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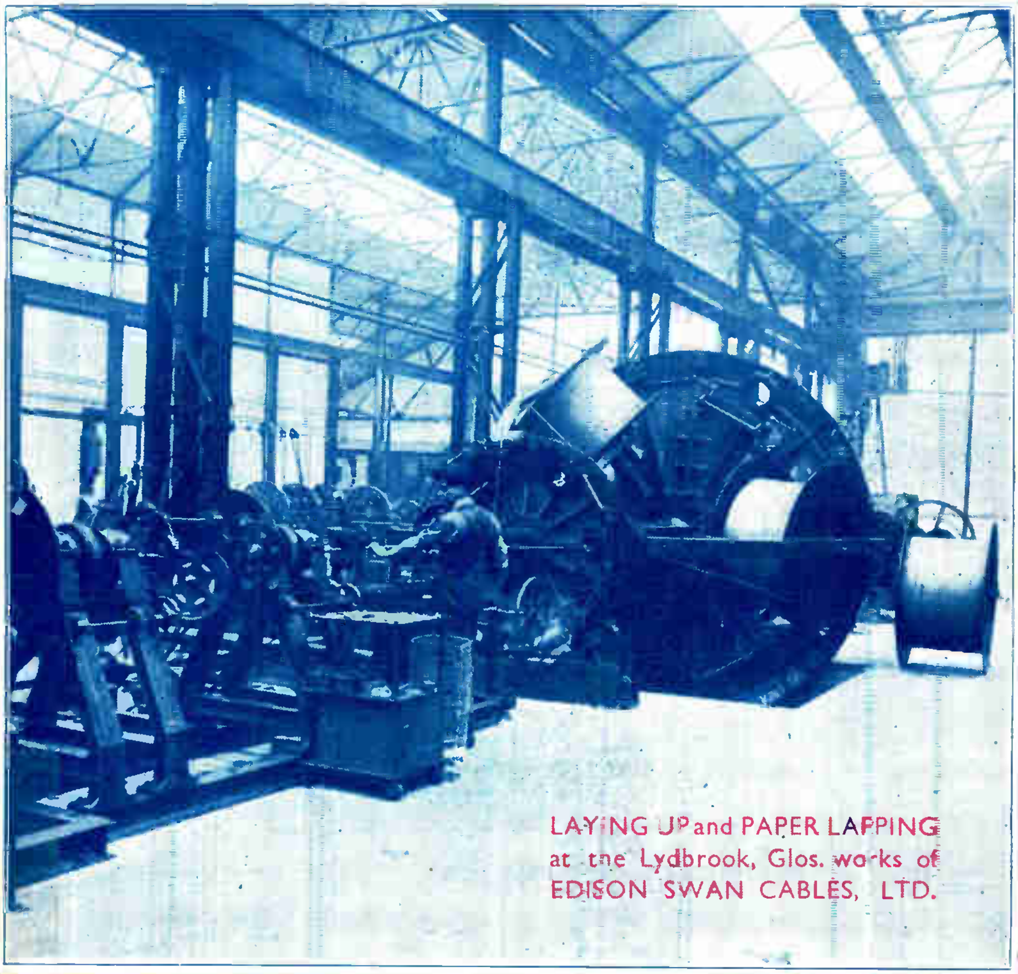

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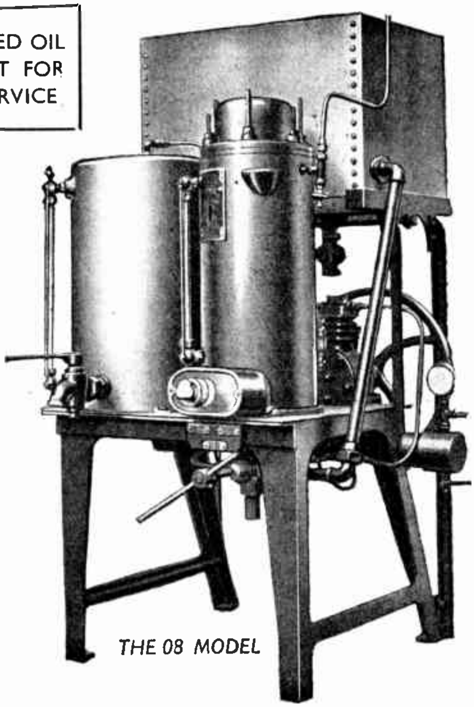

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The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

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Must We Always Have One Million Unemployed ?

A very eminent politician recently expressed the opinion that we must, even in a time of prosperity, expect to have a large surplus of unemployed workers numbering in the neighbourhood of one million. A very depressing fact if true, but is it true ? This question was propounded by a well-known electrical engineer at a friendly after-lunch discussion at which we were privileged to be present. Our engineering friend stated that in his opinion the potential capabilities of modern manufacturing plant for producing commodities was substantially in excess of the maximum possible world demand. He suggested that if this is actually the case the obvious remedy would be to introduce shorter working hours throughout industry. He agreed that for such a movement to be effective it would need to be world wide, and he admitted that as he was an engineer and not a politician, the ways and means by which such an effect could be brought about were beyond him.

Getting Down To " Terminals "

It will be observed that the above argument is only indirectly concerned with the present state of unemployment which, it may be fairly stated, *is purely temporary and due to dislocation of world credit.* The point at issue is not " what is the cause of to-day's unemployment ? " but, " are the world's, and in particular, this country's factories and workshops now capable of producing far more goods than can ever be absorbed by the population which they serve ? "

We think not. Let us bring the problem down to " terminals "—to paraphrase an old tag. Nearly everyone who reads these words is engaged in some branch of the electrical profession. Ask yourself whether *you* have everything you would like to have in the way of electrical appliances. Possibly you have an all-electric house equipped with electric fires, cooker, electric clocks, hot plates and kettles. Perhaps you also have a radio-gramophone, an electrical refrigerator, an electric toaster and a home talkie outfit. Your wife may have an electric hair-drier, an electric washing machine, an electric iron, heated towel racks, electric hot water supply, and you may possibly have fans for use in the summer and artificial sunlight equipment for use in the dark winter months. Perhaps you also have a perfect bell system, efficient burglar alarm, and house telephones installed. Your garage may be wired for lighting and power, and even equipped with a small battery charging plant which you can use for giving a boosting charge to your starter batteries in cold weather. Also, being an engineer and a practical man, you may have a workshop with a small electrically driven lathe and all the instruments which can gladden the heart of the man who wishes to experiment with, and test all kinds of new ideas. If you are blest with a family you may even have small mains transformers installed at convenient points enabling you to work low voltage apparatus such as an electric train set, or a lighting installation for a doll's house.

If

If you have all these things, there is at the moment not really a great deal more that you can wish for in the electrical field as far as your home is concerned, but remember that you are one in a million. Probably there are at least a dozen items mentioned above which you would like to have, providing you had the ways and means of obtaining them without keeping the income-tax collector waiting too long.

There are at the present time about four million houses in this country which are wired for electricity, and there are between eight and nine million still to be wired. The time may come when all these consumers and potential consumers have everything electrical that they could wish for, but we believe you will agree that this state of affairs is still a long way off.

Until it arrives there is plenty of work waiting for electrical manufacturers, contractors and retailers. The bulk of it will be done by the most enterprising in each group. See that you secure your share of it.

Progress

We have just received from the British Thomson-Houston Company an interesting statement of progress during the past year. This statement should be in the hands of every electrical engineer. It is a wonderful record of achievement. Every electrical engineer knows that this great company is famous for heavy electrical machinery, switchgear, transformers, and turbo-alternators, and during the past year notable progress has been made in each of these sections. There are, however, many other branches of electrical activity where progress is being made at an equal rate.

A Few Examples

As examples may be instanced, a new type of electric clock, an electric stethoscope for medical use, electrically driven blowers and compressors, gas boosters, mercury arc rectifiers, diesel electric locomotives, electrical equipment for an aeroplane testing wind tunnel, gearless electric lifts, special plating generators capable of delivering 3,000 amps. at 7 to 14 volts, frequency changers, and motors large and small for all kinds of industrial purposes, including rolling mills, coal cutting machinery, woodworking, and papermaking machinery. The development in fractional horse-power motors is also of interest, particularly noteworthy being the "Selsyn" unit which can be used for transmitting a small movement e.g., from a water level indicator or an instrument dial-reading, to a point remote from the origin. We have not yet seen one of these units in action, but assuming that they are up to the usual "B.T.-H." standard of performance they should have a very wide field of application in the near future. Talking films and public address systems form another interesting branch of activity.

It may be pointed out that whilst routine production of stock lines may offer the most remunerative return in the immediate present, the continued prosperity of any firm depends upon the development of new ideas and improvements.

It is good to know that our best electrical manufacturers not only realise this, but shape their policies accordingly.

STORAGE BATTERIES FOR EMERGENCY LIGHTING AND STAND-BY SERVICE

By A. T. Dover, M.I.E.E.

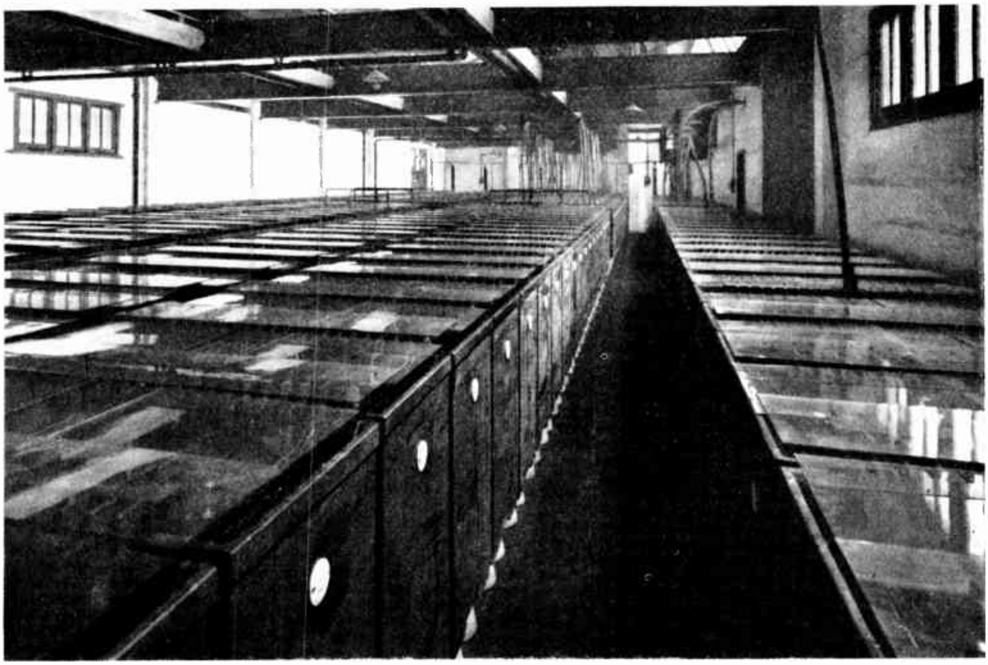


Fig. 1.—A Large (4,000 amp.-hour) Stand-by Battery at the Bankside Generating Station of the City of London Electric Supply Co.

This battery is maintained in a fully charged condition by trickle charging. (*Courtesy of The Chloride Electrical Storage Co. and the City of London Electric Supply Co.*)

Why Storage Batteries are Necessary for Emergency Lighting.

NOTWITHSTANDING the increasing use of alternating current for electric lighting and the changing over of many direct-current systems to alternating-current supply, a source of direct current is still a necessity in installations where *emergency* lighting has to be provided to meet the contingency of an interruption of the main supply. The source of direct current is a storage battery, as this is the only apparatus in which electrical energy can be stored so as to be instantly available in emergencies.

Necessity for Emergency Lighting.

Emergency lighting is a necessity in power stations, hospitals, theatres, cinemas, concert halls and other places of public entertainment, large hotels, large banks, departmental stores, town halls, underground tube railways, cement works and similar factories operating continuously, etc. In all these cases uninterrupted lighting is essential to safety and safe operation of the plant and processes. Moreover, in many large business premises and banks, time—particularly at certain seasons of the year—is of the utmost value, and even a short stoppage of work, due to an interruption of the lighting or the electric supply for the modern accounting machines, may result in a heavy financial loss.

Emergency Lighting in Theatres, Cinemas and Entertainment Halls.

Emergency (dual) lighting is compulsory in theatres, cinemas and all entertainment halls. The emergency (called "safety") lights must be illuminated the whole time that the public is present in the building, and must be fed from a source which is independent of that of the main lighting. Except in very special cases a storage battery must be installed to provide the independent supply for the safety lights. A special article on this subject was published in the January issue of this magazine.

Emergency Lighting in Hospitals.

In hospitals emergency lighting is required not only in the corridors, staircases and wards, but also in the operating theatres. The lighting in the operating theatres, however, must be absolutely infallible, and even the contingencies of the burning out of the lamp filament or the blowing of a fuse must be provided for. These contingencies can be met by arranging that the special emergency lights in the operating lamp fitting of any theatre are controlled directly by a special relay, the operating coil of which is connected in series with the main lamp.

The general emergency lighting and the special emergency lamps in the operating lamp fitting are supplied from a storage battery and are controlled by a special type of automatic switch which is described later. The scheme of connections is shown in Fig. 9.

Emergency Lighting on the Trains of the London Underground Tube Railways.

The importance of emergency lighting on the trains of underground railways cannot be over-estimated, and, therefore, some notes on the system adopted on the London tube railways will be of interest.

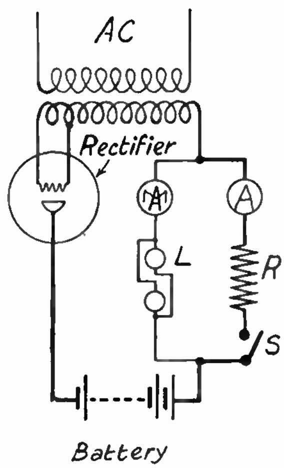


Fig. 2.—How the Trickle and High-rate Charging Currents are Obtained from a Rectifier.

The trickle-charging current is adjusted to the correct value (read on the milliammeter) by the lamp resistances, L. The high-rate charging current is adjusted to the correct value (read on the ammeter, A) by the resistance, R, this circuit being controlled by the switch, S.

The trains on these railways are made up of either one or two "train-units," a train-unit consisting of one motor-coach coupled to one or two trailer coaches.

The passenger compartments of all coaches are fitted with two 12-volt emergency lamps, located one at each end of the compartment. An emergency lamp is fitted in the motorman's cab, and one is also fitted in the tail-light fitting in addition to the ordinary tail-light bulb, which is supplied from the traction circuit.

The emergency lights are supplied from a 48 ampere-hour 6-cell Exide battery carried on each motor-coach, and are controlled by a relay, the operating coil of which is connected in series with the ordinary tail light. The emergency lights, therefore, come into operation either (1) with a complete failure of the traction supply (from which the ordinary lighting of the trains is obtained), or (2) if a defect occurs in the ordinary tail light. This arrangement ensures that light is always available for the tail light and in the motorman's and passenger compartments.

The batteries are removed for inspection every 14 days. They are discharged to 1.8 volts per cell before being recharged (at the train depot) and fitted to another train.

Stand-by Supply in Power Stations.

In power stations a stand-by supply, entirely independent of the main generating plant, should be available for the station lighting, the protective switchgear, and the vital auxiliary machinery. In both D.C. and A.C. generating stations this stand-by supply is usually furnished by a storage battery.

The battery has usually a moderate ampere-hour capacity. For example, at the Lots Road power station of the Underground Railways of London a battery of 62 cells of 2,764 ampere hours capacity at the 10-hour rate is installed for operating the main high-voltage switch groups and emergency lighting in the power house and control room.

Stand-by Batteries for D.C. Distribution Networks.

In many D.C. stations which supply the central districts of large cities where continuity of supply is of extreme importance, a large battery of several thousand ampere-hours capacity is installed to act as a stand-by to the main generating plant.

Examples of large stand-by batteries are to be found in all large cities in which energy is distributed on the D.C. system.

As a typical example of this may be mentioned the electricity supply in Stockholm, where in substations supplying the D.C. network in the city, there are installed stand-by batteries aggregating approximately 75,000 ampere-hours and involving a total of no less than 3,274 individual cells. The batteries collectively can supply to the D.C. distribution system a current of approximately 40,000 amperes for one hour.

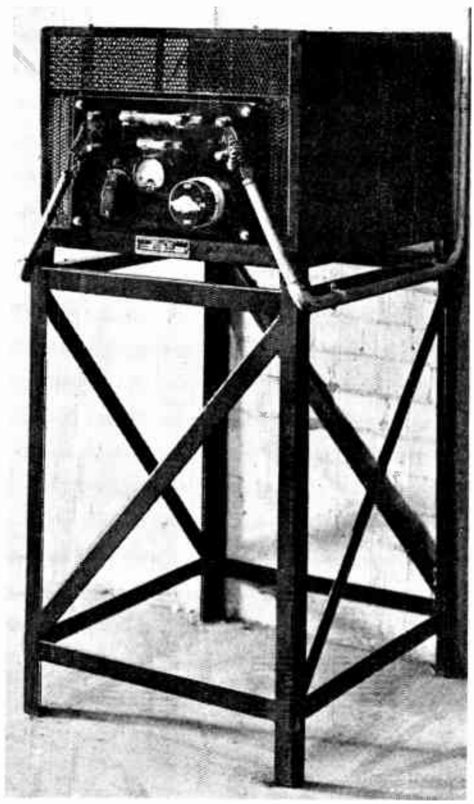


Fig. 5.—Westinghouse 500-watt Copper-oxide Rectifier for Trickle Charging the Battery Illustrated in Fig. 4. (*Courtesy of The Westinghouse Brake and Saxby Signal Co.*)

A Large Central Station Stand-by Battery.

Fig. 1 illustrates a large stand-by battery (244 cells, 4,000 ampere-hours at the 10-hour rate) at the Bankside generating station of the City of London Electric Supply Company. This battery is employed as a stand-by supply to the station bus bars to maintain the station lighting and auxiliary power supply in emergencies. It is capable of giving 2,000 amperes for one hour, and has, on occasions, given discharges of 1,500 amperes for 45 minutes.

Stand-by Battery for Load Levelling.

In many traction substations supplying D.C. railways large batteries are installed for both stand-by and load levelling purposes. In these cases the battery works permanently in parallel with the converting machinery: it assists the latter (viz., by discharging) at peak loads, and is charged at light loads, thereby maintaining a more uniform load on the converting plant than would be possible otherwise. At the same time the battery is available for emergency service in the event of a breakdown of the converting plant. This use of a battery is somewhat different from that of the cases previously considered (viz., where the battery is used solely for emergency supply), and it also involves the employment of auxiliary plant (e.g., an automatic reversible booster) which is not required when the battery is used solely for emergency supply.

EMERGENCY LIGHTING EQUIPMENT.

How the Emergency Lights are Wired and Controlled.

The emergency lights are usually wired on a separate low voltage circuit (25, 50 or 100 volts), and are connected to the

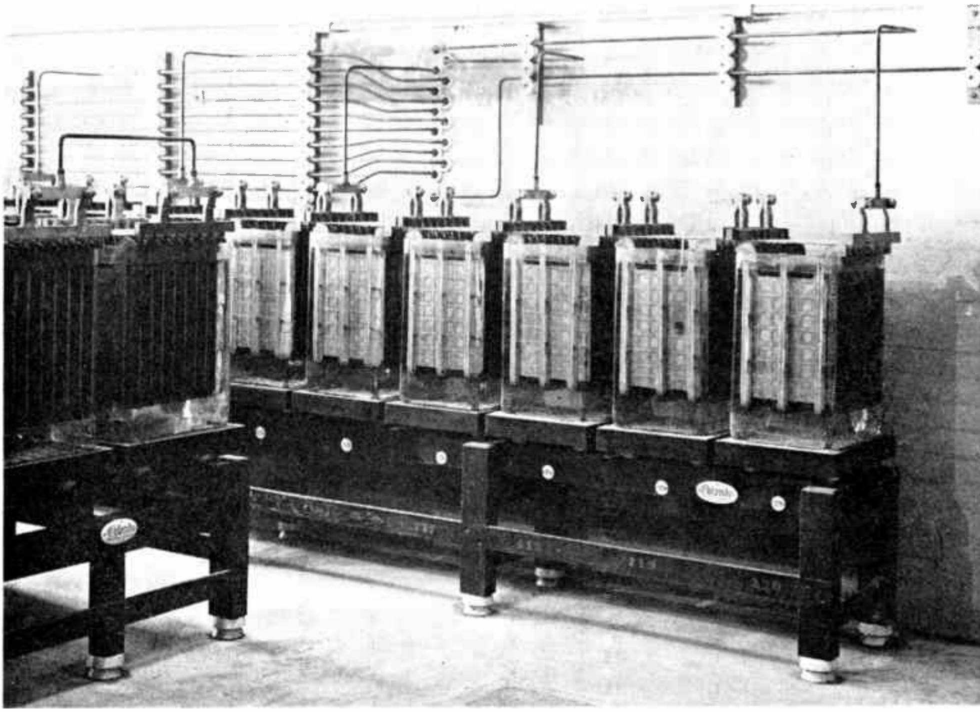


Fig. 4.—Part of a 120-cell, 800 amp.-hour, Chloride Stand-by Battery at Olympia Exhibition Buildings, London.
(*Courtesy of Olympia, London, and The Westinghouse and Saxby Signal Co.*)

storage battery by an automatic switch which functions immediately an interruption occurs in the supply to the main lighting. The emergency lights are switched off automatically as soon as the supply to the main lighting is restored.

The equipment additional to the emergency lights comprises: (1) a storage battery; (2) an automatic switch; (3) means for recharging the battery after an emergency discharge, and (4) means for maintaining the battery always in a fully charged condition.

Size of Storage Battery Required for Emergency Lighting.

The ampere-hour capacity of the battery will depend upon the number of emergency lights and the power of these lights. Usually the emergency lights are of relatively low power compared with the main lights, and they are located only at essential points, as with this arrangement the cost of the emergency lighting equipment is kept low. Particulars of standard equipments for emergency lighting are given in Table I.

Cases When the Normal Lighting Intensity Must be Maintained in Emergencies.

In power stations it is essential that the normal lighting intensity be maintained in emergencies. In some of the largest and most modern hotels in London this requirement is also considered to be essential for the public rooms, main corridors and staircases. In these cases no auxiliary lighting circuits are installed, but the appropriate main lighting is arranged so that it can be switched over directly to the battery in the event of failure of the normal supply. The voltage of the battery must, therefore, be equal to that of the supply system, and accordingly the size and rating of the battery will be much larger than those given in

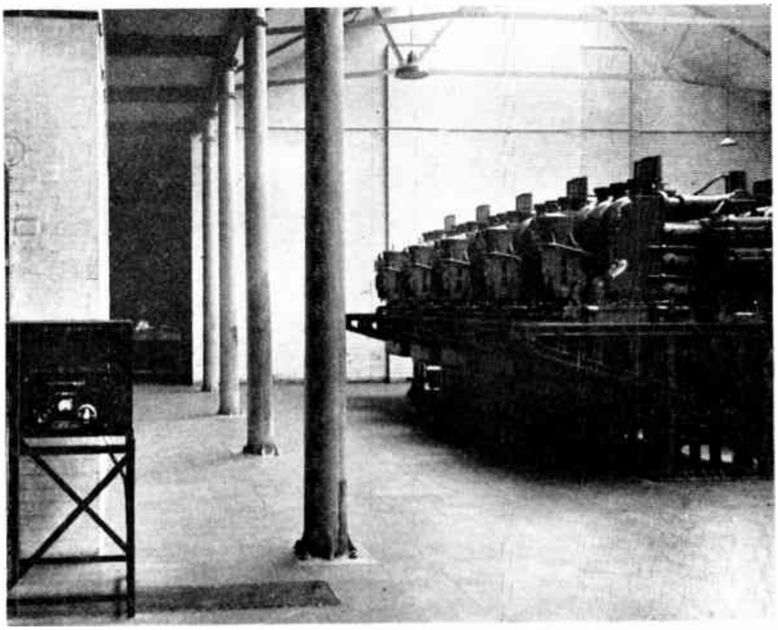


Fig. 5.—The Westinghouse Trickle Charging Equipment for the Switch Operating Battery at a Sub-station of the London Power Co. The battery is used solely for supplying direct current for the solenoid operating gear (closing and opening) of the metal clad oil switches on the right-hand side of the illustration. (*Courtesy of London Power Co. and Westinghouse Brake and Saxby Signal Co.*)

Table I. For example, at the Dorchester Hotel, London, the battery is of 300 ampere-hours capacity at the 10-hour rate, and can supply a load of 20 kW.

Again, in the operating theatres of hospitals the normal intensity of lighting on the operating table must be maintained under *all* circumstances, including even the contingencies of the blowing of a fuse and the burning out of the lamp filament. To meet this case, emergency low-voltage lamps, equal in intensity to the main lamp, are arranged in the operating lamp fitting.

METHODS OF CHARGING EMERGENCY AND STAND-BY BATTERIES.

How a Battery is Maintained in the Fully Charged Condition.

An emergency or stand-by battery must always be maintained in a fully charged condition in order that the full capacity of the battery may be available on emergencies.

TABLE I.—Particulars of Batteries for Standard Emergency Lighting Equipments ("Keepalite" System).

Equipment reference No.	Number of cells.	Voltage of emergency lighting circuit.	Ampere-hour capacity of Battery.			Total load in kW. which the battery can supply for—	
			1 hour discharge.	3 hours discharge.	10 hours discharge.	1 hour.	3 hours.
1	14	25	15	21	30	0.375	0.179
2	26	50	15	21	30	0.75	0.358
3	26	50	30	43	60	1.5	0.716
4	26	50	45	64	90	2.25	1.075
5	26	50	60	86	120	3.0	1.433
6	50	100	45	64	90	4.5	2.15
7	50	100	60	86	120	6.0	2.866
8	50	100	90	129	180	9.0	4.3

Normally the battery is kept continuously *trickle charged* at a very low rate, which is just sufficient to balance the loss of energy when standing on open circuit, but after an emergency discharge the battery must be given a quick recharge at the normal charging rate.

Trickle Charging.

This is a method of maintaining a *fully charged* standing battery in the fully charged condition by passing a very small charging current continuously (i.e., *day and night*) through the battery. The current must just balance the losses (e.g., self discharge due to surface leakage, gradual sulphation, etc.) which occur in the particular battery on open circuit.

Trickle charging is *not* a method of recharging a partially discharged battery.

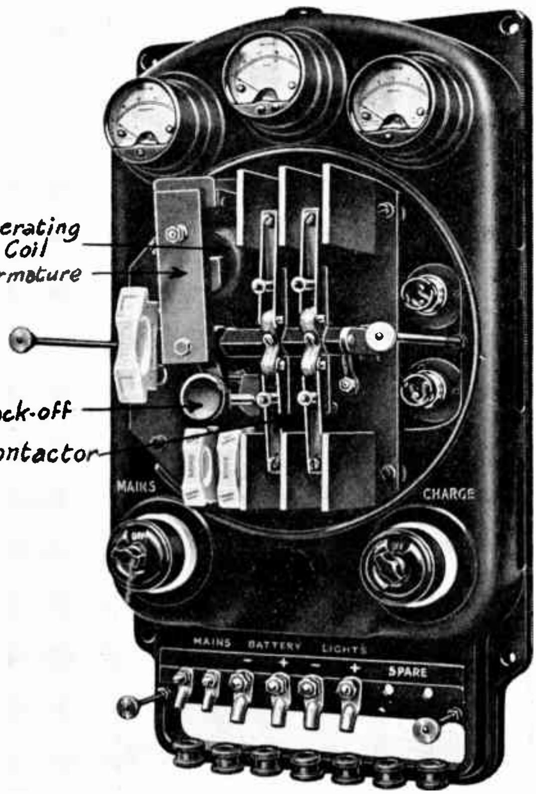


Fig. 6.—STANDARD "KEEPALITE" CONTROL PANEL WITH COVER REMOVED. (*Chloride Electrical Storage Co.*)
The "mains" switch is a double-pole switch for isolating purposes. The "charge" switch is a single-pole switch for high-rate charging, and is marked S in Fig. 7. The "lock-off" is a mechanical device for locking the contactor in the "off" or neutral position shown in the illustration.

Advantages of Trickle Charging for Stand-by Batteries.

Trickle charging, when properly carried out, prevents any tendency for the electrolyte to combine with the active material of the plates. Thus the plates never become sulphated or sluggish and retain their full capacity for an indefinite period.

Very little supervision and maintenance is necessary for a stand-by battery on trickle charge, owing to the entire absence of heating and gassing of the electrolyte. There is in consequence no loss of acid and scarcely any wear of the plates through scrubbing action (which occurs when a battery is gassing during a normal charge). Hence the life is far longer than that which would be obtained if the battery had to be worked under the usual cycles of charge and discharge to maintain it in good condition for emergencies.

The electrolyte retains its original specific gravity, and very little sediment, if any, is thrown down from the plates. For instance, in the 4,000 ampere-hour, 244-cell stand-by battery at the Bankside generating station of the City of London Electric Supply Company, the sediment, after 5½ years of emergency service and trickle charging, is insufficient to mark a clean stick.

Current Required for Trickle Charging.

The current required for trickle charging is very small—only a few milliamperes in some cases—as a modern Planté type stationary battery does not lose more than

2 per cent. per day of its ampere-hour capacity at the 10-hour rate. Thus, with a 90-ampere-hour battery (10-hour rate) having an open circuit loss of 2 per cent. per day, the loss of ampere-hour capacity during 24 hours would be $\frac{2}{100} \times 90 = 1.8$ ampere-hours, which must be compensated by the ampere-hours supplied by the charging current. Hence, the charging current $= 1.8/24 = 0.075$ ampere, or 75 milliamperes.

In practice, the current is usually fixed slightly on the liberal side to take care of variations in the open circuit losses. The correct value may be ascertained by observation of the specific gravity, voltage, and gassing of the cells, as explained in the later paragraphs on maintenance.

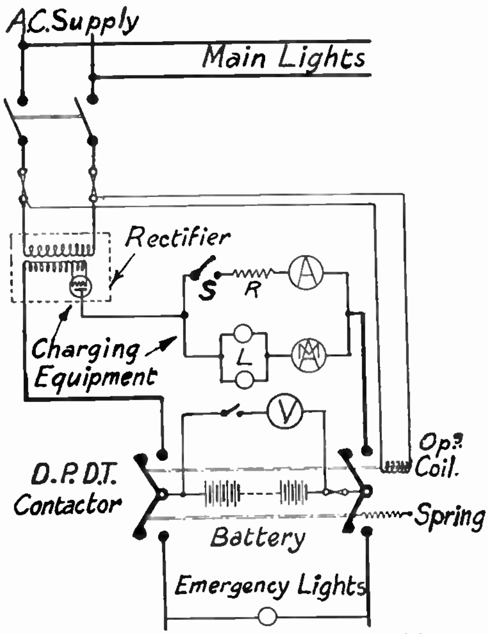


Fig. 7.—CONNECTIONS OF "KEEPALITE" SYSTEM FOR A.C. MAINS.

CHARGING ARRANGEMENTS.

The charging arrangements will depend upon the size of the battery and the nature of the main supply.

Charging from A.C. Mains with Rectifier.

When the main supply is alternating a rectifier outfit is employed to provide both the trickle charging current and the high-rate charging current for the standard equipments given in Table I.

How the Trickle and High-rate Charging Currents are Adjusted.

The trickle charging current is adjusted to the required value by suitable series resistances (usually lamps), and the high-rate charging current is obtained by switching a resistance in parallel with the trickle charging resistance. Fig. 2 shows the general scheme of connections when a valve rectifier is employed.

Alternatively, a small valve, or preferably a copper-oxide, rectifier could be used to supply the trickle charging current, and a larger valve rectifier for the high-rate charging current.

The advantage of this arrangement is that the continuous trickle charge can be given very efficiently since the copper oxide rectifier may be rated for no more than the trickle charge current, i.e., it will work on practically full load. There is a slight advantage in that an increase in the life of the valves is obtained, but it should be understood that modern gas-filled valves used for both trickle charging and occasional full-rate charging work normally at about one-fiftieth of their full load output and experience has shown that under these conditions several years' life is obtained.

Where current is expensive the improved efficiency and somewhat longer valve life might easily pay the extra cost of the combined form of charger.

Motor Generator Set.

When the high-rate charging current exceeds that which can be obtained from a valve rectifier, either a mercury-arc rectifier or a motor-generator set must be used (see THE PRACTICAL ELECTRICAL ENGINEER, November, pp. 98, 103, for diagrams of connections). In these cases the motor-generator set or mercury arc rectifier is used only for high-rate charging, and a small rectifier (valve or copper-oxide type) is provided for trickle charging.

As the high-rate and trickle charging currents are obtained from separate circuits a double-pole change-over switch is necessary to change over the battery to the appropriate charging circuit.

Examples of Trickle-charging Equipments for A.C. Mains.

Fig. 3 shows a copper-oxide (Westinghouse) 500-watt trickle charger for a stand-by battery (120 cells, 800 ampere-hours at the 10-hour rate) installed at Olympia Exhibition Buildings, London. The high-rate charging current is supplied from a motor-generator. The battery is shown in Fig. 4.

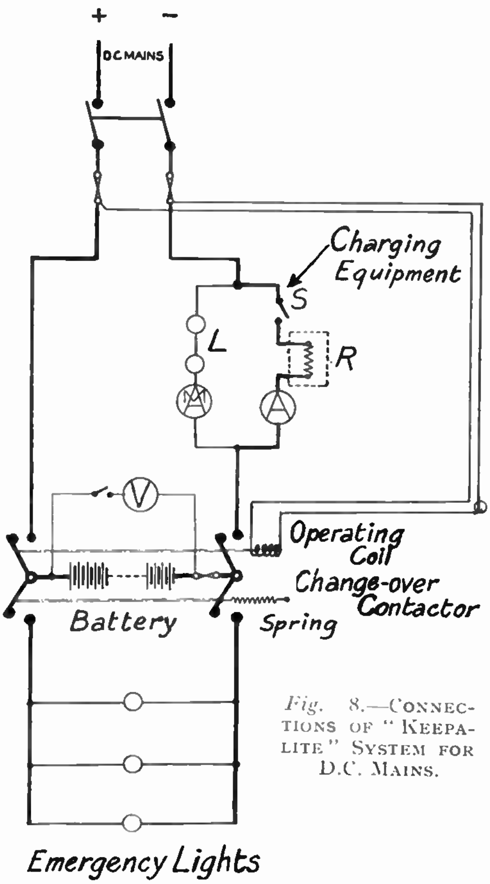


Fig. 8.—CONNECTIONS OF "KEEPALITE" SYSTEM FOR D.C. MAINS.

Fig. 5 shows the charging equipment for a switch-operating battery in one of the distributing substations of the London Power Company. Although not exactly stand-by service, the duty on this battery (and similar batteries in power stations) closely resembles that on a stand-by battery, as heavy discharges of very short duration (one or two seconds) are required at relatively long intervals. It is, of course, of supreme importance that the battery should be kept in a fully charged condition, and this is effected by a copper-oxide (Westinghouse) rectifier.

Charging from D.C. Mains.

When the main supply is direct current, series resistances are used for both trickle charging and high-rate charging, except in the case of a central station stand-by battery of the same voltage as the main bus bars when a booster set is necessary.

AUTOMATIC CONTROL EQUIPMENT.

Keepalite Automatic Switch and Control Panel.

The automatic switch in the Keepalite system of emergency lighting fulfils two functions, viz. : (1) It connects the emergency lights to the battery when the normal supply fails ; (2) it reconnects the battery to the charging circuit when the main supply is restored and maintains the battery continuously on trickle charge during normal conditions.

A typical control panel is illustrated in Fig. 6. This type of control panel is used in all standard "Keepalite" equipments, and a slightly modified form is used in cinema equipments.

In the standard type of control panel the automatic switch consists of a double-pole double-throw contactor, the lower moving contacts of which are biased by gravity (and a spring if necessary) to the lower pair of fixed contacts. These contacts are connected to the emergency lights, and the moving contacts are connected to the battery.

How the Automatic Switch Works.

The operating coil is permanently connected across the main supply. Hence, as long as this supply is maintained, the armature will be attracted to the pole piece, the upper moving contacts will make contact with the upper pair of fixed contacts and the lower contacts will remain open. As the charging supply is connected to the upper fixed contacts the battery will be trickle charged all the time that the main supply is maintained on the operating coil. But immediately this supply fails the contactor will drop over to the lower contacts, and the emergency lights will be connected to the battery. When the supply is restored the contactor will switch the battery over to the charging contacts. The battery may then be given a high-rate charge, if necessary, by closing the " charge " switch.

The trickle and high-rate charging currents are indicated on separate ammeters.

Connections for Standard " Keepalite " System for A.C. Mains.

Fig. 7 shows the connections for this system when the supply is alternating and the charging currents are supplied by a single rectifier according to the scheme of Fig. 2.

Connections of Standard " Keepalite " System for D.C. Mains.

Fig. 8 shows the connections when the supply is direct current. In this case the voltage of the battery is less than that of the D.C. mains, so that both trickle-charging and high-rate charging can be effected from the mains by series resistances.

Connections of " Keepalite " System for Hospitals.

Fig. 9 shows the connections for hospitals. In this case special provision is made to ensure continuous lighting in the operating theatres under *all* contingencies, including the burning out of a lamp filament or the blowing of a fuse.

The operating lamp fitting has, in addition to the normal special type lamp, a group of low-voltage emergency lamps giving an illumination equal to that of the normal lamp. These emergency lamps are wired direct to the battery through relays, a separate relay being used for each operating lamp. The actuating coil of the relay is connected in series with the normal operating lamp, and under normal conditions this coil is energised and the switch in the emergency circuit is open. If, however, the supply to the operating lamp fails or the lamp filament burns out the relay loses its excitation and the switch automatically closes the emergency circuit. A double-pole isolating switch is incorporated with each relay for the purpose of isolating both the main and emergency lamps when any particular theatre is not being used.

NOTES ON THE MAINTENANCE OF TRICKLE-CHARGED BATTERIES.

Importance of Correct Rate of Trickle Charging.

The trickle charging current *must* be maintained at the correct value, as too

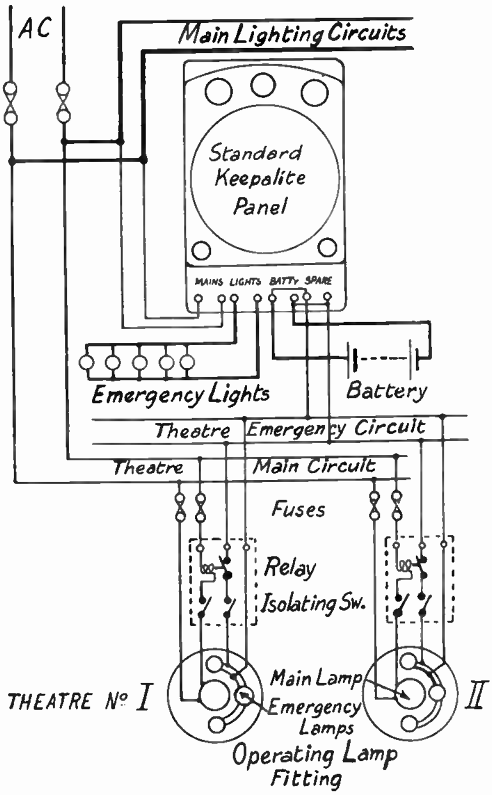


Fig. 9.—CONNECTIONS OF " KEEPALITE " SYSTEM FOR HOSPITALS.

The emergency lamps in the operating lamp fitting in each operating theatre are wired directly to the battery, the lamps in each fitting being controlled by a relay which closes this circuit in the event of any interruption of current in the main lamp.

high a current will eventually cause gassing and over-formation of the positive plates, and too low a current will cause sulphation.

The correct value is the minimum current which will maintain the constancy of the specific gravity of the acid in the cells at its maximum value, which varies with the temperature, make and design of cell. Fairly common values are :—

Temperature °F.	50	60	70	80	100
Specific gravity ..	1.214	1.210	1.206	1.202	1.195

The cell voltage is also a useful guide and should be between 2.20 and 2.3 volts, when battery has been fully charged and has settled down on trickle charge.

In actual practice the trickle charging current is adjusted to its correct value in accordance with the indications of: (1) specific gravity; (2) tendency to gas; (3) cell voltage. When once the exact voltage corresponding to the correct trickle charging rate has been determined, this voltage can be used in future as an indication that the cells are receiving the correct trickle-charging rate.

Careful records should be kept of these quantities, specific gravity, temperature, cell voltage, tendency to gas, which should be taken at weekly intervals on selected or pilot cells, together with similar readings at monthly intervals on all cells.

Topping-up Water.

Owing to the absence of electrolysis, the amount of topping-up water required for a trickle-charged battery is comparatively small.

When adding water it should be *poured to the bottom of the cell* by means of a funnel and glass tube to ensure thorough mixing with the electrolyte. Give a quick charge until there is sufficient gassing thoroughly to mix up the acid and added water.

Level of Electrolyte.

If reliance is to be placed on specific gravity readings, the level of the electrolyte should be as constant as possible, and should never exceed ¼-in. from the normal level in cells of medium size. With open-type cells evaporation may be reduced by covering the top of the electrolyte with a thin layer (⅛-in. thick) of anti-spray oil film.

Cleanliness.

Very careful attention must be paid to cleanliness, as any accumulation of dust, dirt and cobwebs in positions where it can cause leakage of current between the terminal lugs of the cell will seriously upset the working of the battery, owing to the reduction of the trickle charging current by the leakage paths. With open-type cells the side supports for the plates must be kept clean, and with sealed cells the top of the sealing cover must be kept clean and dry.

In dusty locations dust covers should be provided and the cells should receive a thorough cleaning and inspection before these covers are fitted and the trickle charging regime is put into operation.

Recharging After an Emergency Discharge.

After an emergency discharge the battery should be given a complete recharge (at the high rate) with as little delay as possible, both in order to keep the plates in good condition and to restore the battery to its normal service. The charging current may have any convenient value between half normal and twice normal charging, but as soon as free gassing commences the current should be reduced to the half normal rate.

It is very important that the battery should be absolutely fully charged before trickle charging is resumed, and to be quite sure of this condition the recharge should be continued until every cell has come up to its maximum specific gravity and voltage for a period of two hours.

Precautions to be Observed When a New Battery is Put on Trickle Charge.

When a new battery is to be put on trickle charge for the first time, it is very important that the active material of the plates should be in thorough working condition and stabilised before the trickle charging is commenced. Usually half a dozen cycles of charge and discharge are necessary to get the plates into this condition.

Acknowledgments.

Acknowledgments are due to the Chloride Electrical Storage Company (the patentees of the "Keepalite" system), the Westinghouse and Saxby Signal Company and the Underground Railways of London for the supply of photographs, diagrams and data.

Neon Signs

By D. Winton Thorpe, A.M.I.E.E.

There is undoubtedly an enormous field for the sale of Neon signs, and in this article Mr. Thorpe gives some useful advice that should help electrical contractors to take advantage of the business offered in this particular field

I WAS about to start this article by saying that the Neon sign was the sign of the future. That would, however, give an entirely wrong impression since it needs little more than a glance round any of our large towns to-day to find that it is the sign of the present. Nevertheless, for every sign of this sort which is working to-day, there will be ten signs working in a couple of years' time.

It is surprising that the electrical contractor and retailer in general is not being so quick to take advantage of the possibilities of selling these signs as one might expect from their obvious popularity and efficiency. Probably the reason is to be found in a certain amount of mistrust which has been fairly naturally caused by one or two misapprehensions on the whole subject. If I can, in the following short article, clear away any of these misapprehensions, it may be that it will have the effect of making people in the retail trade realise what a gigantic opportunity they are missing if they neglect to take the fullest advantage of the sale of Neon signs.

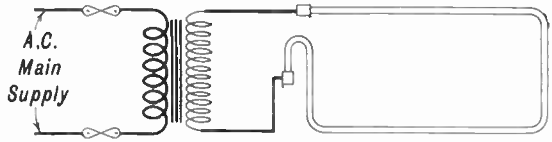
Fitting up a Neon Tube on a Sign at Facia Height.
See page 256 for practical notes re fixing.

Neon Signs Have No Filament.

It must, first of all, be understood that the light produced in a Neon sign is unlike the conventional form of electric light inasmuch as there is no filament; that is to say, there is no piece of wire carrying the current from one terminal of the tube or electrode, as it is called, to the other.

How the Neon Tube is Constructed.

The Neon tube, or Neon lamp, consists of a length of glass tube with a piece of metal, the electrode, inside each end and sealed into it, but with a metallic connection coming through the glass to the outside. This hermetically sealed tube is exhausted: that is to say it is reduced to as near a vacuum as is commercially possible, by pumping out all the air that is in it. When the tube is exhausted a very small quantity of gas is allowed into it. The gas which is let in is in many cases Neon gas, and it is from the name



THE SIMPLEST NEON SIGN CIRCUIT.
Note fuses on L.T. side.

of this gas that this particular form of lamp first took its name. Nowadays it is usual to find a number of various gases used in order to obtain various colours.

Bending the Tube to Various Shapes.

Before the tube is exhausted and gassed it can be bent into any desired shape, even, when required, into the shape of a letter, and when the sign is lighted up, the tube, being in the form of a letter, will give a penetrating glow in the form of that letter, or any other type of design.

How the High Operating Voltages are Obtained.

So much then for what we may term the mechanical side of Neon tubes. The electrical side of the Neon tube or lamp depends upon the principle of applying a very high voltage across the two terminals or electrodes. The voltages actually in use in commercial Neon signs to-day vary, for the most part, from 1,500 to 6,000 volts, though there are on the market signs operating on lower voltages. This high voltage is obtained, in the case of alternating current, by means of a transformer, the low tension mains being connected to the low tension terminals of the transformer and the high tension terminals of the transtormer being carried to the electrodes at each end of the tube to be lighted. When this high voltage is applied across the electrodes there is a discharge from one electrode to the other which is made possible by the presence of the gas in what would otherwise be a vacuum. According to the gas which is used and the amount of gas which is used, so we get the variation in colours and the depth in colours.

Production of Neon Signs.

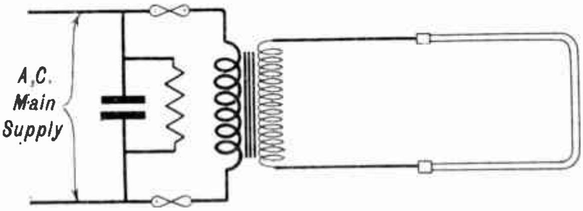
That all sounds from the manufacturing point of view very simple. Actually, of course, the manufacture of Neon signs and Neon tubes generally is not a simple matter, but requires a very great deal of knowledge and skill. There are such processes as ageing and a multitude of other intricacies which enter into the production of Neon signs efficient enough to stand up to the service which is demanded of them. But this article is written, not for the person who may contemplate the manufacture of Neon signs, but for the person who contemplates the sale and erection of Neon signs.

Static Discharge.

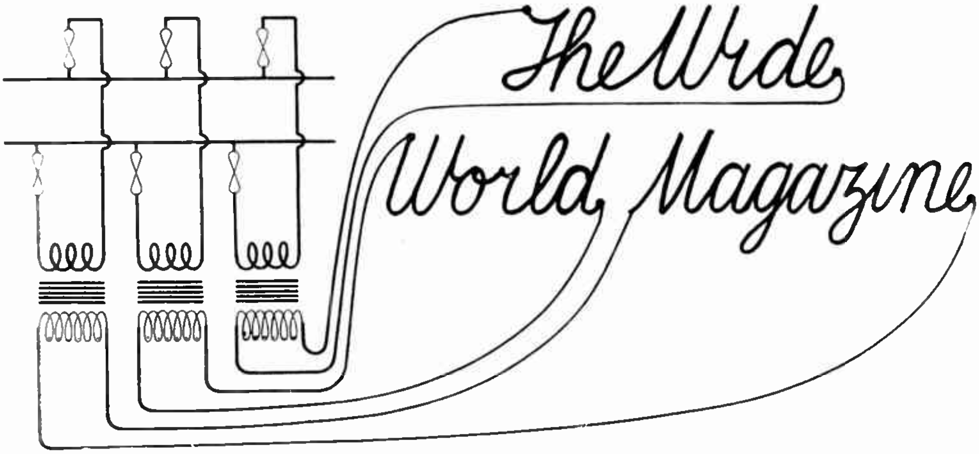
Since the discharge in the Neon tube is in the nature of a static discharge, very little current passes. And what current does pass is converted almost entirely into light. It is as well to remember that with the ordinary filament type of electric lamp about 92 per cent. of the energy put into that lamp by electricity is given off in the form of heat. Only about 8 per cent. is left to be turned into light. Therefore, the ordinary filament type of lamp, useful as it is and indispensable as it is, is a highly inefficient piece of apparatus; it is, in fact, only 8 per cent. efficient. If we could take that remaining 92 per cent. and turn it into light instead of heat we should, of course, have a 100 per cent. efficient piece of apparatus.

Efficiency of the Neon Tube.

The Neon tube gets much nearer to this desired efficiency. For if anyone places his hand upon a Neon tube while it is working he will find that it is quite cool. It is not, in fact, giving out any appreciable



A CONDENSER OR BANK OF CONDENSERS PLACED ACROSS THE PRIMARY INCREASES THE EFFICIENCY.



SEVERAL TRANSFORMERS ARE NECESSARY WHEN A GREAT LENGTH OF TUBE HAS TO BE ILLUMINATED

amount of heat; in other words, what little current is taken to operate a Neon sign is nearly all given out in the form of light. This, of course, is one of the strongest selling points in connection with Neon tubes, since the running cost of a sign fades into insignificance beside the running cost of an equivalent sign carried out in ordinary electric filament lamps. For obvious reasons, such as the intricacy of manufacture and the fragile nature of the sign when it is being conveyed to the point of erection, the Neon sign is, in the first instance, rather an expensive investment. But that it is a sound investment is beyond dispute.

Fog-penetrating Power of Neon Tubes.

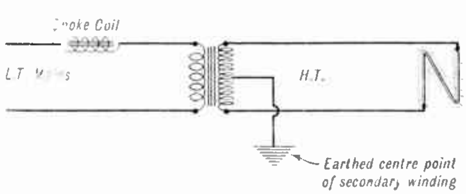
Another small point in connection with the advantages of Neon tubes is to be found in the fact that the red Neon, that is to say the tube which is charged with actual Neon gas, has greater fog-penetrating powers than practically any other type of lamp. For this reason it has a much greater advertising value where the site is one where fogs are at all prevalent, as in this country.

Value of Neon Lamps.

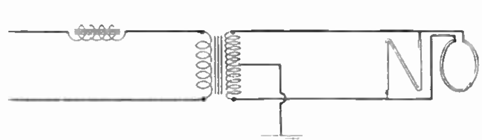
The obvious and most important advantage of Neon signs is, of course, that they do have a compelling power beyond anything which has yet been produced. It is impossible not to look at a Neon sign, whether you like it or not. Outline work, that is to say the running of a strip of Neon tubing round the outside of a building, even where there is no lettering attached to it, has an amazingly satisfactory advertising value. Moreover, this form of Neon sign work is comparatively cheap, since most of the expense of bending the tubes is removed.

Use of High Tension Supply Not Dangerous.

Many people have a wholesome fear of any voltage above that used in the general distribution of electricity for domestic purposes. Yet a moment's reflection will

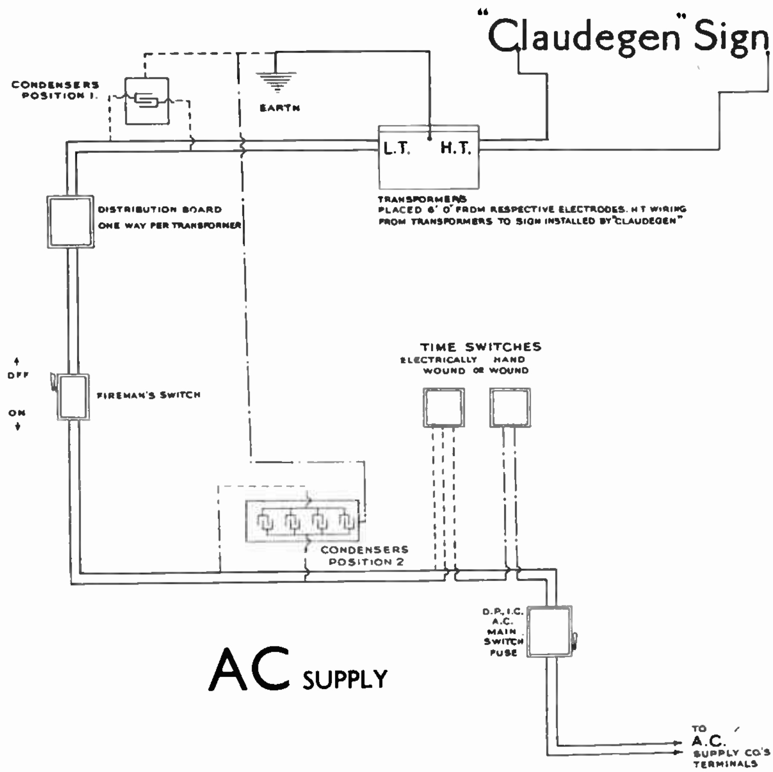


THEORETICAL DIAGRAM OF CONNECTIONS FOR A SINGLE LETTER.



CONNECTIONS FOR TWO-SECTION SIGN USING ONE TRANSFORMER.

remind these people that the voltage used for the sparking plugs on any motor-car, whether provided by a magneto or a coil, is also of a very alarmingly high figure. In the case of Neon signs the voltage is high, but the high tension side of the transformer is so well insulated, so completely protected, that danger from this source can be entirely ruled out.



METHOD OF WIRING A "CLAUDEGEN" SIGN FOR USE WITH AN A.C. SUPPLY.

Signs Made Up in Sections.

In most signs of reasonably large dimensions, what appears to be one sign is, in effect, a number of signs, representing sections of the whole. In the word "Restaurant," in three-feet letters, probably each letter and certainly not more than every two letters, would represent a separate sectional sign on their own.

SOME PRACTICAL POINTS.

The wiring of Neon signs does not present any great difficulties. Alternating current is used in connection with transformers, the latter allowing a voltage of between 5,000 and 15,000 volts to be applied to the electrodes. The diameter of the tubes ranges from 10 mm. to 30 mm. diameter, and the current from 15 to 250 milliamps.

The most convenient length for handling is usually up to 15 feet, but the highest efficiency is obtained in leaving the length of tube as long as possible. The low tension wiring is quite straightforward, ordinary circuit wiring being run to the primary side of the transformers.

Points to Observe in Installing Neon Signs.

Great care should be taken with high tension side of the transformers to prevent leakages which might cause burning of the high tension cable. High tension wiring should be either of bare wire, or, if desired to be protected, run in glass tubing, and kept well away from all earthed objects such as walls, gutters and iron fixings.

When making connections from the high tension rubber and lead-covered cable they should be protected either with the special joints for this purpose or by means of glass bell-heads, which prevent damp coming in contact with the installation. Half an inch air space should be left around electrodes passing through letters. Keep tubes $1\frac{1}{2}$ in. away from those of letter, except when run with comparatively low voltage, when they can be placed in direct contact with face of letter. Only a comparatively few feet of tubing is required for one low voltage transformer.

Transformers should be kept as close as possible to the tubes.

PRACTICAL NOTES ON THE INSTALLATION OF "CLAUDEGEN" SIGNS.

All wiring should conform to I.E.E. wiring regulations, and rules laid down by the L.C.C. Fire Brigade Department, the local supply company and any fire insurance company involved.

The fireman's switch only is supplied with the sign. The low-tension wiring comprises supplying, fixing and connecting all necessary wiring and fittings from the supply company's terminals to the low-tension terminals of the transformers and to condensers where specified; also the fixing and wiring of the fireman's switch supplied with the sign.

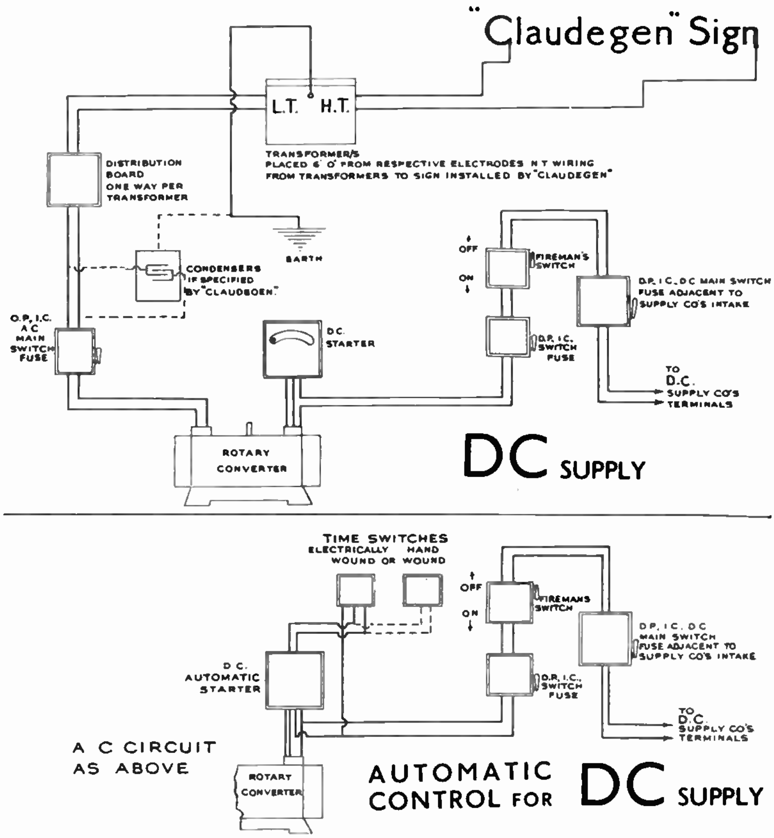
Fireman's switch is to be fixed about 9 ft. from ground level on face of building with the "off" position on top.

Where D.C. is available a rotary converter and hand starter are recommended.

Condensers may be in either position 1 or 2. As specified by Claudegen.

What to Do if More than One Transformer is Supplied.

The number and primary current of the transformers will be specified with the sign. If more than one transformer is supplied, a double-pole ironclad distribution board must be fitted and fixed in the low-tension circuit, in close vicinity to the sign, with a double-pole fuse for each transformer. Mains must be run from the supply terminals to this distribution board, and from the distribution board separate feeds to each transformer.



METHOD OF WIRING A "CLAUDEGEN" SIGN FOR USE WITH D.C. SUPPLY. The lower drawing shows how automatic control can be arranged.

Method of Wiring.

The wiring throughout should be in screwed steel conduit, and a 7/.029 bare copper earth wire should be drawn through the tube with V.I.R. cables, earthing all switchgear and the condenser and the transformer cases to nearest lead watermain

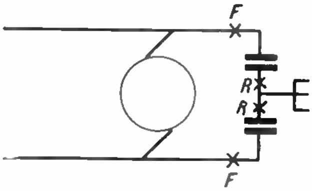
The mains must first be brought to the fireman's switch from main switch, which will isolate the whole sign in emergencies.

How to Eliminate Mains Interference with Wireless Receivers

By "Electrode"

Interference from electric motors and generators, high-frequency medical apparatus, flashing signs, lifts, etc., is sometimes a considerable source of annoyance to wireless listeners. In this article our contributor deals with the most likely causes of mains interference and discusses the best methods of curing it

MAINS interference with broadcast reception is by no means a matter of new occurrence or discovery, but has assumed its present undoubted importance on account of a number of factors such as (1) the increasing number of listeners; (2) the improved sensitivity of sets; (3) the increased use of mains supply to broadcast receivers; (4) the spread of electric supply generally; and (5) the increased use of the supply for domestic and industrial purposes.

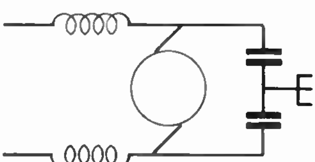


Silencing a Noisy Motor. This can be done by condensers, each of 2 mfds. or more. F is a fuse and R a resistance of from 5 to 10 ohms, which may be an additional help.

Broadly speaking, general hum from the mains must be classified as an interference, since it certainly interferes with the enjoyable reception of a programme. Usually, however, interference from the mains is taken as referring to noises of the crash type, frequently called "man-made" atmospherics, since they do frequently amount in the aggregate to the same effect as continuous atmospherics.

Avoidable Hum.

Before considering this, however, it is necessary to deal briefly with avoidable hum. In the case of a mains set, hum of any sort is usually largely the fault of the set itself, but there are other factors that may also be active. In the case of a D.C. mains set, a hum at about 300 cycles may be due to really noisy mains.



Silencing a Noisy Motor. High frequency chokes inserted as shown help to make the condensers more effective by-pass paths for high frequencies.

Reversing the Mains-plug is Sometimes Helpful.

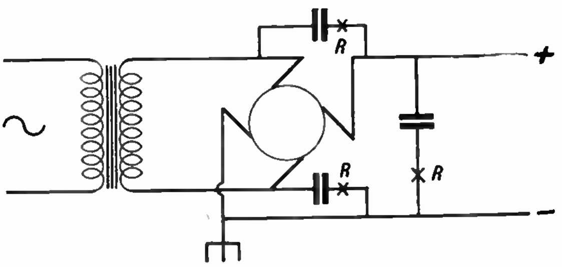
The hum from a good A.C. mains set ought normally to be very small indeed, but frequently it is worse with one direction of the mains-plug than with the other. Mains sets generally work fairly efficiently without an earth so far as aerial pick-up is concerned, but an actual earth is usually very helpful in cleaning up hum.

Noise From House Wiring.

Hum may also be picked up on any set from the type of house wiring. Assuming metal-cased wiring — conduit or lead sheathing—discontinuity of bonding or omission of an earth may often bring up hum, even on a battery-operated set. This is particularly so if the metal casing is run everywhere on dry-seasoned wood and makes little contact with earthy walls of any sort.

Lead Sheathing Must be Properly Earthed.

The writer has known the D.C. supply to speak quite badly into a battery set when the earth was removed from the lead sheathing of the house wiring. In this instance, the casing was certainly moderately well insulated until an actual earth connection was effected. In a similar case it was found, also, that considerable mains hum was picked up by an A.C. mains set when the earth was removed from the casing.



A METHOD OF SILENCING A ROTARY RECTIFIER.

In persistent cases of annoying hum the above points are well worth attention.

The Listener's Own Appliances.

Apart from the above types of hum interference, due to the listener's own premises, interference is also often experienced from vacuum cleaners, refrigerators, fans, etc., in the listener's home, without him being aware of the cause. No doubt it is stupid and slow of him not to correlate cause and obvious effect, but often he fails to do so. The practical man called in, perhaps, to investigate the matter is thus well advised first of all to make sure that the noise is not generated in the complainer's own premises.

Noise-producing Devices.

Assuming that the interference is definitely traced to be coming from outside the listener's house, we may first consider the various types of electrical devices that are known to be noise-producers. These are :—

(A) Motors and generators, A.C. and D.C. ;
(B) Battery-charging rectifiers ;
(C) High-frequency medical apparatus ;
(D) Flashing signs ;
(E) Electric ovens and heating pads, thermostatically controlled ;
(F) Neon signs ;
(G) Lifts ;
(H) Tramcars and trolley buses ;
(I) Mercury arcs.

Interference at High Frequency.

Most interference has been found to be high frequency in character, and is due to sudden changes of current in the circuit. Thus, the making and breaking of commutators, contactors, keys, switches (including imperfect connections acting as partial switches) are all liable to cause sudden changes of potential of some part of the circuit wiring, "shock-exciting" it or a section of it into oscillation at high frequencies, often within the broadcast band.

Two Types of Interference Caused.

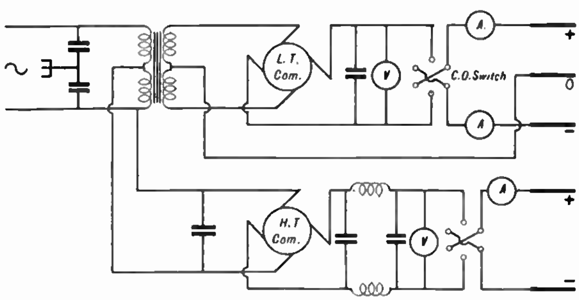
Two things may thus happen : (1) the wiring may behave as a transmitting aerial and radiate waves which are picked up by the receiving aerial ; (2) the high-frequency currents so generated may travel along the supply wires and so get on to the internal wiring of the listener's premises, where they may be picked up by the adjacent aerial and/or lead-in, or it may become impressed on the set by its connection to the mains for its operating supplies. The second type of interference propagation is the more usual.

Basic Principles of Remedies for Interference.

All remedies for interference of the high-frequency character are based on methods of (A) reducing to negligible proportions the H.F. voltages on sections of the mains or wiring capable of radiation ; (B) restricting the H.F. voltages to as small a section of the mains as possible or to sections of the wiring remote from the receiver.

Right of Complaint.

The right of the listener to complain

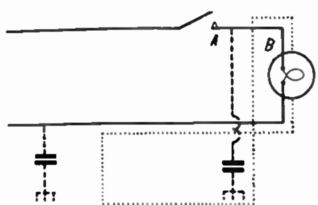


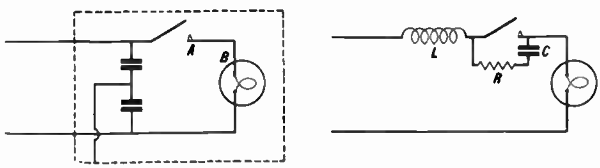
SILENCING DEVICES APPLIED TO H.T. AND L.T. BATTERY-CHARGING ROTARY RECTIFIERS.
The mains condensers are all 2 mfds. ; the L.T. condenser, .1 mfd. upwards ; first H.T. condenser, 4 mfds. ; and second H.T. condenser, .25 mfd. upwards.

about mains interference is fully recognised, and official organisation exists for dealing with it. Complaints should first be addressed to the B.B.C., who send a form to be filled up with full particulars. The complaint is then handed over to the Post Office for investigation, since the P.O. has technical representatives so widely spread all over the kingdom, while the B.B.C. has no such technical organisation. The P.O. then investigates the matter under the direction of the Radio Section at Engineering Headquarters.

As the law stands, the P.O. has no authority, apparently, to *enforce* the application of such remedies, but it has been stated that the owners of offending plant are usually quite willing to assist in the application of remedies that have been shown to be effective.

While, therefore, the chief work of interference tracking and silencing is one for large organisations, many practical men find themselves concerned with problems in connection with the effective silencing of individual pieces of plant. Fortunately, as a result of the P.O.'s investigations a considerable amount of information is now available as to the methods which have been found successful in various cases.





SILENCING TREATMENT FOR FLASHING SIGNS.
The lead A B in top picture is "shock-excited" into oscillation and high frequency currents follow the dotted path. The left bottom figure shows the addition of a protective screen, and on the right a quenching circuit is shown.

Noise From Motors and Generators—

The considerable use of motors causes them to be a big source of interference which appears to be entirely of a high-frequency character. Although locally severe it rarely extends to a greater distance than 200 yards. Usually becomes inaudible at 50 yards.

—And Its Cure.

The cure is to form a low-impedance path for the high-frequency currents to flow to earth, for example, by the condensers, each of 2 mfds. or more, as shown. Sometimes it is necessary to insert an H.F. choke in each mains lead (see diagram) to increase the H.F. impedance of the mains and so make the condensers more effective in shunting the high frequencies to earth. Occasionally a resistance of 5 to 10 ohms, as shown at R, is also of assistance. These methods apply equally to D.C. motors and to A.C. motors of the commutator type (induction motors give very little trouble).

Fitting the Silencing Devices.

The silencing devices should be fitted as close as possible to the machine with very short leads and also with a short heavy earth-lead. It is interesting to know that adjustment of brush position can also help to reduce interference.

Interference from Generators.

Generators produce both high-frequency and low-frequency interference. In the case of small machines the interference is generally of the high-frequency type and is amenable to the same treatment as for motors as already shown.

Real low-frequency interference is experienced due to ripple on large supply-machines, and is usually only experienced on mains-operated sets, where the cure is improved smoothing. The same is true in the case of ripple on D.C. supplies derived from mercury-arc rectifiers.

Rotary Rectifiers and Battery Chargers.

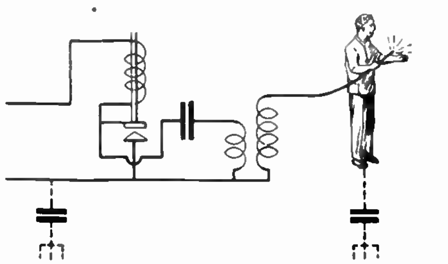
Rotary rectifiers give rise to H.F. interference in the same general manner as motors and over the same general sort of distance. Direct radiation may be aggravated by batteries on charge on the D.C. side.

How Rotary Rectifiers are Silenced.

A general method of silencing such rotary rectifiers is show in the diagram, where it is again often found of advantage to use a resistance of 5 to 10 ohms as shown at R. A rotary rectifier for L.T. and H.T. battery charging is also shown, with the silencing devices that have been found helpful. Chokes are of advantage in the H.T. leads, as shown, a suitable choke consisting of about 20 yards of the necessary gauge of wire wound on a former of about 8 in. diameter.

Why a Fuse Should be Fitted.

In applying smoothing condensers in all the above cases it is advisable to fit a fuse or other protective device to protect the mains in the case of the condensers ever being broken down by a heavy surge. Alternately, of course, much more highly rated condensers can be used.



High Frequency Medical Apparatus.
The patient acts as a good aerial, in addition to the high frequency currents sent back to the mains.

Flashing Signs.

These consist, in their simplest form, of a contact or switching device operated either automatically or by thermostat or the like. The simplest type of circuit is that on page 260 (top picture), which locates the point of interference to the lead A B. When the switch is closed A B is mains-voltage above earth, but when the switch is opened the potential of A B falls to zero and causes the capacity-to-earth of A B to discharge through the path shown dotted.

Using a Constant-potential Screen as a Cure.

One form of cure is to surround the apparatus by a constant-potential screen as shown in the left-hand picture, with the condensers shown. An alternative method is shown in the right-hand picture, which has a choke in the mains and a quenching circuit across the contact. The choke should be as near as possible to the contactor, and should preferably be screened. The first method is considered to be generally the better, but the second is of advantage if the apparatus cannot be screened or if it is some distance away from the switching mechanism.

Multiple-contact Signs.

Multiple-contact signs are exactly similar in principle and are amenable to the same treatment. This method of silencing is also applicable to electrical ovens, heating pads and other devices using thermostatic control.

High-frequency Apparatus.

Apparatus generating and using high-frequency currents as part of their operation are naturally serious offenders—the most serious technically, although fortunately not so numerous. Notably in this class comes H.F. medical apparatus of the so-called "ultra-violet-ray" class.

This uses a frequency somewhere between 60 and 150 kc. (2,000 to 5,000 metres) and is effectively a "spark" transmitter, stepped up to the patient, the high-frequency currents flowing through his effective capacity to earth.

The Only Cure for Interference from High-frequency Apparatus.

With this type of apparatus, as at present designed and made, the only cure is the construction of a complete metallic screen, large enough to enclose both patient and apparatus. This method of cure is too expensive to commend itself to the user, except in the case of large installations, such as hospitals, etc. In smaller cases, however, a small screened cage may be practicable. Future improvement involves redesign of the apparatus, and would no doubt be helped also by the use of valves as generators instead of spark methods.

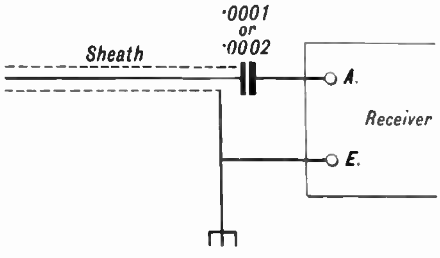
Neon Signs.

Another type of high-frequency apparatus is met in neon signs. These are made both for low-frequency and for high-frequency operation, the latter usually being installed indoors to avoid risk of shock. Although using the same method of generation as in the medical apparatus, the fact of the H.F. secondary being closed on the tube should make them less objectionable. Interference is, however, experienced on account of currents between the H.F. secondary and primary, these being due jointly to insulation and to capacity. A capacity screen between the windings is of help.

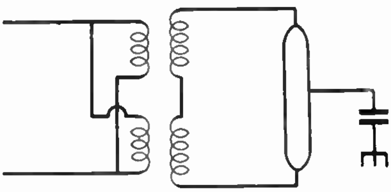
In some cases the H.F. step-up transformer consists of two transformers, and improvement can be effected by joining the primaries in parallel and the secondaries in series, joined at those ends nearer to the primary. Adjustment of slight out-of-balance capacity to earth can be made by a small capacity to earth at a suitable point along the tube as shown. Screening of the whole apparatus is, of course, an excellent cure as in the case of medical apparatus. Little trouble seems to have been experienced from low-frequency neon signs.

Lifts.

In the case of lifts, several types of induction motor are in use and some give very little trouble. Those that are noisy can be helped by H.F. chokes in the mains and the mains bridged *on the controller side* of the chokes by two condensers each of at least 4 microfarads. It is usually necessary to apply further silencing to controller noises, a suitable arrangement being 2 microfarad condensers across each contactor, or better still a condenser-resistive "quench" circuit of the type already described.



A SCREENED AERIAL LEAD-IN IS A GREAT HELP TO THE LISTENER IN ELECTRICALLY "NOISY" DISTRICTS.



HIGH FREQUENCY NEON SIGNS.
A small balancing condenser to earth is usually of help.

The same general treatment also applies to D.C. motors.

Tramcars and Trolley Buses.

Several successful methods of cure have been developed, but as treatment of this interference is in the hands of an authority or corporation there is no need to discuss them here.

Curing Incoming Interference at the Listener's Premises.

Since most of the H.F. interference enters the listener's house by the mains, and is radiated or induced by the house wiring, additional help can usually be obtained by H.F. filter devices applied to the mains where they enter the house. Condensers, as for motor-smoothing, are usually an improvement in noisy districts, and, if insufficient, can be implemented by chokes in the mains. The chokes must, of course, be of adequate copper to carry the A.C. or D.C. current of the house load.

Methods of Reducing the Interference.

Interference can often be reduced by altering the direction of the aerial, also by using a "counterpoise" earth. Recently it has been found that improvement can mostly be effected by the use of a screened lead-in from the aerial to the receiver.

Some Interesting Circuits.

Some interesting circuits for the elimination of interference with radio reception are given in a booklet entitled "The Design and Construction of Radio Power Units," published by The Telegraph Condenser Co. We have made arrangements for a copy of this book to be sent free to interested readers who apply to The Telegraph Condenser Co., Ltd., Wales Farm Road, North Acton, W.3, mentioning the name of this magazine.

The Changeover Problem in Electrically Driven Factories

By Robert Rawlinson

In the January issue Mr. Rawlinson outlined the various questions which arise when changing over from D.C. to A.C. In this article he deals thoroughly with the problem of determining the horse-power required

ONE of the first problems that arise before commencing any alterations to the factory drives is:—" How many horse-power do the factory machines require to drive them ? "

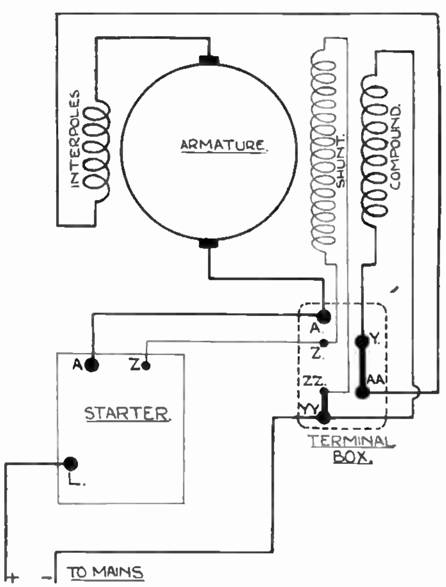
Measuring the Horse-power Required.

By far the best way is to measure the actual power which the driven machines demand. This is quite easily done by measuring the current and kilowatts which the original motors take, and, after working out and deducting the losses in the motor, estimating the actual horse-power which is supplied to each driven machine. Suppose that there are a group of 10 machines driven by one D.C. motor, which is of the compound wound type and fitted with interpoles, then the procedure should be as follows :—

Arrange matters so that each driven machine can be fully loaded; that is to say, have the largest size of article which is to be worked on in the machine, or arrange to take the heaviest cut on the hardest material which it is usual to work on the machine in question.

Preliminary Readings.

Before starting the motor it will be necessary to measure the resistances of its various circuits so that the losses in them can be calculated. If a Post Office box type Wheatstone bridge is available, this can be used, but as an instrument of this type is seldom available in the average factory, the measurements we require can easily be computed from voltmeter and ammeter readings.



Connection Diagram of a Compound Wound D.C. Motor.

This diagram shows the connections between motor and starter, the main switch and fuses being omitted for clearness. Note that terminals A and AA may be interchanged, depending upon the direction of rotation of the motor.

Equipment Required.

The instruments, etc., necessary to make the tests will depend to a certain extent upon the size of motor which is under investigation. Suppose that the motor nameplate is stamped as follows :—

20 h.p., 440 volts, 38.5 amps., 650 r.p.m., 1.3 shunt amps.

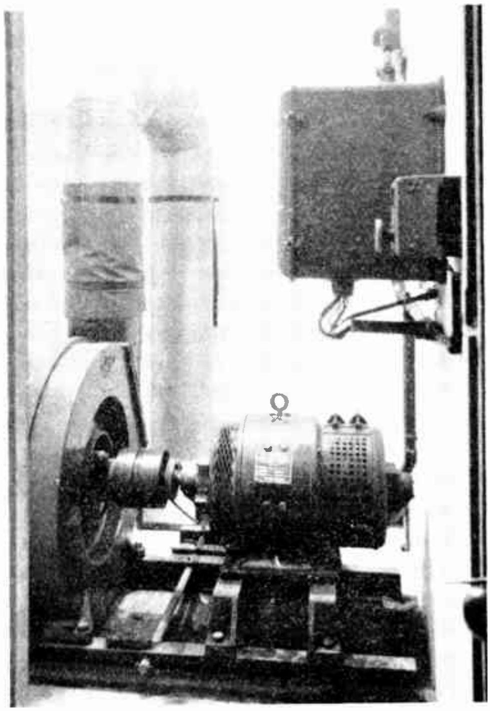
The equipment selected should then be:

A .. 1 voltmeter reading to 500 volts (to measure main volts).

B .. 1 ammeter reading to 50 amps. (to measure main amps.).

C .. 1 voltmeter reading to 15 volts (to measure loss volts).

D .. 1 ammeter reading to 15 amps.



ELECTRICALLY DRIVEN BLOWING FAN FOR CINEMA ORGAN.

This illustration depicts the D.C. motor driven blower which supplies the necessary air to the organ in a large cinema. It will eventually be converted to A.C. and the method on which the conversion should be made is described in this and later articles. (*Metropolitan-Vickers.*)

(to measure no load amps.).

E .. 1 revolution counter.

F .. 1 accumulator of about 6 volts (a car battery is very suitable).

Multi-range Voltmeters and Ammeters.

Note that the voltmeter A must always have a maximum reading greater than the voltage of the supply to the motor. It may very conveniently be of the multi-range pattern and in this case voltmeter C may not be required. For instance, a very suitable and commonly used instrument for maintenance work has four ranges of 1.5, 15, 150 and 600 volts, and it is clear that an instrument of this type will take the place of both A and C. The same remarks apply as regards the ammeter. If a multi-range instrument is available, it can be used instead of B and D. These multi-range instruments are very useful in maintenance work and should be available to the maintenance electricians of any reasonable-sized factory.

The Resistances to be Measured.

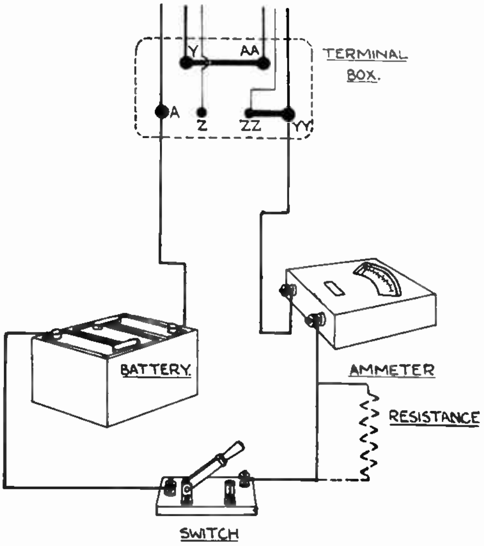
In order to calculate the losses, we must measure the resistances of the following windings of the motor :—

1. The armature.
2. The interpoles.
3. The series (or compound) coils.

We must also measure the current taken by the motor when running without any load, i.e., with the belt off, uncoupled or out of gear as the case may be. However, let us for the moment consider only the measuring of the resistances.

Connecting Up for Resistance Measurements.

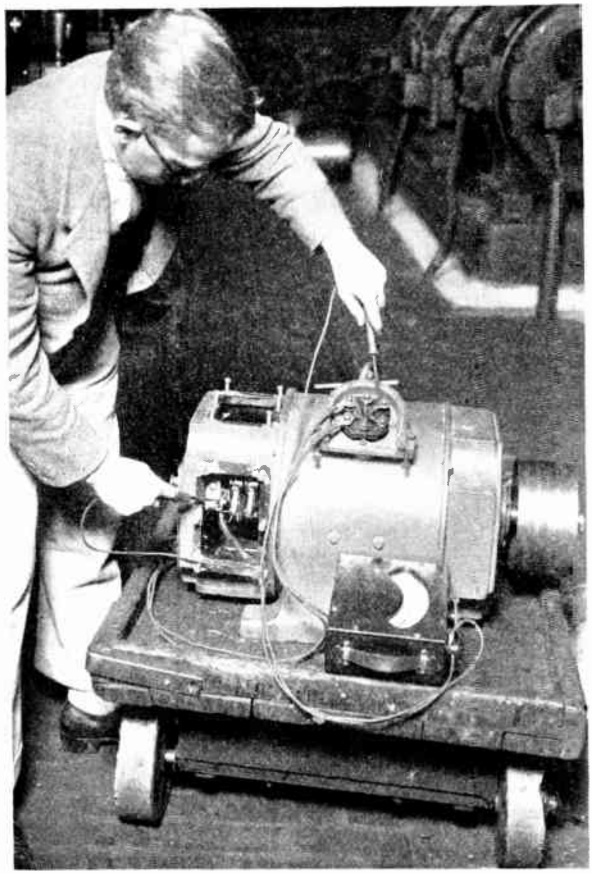
The accumulator battery should be



CONNECTIONS FOR TAKING RESISTANCE READINGS.

This diagram shows the connections between motor, battery, switch and ammeter when taking resistance readings. Note that in some cases of large motors it may be necessary to connect a resistance in the circuit to limit the current to a reasonable value. When this is necessary the resistance should be connected between the switch and ammeter, as shown dotted. The switch must be closed only for the few seconds required to take readings, so as to avoid heating the windings and running down the battery.

fully charged and it should be taken, together with a single-pole knife switch (mounted and about 50 amps. capacity) and the instruments B and C previously mentioned, to the motor. The battery should be connected through the knife switch and ammeter B to the motor terminals as follows :—With the usual type of D.C. motor starter it will be found that there are three cables entering the motor terminal box, two of these being of heavy section and the other one considerably smaller in size; this will be clearer on reference to the diagram of connections, which shows the heavy cables in thick lines and the smaller one thinly.



MEASURING THE INTERPOLE RESISTANCE.
The operator is holding one point on terminal AA and the other on the brush arm, while he reads the voltage drop across the interpole winding. In this case the current is fed into the machine by the two leads which are connected to the two left-hand side terminals A and YY. (*Metropolitan-Vickers.*)

The Procedure.

Proceed now in the following manner:—Remove the heavy cables from the motor terminals and connect in their places the cables from the battery, ammeter and switch, so that one terminal of the battery is connected to one motor terminal, the other battery terminal being connected to one knife switch terminal. The remaining knife switch terminal must be connected to the ammeter and the free side of the ammeter should then be connected to the second motor terminal in place of the other heavy cable.

Main Switch Must be Off.

These connections are as shown and it should be noted that the main switch *must* be "OFF" before any connections are altered or made, and that the knife switch must be kept open until we are ready to take readings. For these connections a fairly heavy cable should be used. The following table may be taken as a rough guide, but the cable size given need not be very strictly adhered to if we remember that the heavier the cable the better, within reason.

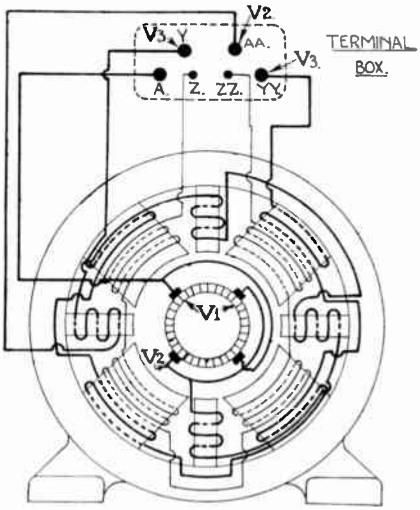
TABLE OF CABLE SIZES.

Motor Nameplate. Full Load Current.	Approximate Cable Size for Resistance Measurement Connections.
Up to 15 amps.	3/.036 or .003 sq. in.
15 ,, 50 ,,	7/.044 ,, .01 ,,
50 ,, 100 ,,	19/.044 ,, .03 ,,
100 ,, 150 ,,	19/.064 ,, .06 ,,
150 ,, 200 ,,	19/.072 ,, .075 ,,

Before Taking Any Readings.

The next step is to locate the points

in the motor and its terminal box across which voltmeter readings are to be taken with the instrument C. Referring to the first figure we can see how the various circuits are connected up inside the motor and in the terminal box, and it will be clear that to measure the voltage across the armature we must make our voltmeter connections on two segments which are under brushes of opposite polarity. To measure voltage across the interpole windings we must make connections, one to the lead from the armature to the interpoles (this is usually situated on one



INTERNAL WINDINGS OF A FOUR-POLE COMPOUND-WOUND MOTOR.

We have here the arrangements of the windings and connections in a four-pole compound-wound D.C. motor. The voltmeter connection points are marked, as described in the text, V1, V2 and V3 for armature, interpole and series windings respectively.

brush arm) and the other to the terminal AA in the terminal box. All other points of connection are available in the terminal box, so there will be no necessity to open up the motor to make them available.

These points are made clearer by the figure which appears above, giving the connection diagram of a four-pole motor of the compound wound type, the points for connection being marked V1 for the armature, V2 for the interpoles and V3 for the series.

A Convenience for Taking Measurements.

It is very convenient if we have a pair of points attached to flexible cables for use when taking measurements with the voltmeter, and as such details may be very easily and quickly constructed, it is as well to provide ourselves with them. The illustration shows the details and construction of such a pair of contact points made from material such as may be found in maintenance shops.

The Readings to Be Taken.

The readings which we are going to take are for the purpose of measuring the resistances of the following circuits :—

1. Armature winding.
2. Interpole coils.
3. Compound or series coils.

In order to calculate the resistance it will be necessary to measure the current or amps. flowing when the knife switch is closed and at the same time we must note the voltage across the terminals of each winding. Having got these readings, we can very easily calculate the resistance of each separate winding and we shall then use this resistance to compute the efficiency and power output of the motor.

Taking the Readings.

Having made all the connections and ascertained the points at which measurements must be made, as previously described, we are ready to make our tests, and to do this we should proceed in the following manner :—The person who is to take the measurements should be accompanied by an assistant who has paper and pencil at hand to note the readings observed. The assistant should have set out his sheet in the form of a typical record sheet so that all readings can be entered readily under the correct headings

The Resistance Readings.

After filling in the preliminary information, such as nameplate particulars and meter numbers, the taking of the resistance readings may be proceeded with as follows :—The voltmeter points are first held in contact with two commutator segments which are *under* brushes on adjacent brush arms, and the knife switch is then closed. This will cause both the ammeter and voltmeter to show a deflection and their readings should be noted and entered on the record sheet. The knife switch should be opened as soon as the readings are taken.

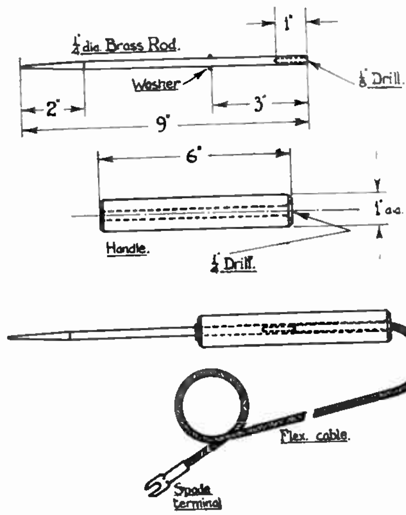
The procedure should now be repeated for the interpoles, making voltmeter connections, one to the lead from brush arm to interpoles and the other to terminal AA, closing the knife switch and entering the voltmeter and ammeter readings on the record sheet as before. The readings for the series coils (if any) must now be obtained, the same procedure being followed and the voltmeter connections being made to terminals Y and YY. When a voltage and current reading has been obtained for each of the three circuits (i.e., six readings in all) we have completed this part of the test and have sufficient information to calculate the circuit resistances which we require. The normal connections between motor and starter should now be replaced.

Uncouple the Motor from Its Load.

The next stage is the taking of the no-load losses of the motor and in order to do this the machine must be uncoupled from its load. It is not sufficient merely to take the load or work off the driven machines. The belt should be removed if the drive is of this type, or, if the motor drives through a coupling, the bolts or links should be removed. In the case of gear drives it is best either to remove the motor pinion or, if this cannot be done, slew the motor round so that the gearing is out of mesh. It is advisable to make quite sure that the pinion is well clear of the driven wheel in these cases, and to clamp the motor so that any vibration will not cause it to move into mesh while running. If this is not done, there is a possibility of serious accidents. Having now made sure that the motor is disconnected from any kind of load we may take the no-load readings.

The Meter Positions.

In order to measure these losses we require readings of the main volts and armature current when the motor is running unloaded at full speed, and to obtain these readings we must connect our meters as follows:—The voltmeter A should be connected across the mains, and the most convenient position to do this is to connect the meter across terminals A and YY in the terminal box. To read the armature current, ammeter D should be inserted in the line which runs from the starter terminal marked A to the motor terminal A (or AA, depending on the direction of rotation). The diagram on page 270 will make these connections quite clear.



Points for Voltmeter Measurements.

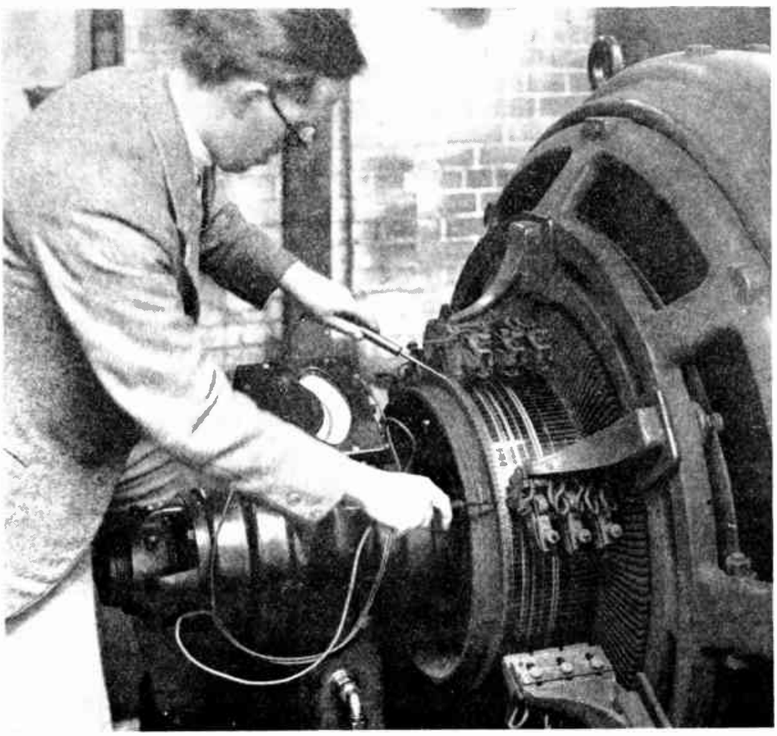
The actual point consists of a length of brass rod pointed at one end and with a hole for the cable drilled in the other end. A brass washer should be sweated on to the rod as shown, to form a location for the handle which is made from a piece of hardwood, fibre, bakelite or ebonite to the dimensions given. A length of about six feet of flexible cable should be soldered into the rod, and the whole should be assembled by threading the cable through the hole in the handle and then pushing the handle on to the point-rod, on which it should be a good tight fit. If some shellac varnish is smeared on the rod before the handle is fitted it will set and make a good joint between rod and handle. A spade terminal at the end of the flex facilitates connections.

Taking the No-load Readings.

Having made these connections the no-load readings may be taken, and in order to do this it is only necessary to start the motor up in the normal way by means of its starter and then read the deflections of the meters, entering them up in the correct places on the record sheet.

The Load Readings.

Having now taken all the preliminary readings, the motor may be recoupled to its load and the separate load readings taken. The positions of the instruments will be the same as for taking the no-load measurements which have just been made, so that it will be unnecessary to make any further connections, although it will probably be necessary to put ammeter B in place of ammeter D. The belt or coupling bolts should be replaced or the gear should be put back in mesh, depending upon the type of drive, and having made sure that the motor is firmly bolted down, we are in a position to take the readings which will enable us to calculate the horse-power required by each driven machine.



MEASURING THE ARMATURE RESISTANCE.

Note that the voltmeter points are on the edges of two segments which are *beneath* two adjacent lines of brushes. When making these resistance measurements on lr ge machines it will sometimes be necessary to use a millivoltmeter when the circuit resistances are of a low value. (*Metropolitan-Vickers.*)

The Horse-power Required to Drive the Lineshaft.

When everything is ready as described above, the motor may be started up in the usual way, and when it is up to full speed, the main volts and armature amps. should be read and noted down on the record sheet. There should be no work in any of the driven machines while this reading is being taken, and if fast and loose pulleys are fitted (as is usual), all belts should be running on the loose pulleys. In other words, for these readings we want to get the power required to drive the lineshaft *only*. Therefore, all machines which are driven from the line shaft should be stationary.

The Horse-power Required by Each Machine.

The next stage is to take the power required to drive each machine separately, and for this purpose it will be necessary to load up each machine in turn and take main volts and armature amps. readings in the same manner as already described for taking the power required to drive the lineshaft. The best procedure is to have work ready by each machine, i.e., if it is a lathe, have a piece of metal to turn, preferably of as large a size as the lathe will accommodate and of the hardest grade which is usually machined in that particular lathe, and when taking the volt and amp. readings take a fairly heavy cut at a rather fast feed and speed so that the load on the lathe is about as severe as will generally obtain in its normal work.

How to Load the Driven Machine.

If one of the driven machines happened to be a sand mill we would arrange matters so that there was sufficient sand to fill the trough and so place the mill on full load, while a pump or fan would be loaded up to its full capacity and greatest pressure.

Taking the Machine Load Readings

When the arrangements for loading each machine are complete, the readings may be taken as follows :—Start the motor and put machine No. 1 in work. All other driven machines should be standing idle at the time. As soon as the load is steadily applied, take a reading of main volts and armature amps. as before and note on the record sheet. When these readings have been taken, the driven machine may be shut down, since we have the information needed to calculate the horse-power required by it.

The volt and amp. readings when the motor is driving the second machine only should now be obtained in the same manner, care being taken that the second driven machine alone is working—all others being idle—and after these readings have been taken and noted, the same procedure should be gone through for the third machine, and so on until all the machines which the motor drives have been dealt with and the corresponding volt and amp. readings noted down on the record sheet.

Working Out the Results.

We have now obtained all the readings we require and may proceed to use them in our calculations to determine the horse-power required by each driven machine when it is fully loaded. The working out is only simple arithmetic and to make it quite clear we give here as an example some typical figures that might be obtained. If the reader will follow through the working of these, the method will be obvious and the following remarks will assist in gaining a mental picture of the processes involved.

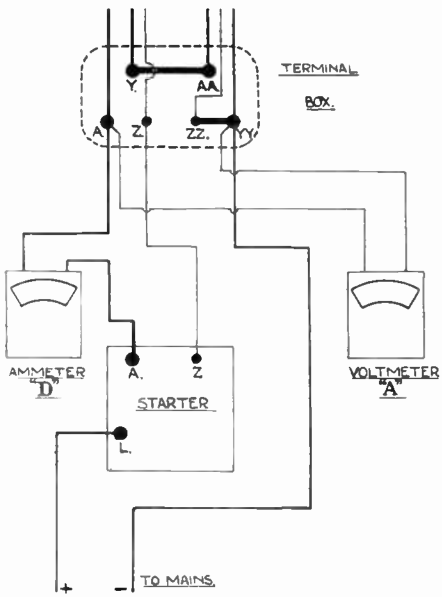
TAKING THE SERIES RESISTANCE.
The points are held on terminals Y and YY while the voltage drop across the series (or compound) windings is measured. (*Metropolitan-Vickers.*)

Resistance Readings.

In order to obtain the resistances of the armature interpole and series windings we must follow Ohm's Law and divide the volts drop across the winding by the current in the winding. The result of this simple division will give us the ohms resistance of the winding at the time the measurements were taken. Suppose, for instance, in our example the drop across the armature is 4.42 volts when a current of 13 amps. is flowing through it ; dividing 4.42 by 13 we get 0.34 ohm, the resistance of the armature winding. This division should be done for each circuit, the ohms being entered down.

The No-load Readings.

It is quite clear that the motor will require some power to make it run, even



CONNECTIONS FOR NO-LOAD AND LOAD READINGS.

This diagram gives the connections for the no-load and loaded readings. In the case of the load readings it may be necessary to put ammeter B (see text) in place of ammeter D. The main switch and fuses are omitted for the sake of clarity.

although it is not carrying any load. The *gross* no-load watts are obtained by multiplying together the main volts and the armature current taken at no-load. Now the armature, series and interpole windings have resistances, the ohmic values of which we have just worked out, and because of this they give rise to losses even when the motor is running on no load. The loss in these windings is easily obtained by squaring the no-load current (i.e., multiplying it by itself) and then multiplying by the number of ohms in the winding. For instance, the armature resistance is 0.39 ohm hot (see below) and the no-load current 1.9 amps. in our example, so that we have :

Current squared × Ohms = Watts loss

1.9 × 1.9 × 0.39 = 1.4 watts

By doing this for each winding we obtain the watts lost in each, and we must then add the separate losses together to obtain the total no-load copper loss. Having got this the nett no-load watts are calculated by subtracting the total no-load copper loss from the gross no-load watts. In the example we have :—

Gross no-load watts − Total no-load copper loss = Nett no-load watts.

836 − 2 = 834

Although the copper loss on no-load is negligible in this case, instances can arise where neglect of this loss introduces errors. It is advisable to form the habit of always taking the no-load copper loss into account for this reason ; hence its appearance here.

The Summary.

The calculations which have so far been made must now be summarised so as to be more conveniently used when dealing with the load readings. The resistances of armature, interpoles and series windings must be added together, giving the total main copper resistance (0.5108 ohm in our example). The nett no-load watts should also be entered in the summary.

An Important Point.

It is very important that the losses should be calculated on the assumption that the motor is hot and for this reason it is desirable to take all the readings after the motor has been working for a full day and is well warmed up. If it is impossible to do this and the readings are taken when the motor is cold, it will be necessary to multiply all resistances by 1.15 so as to allow for the increase when the motor temperature rises. For instance, in our example the resistances were taken cold, the armature coming out at 0.34 ohm ; when this reading is transferred to the summary it is put down as 0.39 ohm, which is 0.34 × 1.15. It will be realised that the series and interpole resistances should be similarly adjusted. Note also that this adjustment is performed in working out the no-load copper loss, the motor being hot when the no-load readings were taken.

The Position at this Stage.

We now find that all our preliminary readings are simplified into two quantities :

I. Total main copper resistance (hot).

II. Nett no-load watts.

These two figures are sufficient to enable us to calculate the horse-power developed by the motor for any input current, it being only necessary to introduce one other very simple quantity to take account of the resistance of the contact between brush and commutator. It should be noted that the voltages at which the no-load and load readings are taken must not differ by more than about 5 per cent. if accuracy is to be obtained.

How to Calculate the Horse-power.

We are now in a position to calculate the horse-power required to drive, first, the lineshaft only, and then each driven machine in turn. Taking the case of the lineshaft only, we find that we have two readings, main volts and armature amps. The armature amps. in flowing through the windings of the motor will give rise to a loss which should be entered as "copper loss watts" on the record sheet. The amount of this loss is equal to the armature current squared multiplied by the total main copper resistance, being, in our example :—

$$7 \times 7 \times 0.5108 = 25 \text{ watts.}$$

To this copper loss we must add the nett no-load watts, which we have already calculated, and the watts lost in the brush contact. The approximate value of this brush contact loss is easily arrived at by multiplying the armature current by two, and the three losses can now be added together to give us the total losses occurring in the motor at this particular input current.

Take the Losses from the Input.

We must now calculate the input watts which are equal to the main volts times the armature amps. (i.e., $440 \times 7 = 3080$ watts in the example), and from this figure we must subtract the losses which we have already calculated. It will be clear that by taking the losses from the input we have the output left, this being expressed in watts. Following this through in our example, we have 873 watts losses from 3080 watts input, leaving us 2207 watts output.

The Horse-power Output.

All that now remains is for us to convert the watts output to horse-power, which we may easily do by dividing by 746.

The Horse-power Taken by the Driven Machines.

Having now calculated the horse-power taken by the lineshaft, we can easily arrive at that required for each driven machine by going through the same procedure. In order to obtain the power demanded by the machine only it will be necessary to subtract the lineshaft horse-power from each machine's calculated horse-power.

Final Notes.

We have now calculated the horse-power taken by each driven machine and it is only necessary to make a note of the speeds at which the various driven machines are running when fully loaded. This information should be noted down at once; its use will be obvious later, when we come to discuss the installation of the new A.C. motors which are being put in when we change over.

Not for Series Motors.

Before closing this article it must be noted that the method of testing described cannot be applied to series wound or heavily compound wound motors. These, however, are almost invariably used for driving cranes or other duties involving only one driven machine, and for this reason the output for change-over purposes may be taken as the nameplate output, neglecting other aspects which will be considered later. The testing method is for the shunt or light compound wound motors usually installed for group drives.

Practical Methods of Using the Cathode Ray Oscillograph

By "Electrode"

In an article which appeared in the November issue our contributor discussed the general principles of the Cathode Ray Oscillograph. The present article outlines the methods which can be used for applying this instrument to the solution of practical problems in Power Stations, Works and Laboratories.

THE general diagrams and notes given here are intended to help the practical man in applying the oscillograph to the various purposes indicated.

Use as an A.C. Voltmeter Taking No Load.

One general application of the instrument that can be indicated is its use as an A.C. voltmeter taking no load. For example, with a Cossor oscillograph with 350 v. on the anode—as might be used on a tube for visual observation—the deflection is 1 mm. per volt applied to the deflecting plates. Thus 20 v. D.C. would displace the spot by 20 mm., while an alternating voltage of 14.14 v. R.M.S. would have a peak of 20 v. and would give a line departing by 20 mm. on either side from the position of the undeflected spot. With any other value of accelerating voltage the deflection can similarly be calibrated by a D.C. voltage and used in this way to measure an A.C. voltage, remembering that the line moves out to points corresponding to the peak voltage (which is 1.414 times the R.M.S. value). The current taken by the deflecting plates is extraordinarily small—so small indeed, that they form almost a "no load" electrostatic device—so that the instrument can be used in this manner without any appreciable effect on a circuit of high impedance.

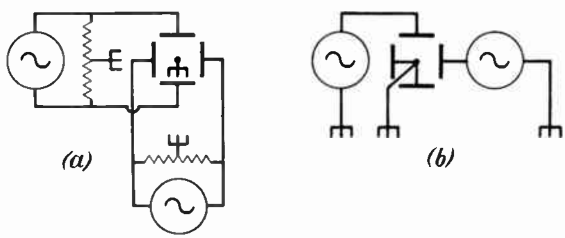


Fig. 1.—Use of the Cathode Ray Oscillograph for Synchronisation of Alternators or Comparison of their Frequencies.

In (*a*) the machines are assumed to have no earth connection. At (*b*) they are assumed each to have one side earthed.

POWER STATION APPLICATIONS.

So far the cathode-ray oscillograph does not appear to have been much used in power station practice, although a number of factory applications have been devised.

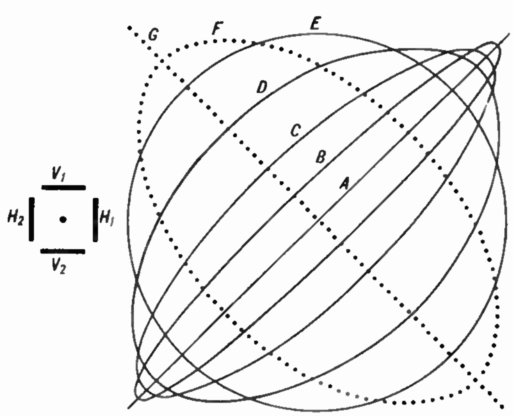


Fig. 2.—Simultaneous Activation of Both Pairs of Plates by Equal Voltages of Varying Phase.

A, V_1 and H_1 in phase; E, V_1 and H_1 90° out of phase; G, V_1 and H_1 180° out of phase (i.e., V_1 and H_2 in phase).

Phase Determination and Synchronisation.

Fig. 1 shows how we could join separate alternators or other A.C. sources to each pair of plates; in (*a*) the machines are

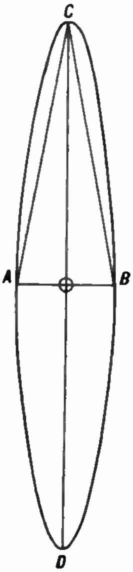


Fig. 3.—DETERMINATION OF PHASE-DIFFERENCE BETWEEN TWO COMPONENTS. Phase angle is ACB.

assumed to have no earth connection and that no direct earth connection is permitted; in (*b*) the machines are assumed each to have one side earthed. Assuming, further, that they are of equal voltage and of the same frequency, we will get a line at 45° as shown at A in Fig. 2 if the phase is such that V_1 and H_1 are always in phase together. If they are not in phase (or if the phase of one can be controlled so as to bring them out of phase) the 45° line opens out into an ellipse as shown at B. It should be mentioned that the sensitivity of departure from phase is remarkably high.

Sensitivity of Departure from Phase.

Thus, if we have a line of 8 to 10 cm. length, a difference of phase of only 1° between V_1 and H_1 is sufficient to cause the line to open into an ellipse with 1 mm. opening between its sides. This sensitivity can be increased, for example, by using

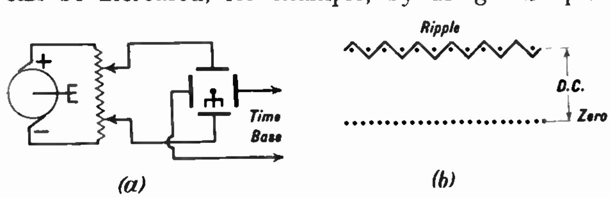


Fig. 5.—PERCENTAGE RIPPLE OF D.C. MACHINE OR SOURCE.

bigger deflections, even if they go well off the screen when an equally small visible opening means a correspondingly smaller difference of phase.

Continuing with Fig. 2, if the phase-difference is continuously changed we would get the deflection opening from the line of A through a narrow ellipse to various ellipses such as B, C and D. When the phase becomes 90° the design becomes a circle such as shown at E. Continuing further, the ellipse turns the other way, as shown at F, until finally when V_1 and H_1 are 180° out of phase—that is V_1 and H_2 are now in phase—we get a line tilted at 135° as shown at G.

Measurement of Phase Difference.

The ellipses such as those shown can be used to measure the phase-difference between two voltages. Thus, Fig. 3 can represent the picture of an ellipse, either traced or photographed from the tube.

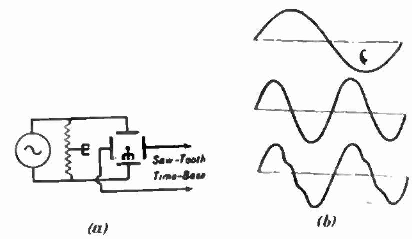


Fig. 4.—WAVE FORM OF ALTERNATOR.

(*a*) Circuit arrangements. (*b*) Typical pictures; top, pure wave form on 1/1 time-sweep; centre, on 2/1 sweep; bottom, 2/1 sweep showing harmonics in wave form.

If we draw the minor and major axes AB and CD respectively, we can construct the isosceles triangle ACB when the apical angle ACB represents the phase difference.

Synchronisation.

The practical application to synchronisation is obvious from the above since it represents the case, already considered, when the phase of one component can be controllably varied until an absolutely *in-phase line* at 45° is obtained, while the fact of the line being exactly at 45° is also an indication of the two machines being exactly of the same voltage.

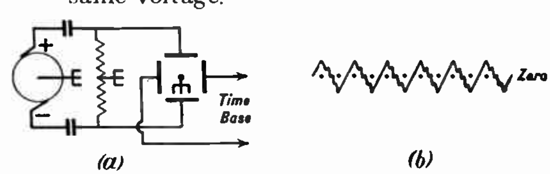


Fig. 6.—EXAMINATION OF RIPPLE WAVE-FORM, D.C BEING EXCLUDED BY THE CONDENSERS.

Z

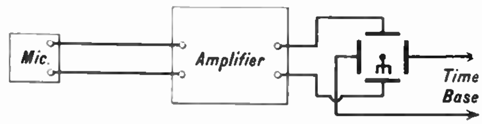


Fig. 7.—CHARACTERISTICS OF SOUND INPUT (E.G., NOISE, SPEECH, MUSIC, ETC.)

One Observation Checks Two Practical Operations.

Two practical operations are checked in one observation. The phase-relations between current and voltage can also be examined, for example, by applying the voltage to one pair of plates while deflection in the other dimension can be obtained by a coil carrying the current.

Comparison of Frequency.

This application is included at this point because certain aspects of it are related to the above, while others have bearing on further applications. A simple case might be that of comparing two machines which are of very nearly the same frequency. The general connections would again be as in Fig. 1.

Voltages Nearly Equal.

If the machines are also of nearly equal voltage the type of picture would be one which changes continually through line, to ellipse, to circle to line, etc., passing continually through all the conditions shown in Fig. 2 as the two slightly differing frequencies fall in and out of step.

Voltages Unequal.

If the voltages are unequal the pattern will vary between a line and an ellipse. The *difference* of frequency is indicated by the cycles of changes-per-second. When the machines are of exactly the same frequency, the pattern will become a perfectly steady one of the type already shown in Fig. 2, according to the phase. Thus identity of frequency, voltage and phase can be checked in one single observation, which appears not a bad accomplishment for a single instrument.

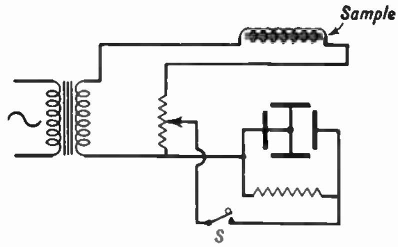


Fig. 8.—EXAMPLE OF OBTAINING "CAUSE AND EFFECT" CURVES.

Circuit for tracing hysteresis loop of iron sample.

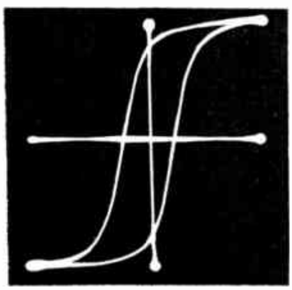


Fig. 9. — PHOTOGRAPHIC RECORD OF HYSTERESIS LOOP OBTAINED WITH APPARATUS OF PREVIOUS FIGURE.

Wave-form of Alternating Voltages.

Before considering the further case of using the oscillograph for the comparison of two frequencies of widely differing value, however, it is perhaps desirable to consider the use of the oscillograph for determination of the wave-form of machines such as alternators, or output of transformers.

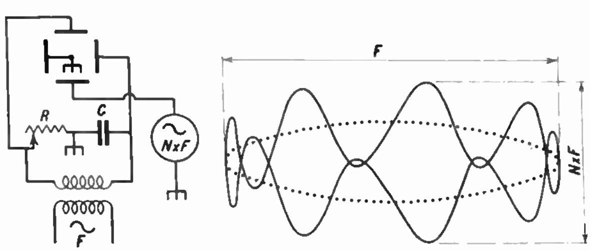


Fig. 10.—COMPARISON OF FREQUENCIES OF DIFFERING ORDERS.

(*a*) circuits for elliptical (or circular) time-scale at low frequency with higher frequency superposed on vertical deflection. (*b*) 8 to 1 frequency comparison.

An improved method is to make the time base in the form of an ellipse so that its back and forward strokes are both visible with the higher frequency imposed on them. Voltage across C and R will be 90° out of phase, and adjustment of R will cause the spot to trace anything from a horizontal line up to a circle. In the case shown, if the low frequency is 50 cycles the higher frequency $N \times F = 8 \times 50 = 400$ cycles.

How This is Done.

This is simply done by applying a time-base to the horizontal plates while the source under examination is joined to the vertical plates as shown in Fig. 4 (*a*).

Time-base Voltage.

The time-base voltage should be one of saw-tooth form. The machine shown is assumed as being non-earthed. The question of adjusting the time base is of special importance.

Correct Adjustment of Time Base.

The time base should be adjusted so that it is either equal to or lower than the frequency of the machine. Thus with a

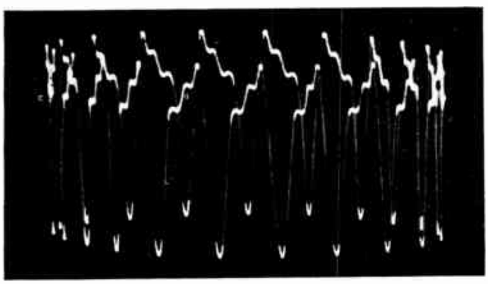


Fig. 11.—ACTUAL PHOTOGRAPH OF 21 TO 1 FREQUENCY COMPARISON.

The low frequency is 50 cycles. It will be seen that there are 21 cycles of the higher frequency to one of the 50 cycles, i.e., the higher frequency is 21 × 50 = 1050 cycles.

50-cycle machine, the time-base would be adjusted to 1/50 of a second, giving a pattern of one cycle of the alternator to one sweep of the base, as in the top picture of Fig. 4 (*b*). The base could, of course, be made 1/25 of a second, giving 2 cycles per sweep as shown in the middle trace of Fig. 4 (*b*), which shows (as does the upper figure) a wave-form free of harmonics. On the other hand, the bottom picture shows the same 2 to 1 design for the wave-form of a machine which has a pronounced harmonic.

General Wave-forms.

The arrangement of Fig. 4 (*a*) is, of course, the general type of scheme for the examination of any wave-form, i.e., to apply the voltage to be examined to the plates giving vertical deflection and to apply to the other pair of plates a time-base voltage of the saw tooth. In cathode ray work, as in all practical work, written instructions may help the beginner very appreciably; but they are not a substitute for actual experience. No doubt, every reader realises this important fact. The frequency of the time-base must, of course, be chosen to be suitable for that of the phenomenon to be examined, but a little experience soon guides the new user in this matter.

Ripple on D.C. Machines.

A further power-station application, however, may be illustrated at this point, since it shows the effects of combining D.C. and A.C. It is the case of examining the ripple of a D.C. machine or rectifier system. The arrangement is shown in Fig. 5 (*a*), which assumes a typical 3-wire D.C. generating system with mid-earth.

Use a Potentiometer to Apply the Voltage.

It is desirable to apply the voltage under examination by means of a potentiometer, so as to be able to keep the deflection just on the screen. In the case of a mid-earthed system this means that two potentiometers are necessary, as shown in the diagram. The time-base is of the saw tooth form already discussed. When the D.C. source is inert the pattern on the tube is the simple time-base line occupying the position marked as zero. Switching in the D.C. generator with the polarity as indicated in the diagram, then raises this line bodily by the amount of the D.C. applied via the potentiometers.

How the Ripple will be Shown.

If the D.C. is entirely free from ripple the pattern will still be a perfectly clean line. If, however, ripple is present it will then show as serrations of the line, the depths of the serrations being proportional to the ripple. Since the mean height is proportional to the D.C. voltage (as would be read by a voltmeter) the percentage of ripple can be determined. The picture of Fig. 5 (*b*) shows a typical appearance on examining a D.C. system working off a mercury-arc rectifier fed by 6-phase A.C. against a time base of 1/50 of a second.

Examining the Ripple Only.

If it is desired to examine the ripple only, the arrangement of Fig. 6 should be adopted. The D.C. is then excluded by the condensers which continue to pass the ripple component. The full A.C. component can then be utilised, giving a bigger picture of the ripple effect. This arrangement is very valuable in examining the efficacy of smoothing devices, permitting check of progressive improvement (if any).

FACTORY AND WORKSHOP APPLICATIONS.

Various applications to factory and workshop practice follow on the lines shown above. For example, examination of wave form and ripple are almost more appropriate to the development workshop (or engineering laboratory) than to the power station itself. An application which has been described before the Institution of Electrical Engineers is that of studying the nature of machine-noise in factories and workshops. The general scheme is shown in Fig. 7, utilising a microphone and amplifier and examining the output of the amplifier against a time-base.

Simultaneous Plotting of Cause and Effect.

A number of workshop applications can and have been devised to permit quick check of repeated operations such as tests or of operations concerned in the progressive adjustment of a product. A typical method is to apply to the horizontal dimension a deflection varying in accordance with the *cause* and to the vertical dimension a deflection varying in accordance with the *effect*. A direct graph of cause and effect is thus directly traced on the screen.

Hysteresis Loops.

An example is shown in Fig. 8 for the delineation of hysteresis in magnetic materials. The sample of material, say a bundle of iron wires, is inserted in a solenoid with one end close to the tube, so that when the alternating current is passed through it the spot is deflected vertically. This movement of the spot is in proportion to the magnetic induction.

Applying a Horizontal Deflecting Voltage.

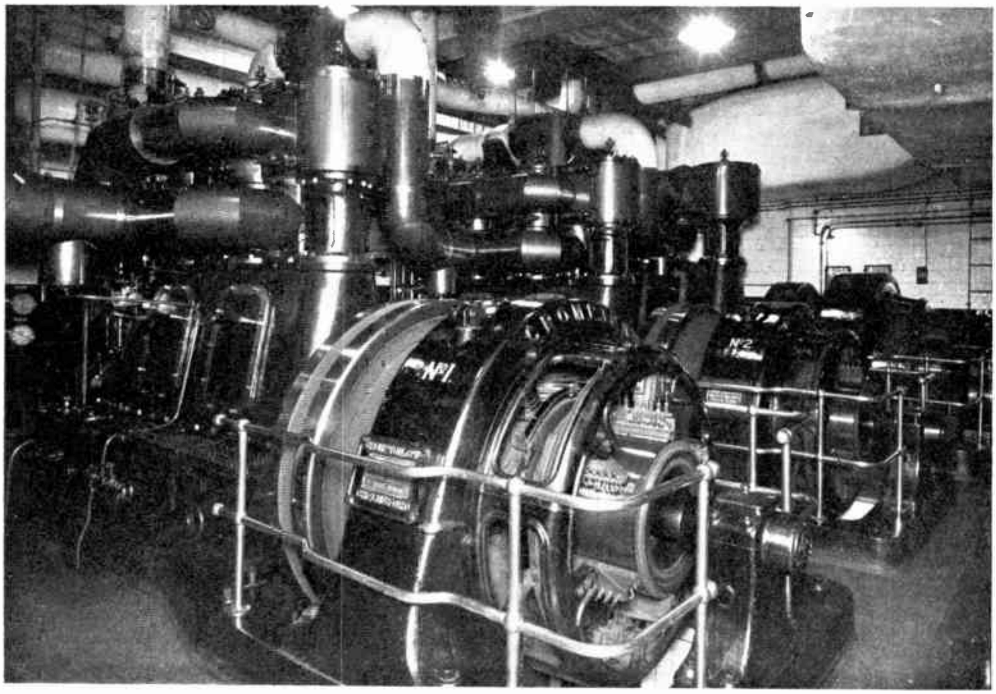
A horizontal deflecting voltage is applied by tapping across a part of the potentiometric resistance in series with the solenoid. This voltage is proportional to and in phase with the current. The pattern on the screen is a curve of the type shown in Fig. 9. The axes may be marked by first opening the switch, thus removing the horizontal deflection from the solenoid, then by removing the solenoid and closing the switch to give the horizontal axis.

Comparison of Different Frequencies.

The case of comparing two frequencies, nominally or very nearly alike, has already been discussed. The oscillograph can also be used for comparing frequencies that are very different in value, i.e., one is many times the other. In this case, the lower frequency can be used as a time base, showing the number of cycles of the higher frequency that exist in one cycle of the lower. Thus a saw-tooth voltage of known frequency can be used in this manner. If however, a good sinusoidal source is available, e.g., the 50-cycle mains, this can be used as a time-base, with very satisfactory results.

ELECTRICITY IN THE HOTEL AND CATERING INDUSTRIES

The firm of J. Lyons and Company is recognised as one of the most successful in this particular branch of activity. Our readers will be interested to see from this article how this enterprising firm utilise electricity for promoting the efficient running of their famous establishments and their allied hotels



THE MAIN GENERATOR STEAM SETS AT THE STRAND PALACE HOTEL.
One triple expansion and two compound Belliss & Morcom engines direct coupled to a 300 kW. and two 220 kW. Crompton D.C generators (215 volts). The diesel and semi-diesel sets are not shown.

MODERNITY and comfort—these are the keynotes of the Strand Palace Hotel, one of London's most luxurious and up-to-date hotels.

One of the Largest Hotels in Europe.

The Strand Palace has 980 bedrooms. There is only one larger hotel in Europe, and that is the sister building, the Regent Palace Hotel, which has 1,050.

Private Generating Plant.

Although this hotel is situated in the heart of London, it is equipped with its own private generating station in the basement of the hotel. There are three steam sets consisting of :—

One 300-kilowatt Belliss & Morcom triple-expansion steam engine, coupled to a Crompton Parkinson generator.

Two 220-kilowatt sets each consisting of a compound Belliss & Morcom steam engine, direct coupled to a Crompton generator.

One 120-kilowatt set consisting of a 6-cylinder Deutz diesel engine direct coupled to a Crompton generator.

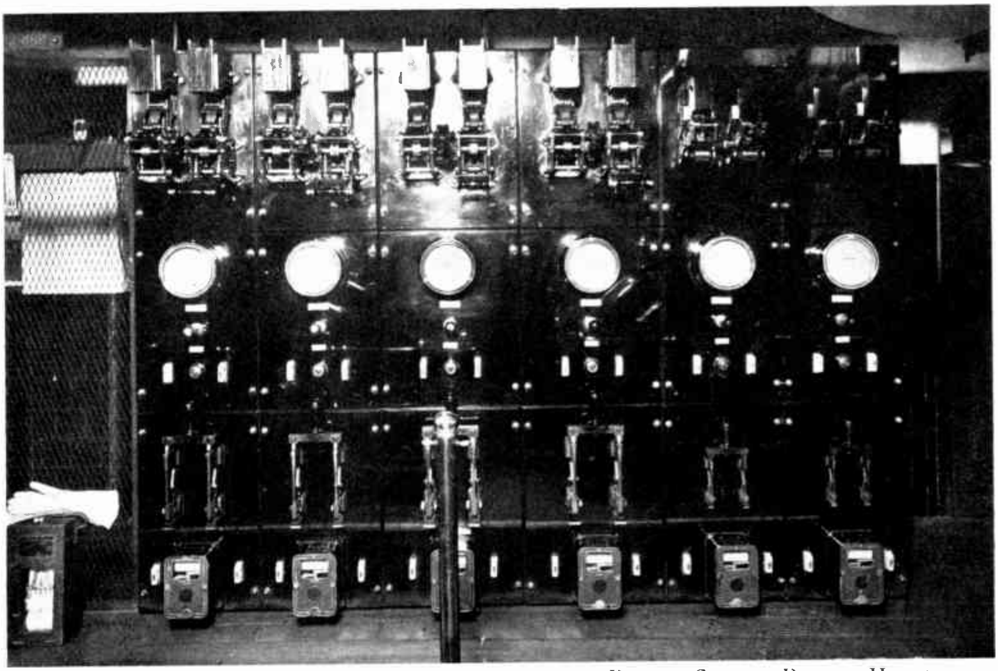
One 33-kilowatt set consisting of Gardner 2-stroke semi-diesel engine direct coupled to a Crompton generator.

The secondary equipment, which is required by the L.C.C. Regulations, consists of one 33-kilowatt set consisting of a Gardner semi-diesel engine and Crompton generator, and one 15-kilowatt set of the same type.

The supply throughout is direct current. The generating voltage is 215, which allows a drop of 5 volts on the cables, the supply voltage being 210.

which is normally closed when the secondary lighting is on.

In operation, the voltage-control relay is permanently connected to the secondary supply, and when the main circuit is alive, the relay contacts are held open, thus keeping the change-over switch main contacts open. As soon as the secondary voltage falls, the relay contacts close and in turn cause the change-over switch to pull in and complete the secondary



THE LIGHTING, HEATING AND POWER DISTRIBUTION PANEL: STRAND PALACE HOTEL.

The supply panels and the distribution panels, which are subdivided for lighting, heating and power, follow the best standard practice.

Automatic Change-over for Secondary Supply.

The double-pole change-over switch is used to put secondary lighting on the ordinary automatically, should the secondary lighting fail. It cannot, of course, act in the reverse direction owing to the very heavy load on the ordinary lighting. The change-over switch consists of two contactors, together with a voltage relay

circuit, this being now fed from the main supply. When the secondary circuit is again resumed, the switch is automatically put back to its initial position.

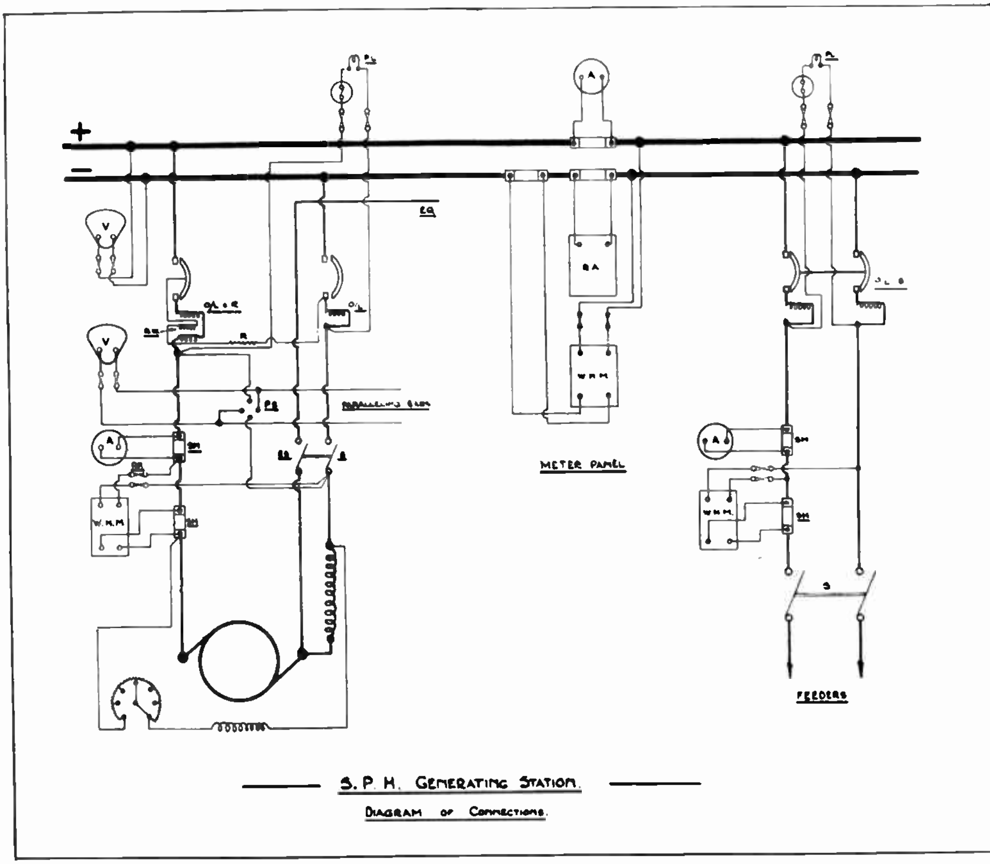
In order to satisfy L.C.C. requirements, the additional contacts had to be fixed in a remote position from the main switch so that the two supplies were not adjacent.

The diagram gives an idea of the working of this. (See page 280).

In the scope of this article it is not possible to deal in detail with the whole installation. We have, therefore, picked out some of the more interesting items for detailed description.

The Smoke Density Indicator.

It is interesting to note that a photo-electric smoke density indicator is fitted into the chimney stack in the basement of the hotel. The arrangement of the cell and exciter lamp is as illustrated in the December issue of the Magazine, but the density indicator, warning lamp and bell circuits have been specially planned by the firm's own engineering staff.



CIRCUIT DIAGRAM OF THE GENERATING STATION AT THE STRAND PALACE HOTEL.

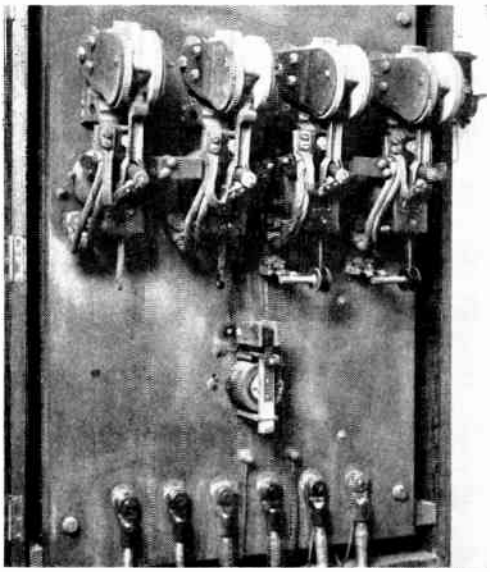
The Electric Time Stamper.

Another very interesting item is the magneta electrically controlled time stamper.

An electric clock in the basement closes a contact once a minute, and through a relay closes a mercury switch which sends an impulse to all the time stamps which are in use in various parts of the building, thus keeping them all in exact synchronism. By the courtesy of the engineers, we are enabled to give herewith a circuit diagram of this arrangement. Notice the 10 - watt lamp and 3 - microfarad condenser which are connected in parallel across the mercury switch contacts. The lamp keeps the circuit "charged," and prevents a time lag in the operation. The condenser prevents arcing across the contacts and also assists the instantaneous operation of the device.

The Silent Signalling System.

One of the most interesting devices is the maid-finder. If one of the maids on any floor is engaged in a bedroom, and is wanted by a guest in another bedroom, her exact location can be ascertained. The guest presses a button in his room ; this flashes a light signal outside his room and also in the service quarters. The message is instantaneously flashed to



THE AUTOMATIC CHANGE-OVER.
This is controlled by a no-volt relay housed in a separate compartment, and in case of failure of the secondary generator sets, it changes over the secondary lighting circuit on to the main generator.

whatever room the wanted chamber-maid may be in.

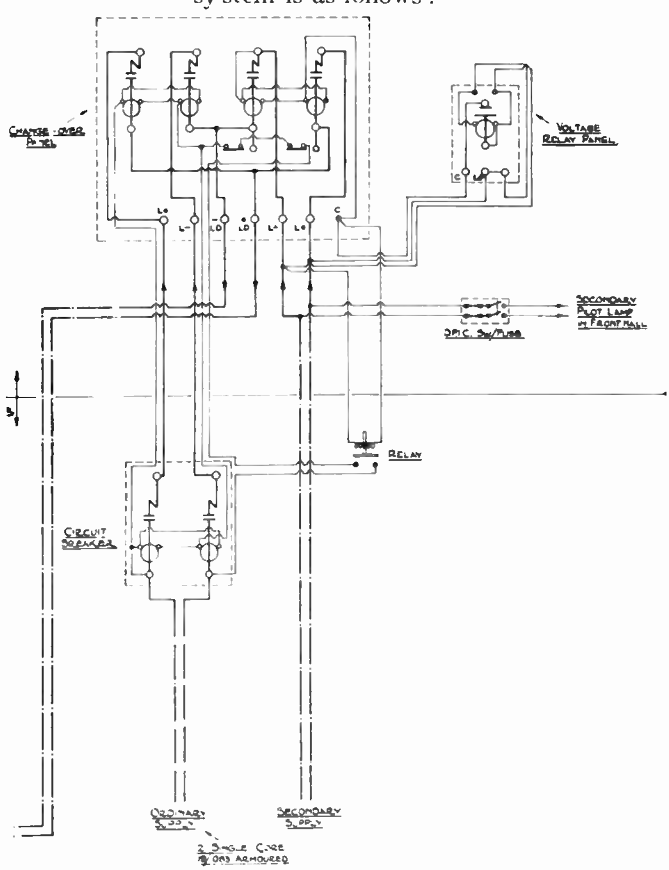
General Arrangement of System.

Each floor is divided into a number of sections, each section having approximately twelve rooms. In each floor service a control board is fitted containing a number of lamps corresponding to the number of sections on the floor. In addition a set of pushes operating corridor section lamps for calling any maid to the service if required, and a system of plugs so arranged that any floor section or sections may be linked to any other or others in any possible combination during certain hours when some of the maids are off duty, are provided. Sometimes only one maid remains on duty, when all sections can be linked. When one or more sections are linked, provision is made to indicate which section is calling.

Call lamps are fitted outside each bedroom, and in the corridors (situated at the junction) two-light fittings suspended from the ceilings are provided, one such fitting per section. One lamp of each fitting is the ordinary call signal from the bedroom; the other denotes to the maid that a meal previously ordered is waiting in the service. This second lamp is operated by pushes provided in the service and is cleared from the service.

The Electric Maid Finder.

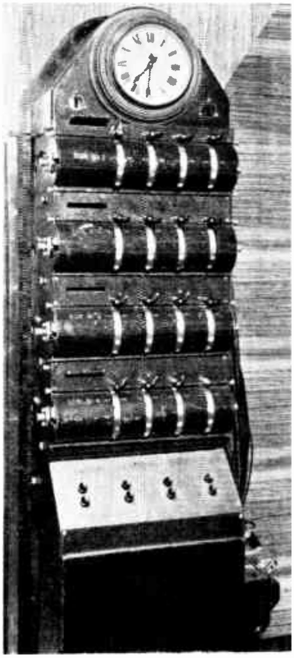
The operation of the entire signal system is as follows:—



CIRCUIT OF THE AUTOMATIC CHANGE-OVER.

A guest desiring the service of a maid depresses a push in the bedroom. This lights up the lamp outside her room, one of the lamps of the corridor two-light fitting on that section, and also the section lamp on the service board. The maid, seeing one of these lamps, will easily locate the room, since, of course, it is only one of perhaps twelve under her control, attend to the call, and clear it from outside the door.

A push with a lamp above is fitted in the corridors, one per section, for the use of visitors wishing to call a maid from the corridor. Not only the lamp above, but that on the corridor section fitting and the corresponding lamp on the service board for that section, are illuminated, so that the maid can easily locate the call.



Transmitter for Page Call Indicators.

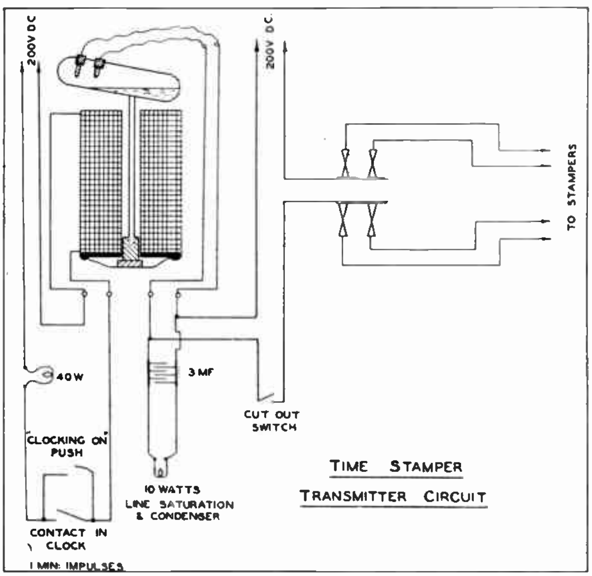
An Ingenious Idea.

A single pole switch in the form of a door bolt is inserted into the door frame, this being normally "off" when the door is shut and the bolt in its socket. This bolt switch is in series with the maid-finder lamp which in turn is connected to every bedroom lamp on that section. When a maid enters a bedroom for the purpose already mentioned, she must pull the bolt out so that the switch is closed. Should a call be made from any of the bedrooms on her section, the maid-finder lamp in that room is illuminated, together with the usual lamps previously mentioned.

The object of this switch being in the form of a bolt is that when the maid leaves the room for good, she is bound to push the bolt in, thus putting the lamp out of circuit. If it were an ordinary switch, she might forget to put it "off" and the maid-finder lamp would be illuminated with every call on the section, so causing annoyance to the guests.

Maid-Finder Lamp.

At certain times during the day the maids are busy in the bedrooms making beds, and tidying. In these circumstances, she would be unable to see any call which might be made for her. To provide for this, a maid-finder lamp is installed in every bedroom. This works in the following manner :—

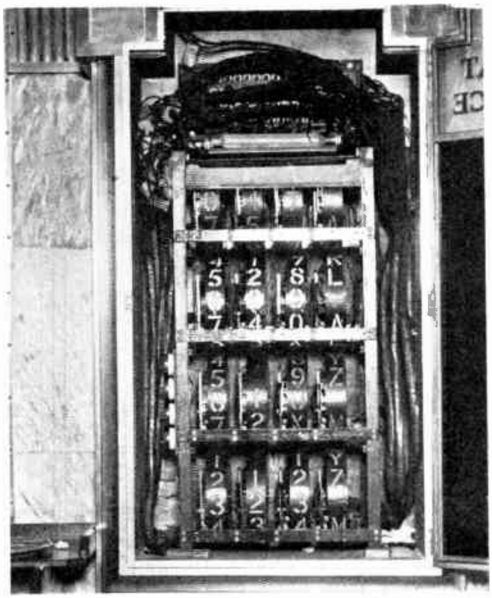


Circuit of the Electrically Controlled Time Stamper. An electric clock closes the relay once a minute, thus tilting the mercury switch and sending an impulse to all the time stampers.

Night Operations.

During the night—say after 11 p.m.—all floor maids are off duty, and the night porter has to attend to any calls made during that

THE ELECTRIC PAGE.
If a visitor enquires for any guest staying in the hotel, the room number of that guest is flashed on suspended signs in every part of the hotel.

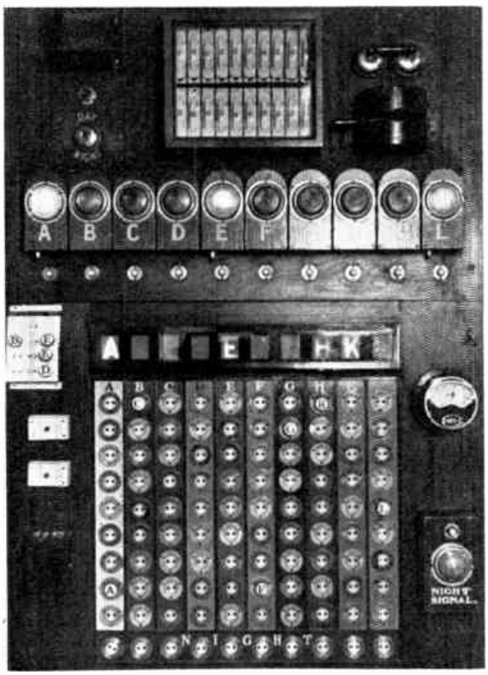


THE ELECTRIC PAGE.
Here we see the inside of the electric page mechanism.

period. In the hall-porter's office, situated on the ground floor near the entrance, a signal lamp board is fitted having a lamp for every section on every floor. A change-over switch is provided to put all floor signals on to the night system. In this case, of course, any call from a room is indicated on one of the lamps in the hall-porter's office, and he attends to same.

Ordering Meals from Bedroom.

The Meal Call is operated in the following manner: When a guest orders a meal from the bedroom, the message is telephoned to the Still Room in the basement. In this room there is a board containing a push for every section of every floor. The meal is prepared and the tray put on an elevator with a slip giving the room number, and it is automatically taken to the correct floor. When the meal is despatched, the push corresponding to the floor and section for that meal is depressed. This indicates on the section lamp in the floor service and on one of the lamps



THE SECTION LINKING BOARD.

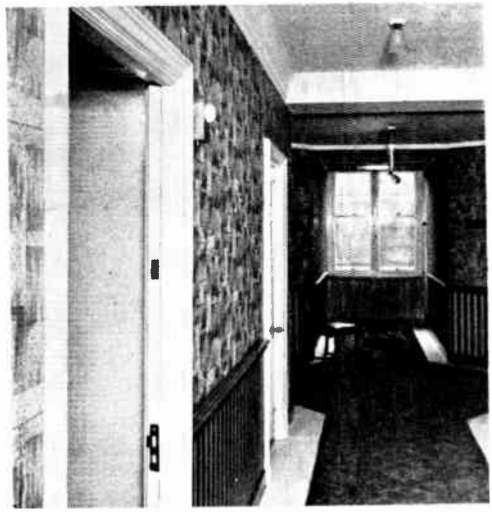
of the two-light fitting on that section. Also, of course, on any maid-finder which may have been put in circuit. The maid is therefore made aware of the meal awaiting her in the service to be taken to the room. This system is patented.

Panel Heating in Rooms.

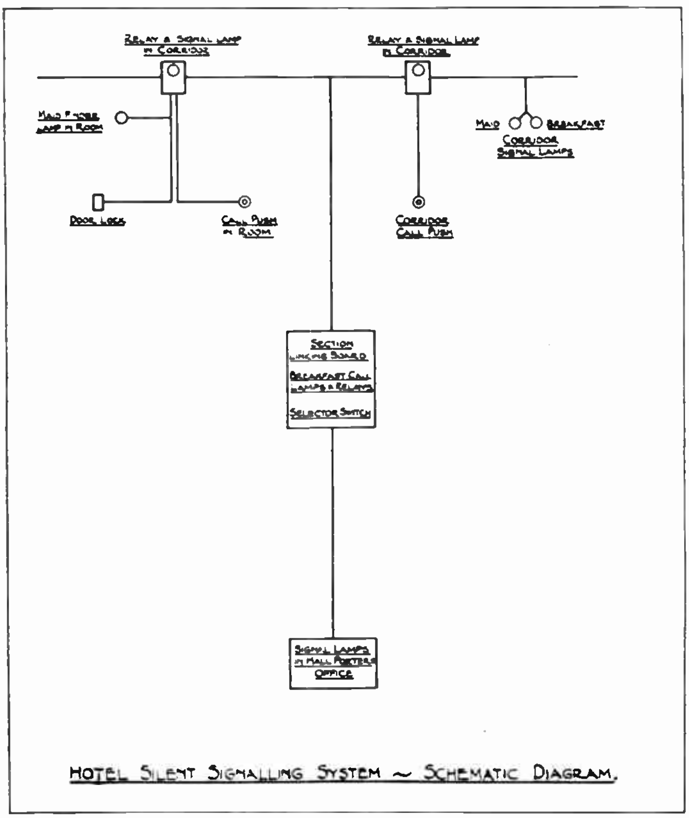
Panel heating of the latest design has been installed in every bedroom. There are independent controls, so that every resident can adjust the heat exactly to his or her liking. Every bedroom has a telephone with facilities for local and long-distance calls.

Lifts and Elevators.

Five high-speed electric lifts, travelling at the rate of 500 ft. a minute, communicate with all floors. Continuous elevators or " delevators " bring meals from the kitchens to the bedroom floors.



THE SILENT SIGNALLING SYSTEM.
Note the light above the door, and the single-pole switch in the form of a door bolt.



CIRCUIT OF THE SILENT SIGNALLING SYSTEM.

Electric Dish Washers.

All the washing-up equipment is new and up to date. Dishes and silver are washed by electrical machinery and sterilised. The plant can deal with 120,000 pieces an hour.

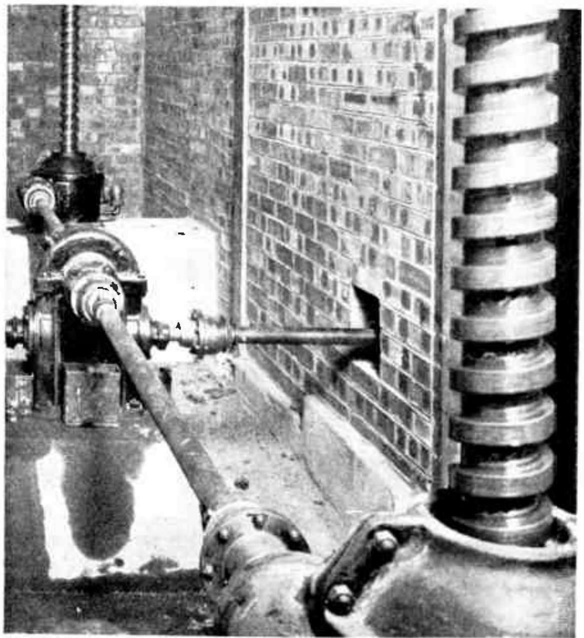
A loud speaker signalling system is used in the kitchen.

The Electric Page—

" Pageing," one of the nuisances of hotel life in the past, is replaced by a system of signalling installed in every one of the public rooms. If a visitor enquires for any guest staying in the hotel, the room number of that guest is flashed on suspended signs in every part of the hotel.

—and How it Operates.

This apparatus consists of a number of indicators prominently



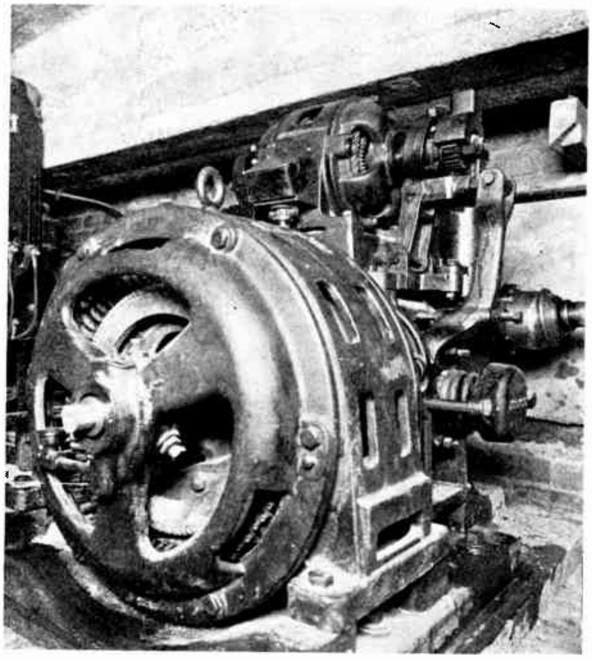
A VIEW OF THE SCREWED PILLARS WHICH WORK THE VANISHING WALL AT THE TROCADERO RESTAURANT, W.

situated in the public rooms of the hotel. These indicators are controlled from a transmitter in the charge of the enquiries clerk in the front hall. Four calls may be displayed at one time and left illuminated until answered or cancelled in favour of further calls.

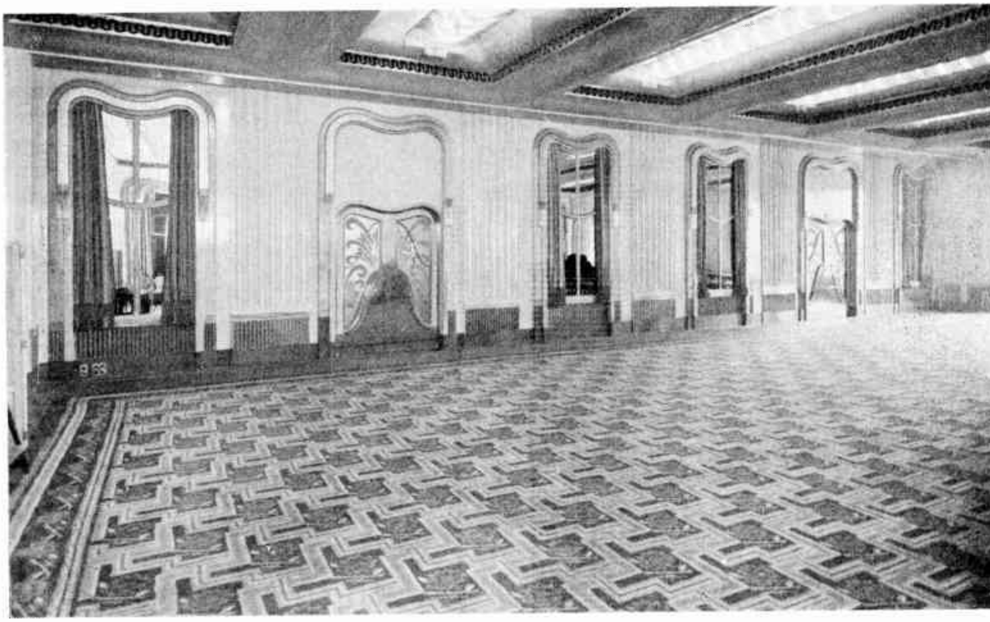
Each indicator comprises four rotors, and each rotor has four discs, each disc being rotated independently. On each of these discs are a number of numerals and letters and by suitably operating any three in a row, any bedroom number in the hotel can be displayed. This, of course, is repeated on the other indicators. The numbers intended for display are brought to a position immediately behind a square of clear glass on the black glass front of the indicators.

The positional control of each rotor is effected by means of the action of fixed electro-magnets upon permanent magnets mounted on the rotor. Each rotor has mounted thereon a number of permanent magnets. For energising these electro-magnets there are three circuits and these three circuits when operated from the transmitter are adapted to be energised sequentially, causing the rotor to be rotated in a step by step manner.

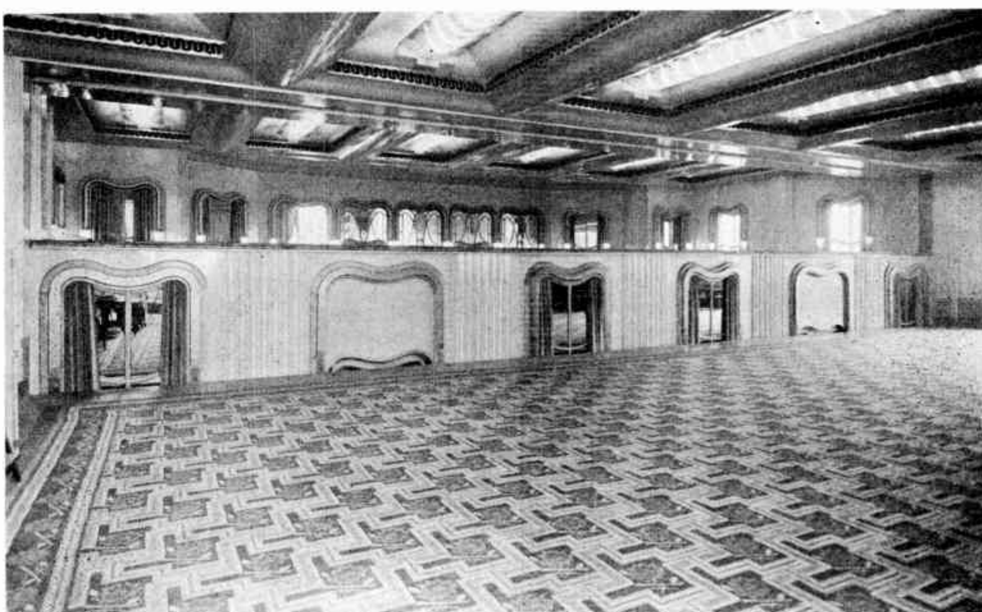
When an enquiry is made at the counter, the enquiries clerk operates the transmitter giving each numeral of the bedroom number separately. The discs rotate to these numerals and when they get opposite the clear glass aperture on the indicators, the power circuit is automatically cut off, a warning bell rings, and lights are illuminated behind the number. When another bedroom is required from the same rotor, the transmitter is operated in a similar manner and the numerals adjust themselves to the new number, some discs rotating perhaps ten steps, others only one or two



THE MOTOR WHICH ACTUATES THE VANISHING WALL.
The gears are driven from the motor and are interconnected by Spicer shafts and universal joints.



THE VANISHING WALL AT THE TROCADERO.
This photo shows the wall in position.



THE VANISHING WALL AT THE TROCADERO.
Here we see the wall half way through the floor.

THE SELF-OPENING DOOR AT THE "OXFORD" CORNER HOUSE.
Showing the door opening as the waitress intercepts a beam of light which normally falls upon the photo-electric cell.

steps. A delay action is incorporated on the transmitter, so that the power is not automatically cut off until the last disc has assumed the correct position. When the call on that rotor is cancelled, the lights are automatically switched off, thus giving no display.

This system is patented.

The Vanishing Wall at the Trocadero.

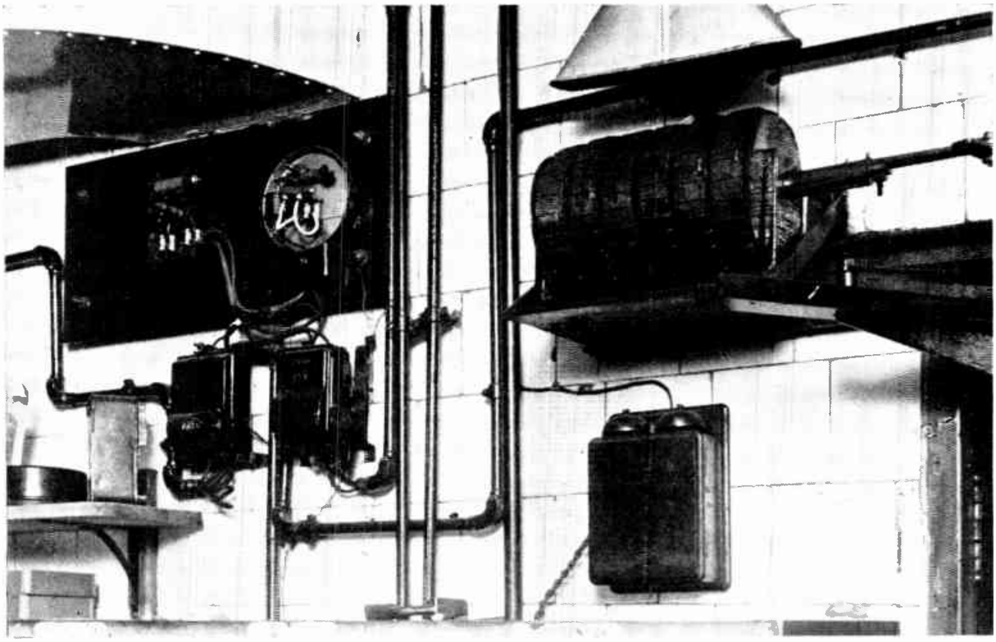
The Empire Room, which is about 82 ft. long and 67 ft. wide, can be divided into two by touching an electric switch. This causes a remarkable "vanishing wall," 13 ft. high and 67 feet long, to rise up through an aperture in the floor.

This wall, which weighs about 19 tons, is complete with all decorations synchronising with the other walls of the room, even to the illuminated tassel fittings. It contains doors which are glazed to correspond with the principal doors, and which, by a special electrical device, automatically lock themselves when the wall is put in motion. Thus, the possibility of "losing" a waiter, who might otherwise vanish with the wall when it disappeared in the floor is entirely obviated.

The movement of the wall is controlled by push buttons in the service room. One button is for lowering the wall, another is for raising it, and the third is for arresting the movement of the wall in any position whenever an emergency arises.

Limit switches are provided for stopping the movement when the wall reaches the upper and lower positions. The wall is raised and

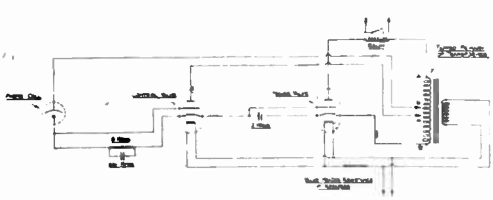
THE MECHANISM WHICH CAUSES THE DOOR TO OPEN.
Showing the arrangement of the actuating mechanism.



CLOSE-UP VIEW OF THE DOOR-OPENING MECHANISM.

When the beam of light outside the door is interrupted it causes a relay to close the contacts of a powerful solenoid which actuates the door-opening mechanism.

lowered by means of five screwed pillars which are spaced equally underneath it and which are operated by worm gearing; the gears being driven from a single motor and interconnected by spicer shafts and universal joints. The arrangement of this is illustrated in the accompanying photographs. The wall was installed by Messrs. Waygood-Otis, Ltd.



CIRCUIT OF PHOTO-ELECTRIC AMPLIFIER WITH DELAYED ACTION.

Function of apparatus:—No anode current (relay open) when light is falling on the cell. On interrupting the beam of light, anode current immediately rises (closing relay). When the beam of light is restored relay remains closed (anode current flows) for a predetermined period. Should beam be interrupted before anode current has died away, same will rise to its maximum. It will be noted that the period for which door remains open is proportional to the rate of cutting the beam of light.

The Self-opening Door.

Space does not permit of our dealing in detail with many of the other interesting electrical devices which we saw in the course of our visit to these establishments, but readers will be particularly interested in the self-opening door which is giving very satisfactory service in the Oxford Street Corner House. The action of this can be clearly seen from the accompanying photographs. As the waitress approaches the service depot she intercepts a beam of light which normally falls upon the photo-electric cell shown on the right of the picture. This causes a relay to close the contacts of a powerful solenoid which actuates the door opening mechanism, as can be clearly seen from the above photograph.

We are indebted to the electrical staffs of these establishments for their assistance in compiling this information.

The Editor invites correspondence from readers on any subject of general interest to members of the electrical engineering profession. Letters should be addressed to THE EDITOR, The Practical Electrical Engineer, 8-11, Southampton Street, Strand, W.C.2.

Using a Commutator Stone.

SIR,—I should be glad if you would let me know how a commutator stone can be used on the commutator of a D.C. motor while the motor is running on load. If the motor was switched on to supply and run up to speed, would the brushes be raised off the commutator before the speed dropped to any extent? Or would the slight remanent field magnetism cause a voltage at the commutator when the speed is running down?

H. STEVENSON (BROTTON).

A commutator stone can be used on the commutator of a D.C. motor whilst the motor is running on load, preferably on a fairly light load, with the brushes bearing on the commutator, of course. After the machine has been shut down, attend to the brushes if necessary, bedding them down to the commutator in the usual way by using a strip of medium or fine-glass paper stretched over the face of the commutator, the abrasive surface to the brushes, and pulling the glass paper to and fro until the brushes bear evenly over the whole surface. Finally, clean out all traces of carbon and copper dust from the commutator, risers and end turns of the armature.

Effect of Sawing or Filing Steel.

SIR,—Recently I have had reason to trim the ends of ⅞-in. steel bars (about 75 carbon) with a machine saw. At the end of the sawing operation I have noticed that the steel possessed magnetism, a state shown perfectly by the steel particles upon the bar (shall we say "sawdust"). Continuing my observations, I placed in the saw a length of steel, which, after testing, was found to be devoid of magnetism, and, as already stated, the bar possessed a certain amount of magnetism after being sawn. Upon placing a length of iron in close vicinity (⅞-in. diam.) the steel particles were attracted by it, but after adhering to this bar for a few seconds, they fell away. Can you please inform me why this occurs, and also from where does the magnetism come?

"STUDENT" (Sheffield).

Before magnetisation the molecules of the steel are arranged in such a manner that the resultant magnetism is practically nil.

The effect of sawing or filing the steel is to disturb the molecules so that the saw dust, and sometimes the material of the bar itself, exerts a certain amount of free magnetism after sawing. The particles of dust are really tiny permanent magnets which will, therefore, adhere to a bar of iron. They soon become magnetically weakened owing to their minute size. That is the reason they fall away from an iron bar after a few seconds.

Size of Welding Transformer.

SIR,—How can I estimate approximately the capacity of a single-phase transformer, as used for low voltage resistance welding machines? The primary is 250 volts; the secondary, 1-4 volts.

J. F. D. (Walsall).

It is not clear from the question whether the querist requires (a) *to estimate the kVA. capacity of a transformer from its dimensions, or* (b) *to know the size of welding transformer required for a given service.*

In the absence of further data it is assumed that (b) *is desired.*

The power required for resistance welding varies considerably with the conditions, such as material to be welded, size of weld, type of weld, and time allowable.

The following are typical figures for butt welding:

Iron bar, ¼-in, dia. Time, 3 secs. Power, 2 kW.

Iron bar, 1-in. diam. Time, 18 secs. Power 12 kW.

A Price Reduction.

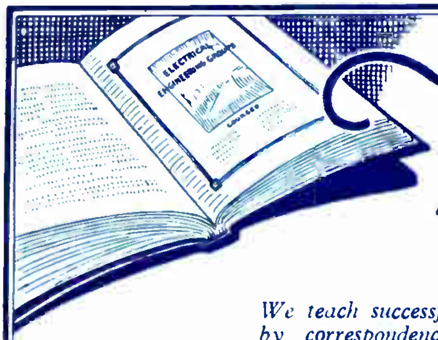
SIR,—We would advise you that as and from the 1st January, 1933, we are reducing the price of our Lewcodensers, Type O and W from 2s. to 1s. 6d.

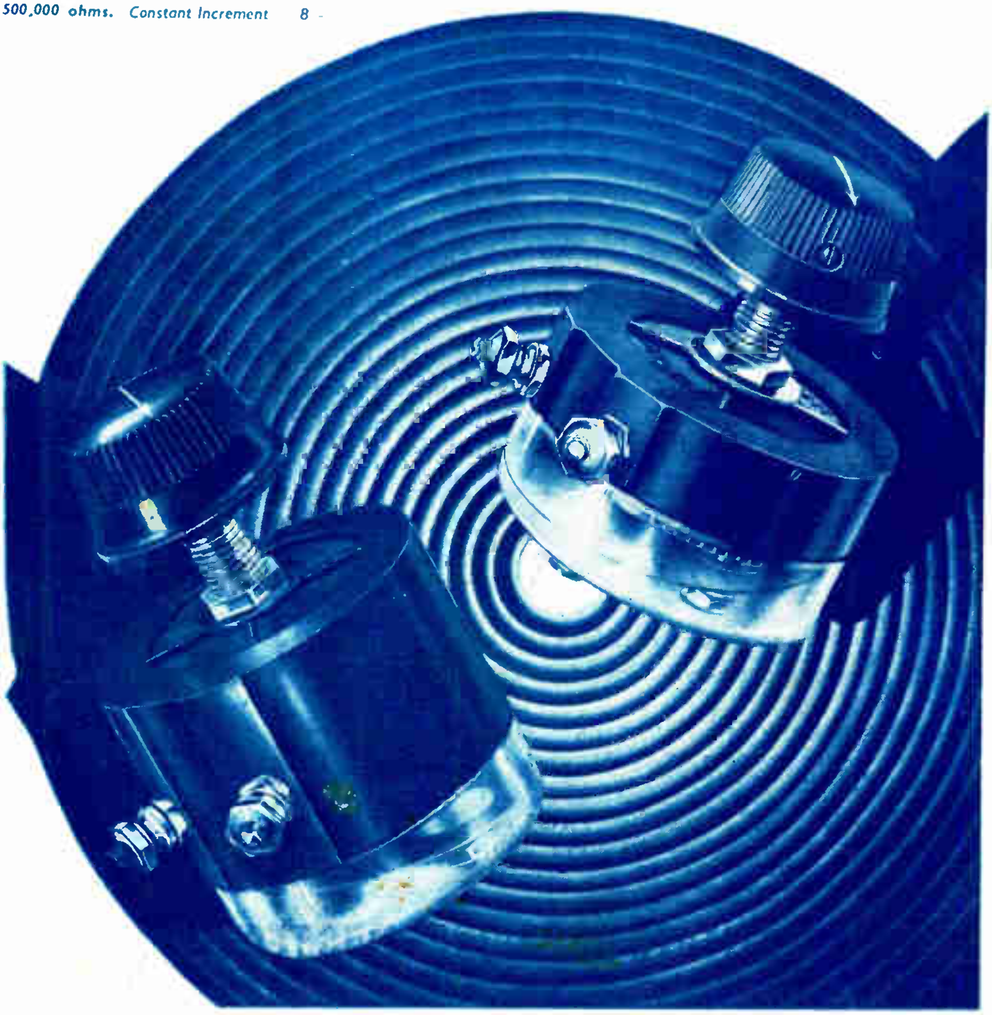
The increasing and constant demand for these condensers has enabled us to reduce our factory costs, and we therefore have much pleasure in passing same on to the public.

THE LONDON ELECTRIC WIRE COMPANY AND SMITHS, LTD.

We have pleasure in passing on this information to our readers.—[ED.]

Owing to the rapid progress in the design of electrical apparatus and to our efforts to keep our readers in touch with the latest developments, we give no warranty that apparatus described in our columns is not the subject of Letters Patent.





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