126,000	70,000	196,000
Without Accumulator	205-190	390-383.9	835,000	842.1	992	59,500	50,000	109,500
	205-180	-379.7	1,410,000	846.0	1670	100,000	50,000	150,000
	205-170	-375.4	2,000,000	849.9	2360	141,500	50,000	191,500

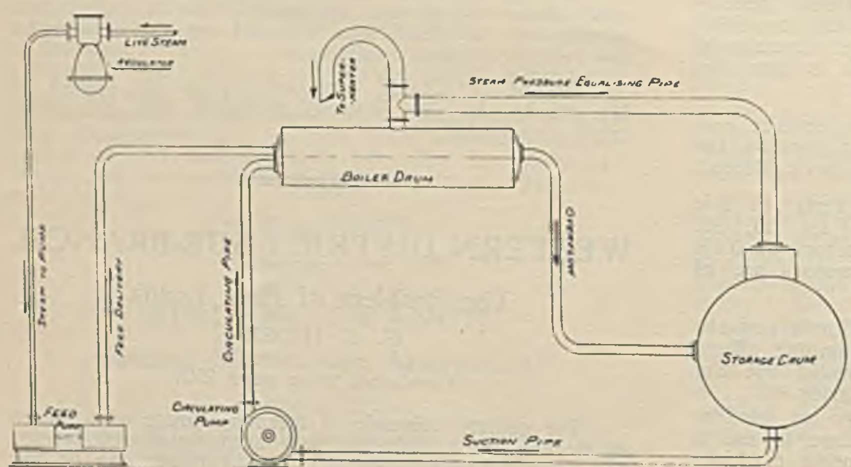


Fig. 5.

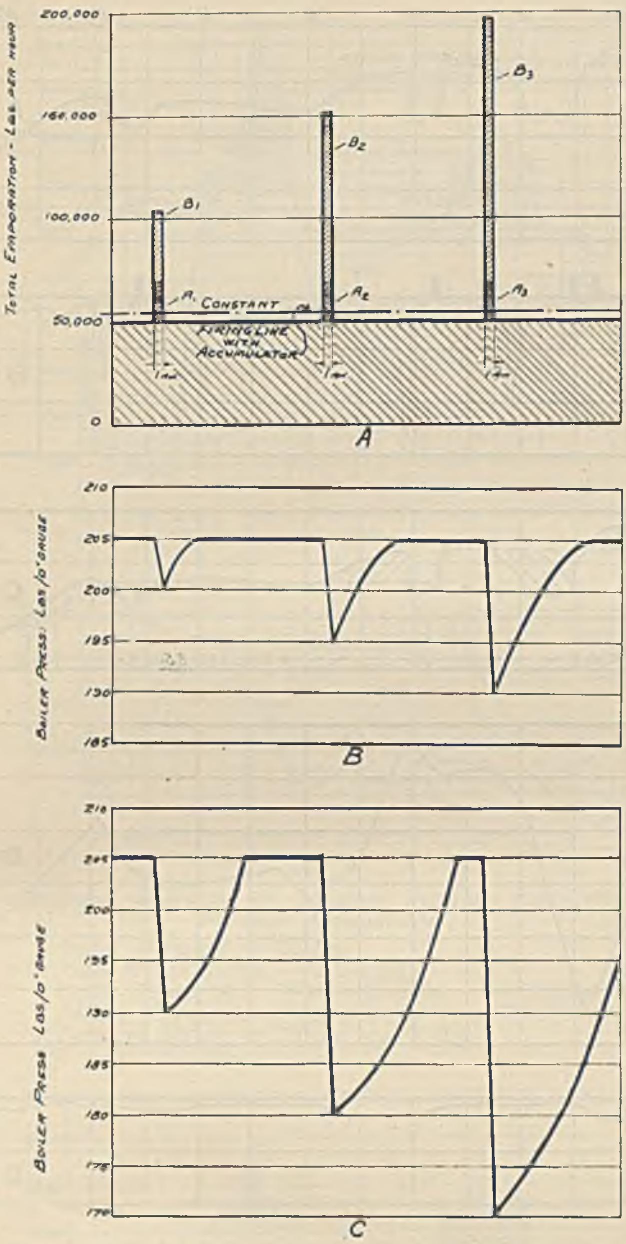


Fig. 6.

Operation of Thermal Storage to meet Peak Loads as applied to Water Tube Boilers.

(*A*) *Imaginary Steam Load for One Hour.* B_1, B_2, B_3, *Automatic Evaporation from Water Content of system due to Pressure Drop.*

(*B*) *Pressure Variation Curve with Accumulator. Note Recovery of Steam Pressure is effected rapidly by the Regulator automatically cutting off the feed at* 160 *degs. F. and supplying feed from Accumulator at, say,* 385 *degs. F. On recovery of Pressure no blowing-off occurs, but feed at* 160 *degs. F. re-starts and accumulator is recharged.*

(*C*) *Pressure Variation Curve without Accumulator. Note Recovery of Steam Pressure can only take place when increased Rate of Firing takes effect or Steam Demand falls below normal. On recovery of pressure blowing-off occurs until fires are reduced to normal.*

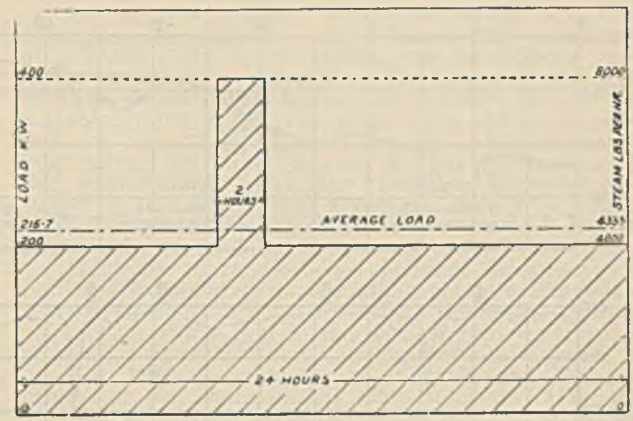


Fig. 7.

require careful investigation of all the factors involved, all of which are easily within the capacity of modern engineers.

In passing this phase it is certain that the question of Interest on Capital expended and the Depreciation of the units will be brought into consideration. These quantities are generally elastic and are not infrequently stretched by the engineer in the direction which will give him the answer he wishes to find. Electrical engineers are notorious culprits in this matter, and the Author would suggest seriously that in the Examinations of the Association a paper on elementary thermodynamics should be included in order that an electrical engineer when analysing the economics of a proposal may make his analysis complete.

Generally, however, load curves are not so simple as those shewn in Fig. 7, and the problem not so easy to solve.

Fig. 8 shows the details of an investigation into a proposed boiler installation to supply a 40,000 K.W. power station supplying electrical energy to rolling mills. As is well known, it is not possible to throw rolling mill motors of several thousand horse power off the line without disturbing the economics of power generation. The top curve A in Fig. 8 shows the probable load curve for such a station. The second curve B shows the probable pressure fluctuation; the block areas at the top of the curve indicate blowing off which occurs without the storage of excess heat, transferred from the gases beyond that which is required in the steam demanded by the load. The fourth curve D shows the charging and discharging of the accumulator.

It will be appreciated that the design of the accumulator necessitates careful consideration of all the quantities. Peak loads up to 25% may be met practically at constant pressure, as is shewn in the bottom curve E of Fig. 8.

It will perhaps now be clear that there are two very distinct methods of meeting peak loads by the instantaneous actuation of certain physical conditions apart from the variation of the heat transmitted from the gases to the water. These methods are:—

(1) The flashing into steam of water reduced in pressure.

(2) The supply of feed water at the temperature of the steam.

In passing this phase it should be noted that we have very reliable data to show that the economy in fuel in the latter case is not merely that due to the fact that no sensible heat is to be supplied. This appears to be quite as we should expect. If we endeavour to heat a body of water by conducting and convection, certain motions of the particle must take place, and energy expended, but if the water be pumped into the boiler at steaming temperature this motion is eliminated and greatly reduced, and the medium is ready to flash into steam upon the reception of heat.

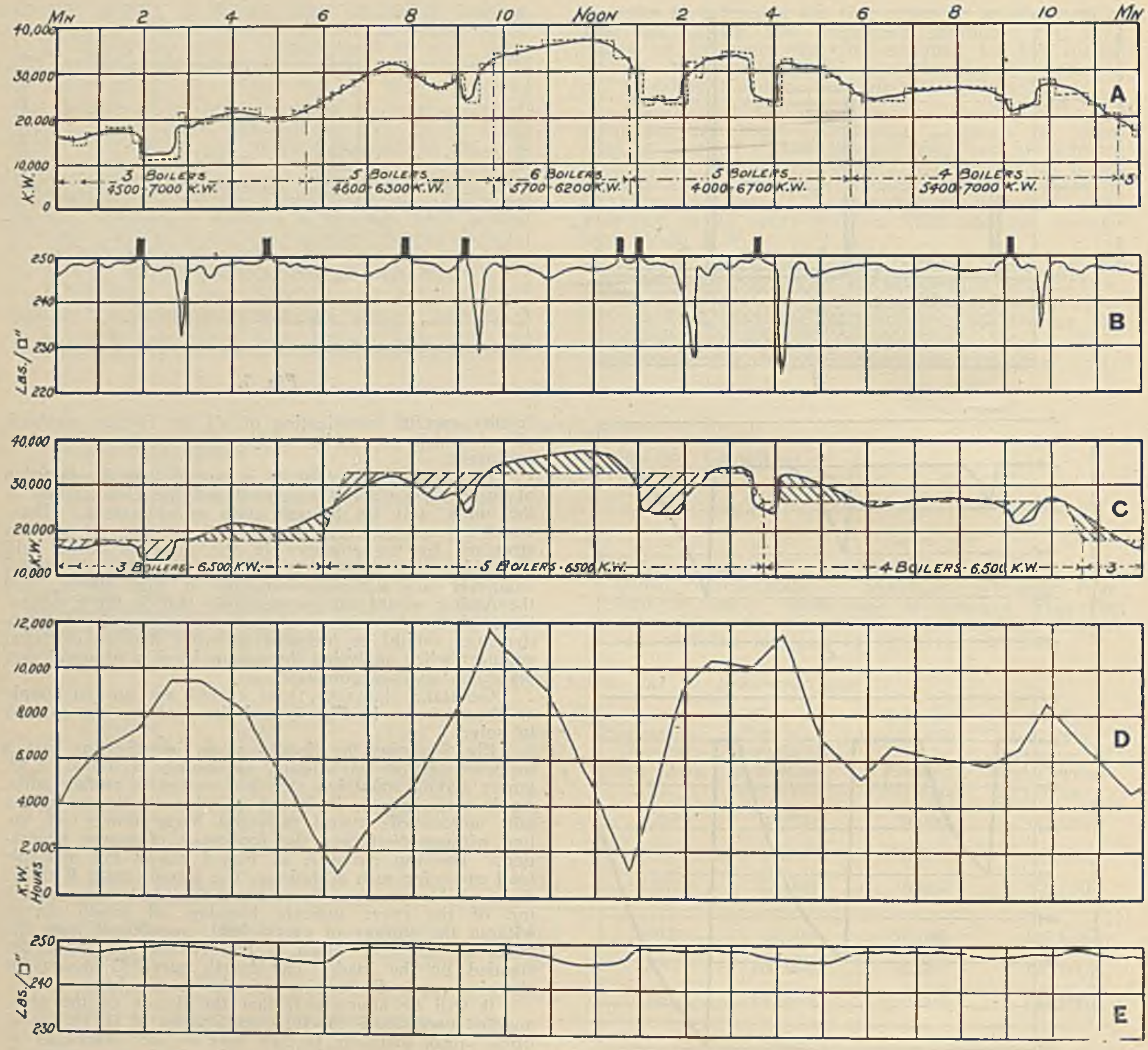


Fig. 8.

A. Load Curve shewing Firing Line regulated to follow the Load.

B. Curve of Boiler Pressure fluctuating with Varying Demand.

C. Load Curve shewing Firing Line with Accumulator installed.

D. Chart shewing Charging and Discharging of Accumulator.

E. Curve of Boiler Pressure shewing the Regulating Effects of Accumulator.

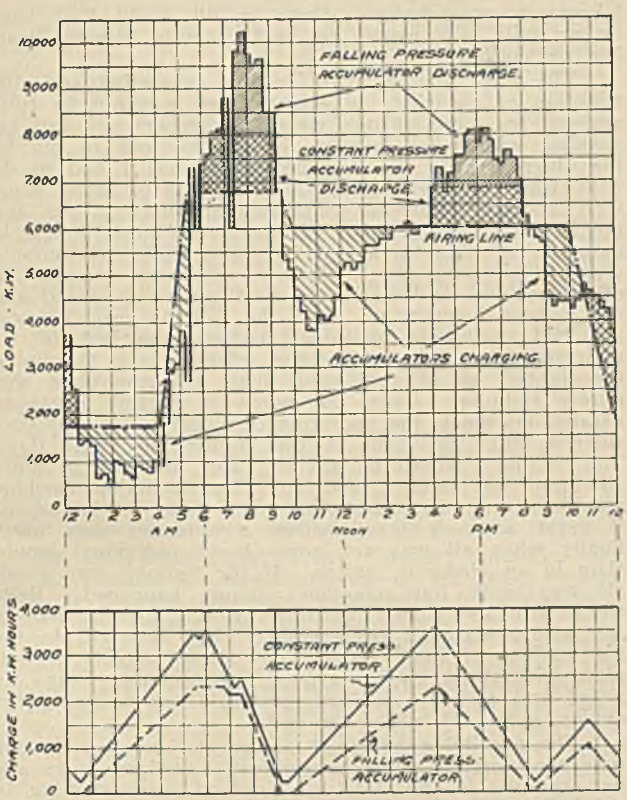
Without Thermal Storage.

With five boilers working, each having water capacity of 70,000 lbs. the heat released by pressure drop from 250 lbs. to 230 lbs. = 2,580,000 B.T.U's. = 3120 lbs. of steam = say, 250 k.w. hours = 3,000 k.w. for 5 minutes. Thus a sudden increase in demand of 3,000 k.w. will cause boiler pressure to fall 20 lbs. in 5 minutes before increased firing becomes effective. Similarly increased demand causes blowing-off until firing is reduced.

With Thermal Storage.

Heat required for steam at 250 lbs. and 650 degs. F. from Feed at 160 degs. F. = 1216 B.T.U's. per lb. Heat required for steam at 250 lbs. and 150 degs. F. from feed at 406 degs. F. from accumulator = 964 B.T.U's. per lb. Increased rate of evaporation with feed from accumulator = 26 per cent.

When demand falls the surplus heat is absorbed in recharging the accumulator. No blowing off occurs.



CHARGE AND DISCHARGE OF ENERGY AT ACCUMULATORS.

Fig. 9.

Combined Operation of Constant Pressure and Falling Pressure Accumulators.

Boiler Pressure = 220 *lbs.*
Feed Water Temp. = 210 *degs. F.*
Cons. Press. Acc. Water Content = 5,000 *cu. ft.*
Falling Press. Acc. Water Content = 10,000 *cu. ft.*
Pressure Range = 220 *lbs. to* 90 *lbs.*

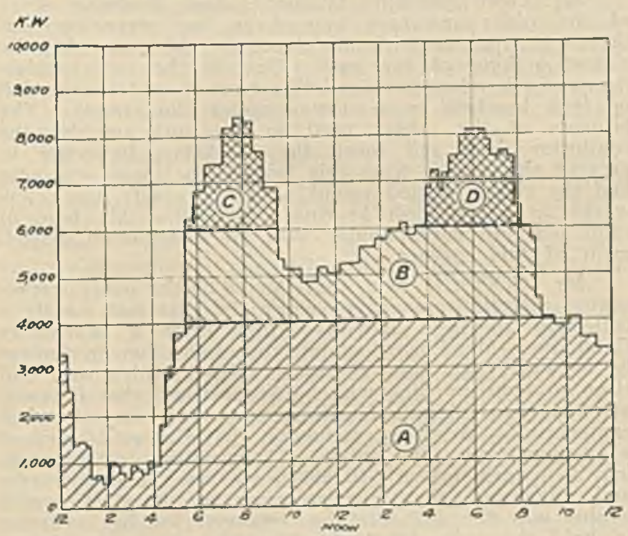


Fig. 10.

A.	82,200 *k.w. hrs.*	*in*	24 *hours*	=	3,425 *k.w.*	*average.*
B.	27,600	„	„ 15½	„ =	1,780 „	„
C.	6,000	„	„ 4	„ =	1,500 „	„
D.	6,400	„	„ 4	„ =	1,600 „	„
Total	122,200	„	„ 24	„ =	5,092 „	„

Let us now examine a curve in which both these principles are utilised. Fig. 9 shows the load curve of a 10,000 K.W. power station. In the 24-hour curve shewn two large peaks occur. The course of the firing lines is shewn. The highest corresponds to a performance of 6,800 K.W. The peaks lying above the firing line are covered by the accumulators, while the excess heat during the steam demand periods is taken up by the accumulators. A falling pressure accumulator of 10,000 cu. ft. capacity with a pressure drop from 220 lbs. to 90 lbs. works in conjunction with a constant pressure accumulator of 5,000 cu. ft.

With the above mentioned pressure drop the steam produced from storage in the falling pressure accumulator is equivalent to 2,500 K.W. hours while the constant accumulator stores heat in the form of feed water supply at boiler temperature equivalent to 3,500 K.W. hours.

The latter accumulator is able to meet the peak demand up to, approximately, 26% in excess of the rate of firing at constant pressure. When this rate of demand is exceeded, steam is released from the falling pressure accumulator. These operations are indicated by the shaded areas above the firing line in Fig. 9.

The curves in the lower diagram of Fig. 9 shew the charging and discharging of the two accumulators. The capacity of the accumulators is in each case expressed in K.W. hours, the equivalent steam being in this case about 14 lbs. per K.W. hour.

In the Railway Power Station mentioned, with boilers of 6,458 sq. feet and 3,983 sq. feet heating surfaces and working pressure of 320 lbs., without accumulators about 25,000 sq. feet of heating surface must be held under fire; that is to say, four of the larger boilers. With the installation of the constant pressure and falling pressure accumulators 17,000 sq. feet is sufficient. This requires only two of the larger and one smaller boiler in operation.

As stated above the falling pressure accumulator with water content of 10,000 cu. ft. has a storage capacity equivalent to 2,500 K.W. hours, i.e., 0.25 K.W. hour per cu. ft. The constant pressure accumulator with a water content of 5,000 cu. ft. has a capacity equivalent to 3,500 K.W. hours or 0.70 K.W. hour per cu. ft. Thus the storage capacity of the constant pressure system is nearly three times as much as the other.

The operation of a constant pressure system in conjunction with a falling pressure accumulator is therefore desirable only when sudden peaks are of such magnitude and duration that they cannot be met by the constant pressure system alone. As far as possible the principal fluctuations should always be met at constant pressure.

If the essential principles be grasped it is easy to see that the engineer can with close accuracy keep the pressure drop within allowable limits, even when he has to contend with peaks of very large magnitude.

We must now briefly discuss certain peak load problems which may best be met by primary peak load units.

The Electricity Supply Act, 1926, is designed to concentrate the generation of electricity into a few super power stations and the distribution of electric energy on a large scale by long distance systems of high tension transmission. According to statistics and the experience of large cities in industrial districts, the units generated to cover the base loads of what are termed the first and second order, may amount to 95% of the total supply. Owing to more even distribution over a lengthy period this demand can be met by only 50% of the power station rating during peak load periods. The peak load is responsible for only about 5% of the total supply but in the case referred to it requires not less than the balance of 50% of the maximum rating. These facts are well known and are a matter of concern to all who are responsible for the production of electricity at the lowest possible rates.

In conclusion, the load curve of Fig. 9 is dealt with in another manner and is shown in Fig. 10. It will be seen that it is divided into base loads of 1st and 2nd order and into the two superimposed peak loads of 3rd order It will be seen that such a curve may be divided into three different kinds of loads, viz.:

(1) A three shift base load of the 1st order practically constant for the 24 hours.

(2) A two shift base load of the 2nd order practically constant for 2 shifts.

(3) A further load consisting of two large sharp peaks lasting about 4 hours each.

From a consideration of such a curve these facts emerge:—

(1) That if the plant is installed capable of dealing with the peak loads much capital is lying idle for a very appreciable part of the year and is entirely unproductive; and, apart from these monetary losses, the operating efficiency is greatly reduced.

(2) The risk of breakdown caused by the production of the small amount of electrical energy represented by the peak loads ought to be carried by special peak load sets, either primary or secondary, and not by the base load sets responsible for the production of, say, 90% ot the units produced.

The essential facts leading to the only solution to to any such problem appear to be fairly easy to determine.

Herein has been discussed with some detail a phase of the peak load problem not too well known, due to its comparative newness to British engineers. The other phases, i.e., the installation of Diesel engines or other primary units to carry the peak loads are more generally well known. The economic advantage of applying either of the possible schemes in any particular case is a question which can only be considered in relation to individual conditions and requirements. The latter include the character of the total steam demand, which wherever possible should be ascertained by direct measurement, and the permissible pressure drop between the boiler and the various consuming units.

These data when available provide bases for the estimation of anticipated savings: in such respects as improved efficiency of the steam raising plant, reduced labour costs, and more satisfactory operation of the consuming units in relation to the capital expenditure involved.

KENT SUB-BRANCH.

Stepping Stones in the History of Electricity.*

Discussion.

Mr. BARNEY—Mr. Lowe is to be congratulated on his paper. I know very well the trouble he has taken in preparing it, and the difficulty he had in getting together the data to make it up. The subject is unusual for an Association such as ours, but I think that at the commencement of a Branch it is useful to review the early difficulties and work of those now gone, as it is on their endeavours that our everyday machines, etc. that we all use were built up, and from the early failures and difficulties of these pioneers much can be learned.

During my short experience with a colliery concern I found that the men engaged in this work were rather inclined to run in a rut; the reasons for this are probably that these men are to some extent isolated from other concerns on account of the position of their collieries, and also to the fact that a machine or other apparatus once proved to be satisfactory was continued with, as gear in the nature of experiments is not favourably looked upon by the management who have to keep the output up.

I, therefore, consider that a Paper of this nature is very useful in order to bring before our members what has happened in the past and how the great industry in which we are engaged has come up from what to-day would only be considered interesting laboratory experiments. There is no doubt that later on we will have papers on matters more directly bearing on collieries.

The huge strides made in the generation and distribution of electricity in recent years may not be fully realised by some of our younger members. I can remember with what interest the stories told to me by the older men in the first power stations I had to do with were received. In those days there were some well known engineers who thought that it was not possible to operate the machines of those times in parallel, so they arranged the generators to suppply separate circuits, and if it was necessary to put another machine on load it was first run up to speed and the voltage brought up, then the running machine was switched out and the new machine switched in. I understand that this process was referred to as "jumping the lights," as of course all load in those days was purely lighting. Later on, when it became usual to parallel machines, the operation of switching in was considered quite an event in the stations of those days. The "Chief" would be advised, and the Station Super (if there was one) turned up. The incoming machine would be run up, paralleling was done by lamps, or if great accuracy was desired a voltmeter was used, finally when all was set, some brave individual would slam in an air-break switch. If the "shot" was good, all was well, but sometimes things happened. Belts would slip and squeak, or ropes would fly off, and the job would start all over again. How different to the big stations of to-day where the control engineer, complete with desk, etc. in a quiet control room rings up a set and puts it on load, probably never seeing the engine room for weeks on end.

The parallel running of power stations was at one time considered a doubtful proposition. Many years ago two stations in the West of England were running in parallel; all went fairly well until one day one of the stations noticed the load increasing rapidly, so the Engineer-in-Charge put more sets on load to cope with this load, finally the whole system shut down. What was happening was that one of the stations had developed a bad short circuit on the switchboard, and the other station was pumping power into this fault. I believe the station busbars had to be short circuited in order to shut the other station down, as the telephone had gone wrong (as they usually do at these times), and the result was a completely wrecked switchboard.

Mr. Lowe mentions bitumen cables, probably some of the older members may have had experience of the early troubles with this type of cable, now happily almost a thing of the past. One of the early undertakings in London employed this type of cable suspended on iron brackets in a subway under the streets. The bitumen of the cables used to get soft and let the conductor drop and touch the brackets. In order to prevent shut-downs from this trouble the mains engineer had the cables turned round on the brackets every few weeks to get a fresh bearing. Naturally this type of cable was not very popular with the distribution department of this concern.

Mr. COOPER said that Mr. Lowe's paper represented a terrific amount of work and was not merely a collection of facts like a section from a Machinery Catalogue. Mr. Lowe had introduced the human element by shewing them how Faraday, a blacksmith's son, had risen to fame by his own endeavours, and that Ferranti at 24, was already leading the way in electrical engineering. Mr. Cooper thought that Ferranti's method of demonstrating the safety of concentric cables working at a pressure of 10,000 volts was rather drastic, and suggested that a convincing proof of Feranti's genius was the fact that he arranged for his assistant to hold the uninsulated chisel which was to be driven into the cable. Mr. Cooper agreed with the author that Faraday's discovery of induced currents was one of the most critical in the history of electrical engineering. Without this knowledge it was difficult to imagine to what extent the progress of electrical science would have been retarded.

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*See *The Mining Electrical Engineer*, Jan. 1930, p. 269.

Another very interesting point was that Mr. Lowe had shewn them the early struggles of pioneers in the electrical industry, those whose names were household words to-day. He confessed to a slight tinge of disappointment when he found that Mr. Lowe was not going to demonstrate how the galvanic battery was discovered, but presumed that this was due to the difficulty of obtaining the necessary frog's leg.

Mr. Cooper also said that there was one point which deserved special emphasis and that was that the electric lamp was invented by Swan, in England, before it was patented by Edison in America, but whilst there were at present great celebrations in America in praise of Edison's discovery, on one appeared to be saying anything about Swan.

Mr. FORD asked the following questions:—

1. On behalf of the Junior Members—why did the disk revolve when Mr. Lowe moved the permanent magnet?

2. Why were the number of revolutions less in the case of the slit disk than with the complete disk?

3. With regard to Ferranti's assistant holding the chisel, what would have happened if the outer sheath of the cable had been insulated rather than earthed?

Mr. LOWE in reply to Mr. Cooper's question said that he thought the opening lines of the paper would serve to explain why the experiment of which Mr. Cooper had spoken had not been given.

Referring to Mr. Ford's first question: when the permanent horseshoe magnet is brought near to and revolved under the copper disk, eddy currents are set up in the latter, thus creating local fields and these endeavour to coincide with the fields of the two legs of the permanent magnet. This condition, however, is never fulfilled, the fields of the magnet always being a little in advance of those set up by the eddy currents in the disk. This state of affairs is equivalent to that between the rotating field in the stator and the speed of the rotor in an induction motor. The difference in the speed of these two being commonly known as "the slip."

With regard to Mr. Ford's second question: the number of revolutions was less in the case of the slit disk, the speed of the permanent magnet being the same, since what amounts to an air gap resistance was inserted in the circuit of the eddy currents thus causing distortion and a consequent weakening of the field.

In reply to Mr. Ford's last question: if a perfect state of insulation had existed the result would have been the same as when the sheath was earthed. The potential to earth, however, and consequent shock the man would have received would depend entirely on the leakage path over the insulators used to insulate the cable.

Mr. LOWE (in a written communication) supplemented his reply and corrected several printers' errors which appeared in the report of his paper. For example: page 271, col. 1, par. 4, line 7, for "Gunbey" read "Gambey"; col. 2, par. 3, line 6, for "obstruction" read "abstraction"; page 273, col. 1, par 6, line 2, for "investors" read "inventors."

The most important correction concerns the description of Faraday's first electrical machine and the method of collecting the current from the copper disk. The conducting strips of copper and lead served as collectors, one being placed in contact with the edge of the copper disk between the magnet poles, and the other held by hand to make the contact with the brass axle of the machine. The wires of the galvanometer were connected to the strips and upon revolving the disk a deflection of the instrument was obtained, the deflection being reversed with a reversal of the direction of rotation of the disk.

Faraday also produced another simple machine in which he utilised the earth's magnetism to energise a single loop of wire which was mounted on a spindle set in brackets in such a manner that it could be revolved. The ends of the wire loop were connected to collecting devices from which wires were taken to a galvanometer. On rotation of the spindle and loop of wire a deflection of the galvanometer was obtained. (Slightly modified working models were exhibited by the author at the lecture, one having sliprings, the other a simple commutator. The modification being that several turns of wire were used instead of the single loop.)

Subsequent to the introduction of the Edison and Swan carbon filaments there followed from 1905 onwards other types of incandescent lamps: first those with filaments of osmium metal, then tantalum and finally tungsten in the form of wire for the filament. The difference between the current consumption per candle-power of metal and carbon filament lamps, which is one watt in the case of vacuum lamps, and as low as about half a watt in that of lamps having a slight internal pressure of inert gas such as nitrogen or argon (commonly known as gas-filled) and four watts in the case of carbon filament lamps, explains the impulse given to electric lighting during that period.

In concluding, Mr. Lowe said he felt some degree of regret that he had not been able to make his lecture more interesting by means of a greater number of experiments or demonstrations, but difficulties of obtaining material had been rather great. Many of the matters about which he had spoken could, he knew, have been dealt with at greater length but the object in view had been only that of giving a review. It had been a great pleasure to him to prepare and give the paper. There were many people to whom he wished to tender his best thanks for valuable assistance. In particular he was greatly indebted to Mr. Barney for the loan of books and other kindnesses, to Messrs. W. T. Henley's Telegraph Works Co. Ltd., and to Messrs. Ferranti, Ltd.

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.—MINES AND QUARRIES FORM No. 11, JANUARY 1930: EXPLANATORY NOTES by H.M. ELECTRICAL INSPECTOR of MINES on the General Regulations governing the Installation and Use of Electricity at Mines. Price 6d. nett.

This is a new edition of a handbook intended to serve as a practical guide to mine managers, electricians, mechanics and others in carrying out their duties under the regulations, in the choice of safe and suitable plant, in its safe installation and efficient maintenance, and generally in the observance of those precautions which experience has shown to be necessary for the prevention of accidents. The previous edition was published in 1924, and many notes on developments in practice since then have been added. New features include suggestions as to the prompt automatic isolation of a faulty circuit, preferably by "leakage protection," to make "earthing" an effective safeguard against electric shock, and as an additional precaution against open sparking in cables.

The application of "remote control" to coalcutting machines, and other coal face machinery, as a means (in particular) of reducing the risk of open sparking at the machine by removing the troublesome starting switch from the machine, is also considered.

The oft debated topic of the frequency with which certain tests and detail examinations, covering all parts of the electrical installation, should be made by the electrician, is dealt with.

Other notes concern the provision of permanent and safe means for earthing the conductors of a circuit, especially upon high voltage systems, before men are set to work upon them: and the utility of "pliable armoured cable" for the service of conveyors and similar semi-portable machinery.

Mines Department.—LIST OF QUARRIES (under the Quarries Act, 1894) in Great Britain and the Isle of Man. (Year 1928). This includes a General Index of Quarries; Index of Owners; and Lists giving Agents, Mineral Works, Number of Employees, Special Rules, etc. Price £1 15s. nett.

Mines Department (Safety in Mines Research Board). —WHAT EVERY MINING MAN SHOULD KNOW.

No. 1 Safety in Coal Mines: Some Problems of Reseach. Price 6d. nett.

No. 2 Gas and Flame. Price 3d. nett.

These are the beginning of a series of publications which will be welcomed by all mine workers. They are well bound, well printed and profusely illustrated. The reading matter is in the simple and interestingly descriptive terms which will carry the lessons of the value of research home to every worker. At these prices there is surely no excuse for keeping anyone in ignorance of the principles of safety in mine working.

THE BLUE BOOK: The Directory and Handbook of the Electrical Engineering and Allied Trades: 1930. London, Ernest Benn, Ltd., Bouverie House, 154 Fleet Street, E.C. 4 Price £1 5s. nett.

This is the 48th annual consecutive edition, and even after such a long and successful sequence it shows that improvements are still possible. The Geographical and Classified Trades sections are unique, and Guide Cards facilitate reference to any section. In every respect the high standard of production associated with this work in the past has been more than fully maintained. Established as the standard electrical guide, it is the only publication that contains a complete Alphabetical directory of the Electrical Industry. The Handbook section which has been entirely rewritten and re-arranged for readier reference, is a compilation of facts, data, and exclusive information needed in every electrical office. In short, this book is indispensible to live business men, and is remarkably low in price.

COMMERCIAL A.C. MEASUREMENTS. by G. W. Stubbings, B.Sc. (Lond.), F. Inst. P., A.M.I.E.E. London, Chapman & Hall, Ltd., 11 Henrietta Street, W.C. 2. Price 15s. nett.

Knowledge of the measurement of current, voltage, power, energy and power factor of alternating current circuits inevitably implies familiarity with electricity in its practical applications: so that, though this book may at first sight be thought only of academic interest, it is one essentially serviceable to the engineer engaged in industry. It can in fact be recommended to such men as an improved and original means of approaching nearer to the practical truths of applied electricity. The mathematics are simple and some 170 diagrams help to make the book readily understandable to those who are not too well advanced in pure science. As a printed production it is all that could be wished for; clear bold type, a handsome binding, and a low price supplement the literary merits which will satisfy many.

DEFINITIONS AND FORMULÆ FOR STUDENTS: COAL MINING. Compiled by M. D. Williams, F.G.S.: London, Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, W.C. 2. Price 6d. nett.

A handy little pocket book which will be found very useful by students and also as a source of data for reference by engineers generally.

INDEX TO BRITISH STANDARD SPECIFICATIONS. New Edition. British Engineering Standards Association, 28 Victoria Street, London, S.W. 1. Price 1s. nett.

This is a complete subject index of the 378 British Standard Specifications issued to date. Some of these include provisions for several articles or materials and consequently classification by subject will be of much assistance to those purchasing engineering and allied material apparatus and machinery. A numerical schedule of the specifications is also included. The index occupies 35 pages and should be in the hands of all drawing offices and costing departments of firms throughout the engineering and allied authorities who have found the British Standards of such benefit in the preparation of contracts.

An inset slip directs attention to the Binders provided for convenience in storing and handling the specifications. Each will normally hold ten specifications; they are in stout stiff "Texhide" covers, gilt lettered, price 5s. each.

THE 1930 PRACTICAL ELECTRICIANS' POCKET BOOK (Thirty-second edition).—Odhams Press Ltd., 85 Long Acre, London, W.C. 2. Price 2s. 6d. nett.

This year's Practical Electricians' Pocket Book contains several new sections. "Testing and Fault Localisation" compiled by G. W. Stubbings, B.Sc. is a valuable reference section, concise and clearly illustrated. Amongst the other new sections are "Induction motors—Synchronous and Asynchronous" and "Law of Contracts" both very useful additions.

A new scheme was adopted last year for the Central Station data: this year a further alteration in the method of presenting this information has taken place and the section greatly extended.

The scope of the book is indicated by the diverse nature of its various sections—electricity in agriculture, mining, armature construction and repair, batteries, cookers, hot water systems, marine electricity, steam raising plant and switchgear. With valuable data upon these and many other electrical subjects, the Practical Electricians' Pocket Book for 1930 will be found extremely useful and interesting.

NEW ADDRESSES.

As from February 17th, the London office of Oerlikon Limited will be Victoria House, Southampton Row, London, W.C. 1.

Kennicott Water Softener Co. Ltd., announce that in future, owing to increase of business, the work of the central office will be removed from London to the works of the Company at Wolverhampton, where all communications should be addressed.

The Liverpool Office of the British Thomson-Houston Company, Ltd., has been moved from 16 South Castle Street to new premises at 27/29 Stanley Street, Liverpool. The telephone number (Bank 5700), and the telegraphic address ("Asteroidal", Liverpool) remain unchanged.

THE G.E.C. IN INDIA.

The General Electric Co., Ltd., announce the opening of two new branches in India at the following addresses: The General Electric Co. (India) Ltd., 7 Brigade Road, Bangalore, Mysore State; The General Electric Co. (India) Ltd. Main Road, Trivandrum, Travancore State

Mr. P. H. Nye of the Shanghai Branch of the General Electric Co. of China Ltd., is returning to England, and Mr. N. G. Beale who for some years has been Chief Engineer for the Company in China has been appointed to succeed him as General Manager in that territory.

Manufacturers' Specialities.

British Industries Fair: Birmingham.

SOME NOTABLE EXHIBITS.

CALLENDER'S CABLE & CONSTRUCTION Co., Ltd.

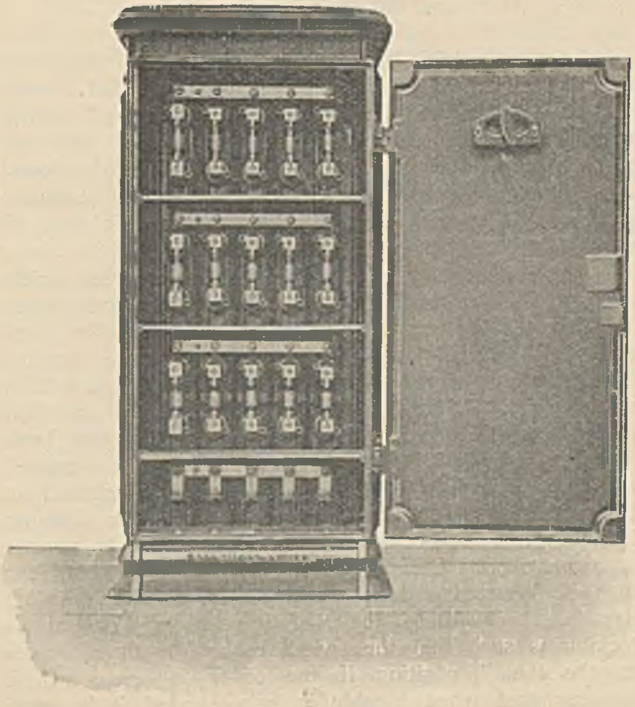
On this stand Messrs. Callenders are showing a complete range of low tension, high tension, and super tension cables up and including those of 66,000 volts. The examples exhibited cover paper, rubber, and cambric insulated cables; lead-sheathed, armoured, taped and braided; special cables for mining, colliery, and marine services; patent rubber cab tyre sheathed cables, and "Ancalite" cables for railway signalling work, etc.; also insulating tapes and compounds, and jointing accessories.

In addition to cables and insulated electrical conductors, Callenders are showing a comprehensive range of electrical distribution appliances, these including distribution pillars, network boxes, straight joint boxes, service boxes, frames and covers, etc. In particular, attention is to be directed to the 66,000 volt single conductor cable straight through joint box which is shown in section; also to the 33,000 volt three-core S.L. cable straight through joint box, shown in section; the unit type distribution pillars; and the cutouts with all-insulated cases.

Another special exhibit is made of the "Kalibond" system of wiring, which is now in general use all over the country for the electrical wiring of houses, municipal buildings, banks hospitals, etc. Samples of the new C.T.S. wiring system with corrosion-proof boxes and lamp fittings are also prominently displayed. "Kalbitum" paint, an anti-corrosive paint for all iron and steel work, is one of the well-established standard Callender products included also.

A. REYROLLE & Co., Ltd.

Messrs. Reyrolle are showing a complete range of their unit-type, metal-clad, air-break switches, fuses and plugs. These equipments are admirably suited for controlling the electrical supply to portable machines and appliances. A notable feature of the design is their adaptability for unit construction. The switches, fuse-



Callender Unit Type Distribution Pillar.

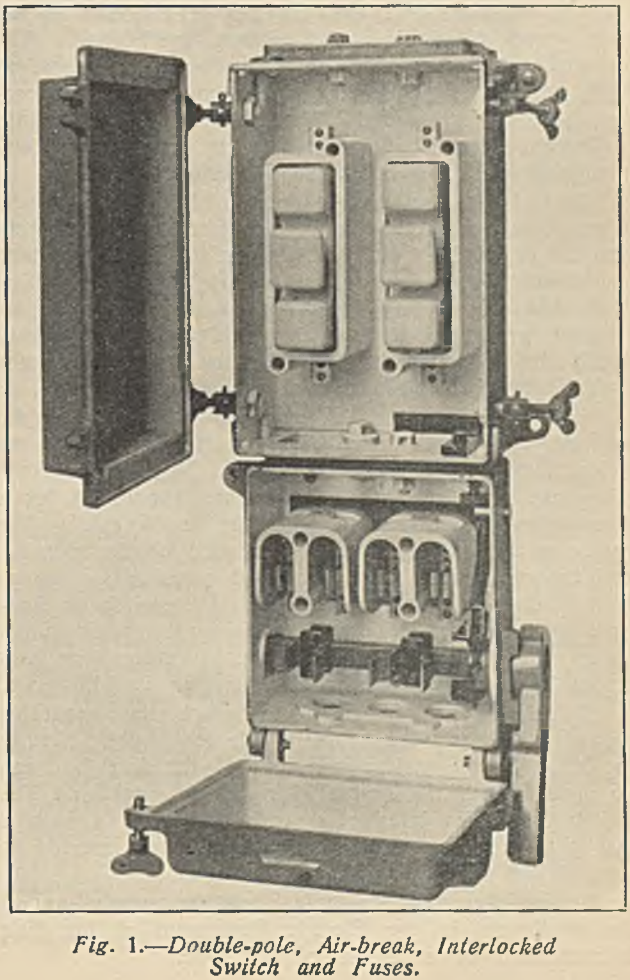


Fig. 1.—Double-pole, Air-break, Interlocked Switch and Fuses.

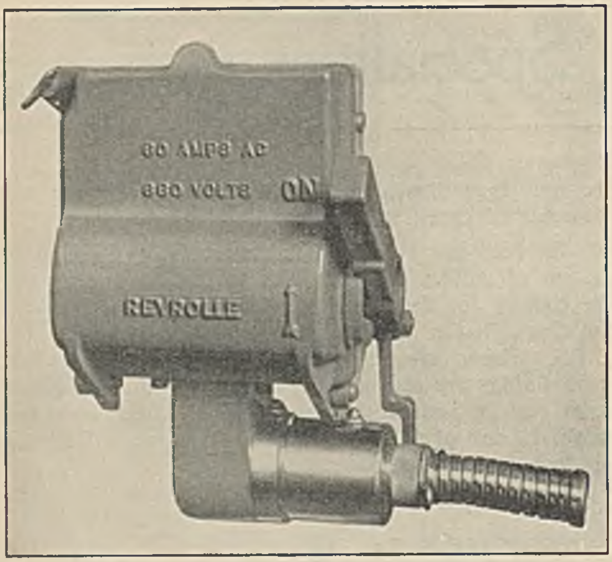


Fig. 2.—Reyrolle Interlocked Switch and Plug Combination.

boxes, and the plug and socket fittings can be supplied either as separate units for independent use or in any required combination.

The switches are suitable for frequent operation on 660 volt circuits, and are capable of carrying 25 per cent. overload continuously without overheating. The movement is of the quick double-make-and-break type on each pole, and self-aligning double-ended terminal contact blocks are provided. The switches are designed to withstand exceptionally rough usage, and they comply with British Standard Specification No. 124.

The fuses are of the ventilated porcelain-handle type, fitted with self-aligning contacts and protecting guards complying with the Home Office Regulations made under the Factory and Workshop Acts. These ventilated self-aligning fuses have a separate hand-grip, of such a shape that it is impossible for the hand to touch live metal inadvertently. They comply with the British Standard Specification No. 88.

The plugs and sockets may be either of the 15-ampere, 30-ampere, or 60-ampere pattern and, like the fuses, they comply with the Home Office Regulations. They are provided with an additional connection for a separate safety-earth conductor in the flexible cable. The casing of the socket may be threaded on the outside, and the plug fitted with a screwed coupling-ring, so as to provide a positive connection to the switch or fuse-box, and prevent accidental withdrawal of the plug. When this thread is provided, the socket may be protected by a screwed cap while the plug is withdrawn.

Interlocks are provided to make the apparatus mistake-proof, and consequently safe to handle. Neither the door of the switch nor that of the fuse box can be opened until the switch is in the *off* position. The switch handle is interlocked with the plug in such a way that the plug cannot be withdrawn or inserted as long as the switch is in the *on* position.

It is interesting to note that the supply to all the appliances in the Electric Restaurant at the Fair is controlled by apparatus of this type.

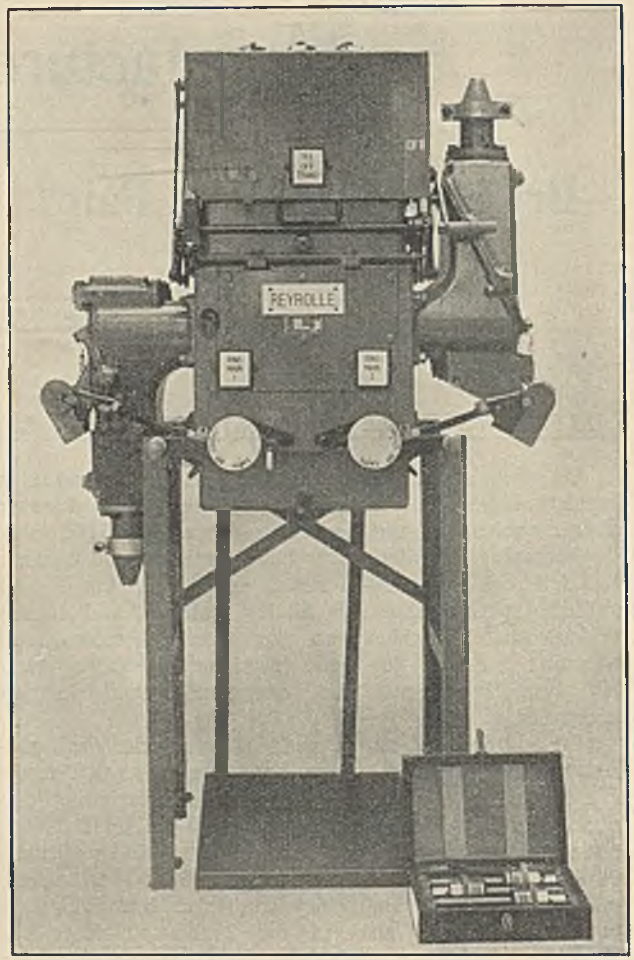


Fig. 3.—Ring-main Isolating Switch for 200-*amp. Main and* 100-*amp. Tee Branch.*

Another notable Reyrolle exhibit is the ring main isolating switch fitted with a switch-fuse so that a connection can be easily and economically teed off a ring main to a small consumer. Although it is only so recently as 1929 that this apparatus was first developed it has proved itself to be so useful to Supply Authority Engineers that already the demand for this type of apparatus has been very considerable.

The isolating switches are of the oil-immersed quick-make and quick-break type, suitable for pressures up to 11,000 volts. Separate switches are provided for each cable of the ring main, and each of these can be placed in any of three positions, namely, "on", "off", and "earth", a definite stop being provided so that it is impossible to move the switch accidentally from "on" to "earth". On changing over to the "earth" position, the cable concerned, having been earthed in this way, is safe to handle; and at the same time an interlock is released which makes it possible to remove a cover over a testing socket. A plug connector can then be inserted and the cable tested, after the switch has been moved to the "off" position. The interlocking is such that the switch cannot be thrown over to the "on" position if the cover is open. If it happens that when a cable is being tested it is made alive from the other end, no serious damage results, because the testing plugs supplied are provided with a small air-gap to discharge any excess pressure.

The switch-fuse for protecting the consumer's property is itself oil-immersed. The fuse elements are supported from a steel lid, and this is made to swing clear of all live parts when replacements are necessary, or when it is required to inspect the fuse. The whole equipment is very solidly constructed and, since it is proof against flooding, it can be safely installed in underground manholes, or in other places where flooding is likely to occur.

J. H. HOLMES & Co., Ltd.

On behalf of Messrs. J. H Holmes & Co., Ltd., the Reyrolle exhibit includes a "Castle" direct-current electric welding set. The equipment consists of a specially designed and constructed generator, an adjustable choking coil usually called a "choke", and a control board complete with electrode holder, shield, and other accessories. An electric motor drives the generator but, alternatively, it may be driven by a prime mover or from a line shaft, and if a direct-current supply is not available for excitation, a small auxiliary generator is provided for this purpose.

The essential feature of these equipments is that they can be set, within the limits of their capacity, for use with any make and size of electrode, and for any thickness of material to be welded. Once the adjustment has been made, the generator will automatically control the voltage and current of the arc in such a way as to afford the greatest possible ease in welding, and will ensure that the arc is struck and maintained at the correct intensity even though the surface to be welded is uneven. This automatic control enables welding to be done, without risk of burning the metal, with a more intense arc than would otherwise be possible, and so not only is the time required for a given weld reduced, but the quality of the weld itself is improved.

No current-limiting devices are necessary or desirable, since the generator is designed to withstand short circuits. The whole of the power developed by the generator is transmitted to the arc and used for making the weld, and the absence of intermediate resistances dispenses with the waste of power that would otherwise occur. The adjustable "choke" is incorporated in the equipment so as to prevent the electrode from sticking to the work when contact is first made; its effect is to limit the initial flow of the current, and so the operator is able to strike and draw the arc immediately and without any jerk. This important feature enables a uniform weld to be made from start to finish.

These notes of the Reyrolle exhibit would be incomplete without a special reference to the stand of the Electrical Power Engineer's Association, whereon are displayed specimen relays as used in connection with the Reyrolle Ratio-Balance Feeder-Protective System. This system was developed specially for protecting sections of the British 132,000 volt Grid, where, owing to the long feeder lines employed, the cost of pilot wires for such protective systems as Merz-Price would have been excessive. The Reyrolle Ratio-Balance System is an

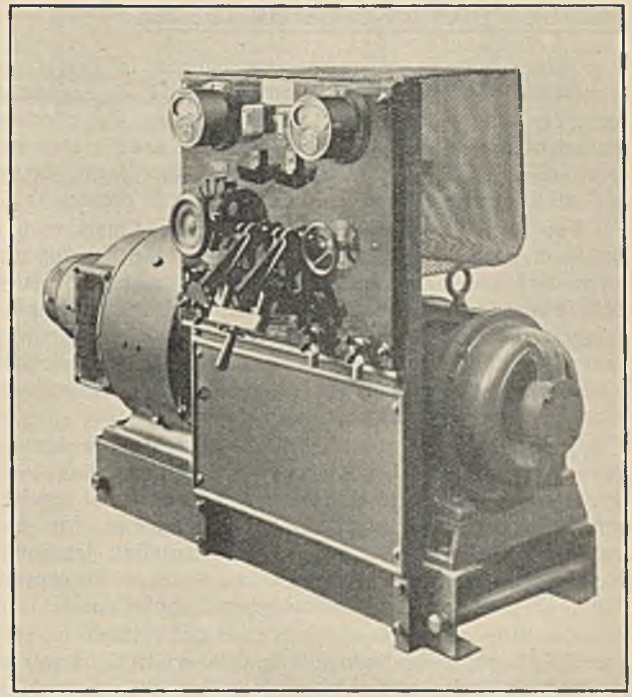


Fig. 4.—A.C.-D.C. Semi-portable Welding Set.

improvement on what is generally known as the "Impedance" type of protection and operates on similar principles.

The operation of the "Impedance" system of protection is based on the fact that, on the occurrence of a metallic short circuit at a point on a single feeder, the ratio of the voltage to the current at the various sub-stations on that feeder is least at the sub-station nearest to the fault and increases towards the power station. The relays installed at the sub-stations are so designed that their times of operation are proportional to the ratio of voltage to current at each relay, and consequently those nearer to the fault will operate quicker than those more remote. The only circuit breakers that will be tripped on the occurrence of a fault are therefore those at the sub-stations nearest to the fault on the faulty feeder.

On the occurrence of earth-faults on extra-high-voltage overhead transmission systems the resistance of the earth-return path varies to a far greater extent than the reactance does. It will therefore be appreciated that the system is likely to be inconsistent in its operation under earth fault conditions.

The Reyrolle Ratio-Balance System of Protection, is therefore made to depend not on the impedance but on the reactance between the sub-stations and the fault, and, being thus dependent only upon the length of line, it is entirely unaffected by any external variable and uncertain resistances. The system has the additional advantage that the relays operate practically instantaneously when a fault occurs within a predetermined distance from the station concerned. A gradually increasing time-delay is introduced outside that distance in order to provide the requisite time-discrimination in the operation of the circuit breakers.

BRITISH THOMSON-HOUSTON Co., Ltd.

This exhibit is of exceptional interest in that it is representative of standard modern electrical equipment for every branch of industry and commerce. The effective lay-out of each exhibit combined with the artistic arrangement of Mazda lamp displays make this large Stand one of the most attractive in the electrical section.

For over a quarter of a century this Company has occupied a very prominent position as the introducers of modern ideas and methods whereby greater efficiency and increased production have been achieved in almost every section of the electrical industry—namely, power generation and distribution, railway electrification, electric traction, and the application of power for collieries and mines and every industrial purpose.

Many exhibits are at work, so that visitors can be shown their method of operation, this applying particularly to motors and control gear for industrial service, comprising in the principal, standard forms for a.c. and d.c. circuits; the sizes on view including fractional horse-power and larger ratings, as well as the newer "built-in" motors, and worm-geared motor units.

For use on single-phase a.c. circuits there is also the B.T.H repulsion induction motor, which is designed to start up easily under heavy load and to run at high power factor at a constant speed. Other industrial exhibits consist of motor generators and "Fabroil" pinions.

One of the most recent and important introductions is the range of "built-in" motors for giving direct drive to machine tools and other machinery where protection of the electrical elements is essential. The stator unit consists of a core and winding in an enclosing shell, and the rotor unit of a squirrel-cage rotor with centrifugally cast aluminium bars and end rings. The units are supplied for assembly by the machine tool makers, housed in frames which are designed as an integral part of the machine tool, and the machine tool makers also provide shaft, endshields, and bearings as part of their design.

For certain machines the B.T.H. "vertical spindle" motors can be applied for horizontal endshield mounting machines, the driving endshield being bolted to a vertical surface so that the motor is overhung with the shaft horizontal.

An entirely new line of worm geared motor units is also represented. These units, with the motor mounted integral with a worm reducing gear, are shewn in two forms—vertical and horizontal. The vertical arrangement is preferable where sufficient head-room is available, but where this is limited, the horizontal unit offers an alternative arrangement. Permanent accuracy of alignment, together with minimum weight and space, is achieved by these equipments, and the elimination of a bedplate avoids a frequent cause of trouble due to bedplate springing. These geared units form a very efficient drive and give high efficiencies over a wide range of ratios, 7½ : 1 to 30 : 1 ratios are standardised, but greater reductions can also be supplied. They will withstand the usual overloads applying to B.T.H. motors and the absence of need for any attention save lubrication, make them eminently suitable for all types of plant drives.

Various motor starters and controllers for both a.c. and d.c., reversing and non-reversing, motors also occupy positions of prominence. These equipments range from examples of control pillars for large motors, down to motors of fractional h.p. rating in forms for either wall or floor mounting.

An improved form of oil-immersed a.c. control panel is the type A.T.M., form T, which is being shewn for

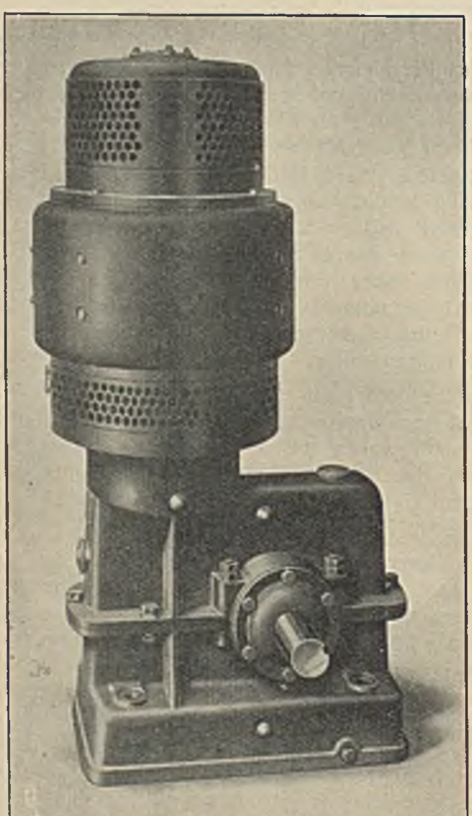


Fig. 1—B.T.H. Worm Geared Motor Set with Vertical Motor: ratio, 20 : 1; 7½ h.p.

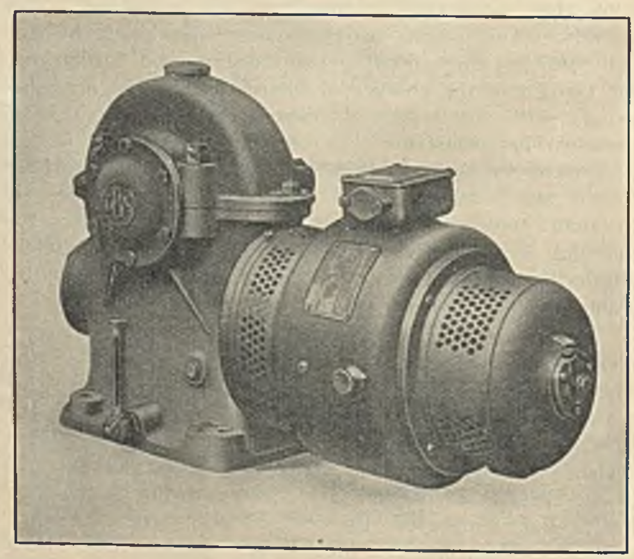


Fig. 2.—B.T.H. Worm Geared Motor Set with Horizontal Motor: ratio, 25 : 1; 1½ h.p.

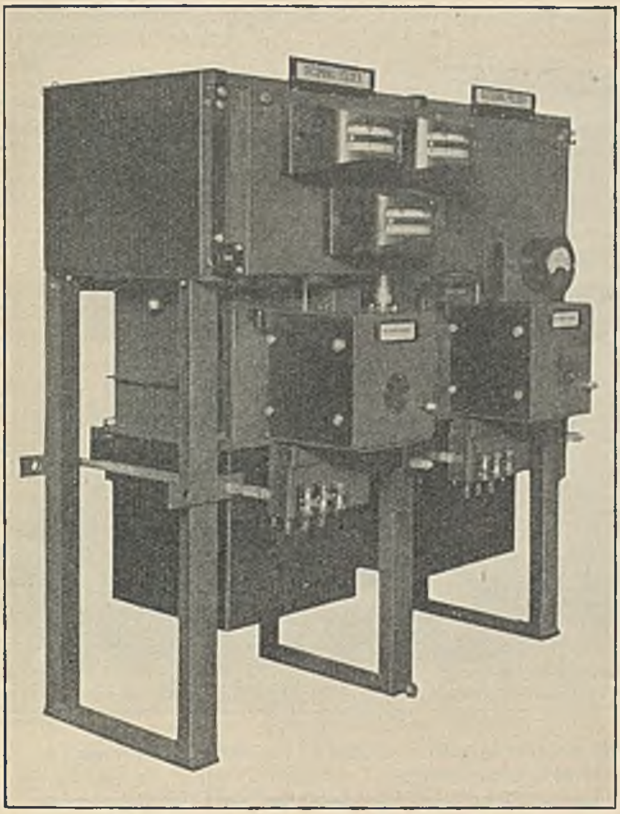


Fig. 3.—B.T.H. Metal-clad Vertical Plugging Switchgear: Two equipment board for 600 *amps.,* 11,000 *volts.*

the first time. This is designed for starting and protecting three-phase slipring induction motors up to 15 to 20 h.p., at any voltage up to 550, and at 25, 40, or 50 cycles; maximum stator current 30 amperes, including the standard B.E.S.A. overloads and rotor current not exexceeding 75 amperes. It is suitable for starting three-phase induction motors against full load torque twice per hour. Over-current and under-voltage features are incorporated and the connections are such that the motor may be stopped at a distance by means of push button when desired.

The B.T.H. thermal type, oil-immersed motor starter and circuit breaker, which is to be seen operating, has been developed for the direct starting of squirrel-cage motors taking current up to 30 amps. on voltages up to 650, and giving protection against every kind of fault on all phases. This starter measures only 8¾ inches high, 7⅝ inches deep, by 6 inches wide, has a dust and drip-proof enclosure, and is under push button control, either local or remote.

A typical totally enclosed a.c. pillar type contactor starting equipment is also shewn, suitable for controlling a non-reversing 25 h.p. slipring induction motor against twice full-load torque with remote push button control. The pillar embodies no volt release, overload protection on all three phases and a self-contained triple-pole isolator, as well as the usual contactors, notching relays and starting resistances.

The B.T.H. metal-clad, vertical plugging switchgear, Class "Z" is again represented. This gear, which is designed for service under the most adverse climatic and other conditions, comprise busbars completely shut off from the other chambers, and oil-circuit breakers plugged into contact socket holes and removable by displacing the breakers vertically downwards, this method effecting substantial economies in space compared with the drawout truck type switchgear. Only one simple lifting carriage is required for a complete switchboard. Guide holes are provided in the frame to accommodate locating spears carried by the oil circuit breaker, ensuring that the breaker is lifted into position in correct alignment. A shutter closes the contact socket holes when the breaker is withdrawn and the method by which the shutter is automatically operated by one of the locating rods of the circuit breaker is of special interest.

Amongst other switchgear equipments is the ironclad, oil-immersed circuit breaker, type OZ, suitable for operating on three-phase circuits not exceeding 660 volts.

The effectiveness of the exhibit is enhanced by a colourfully illuminated model after the popular picture "Beauty Enriched by Light" now to be seen all over the country focussing attention on Pearl Mazda Lamps, which are rapidly superseding clear lamps for many purposes. The model, representing a dancing girl on a draped stage, is illuminated by continually changing coloured light, a motor driven control apparatus being employed. Other lamp displays are in the form of Pearl bowls, each of which employs a highly effective colour changing device.

DAVIDSON & Co., Ltd.

All are interested to-day in the prevention of atmospheric pollution and this exhibit affords the opportunity of seeing in operation one of the well-known air washers made by this firm. Apart from its ability to cleanse thoroughly the air supply in connection with ventilation schemes this washer also plays an important role in "Sirocco" air conditioning plants in which relative humidity and temperature control are important factors under definite control.

The firm specialises in dust removal installations of every description, and an excellent example of their work of this nature is exemplified by a small plant applied to two double-ended grinders, the dust being very effectively caught by well-designed hoods and extracted from the air current by a "Sirocco" collector.

The well-known Sirocco type of mine fan is represented by a working model, the transparent sides of which allow the visitor to see clearly not only the general design of the fan, but the arrangement and operation of the gear for reversing the air current.

The "Sirocco" packer, also shown in operation, has a special interest for those connected with the chemical industry, or who are interested in packing the maximum quantity of materials in granular or powder form into cases or chests without the application of pressure.

Finally, and not least in topical interest is the working model of the "Davidson" Patent Flue Dust Collector; a very representative range of "Sirocco" fans suitable for all purposes for which a fan can be employed also go to complete a striking display of a specialist British firm.

W. H. ALLEN, SONS & Co., Ltd.

Two examples of the "Allen" airless injection Diesel engines, one capable of developing 100 B.H.P. and the other 200 B.H.P., make a prominent exhibit. The smaller engine is shown in operation direct coupled to an "Allen" d.c. dynamo. This engine is representative of a range made with 2, 3, 4, 5, and 6 cylinders, the outputs ranging from 65 B.H.P. to 200 B.H.P., the speed in each case being 500 r.p.m. The 100 h.p. example exhibited is of the three-cylinder type and is exceedingly compact, the space occupied being only 7 ft. 8 ins. long by 4 ft. 2 ins. wide, the overall height being only 6 ft.

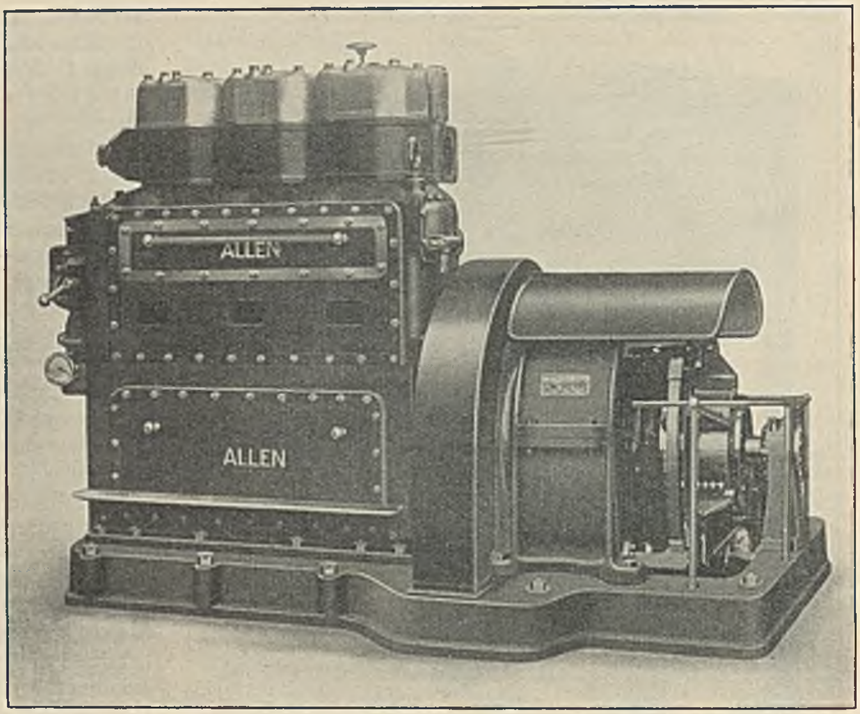


Fig. 2.—Allen airless injection Diesel Engine and Dynamo.

These engines are of the vertical four-stroke type, and start at once from cold without the use of blow lamps, cartridges, electrical device, or other external source of heat, the compression pressure being about 430 lbs. per sq. inch, which is sufficient to ensure ignition of the charge under all conditions of running.

An illustration of this engine, together with its dynamo is shown in Fig. 1. The dynamo is of the direct current, multipolar, open type, designed for continuous working and in general construction complies with the latest requirements of the British Engineering Standards Specification. It is rated for an output of 65 k.w., 220 volts. A substantial cast iron baseplate is provided to carry both the engine and the dynamo.

The larger engine exhibited is representative of the range of engines of this type manufactured by Messrs. Allen with 2, 3, 4, 5, or 6 cylinders for outputs of 130 B.H.P. to 750 B.H.P. The particular engine shown is designed for a speed of 400 r.p.m. and is also of the vertical four-stroke type, arranged for starting immediately from cold. The engine is direct coupled to an "Allen" d.c. dynamo similar to the one described above, but capable of an output of 132 k.w.

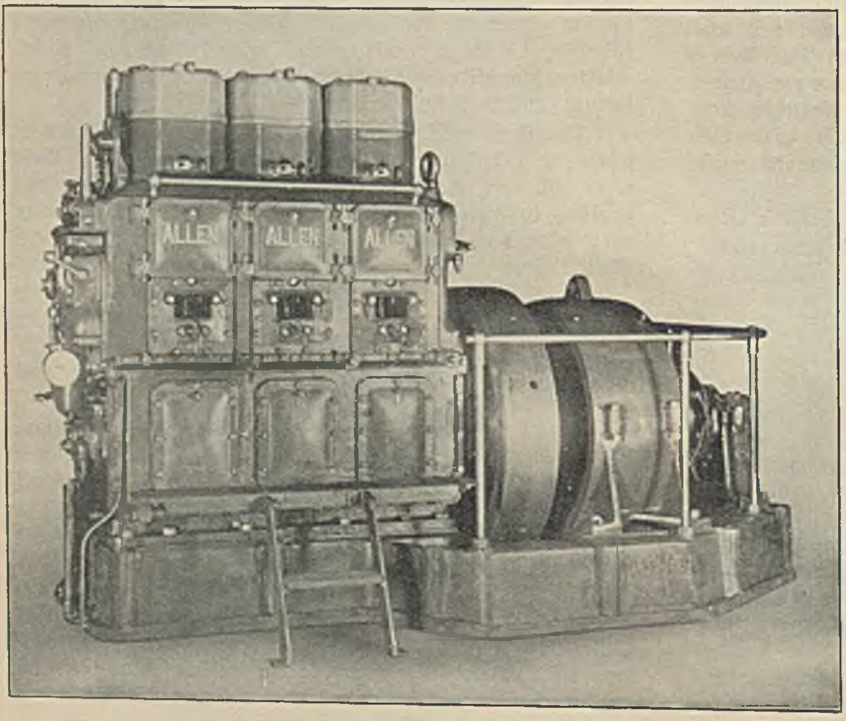


Fig. 1.—Allen airless injection Diesel Generating Set.

In both engines particular attention has been paid to the question of filtration of both the fuel oil and the lubricating oil supply, dual type filters being provided in each system. The likelihood, therefore, of stoppage of the engine due to the presence of dirt or other foreign matter in either the fuel oil or the lubricating oil is reduced to a minimum.

The fuel consumption of these engines is exceedingly good, and does not exceed 0.39 lbs. per B.H.P. hour at full loads when using a standard grade Diesel oil having a calorific value of approximately 18,500 B.Th.U's. per pound.

The firm are also manufacturers of air injection Diesel engines of the Burmeister & Wain Type (under licence from Messrs. Harland & Wolff of Belfast) and these are made in various sizes from 130 B.H.P. to 1200

B.H.P. Attention is directed to these by a series of representative photographs.

One of the firm's two-cycle type heavy fuel oil engines is shown, this being rated at 15 B.H.P. when running at 450 r.p.m. This engine is offered with 1, 2, or 4 cylinders in various sizes up to 200 B.H.P. These engines are simple and of very robust construction. Air filters are provided to ensure that only clean air shall be drawn into the crankcase which is used for the initial compression of the air. The compression pressure is about 150 lbs. per sq. inch and an electrical device or, alternatively, a blow lamp is used for the initial starting, after which the heat of the hot bulb of the combustion chamber is sufficient to ensure the ignition of the mixture. The engine shown is arranged with a belt pulley, but these engines can be arranged for direct coupling to generators or other machinery to be driven.

Included in the Allen exhibit are also two examples of "Conqueror" pumps. One of these is provided with 5 inch branches arranged for belt drive, fast and loose pulleys being fitted to the driving shaft. This pump is suitable for various speeds from 1000 r.p.m. to 2000 r.p.m., has a capacity up to 1400 g.p.m., and is suitable for working against a head up to 160 ft. The second pump shown is provided with a discharge branch 6 inches diamefer and a suction branch 8 inches diameter, also with fast and loose pulleys. This pump is representative of the range of "Nile-Conqueror" pumps manufactured by the firm suitable for heads up to 50 ft., such pumps being supplied for various outputs from 200 g.p.m. to 3400 g.p.m.

GEORGE ELLISON Ltd.

The distinctive and representative range of modern switchgear shewn by Messrs. Ellison, comprising metal-clad cubicle, truck, drop-down and draw-out types of high-tension units for sub-stations; pole mounting switches for overhead lines; various types of low and medium pressure metal-clad switchboards for industrial installations; totally-enclosed industrial and flame-proof circuit breakers of air and oil-break types and a variety of motor starting and controlling apparatus.

The several illustrations shew leading examples of the many exhibits. The cubicle type of unit for 11000 volt sub-stations is shewn in Fig. 1. It will be noted that this design provides good spacing of component parts, clear runs for connections and easy accessibility. The cubicle construction lends itself to sub-division in any desired manner for the accommodation of any combination of circuit breaker, isolating switches, meters, instruments, current and potential transformers, and cable fittings. The framework is an exceptionally strong welded structure which does not depend upon the enclosing plates for bracing.

The second photograph, Fig. 2, shews the truck type of unit for 11000 volt sub-stations. This design is a combination of the draw-out and cubicle principles. It is a safe and convenient construction for sub-stations where there is sufficient space to withdraw the truck

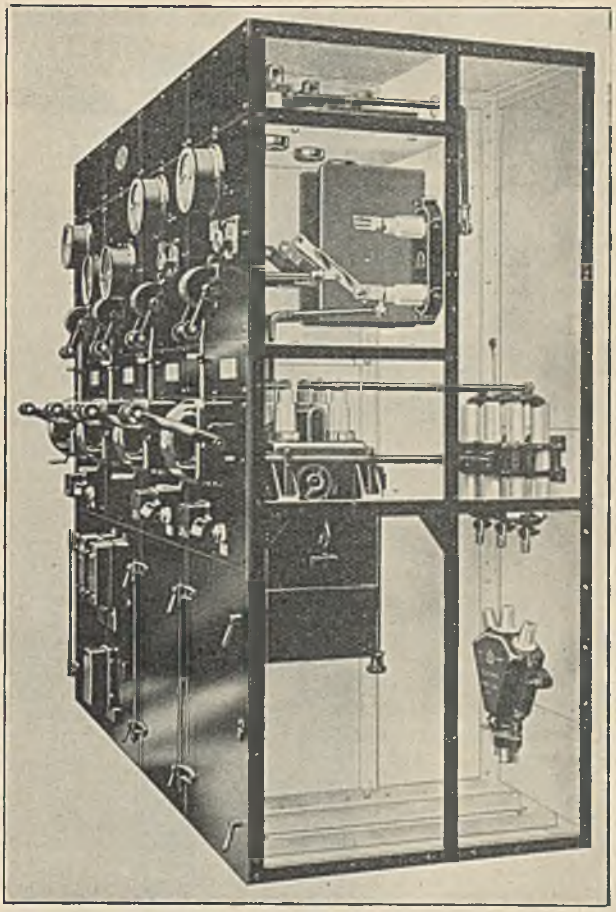


Fig. 1.—Ellison 11,000 volt, Cubicle Type Switchgear.

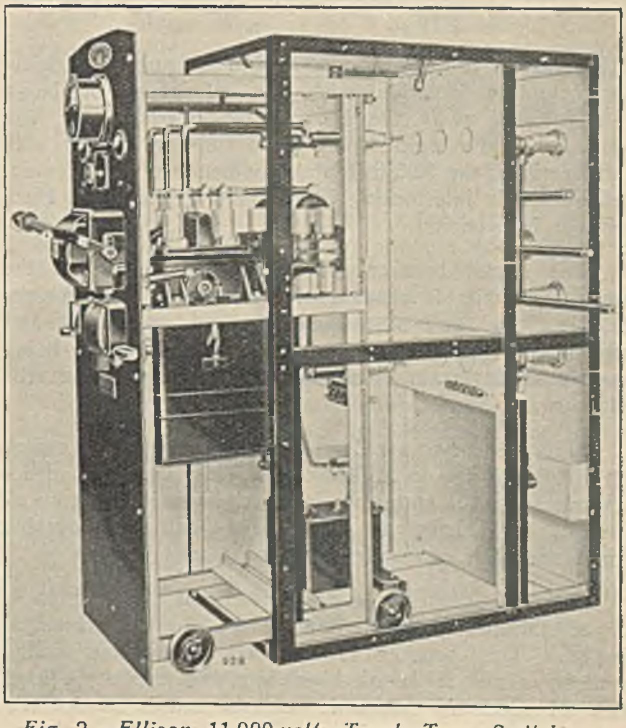


Fig. 2.—Ellison 11,000 volt, Truck Type Switchgear.

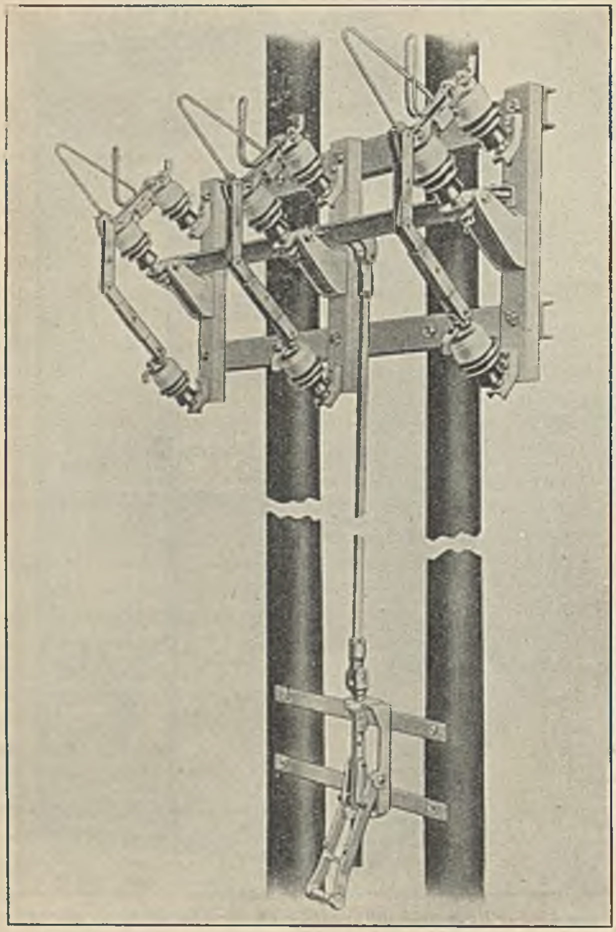


Fig. 3.—Ellison Pole-mounted 33,000 *volt Switch.*

which carries the circuit breaker and instruments, achieving complete isolation with the advantage of being able to take away the breaker for overhauling. The frame is rigidly welded, the truck runs on wheels with ball bearings, the isolating plug contacts are self-aligning, and automatic interlocking is arranged to make the truck safe for inspection.

The circuit breaker for both the cubicle and the truck type units is capable of interrupting 150,000 k.v.a. It is enclosed and pipe ventilated and its closing and tripping mechanism requires little effort, while being sensitive and certain in action. All the usual automatic releases are fitted.

Figure 3 shews a pole-mounting overhead line switch for pressures up to 33000 volts. This switch is proof against corrosion and was designed to satisfy the specifications of engineers who have had considerable experience with power transmission lines.

Figure 4 illustrates a flame-proof oil circuit breaker on a stand, for installation where the headroom is limited. This breaker is enclosed in a flange-jointed cast-iron case; it is of high breaking capacity, fitted with all necessary automatic releases and is particularly convenient for armoured or trailing cable connections.

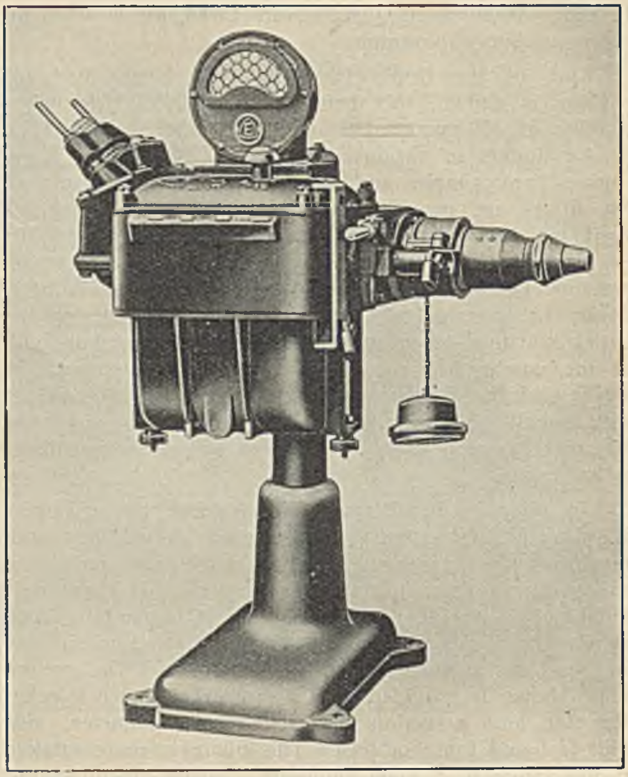


Fig. 4.—Ellison Flame-proof Oil Circuit Breaker

Another notable example is the flame-proof air-break circuit breaker on a skid frame for use in collieries (Fig. 5). This breaker is enclosed in a welded steel case with relief vent. It is employed in many mines for controlling the supply to coalcutters, loaders, and conveyors. Also of particular interest is the cable end coupling which is used for simplifying the installation of cables in mines. This is shewn in Fig. 6; it consists of two sealed ends bolted together and with the cable cores connected by links. The terminal end of the cable is the same fitting and is bolted on to the circuit breaker.

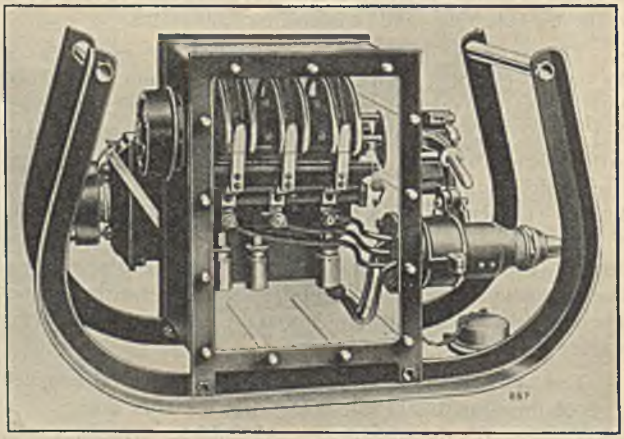


Fig. 5.—Ellison Flame-poof, Air-break Circuit Breaker on Skid.

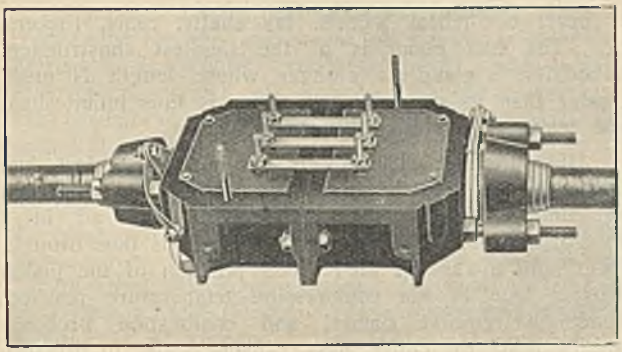


Fig. 6.—Ellison Mining Type Cable End Coupling.

This is but to mention a few of the more recent Ellison developments which are of greater importance to mining men. The exhibit also comprises a comprehensive range of switchgear for all kinds of industrial and power station purposes and controlling devices for slip-ring and squirrel-cage induction motors, including star-delta, auto-transformer and resistance starters and drum type controllers.

GENT & Co., Ltd.

The Company has staged a fine collection of the many electrical automatic and accessory appliances in which they specialise. The many items include improved mining bells and relays, suitable for working in parallel on bare wire signalling, and passed by the Home Office; also improved tapper keys, mining pushes, heavy duty power pushes, telephones, all of which are of incombustible and flame-proof designs.

Other specialities are water level indicators and alarms for indicating and recording step-by-step the rise and fall of liquid level. A new "Tangent" high and low liquid level alarm with diversion relay, suitable for a.c. or d.c. circuits; and a new model range of float switches.

Audible signals shewn include motor syrens a.c. and d.c. in sizes ranging from 1/10th to 4 horse power suitable for sound signals, fire alarms, etc., for use at mines and other industries, and, and also for coding signals. There is also a new "Tangent" electric motor bell operated by a 1/10th h.p. motor suitable for fixing in the open and for use at landing stages, ferries, fire stations, etc.

The latest designs of time pieces include the "Pulsyn-etic" electric clocks; clocks in bakelite, cast iron, watertight and Wood cases; process timing clocks, together with "Start and Cease" sound signals, all controlled by a master transmitter on the Exhibition Stand.

The well-known "Waiting Train" turret clock shown on the Stand is capable of driving four 5 ft. dials. A similar "Waiting Train" movement, but of greater size, is driving the four 25 ft. dials at the Royal Liver Buildings, Liverpool, and the four 26 ft. clocks at the Singer Manufacturing Company, Glasgow. A motor driven striking apparatus, controlled by a time transmitter through an hourly contact maker, is exhibited in operation, counting the hours on a ¾ cwt. bell.

Amongst the many other examples exhibited may also be mentioned the "Parsons-Sloper" secret interphones, improved push button "Regent" interphones, domestic telephones, etc. Staff locaters for getting in touch with members of the staff immediately in case of trunk or other urgent and emergency calls. Indicators of the luminous, pendulum, and drop patterns, suitable for hotels, ships etc. Pneumatic bells and pushes for buses and trams. Idle machine and output recording apparatus. Wireless apparatus, eliminators, screen-grid valve receivers, all-mains sets, etc. Signal lamp relays, contained in iron cases, suitable for police calls, as used in many large towns.

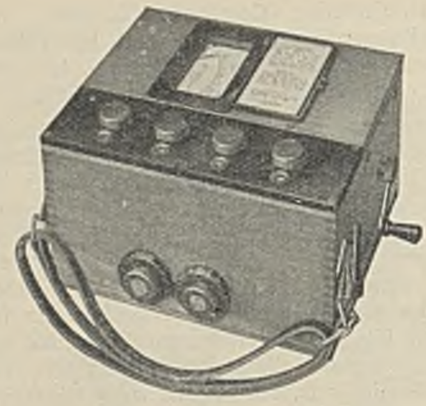
RECORD ELECTRICAL Co., Ltd.

The Record Electrical Co. are exhibiting their standard moving iron and moving coil switchboard and portable pattern instruments; also a typical range of their well-known "Cirscale" instruments, noted for clear open scales. An improved moving iron "Cirscale" instrument for alternating current and having a reduced coil impedance is also shown.

Of the portable series of instruments, the change-coil test sets are worthy of note, particularly by those who require a compact set for use on a large variety of circuits. For those wishing to obtain current and voltage measurements in a.c. and d.c. circuits, is recommended the change-coil combined double movement ammeter and voltmeter having six current ranges from 1 to 600 amps. and five voltage ranges from 1 to 750 volts. For the purpose of obtaining only current measurements there is the change coil multi-range ammeter having six current ranges only from 1 to 600 amps., also useful for a.c. or d.c.

As pioneers of the light-weight model combined "Record" ohmmeter and generator, this Company makes a special feature of the exhibit of a few of their standard models having 500 volt generators and scale up to 100 megohms. To meet the increasing demand for resistance measurement equipment—Mr. J. W. Record has patented a light-weight bridge ohmmeter which is particularly interesting for its compactness, wide range, and speed of operation. The set comprises an ohmmeter and a Wheatstone bridge with a testing range on the ohmmeter from 10,000 ohms to 100 megohms and on the bridge from 0.01 ohm to 999.900 ohms. Tests can be made consecutively by the ohmmeter and bridge method by moving one switch, while the resistance under test remains connected to the same pair of terminals. The containing case is made of strong teak having a highly polished finish, and a handle is provided which enables the instrument to be carried either by hand or slung over the shoulder.

There has lately been a growing call for electrical tachometers because they have the advantage over the mechanical models of being more adaptable for use at



The Record Bridge Ohmmeter.

any distance away for the actual machine or shaft, of which the speed is required to be measured. The Record "Cirscale" instrument, due primarily to its clear open scale which extends over an arc of approximately 300 degrees, and its noted accuracy and reliability, has proved to be particularly serviceable as a speed indicator. The Record Company has anticipated the demand and is now manufacturing Cirscale R.P.M. indicators complete with the necessary generators. Two models are shown: a 2¾ inch dial with a light-weight generator for air ships; and a 16 inch dial and more robust generator for engine rooms, etc.

PETTERS Limited.

One of the most impressive of the working exhibits is the 195 B.H.P. three cylinder Atomic Diesel cold starting airless injection heavy-oil engine, made by Petters Limited. This is the largest size of this type yet exhibited. Petter engines of this type are made in one, two, three, and four cylinder units in sizes from 25 B.H.P. to 260 B.H.P. for all industrial purposes. They possess Diesel high thermal efficiency without the disadvantages generally associated with this type of engine. Reliability is claimed as the first essential in this prime mover: which with a thermal efficiency on brake horse power of 33.6 per cent places the engine in the very forefront of economic performance. It is further claimed that this engine is exceptionally free from mechanical weakness consequent upon its simplicity of design due to the two-cycle principle. This simplification is extended to the cylinder head by the avoidance of all inlet and exhaust valves working in the combustion chamber. All valve grinding-in, and delicate valve adjustments are eliminated, together with the valve operating mechanism such as bevel or helical wheels, lay shafts, cams, rockers, etc. The fuel pump is of the simplest construction, embodying a glandless plunger whose length is much greater than its diameter; the wear is thus infinitesimal and leakage is noticeably absent.

High thermal efficiency is attained by perfect fuel combustion in a special design of chamber. An intimate and uniform mixture of atomised oil and air in a state of high compression and turbulence is thus brought about, and always at the correct position of the piston stroke. Due to the compression temperature reached, immediate ignition occurs, and combustion proceeds rapidly along the entire mass, causing a rise in pressure near the beginning of the working stroke, and continuing over a portion of the same. The whole process is developed without shock, and high thermal efficiency is secured

Practically all grades of fuel oils can be employed including crude, residual, or refined petroleum, tar, shale, vegetable and animal oils.

The high efficiency obtained during test when the engine is new and in perfect order, is maintained over lengthy periods, and in many cases is improved—the cylinder head being free from the deterioration which occurs from the pitting and burning of poppet valves, etc., in the four-stroke cycle. With the object of avoiding mechanical complexity the makers adhere to the employment of crankcase scavenging. The main bearings remain free from the effects of crankcase suction and compression, by the use of special sealing rings, and thus low lubricating oil consumption is secured. A dry crankcase is employed, the oil being drained into a receptacle for use again, after filtration.

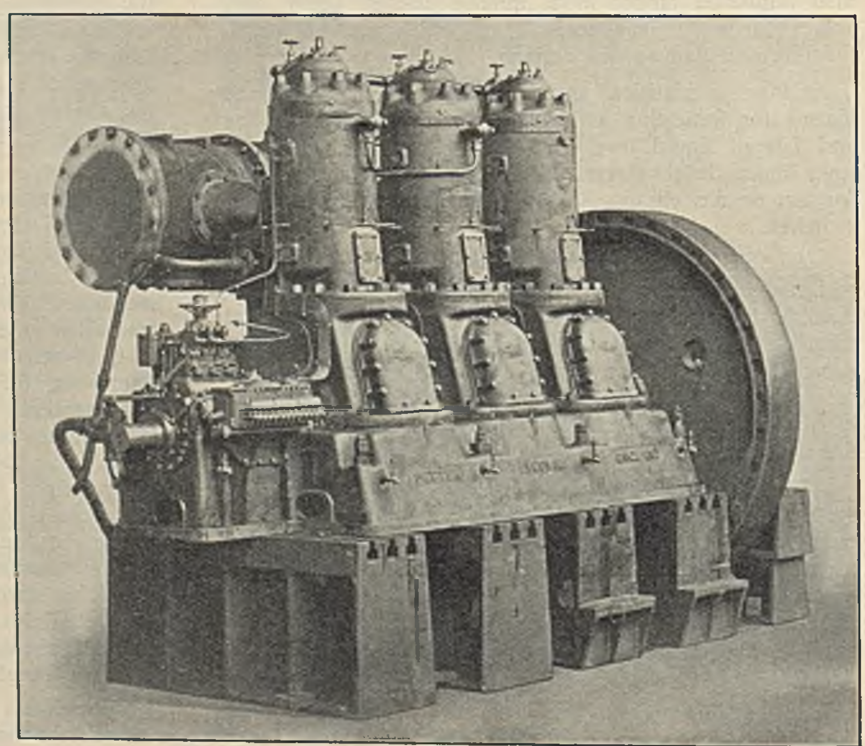


Fig. 1.—The Petter "Atomic" Diesel Engine.

On account of the solid injection of fuel, there is no necessity for the installation of a high pressure air compressor, intercooler, receiver, valves, piping, and mechanically operated oil sprayer. By the removal of these encumbrances some 5 per cent. is added to the mechanical efficiency.

A centrifugal governor, sensitive in movement, controls the speed by varying the amount of fuel injected into each cylinder per working stroke; any excess pumped, over that required by the load, is by-passed. A hand-wheel attachment enables the speed to be reduced from normal through a wide range; the governor operating at all speeds.

The lubrication is of the forced feed "sight feed" type and supplies piston, cylinder, and crankpin. The main bearings are "ring" lubricated. The engine is totally enclosed, and the atmosphere remains free from contamination.

Another example shown in operation is the Auto-Petter 950 watts output electric lighting plant with improved controller and starting gear. This controller and starting gear is here exhibited for the first time. The plant—without large storage batteries (only a 12 volt battery for starting purposes) and entirely self-contained—is suitable for lighting buildings and premises where light is required for a relatively short period, and where numerous storage batteries would be out of use and unattended for long periods. The plant consists of a 2 B.H.P. two-stroke petrol engine, direct-coupled to a compound wound dynamo at 110 volts. A standard type self starter with Bendix drive is fitted to the engine, similarly to the motor car method. A centrifugal governor, mounted directly on the shaft, controls the speed and regulates the petrol consumption in proportion to the lamps in use.

Petters Limited have produced a robust controller capable of meeting the most exacting demands. The controls are mechanically interlocked with self-cleaning contacts. The pressure on the contacts is intense whilst the energy required in the actuating coil is very small—due to the efficient magnetic circuit employed. Large gauge windings are employed, which remain idle except during the few seconds occupied in starting and stopping. The control switches may be placed anywhere in the house as desired.

The controller functions as follows:—To obtain light the nearest control switch is pressed downwards, causing a powerful electro-magnet in the controller to close contact, by means of which the motor starter sets the engine running. The "earthing" of the magneto—which had occasioned the previous shutdown—is now automatically removed and regular ignition takes place in the cylinder. As soon as the engine gathers speed the lamps in the house begin to glow; then the operator releases the switch, and the starting controller windings are cut off from the starting battery. All these operations occur simultaneously and a momentary pressure on the switch suffices to obtain light.

As soon as correct voltage is generated by the main dynamo, a robust cutout, which is part of the controller, automatically puts the starting battery on "Trickle" charge to make up for the starting current used, but at a very low rate of supply which prevents the over-

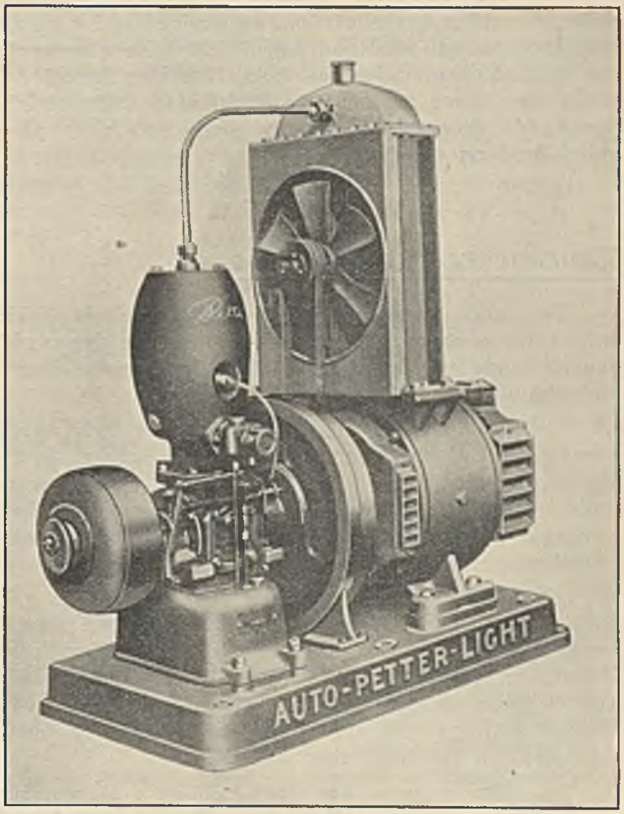


Fig. 2.—The Petter Automatic Electric Lighting Set.

charging of the batteries. To discontinue the supply of light, all that is necessary is to press the nearest control switch into the position marked "Stop" the lights quickly become dimmed, the switch can be released at once, and the engine soon comes to rest.

For electric generation of power and for marine work in Barges, Tenders, Fishing Craft, Launches, etc., the twin cylinder Petter crude oil engine is recommended as it starts instantly from cold, without preheating or electrical equipment with the same cheap oil as is used for running. It has a pronounced advantage over the four-stroke cycle in regularity of motion, simplicity of design and greatly reduced maintenance costs. With a calorific value of 19,000 B.Th.U's. per lb. the fuel consumption is approximately half a pint per B.H.P. hour on the smaller sizes. As this fuel only costs 4½d. per gallon compared as say with 1/4½ per gallon for petrol, an 8 B.H.P. engine in a year's working will show a fuel bill economy of over £90 against the corresponding cost of a similar sized engine operating on petrol.

Other exhibits include examples of the Petter Universal small power oil and petrol engines in sizes ranging from 1½ to 5 B.H.P. They are equipped for working on either paraffin or petrol fuel at the user's option without sacrifice of economy in either case. This result is accomplished by the insertion or withdrawal of a simple compression ring placed between the cylinder head and cover; the change over can be done in a few minutes, the ring being used when working on paraffin, but removed when petrol is employed. At the same time, without making any alteration, an engine set for paraffin will work at all loads on petrol, but with a somewhat higher fuel consumption than when the ring is removed; whilst an engine set for petrol will work quite satisfactorily and economically up to about two-thirds of its rated load on paraffin.

GENERAL ELECTRIC Co., Ltd.

The large space occupied by the G.E.C. is divided into three sections. The centre is in the form of a lounge, and both the end sections are mainly devoted to exhibiting electric furnaces in operation.

The walls of the lounge are hung with aerial photographs of the company's principal works, flanked by photographs of representative products of such works and a composite photograph of the company's head office, research laboratories, and home and overseas branches.

The left-hand section of the stand has as its chief feature a standard Magnet type electric furnace actually annealing brass stamping, spinnings, etc. Two other electric furnaces are also shown, viz.: a muffle furnace and a high temperature steel hardening furnace—the former serving to pre-heat high speed steel tools before they go into the hardening furnace.

The other wing of the stand exhibits a Magnet type electric furnace, designed for annealing steel and case-hardening steel: this furnace is shown in operation. Alongside this is a lead melting pot with its contents molten, and an electric still, while at the rear is an electric cyanide pot (not shewn in operation, owing to the fumes which would be given off).

Another exhibit of exceptional interest is the sectional model of the Grunewald electric bright annealing plant, for steel and copper strip and wire in coils. Specimens of work which have been bright annealed are displayed. The remarkable efficiency of the Grunewald process (for which the G.E.C. have the sole manufacturing and selling rights for the British Empire) make this exhibit one of the outstanding features of the Fair.

DRAYTON REGULATOR & INSTRUMENT Co., Ltd.

This Company's exhibit includes a range of automatic switches and contact devices operated by temperature, humidity, pressure, and level impulses. A number of new patterns which have been standardised over the last twelve months are here exhibited for the first time. A particularly interesting example is the H.C. humidity contactor, which actuates relay switches on valves through a three-wire circuit. The contact arm is actuated by the deviation from a set wet bulb depression. The H.C. contactor can be applied to the control of humidity in automatic sub-stations, work-rooms, stores, and air conditioning generally. The R.C. temperature contactor operates in a similar manner, the contact arm being actuated by a bi-metal thermostatic coil.

ELECTRIC FURNACE Co., Ltd.

This Company has a joint exhibit with The Electric Resistance Co., Ltd. The Electric Furnace Co. deals with electric melting furnaces of all types, such as the Héroult arc furnace, the Ajax-Wyatt induction furnace, the Ajax-Northrup high frequency furnace and so forth. The furnaces which they construct are generally too large to show in operation at an exhibition, hence their principle furnaces are shown by photographs of installations or drawings.

A small Ajax-Northrup high frequency furnace, suitable for use in laboratories and illustrating the principle of high frequency melting is, however shown in operation: also a new type of poking machine, used for stirring brass swarf in Ajax-Wyatt furnaces.

The Electric Resistance Furnace Co., Ltd. exhibit a melting pot heated by electric resistors, which is suitable for metals of low melting point, the pot shown has a capacity of about 200 lbs. of aluminium, but they can be made in sizes varying from 20 lbs. to 5 tons.

Also exhibited is an air heater for supplying hot air for drying purposes of all kinds: this heater being of very simple construction and of 3.4 k.w. rating. Other items of interest are photographs and drawings of pottery kilns, large slab-heating furnace, annealing furnaces, continuous strip furnace, tube-annealing furnace; and a number of electric furnace products, including intricate castings of steel made in an Ajax-Northrup furnace, and decorated pottery, etc.

VICTORY VALVES Ltd.

A notable exhibit comprises a representative range of Victory valves, manufactured with wrought steel bodies, in all types, and in sizes from ½ in. to 24 ins. bore. These valves are suitable for the highest working temperatures and pressures obtaining. Having bodies of wrought steel, they are free from the troubles usually associated with steel castings, such as porosity, cavities, uneven thicknesses and blow holes; and, because of the unique method of securing the valve seatings, it is claimed that all troubles of distortion, etc., are obviated. Amongst the installations of Victory valves at the present time is one where the steam pressure is 955 lbs. per square inch, with a temperature of 800 degs. F., and another where the temperature is in excess of 1,000 degs. F.

Of particular interest is the 14 ins. electrically operated patent parallel slide valve; their system of electrical operation is efficient in practice and offers peculiar advantages.

The full flow parallel slide valve shown is of a special design which permits of the use of "loose" flanges, in extra high pressure installations, where it is desired to adopt particular types of welded joints.

Stainless steel valves for the chemical and allied trades are another of the firm's specialities, of which examples are shown.

EDISON SWAN ELECTRIC Co., Ltd.

The great variety of electrical accessories shown include ironclad switches and fuses, standard switches and sockets and plugs, and Bakelite switches. A full range of Tungar rectifiers is being exhibited.

The electric cable and wire displays include samples of mining and other cables, and the Ediswan earthed and unearthed wiring system. Sangamo-Ediswan meters; electric fires and domestic appliances include metal "Raymond" reflector, dome, imitation coal and bowl fires; also electric irons, boiling rings and kettles. There is also a representative collection of commercial, industrial, and other fittings in use for illuminating the stand. Ediswan lamps are in profusion, including the Fullolite and Pearl. For the radio trade one may note the all-electric and battery operated receivers and a moving coil and other types of loud speakers. Also included are the B.T.H. electric gramophone motor and pick-up and tone arm. Battery eliminators and transformers for various purposes are also exhibited, as well as accumulators, dry batteries, h.t. batteries and four types of transmitting valves.

ALFRED HERBERT, Ltd.

A motor-driven No. 6 "Atritor" coal-drying, pulverising and firing machine is exhibited in operation, actually firing a metallurgical furnace. A similar machine opened up for inspection is also exhibited. The No. 6 "Atritor" has a normal capacity of 500 lbs. of pulverised fuel per hour. Samples of work produced by "Atritor" fired furnaces are exhibited, as well as a model "N.O.C." installation, suitable for a battery of six boilers, for the prevention of scale and corrosion in boilers.

G. A. HARVEY & Co. (London) Ltd.

The many examples here shown illustrate the innumerable industrial purposes served by perforated and woven metalwork. Extensive uses are for the screening, grading, cleaning, sifting, separating, or filtering of a vast number of commodities from coal, coke ore, stone, gravel, to sugar, fruit juices, and fine chemicals. Many patterns of ornamental metalwork for radiator and electric heater covers, pipe guards, grilles and ventilator panels, are also shown. These perforated and embossed designs are of outstanding decorative excellence and provide an artistic method of dealing with the unsightly radiator, corridor piping, etc. Charming panelling effects are produced in a wide variety of designs and there is a choice of a large number of beautiful finishes, such as oxidised silver and lacquered and antique effects.

A large part of the output of the Harvey works consists of steel platework and constructional work, and amongst the many diverse forms of industrial equipment they produce, are storage vessels, stills, condensers, cylinders, etc., for ammonia recovery, benzole, chemical and creosoting plants, water softening plants, storage tanks up to 116 ft. diameter, hydraulic pressings, tar still bottoms, angle section rings, vulcanising pans, bunkers, and structural steelwork of all kinds. Specimens of flanged steel plates up to ⅝ in. thick, as well as angle sections, bent or rolled to various sizes, form an important part of this exhibit.

A header of gilled tubes for transformer tanks is of especial interest to electrical engineers. Messrs. Harvey & Co. are specialists in this class of work and manufacture gilled tubes in any size by an improved method.

RICHARD JOHNSON AND NEPHEW Ltd.

The exhibit consists of wire in great variety covering a range in iron and steel from 0.500 in. to 0.0124 in. diameter. In copper, aluminium, and other alloys from 4 ins. wide to 0.0124 in. diameter.

In addition to round wires there are exhibits of wire drawn to a variety of shapes, such as wires for lock section wire ropes, hexagons and squares for machine work, as well as sections for electrical purposes, half round wires for cotter pins, etc. There are galvanised wires shewn for fencing, chains, hose armouring railway signals, telegraphs, and wireworking, etc. It is claimed that Johnsons were the first to introduce, in 1860, the continuous method of galvanising wire, and ever since that time they have been endeavouring to produce a wire which would wrap over itself without the zinc flaking or peeling. Wire galvanised by the Company's "Crapo" method accomplishes this and as part of the exhibit specimens are practically subjected to the severest possible test.

Amongst the non-ferrous exhibits are copper wires in the usual round sections and also rectangular sections for busbars and electrical work. There are strips which are supplied in bar form as well as strips supplied in specially wound square faced coils, all familiar to those interested in the electrical trades. On the non-ferrous side some years ago the Company introduced the alloy cadmium-copper which is sold under the trade mark "Caduro". This new alloy has found great popularity amongst tramway engineers and those engaged in power work owing to its combined high tensile and high conductivity.

TURNER'S ASBESTOS CEMENT, Ltd.

This company exhibits "Sindanyo" asbestos electrical insulating and arc-resisting materials, and, following upon the amalgamations in the asbestos industry of the past year, other similar products are shown, viz., "Siluminite," "Ebbinita," and "Macolite." The exhibit includes a variety of "Sindanyo" switchboard panels upon which are mounted electrical equipments by several manufacturers. The large range of shaped parts produced in "Sindanyo" is also shown to advantage. Asbestos paper for electrolytic work, asbestos paper tape for cable insulation and asbestos paper tubes, are displayed, together with a comprehensive group of insulating mouldings of "Siluminite" and "Ebbinita," products hitherto sold by the Siluminite Insulator Co., Ltd., in addition to "Macolite" sheets and mouldings formerly sold by Bell's United Asbestos Co., Ltd.

CHLORIDE ELECTRICAL STORAGE Co., Ltd.

The batteries shown fall into four main categories. The first comprises "Chloride" batteries for stationary installations, such as country house lighting plant and central power stations, and for marine work. These are also designed for the emergency lighting equipment of theatres, kinemas, shops, and public buildings.

The next class is "Exide" batteries for radio valve anode and filament purposes, talking-film installations, and sound-projector systems. These include a comprehensive range of unspillable cells for portable wireless sets, and also unspillable cells for miners' handlamps.

Batteries for marine work form the next group, and batteries for land traction, such as the propulsion of electric vehicles, trucks and cranes, are shown. "Lux" batteries for lighting railway trains are the fourth class. Among the particular applications of batteries, attention is drawn to the company's switch-tripping service demonstrated on the stand. A working model of a h.p. switch is shown being tripped by a small battery of "Exide" "Mass" type cells.

W. & T. AVERY Ltd.

This year the firm of Avery, known the world over, celebrates its 200th anniversary. It is but natural, therefore, that a special effort has been made to provide a fitting exhibit worthy of the occasion, and so successful is the outcome that the Avery stand is one of the most striking of the many elaborate stands. Built practically entirely of glass, the modern section is of futuristic but beautiful design, lighted by cunningly hidden lamps, and exemplifying the fastidious cleanliness of the modern weighing scale.

At the opposite end of the stand is a model shop representing the first House of Avery on its humble but portentous beginning at Bigbeth, Birmingham.

Around the buildings and on the large area remaining are grouped the Avery exhibits. Here are testing machines for carrying out all kinds of physical tests; counting machines for industry, lessening the burden of overhead costs; industrial visible weighers for use in any and every trade where weighing operations take place, reducing to a minimum the time taken in this necessary operation; automatic weighers for weighing without attendance coal, grain, and many kinds of liquids; visible weighers for the grocer, the butcher, and the baker, giving visible indication of weight quickly, accurately, and without falter; personal weighers—some having platforms, some with a seat upholstered in red leather—for checking peoples' weight.

Another exhibit is a petrol pump made by Avery of a type which can be seen everywhere on the roadsides of the world. Also there is shown a most ingenious and original instrument for obtaining, without calculation, the specific gravity of substances, both solid and liquid.

(*To be continued*).

Lampholder—Plug Fitting.

W. E. Beardsall & Co., Ltd., are the sole selling agents of the "Xtra-Point" combined lampholder and plug. This is an ingeniously simple and effective substitute for the ordinary lampholder which will, unlike the better known heat-and-light adaptor, hang straight. The plug entries are inconspicuously placed in the cylindrical body of the upper part of the holder. The plug, if subjected to a violent tug, unlike the adaptor which is locked into position, will leave the socket and not bring the pendant with it.

It is made of bakelite and has metal parts of ample carrying capacity and has an improved cord-lock effectively separating the flexibles without compression and capable of suspending heavy weights.

The plug element takes the current direct to the iron or other apparatus used and not *via* the lampholder plungers so that there is no danger of the plunger springs, through overheating, losing their tension, with the consequent sticking of plungers, arcing and burn-out. The plug is rated to carry five amperes continuously without overheating.

Another advantage is that the plug can remain permanently in position in the holder; it can be inserted in alternative positions, when reversed it will control either the light, the appliance, or both. The plug in position does not foul or tilt the shade or holder. It is low in price and protected by patents.

Montevideo Power Station.

The Metropolitan-Vickers Electrical Company Limited have secured the order for the complete machinery and plant for the new Montevideo State Electric Super Power Station. The order comprises two 25,000 k.w. 3000 r.p.m., turbo generator sets, each with direct coupled exciter and 750 k.w. auxiliary alternator; the central flow condensing plant, with motor driven circulating and extraction pumps, and full capacity air ejectors; and also a 750 k.w. geared turbo alternator.

The steam generating plant is included, consisting of the necessary water-tube boiler equipment, pipe-work and valves.

The electrical control and distributing apparatus comprises electrically operated circuit breakers, the control equipment being of the double fronted desk type, all with provision for extensions. The auxiliary service switchboard is also included. There are, moreover, 7,400 k.w. of three-phase station auxiliary transformers; accumulators and charging equipment; cable work and automatic telephone equipment.

The whole contract, running into nearly three-quarters of a million pounds and including no civil work or buildings, is probably one of the largest ever placed in this country for a power station overseas. The site of the new power station will be close to the sea wall and less than half a mile from the existing station.

Pigmy Lamps.

A new range of Osram pygmy lamps is now available in the standard colour sprayed finishes of white, red, orange, yellow, green as well as the clear type. These are employed for sign and decoration work and also in totalisators and other forms of indicators, score-boards, etc., in use at racecourses and sports centres. They are however suitable for many industrial and domestic services and, in particular, for signalling purposes. They have the great advantage of providing miniature lighting points on parallel circuits. As the name indicates, the lamps are of small dimensions, the maximum overall length of the B.C. type being only 2¼ inches long by 1¼ inches in diameter, the E.S. model being 2⅜ inches long. The colours are fast and durable. Standard voltages are 100/130 and 200/260 volts. They are rated at 15 watts.