Recent Developments in Luminous Signalling

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY MAGAZINE OF ELECTRICAL PROGRESS

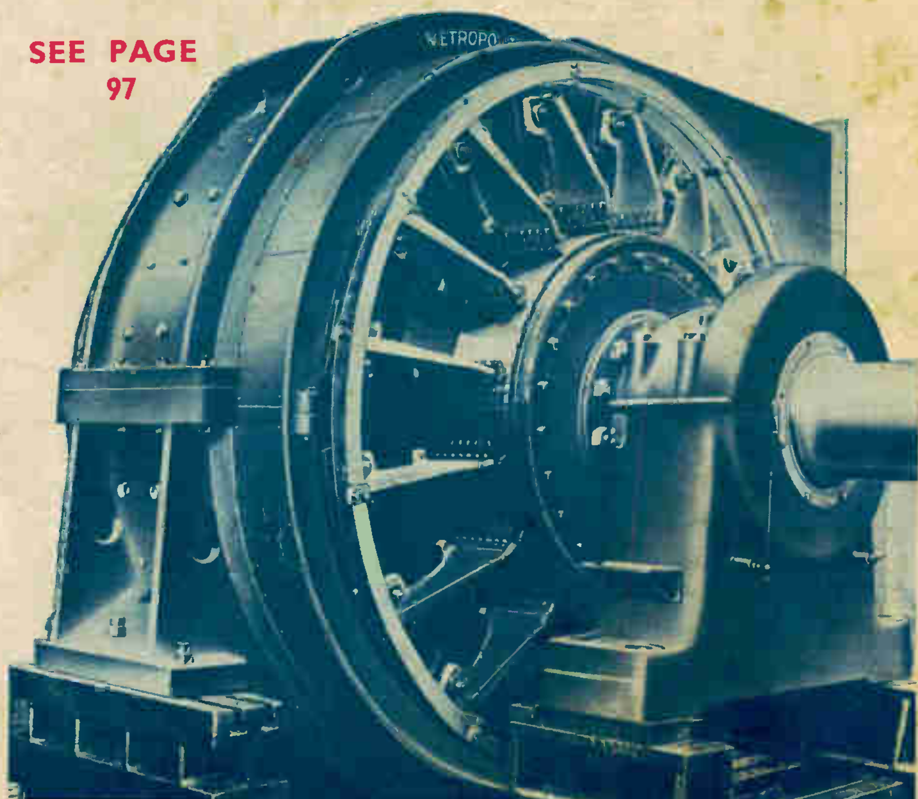
VOL. II.—No. 15

NOVEMBER, 1933

SPECIAL ARTICLE ON DYNAMO DESIGN

By MILES WALKER, M.I.E.E., F.R.S.

SEE PAGE 97



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GEORGE NEWNES LTD.

NOVEMBER PRACTICAL EL... INEER NO. 15

The PRACTICAL ELECTRICAL ENGINEER

A MONTHLY SURVEY OF MODERN PRACTICE IN ELECTRICAL ENGINEERING

VOL. II | NOVEMBER, 1933 | No. 15

Published by GEORGE NEWNES, *Ltd.*,
8-11, Southampton Street, Strand, London, W.C.2.

Telephone—Temple Bar 7760
Telegrams—"Newnes, Rand, London"

Price - 1/- Monthly
Yearly Subscription, 14/- Post Free
6 months' Subscription, 7/- ,, ,,
Registered for Transmission by Canadian Magazine Post
Canadian Rate: Yearly Subscription, 13/6 Post Free
6 months' Subscription 6/9 ,, ,,

Enterprise and the National Grid.

Through the enterprise of Messrs. Johnson and Phillips, Ltd., a Rural Electrification Scheme has been brought into successful operation to serve the districts of Ringmer, Alfriston, Asham, Plumpton and Glynde. The area covered by this scheme lies behind Brighton, Newhaven and Seaford on the South Coast and is approximately 63 square miles, and is under the Ringmer and District Electricity Co., Ltd., who purchase supplies from the Grid and distribute to their consumers. The latter include factories, farms, houses and shops. Already the undertaking is distributing at the rate of 3,000,000 kilowatt hours per annum. The prices charged to consumers range from ¾d. per kilowatt hour for off-peak water heating to a flat rate of 1½d. per kilowatt hour for power consumers taking more than 5 h.p.

These are the kind of prices which we believe will do more than anything else to stimulate rapid expansion in the use of electricity. We offer our congratulations to the firm of Johnson and Phillips, Ltd., on an achievement which sets a fine example.

Selling Electric Lamps.

The lamp situation continues full of interest. Mr. Os and Mr. Ram continue to amuse everyone with their witty remarks, whilst the Crompton-Kye organisation are gradually spreading the news that good British lamps are now obtainable at the price of 1s. Supply voltages are still far from uniform all over the country—200 volts, 205 volts, 210 volts, 220 volts and 230 volts are to be found within a short radius of Charing Cross.

Electrical engineers know that a slight variation from the rated voltage of a lamp may make a big difference in the light obtained or in the length of life of the lamp. We venture to think that not more than 50 out of every 100 consumers of electricity know the exact voltage of their supply. We suggest that a rather interesting lamp advertisement would be one containing the supply voltages for different districts. It might not be possible to cover all districts in a single advertisement, but we believe that the firm who ran a series of advertisements on these lines would have made the first step in educating the public to think electrically.

Mr. Winton Thorpe.

The new Northampton College of Technology possesses one of the best electrical equipments of its kind in the country. Readers will be interested to hear that the Consulting Engineer was Mr. D. Winton Thorpe, A.M.I.E.E., to whom we offer congratulations.

Ultra Violet Lamps.

A few years ago there was a growing demand for ultra-violet ray lamps for use in the home. Articles were then published in the newspaper press drawing attention to the dangers of the unscientific use of these lamps. These articles had the effect of greatly reducing the demand. It is quite certain that a great deal of new business could be obtained during the coming winter by the sale of suitable domestic equipment. Full instructions should be given as to the correct methods of using the lamps. Ultra-violet lamps improperly used are dangerous, but so are motor cars. This is just another example of the fact that electrical manufacturers must realise that if they wish to extend their business they must be prepared to spend time, trouble and money in educating the public. Who else is there to do it?

A Great Designer.

Modern electrical generators are amongst the most efficient machines produced by the ingenuity of man. Efficiencies of 98 per cent. and higher have been obtained. That is to say, for every 100 h.p. used in driving a large dynamo it is possible to obtain an output equivalent to about 98 electrical h.p. There are very few other machines capable of such a performance.

Professor Miles Walker, F.R.S., who has contributed an interesting article on Dynamo Design to the present issue is one of the engineering geniuses whose work has conduced to these astonishing results. His article is well worth careful study.

A.C. Motors.

The gradual adoption of A.C. supply all over the country is leading to increased use of induction motors. Like most other electrical machinery, once the motors have been correctly installed little or no skill is required to operate them. Upon the works engineer rests the responsibility of seeing that this installation is carried out correctly. The article beginning on page 102 contains much useful information for the man who is, or intends one day to be, the engineer-in-charge of a works or factory.

An Electrified Pump.

On page 106 we show an interesting example of an electric motor for driving one of the old hand-operated pumps. There must be thousands of such pumps all over the country. The profit on installing a 1 h.p. motor and accessories may not be very large, but little fish are sweet. In many rural districts it is easier to find 20 customers who can spend £5 or £10 than it is to find one or two customers who can spend £100 or £200.

The Westector.

An interesting application of the Westinghouse dry plate rectifier is described in the article beginning on page 125. This development is known as the Westector and can be used in place of a rectifying valve in wireless sets containing at least two stages of high frequency amplification.

I.E.E. Regulations.

We have much pleasure in acknowledging the courtesy of Messrs. Evershed and Vignoles for allowing us to use in this month's issue a number of diagrams taken from their new publication, "How to Avoid Electrical Breakdowns." Every reader interested in this subject is strongly advised to write immediately to Messrs. Evershed and Vignoles for a copy of the publication in question. Write to Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, London, W.4, mentioning THE PRACTICAL ELECTRICAL ENGINEER.

Luminous Signalling Systems.

We are fortunate in being able to include in this month's issue advance particulars of some of the latest developments in luminous signalling systems.

The author, Mr. S. W. Richards, of the General Electric Company, has developed the subject clearly by easy stages from the simplest relay circuit so that readers who have not specialised in this subject can now bring themselves right up to date by a careful study of this article.

Questions and Answers by Practical Men.

Since this new feature was started we have had a great pressure on our space. This feature promises to become one of the most popular in the magazine. We have been obliged this month to hold over a number of questions and answers, but readers may rest assured that every letter is receiving attention and will be dealt with as and when our space allows.

Have You Had Your Copy ?

We have examined a copy of the first part of Sir Ambrose Fleming's new work *Principles of Electrical Engineering*. It is compiled on original lines and makes study a pleasure. Items included in Part 1 are "Laboratory Demonstrations," "How to Read Electrical Circuits," "Resistance of Wires," "Principles of Neon Tubes, Cathode Ray Tubes and X-Ray Tubes," and "Designing Electrical Circuits." An excellent shillingsworth, and we hear that the first number has been sold out.

The Utilisation of Space in Dynamo Design

By Professor Miles Walker, F.R.S.

THE space taken up by a dynamo is occupied mainly by four materials: (1) iron; (2) copper; (3) insulation; and (4) air. In a good design the right amount of space is allotted to each of these. Although air costs nothing, the spaces occupied by it inside a dynamo increase the size of the machine and the amount of iron and copper, and for that reason the air space must not be unreasonably extended. If we had no air spaces the cooling would be bad.

AIR SPACE.

The very greatest diversity of opinion exists among dynamo designers as to the allocation of air space. Before we decide upon the amount of air to allow, we must know how fast the air will be moving. In turbo generators, where an elaborate system of ventilation is provided and the velocity of the blast reaches high values, the total amount of air space is relatively small; whereas, in the old-fashioned slow-speed, self-cooled machines the amount of air space was relatively large. Two important considerations must be kept in view:—

(*a*) Enough air must be provided to carry away the heat.

(*b*) Enough surface must be provided to communicate the heat from the solid parts to the air.

Calculating the Amount of Air Required to Carry Away Heat.

The amount of air required can be arrived at by making an estimate of the total losses. The amount measured in cubic metres per sec.

$$= \frac{\text{watts lost}}{\text{temp. rise of air} \times 1{,}150}$$

This assumes a barometric pressure of 760 millimetres of mercury and a mean temperature of 35° C. To get the volume at any other pressure, p in millimetres and mean temperature, T in °C., multiply by

$$\frac{273 + (T - 35)}{273} \times \frac{760}{p}$$

It is usual to allow a considerable margin over the figure derived from this formula because a good deal of air escapes without being heated very much. The margin to be allowed will depend upon the system of ventilation adopted. Where, as on a turbo generator, the paths for the air are very definite, and one can rely upon each channel for the air doing its share of the cooling, only a small margin need be allowed; but, in general, one allows about 50 per cent. more than the amount theoretically required.

Designing the Air Ducts.

After deciding upon the amount of air required, the next step is to allow a sufficient area of cross-section of air ducts for the air to pass through. The smaller the cross-section of the channel the greater the speed of the air, and therefore the greater the number of watts which can be passed to the air with a given temperature difference. But if the channels are not given sufficient cross-section, the pressure required to drive the air through them will be too great. The pressure required goes up as the square of the velocity; whereas the specific cooling only increases as the first power of the velocity. In many machines one is contented with a mean velocity of about 3,000 ft. per minute, or, say, 10 metres per second. Higher velocities than these would, in general, require some special form of blower. On small diameter machines the velocity is still smaller. This gives one an approximate idea of the amount of room required for the air passages.

The provision of sufficient cooling surface* to pass the heat from the solid parts to the air is a matter which does not fall within the province of this article.

APPORTIONING THE SPACE BETWEEN IRON, COPPER AND INSULATION.

The method to be adopted in apportioning the space between iron, copper and insulation depends on whether we are dealing with an armature or a field magnet.

D.C. Armatures.

In the case of armatures such as are used for direct current machines or synchronous converters, the output depends upon the amount of space available in the armature; for the field magnet, being external, can be made as large as we like. In the case of revolving field magnets for A.C. generators, the output is often fixed by the amount of space available in the field magnet. This latter case we will consider after we have dealt with the D.C. armature.

Consider a D.C. armature of large diameter so that the taper of the tooth is not sufficient to greatly affect the result. In Fig. 1 the slots and teeth are drawn as if the armature had an infinite radius. The effect of a taper is shown by the dotted line.

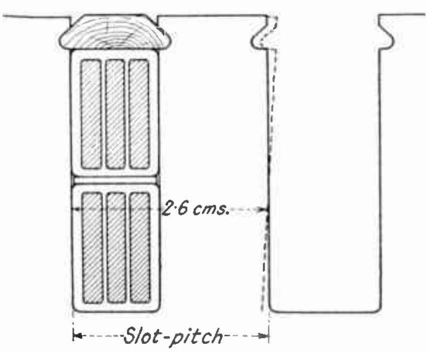


Fig. 1.—SHOWING THE SPACE OCCUPIED BY COPPER, INSULATION AND IRON IN A D.C. ARMATURE WHEN THE SLOT IS 1.15 CMS. WIDE AND THE TOOTH IS 1.45 CMS. WIDE.

The effect of taper of the tooth is shown by the dotted line.

The dimensions upon which the output mainly depends are: (1) the cross-section of the iron of the teeth; (2) the cross-section of the copper; (3) the thinness of the insulation.

Fixing the Depth of Slots.

The greater the depth of the slots the more room there is for copper; but to get good commutation the slots must not be made too deep. In actual practice it is not found advisable to make the slot depth greater than 10 per cent. of the pole pitch. To fix upon the optimum depth of slot for any particular machine is a rather complicated matter as it involves the consideration of the eddy currents in the conductors as well as the effect of depth upon commutation. For the purpose of this article we will assume that the depth of the slot is fixed at, say, 10 per cent. of the pole pitch.

Thickness of Insulation.

The thickness of the insulation will depend upon the voltage of the machine. The amount of room taken up will depend upon the number of slots per pole and the number of conductors per slot. In D.C. armatures the thickness of the insulation depends mainly on getting sufficient mechanical strength.

Number of Slots per Pole.

In order to improve the commutating conditions the number of slots per pole must not be made too small. The fewer the number of slots the cheaper the machine; but designers will not risk putting very few slots per pole except on very small machines. For machines of 100 kW. and more, 10 slots per pole should be regarded as a minimum, and numbers up to 24 slots per pole are usual on machines of large output. For the best commutating conditions it is inadvisable to have more than six conductors per slot, though eight or even 10 conductors per slot are sometimes found operating well on fairly big machines. One can work the copper at a higher current density when fewer conductors are used per slot, and this in a measure compensates for the extra insulation space required when more slots are

* See "Specification and Design of Dynamo Electrical Machinery" (Longmans).

used. When we are given a certain depth of slot and a certain pitch of slot (Fig. 1), and also a certain total thickness of insulation per slot, the question arises how shall we apportion the space between the iron and copper.

The more room we allow for the iron, the greater the total flux per pole, and therefore the greater the voltage generated for a given number of conductors.

The more room we allow for copper the greater the current the conductors can carry.

Since the output of the machine is the product of voltage and current, it is seen that both the iron and copper make important claims for space, and since the space is limited what we give to the one must be taken from the other.

In order to see clearly how the output of the machine varies as we alter the proportions between iron and copper, we may make a diagram like that shown in Fig. 2.

The abscissæ in this figure represent distances along the periphery of the machine or along the slot-pitch. To simplify matters and fix our ideas, we have drawn Fig. 1 as if the armature had such a large radius that the taper of the teeth can be neglected. In practice, when the taper of the teeth is not excessive, we may take the dimensions of the tooth at one-third of a tooth length from the bottom of the slot and then regard the tooth as parallel for all practical purposes. The slot-pitch has been taken as 2.6 centimetres. This would give $15\frac{1}{2}$ slots per pole with a pole-pitch of 40 centimetres. The circumference of the armature in a 10-pole machine being about 400 centimetres. The depth of the slot is 4 centimetres and the depth of the copper 3 centimetres. With six conductors per slot the total thickness of insulation (on a 600-volt armature) with suitable clearance would be about 0.4 centimetre.

We set off the slot-pitch 2.6 centimetres along the horizontal line at the base of the figure and mark off 0.4 centimetre for insulation and clearance. The remaining 2.2 centimetres are available for iron and copper, and the problem is to find how the output of the machine varies as we vary the proportions.

How the Flux per Pole Depends on the Size of the Teeth.

The total flux per pole will be almost proportional to the width of the teeth. To fix our ideas we will take the flux density in the teeth at 21,000. Assuming one ventilating duct 0.8 centimetre wide for each 5 centimetres of iron, when the tooth is 1.1 centimetres wide and the slot 1.1 centimetres wide the ratio of (iron + air space) to iron space is 2.8, and at an actual flux-density of 21,000 the apparent density is 23,000. Dividing 23,000 by 2.8 we get 8,200 as the density in the air-gap when the 2.2 centimetres of space is divided equally between iron and slot. Above the point 1.5 centimetres, plot the point B = 8,200. There will be about 5,000 A.T. on the pole, so that even if there were no iron at all the flux density would not be zero. The normal air-gap of 0.5 centimetre would be increased to 4.5 centimetres, so that the flux density for no iron would be :—

$$\frac{5,000}{4.5 \times .8} = 1,400$$

Plot the point B = 1,400 above the abscissa 0.4. This is the case where the slot space completely eliminates the iron of the teeth.

Next take the case where there is no room for copper at all. The ratio of (iron + air) to iron is now 2.6×5.8 to 2.2×5 or 1.37, so that a density of 21,000 in the teeth will give 15,400 in the gap. Plot this point above 2.6.

The line marked flux density in Fig. 2 gives the density in the gap for any width of tooth. The voltage generated is proportional to the density in the gap. For the purpose of this example it is convenient to fix our ideas and work out the relation between flux density and voltage, though it will be seen later that this part of the calculation can be omitted in actual practice.

Let the speed be 600 r.p.m., the axial length of the armature 30 centimetres and the ratio of pole-arc to pole-pitch 0.7. Then, as there are 93 conductors per pole,

$$\text{volts} = 0.7 \times \frac{600}{60} \times 93 \times 30 \times 400 \times B \times 10^{-8}.$$

When B = 8,200, the volts = 640.

We can plot the line marked volts in Fig. 2.

We have taken the simple case where the tooth density is constant. Theoretically the density can be increased slightly as the teeth are made narrower.

How the Current Depends on the Copper Space.

Next we must see how the allowance of room for the copper affects the amount of current that the machine will deliver without overheating. Let us allow 15° C. difference of temperature between copper and iron and assume that the thickness of insulation is 0.13 centimetre, while the heat conductivity of the insulation is .0012 watt per square centimetre per degree difference of temperature. Then the heat flow (measured in watts) per square centimetre will be :—

$$15 \times .0012 \div 0.13$$
$$= 0.138 \text{ watt.}$$

One metre of coil will have an effective area of 800 square centimetres, so it can get rid of 110 watts. The I^2R loss in a metre length of coil ought not to exceed this. In practice there will be eddy currents in the conductors which will increase the losses, but the allowance of 15° C. rise above iron is so conservative that we may neglect these eddy current losses. They will, of course, take up the temperature to points higher than 15° C. above iron.

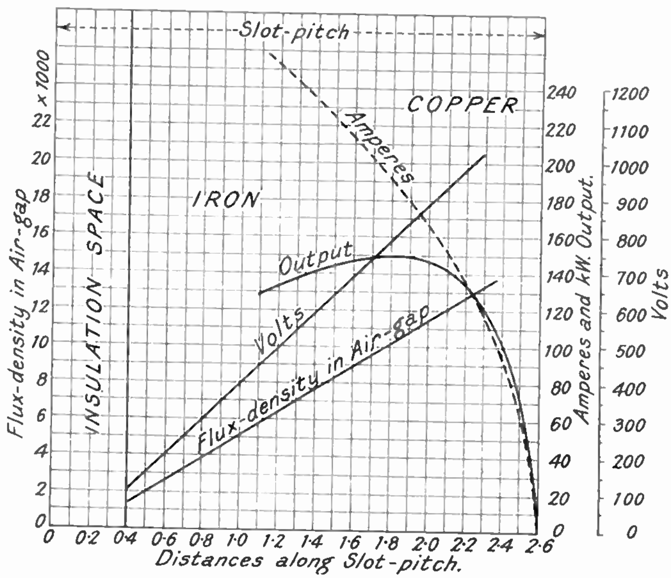


Fig. 2.—DIAGRAM FOR FINDING HOW THE OUTPUT OF A D.C. ARMATURE VARIES AS WE CHANGE THE RELATIVE SPACES FOR IRON AND COPPER, KEEPING THE INSULATION SPACE CONSTANT.

In the case where the tooth is 1.1 wide and the copper space 1.1 wide, the resistance of the six conductors (each 0.3675 × 1.5 centimetres) in one metre length of coil is 0.0022 ohm. The current I that can be permitted in this case is obtained from the equation :—

$$I^2 \times .0022 = 110$$
$$I = 224$$

The watts dissipated by one metre length of coil may be taken as approximately constant. It is true that when the copper strap is wider the surface of the coil is a little greater, but that fact is compensated for by the poorer heat conduction of the thinner teeth. So we may work out the currents that can be carried by various thicknesses of conductor on the assumption that the watts dissipated will be 110. Since the resistance of the strip varies inversely as the thickness and the watts vary as I^2R, an increase of the resistance to double will reduce the permissible current by the divisor 1.41 (the square root of 2). Applying this rule at various points along the abscissæ and plotting the permissible currents, we get the curve in Fig. 2 marked "Amperes."

How to Develop the Output Curve.

Multiplying the volts by the amperes for various proportions between iron and copper, we get the curve marked "output." The figures in the margin give output per pole. If the machine has 10 poles, we must multiply them by 10. Thus the maximum output is 1,500, at the abscissa reading 1.8. The copper space is here 0.8, making with the insulation a slot space of 1.2 centimetres. This leaves 1.4 centimetres for the width of the tooth.

It is very important to observe, however, that the output curve is fairly flat on the top. All the way between the abscissæ 1.4 and 2.05 the output is higher than 1,400. That is to say, with a tooth only 1 centimetre wide, leaving 1.2 centimetres for copper, we get the same output as if we make the tooth 1.65 wide and leave only 0.5 for copper. And note that over the whole of this range the output, while it is over 1,400 kW, is never more than 1,500.

Copper Space and Iron Space may be Widely Varied.

This illustrates a fact well known to designers of D.C. machines that the ratio of iron space to copper space may be varied over a fairly wide range without affecting much the output of the machine so long as we do not go to extremes. It will be seen that after the copper space has been narrowed to 0.4 centimetre the output drops rapidly, and, of course, if there is no copper there is no output. By reducing the teeth and making them narrower than 1 centimetre the output is also rapidly reduced ; but we cannot plot the curve for very narrow teeth without introducing a number of other considerations. When the teeth are very narrow the heat conductivity along them can no longer be relied upon to carry away the heat received from the copper. Moreover, the ventilation is bad. We have, therefore, not plotted the " amperes " curve beyond the 1.2 abscissa, where the tooth is only 0.8 centimetre wide.

End Connections.

The reader may raise the question: How about the end-connections in a D.C. armature ? Do not these also limit the output ? The answer is that with modern systems of ventilating the end-connections on D.C. generators the copper at these parts keeps cooler than the copper in the slots. There is no iron in their vicinity creating additional loss, and the air blows directly on the insulation of the coils, so that we may have a permissible difference of temperature of perhaps 45° C. between copper and iron instead of only 15° C. as we allowed in the above calculation. We may in most modern D.C. generators rely upon a good deal of the heat generated in the slots being conducted along the copper to the end-connectors. This still further increases the possible output.

Choice of Proportions.

When we realise that the proportions of copper to iron may be varied over fairly wide limits without greatly affecting the output, the question arises : Shall we make rather narrow slots and wide teeth or *vice versa*.

Twenty years ago, when iron was very cheap and copper dear, one could save quite a lot of money by making narrow slots and running the section of the copper down to a point corresponding to the abscissa 2.2 in Fig. 2. This did not make an efficient machine. It had a high iron loss and a fairly high copper loss (considering the current output). The copper was worked at a higher current density than would be permissible in an ordinary machine, so that the I^2R losses were high. Even in these days when iron is not so cheap and copper is cheaper than it was 20 years ago, we may make a fairly cheap machine by keeping down the weight of copper ; but the saving is not worth while when the loss of efficiency is taken into account. Machines with almost equal slot and tooth spaces are made by nearly all makers, though there is a tendency to make the tooth rather greater than the slot.

If we wish to build a machine which will give a very high all round efficiency when running at varying loads (often running light), we should cut down the teeth and put in more copper.

Consider two machines. One has a slot 1 centimetre wide, there being three straps side by side each 0.2 centimetre wide, and the other has a slot 1.4 centimetres wide with four straps side by side each 0.25 wide. The iron loss of the second machine is reduced in a rather greater ratio than 4 to 3 for the same voltage generated, while the copper loss at full load is only increased 6 per cent. Now if the machine is running light a good part of the day with very little copper loss, the second design is greatly to be preferred.

The Installation and Operation of Induction Motors

DURING recent years there has been an increased demand for A.C. motors of the induction type, and in the following article are explained many interesting points which have to be considered when installing and putting these machines into operation, with a view to helping the engineer engaged on work of this nature. Some of the information will perhaps appear rather elementary, but nevertheless all the details should be carefully observed, and are particularly useful to engineers at works which are changing over to A.C. supply.

The Location of an Induction Motor.

The location of the motor is a primary consideration, as it is essential that it be placed where it is readily accessible for inspection, cleaning, oiling or repairs. Unless it is a totally enclosed machine, every precaution has to be taken to prevent it being exposed to moisture, dirt or coal dust. Adequate ventilation must be provided, and the motor should be mounted so that there is sufficient distance between its pulley and the pulley on the machine which it is driving to permit the belt to drive efficiently and without excessive tension.

Foundations to be Used.

The best foundation for the motor is concrete, as this is sufficiently heavy to obviate the risk of vibration when the motor is running. The driving motor should be set in its foundation in such a position to the machine which it is driving to ensure that the two shafts are parallel. This is so that the rotor of the induction motor will float in its bearings.

Precautions to be Taken When Lining Up a Belted Induction Motor With the Driven Pulley.

It is important that the position of the motor with respect to the driven machine should be arranged so that the belt is tight enough to run without slipping, but not too tight so that the bearings become overheated. In order to prevent the belt from wobbling, the crowns of the two pulleys should be as nearly similar as possible, with the largest diameter in the centre, so that the belt will travel true and allow the rotor shaft to float. All dirt and grease must be

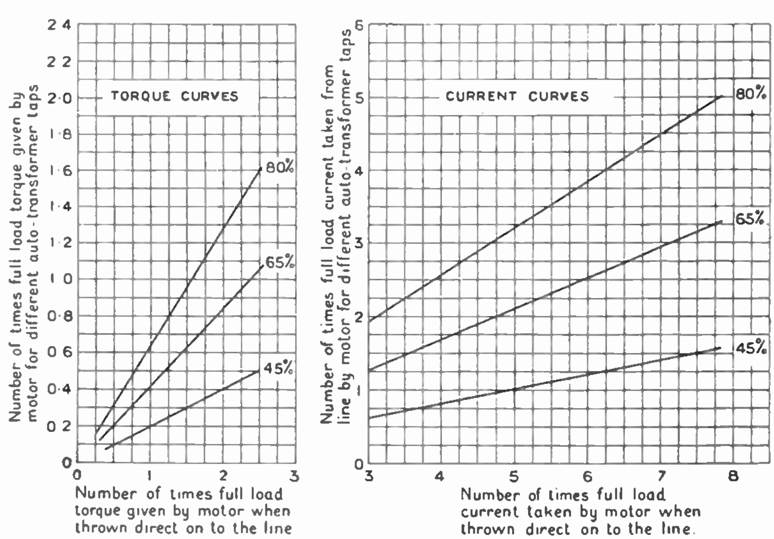


Fig. 1.—INDICATING THE RELATION BETWEEN THE "PERCENTAGE" TAPS, STARTING CURRENT AND TORQUE.

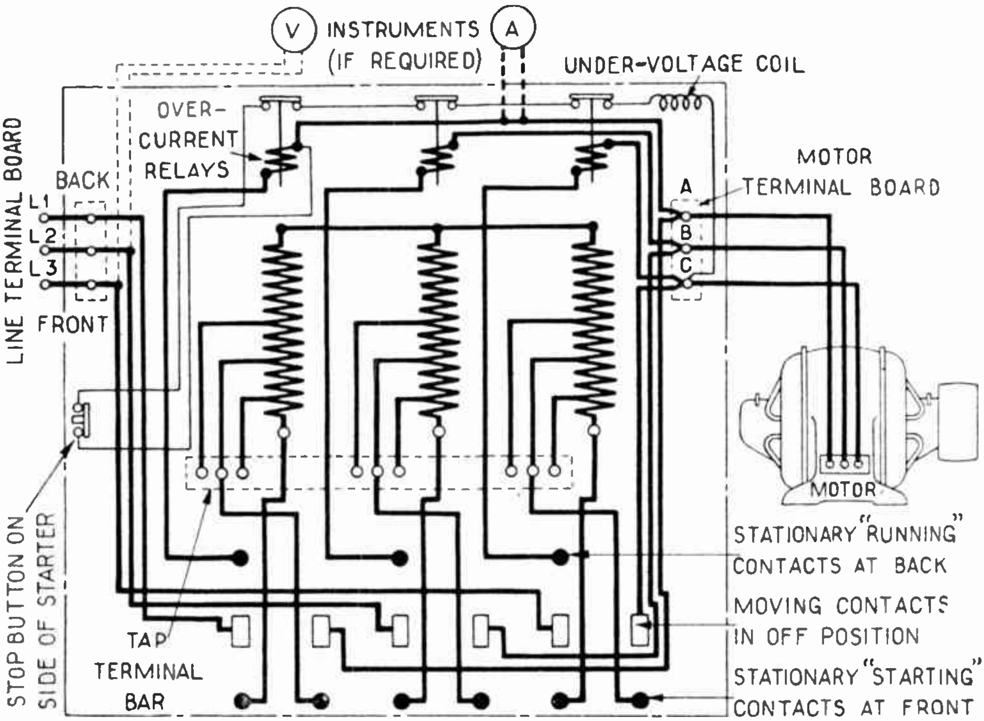


Fig. 2.—A Typical Diagram of Connections for Operating an Induction Motor with Auto-transformer Starter.

wiped off the belt to prevent it slipping, and it should stretch equally so that there is no sidewise movement of the belt on the pulleys.

Precautions When Aligning a Direct and a Geared Motor.

When a motor is to be direct connected to the machine which it is intended to drive, the shafts of the two machines must be in perfect alignment. Every precaution should be taken to ensure that the alignment is maintained, and the foundation of each machine should be such that there is no fear of vibration.

Where a motor is to be geared to its load, the shafts must be adjusted to absolute parallelism, and set the required distance apart. Although the pinion should fit securely on the shaft of the motor it should not be so tight that it can only be forced off when undue pressure is brought to bear. If heavy blows or great pressure are required to drive on the pinion it is likely that the rotor conductors will be moved out of place and damaged.

Size and Capacity of Conductors and Fuses.

Of course, the size of conductor to be used is determined by the amount of current the motor takes, this being stamped on the name-plate in most cases. The conductors and fuses for ordinary service should have a capacity $1\frac{1}{2}$ times the full load, but wherever there are heavy starting conditions the capacity of the fuses should be $2\frac{1}{2}$ times the full-load current.

Operation.

The starting conditions of different induction motors vary widely. Some start with full-load current and full-load torque, while others, operating under similar conditions, require over twice their full load current in starting. Single-phase induction motors start with a lower torque and higher current than 2-phase and 3-phase induction motors.

The starting of a squirrel-cage induction motor by switching directly on the line is liable to disturb the voltage regulation of the A.C. system, since it involves a heavy starting current amounting to from four to seven times full-load current.

It is necessary, therefore, to employ an auto-transformer, so that a reduced voltage is applied to the motor during starting, the current drawn from the line, and the starting torque of the motor, being reduced as the square of the reduction of voltage.

When supplying an auto-transformer, manufacturers usually provide the customer with a wiring diagram and also instructions regarding transformer tapping connections.

Transformer Tappings.

In Fig. 1 are shown curves indicating the relation between the "percentage" taps, starting current and torque. By means of the curves and the following table of starting current taken, and torque given, by induction motors when connected direct to the line, it is possible to find approximately the current taken from the line and the starting torque given by a motor using any of the taps provided on a typical auto-transformer.

In the following are given examples of how to find the current taken, and torque exerted at starting, by a 40 h.p. motor, when using a 45 per cent. transformer tap.

To Find Current.

From the table of mean starting currents and torques a 40 h.p. motor is found to take, when thrown direct on to the line, a maximum starting current of 5½ times that of full load. Look up the point on the horizontal scale having the value of "5.5" and from thence follow a vertical line to a point on the 45 per cent. tap curve, then a horizontal line produced from this point on to the left-hand vertical scale gives the required value in terms of "number of times full-load current" (in this case 1.1 times full load current).

Conversely, it is possible by means of the curves to find which transformer tap should be used, in order that a fixed limit for the starting current shall not be exceeded.

To Find Torque.

From the table previously referred to, a 40 h.p. motor gives, when thrown direct on to the line, a minimum starting torque of 1.25 times that at full load. Look up the point on the horizontal scale having the value "1.25" and from thence follow a vertical line to a point on the 45 per cent. tap curve, then a horizontal line produced from this point on to the left-hand vertical scale gives the required value in terms of "number of times full load torque" (in this case 0.25 times full load torque).

Starting the Motor.

To start the motor the starting handle must be pushed backwards into the "starting" position, thus connecting the transformer windings to the supply, and the motor across a portion of the transformer windings, as determined by the tap selected. The starter handle must be held in this position until the motor is up to speed, or the strong spring will bring the handle back to the "off" position, thus necessitating a fresh start.

H.P. Rating of Motor.	Approx. max. starting current taken by Motor when thrown direct on the line.	Approx. min. starting torque exerted by Motor when thrown direct on to the line.
0.5 to 1	4.5 times full load current ..	1.0 times full load torque.
2 ,, 5	5.5 ,, ,, ,, ,, ..	1.25 ,, ,, ,, ,,
6 ,, 10	5.5 ,, ,, ,, ,, ..	1.25 ,, ,, ,, ,,
11 ,, 20	5.5 ,, ,, ,, ,, ..	1.5 ,, ,, ,, ,,
21 ,, 40	5.5 ,, ,, ,, ,, ..	1.25 ,, ,, ,, ,,
41 ,, 100	6.0 ,, ,, ,, ,, ..	1.0 ,, ,, ,, ,,
100 ,, 150	6.0 ,, ,, ,, ,, ..	0.66 ,, ,, ,, ,,
151 ,, 300	6.5 ,, ,, ,, ,, ..	0.66 ,, ,, ,, ,,

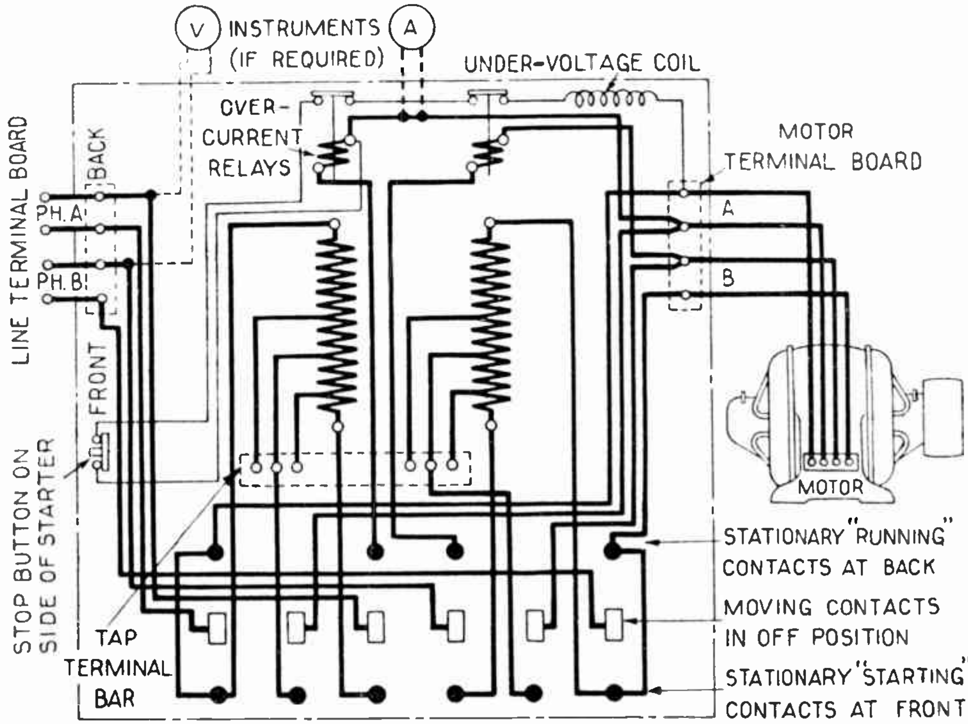


Fig. 3.—Typical Diagram of Connections of Two-phase, Four-wire Auto-transformer Starter.

When the motor is up to speed, the "starting" handle must be pulled rapidly forward through the "off" position to the "running" position; this cuts out the transformer winding and connects the motor direct to the supply through over-current relays (if supplied).

Fig. 2 is a typical diagram of connections for starting an induction motor by means of an auto-transformer starter, while Fig. 3 shows a diagram of connections of a 2-phase, 4-wire auto-transformer starter.

The operator should remember that under no circumstances should the motor be started by "inching," that is by throwing the starting handle a number of times into the "starting" position. This does not reduce the starting current, but on the contrary, it causes a number of successive high-current peaks, leading inevitably to severe burning of the contacts and overheating of the transformer windings.

Protective Devices.

In many cases where auto-transformer starters are used, over-current relays are fitted, and when the current taken by the motor exceeds the value for which the over-current relays have been previously set, the latter operate—after a time delay—and interrupt the circuit of the under-voltage coil, this causing the motor to be shut down.

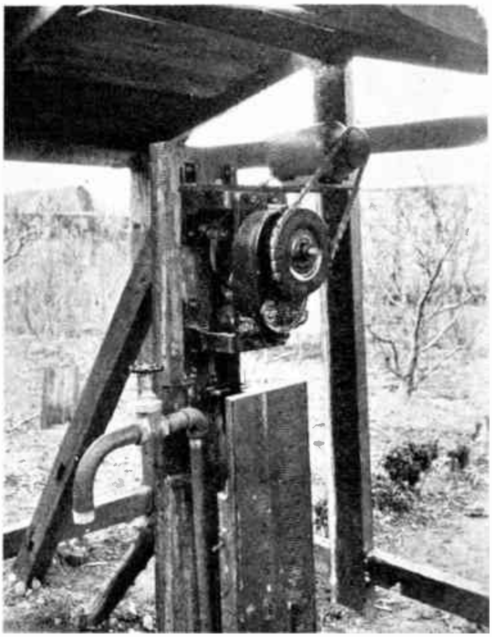
In the event of the voltage failing, or being considerably reduced in value, the under-voltage release causes the starter to return to the "off" position.

Shutting Down the Motor.

All that is necessary to stop the motor is to press the button on the side of the switch box (see Figs. 2 and 3). This interrupts the circuit of the under-voltage release, and shuts down the motor. In this position both motor and transformer windings are entirely disconnected from the line.

An Electrified Pump

The Pump Before Conversion to Electric Operation. (*B.T.H.*)



Showing How the Electric Motor Was Fitted. (*B.T.H.*)

AN interesting conversion to electric operation was carried out recently near Wrexham, in connection with a manually operated water pump.

The pump, which was of the old-fashioned type, as will be seen from the first illustration, stands in the garden of what was once a country house, about a mile from Wrexham. The stables of the house have now been converted, and are used by a wholesale and retail butcher for the making of pork pies, sausages, etc. The business required a refrigerator, and, of course, a considerable water supply, and it was decided that instead of purchasing water from the town, the well on the premises should be used efficiently by converting the pump to electric drive, and arranging for a supply of electricity, which comes overhead for about a quarter of a mile from the Wrexham mains.

Water Supply Automatically Controlled.

The water supply for the refrigerator is controlled automatically, according to the temperature of the atmosphere, from a tank and in turn the water supply to the tank from the pump is controlled by a contactor starter and float switch.

The pump, when operated by hand at the normal rate, had a capacity of about six gallons per minute, the surface of the water being about 36 ft. below ground level. It was impossible to mount the pump down in the well, so it was decided to make use of the existing pump barrel, which is fixed at the water level. A pumping equipment, manufactured by Messrs. Abell & Smith, and driven by a B.T.H. 1 h.p. motor, was then installed by Messrs. E. N. Jones, electrical contractors, of Wrexham.

This converted pump, which is shown in Fig. 2, is giving most successful service.

The motor is a B.T.H. 3-phase, 400-volt, 50-cycle machine running at 1,420 r.p.m., and is controlled by a B.T.H. contactor starter operated by a float switch.

Developments in Luminous Signalling Systems

By S. W. Richards, M.E.

In this article Mr. Richards, who is an acknowledged authority on the subject, gives a most interesting survey of present-day practice. This is a most valuable article for electrical installation engineers, workshop engineers and engineers responsible for the maintenance of electrical equipment of hotels, theatres, hospitals and other large buildings

THE advantages of luminous signalling over the ordinary mechanical replacement and pendulum type of indicators are generally known and appreciated.

The possibilities of luminous signalling are infinite and particularly varied, and it is the purpose of this article to describe some of the most recent developments in this direction.

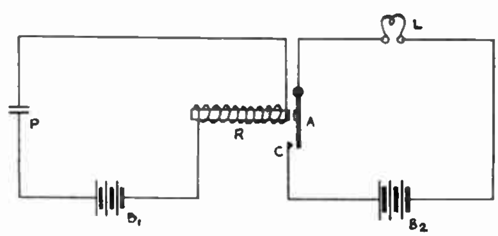


Fig. 1.—The Simplest Application of a Luminous Signalling System.
A circuit is given by pressing the push P, which closes the circuit of the battery B1, around the electro-magnetic relay R, which then attracts armature A, causing contact to be made at C. This closes the lamp circuit from battery B and lamp L is illuminated while push P is held closed.

Basic Operation of a Luminous Signalling System.

First, we must understand the basic operation of such a system and in Fig. 1 is shown the simplest application of same, shown schematically.

A signal is given by pressing the push P which closes the circuit of the Battery B1, around the electro-magnetic relay R. This magnetises the relay which attracts armature A and contact is made at contact C. This closes the lamp circuit from battery B and lamp L is illuminated while push P is held closed. When push is released, the relay is demagnetised and the armature falls back. It is only a logical step to arrange for a small spring catch to hold armature A in position when it is attracted by the relay and thus keep the lamp lit even when the push is released. The lamp can be extinguished and the relay reset by releasing such a catch with a lever or push. This would be called a locking or resetting relay. This gives us the basic idea of a luminous call, but generally an audible call is required in addition. If such audible call is desired to operate continuously, it would be a simple matter to connect a bell or buzzer in parallel with the lamp so that the relay would close both the bell and lamp circuits.

Lamp Remains Lit Until Reset.

Usually, however, the bell is only required to ring during the time the push is depressed, while the lamp should remain lit until reset.

This is usually performed as shown in Fig. 2. Here we see the same circuit as regards the push operation, but we have

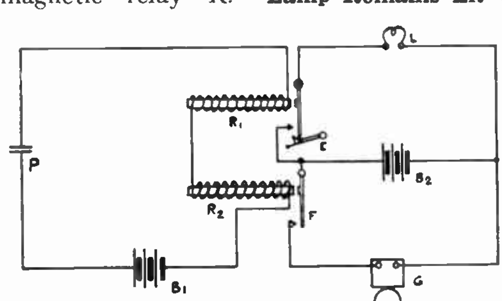


Fig. 2.—A Slightly More Elaborate Circuit.
This enables the bell to be rung only while the push is depressed, but the lamp remains lit until reset.

two relays in series, R1 being a locking relay and R2 being a non-locking relay. When the push is pressed, both the relays are energised, relay R1 attracting armature which lights the lamp and R2 the armature which closes the contacts of a bell G. The armature of R1 being locked by the trigger E remains in contact after the push is released, but the armature of R2 is released and the bell is silent.

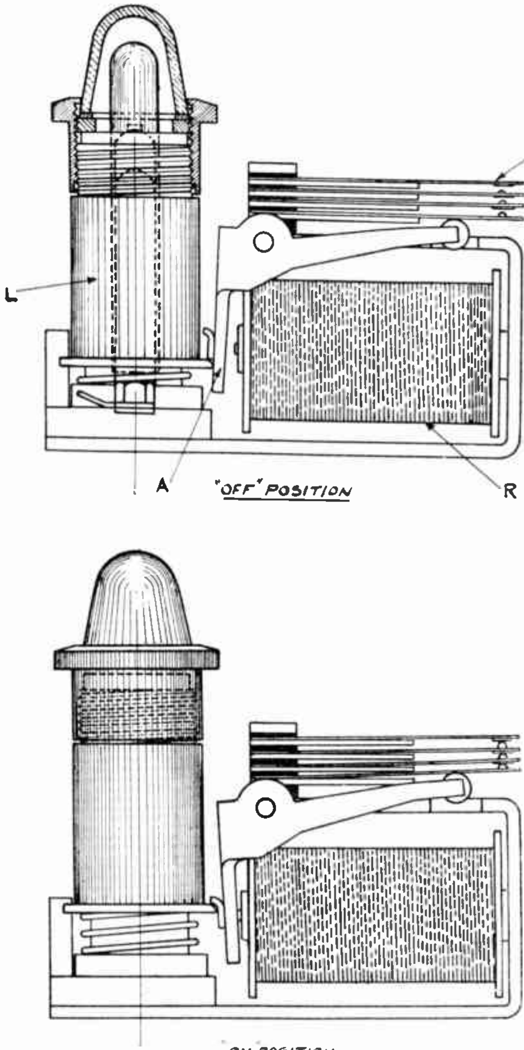


Fig. 3.—THE PUSH LAMP SYSTEM UNIT.
Showing the relay coil R which attracts the armature A. When the armature is attracted it closes the bank of contacts C.

This then, represents the basic principle of luminous signalling.

The Resetting Medium.

Modifications and conditions require the relays, bells and pushes to be in various positions, but the usual practice in luminous signalling systems is for the resetting medium to be near the point of call; for instance, in hotel, hospital or ship installations, it is usual to have same mounted outside or inside the door of room where the push is fitted. The bell or buzzer obviously is fitted in the service room and also the source of the current. It follows also that as there must be a great number of calling points operating on the same bell, that the relay controlling the bell should also be in the servery. The signal light should be placed at a convenient spot near the point of call, usually in the form of an overdoor lamp, and sometimes this is duplicated in the service room.

Earlier types of apparatus consisted of the overdoor lamp and a push button resetting relay fitted alongside the door, but the most recent development is to mount an indicating lamp inside the resetting button.

The Push Lamp System.

This is done in the push lamp system and a drawing of the unit is shown in Fig. 3.

Here will be seen the relay coil R which attracts armature A. This armature when attracted closes the bank of contacts C. Immediately the armature is attracted to the relay coil, it releases the spring loaded lamp tube L which locks the armature in position. Inside the lamp tube is fitted a small telephone lamp of the tubular type. One terminal of this lamp is continuously connected to one pole of the supply system; the other terminal of the lamp is connected to the second spring of the contact bank. The lowest spring is connected to the remaining pole of the supply so that when the relay is energised, the lamp is lit.

Pressure upon the lamp cap releases the armature and so extinguishes the light. The remaining springs are connected to the group or section lights and function in the same manner.

Some Applications of the Push Lamp System.

Having described the general principle and the unit which is the base of this system, we will consider some applications of same.

Four Calling Points.

Fig. 4 shows one system where four calling points desire to call to a centre point, the calls being audible as well as visual.

Here we see the supply wires connected to the central station indicator, the positive wire being connected to the bottom springs of each push lamp and also commoned to each of the calling pushes. The other side of the calling pushes are each connected to the relay coils of their respective push lamp. The other terminals of the coils are connected in common and then connected to one terminal of the bell relay, the remaining terminal of this relay being connected to the negative terminal of the supply.

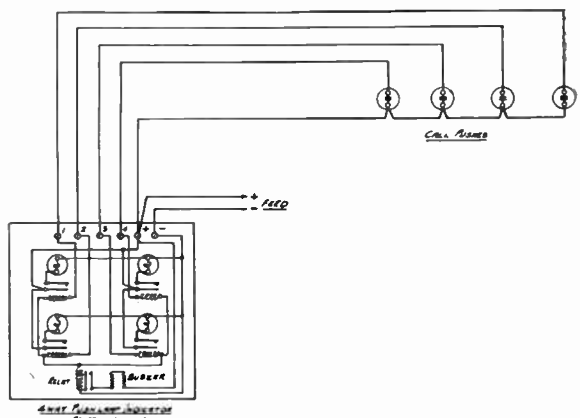


Fig. 4.—Diagram of a System where Four Calling Points Desire to Call from a Centre Point, the Calls being Audible as well as Visual.

It will easily be traced how this system functions, the respective push lamp being locked up by a call and the buzzer simply sounding during the time the push is depressed.

Ten-way Indicator.

Fig. 5 shows an elaboration of the above system. Here we have a ten-way indicator at a central station, on which five ways are shown schematically. Ten special call pushes are supplied, each fitted with one push and a pilot lamp. In this system we see that the relays are energised in the same manner as formerly, saving that no audible call is given in this instance. When the relay is set up, however, it lights both its own lamp and the pilot lamp on its corresponding push, which is shown connected to one of the springs of the relay. This system fulfils a dual purpose—it gives an indication of a call at central station ; it also gives to the caller an indication that his call has been registered and also when the person at the central station cancels the call by pressing the push lamp, indicates to the caller that his call is being attended to.

Four-way Indicator in an Outside Office.

In the foregoing systems, calls are made to a central station and the next system, Fig. 6, shows a system where a central station such as a manager's room calls out to a four-way indicator in an outside office ; a logical elaboration of this system would be to have four single-way indicators fitted with lamp and buzzer at four different positions.

Referring to the diagram, we see a four-way call unit fitted with four pushes, P.U.C.V. and also four push lamp units.

Outside we have a four-way wall indicator, fitted with four pilot lamps and buzzer.

What Happens When the Push is Pressed.

Upon the manager calling any person, he presses the corresponding push which puts up his own corresponding push lamp. This lights up the pilot lamp on the indicator relating to the person called and the buzzer is sounded during the time the push is depressed. In this instance, the bell relay is unnecessary as the distance is usually short, the buzzer coils functioning

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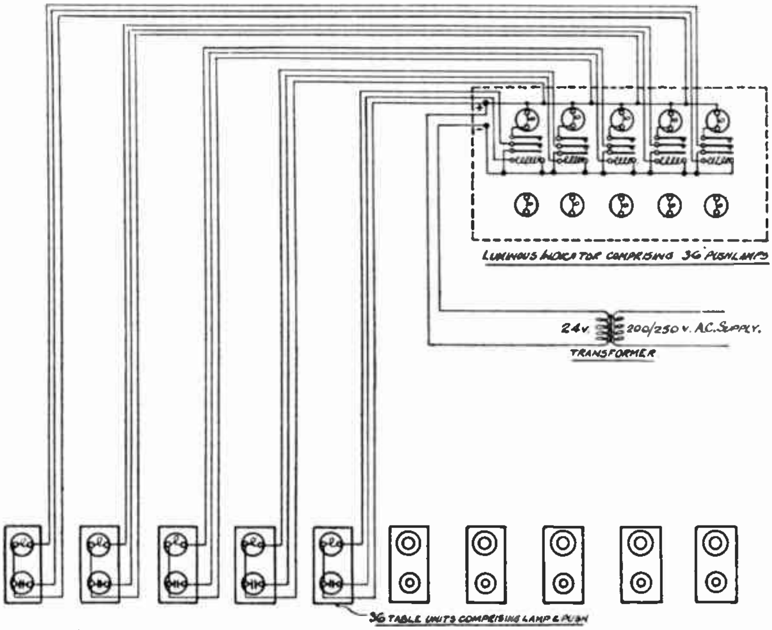


Fig. 5.—AN ELABORATION OF THE SYSTEM SHOWN IN FIG. 4. This is a 10-way indicator at a central station on which five ways are shown schematically. Ten special call pushes are supplied, each fitted with one push and a pilot lamp.

in the same manner as the bell relay in previous systems.

One advantage of this system is that if the person called is absent from his room, the manager can cancel the call.

A Modification of this System.

A modification of the above system is shown in Fig. 7, where the manager again calls out to members of the staff.

In this case, the push lamp resetting units are placed with the staff, usually in the form of desk units. The manager is supplied with a desk unit consisting of a multi-push board with a corresponding number of pilot lamps. When he calls out to a member of the staff he sounds the buzzer at the member's desk unit and puts up the push lamp unit there. This lights his own pilot lamp which shows him that the call has been given. Upon receiving the call, the person called presses the lamp cap and extinguishes both his own and the manager's pilot lamp, indicating to the manager that his call has been received.

One slight drawback to this system is that if the person is not in his room, the light remains up until cancelled by someone going to his room.

This, however, may be advantageous in another way, as it would show the person when returning to his room that a call had been made.

To get over the above difficulties, a system has been devised and patented where the call can be cancelled from either end. This dual-control system has the advantage that it notifies the caller when the call is answered, and allows the caller to cancel his call. This is described

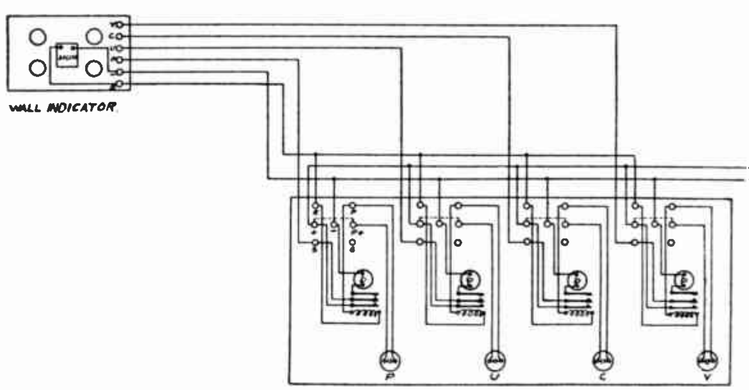


Fig. 6.—ANOTHER TYPE OF SYSTEM IN WHICH CALLS ARE MADE A TO CENTRAL STATION.

later. This improved system can of course be used in a variety of ways and to conform with varying conditions.

Application of Push Lamp Units for a Hospital Call.

Fig. 8 shows an application of push lamp units for a hospital call and the diagram shows a room in two sections with their attendant overdoor fitting and also the connections to the common servery or rooms.

It will be seen on this schematic drawing that a three-way system is used, but only two, viz.: the Maid and Nurse calls, are taken along to the serving rooms. The remaining call is an Engaged call and only operates on the local lamp in the resetting unit and the red lamp in the overdoor unit.

The calling unit consists of a two-way push with an additional switch attachment.

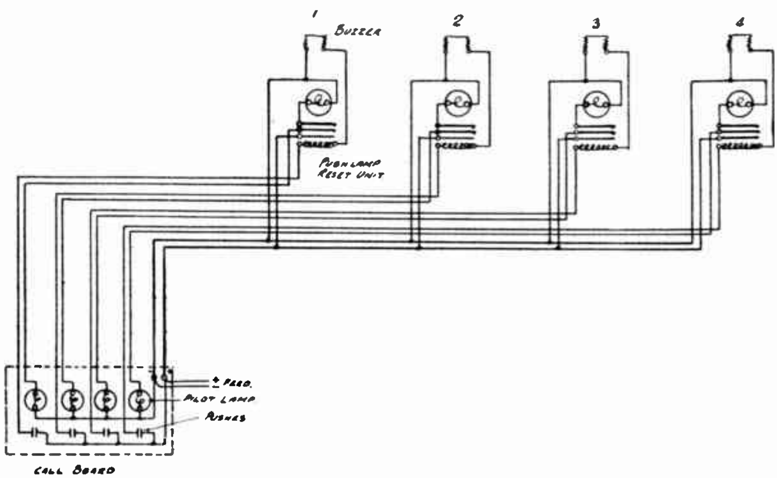


Fig. 7.—A Modification of the System shown in Fig. 6.
The push lamp resetting units are placed with the staff, usually in the form of desk units.

What Happens When a Call is Made.

Following the diagram, we see that if a call is made for Maid or Nurse the reset unit is energised and also the bell relay in the serving room, calling either the Maid or Nurse. Simultaneously, both the push lamp and the coloured lamp in the serving room are put up, together with the coloured lamp in the overdoor unit.

In this case, red was used for the "Engaged" signal, green for the "Maid" and amber for the "Nurse." When the attendant answered the call, she would press the corresponding push lamp cap and cancel the call, extinguishing all the lamps.

With regard to this, if another call is already up in the same section, she would only cancel the push lamp and overdoor lamp; the section lamp would remain up until all the calls were cancelled in the section.

The overdoor "Engaged" lamp is put up by operating the switch provided on the push unit. The push lamp unit is fixed inside the room to indicate to the patient that he had given a call.

A Master Indicator.

It might be desired that the matron or someone in authority should have evidence of a call having been made and to check the time such call would remain unanswered.

This is arranged by means of the addition to the system as shown in Fig. 9.

Here we see the system as Fig. 8, but with each push lamp unit connected to a master indicator. This indicator is fitted with pilot lights which are controlled in a similar manner to the section or servery lights, i.e., they would remain alight until all units in the section had been reset.

"Engaged" and "Enter" System.

Another feature of luminous signalling which has been recently developed is the "Engaged" and "Enter" system.

In this system—illustration of which is

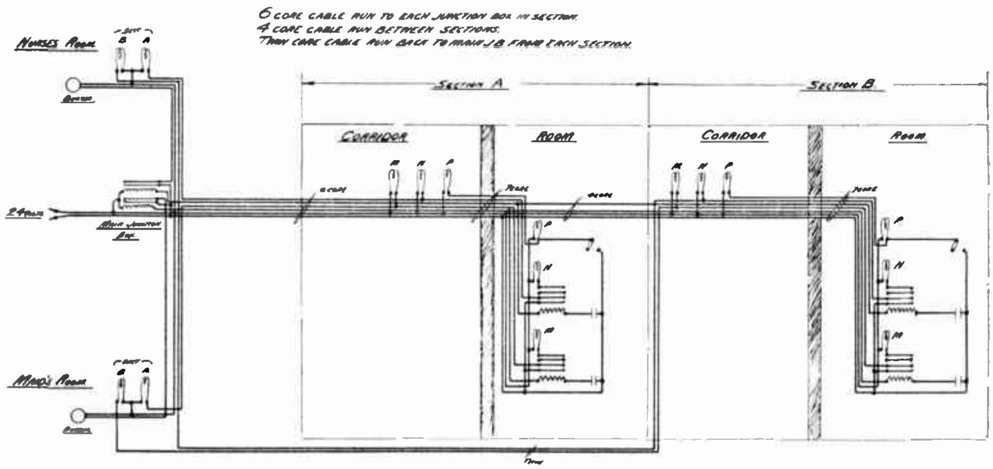


Fig. 8.—AN APPLICATION OF PUSH LAMP UNITS FOR A HOSPITAL CALL.
Showing a room in two sections with their attendant overdoor fitting and also the connections to the common servery or rooms.

given in Fig. 10, a luminous indicator consisting of a small box with the words "Engaged" and "Enter" written in ground glass screens is fitted outside the room door, either flush or surface fitting. This is connected to a call unit placed upon the desk of the person within the room.

In the schematic diagram, the lever is shown beneath the essential contact springs and magnet.

When the lever is depressed, it closes two contacts and these energise the electro-magnet through the pilot light on the indicator and the "Engaged" light outside the door. By the depression of the lever, the armature on the end of the lever is brought up to the pole piece of the electro-magnet which, being magnetised, holds it in the "On" position.

The magnet coils, however, are supported on a flexible support, so that by a further pressure on the lever, the magnet coils allow a further travel of the lever. This enables the lever to break the contact A, extinguishing the "Engaged" lamp and

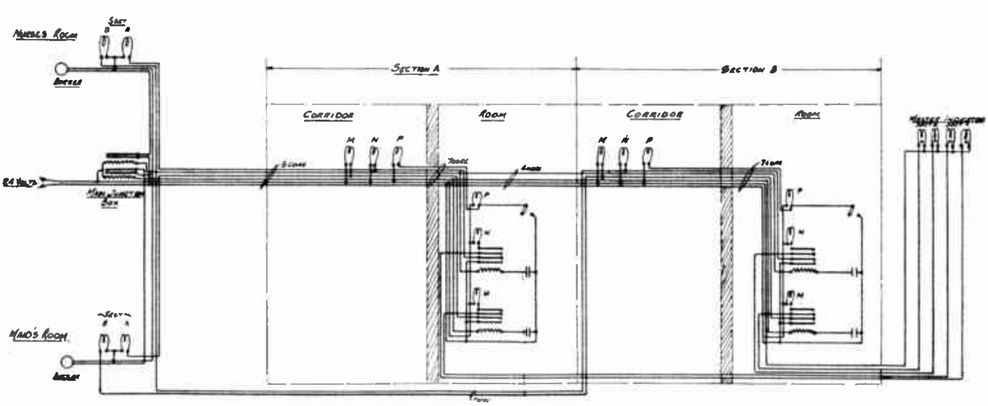


Fig. 9.—HOW A MASTER INDICATOR CAN BE ADDED TO THE CIRCUIT SHOWN IN FIG. 8
Each push lamp unit is connected to a master indicator.

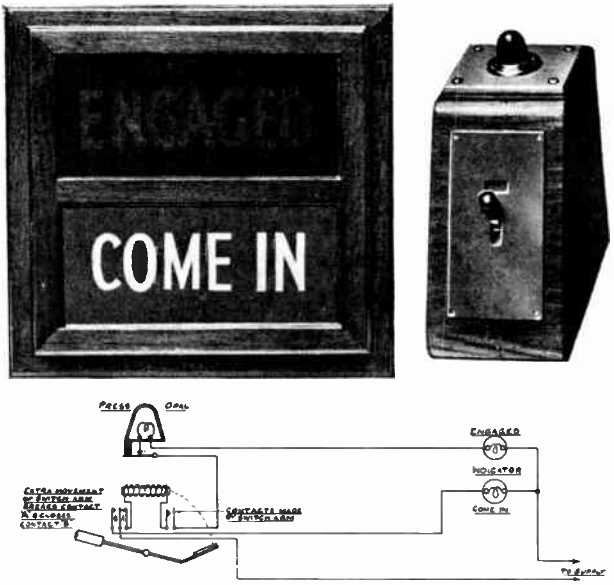


Fig. 10.—The "Engaged" and "Enter" System. Showing the luminous indicator box, the call unit and the circuit used.

puts up the "Come in" signal. Upon releasing the lever, it automatically falls back into the "Engaged" position.

If this is required to be cancelled, mere pressure on the lamp cap accomplishes this by breaking the holding current of the magnet. This system has been patented and is now on the market.

DUAL-CONTROL SYSTEM.

Fig. 11, shows another application of luminous signalling, previously referred to where a call set up can be cancelled at either end. The calling unit is generally the same as in Fig. 10, save that one contact is done away with and also the pilot lamp. The position of the lever gives evidence of a call having been put up.

As will be seen, pressure upon the lamp cap of the called unit will cancel the call by demagnetising the calling unit.

SOURCE OF SUPPLY FOR OPERATING LUMINOUS SYSTEMS.

Luminous systems can be operated from various sources of power, primary and secondary batteries and also transformers.

The decisive factor to determine the type of supply, naturally, is the probable amount of current which will be needed, and in this direction perhaps a few practical observations would be in place.

Leclanche Cells and Secondary Accumulators.

The usual pressure of the supply is 24 volts and this can be supplied by batteries of sac type Leclanche cells for small systems, or secondary accumulators for larger systems; while for a very large system, even a motor generator or rotary converter is necessary.

Transformers for A.C. Supply.

Transformers of various ratings will also supply the current where A.C. is not disadvantageous. In connection with the latter type of current, it is sometimes practically impossible to eliminate hum or chatter on the relays. In order to overcome this disadvantage, rectifiers are

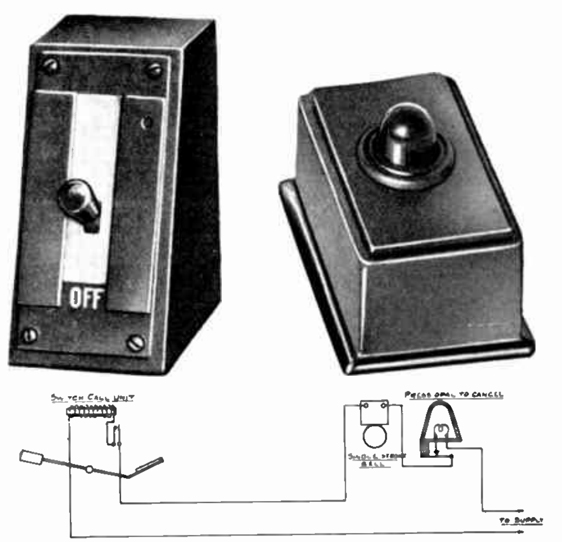


Fig. 11.—Another Application of Luminous Signalling where a Call Set Up can be Cancelled at Either End.

often used, but the inherent disadvantage of a rectifier is its fluctuating voltage under a variable load.

This is not particularly disturbing where relays and bells only are used in a system, but where luminous signals are used, a fluctuating voltage obviously means either a lack of luminosity at one end of the fluctuation, or burnt out lamps at the other end. This can be overcome by using a very much larger unit than what normally would be necessary—the fluctuation factor would thus be very much less, with the normal load.

To explain this, a rectifier unit which would give 24 volts with a load of 3 amps., might easily give 32 volts on open circuit or 29 to 30 volts on .25 amp. Whereas, if we were to have a rectifier to give us 24 volts at .25 amp., there would be a considerable drop to approximately 16—17 volts at 3 amps. and a maintained load at this current would seriously overload the unit. If, however, we obtain a unit capable of giving 5 to 6 amperes at 24 volts, the ratio of voltage increase when using .25 amp. is not so considerable, but, naturally, such a unit would be considerably more expensive than the former.

How to Estimate and Determine Source of Supply.

To estimate and decide upon our source of supply, we must ascertain the probable consumption, and for this, we require to know the approximate current of lamps, relays and bells in the circuit.

Adopting the voltage of 24 volts as standard, we can assume the following currents as being fairly approximate.

The small telephone tubular lamps in the units consume .1 amp. while the festoon bulbs often used in indicators and overdoor lamps take .25 amp. The relays usually require 15 to 20 milliamperes and small indicator and extension bells take approximately .15 to .2 amp.

Assessing Total Current Required.

To assess the current required, it is unnecessary to sum up the total possible current required and act upon this ; it is usually sufficient to assume that in normal installations, one-sixth to one-eigth of the total current may be required at any instant.

A.C. or D.C. Compared.

In comparing A.C. and D.C., the lamps act in a similar manner with the two types as respecting current consumption, but in the case of relays and bells, the resistance of the windings enters very seriously into the calculations. It can always be assumed that relays and bells require a very much greater resistance when operating with D.C. of the same voltage as A.C.

As a concrete example, if we take the push lamp unit referred to earlier in this article—if this unit is used on 24 volts D.C., the resistance is 150 ohms, while if used on 24 volts A.C., the resistance has to be reduced to 12 ohms.

This is, of course, due to the very much increased impedance of an inductive winding, where used on A.C. working.

A NEW THREE-IN-ONE VALVE

One of the most interesting of the new types of valve produced recently is the Mullard double-diode-triode, Type T.D.D.4.

In the double-diode-triode, the two duties of the valve—detection and amplification—are carried out by separate sets of electrodes. The T.D.D.4 consists of two small diodes (or two-electrode valves) and one triode (or three-electrode valve) contained in one bulb, the only element common to all three sections being the cathode.

One method of using the T.D.D.4 is to employ both diode portions for full-wave rectification, the output of this section of the valve being then passed to the grid of the triode portion for low frequency amplification prior to the output stage.

This valve also enables a more perfect form of volume control to be applied, namely that which is known as amplified and delayed control.

Practical Notes on Regulations for the Electrical Equipment of Buildings (I.E.E. Wiring Rules)

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

THE regulations dealt with in this article concern some important subjects, namely, incandescent lamps, the control of motors, etc., and the testing of complete installations.

TEST TO EARTH ON A HOUSE INSTALLATION.
The Regulations which cover this important branch of electrical installation engineers' work are dealt with in this article.

(Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication "How to Avoid Electrical Breakdowns.")

Incandescent Lamps.

Regulation 113 :—

A. Incandescent lamps shall be provided with caps of a pattern as follows :—

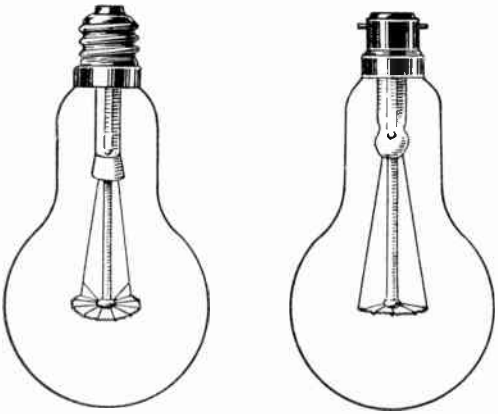
Up to and including 100 *watts: Standard Bayonet (B.C.).*

Above 100 *watts and not exceeding* 200 *watts: Edison Screw (E.S.).*

Above 200 *watts: Goliath (G.E.S.).*

Sub-sections (B) and (C) do not really concern us, but Sub-section (D) states: "Fittings for lamps shall be so designed as to provide for adequate dissipation of heat from such lamps." Both Sub-sections (A) and (D) require some comment. We have it quite definitely here, in black and white, that above 100 watts and not exceeding 200 watts Edison screw-holders and caps shall be used. In point of fact, most manufacturers manufacture lamps with B.C. caps up to 150 watts, and, personally, I have not found them give any trouble. It is probable that when a revision of these Regulations is published, definite permission for B.C. caps for 150-watt lamps will be given. At present, however, such a practice is, strictly speaking, against the Regulations. It may, however, be worth noting that the reason for this Regulation is that the bayonet cap and holder, while providing an adequate contact for small current, is, after all, dependent entirely on the spring plunger pressing against the fairly uneven surface of soldered terminals on the lamp cap, and this is not a first-class contact where heavy current has to be carried.

With regard to Sub-section (D) the electrician may occasionally find himself placing in an existing fitting a lamp of a higher wattage than that for which the



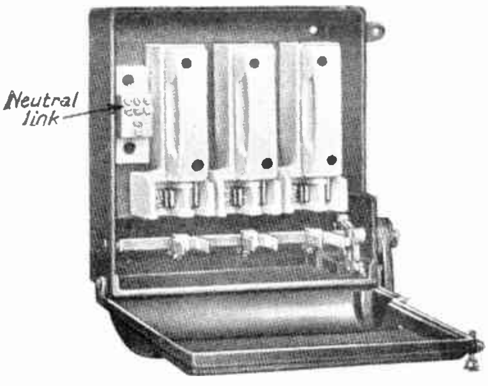
Screw and Bayonet Cap Lamps.

fitting was originally designed. Very often this cannot be helped, and although it is not a very efficient practice it sometimes solves one's immediate difficulties. Nevertheless, it must be remembered that a larger lamp gives off more heat, so that a fitting designed to provide for "adequate dissipation," say, from a 60-watt lamp, will not necessarily dissipate the heat in an adequate manner from a 100-watt lamp. In the case of metal reflector fittings this difficulty may sometimes be overcome by drilling extra holes in the tops of the fittings.

Concerning Arc Lamps.

Regulation 115 deals with arc lamps and states :—

A. Arc lamps shall have the whole of



Example of Three-phase Ironclad Switch with Neutral Link. (*G.E.C.*)

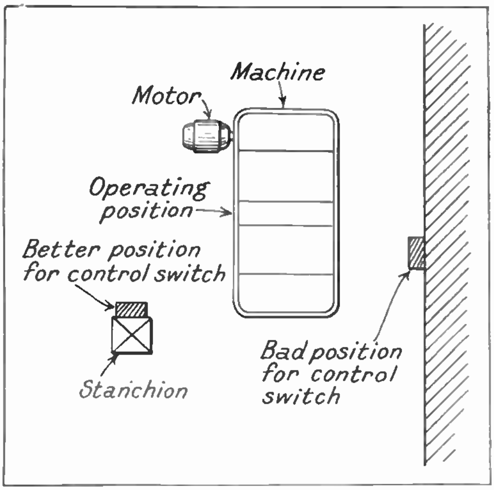
their live parts insulated from the frame or case.

B. Needs no comment.

C. In situations in which an open arc is essential, as in photographic work, the floor immediately underneath the lamp shall, if necessary, be protected from falling particles of carbon by a non-ignitable covering.

F. Every arc lamp circuit shall be controlled by a fuse and switch on each insulated pole. When more than one pole is insulated the switches shall be linked.

To all intents and purposes the use of arc lamps to-day is confined, so far as the

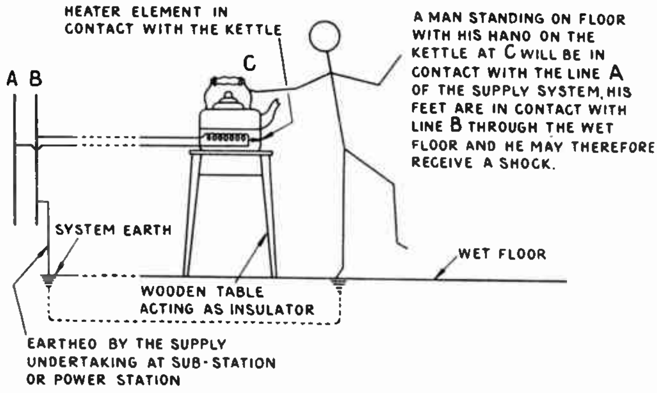


Plan View of a Machine, Motor and Control Gear.

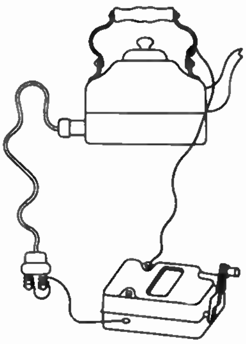
Showing operator's normal position and example of bad and good position for control switch.

average electrician is concerned, to photographic work and projection work such as in cinemas. With regard to the latter, an entirely over-riding set of precautionary Regulations are enforceable, due to the licences under which such operations are carried out, and the subject is rather too large to enter upon here. I may, however, remind readers that when dealing with cinematograph projection apparatus, it is as well to be quite sure as to what bye-laws and County Council Regulations must be adhered to.

With regard to photography, this Regulation 115 is fairly liberally disregarded. This is not always the electrician's fault,



SHOWING HOW A SHOCK MAY, UNDER CERTAIN CONDITIONS, BE OBTAINED FROM THE CASING OF A PIECE OF APPARATUS. (*This and the diagram on the right are taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication "How to Avoid Electrical Breakdowns."*)



TEST ON KETTLE BETWEEN CIRCUIT AND FRAME OR EARTH.

since it may be argued that he can scarcely be responsible for the material of which the floor is made or with which it is covered. It is, I think, his job, however, when called in to install or carry out work upon an arc light, to point out to his customer or client that this Regulation is being disregarded if he finds that the conditions do not conform with this particular sub-section.

Earthing Terminal on Motor Frame.

Regulation 117 deals with Motors, and Sub-section (B) states that: "The frame of every motor shall be provided with a suitable terminal to which the earthing lead may be connected." There is only one comment necessary here, and that is obvious but very important, *the frame of motors must be earthed.*

Position of Motors.

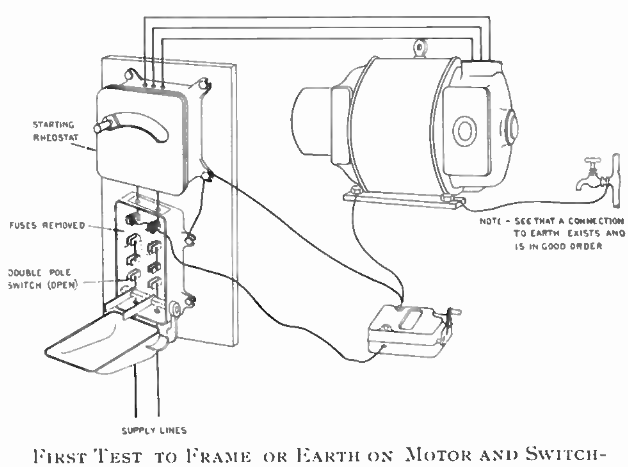
Regulation 118 deals with the Position of Motors and should be read by electricians carrying out motor work, if only as a guide to good practice. All the sub-sections, however, are so much qualified and so vague and indefinite that they cannot be considered to be much more than indicating good practice and the principles involved.

Control of Motors.

Regulation 119 deals with the Control of Motors.

A. Every motor shall be protected by efficient means suitably placed and so connected that the motor and all apparatus in connection therewith may be isolated from the supply; provided, however, that when one point of the system of generation or supply is connected to earth, it shall not be necessary to disconnect on that side of the system which is connected to earth.

B. Every motor shall be provided with an efficient switch or switches for starting and



FIRST TEST TO FRAME OR EARTH ON MOTOR AND SWITCH-GEAR.
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication "How to Avoid Electrical Breakdowns."*)

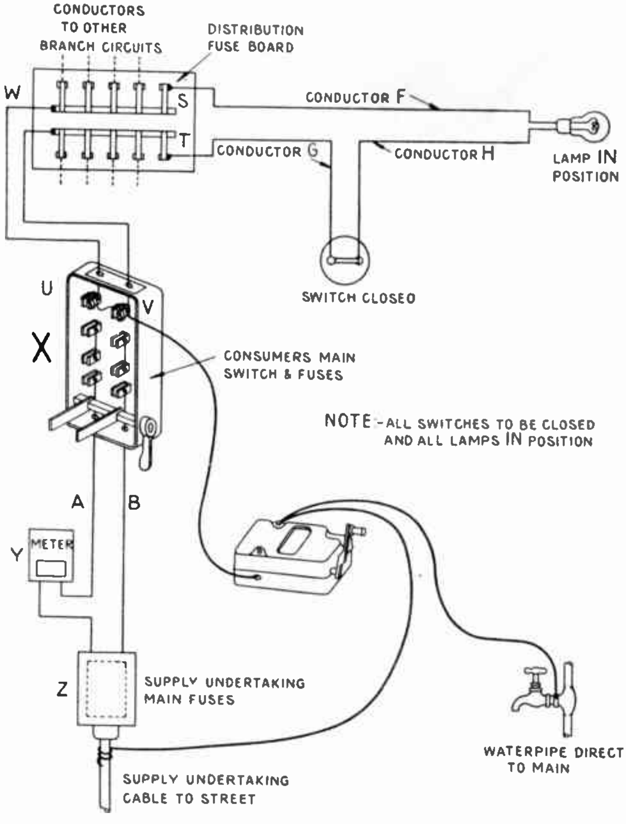
stopping, so placed as to be easily operated by the person controlling the motor; and every motor having a rating exceeding one-half horse-power shall in addition be provided with:—

(a) *Means for automatically opening the circuit if the supply pressure falls sufficiently to cause the motor to stop;*

(b) *In the case of direct-current motors a starter or switch for limiting the current taken when starting and accelerating;*

(c) *In the case of alternating-current motors, such starter or switch for limiting the current taken, when starting and accelerating, to the value (if any) required by the supply undertaking.*

C. *In every place in which a machine is being driven by a motor there shall be means at hand for either switching off the motor or stopping the machine if necessary to prevent danger.*



TEST TO EARTH ON AN INSTALLATION WHICH IS ALREADY CONNECTED TO THE SUPPLY MAINS.

Showing alternative methods of making earth connection. (*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

The whole question of the control of motors is very important, and it must be borne in mind that in many places, if not in most, where any large number of motors are in operation, the premises are likely to be governed by the provisions of the Factory Act and to call for a certain amount of study of the Home Office Regulations in this connection.

Complete Isolation of a Motor on Both Poles.

We are dealing here only with the Regulations for the Electrical Equipment of Buildings, and it must be noted that in Sub-section A the possibility of complete isolation of the motor is called for on both poles; except that when one point of the system of generation or supply is connected to earth, this need not be isolated. In the case of a single-phase motor, operating from one phase to earthed neutral, a single-pole switch isolation seems to fulfil the conditions of this Regulation. In actual practice the fact that a neutral is earthed does not necessarily mean that it is not " alive." Sometimes an out-of-balance potential arises giving a fairly substantial potential difference between the neutral and earth at the points where it may come in contact with a human being.

Starting and Stopping Switch.

Sub-section B asks, in the first place, for a starting and stopping switch to be placed in a position where it is easily operated by the person controlling the motor. Walking round many factories to-day, one is apt to be struck by the inaccessible position of starting switches where, for convenience of wiring, the switch has been placed, perhaps, on the wall at a distance from the actual motor and machine which it is operating.

No Volt Release.

Sub-section (*a*) refers generally to what is known as the " no volt release " designed to eliminate the possibility of a sudden application of the full voltage to the closed and loaded circuit, and also to avoid the possibility of an idle motor, which has ceased working through some temporary drop in voltage, being regarded by the operator as being out of circuit. It needs a very little intelligence to realise the serious possibilities of accidents which might arise from an apparently idle motor suddenly starting up without the operation of any switch.

The other sub-sections speak for themselves, though Sub-section (*c*) is interesting, inasmuch as it is one of the few, if not the only, reference in these Regulations to the necessity for bowing to the requirements of the supply undertaking. Personally, I cannot see that the requirements of the supply undertaking, which are in a sense of a purely commercial nature, have any place in technical Regulations of this sort.

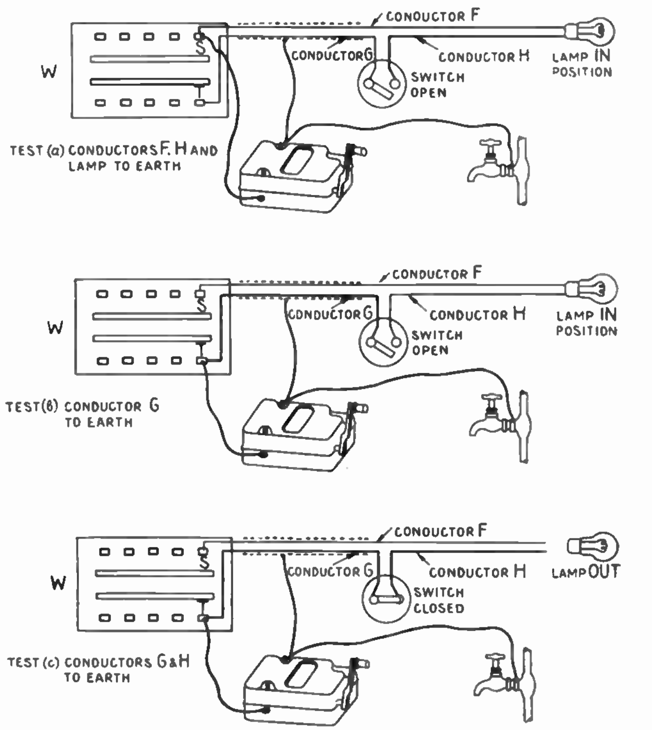
Sub-section C is, in a way, a qualification of Sub-section A, and appears to call for push-buttons or some other immediate control on or adjacent to the machine for emergency stopping.

Regulations 120 and 121 are in much the same category as Section 118, that is to say, they represent good commonsense precautions which should be taken, but do not provide any serious pitfalls.

Lifts.

Regulation 122 again refers to Lifts, which is such a specialist occupation that the ordinary electrician is unlikely to find himself concerned with the Regulations under consideration.

Regulation 123 deals with the General Construction of Heating and Cooking Appliances and contains Regulations which are entirely the concern of manufacturers.



TEST TO LOCATE FAULT TO EARTH ON BRANCH CIRCUIT.
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

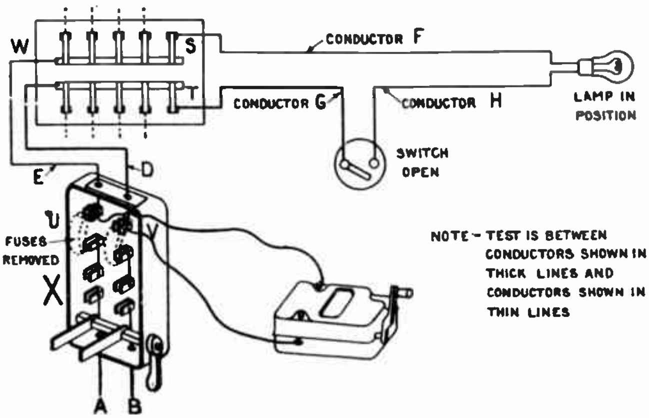
Control of Heating and Cooking Appliances.

Regulation 124, however, deals with the Control of Heating and Cooking Appliances and is important to the electrician to observe.

Sub-section A states :—

Appliances shall be protected either individually or collectively by a fuse on each insulated pole.

B. Fixed appliances shall be controlled as a whole by a switch which may, if desired, be on the apparatus. Portable appliances may be controlled by a switch or switches



FIRST TEST BETWEEN CONDUCTORS ON WHOLE INSTALLATION.
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

be served from one way of a distribution fuseboard provided that a fuse on each leg is provided. This clearly is not intended to suggest that large current-consuming appliances, such as electric fires, can be grouped under a collective fuse of this sort. Indeed, Section 95, which I have already dealt with in this series (August, 1933), must be regarded as an over-riding Regulation and taken into consideration when applying the requirements of the Section that we are at the moment considering.

on the apparatus, but shall be controlled as a whole by a switch fitted on a wall or ceiling, or by a plug and socket (where such are permitted under Regulation 122) *fitted on a wall.*

Note.—*Where non-luminous heaters or heating appliances, smoothing irons, etc., are used, an effective indicator such as a red pilot lamp is desirable.*

C. Where a switch or switches are fixed on the frame of a portable luminous heating appliance, at least one section of the heating element shall not be controlled by such switches, so that the luminous heating element is permanently connected to the wall plug or similar device in order to indicate that the circuit is broken and that current is still flowing.

The phrase "heating and cooking appliances" is apt to suggest something in the nature of electric fires or cookers only; in point of fact it includes independent hot plates, irons, toasters, and a lot of small appliances, and this apparently explains the implicit permission given in Sub-section A for such appliances to be protected collectively.

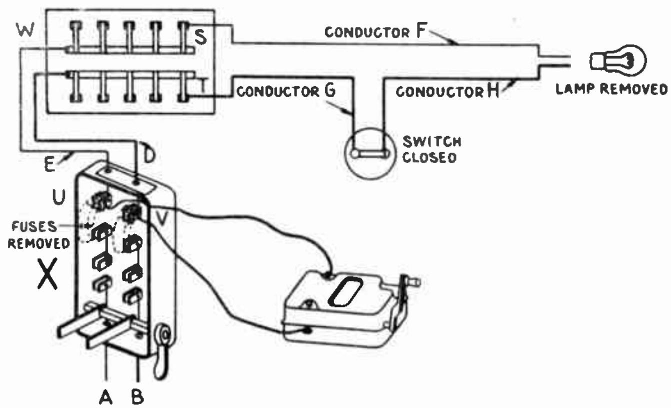
According to Sub-section A, a number of circuits serving such appliances can

Fixed Appliances.

Sub-section B refers to fixed appliances, and I think the term "fixed" here is intended to cover all appliances which, from their weight or from any other reason, are not conveniently transportable such as electric cookers, etc., in addition to the definitely fixed appliances such as water-heaters; it is to be noted that in such cases they shall be controlled by an independent switch.

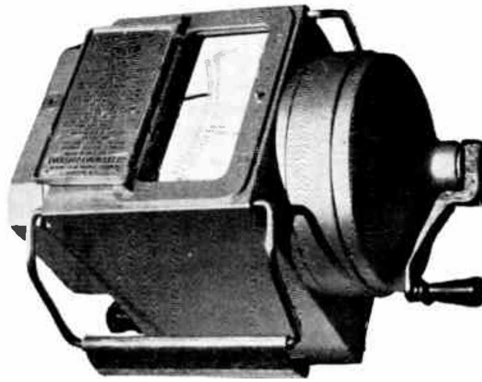
Use of Pilot Lamps.

With regard to the Note as to the use of pilot lamps, some modification is probably desirable in this case. There is no doubt



SECOND TEST BETWEEN CONDUCTORS ON WHOLE INSTALLATION.
(*Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns."*)

THE WEE-MEGGER-TESTER. (*Evershed and Vignoles, Ltd.*)



THE MEG INSULATION TESTER. (*Evershed and Vignoles, Ltd.*)

that a pilot lamp with cookers and one or two appliances of that sort is extremely desirable and comparatively easily fitted. But the use of non-luminous heating appliances is growing so much to-day that it is questionable whether the installation of pilot lamps is really a practical possibility. For instance, if we have a large institution heated by tubular heaters, although it might be a very delightful refinement to have each tubular heater giving evidence that it is on circuit by means of a pilot lamp, such a measure would unnecessarily increase the cost of the installation and, in addition, detract from the æsthetic qualities of this form of heating.

Switch on an Electric Fire.

Sub-section C may appear at first sight to refer only to the manufacturers. Most luminous electric fires sold to-day are arranged in such a manner that they cannot be entirely switched off by any switch on the apparatus itself, the last independent element having to be switched off by means of the main controlling switch on or adjacent to the plug on the wall. It does sometimes happen, however, that a householder who has a particularly inaccessible switch-plug controlling a fire, asks an electrician to fix a switch on the radiator itself which shall control the third element and make it possible for him to switch off the fire by operating switches on the fire. The purpose of this Regulation is definitely contravened if an electrician does so fit a switch, since it is possible to have the fire turned off, and left perhaps throughout the summer with the flexible cord connecting it to the plug still alive.

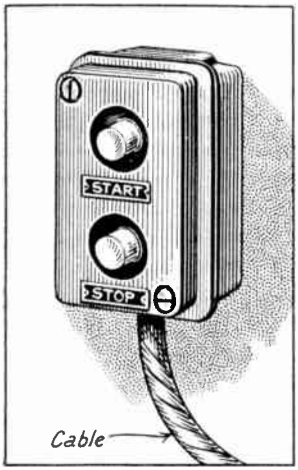
Regulation 125 calls for the very obvious precaution of not fixing heating or cooking appliances near to inflammable materials.

Regulation 126 may be conveniently omitted so far as these notes are concerned.

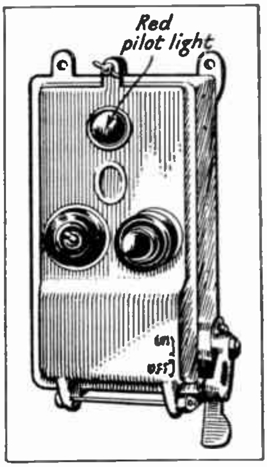
TESTING OF COMPLETE INSTALLATIONS.

The next and final two sections refer to the Testing of Complete Installations and Additions to an Existing Installation. Before quoting the Regulations perhaps it is worth mentioning that the testing of installations generally is a matter of considerable misapprehension in the eyes of most laymen and some engineers. The tests as prescribed by these Regulations are sound tests and the only ones which can reasonably be applied. On the other hand, they achieve little more than does the stethoscope of a doctor when he examines a patient. No doctor would be foolish enough to state that he can give a patient a clean bill of health merely on the result of the use of his stethoscope; nor would he say that what he hears through his stethoscope on one occasion will remain unchanged on a future occasion.

The testing of a completed installation is a formality which must be performed to



APPARATUS FOR PUSH-BUTTON CONTROL.



COOKER CONTROL SWITCH WITH PILOT LIGHT.

satisfy both the installing engineer and client and also to satisfy the supply undertaking that the installation has an insulation resistance sufficiently high to connect up. For it is laid down—and here we come into contact with one of the very few statutory regulations referring to electrical installations—that a certain standard of insulation *must* be reached before the supply undertaking is empowered to connect up to its mains. But the conscientious engineer will look over the entire installation, in addition to taking the prescribed tests, before he hands it over as being in perfect order.

In addition, it must be remembered that the initial test must not be taken as a guarantee against deterioration for many years, but that a periodical test is extremely desirable, if not necessary, in the case of most electrical installations.

Requirements to be Complied With.

Regulation 127, which is entitled Testing: Requirements to be Complied with, states: "Before an installation is permanently put into service it shall comply with the requirements of the following tests:—

A. Insulation Resistance:—

(a) *The insulation resistance shall be measured by applying between earth and the whole system of conductors or any section thereof, with all fuses in place and all switches on, a direct current pressure of not less than twice the working pressure. Where the supply is derived from a three-wire (alternating or direct current) or polyphase system the neutral of which is connected to earth either direct or through added resistance, the working pressure shall be deemed to be that which is maintained between the outer or phase conductors and the neutral.*

(b) *The insulation resistance of an installation measured as in A* (a) *above shall not be less in megohms than 25 divided by the number of points on the circuit, provided that—*

(i) *Any installation shall not be required to have an insulation resistance greater than 1 megohm;*

(ii) *Lighting circuits shall be tested with all lamps in place, except in the case of earthed concentric wiring systems;*

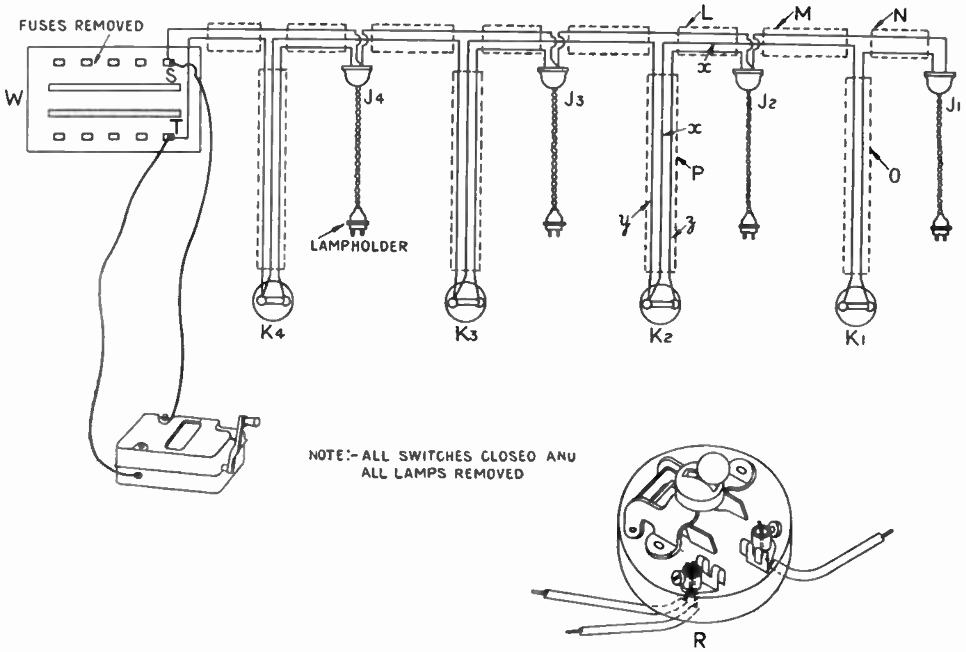
(iii) *Heating and power circuits, with or without lighting points, may be tested, if desired, with the heating and power appliances disconnected from the circuits, but with the lamps (if any) in place;*

(iv) *The insulation between the case or framework and every live part of each individual dynamo, motor, heater, arc lamp, control gear or other appliance shall not be less than that specified in the appropriate British Standard Specification, or, where there is no such specification, shall not be less than half a megohm.*

Note.—*In addition to the foregoing tests, it is advisable, wherever practicable, to take an insulation test between all conductors connected to one pole or phase and all the conductors connected to the other pole or phase of a system.*

B. Continuity of Metal Sheathing:—

The metal conduits or metallic envelopes of cables in all cases where such methods are used for the mechanical protection of



TESTING A BRANCH CIRCUIT WHERE SEVERAL POINTS ARE LOOPED TOGETHER.
(Taken by permission of Messrs. Evershed and Vignoles, Ltd., from their publication " How to Avoid Electrical Breakdowns.")

electrical conductors shall be tested for electrical continuity, and the electrical resistance of such conduits or sheathing, measured between a point near the main switch and any other point of the completed installation, shall not exceed 2 ohms.

C. Earthing:—

(Investigations are being made with a view to specifying the conditions required for the satisfactory earthing of an installation, and it is proposed to include such specification in a later edition of these Regulations.)

Here, then, in a comparatively small compass, we have what may be considered the official tester's bible ; whatever other fancies he may have as to ensuring that an installation is in order, he must observe the requirements of this Section 127.

Making the Measurement.

The actual measurement of insulation resistance called for, it will be noted, is not between pole and pole—a very common fallacy—but between all conductors bunched and earth. The test may be taken in any convenient manner by which, given the voltage and the current, the resistance can be calculated ; or, as is more usual, it can be taken on one of the instruments known as an Insulation Tester, which is designed to do this mathematical calculation itself for the operator and record in terms of ohms and megohms the insulation resistance reading. It is important that a good earth be obtained for the earth connections of the insulation testing apparatus, and it is usually found that there is adjacent some water pipe which has a direct connection with earth. Unless the conduit or sheathing has been already tested and proved to be satisfactorily earthed according to Sub-section B, it is unwise to use such conduit or sheathing as the earth connection for insulation testing.

Pressure.

Reference is made in Section 127 (A) to the application of a pressure of at least " twice the working pressure." Since, to all intents and purposes, in two-wire installations the working pressure to-day never exceeds 250 volts, the pressure of 500 volts—which is usually applied in such instruments as the Insulation Tester mentioned—satisfies this condition. In the case of three-phase motors operating, for instance, at 415 volts, it will be in accordance with the Regulation to consider the working pressure only to be 230, that is to stay, the pressure between the phase-conductor and the neutral.

Measuring Insulation Resistance of an Installation.

Sub-section A (*b*) merely calls for a mathematical calculation and, to make matters a little clearer, perhaps I may add that if we have an installation with 100 points, the insulation resistance must not be less than one-quarter of a megohm, that is 250,000 ohms. On the other hand, if we have an installation with only five points, our mathematical calculation will give us a minimum of five megohms, but this is not required owing to the provision of A (*b*) (i).

The Note at the end of this section suggests that, where practicable, it is desirable to take the insulation test between conductors as well as between the bunched conductors and the earth. The reason for this is obvious, since it is possible to have a short circuit between conductors (where neither conductor is at earth potential) which will not necessarily show itself at the time.

Continuity of Metal Sheathing.

With regard to Sub-section B—Continuity of Metal Sheathing—the usual practice in the past has been to test for continuity by means of a 4-volt battery and a bell ; that is to say, to make an artificial circuit which contains as part of the conducting circuit the whole length of tube or sheathing to be tested ; if the bell rang the continuity was considered to be O.K. Recently, however, there has come on to the market an insulation tester which incorporates a switch by which readings of low resistance can be taken. This makes it possible to use the same instrument both for testing the insulation and subsequently for testing continuity. It has the great advantage that one does in this manner get a definite record as to whether or not the continuity satisfies these Regulations by not exceeding 2 ohms.

Care Required in Making Additions to Existing Installations.

Finally, Regulation 128, which is entitled, Care Required in Making Additions to Existing Installations, is self-explanatory, but should be quoted :

Before an addition is made to an existing installation care shall be taken to ascertain whether the existing conductors, switches, etc., affected by the additions are of sufficient capacity for the augmented current which they may have to carry.

Note.—*Alternative plug positions are often provided for electric heating appliances, and in such cases it should be ascertained whether the existing conductors are of sufficient size to allow of the silmultaneous use of apparatus connected to more than one plug.*

Only too often where alternative plug positions are provided for electric heating apparatus the circuit wires are not capable of carrying sufficient current to cope with both these alternative plug sockets if they are simultaneously loaded. Whatever may have been the original intention of the consumer, the existence of two plug sockets may prove too great a temptation and cause him to use both at the same time. Hence the necessity for careful observance of this Regulation and Note.

THE WESTECTOR

THE Westector has been evolved on the same principles as the well-known Westinghouse metal rectifier. It is a small form of metal rectifier specially designed for use in place of a valve in detector circuits. It will operate exactly as a rectifying valve and in the same circuits, although its simple nature enables it to be used in circuits which are preferable to those already developed.

It is designed for use as a detector handling high voltages, and it must be remembered that it will not operate satisfactorily in low-power circuits, nor as a "crystal" detector. For detection purposes, it is best used in a receiver preceded by at least two stages of high frequency amplification and is, therefore, particularly suitable for superheterodyne receivers. It will be realised, of course, that its sole purpose is to rectify, and it does not give any amplification to the signal.

For this reason, although it may replace the detecting function of a power grid, anode bend or diode detector, the sensitivity must be maintained by utilising the valve stage released as an additional I.F. or L.F. amplifier with appropriate couplings and grid bias.

The Westector does not require any high tension supply, neither is there a filament to heat, and it is, therefore, a simple matter to incorporate it in a receiver, especially as no valve holder is required, terminals being provided on the Westector itself, so that it can be included in the wiring of a set.

Fig. 1.—A TYPE WA WESTECTOR.

Simplest Detector Circuit.

A detector circuit using a Westector and reduced to its essentials is shown in Fig. 2. It will be seen that this is similar to a simple half-wave rectifier circuit, with the exception that the input transformer is replaced by a tuned circuit, which may be either condenser or transformer coupled to the preceding amplifiers. This is shown in Figs. 2 and 3.

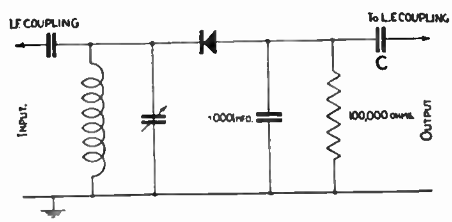


Fig. 2.—SIMPLE DETECTOR CIRCUIT USING A WESTECTOR.

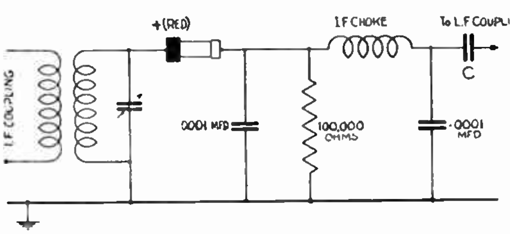


Fig. 3.—HOW FURTHER FILTERING CAN BE OBTAINED.

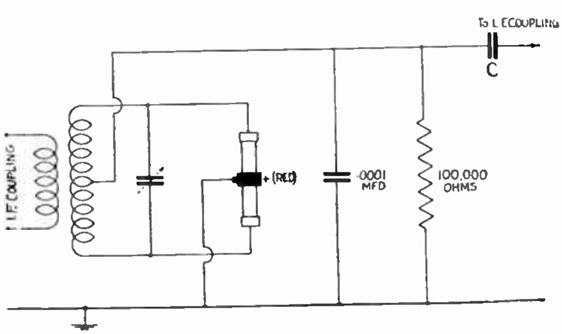


Fig. 4.—A DOUBLE-DIODE CIRCUIT.

Why a Tuned Anode Circuit Cannot be Used.

Note that a tuned anode circuit cannot be used because it is essential that there should be a D.C. conducting path from the Westector through the tuned circuit to the load resistance, i.e., there

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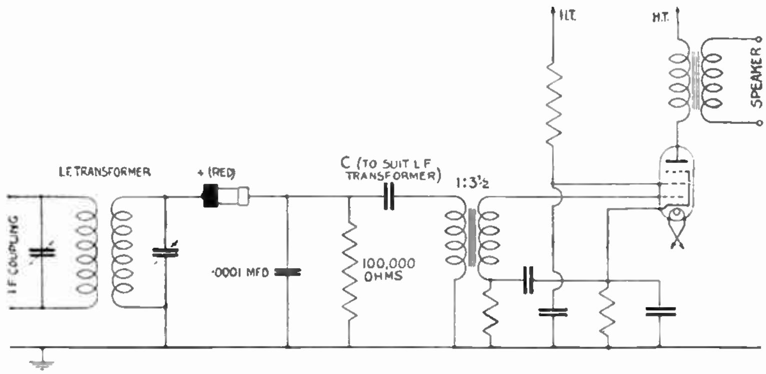


Fig. 5.—Pentode Output, Transformer-coupled to Westector. Output Transformer Ratio 1 to 3½ or 4.

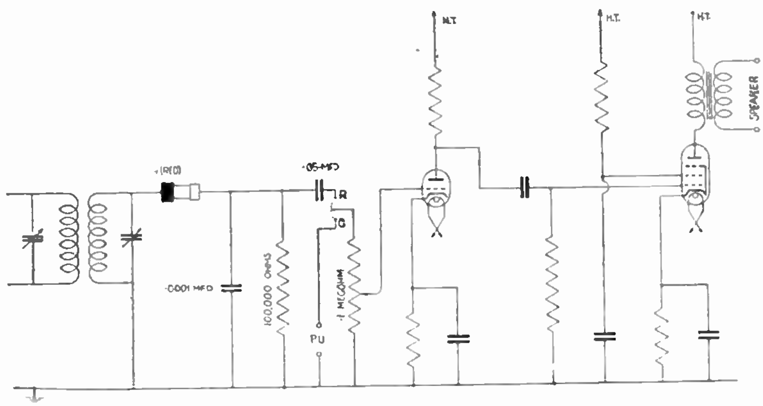


Fig. 6.—Pentode Output with Intermediate Low Frequency Valve Resistance Coupled.

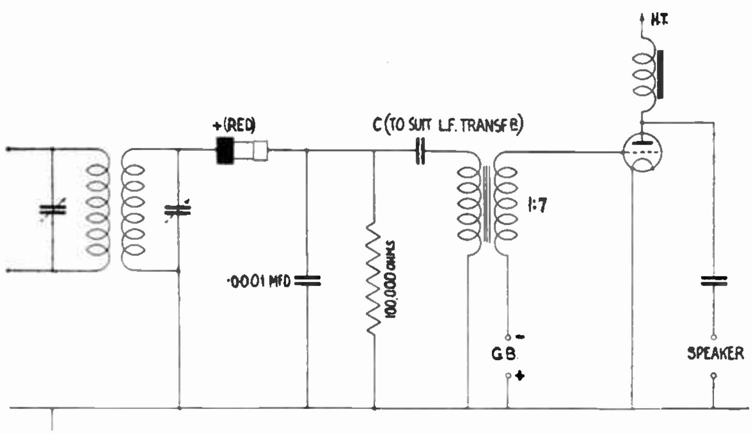


Fig. 7.—Small Power Valve Output with High-ratio Step-up Transformer. Ratio about 1 to 7.

must not be a blocking condenser in series with the tuned coil.

A suitable value for the load resistance is 100,000 ohms. By the addition of a reservoir condenser, the output of the Westector may be increased, the maximum size of this condenser being limited by the range of audio frequencies it is desired to receive. A suitable value is 0.0001 mfd. The L.F. output from this load circuit is fed to the succeeding L.F. amplifier through the condenser C to a transformer, L.F. choke or resistance coupling. By employing the Westector in the above way, the reservoir condenser is used to obtain a valuable amount of filtering of the I.F., a result which cannot be obtained by any other detector circuit except the double diode. Further filtering can be obtained in the usual manner by inserting an I.F. choke and an additional 0.0001 mfd. condenser.

Double Diode Westector Circuit.

A double diode Westector circuit is shown in Fig. 4. The only advantage of this circuit over that described is a further improvement in filtering, but this improvement is not sufficient to merit the additional complications involved.

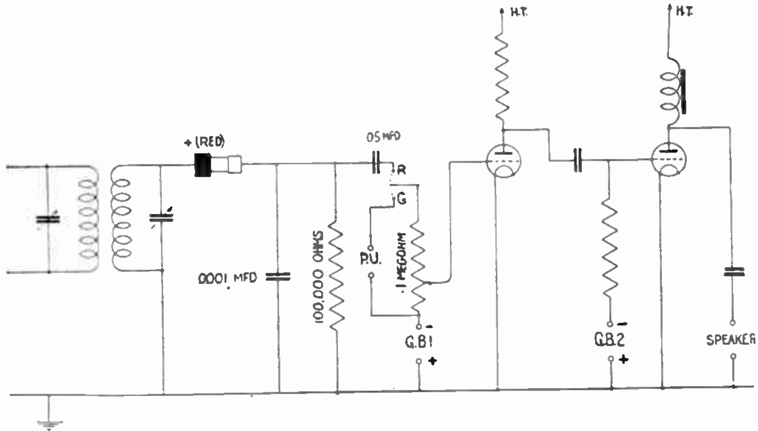


Fig. 8.—Small Power Valve Output with Intermediate L.F. Valve Resistance Coupled.

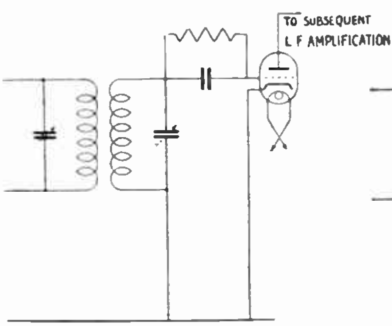


Fig. 9A.—Power Grid Circuit Before Converting.

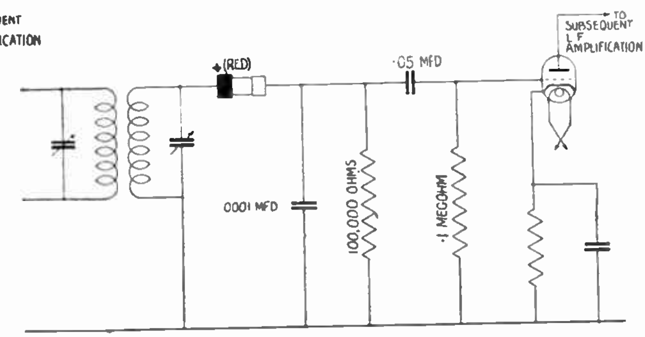


Fig. 9B.—Circuit After Converting.

Amount of L.F. Amplification Required.

Figs. 5-8 are examples intended as a guide to the amount of L.F. amplification required when the Westector is used as recommended. When it is desirable to use an L.F. amplifier in conjunction with a gramophone pick-up, an intermediate L.F. valve is necessary, and the pick-up should be connected at the points marked P.U. in Fig. 8.

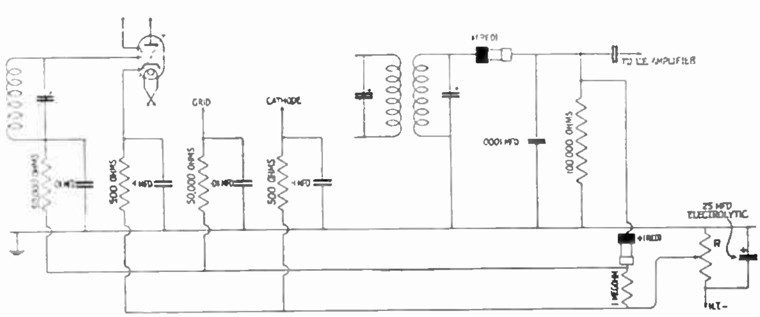


Fig. 10.—Circuit for Automatic Volume Control.

Converting an Existing Receiver.

Figs. 9A and 9B show a typical conversion from a power grid to a Westector unit, in which the released valve has been arranged as an L.F. amplifier. This

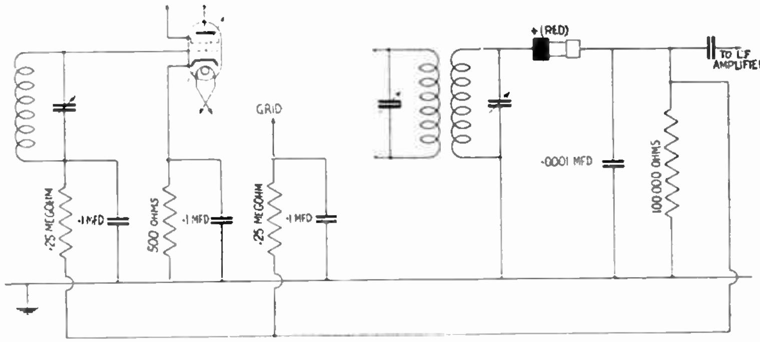


Fig. 11.—METHOD OF OBTAINING DELAYED AUTOMATIC VOLUME CONTROL. This and the previous diagrams are taken from "The All-metal Way, 1934," published by the Westinghouse Brake and Saxby Signal Co., Ltd.

conversion should only be made when the power grid detector is easily overloaded, as otherwise it is unlikely that the available input voltage will be sufficient to operate the Westector to its best advantage. In making such a conversion care must be taken to see that there is a D.C. conducting path through the preceding tuned circuit, while it may be found necessary to re-adjust the trimming condensers on the preceding I.F. transformer after converting to the Westector circuit.

Automatic Volume Control.

Figs. 10 and 11 show how the Westector can be used as a means of obtaining automatic volume control. Fig. 10 gives a typical theoretical circuit of a detector and one controlled H.F. stage with all subsidiary apparatus omitted. It must be understood that the load resistance and detector are arranged to provide a point at negative potential with respect to earth. The voltage across this load resistance is not steady D.C. but has the L.F. component superimposed upon it, and this component must not be allowed to feed back into the grid circuit of the H.F. valves. To avoid this a resistance-condenser filter is used. The valves of components used are such as to give good filtering down to the lowest probable audio frequencies and yet, at the same time, leave the response quick enough to follow the fastest likely period of fading.

A method of obtaining delayed automatic volume control is shown in Fig. 11, the function being to make the automatic volume control inoperative on moderately weak signals and only begin to function on signals of more than a certain preset value. The potentiometer R determines the particular value at which the control becomes operative.

NEON TUBE PRACTICE

The practical application of Neon lighting is a subject that is rapidly becoming of increasing importance to electrical engineers. We believe, therefore, that many readers will be interested in Dr. W. L. Schallreuter's book, "Neon Tube Practice" (Blandford Press, Ltd., 10s. 6d.).

Dr. Schallreuter covers the subject from many angles. Not only does he give some very interesting details about the physical and electrical conditions of a gas discharge, but he deals thoroughly with the practical use of Neon and the erection of a Neon sign.

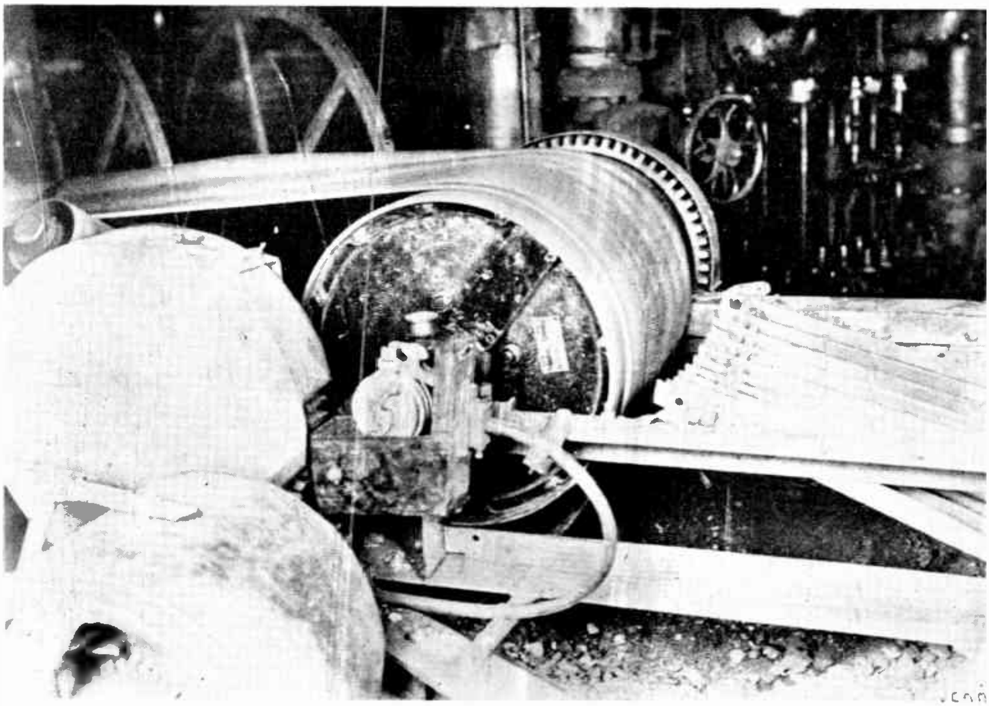
Dealing with the question of electrodes and the pressure in the tube, he says :—

"For pure neon gas, the most favourable pressure regarding conductivity and efficiency is approximately .95 mm. (roughly $\frac{1}{800}$ of an atmosphere). With such pressure the efficiency of neon is .64 watt per candle power, so that such tubes do not compare unfavourably even with the best gas-filled incandescent lamps. In practice, however, neon tubes must be filled with a pressure of at least 5 to 15 or even 25 mm. (i.e., from $\frac{1}{150}$ to $\frac{1}{30}$ of atmospheric pressure)."

Perhaps one of the most important chapters from our readers' point of view is that dealing with the electrical supply for Neon tubes.

A useful and interesting treatise for the serious student of the subject.

Magnetic Separation for Protection of Pulverising Machinery



The Igranic Magnetic Separator Pulley Used for Removing Bolts, Spikes, Nuts, Etc., in the Manufacture of Coal Briquettes.

CONSIDERABLE development has recently taken place in the use of pulverised fuel for boiler firing. Coal which is delivered to coal pulverising plant invariably contains a surprising amount of stray iron such as nails, bolts, nuts, hammer heads, pick heads, etc. which would cause considerable damage to the delicate pulverising mill. The elimination of such stray or tramp iron can easily be accomplished by means of a magnetic separator pulley.

How the Magnetic Pulley Works.

The separator pulley is inserted in the conveyor line to the mill, and as the material is passed over the separator pulley, the tramp iron is attracted and held firmly against the belt with which it remains in contact until it leaves the magnetic zone, which is at a point beyond the under side of the magnetic pulley. The tramp iron drops from the belt after leaving the pulley, and is delivered into containers by means of a chute ; the coal continuing its course to the mill without interruption. The principle of the magnetic pulley is clearly shown in the accompanying diagram.

The separator pulley consists of a number of steel discs keyed to a shaft, an electromagnetic winding being placed between alternate discs. The magnetising coils are wound on steel bobbins, which are dowelled to the discs to prevent shifting.

The coils are vacuum impregnated with a moisture repelling and insulating compound ; this ensures perfect protection from moisture and since the compound is a better heat conductor than dead air, cooler operation of the pulley is secured.

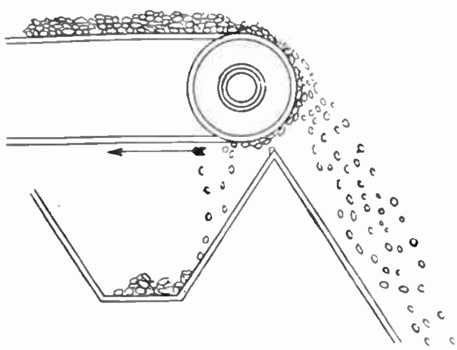
How the Coils Are Connected.

The coils are all connected in series and terminal wires brought through a hole in the centre of the shaft to a pair of collector rings fixed far enough beyond the edge of the pulley to permit a bearing between the collector rings and the pulley.

A tubular brass spacer which also performs the function of a coil shield, is placed between adjoining steel discs. After assembly the pulley is turned and crowned.

Main Features of a Magnetic Separator.

In judging a magnetic separator pulley



THE PRINCIPLE OF THE MAGNETIC PULLEY.
The separator pulley is inserted in the conveyor line to the mill and as the material passes over the pulley, the tramp iron is attracted and held firmly against the belt until it leaves the magnetic zone which is at a point beyond the underside of the magnetic pulley.

it should be borne in mind that dimensions and weight are not the only features to be considered; in fact, two separator pulleys of the same weight and dimensions could be made that would not be of equal efficiency. One may have less copper and more steel to secure a cheaper construction, while the other, which has an abundance of copper and is not cheap, may be spoiled by the lack of steel in the magnetic circuit.

Magnetic pull varies as the square of the number of lines of force per square inch of pole area, from which it may be seen that a small reduction as from 100,000 lines per square inch to 90,000 lines per square inch reduces the pull to 81 per cent. Too much steel in the poles reduces the number of lines of force per square inch just as too little copper does.

The windings, if placed near the shaft instead of near the outside of the pulley, will require much less copper but the efficiency will be reduced on account of excessive leakages.

The pulley is magnetised by passing direct current through the coil winding in its interior.

The current sets up a magnetic flux which passes through the belt and attracts any iron or steel that may be contained in the material carried by the belt.

Large Diameter Pulleys Give Best Results.

It should be borne in mind that large diameter pulleys will in every case give better results than those of small diameter from the standpoint of magnetic separation and will reduce wear and tear of the belt.

Assuming the belt speed to be the same in both instances, it is obvious that the rate at which the direction of motion of a piece of iron or steel is changed will be lower on a large diameter pulley than on a small one; consequently with the same intensity of magnetisation of the separation accomplished by a large pulley will be more perfect than that by a small one.

From the standpoint of belt life, the desirability of using a large diameter pulley is universally recognized. The pulley diameter must be large enough to give the required traction and to suit the thickness of the belt. Good practice allows 3 inches diameter per ply; as for example, 18 inches diameter for a 6-ply belt.

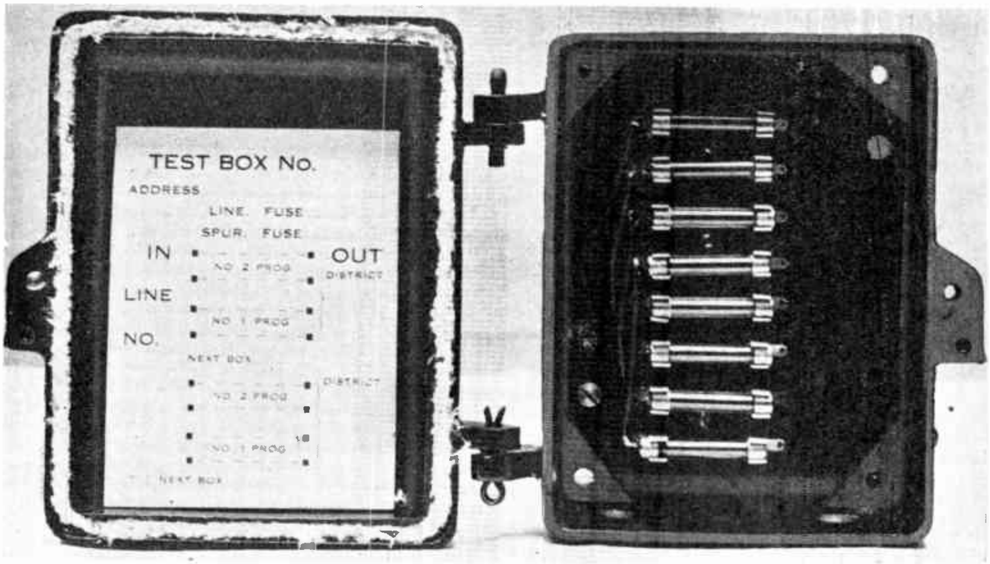
When Small Diameter Pulleys Would Be Permissible.

Small diameter pulleys, however, are much lower in first cost, and where a short belt is installed, their use is permissible. Where conveyor flights are long and especially where the magnetic pulley is a driving pulley for the conveying belt system, it is frequently economical to use a large diameter narrow face pulley because of the saving effected in the cost of a narrow belt.

Erecting Radio Relay Lines

By C. W. Watson

This article describes the practical methods of erecting radio relay lines and describes the apparatus required



Test Boxes with Protection Devices should be Arranged at Each Point where the Spur Leaves the Main Line.
Showing a box containing eight fuses for D.P. lines.

Radio relay lines to the "man in the street" differ very little from telephone and other lines. but even a little consideration proves that this is not the case. Telephone lines, for example, are nowadays composed of individual circuits, that is, so far as town wiring is concerned, and a fault on a pair of lines affects only one subscriber, whilst, on the other hand, power wires form a network with many branches to different districts, and a fault on any particular circuit, except as provided for in the protection devices, affects the whole system.

One Pair of Wires Feeds Upwards of 500 Installations.

In radio relay lines we have a sort of compromise between the power wires and the telephone lines, one pair of wires often feeding upwards of 500 installations, though the materials used and the current carried have much in common with the telephone system. Many people with little or no experience of overhead wiring have ventured into the relay business, and in many cases experience has been gained at considerable cost.

Protection of Outgoing Wires from Lightning.

The outgoing lines from the radio relay station should be protected against lightning, and a suitable distribution board provided in order that the lines may be changed over between the various amplifiers or linked together as may be desired; it should also be possible to isolate each line for testing purposes.

Use P.O. Type Protectors.

Where more than six pairs of wires are to be used, the most suitable arrangement is to provide P.O. type 4106 protectors, fitted with heat coils and an alarm bell circuit, and wired in such a manner that a short circuit on one of the lines will drop one or both of the heat coils in circuit with that line and operate the alarm bell. The alarm bell transformer should be wired in parallel with the mains transformer to the amplifiers so that there is no fear of the alarm bell operating in the middle of the night or at some time when no operator is in attendance. This precaution may seem unnecessary, but is nevertheless advisable, experience having proved that whether amplifiers are operating or not, one never knows what some "kind friend" may couple to the lines elsewhere.

Adjusting the Coils for Different Currents.

This type of protector is obtainable from Standard Telephone and Cables, Ltd., Hendon, and the heat coils which are designed to operate at .5 amp. may readily be adjusted for different currents according to the size of the lines and the amplifier which is feeding same. This is done by shortening or lengthening the coils as may be necessary and reading resistance on an "Avometer."

For a medium-sized station supplying, say, up to 1,000 subscribers, about six pairs of lines should be provided for single-programme working and six sets of four wires for dual programme, whilst for larger stations lines should be provided for each 200 or so loud-speakers as necessary. If, however, wayleave difficulties arise, there is no great difficulty in arranging as many as 500 subscribers on one line.

The Distribution Pole or Mast.

Where it can conveniently be arranged, it is perhaps best for the distribution pole or mast to be some distance, say 50 yards, from the station itself in order to isolate same from the aerials, and lead-covered cables, underground if possible, run from the station to the point of distribution. These lead-covered cables act fairly well as condensers in case of lightning and cut down a certain amount of static interference. In any case, the distribution post for the lines should conveniently be arranged so that in case of mysterious faults, tests can readily be made to ascertain whether the fault is in the outgoing leads or in the open line. It is also advisable that this mast should be as high as possible in order that longer shots may be taken if nearby wayleaves are scarce.

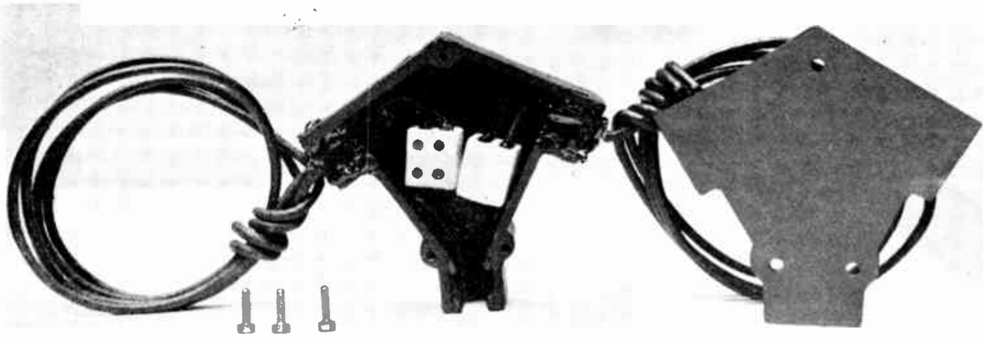
Wire and Cables.

Systems at present in operation employ open-span wiring with bare conductors, two-core insulated cables with self-contained earth wires, open-span wiring with insulated conductors, certain amount of underground wiring, suspended lead-covered multi-core cables and lead-covered cables running along masonry. Suspended insulated conductors often develop numerous minor faults and they are only suitable for erection on permanent runs. The most popular system by far in this country is, therefore, that of open span wiring, whilst chiefly on account of cost and to keep down weight, bare conductors predominate.

Insulators.

To facilitate testing, all insulators used for radio relay work should be of the double-groove type in order that the loops may be cut when necessary to isolate a portion of the line. Where single-groove insulators are used it is often found necessary to unpick one wire and remove it from the insulator altogether before a test reading can be taken, otherwise both wires being in the same groove cannot be separated.

On a small system, say up to 500 loud-speakers, fairly good results can be obtained by using reel-type insulators if these are of the two-groove variety. This type of insulator is much cheaper to erect and can be made very neat in appearance, but owing to its short leakage path to the bolt it is not advisable to use reel insulators where large networks are concerned. The most popular type is, therefore, the Sinclair double-groove, double-skirt pattern used in conjunction with P.O. or similar types of brackets.



WHEN FOUR-CORE CABLES ARE TO BE USED AND ELABORATE PRECAUTIONS TAKEN AGAINST CROSS-TALK BETWEEN PROGRAMMES, A JOINT BOX SUCH AS THAT SHOWN SHOULD BE USED.

Brackets.

It is to the advantage of the relay operator to erect all lines as high as possible, thus enabling longer spans to be erected and usually carrying the wires well over the average aerial and remote from Post Office lines, which are mainly erected as low as reasonably possible. For these reasons the majority of radio relay lines are carried on chimney stacks and the brackets used for this purpose are generally of the type known as band brackets. These brackets are strapped round the chimney by means of galvanised stay wire, corner plates and draw bolts.

Brackets erected in this manner do not become fixtures under the Property Acts and do not in any way harm the masonry ; as a matter of fact, in many instances chimney stacks are actually strengthened by their presence. These brackets should be designed to take one or more double "J" bolts as may be necessary, these bolts carrying two insulators each. Where difficulty is experienced in crossing over a ridge of a building it is often found necessary to use the inverted type of "J" bolt or, in some instances, to carry an insulated conductor to a bracket on the opposite side of the ridge.

Leading In.

Where two-core cab tyre or lead-covered cables are used for leading in it is not generally considered necessary to use a joint box at the bracket whilst the pothead type of insulator, in which the insulated lead-in wire is carried up inside the insulator, are usually considered too expensive, but where four-core cables are used and elaborate precautions are to be taken against cross talk between programmes, a joint box is essential, if an efficient service is to be maintained. A very useful type of box for this purpose being shown in the accompanying photograph.

Keep Lead-in Cables as Short as Possible.

The lead-in cables being more expensive than those used for inside wiring, and inside wiring being easier to maintain, it is advisable that the lead-in cables should be kept as short as possible, and for this reason, where possible, the leads should be taken through the roof at the base of the chimney stack.

Insert Wire Under Guide Slate.

This method is generally facilitated by the presence of a guide slate at this point. This guide slate can generally be identified by the lead strip which holds it in position, and when this strip is turned down the slate can usually be easily withdrawn, the wire passed under, and the slate replaced without any damage to the building, secured in position again by the lead strip and an application of a little "Rito" or other roof compound will seal the inlet and prevent any moisture following the wires into the building.

Inside the Building.

Inside the building, as near to the point of entry as possible, protection devices should be fitted which also provide a connection for the cheaper form of bell wire which is used to carry the programmes to the point where the loud-speaker is to be installed.

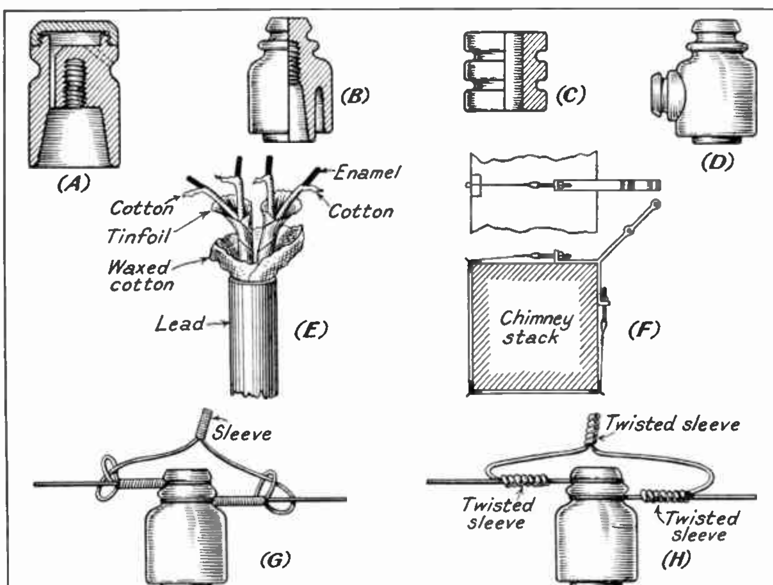
Best Form of Protector.

The best form of protector is found to be a fuse of about 60 milliamps. carrying capacity one of which would be used in each lead; the usual form of tubular fuse, fitted in a miniature screw holder, is quite suitable for this purpose, but a much neater effect is obtained by using the new four-way fuse holder designed for this purpose by Belling Lee, Ltd. This device has also the advantage that it may be sealed to prevent interference by unauthorised persons.

When these types of fuses are used, samples should be carefully tested to ascertain their fusing point, which should not be over 100 milliamps.; they should also be tested in the relay station to ensure that the output from the amplifiers is sufficient to break them down. As a guide in this respect, a pair of DO25's or LS5A or similar valves will easily break down a 60-milliamp. fuse if the amplifier is not already overloaded.

Branch Lines.

Where a spur is taken from a single pair of lines a double bracket with four insulators should be used to avoid the necessity of two wires being in one groove and to facilitate testing, whilst where a spur is taken from a two-pair line, precautions must be taken against the wires branching from inside the bracket making a contact with the outside pair at the point where they cross. It is quite common to see two or more brackets attached to a chimney in order to get over this difficulty, but a much simpler remedy is found in the cranked type of bracket, which is arranged so that one wire from each pair crosses mid way between the other pair, and there is no danger whatever of a contact unless the spur is taken at an angle very far from the horizontal.



DETAILS OF THE INSULATORS FOR USE WITH RADIO RELAY LINES.

A, B, C and D show various types of insulators; E shows how the end of the lead-covered cable is exposed; F the method of erecting band bracket round a chimney stack; and G and H, how two wires are joined at an insulator. In connection with the band brackets, it should be noted that these are strapped round the chimney by means of galvanised stay wire, corner plates and draw bolts.

DUAL PROGRAMME LINES.

Precaution Against Cross Talk.

In dual programme, four-wire circuits

precautions have to be taken against cross talk, the commonest being the transposing of wires. The most efficient and simplest method is to carry one pair of lines straight through and transpose the other pair at frequent intervals. In telephone circuits a special type of insulator is often used for transposing, these having extra grooves and a small extra skirt to provide for the lines being changed over between the insulators, but for radio relay work where higher voltages are employed it is advisable to use six insulators on a transposition bracket.

A Good System of Wiring.

A good system of wiring for dual programme is to use white insulators for one programme and brown for the other. Thus at a transposition point, two white and four brown insulators would be employed, if the brown line was the one to be transposed. Transpositioning should be arranged in the case of heavy systems at about every fourth bracket, and it is often found good practice to use a transposition bracket in every case where a spur is tapped off from the main line. If the spur is a large one, further transpositions will also be necessary along the spur itself.

In the case of small spurs with, say, four or five spans and no transposition, care should be taken to see that two adjacent spurs are not connected in the same phase relation. The lead-in wires used for this purpose should be two separate twin lead-covered cables with their coverings bonded and earthed, or a four-core cable, laid up in pairs and screened between the pairs. These cables should be connected to the lines by means of a joint box and sealed leaders as previously mentioned.

Testing.

To facilitate the location of faults and to restrict the area affected by these faults when they occur, test boxes with protection devices should be arranged at each point where the spur leaves the main line—an illustration of a test box containing eight fuses for D.P. lines appears on page 131. In the lid of each box is inserted a card, duplicates of which should be kept in the engineer's office for reference. With the use of these boxes it is not necessary for a linesman to be particularly familiar with the lines, as the card in each box bears the address where the next box on the line is and also what spur is affected. It is, therefore, only necessary to work from box to box to the point where the fault is found to be back along the line, then examine the line between the two boxes, whilst the fuse can be left out at the last box, thus leaving only a portion of the line dead until the fault is cleared.

Earth Leaks.

Earth leaks on radio relay lines should be particularly avoided, especially in the case of dual programme working, as two earths on a transpositioned line, if they occur on the opposite wires, produce, if not a short, a very heavy load on the line in question; whilst earth leaks on two lines which may be a mile apart and in no way connected, can, if they occur on opposite programmes, produce puzzling cross talk effects. For this reason it should be the duty of the station operator to read the resistance of each line to earth, first job each morning, in order that these faults may be remedied without delay. For earth leaks and short circuits on the line an Avometer is invaluable, readings being obtainable over very useful ranges without the trouble of operating a generator, as would be necessary if a megger were used.

Crossing Streets.

Difficulty may be experienced in erecting wires over busy streets, but a little ingenuity greatly simplifies the task. Where a busy street has to be crossed by wires it is generally best to erect the ladders at the rear of the buildings on each side; the linesman on each building then lowers an end of his rope, which is an indispensable part of his equipment; during a lull in the traffic the ends of the two cords are joined together; one linesman should then draw up the cord as far as possible and attach the free end of his own cord to it, the man at the other side then draws the cord across until the knot reaches him and taking the free end of his own line ties the two ends together, forming an endless rope over the street.

This operation can be carried out unobtrusively and the coils of wire can then be passed to and from each building at will. Where tram wires have to be crossed, insulated wire must be used, and after all preparations have been made to ensure a quick crossing a telephone message to the tramways depot will usually result in the tower waggon being immediately on the spot and a very few minutes should see the job complete. This is a far better method than throwing ropes over live wires and the tramway authorities are always ready to oblige in this respect, if only in their own interests.

H.F. on the Lines.

Where radio relay lines pass closely to overhead trolley wires and through industrial areas, it is quite common for H.F. radiated from trolleys and electrical machinery to follow the course of the line back to the relay station and cause an appreciable amount of interference with the reception. A good plan for guarding against this is to earth each line through a condenser of .01—.1 mfd., when the interference will be found to disappear; in fact, lines arranged in this manner, in practice, seem to aid reception if tests are carried out with and without the condensers.

Effect of Weather on Brackets and Conductors.

Experience over a few years of climatic effects on overhead equipment go to prove that although galvanising of brackets is undoubtedly an advantage, these should be painted on erection, particularly the "make-offs" of the stay wires, and re-painted at least once a year. A good practice is for the linesmen to carry paint and brush with them and give another coat to each bracket on which they operate. Copper wires are particularly susceptible to smoky climates and as most relay systems are operated in industrial areas, the cadmium copper alloy is found to be most suitable. Although many companies use heavier gauges, single 18's conductors give quite satisfactory results, and the weight, working out in the region of 40 lb. per mile, does not involve too great an expense.

Resistance of Conductors.

Most new-comers to radio relay attach great importance to the resistance of the conductors and go to great trouble and expense to keep these resistances as low as possible. In practice, however, it is found that the resistance of the lines, particularly in the case of large networks, is very useful, because a short circuit in one area does not always seriously affect the reception of subscribers on the same line, and restricts in a measure the area affected. In the writer's opinion, although resistance of the lines should be kept reasonably low, a moderate resistance is useful.

NOVEL DOG TRACK LIGHTING SYSTEM

The lighting system chosen for London's newest greyhound racing track at Stamford Bridge consists of 70 G.E.C. reflectors similar to those employed with so much success at the White City and other well-known tracks. These are equipped with 1,000-watt lamps.

An interesting feature of this installation is the use of a new type of collapsible standard specially designed by the G.E.C. for the track. Inclined poles are used, and these can be swung round from over the track and lowered by means of a ball and socket joint incorporated in the base, to the side of the track, where the fittings are protected by the wire fence. A folding support is also incorporated in each standard for use in the "down" position. These poles are sufficiently light to be handled by one man, and can be very quickly raised and lowered. The obstruction to vision due to the poles is practically non-existent. When football matches are being played the poles are completely out of the line of sight of spectators, and by arranging some of the poles to lay to the left, and others to the right, provide a clear path to the ground.

Questions and Answers by Practical Men

Readers are invited to send problems of practical interest. Letters should be addressed to "The Practical Electrical Engineer," 8-11, Southampton Street, Strand, W.C. 2. Envelopes to be marked "Problem" in the left-hand corner. Replies to questions are also invited and all replies published will be paid for at our usual rates

THIS MONTH'S NEW QUESTIONS

Solenoid Coil for A.C.

I wish to make a solenoid coil for A.C. 230 volts, 50 watts, with a pull of 20 lb. for $\frac{1}{4}$ in. (I just want the first pull up or slam acting for about a second just to get something up in position). I do not wish to use any form of converter if I can help it.

ARTHUR S. NUNN (Nottingham).

Converting a D.C. Motor into an A.C. Motor.

I have a 200-230-volt D.C. shunt-wound fan motor, the dimensions of which are shown on the enclosed sketch, and wish to convert into an A.C. series motor to run from 230-volt, 50-cycle mains. Please be good enough to furnish me with a winding specification for same. Will you tell me how the coils should be disposed on the armature?

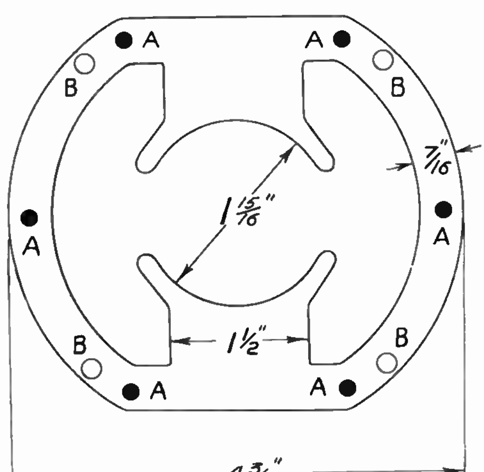
The dimensions and details of the motor are as follows:—

Length of armature, $1\frac{5}{16}$ in. Diameter of armature, $1\frac{13}{16}$ in. Diameter of armature tunnel, $1\frac{15}{16}$ in. Number of armature slots, 12. Depth of armature slots, $\frac{5}{16}$ in. Width of armature slots at the top, $\frac{1}{4}$ in. Width of armature slots at the bottom, $\frac{1}{8}$ in. Number of commutator segments, 24.

The six thick dots on field magnet marked A are rivets holding the laminations together. The field magnet is laminated to a thickness of $1\frac{1}{4}$ in.

Also the four holes on field magnet marked B beside them are for passing the long screws through to clamp up the end covers of the machine.

G. E. HOLSINGER (Ceylon).



DIMENSIONS OF THE SHUNT-WOUND FAN MOTOR REFERRED TO BY MR. HOLSINGER.

Windings for a Small Motor.

Could you please advise me the gauge and number of turns to wind a small motor for 30 volts, 2 amps. D.C.? The particulars are as follows: Armature, $2\frac{1}{2}$ in. diameter, 3 in. long. Fifteen-slot circular about $\frac{3}{8}$ in. diameter. Fifteen-part commutator. Four fields, $2 \times 1\frac{1}{2} \times \frac{1}{2}$ in. each.

A. T. WILSON (Ayr).

D.C. or A.C. for Shipping Purposes.

What are the advantages of using D.C. current in preference to A.C. for shipping purposes? Also, why is a 25-cycle current better for power purposes than 50-cycle?

JAS. H. FRANCIS (Liverpool).

REPLIES TO PREVIOUS QUESTIONS.

Enamelling the Outside of a Floodlight.

I shall be glad if you would give me advice on the following points :—

(1) *For enamelling the outside of a 300-watt sheet metal floodlight, what would be a suitable heat-resisting black enamel to give :*

(a) *a dull finish ;*

(b) *a glossy finish ?*

(2) *Can you give me the name of a firm who wholesale or manufacture mounted or unmounted lenses and glass reflectors suitable for spotlights and projectors ?*

C. W. S. (Chingford).

The three enamels given below will all stand great heat :—

(*a*) Dullite.

(*b*) Blackall.

(*c*) Raphaelite.

The first-named will give a dead flat finish, while the second and third mentioned enamels give a glossy surface.

A very pleasing eggshell finish can be obtained by using (*b*) or (*c*), and when dry and quite hard slightly "flat" the surface by rubbing with a wet rag impregnated with powdered "rotten stone," or very fine pumice-stone.

The best firm specialising in the manufacture of high-class lenses is Messrs. Ross, Ltd., Old Town, Clapham, S.W.4. This firm also make reflectors at a subsidiary factory ; in fact, they deal with all types of optical work. H.J.B.

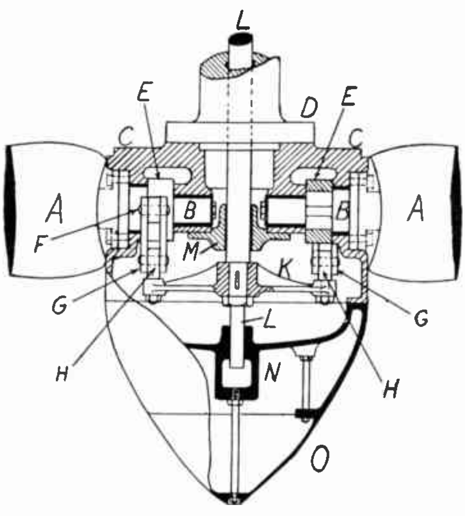
The Kaplan Turbine.

Could you give more information as to how the adjustable blades of the Kaplan turbine are arranged and worked ? The article in which this turbine was mentioned was published in the December, 1932, issue of THE PRACTICAL ELECTRICAL ENGINEER *in the article on "Power Distribution in Sweden."*

W. A. B.

The Kaplan water turbine is of the vertical shaft type and has adjustable impellors for the purpose of obtaining a high efficiency over a wide range of loads (see page 159, Vol. I of THE PRACTICAL ELECTRICAL ENGINEER).

Each of the four impellers, A, is coupled to a short horizontal shaft, B, and each of these shafts is mounted in separate bearings in the upper portion, C, of the boss, which is coupled to the lower extremity of the vertical main shaft, D.



THE ADJUSTABLE BLADES OF THE KAPLAN TURBINE.

Each of the impellor shafts is fitted with a crank E, and each crank pin, F, is connected by links, G, to an eye bolt, H, fitted to a four-armed spider, K. This spider is keyed to the regulating shaft, L, which is located inside the main shaft, its lower end being guided by the bearings M and N. This shaft, as already explained in the above - mentioned article, is given limited up and down movements by a servo motor controlled by the governor of the turbine, and by means of the spider and links these movements are imparted to the crank pins F, thereby causing corresponding angular movements of the blades of the impellors.

The lower portion of the boss and the cap O are shaped as shown in order to give minimum resistance to the passage of the water.

A. T. DOVER.

Miniature Circuit Breaker for House Lighting.

Is there any definite regulation prohibiting the use of a miniature circuit breaker on the live leg of an ordinary house-lighting circuit, the neutral being connected direct to a neutral bar? I have in mind a sub-circuit as above, permitting the one control only and therefore dispensing with the usual fuse in either leg and a tumbler switch on the live leg.

The neutral is at earth potential, and provided the neutral wire can easily be disconnected for testing, is there any reason for insisting upon two fuses?

R. W. Kane (Johannesburg).

The use of a single-pole circuit breaker is never prohibited, except in the neutral of a complete three-wire D.C. system, which does not apply in ordinary house lighting. If your neutral were to develop a dead-short to earth, and if, simultaneously, a very large leak were to go to earth on one of the lines in your neighbourhood, the leakage current might try to return to the neutral via your system, with disastrous results, unless your connection to the neutral is protected by a fuse or circuit breaker. If your circuit breaker is carefully set, the inclusion of fuses need never give you any bother. W.M.

Trickle Charger for a Model Railway.

I wish to set up a trickle charger in connection with a model railway. The power is obtained from a 12-volt car accumulator of 40 amp.-hour capacity.

It is proposed to use a Westinghouse metal rectifier giving 12 volts 1 amp., as this is the most convenient. However, since one cell when fully charged gives 2.2 volts, six such cells will give 13.2 volts; in other words, the accumulator is never fully charged. Is there any way of getting over this difficulty other than, say, charging three cells at a time from the rectifier?

B. W. Hind (Pinner).

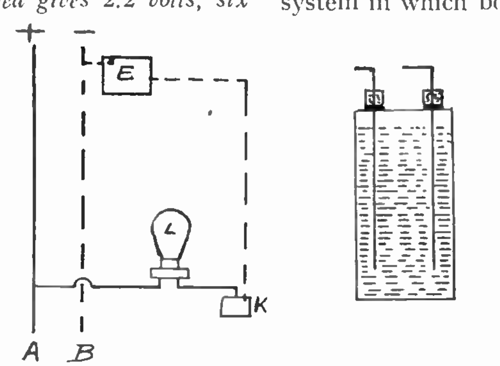
It will be quite all right to use the 12-volt, 1-amp. Westinghouse metal rectifier and charge the 12-volt accumulator without altering the arrangement of the cells, as although the rectifier is rated at 12 volts, it takes a much larger voltage than this to send 1 amp. through the 12-volt battery, and this is allowed for by the makers of the rectifier. If a transformer with a suitable winding is chosen, so that when the battery is discharged, i.e., down to 10.8 volts, the voltage is sufficient to send 1 amp. through the battery, then, when the back pressure of the battery rises the only result is a fall in the value of the charging current, to something less than 1 amp. J.S.M.

Finding the Live Wire on a D.C. Circuit.

When testing for a live wire on A.C. it is possible with a pair of leads, a lamp holder and lamp, to make the lamp light when the "live" wire and an earth are touched on. Is it correct that on a D.C. circuit by this method you cannot tell which is the live wire? If this is so, would you kindly tell me the best way to find a "live" wire on a D.C. circuit?

F. W. Clarke (Edmonton).

Tramway systems and many private plants work on a D.C. two-wire system with one pole earthed at the generating station. On such plants it is always possible to find the positive wire by means of testing leads and lamps as shown in the diagram. If the positive testing lead be put in contact with the positive wire A and any good earth as at K, a circuit will be established back to the station earth E, and the lamp L will light up. On a D.C. system in which both poles are insulated, or on the three-wire D.C. system which has the neutral earthed and the main negative and positive poles insulated, other means can be used. Pole indicating paper is sold made up in books like books of litmus paper. One of the leaves is taken out, damped, and both testing



Two Methods of Finding the Live Wire on a D.C. Circuit.

leads held on to it. The wire attached to the negative lead will turn red. If an ordinary D.C. voltmeter suitable for the circuit voltage is available this can be used. Try the voltmeter across the bus-bars to test its polarity. Voltmeters of this type read from left to right and have the positive terminal on the left; often this is marked. If this be placed across the wires to be tested, the voltmeter will give a reading from left to right when its left-hand terminal is placed on the positive line, and the right-hand terminal on the negative side; if the leads are then reversed, the voltmeter needle will read in the reverse direction; that is, the needle will come hard up against the stop at the left hand of the scale; thus giving a check on the test. On a three-wire system the same test can be made, but the voltmeter must, of course, be capable of reading the full pressure across the outers.

Another method is to take two strips of lead—old lead sheathing from cables, hammered out flat and cleaned, will do—and suspend them in a tub as shown in the diagram. Fill the tub well up with water, keep the lead plates, say, 4 in. apart, and throw into the water a table-spoonful of salt and connect the testing wires to the lead plates Adjust the distance between the lead plates so that a current of, say, 10 amps. is maintained. In a few minutes the plate attached to the positive pole will turn brown There is also a glass tube tester sold, containing two electrodes in a transparent liquid. When the testing wires are attached to the terminals of the electrodes, the negative electrode becomes surrounded with a bluish tinge; this colour being absorbed into the liquid again when the test wires are disconnected.

W.T.W.

Finding the Live Wire on a D.C. Circuit.

If a D.C. moving coil voltmeter of a suitable range be available, the "live" side of a D.C. circuit may be found quite simply. The moving coil voltmeter will only indicate over its scale when the positive wire of the circuit is connected to the positive terminal of the instrument. If the connections are reversed the voltmeter merely tends to give a negative reading.

Should the system be D.C. 3-wire at 460 volts between outers and 230 volts outer to neutral, care must be taken. As far as positive to neutral is concerned the above instructions apply, but when the voltmeter is connected between the neutral and the negative outer the neutral wire is the "positive" and should be connected to the positive terminal of the instrument.

Should no voltmeter be available, the live side can be found by other methods. The neutral wire of the 3-wire system is always earthed, and the outers may be found by using the test lamp as suggested in the question.

To discover which is the positive outer and which the negative, use may be made of pole finding paper. This paper may be bought in small rolls. A portion of the paper must first be damped; the two ends of the live circuit are then applied to the paper at a safe distance apart. The "negative" wire of the two will make a distinct mark on the paper.

With a two-wire D.C. circuit, the pole-finding paper may alone be used.

Further possible methods, though only suitable for low voltages, would be to rig up a water voltmeter for the electrolysis of water, or a copper sulphate bath as used for plating.

THOS. G. FRANCIS, B.Sc., A.M.I.E.E.

Finding the Live Wire on a D.C. Circuit.

Is it possible that you are confusing "finding the live wire" with finding the polarity. The live wire being the one which is at a potential different from that of earth, may always be found with a test lamp, but on a D.C. circuit (3-wire) this gives no indication of polarity, which may be found by means of pole paper, using the test lamp as a resistance. The reason for this is that both the positive and negative "outers" are live wires.

W. M.

Printed in Great Britain for the Proprietors, GEORGE NEWNES, LTD., 8-11, Southampton Street, Strand, W.C. 2, by WILLIAMS, LEA & Co., LTD., Clifton House, Worship Street, E.C. 2. Sole Agents: Australasia: GORDON & GOTCH (Australasia), LTD. South Africa: CENTRAL NEWS AGENCY, LTD.