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PART 38

A PRACTICAL WORK WRITTEN BY EXPERTS

room secures much advertising value from a signboard outside the premises, more particularly so as such premises, as I shall endeavour to show later in this article, should be as cheap as possible and quite unpretentious, and therefore presumably in no very conspicuous position in a populous street.

What Form of Publicity is Best?

The choice really amounts to one of the first three, and there is a considerable division of opinion as to which of these three brings the best results. Even after considerable experiment, it is not altogether easy to decide which brings the results, since it is very difficult to key the particular form of publicity so as to be certain of the form which has brought work.

Let me give an example. The contractor may insert a weekly advertisement in the local paper and canvass the neighbourhood personally and at the same time send out circulars. After a few days or a few weeks a customer rings him up for an estimate for some electrical work. It is clearly a very difficult matter to decide with any degree of certainty whether that custom has been secured by one form of publicity more than by another; even a pointblank question to the customer is not always satisfactory, for it is a remarkable thing that customers never seem to remember how or where they received the suggestion that they should patronize a particular firm.

Why Circulars are Generally Best.

Although it is impossible to collect any definite opinion on the subject, it is possible here and there to get at least a suggestion as to which is the better form of publicity for the electrical contractor. My own experience goes to show that the circular gives the best return for money spent, for although only a small proportion of the circulars sent out brings in business, that which it does bring in is usually found to pay for the cost of circularising with a good deal to spare. So long as the results of a circular pay for its cost it is clearly only a matter of mathematics to decide that circularising must be at least one of the forms of attracting business to be employed.

Personal Canvass.

Personal canvass at times may be extraordinarily valuable. Particularly is this the case when dealing with architects and builders who know at least something of the trade of an electrical contractor and in many cases are quite agreeable to discuss the matter, with the result that the electrical contractor may get an opportunity for tendering for work to such architects or builders. Personal canvass to ordinary householders may in certain circumstances be of value as well, but usually it is a very difficult proposition unless a contractor goes to the house with some specific article or some definite story to tell.

Importance of Personality.

One must be particularly careful here, for I know that many contractors do successfully canvass their localities, but I feel that such contractors probably possess a particular personality which forces its way through the front door and over the hall doormat. With many contractors—probably the average contractor—a personal canvass of householders represents a very great expenditure of time, resulting in one or two rather ineffectual talks with the lady of the house, the householder being away at work. I do not count the mere presentation of a card as being personal canvass, for it really comes into the category of circularisation, though the circular in this case is a trade card and is delivered personally instead of through the post. If the electrical contractor has some particular proposition to put to people in the district, then a personal canvass may be extremely valuable. If he takes up the agency for some interesting device, for instance, he may well get a hearing at many houses which will stand him in good stead.

Advertising in the Newspapers.

Newspaper advertising is a real problem, and I have not altogether satisfied myself on this point. Here again it is almost impossible to assess its value in terms of results in any but a very vague manner. One thing is certain; spasmodic advertisements in any paper are valueless to the electrical contractor. Sustained re-

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petitive advertisements appearing weekly or daily in the same part of the paper and of a similar layout to one another certainly do have a value. Whether or not the value is as great as would be that resulting from the same amount of money spent in circulars I am not prepared to say. In fact I will admit that I have a very strong respect for the good old circular as a business-getter.

CAPITAL.

In order to start a business some capital is necessary. It may be large or it may be small, but one cannot possibly get away from the fact that *some capital is necessary.* It may be argued that a man who can live at home with no cost to himself, either for board or lodging, who is allowed to use one of the rooms in the house without cost, and is even permitted to make use of the house telephone need have no capital if he is prepared to start in business by doing these jobs himself. But the existence of these facilities for starting business is really only another form of capital.

The average man, however, will probably start on a slightly more pretentious scale; and even though he is beginning in only a small way of business, he may want premises; he may want staff; he will want a telephone; in fact, he will want some or all of the various things which cost money, and to which I refer in this article.

Turnover Depends on Capital.

With a given amount of capital it is impossible to do more than a given amount of turnover. By starting in a small way and carefully conserving what profits he may have made from year to year he can accumulate sufficient reserve to increase the turnover of his business. If he takes out of the business every bit of profit which it makes he cannot possibly hope to increase the turnover. This is really rather a fundamental fact, and it is of very great importance since a man does not start his business in a small way expecting to continue in a small way for ever. He has visions of that mansion in the country and that Rolls-Royce which he is going to buy when he has made money.

Large Contracts Cost Money.

Now there is probably no reason at all why he should not make quite a lot of money as an electrical contractor, provided his business expands. But his business will not and cannot expand if he has not got the financial resources to expand. A large contract costs a lot of money to carry through, though at the end of it there may be a substantial profit attaching thereto. Unless a contractor has got, or can get, the necessary money to finance him through a large contract, or a large number of small contracts, then he cannot accept those contracts.

Consult an Accountant.

The whole matter is one of accountancy and, just as I take the view that a person requiring information on electrical subjects gets the best information from an electrical engineer, so I have always held that in the matter of finance or accountancy a man who tries to work everything out for himself is a fool. He should go to an accountant, whose profession it is to study these matters. It will not cost him much and it will repay him handsomely.

CHOICE OF DISTRICT.

Many—probably the majority—of those who decide to go in for the electrical contracting business are more or less forced, for some reason or another, to start business in some particular district. It may be that it is the district which has given them the idea of starting; it may be that they have a large number of friends and acquaintances who may help them in the early days by patronage and publicity. For the benefit of those who do not care in what district they set up shop, however, it may be worth while considering those points which should influence an electrical contractor in his choice of districts.

The Most Important Consideration.

Most people would probably say that the degree of competition already existing in a certain district is the biggest, if not the determining, factor in one's decision.

Personally I do not agree with this. I think that there is a far more important factor which is often neglected. That is the price at which electricity is being supplied by the local electricity supply undertaking. I think, perhaps, that I can make the importance of this factor clearer by pointing out that, assuming an electric iron is used for about one hour per day, as it is in many households, it consumes in electricity in any year current to about twice its own value, if that electricity is supplied at the cheap figure of one penny per unit. All that sounds a bit involved, but the point is this, that a difference in price of electricity of 1d. per unit—that is to say, the difference between threepence and twopence, or between twopence and a penny—represents to the consumer a saving or a loss in any one year of twice the value of the electric iron. Thus a customer is more likely to be influenced in the degree to which he uses electricity by the cost of current than by the price of the commodity or of the wiring. Where there is an attractive tariff for electricity supply it will be found in nearly all instances, however great the competition, that most of the electrical contractors in that district do well. I know that this is rather a bone of contention, and that supply undertaking engineers in many cases maintain that it is the cost of wiring which influences domestic electrical progress, and not the cost of current ; for all that, I am inclined to think that a little bit of mathematics and accountancy puts the matter beyond any dispute.

Competition.

Competition is, of course, an important factor. Not so much the quantity of the competition, but the quality of the competition. In a good progressive district with a cheap electricity tariff, a large number of good-class electrical contractors can flourish. But in a similar district where the quality of workmanship is of a low standard the matter becomes one of price-cutting and nobody flourishes.

Competition from a Supply Undertaking.

There is one form of competition which stands in a class by itself ; that is competition from a supply undertaking. Certain undertakings throughout the country obtain powers to operate a wiring department. As such they immediately begin to compete with the electrical contractor. I don't suppose there is anyone, except supply undertakings themselves, who has a good word to say for a state of affairs which permits of competition in this manner ; but, unfortunately, however much we may be agreed that the thing should not be, we have got to face it. These undertakings represent in most cases the worst form of competition that an electrical contractor has to put up with.

Districts to Avoid.

I should emphatically advise any electrical contractor to avoid, if he can, a district where the supply undertaking has a wiring department and comes into the market in competition with the electrical contractor. It may be added that the work of the wiring departments of these undertakings is sometimes below the standard which many electrical contractors set themselves.

Where Supply Undertakings Have the Advantage.

The supply undertakings have two outstanding advantages over their contractor-competitors. In the first place, to the lay mind of the general public, anyone who is connected with that mysterious place, the "power station," seems to be almost a god in the matter of electrical engineering. They are, quite wrongly, considered to be the highest authority in the land on every subject connected with electricity. This impression is natural, but erroneous, and it does give to the wiring department of the supply undertaking a moral pull over their competitors ; for where a customer may be undecided as to whom he should go, he is apt to fall back on the phrase : "Well, I can't be wrong if I go to the supply people." The second advantage is that in the exercise of their normal functions, that of making and selling electricity, they have behind them the authority of Parliament. They have in this responsibilities and privileges of a

Fig. 3.—An Example of Up-to-date Practice in the Arrangement of an Electrical Showroom.
(*Photo by courtesy of Messrs. Troughton and Young, Ltd.*)

statutory nature. But whereas this statutory authority refers only to the making and selling of electricity, it is natural for the public to think of their wiring department as being in some way official.

A Third Advantage.

I said that they had two outstanding advantages, but there is really a third; for where they do find themselves faced with a competitive estimate, they are in many cases able to arrive at a cost considerably less than that of the electrical contractors owing to the fact that through the generation and distribution side of the undertaking they are very large buyers of certain classes of materials and, as a result, get special discounts and favourable terms.

To sum up, therefore, we may say that the choice of district in which to open up business should be influenced by the price at which current is sold in the district, the quality of the competition in that district and the question as to whether or not the supply undertaking does undertake wiring work or is likely to do so in the near future.

PREMISES.

There is really very little to be said on the question of premises for the electrical contractor apart from the question of showrooms, dealt with in another section of this article. The contractor will have to visit practically all his customers, and it will be rare for a customer, whether architect or principal, to visit the contractor at his own office. This fact relieves the contractor of any feeling that he must occupy impressive or elaborate premises. The contractor can definitely suit himself without reference to anyone else.

Two Rooms Sufficient at First.

He will probably find that, however small the business is when he starts, he will require at least two rooms, one of which will be the office, the other the stock-room or store. As the business grows it may become necessary for a workshop to be added for odd repair jobs which are required to be carried out. But at the same time that any expansion demands such an extra room as a workshop, it will probably demand an extra room on the office side for a private room for the principal.

Store Room Must Be Dry.

For the purposes of this article the office accommodation does not really matter: it is merely a question of what our electrical contractor and his staff are prepared to put up with in the way of discomfort, for the less comfortable they are the cheaper will the premises be, and the less will be the overhead expenses. But the store must be regarded in rather a different light; for on its position and construction will depend to a great extent the degree to which the stock remains in good condition and saleable. Damp is quite the worst enemy to be feared, for there are very few pieces in the electrical contractor's stock which are not liable to be damaged by damp.

Beware of Conduit Rusting.

Conduit, which is after all the backbone of the electrical contractor's business and therefore of his stock-room, will begin to rust very rapidly at various points if it is stocked for long in a damp store-room. This material is, in theory, enamelled all over inside and out, but in practice there are little pinpricks where the enamel has chipped or worn off, in addition to the threads or ends of short lengths. Although a little bit of rust does not necessarily mean that the tube is useless for its purpose it does not give a nice impression to send any but clean black tubing on to a job. Apart from visible damage it is very necessary to remember that cable, if left in a damp atmosphere, will absorb so much dampness into the insulation that when the cable is erected into position for some contract the insulation test becomes very, very bad.

See that the Store-room is Accessible.

While on the subject of conduit remember that the store-room must be accessible for all tools and stock. I myself had, on one occasion, very nearly decided to rent a particular room as a store-room, conveniently placed, airy and dry, and it was not until I was on my way out after inspecting it that I realised that the narrow, twisting stairs entirely precluded the possibility of carrying conduit in and out.

EQUIPMENT.

The equipment of the electrical contractor can be divided into three classes. The first is office equipment; the second what I will call technical equipment; the third, productive equipment.

Office and Technical Equipment.

By office equipment I mean such things as telephones, typewriters, adding machines, invoicing machines, filing systems, etc., in fact, everything which relates to the running of the business from the office.

What I have called technical equipment embraces all those pieces of apparatus which are sometimes desirable and sometimes necessary to the proper conduct of the business from its more technical aspect. I refer to such things as an insulation tester, voltmeters, ammeters, foot-candle meters, etc. It is impossible to say that a business cannot be run without them, for many businesses do carry on without any equipment of this sort, nevertheless they are important enough to justify a position under the head of "equipment."

Productive Equipment.

Finally we come to productive equipment, which relates to any piece of apparatus which produces or is used to produce the particular commodity which the enterprise is trying to sell—in other words, wiring installations and the like. Examples of this class of equipment are found in the pipe-vice, the electric hammer, the pipe-bender, etc. All these pieces of productive equipment make an actual contribution to the electrical installation work which the firm is carrying out. That contribution may or may not be compatible with the cost of equipment; and that is precisely the point which has to be considered.

A Telephone is Essential in the Office.

The question of office equipment may be quickly disposed of, so far as this article is concerned. Practically the same principles apply in the case of any business undertaking, and since I am writing about the business of electrical contractors, I do not intend to be swept away into the ocean of general business equipment. Before leaving the question of office equipment, however, I should like to emphasise the fact that among the admirable economies which can and should be practised in the early stages of such a business that of trying to carry on without a telephone is quite hopeless. A telephone is more important than a desk or a chair.

Don't Buy Too Much Equipment.

With regard to that equipment which I have called technical equipment, a certain amount of it, though necessary from time to time in the conduct of the business, need not be bought outright at the start; in many cases it is possible to borrow a voltmeter or an ammeter. Although these instruments are fundamental to any electrical business, it will in practice be found that it is comparatively rarely that one is called upon to make use of them. Unless one walks warily in the early days in the matter of buying equipment of this nature, one can very easily run oneself into a very great deal of expense, and it is wise always to remember that every bit of capital expenditure ought to provide a definite return to the value of the interest and capital depreciation of that amount. If it does not, then it is not, so to speak, earning its keep, and it may be cheaper to hire the necessary apparatus when it is required—that is, if it is impossible to borrow it.

An Insulation Tester is Essential.

Quite the most important piece of apparatus coming into this category is the insulation tester, a machine made under various proprietary names, the best known of which is probably the "Megger." This appliance contains a hand-operated dynamo which applies to the conductors to which the terminals are connected a pressure of 500 volts, measures the current which passes and by a suitably graduated and marked scale under the pointer shows the result, not in terms of amperes, but of ohms and megohms resistance. This instrument is certainly necessary: that is to say, it has got to be used in electrical wiring installations of every sort when the job is complete and has to be tested for handing-over purposes. In every case where a new service is given by a supply undertaking the latter will make this test with their own insulation tester to satisfy themselves that the installation comes up to the required standard. In spite of this, it is much more desirable that the electrical contractor responsible for the wiring should have been in a position to make this test himself before the supply undertaking came into the picture at all.

Another occasion on which the insulation tester is valuable is when the electrical contractor is called in and asked to give an estimate for repairing any defect in the wiring of a house, or for rewiring any parts which he finds to be faulty. The insulation test is in such cases the obvious point at which he starts to decide what is or is not necessary. A foot-candle meter is a very delightful luxury to possess, but it is a luxury. It is an example of an instrument which comes at the opposite end of the scale from the insulation tester.

New Pieces of Apparatus.

From time to time new pieces of apparatus of this sort come on the market, and one is very often tempted to buy an instrument because it fills what one imagines to be a long-felt want. When such occasions do arise, however, it is just as well to reflect carefully as to whether that long-felt want is genuinely in the interests of profit-making or merely desire for a rather fascinating toy.

Labour-saving Devices.

Lastly, we come to that equipment which is productive in every sense of the word. Equipment which is to all intents and purposes the same as tools. The electrician himself provides a certain number of tools, but there are others which he does not, in fact cannot, own himself, and which are supplied by the proprietor if the latter intends that his work shall be carried out by means of such tools. They are mostly, in a sense, labour-saving devices, and whether they save sufficient labour to compensate the proprietor for the price he has paid for them must be the deciding factor as to whether such appliances are or are not desirable.

Points to Consider Before Buying Expensive Equipment.

These pieces of equipment range from such obvious necessities as the pipe-vice to interesting and sometimes valuable instruments such as the electric hammer. In general, the value of equipment of this sort is proportional to the size of the contract on which they are being used. If one electrician and his mate are sent to install one point in a house, it will clearly not pay the contractor to make them carry round with them an electric hammer, a pipe-bender and other weighty gear of this sort; it will be more economical that they should make the best of the job without these scientific aids; that they should bend their tube through a hole in a piece of timber and make their holes in the wall with a hand hammer and jumper. If, on the other hand, there are twenty men on one contract, pipe-vices, pipe-benders and electric hammers can be kept employed by one or other of the men practically every minute of the day, to the enormous benefit of the labour costs on that particular job.

All this seems very obvious, I know, but obvious as it is, it is amazing how apt one is to lose sight of the real purpose of any labour-saving device, which is to save time and money; if it does not save time and money, it is not an economical device, however convenient it may be.

The following is a list of various appliances for productive equipment in the order in which it will probably be found that the electrical contractor finds it necessary to buy them.

Steps.
Pipe-vice.
Stocks and dies.
Drilling machine (hand or electrically operated).
Parallel jaw vice.
Electric hand drill.
Cooke's cutters.
Conduit taps and dies.
Pipe bender.

Automatic hammer (hand or electrically operated).

Before I leave this subject may I point out that it is a very wise maxim to regard all equipment as guilty of extravagance until it has been proved innocent.

STOCK.

One of the most fascinating thoughts about going into some business is that which pictures a large stock of all the many hundreds of accessories which one has so long wanted to possess, and now at last will possess. In just this way the embryo electrical contractor, at any rate if he is like me, will derive a certain amount of satisfaction from the anticipation of standing in his own store and looking at his own stock: dozens upon dozens of switches, hundred-yards upon hundred-yards of cable, gross upon gross of connectors, long lengths of conduit neatly graded and stacked; in short, everything that he can possibly need in his business available to his hand. This is a pretty dream but rather dangerous.

A Heavy Charge on the Business.

Stock can be compared with a workman: the latter pays the firm only when he is kept at work. As soon as he comes back to the shop and starts to twiddle his thumbs, not having another job to go to for the moment, he becomes a heavy charge on the business which is paying him money and receiving no work in return. So with this stock, every single item which is kept in stock is costing the firm some money in terms of interest and depreciation, in addition to the rent of the space where it is lodged. The amount may not be great, but it exists and it is inevitable.

Where Large Stock is Permissible.

The only way in which stock can earn the contractor money is by being used. So long as any given item is being turned over rapidly, that is to say, is being used frequently, necessitating a frequent re-stocking of that particular thing, then a large stock does not matter; it will, in fact, be an economic convenience. But where stock is not being turned over; where it is lying week after week, month after month, even year after year, waiting for that customer who never seems to want to buy it, then we may safely say that that stock should never have been in its particular bin; it should never have been bought, and if it has been bought, it should be sold immediately at whatever sacrifice is necessary. I once bought a gross of some particular accessory, not because I wanted them, but because I thought they were cheap. I bought them three and a half years ago, and I have sold one. If any person wants the remaining one hundred and forty-three, they can have them for the taking.

What to Start With.

To start with, the electrical contractor should buy what he wants and only what he wants. He should live almost from hand to mouth, keeping a messenger hard at it running out for single switches, ten yards of cable and such small items. After a comparatively short period he will, or should, have learnt exactly what he *must* have in stock, and exactly what he can do without. In the case of items which are rarely asked for, or rarely required in wiring work, he will find that it will pay him better to send a special messenger to his supplier when the occasion arises than to keep in his store a wasteful stock of these items.

PERSONNEL.

The personnel required when a start is made with a new business must naturally vary according to the energy of the principles and the amount of work which the contractor expects to get in the near future. The actual productive labour, that is the tradesmen or craftsmen who work at the actual job of erecting installations as opposed to persons who contribute to the running of the business in the office or in any other part of the organization, and who are known rather unkindly as "unproductive workers," will fluctuate in the employment of the electrical contractor according to the amount of work which is being done at the moment. Except in particular circumstances such men will be taken on as and when there is work for them and will be paid off as and when the contract comes to an end or work diminishes.

The unproductive workers, however,

are somewhat differently placed. The notice to them will, of necessity, be longer and one does not expect to have frequent fluctuations in the quality or quantity of one's unproductive personnel.

Obtaining the Contracts.

The principal will, presumably, obtain and carry out all contracts. He may even, in the early days of a small business venture, do the work with his own hands, though I do not really think that this plan, economical as it is, will lead to much progress, since the principal should be perpetually on the look-out for more work and, having secured it, should hand it over to an electrician to do the actual work while he himself supervises.

A Good System of Working is Essential.

One of the most important, if not the most important, thing in an electrical contractor's office is a good system of costing. If the contractor is competent to work out a system and keep the records of this sort himself and if, in addition, he has the time, then the problem solves itself; but if he has not, I think he should employ some competent person to do this work as the most urgent requirement of his business. He may be lucky and secure a typist who can do this work; if so, he has secured a pearl of great price.

Messengers Will Be Needed.

When he gets really busy he will find that a messenger of some sort is essential, for goods will have to be collected specially from suppliers and delivered either to customers or to the workmen on a job. In fact, when things really begin to hum, one messenger will be quite insufficient. I don't think that a storekeeper is actually necessary in the early days of a small business, for the principal can arrange to do all the work that is necessary here, even if he does from time to time have to call in a little extra help. But when he does take on a storekeeper, that storekeeper must be efficient and honest.

SHOWROOMS.

The showroom of an electrical contractor must be regarded as an entirely separate business from the electrical contracting side of the concern. The two branches can, and should, work in close harmony and help one another a great deal, but they are distinct and should, I think, be kept so. The main principles of running a showroom apply to a certain extent to all forms of retail business. But in the case of the electrical contractor's showroom he is liable to have his technical work as an installation contractor judged on the merits of his showroom.

Disadvantages of a Large Stock.

The showroom must be up to date, but, like the store room, it should not be overstocked. Prices and fashions in electrical equipment change so quickly that overstocking of a showroom may well result in the proprietor being landed with a lot of useless and valueless stock. It is probable that, for the selling of electrical equipment from a showroom, a man is better than a woman, as an assistant or showroom manager. I don't think, necessarily, that his intrinsic worth as a salesman is any greater, but since a great deal of domestic electrical apparatus is still regarded with a certain amount of suspicion by the average householder, it does seem to inspire more confidence if a certain piece of apparatus is sold to him by a man than if it is sold to him by a woman.

Don't Create an Atmosphere of Mystery.

Arising out of this, a lot of salesmen of electrical apparatus do, I feel, make rather a mistake in encouraging this air of mystery and suspicion. They will sell, for instance, an electric iron with the air of a conjurer showing a bit of real magic, instead of trying to impress their audience with the fact that an electric iron is one of the simplest pieces of apparatus imaginable, containing practically nothing to go wrong and nothing to cause the least degree of alarm. Most people are amazed on being shown the inside of an electric iron, for they find it so much more simple in form than they had expected. I think that emphasis on this simplicity may be turned to very good account in selling all apparatus.

However, I do not propose to waste much space on the subject of showrooms,

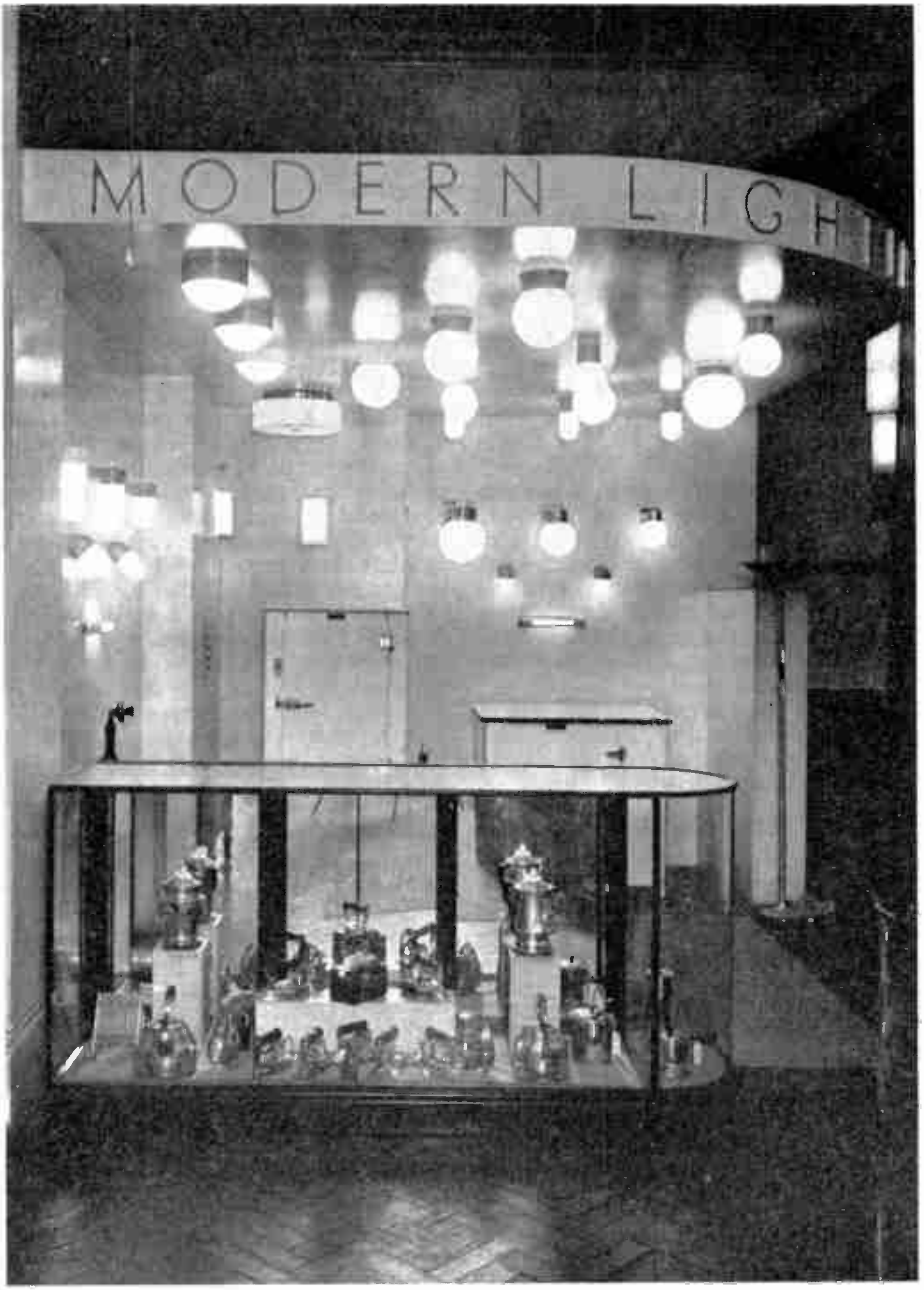


Fig. 4.—A Special Display of Modern Lighting Units in an Electrical Showroom.
(*Photo by courtesy of Messrs. Troughton and Young, Ltd.*)

for it is with the other side of the business that I am concerned at the moment.

SALESMANSHIP.

One is, perhaps, rather too prone to think that the art or science of salesmanship applies only to those persons who are occupied with the sale of goods over a counter, or with a door-to-door canvass. The electrical contractor soon finds that this is not so, and that salesmanship enters very deeply into his daily work. Salesmanship is, after all, the art of knowing and understanding the psychology of the buying public, and putting that knowledge to good effect.

Always Give an Estimate.

Nowadays, nobody buys anything until he knows the price. It is a very rare thing to discover a man who says, " Go ahead and send in the bill when you've finished." Nevertheless, these rarities do exist, and the art of salesmanship is, I think, very well served in such cases if the electrical contractor gives an estimate whether it is desired or not. I have found this usually impresses the customer favourably ; and even if the price is larger than he had expected, he reads it on the estimate form with a bit of a shock, but later in the day he recovers and the work proceeds. At the end of the job the account comes in and it is no shock to him to receive it.

Had the contractor hurried on with this work without having presented an estimate, the shock, when his account came in, would have been accompanied by complete antagonism on the part of the customer. He would say that the account was outrageous, that he would never employ that contractor again, that he would not pay it, and so forth and so on ; the net result might be a profit to the contractor, but it would most probably result in a considerable loss of goodwill. Now, as I have pointed out previously, goodwill is everything to the contractor and he is not a true salesman if, in his negotiations with his customers, he does not take into account the goodwill which he will gain or lose on a job.

Be Ready to Answer Any Question.

When asked a question, never hesitate. Prevaricate, if you like, but never hesitate. The general public look upon engineers as technical men, either knowing their job, or not knowing their job. Those who know their job have an immediate and ready answer to any question ; those who do not know their job are those who preface their answers by " I think." It is a peculiar thing that a man will allow his doctor to be uncertain ; to call in a second opinion ; or even to say, " We'll try this medicine and see if it does you any good." But they will not extend this privilege to electrical contractors. It is sometimes very difficult indeed when one is asked a poser of a question which quite reasonably may entail the reference to some book or other, or to a manufacturer's catalogue, to put into execution the advice which I have just given. But an agile and ready wit can usually contrive an answer which, while seeming to be definite, in fact is no answer at all. I must leave it at that, I am afraid.

Creating Confidence.

Hand in hand with this readiness to give a definite answer to everything goes what I would term the avuncular form of salesmanship. One takes the customer under one's wing, so to speak, avoids questions as far as possible and adopts a " Now-you-leave-it-to-me-sir-and-it-will-be quite-all-right " attitude. In many cases the customer will react favourably to the suggestion, and although he will not leave it to you but will, in fact, be nosing around the whole time the job is being done, he will think a great deal of the contractor and will tell his friends, " Good fellow, that Mr. So-and-so ; thinks of everything. I don't have to think ; comes up here and takes everything off my shoulders : good fellow ! "

ESTIMATING AND COSTING.

Estimating and costing represent such an important part in the electrical contractor's life that many volumes have been written upon the subject. Since they are, moreover, undoubtedly the most difficult branches of his work to carry out satisfactorily, it will be seen that my task in commenting on them in a short space is so responsible that I must try to shelve some of that responsibility by advising everyone at the outset to read up the subject, either in the books that are published or, alternatively, the many articles on this subject which are frequently published in the technical Press. Readers are specially advised to read the article entitled "Estimating for Wiring Contractors" which starts on page 1730.

The First Steps.

However, I cannot leave the subject at that. The word "estimating" is unfortunate, since it suggests a process rather like that of guessing the weight of a pig at a fête. There are, undoubtedly, occasions when the irrevocable decision to put so much profit on a job *is* rather like guessing the weight of a pig, but the man who regards all estimating from beginning to end on these lines will soon come to grief. It is clearly impossible to go very deeply into the question of estimating, but it may be a slight guide to suggest that this apparently impossible task is usually done by first estimating—which is only another word for calculating—the material which will be required on a given job and, after this has been ascertained, making a further calculation which will show how much of a man's time will be required to erect this material into position.

Minor Points that Affect the Estimate.

The estimate is not finished, however, when a calculation, however accurate, has been arrived at, as to the cost of the material and the cost of the labour. There still remains the question of the cost of selling the installation. Presumably some member of the staff has, in the first place, been occupying his time in getting the order. In the same way someone has been spending his time making out the estimate; a typist has had to type out the estimate; many telephone calls have been put in; the rent of the office has been paid—or, we hope it has—while the preparatory work on this job has been carried out; various insurance policies have been kept going; in short, all those innumerable expenses which are classified under the heading of "overhead expenses" have been incurred, not all for this particular job, but a very definite proportion for this job.

Moreover, these same expenses will continue during the progress of the job. These overhead expenses can either be allocated to each particular estimate, according to the amount of expense which is actually incurred for that job, or they may be allocated in the form of a percentage arrived at by taking the ratio of the annual overhead expenses of the office to the annual turnover of the business.

The Question of Profit.

When the cost of any given job has been estimated—I think I prefer the word "calculated"—and the necessary figure has been added to the estimated cost to cover the overhead charges, the contractor is then free to put on his profit. It is impossible to make any rule or to give any advice as to what profit he should put on; it is influenced by so very many factors, such as competition, the state of the contractor's own business and, of course, what the contractor actually wants to get out of it. But if the original estimating and additional oncost—that is, the figure for overhead charges—have been properly arrived at, the contractor can have the satisfactory feeling that whatever profit he puts on *is* a profit. If his cost for labour and materials comes to £50 and his oncost figure comes to another £10, resulting in a total cost of £60, then he knows that if he puts in an estimate for £60 0s. 1d. he will get a penny profit. Some contractors, I believe, ignore the oncost figure and rely in getting it back from the profit which they have put on to the net cost of labour and materials. This may work out satisfactorily, but the system fails to give that clear-cut, decisive information to the contractor as to what his real net profit is going to be.

Why Detailed Records Should Be Kept.

When the job starts it is imperative that the most detailed records should be kept of every item of material and every minute of labour which go to the execution of that job, and properly recorded in a manner which facilitates quick reference. This is necessary from many points of view. First, and most important, it enables the contractor to "hold an inquest" on the job after it is finished to see whether he

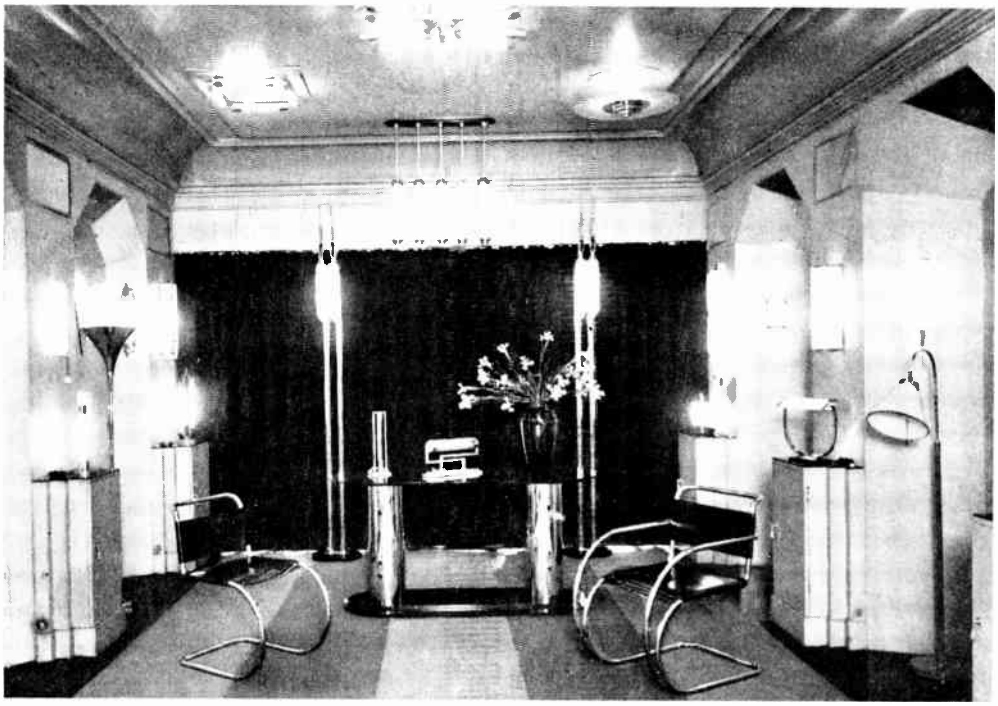


Fig. 5.—Another Display of the Most Up-to-date Electrical Fittings.
(*Photo by courtesy of Messrs. Troughton and Young, Ltd.*).

has made a profit, and if so, how much profit; or, if a loss, how much loss; and, again, what his unexpected profit or loss was due to. He may find that in his estimate of quantities he had allowed for so many yards of cable, whereas his cost card of that job when it is completed shows that he has used considerably more cable than he had expected. This will teach him that when he next estimates for a similar job he has got to be careful about the estimated quantity of cable. In the second place, the cost card of this sort enables the contractor on a long job to check how the job is going as it proceeds.

This applies more particularly to the labour, for if he has estimated that the job will take one month and, when half-way through, he sees from his cost card that he has already spent more than half the amount of money which he had allowed for labour, he can then hurry round to the job and "put a jerk" into the workmen. Finally, it is the only method of keeping a check on the material sent to a job in order to avoid pilfering. If a dozen switches are sent to a job and only eight appear on the cost card as having been used, then four should have been returned to the store at the termination of the job. If these four have not been returned, there has been a leakage.

Cost Cards.

In referring to the cost card perhaps I have been a little premature, since the essence of the system is that records be kept, whether in a book, or on sheets of paper, or on pieces of cardboard. I have myself found, however, and I think that many contractors would agree with me, that for quick and easy reference these costs are best kept on cards which are filed in a filing cabinet with an index. If some form of general subdivision of these cards is desirable, they can be used in various colours. Thus, a white card could be the cost card for an ordinary installation job, where a pink card would be the cost card for maintenance work and a green card, perhaps, for that referring to a contract for the supply of electric lamps. The system has to be worked out by each individual, but by using cards for one's costing there are considerable possibilities.

How Time and Money Can Be Wasted.

One of the ways in which a contractor can lose money—perhaps I should say fail to make money—is by having to spend a lot of time, and therefore money, in getting information before he starts a job. Let me give an instance. If Mr. X rings up and asks for a 2-pint copper electric kettle to be delivered at his house, the contractor may have to go round to the house to find out what type of plug socket is installed, so that he can send a kettle with the correct plug. This journey represents a definite expense, an expense which is not far short of the profit which he will make on that kettle. In some cases this cannot be avoided, but if at the top of every cost card (or, if he keeps cards for all his customers, on their own card) he allows a space for the entry of all relevant details of this sort, when he gets the telephone order he will merely refer to his card and find the size of plug required, the voltage of supply and other important details.

CARRYING OUT CONTRACTS.

Practically every contract that an electrical contractor carries out is subject to some form of guarantee. This guarantee is, in most cases, included with the contractor's estimate, but if it is not, it is there none the less, in accordance with common law. That is to say, that any defect which may arise in the work of the electrical installation which the contractor has carried out, if it be due to faulty workmanship or materials, will have to be rectified at the contractor's own cost.

Importance of Good Workmanship.

This fact alone is sufficient reason for insisting upon a good standard of workmanship. But even if such a defect does occur, and the customer has it put right at his own expense by another electrical contractor, the result may be even more damaging to the original contractor. To be reduced to having one's work put right by a competitor is an unpleasant fate, and one which usually means that the contractor has started on the downward path which will finally lead to failure. Electrical installation work, obviously, cannot always be of the best class. Within limits one has to cut one's coat according to one's cloth. If a customer will give no more than £1 per point he cannot expect so good a job as the customer who is willing to pay £2 per point. But, unless the electrical contractor has seen his way to doing at least a fairly reliable job at the price which he has quoted, it would have been better to have refrained from quoting.

Don't Cut Down the Quality after the Estimate has been Accepted.

Even having quoted and having, presumably, intended to put in a reliable job, some contractors experience a tendency to try to make a rather larger profit than that which they have allowed for, by cutting down the quality after the estimate has been accepted. A contractor may have sent in his estimate on the basis of using brazed conduit with pin-grip fittings; but, after the estimate has been accepted, he may feel an overmastering temptation to put in close-joint tubing with slip fittings without any continuity grip device. Such an alteration of his plans would undoubtedly save a considerable amount of money and would increase his profit on that job; but the temptation must be resisted. Apart from the normal code of business morality it would be quite fatal for him to be found putting in materials of a lower grade of quality to that which he had specified in his estimate—he would, for instance, be speedily expelled from the National Register of Electrical Installation Contractors, if he were on that Register.

Control of Labour.

The most difficult part of the electrical contractor's occupation is undoubtedly the proper control of his labour. Up to a point materials will look after themselves, but the labour question will not look after itself. If he employs trades union labour—and he will find that in most cases this course is necessary, even desirable—he finds himself faced with the fact that every wireman is entitled to the same amount of money for a given number of hours' work. No two wiremen, however, will do the same amount of work in a given period of time. Therefore it becomes of paramount importance that a contractor employs none but the best wiremen he can find. If he is clever he will, in course of time, collect around him a group of wiremen upon whom he can rely utterly. Then, after having found by bitter experience how very, very bad a bad wireman can be, he will learn how very, very good a good wireman is.

Supervise Every Contract.

With the best wiremen in the world, however, he must on no account neglect to supervise every contract methodically and frequently. Human nature being what it is, if he gets the reputation of leaving the job to the wiremen, the latter will in time start to take advantage of this fact. They will not necessarily be trying to get the better of the employer, but they will naturally take the view that there is no particular need to hurry. And there *is* need to hurry on every job, provided that the work is not skimped. Besides, there is the effect on the customer's mind.

Customers' Queer Ways.

One might suppose that, having accepted an estimate for a certain job of work to be done, the customer would sit back in his armchair and smoke a pipe, metaphorically speaking, until he got the bill when, assuming that the work has been satisfactorily carried out, he would pay it. Our young contractor will soon find that this is very far from being the case. He will find that in the vast majority of cases the customer evinces an amazing interest in every little aspect of the work while it is being carried out.

He will make a mental note of everything that is going on in connection with the work; in many cases he thinks that he knows far better how the work should be carried out than the contractor himself. Having successfully wasted a good deal of the wiremen's time he will, at the end of the contract, decide that those wiremen have not been working as hard as they should have done.

And, instead of reflecting that this is the contractor's funeral, he will argue to himself that if the contractor is making a profit out of work carried out so slowly, then a good contractor who had his work carried out more rapidly would have been able to put in a lower price, and he will pigeonhole this fact, in his mind, when he requires more installation work.

But if he sees the principal, or his deputy, come round and check up the work which has been done on the previous day, he will say to himself, " These people are hustlers." In addition, he will be afraid of being taxed by the principal for wasting the time of the wiremen, and he is more likely to make himself scarce until the contract is finished. There is no doubt about it, that, except for the fact that the customer is the man who pays the contractor, the latter would be much better without a customer at all!

Humouring a Customer.

I have referred to the fact that the customer is the man who pays the contractor. This should be kept well in mind at all times, for it excuses a lot. Just as there is a well-known London store whose motto is " The customer is always right," so the contractor must remember that his customer is always right. If there is difficulty with a customer during the course of a contract, there are two ways of getting over that difficulty. One is to persuade the customer that he is wrong, and the other is to admit that the customer is right, and to get one's own way, either by flattery or surreptitious means. The latter method is undoubtedly the only method which brings real success. Flatter the customer and he will be your customer for ever.

JOBBING WORK.

In addition to contract work, the electrical contractor will find that he is called upon to do a good deal of jobbing work. This phrase covers those little jobs which are little more than errands on the part of a wireman, the work carried out being of a very insignificant nature. This type of work is one of the biggest problems of the electrical contractor. Unless he has a lot of it, it will not pay him; on the other hand, he cannot possibly afford to ignore it, for nearly all jobbing work is of an urgent nature and the contractor who will not help his customer over an urgent difficulty may rest assured that he will not be given the chance of quoting for big work.

Emergency Calls.

When the contractor gets a call on the telephone to say that the electric cooker has ceased to function at half-past eleven in the morning and that two people are coming to luncheon, there is only one thing which the contractor can possibly do, and that is to send an electrician along to replace a fuse or repair whatever little defect has caused the trouble. But in order to be prepared to answer at all times these emergency calls, he must either have an electrician in attendance in his office or in his shop or, alternatively, he must disturb one of his local contracts—possibly to the great annoyance of his customer—and borrow a man from that job for half an hour or so.

Day and Night Service.

Therefore, I say that one of the urgent requirements of the electrical contractor, newly in business, is to establish a clientele of jobbing customers at the earliest possible opportunity sufficiently large that he can, as soon as possible, rely on having one man or more kept permanently at work on this class of work. It is in this respect that the supply undertaking, if it has a wiring department, is a serious competitor. For it is in most cases the first place that the customer turns to if that customer is in trouble with his electrical equipment. Moreover, the supply undertaking can conveniently give a day and night service. There is no getting away from the fact that in order to maintain a successful jobbing business a day and night service is essential.

Charging for Jobbing Work.

Charging for jobbing work is another problem; for the customer takes into account only the time which the electrician spends in his house repairing the fault. If this fault is a blown fuse, requiring three minutes' time to change it, the customer is apt to be a little annoyed when he gets a bill for more than sixpence, and it will take the contractor all his time, in many cases, to persuade the customer that his electrician may have spent three minutes on the fuse, but that he spent twenty minutes getting to the job and twenty minutes getting back to the shop.

The only way really to make this class of work pay when there is insufficient of it to keep a man employed all day is to take great pains in the selection of the electrician who is sent out to make these repairs. If he is, in addition to being an electrician, a clever salesman, he will, in many instances, pay for that time when he is idly twiddling his thumbs in the shop by selling an electric iron or by suggesting some alteration in the fittings at the house to which he is called. Though in this the contractor must be very guarded, for he must at all costs avoid the reputation of trying to make work for his men. This reputation is a very evil one.

INSURANCE POINTS.

To move from the more interesting aspect of getting business to its more prosaic side, it must be mentioned here that the electrical contractor starting in business must be very, very careful that he is insured for all risks which are insurable that are in any way likely to overtake him. This is not quite the platitude that it may appear, for the field of insurance offers more examples of shutting the stable door after the horse has got out than any other.

A man will continue in business, patting himself on the back every now and then because he is doing well, until one fine day an electrician drops a pair of pliers from the top of a ladder on to the head of a passer-by, and the entire profits made by the business for the year disappear in the damages which the electrical contractor has to pay.

Policies You Should Take Out.

Workmen's Compensation Insurance is, of course, essential and, following very closely on this, comes the Third Party policy, whereby any claim made on an electrical contractor by any other party, arising out of the contractor's conduct of his business, is met by the Insurance

Company. Another policy which is well worth considering is one which indemnifies the proprietor of a business against temporary injury or illness which incapacitates him from working for a stated time. In fact, on looking through my own insurance policies, I find that I am insured against the following risks :

Third Party;
Fire, Burglary and Theft;
Employer's Liability;
Cash in Transit;
Sickness and Injury of Principals.

A Fundamental Principle.

Above all things it is necessary, especially at the start when the romantic and the fascinating side of the business is apt to be paramount, to bear in mind that the purpose of the business is to make money, and that is to make a profit. If the contractor buys an article for one price and sells it for a higher price it does not necessarily mean that he has made a profit. I am sorry to labour this point, but it is so vital that it cannot be too emphatically impressed on all who are starting in the business. Know how much the article costs you, know how much it costs you to sell that article, add the two together and make sure that you sell it at a price which leaves at least some margin of profit. However, this matter is dealt with elsewhere.

RULES AND REGULATIONS.

Although electricity, when it is properly installed and properly employed, is a harmless enough medium, it can scarcely be disputed that it has certain lethal qualities when it is abused. In face of this, it is a decidedly serious thing that there are no general rules applicable to the installation of electricity in a building which have behind them the authority of Parliament. There are, it is true, Home Office regulations applying to certain electrical work in factories ; in addition, a handful of boroughs throughout the country have incorporated wiring rules in their bye-laws, thus indirectly making use of the backing of Parliament to enforce a certain standard of wiring in their own districts. Again, there are a few—very few—points upon which a supply undertaking is authorised to make conditions as to the standard of wiring in a building to which it is asked to connect a supply of electricity.

Wiring Regulations.

But the only code of generally applicable wiring rules is that now known as the Regulations for the Electrical Equipment of Buildings (formerly the I.E.E. Wiring Rules), issued by the Institution of Electrical Engineers. This code of wiring rules has been produced by a committee of electrical engineers representative of most of the interests at stake and under the auspices of the Institution of Electrical Engineers. Insurance companies' engineers, electrical contractors, electrical manufacturers, consulting engineers, etc. have all put their heads together to produce what must definitely be regarded as the only set of wiring rules with any moral authority behind it. Nevertheless, these rules have no statutory authority whatsoever, and it is within the discretion of any electrical contractor whether he does or does not carry out his wiring in accordance with them. In my own mind there is not an atom of doubt that if these regulations err, it is on the side of leniency rather than on the side of strictness ; and it is a poor electrical contractor indeed who does not at least live up to the standard recommended by these regulations.

Rules Issued by Supply Undertakings.

Practically every supply undertaking in the kingdom issues a little book of wiring rules for the edification of electrical contractors installing electric wiring in that particular area. Most of the rules so issued are admirable in purpose ; indeed, they are in most cases modelled closely on the Regulations for the Electrical Equipment of Buildings. But these rules have no more authority behind them than have the Regulations on which they are modelled.

It should be observed here that the supply undertakings have certain rules which they are allowed, even bound, to insist upon before they may connect up, but these rules relate only to such things as insulation resistance and provision against faults which may react back on their own mains to the detriment of neighbouring consumers. In general, the rules may be considered to be so much well-meaning and laudable bluff.

Wiring in Factories.

Wherever electric wiring is carried out in factories or premises coming under the Factories Act, then the wiring installation also comes within the provisions of the Home Office regulations, which are enforceable by law.

Insurance.

The insurance companies themselves make rules or alternatively stipulate that the wiring installation on premises which they insure shall be carried out according to the standard set by the Regulations for the Electrical Equipment of Buildings. This is probably the most important thing to bear in mind, for whereas it gives no real authority to the Regulations it does at least mean that failure to observe these Regulations may result in the insurance of the premises being refused by one of the companies. In general it is found that insurance companies rarely bother their heads much about private houses unless these are of considerable dimensions.

CONTACT WITH SUPPLY UNDERTAKINGS.

The question of rules brings us rather naturally to the question of contact between an electrical contractor and the supply undertaking. As this is a branch of the electrical industry with which the electrical contractor is bound to come into frequent contact, it may be worth devoting a little space to the consideration of one or two aspects of the matter.

Supply and Sale of Electricity.

Every electricity supply undertaking, whether it be a company or the electricity department of a municipal council, operates under Act of Parliament, qualified by what is known as a Special Order relating to any peculiar features of the district. During the comparatively short life of electrical progress there have been several Acts dealing with the supply and sale of electricity, the first of these being one dated 1882, and the most recent that of 1926, which inaugurated the Central Electricity Board. These Acts and auxiliary regulations made under their provisions give power to the respective supply undertakings to generate, distribute and sell electricity within a prescribed area; and they further provide that there shall be no competition between supply undertakings by the overlapping of areas. Thus, this particular branch of the industry has to what is to all intents and purposes a monopoly, each in its own area. With these privileges of monopoly, however, go certain responsibilities.

Read the Electricity Acts.

The chief of these responsibilities is that, with one or two comparatively unimportant exceptions, the supply undertaking is bound to supply electricity if it is asked to do so. But, as I have mentioned in a previous part of this article, where a supply undertaking carries out wiring work in addition to generating and supplying electricity, this wiring department is carried on as a distinct entity, and no parliamentary monopoly applies to the work of this department. I can strongly recommend any young electrical contractor to read from beginning to end all the Electricity Acts from 1882 onwards. This may seem a fearsome task, but to an engineer of average intelligence it is both interesting and very, very helpful in his work as an electrical contractor.

TRADE ASSOCIATIONS.

It would be a very noble thing if love for our fellow men were the reason uppermost in our minds for joining trade associations. Unfortunately, human nature is not quite so perfect as this and we are apt to ask for some rather more cogent reason before we commit ourselves to the joining of some association which costs us money in fees. Indeed, my own remarks earlier in this article, provide a reason for requiring some economic justification for such a step.

The Electrical Contractors' Association.

In the case of the electrical contracting industry the interests of the whole are particularly well served by an association known as the Electrical Contractors' Association or, for short, the E.C.A. The function of this association is not one of price regulation, but purely and simply one of looking after the interests of its members from the heights of promoting bills in Parliament (if they should be advantageous to the electrical contractors of the country) to the depths of circularising its members to beware of fraudulent persons and hoaxers when such gentlemen are active with electrical contractors. As a body the Association provides its quota on all committees which may be convened for the study or protection of any branch of electrical engineering which affects the electrical contractor.

Affiliated to this Association are two other associations known, respectively, as The National Electrical Contractors' Trading Association—N.E.C.T.A. for short —and the National Federated Electrical Association, or N.F.E.A. The former is concerned solely with the commercial side of the electrical contractor's activities. It treats with manufacturers on the subject of discounts and takes up the cudgels on behalf of members in any dispute relating to such matters. The latter is purely a trade union to discuss and, if necessary, to take action about the various points which are perpetually arising as between employer and employed in the electrical industry.

I will not advise any young contractor to join the Association, nor will I advise him to refrain from joining it; I will content myself with observing that I have never regretted having joined.

The National Register.

In addition to the E.C.A. and its affiliated associations there is a comparatively young organisation known as the N.R.E.I.C., which stands for The National Register of Electrical Installation Contractors. This must not be confused in any way with the E.C.A., since its functions do not overlap or clash with the E.C.A. in any respect. The National Register is merely a register of names of electrical contractors, all of whom undertake to carry out their electrical installation work only in accordance with irreproachable standards. Candidates for registration are examined and their work is noted. They must satisfy certain well-defined requirements in addition to satisfying the committee that they are, generally speaking, worthy to be included on the Register. If any member of this Register disgraces himself by doing bad work, or in any way ignoring the undertaking which he has given in order to gain access to the Register, he is expelled from the Register. Being a comparatively young organisation, it is not unfair to suggest that the N.R.E.I.C. has not yet become quite the power in the land it will be in the future.

Nevertheless, in its comparatively few years of existence it has achieved such a name that there are very many engineers throughout the country who will not place electrical installation work with any firm unless that firm is a member of the National Register. It costs little to join, and I frankly advise any young electrical contractor to offer himself as a candidate for this Register, for if he can satisfy the committee of his suitability to be admitted he will find that it can do him no harm and will probably do him a great deal of good.

FINAL NOTES.

I should like to end up on the note on which I began. The work of the electrical contractor is neither a romantic nor a dull occupation. It is not all engineering nor all commerce. Both have a very large part to play and I think it would be difficult for anyone to say which is the more important of the two. Technical aptitude without commercial aptitude will get one nowhere; and the reverse is just as true.

Technical Considerations Must Be Paramount.

One point, perhaps, may be mentioned here. It does sometimes happen that technical considerations and commercial considerations are pulling in different directions. The electrical contractor may find himself faced with the problem as to whether the technical considerations are more important or the commercial considerations. On this point my own view is definite. The technical considerations must be paramount. For instance, it may suddenly dawn on the electrical contractor that he could profitably carry out wiring work at 5s. 6d. per point, provided that he did not care what materials he used and how he did the wiring. Further, he might be able to command plenty of work at this price, and, accordingly be tempted to enter this field. Against this commercial viewpoint, however, his technical conscience whispers to him that such work would not be a credit to him and would not be, in any sense of the word, technically sound. In such a dilemma my advice to the electrical contractor is that he should follow the dictates of his technical conscience. Sell a man a Rolls Royce or a Morris Cowley, whichever he asks for, but do not sell a man a car which has no wheels !

Increasing Use of Electricity.

This country is very backward in its use of electricity. Statistics show that countries like the United States of America, Canada and Germany are far more advanced than we are, and that electricity is used to a far greater extent than it is in this country. In spite of this, the countries which I have mentioned anticipate considerable further increases in the future. From this it may reasonably be deduced that there is an excellent prospect that the use of electricity will sooner or later increase by leaps and bounds in this country. Whenever the use of electricity increases there is work for the electrical contractor. There are many to-day who will say that the profession of the electrical contractor is overcrowded. Among that class which takes no account of technical perfection, but exists by sacrificing quality to price, the profession probably is overcrowded. But in the field of conscientious electrical installation work there is room for many more.

Wireless Department.

In the earlier part of this article I deliberately refrained from touching on the wireless, or radio, side of the electrical contractor's business. I do not propose to start discussing it at length at this stage. But I do seriously recommend any electrical contractor who intends to launch out with a wireless department to think very seriously about it before doing so. This remark is not intended to dissuade electrical contractors from doing so, but it is intended to remind them that because a man is an electrical engineer, it does not mean, necessarily, that he has either the aptitude for wireless or the time to give to it. It is, nowadays, almost a separate science from that of the more conventional electrical engineering. There are, of course, undoubtedly cases where an electrical contractor is called upon to sell, or repair, or give advice upon a wireless set. But, unless he knows his subject very well and has the time to give to it, he will, I think, find that it pays him, as far as possible, to refer his customer for this class of trade to a man who specialises in such work.

Different Methods of Wiring.

I have also refrained from attempting to discuss the more technical aspect of the electrical contractor's work. There are many different methods of wiring, for instance, and each one has its particular technical attributes, which must be taken into consideration when selecting a system of wiring for a given job. A dissertation on this subject, however interesting it might be, is not within the scope of this article. I should, however, like to observe that to classify wiring systems in one's mind according to price only, and without reference to their technical suitability for the particular job, is quite unreasonable. The prices of various systems may vary ; for instance, screwed steel tubing is considerably more expensive to install than cab-tyred sheath cable. But this does not mean that there are not many jobs for which cab-tyre sheath cable is ideal and screwed steel conduit almost useless.

Final Word of Advice.

One final word of advice. Anyone who is thinking of becoming an electrical contractor should possess himself of all the facts relevant to that profession, and should decide for himself. It would be unwise to allow himself to be unduly influenced by people inside or outside the trade. Those inside the trade are usually prejudiced, while those outside are ignorant.

OPERATION AND MAINTENANCE OF ARC LAMPS

By H. W. Johnson

Humphry Davy, in 1800, noticed that when two pieces of carbon, which were included in a circuit through which a current was passing, were brought apart a short distance, an arc was produced between the separated ends, and a brilliant light was emitted from the arc and the white hot ends of the carbons.

Why the Arc is Produced.

When the carbons are separated, the spark produced volatilizes a little of the carbon on the ends. Carbon vapour is a partial conductor and allows the current to flow through it if the gap between the separated ends is not too great. The carbon vapour has a high resistance and it becomes white hot, due to the passage of the current through it, and the ends of the carbons become hot also. Solid matter is a better radiator than gaseous, and the ends of the white hot carbons give more light than the arc itself, although their temperature is not so high as that of the arc.

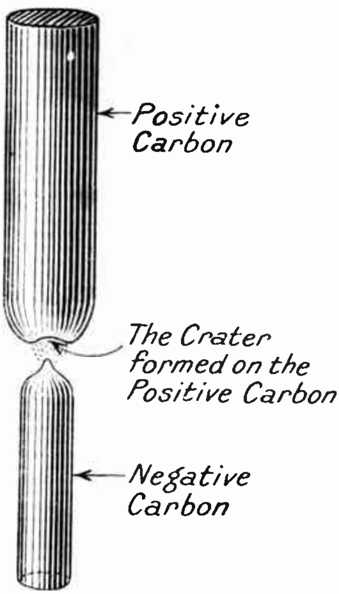


Fig. 1.—Arc Produced by a Direct Current.
This forms a crater in the end of the positive carbon, and tends to point the end of the negative carbon, if it is not cored.

The Temperature of the Arc.

The temperature of the arc is 4000° Centigrade, whilst the temperature of the crater which is formed at the end of the positive carbon when the arc is fed with direct current, is 3500° Centigrade.

The Formation of the Crater.

As the arc continues to burn, particles of the positive carbon are volatilized and torn off and the end becomes hollowed out to form a crater, and if the gap is small, some of the particles are deposited on the end of the negative carbon, which now assumes a pointed shape. If the arc is fed with alternating current, no crater is formed, and the ends of each carbon are flat.

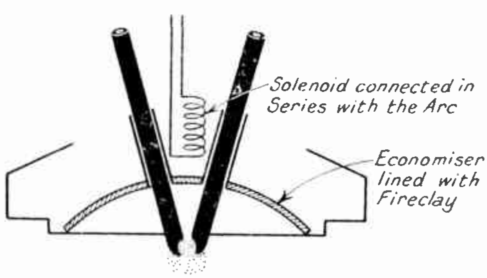


Fig. 2.—Arc of the Flame Type Lamp.
This burns inside a saucer-shaped bowl called the economiser, and is bent out into a flame by the action of a magnetic field produced by a solenoid connected in series with the arc.

The Importance of Connecting a D.C. Arc Lamp in the Correct Way.

The positive terminal of a D.C. arc lamp must be connected to the positive side of the supply mains in order that the crater will be formed on the positive carbon. If the negative terminal of the lamp is connected to the positive main, the light from the arc, and the crater, will be projected upwards and the negative carbon

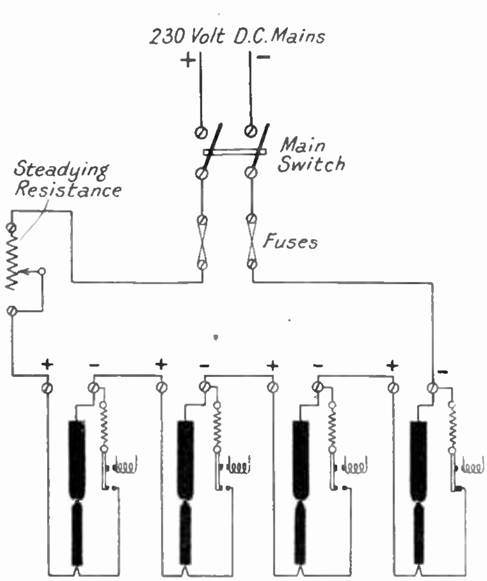


Fig. 3.—A SERIES ARC LAMP CIRCUIT.
Four open-type arcs are connected in series on a 230-volt circuit. A series resistance for steadying and regulating purposes is used in the circuit. The circuit is controlled with a D.P. switch and protected with a fuse on each pole. Each arc lamp is fitted with an equivalent resistance which is cut in circuit when the lamp fails.

will be consumed much more quickly than the positive, causing damage to the negative carbon holder, which in time will come into contact with the positive carbon.

Rate of Consumption of Carbons.

The positive carbon is consumed at approximately twice the rate of the negative and consequently the area of cross section of this carbon is generally about twice that of the negative carbon. In an open type arc the rate of consumption is about half an inch per hour, but in the case of flame type arcs the consumption is greatly in excess of this figure and may be, in some types of flame arcs, as much as 2 in. per hour. The carbons used in A.C. arcs are the same diameter.

The Use of Cored Carbons.

There is always a tendency for the arc to wander round the edge of the carbons : this is particularly the case in enclosed type lamps, and in order to prevent this tendency, the positive carbons, and often the negative, are provided with a soft core composed of a mixture of lampblack and potassium silicate. This core is more readily consumed than the outer hard carbon covering. Cored carbons should always be used for A.C. arcs.

The Length of the Arc.

The length of a normal arc to which the air has free access should be from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. If the arc is too long, it flames and becomes unsteady ; also the light emitted is of a bluish tint, while on the other hand, if it is too short, it begins to hiss and causes large fluctuations of the current through it. A hissing arc may occur when the carbons used are of too small a diameter.

The length of the enclosed arc is about $\frac{5}{16}$ in., and owing to the light from it having powerful actinic properties, it is used for photographic and blue printing purposes.

Voltage Necessary to Maintain an Arc.

A D.C. arc exerts a back E.M.F. of 39 volts, and consequently an E.M.F. of

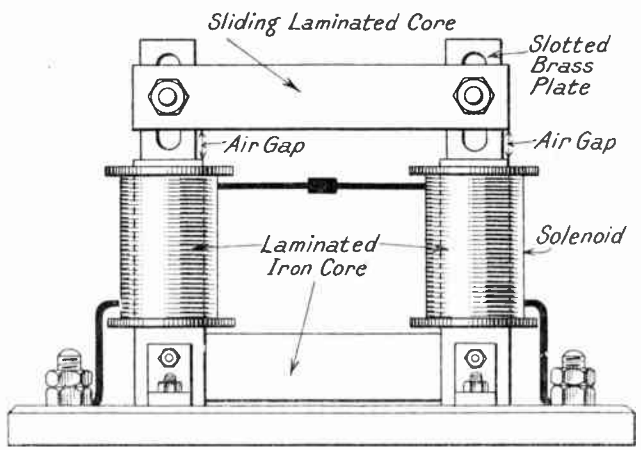


Fig. 4.—VARIABLE CHOKING COIL FOR USE WITH SERIES BURNING A.C. ARC LAMPS.
The impedance of the choking coil is varied by increasing the air gap between the sliding laminated core and the laminated core of the solenoids.

about 50 volts is necessary to overcome the back E.M.F. and internal resistance of the arc; in the case of the A.C. arc, the back E.M.F. is less, about 30 volts, and an E.M.F. of about 40 volts is required to maintain this arc.

A Steadying Resistance is Necessary in an Arc Lamp Circuit.

Owing to the variation of the specific resistance and area of cross section of an arc, a steadying resistance should always be used in a D.C. arc circuit, to maintain stable conditions of burning and a steady current if the arc circuit is supplied at a constant pressure. A choking coil may be used in an A.C. arc circuit, as this is more efficient and wastes less power than an ohmic resistance. A very large current would flow when the arc was struck, owing to the carbons being momentarily short-circuited, if a steadying resistance or choke coil was not included in the circuit.

The steadying resistance or choking coil should be capable of adjustment in order to allow for the correct burning of the arc lamps in the circuit. It should be fixed in a position where it is well ventilated and there is no danger from fire. If mounted

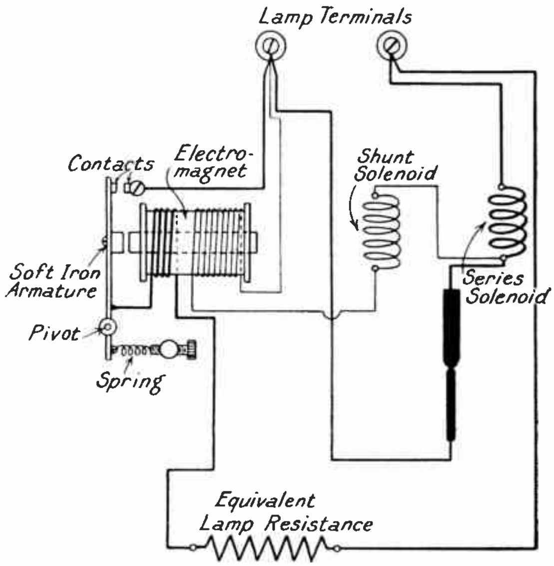


Fig. 5.—AUTOMATIC CUT-OUT FOR SERIES BURNING ARC LAMPS.

To prevent an interruption of the current in a series arc lamp circuit in the event of a failure of a lamp, a cut-out is fitted in each lamp, which provides an alternative path for the current in the faulty lamp.

The shunt coil of the lamp has an electromagnet, fitted with a pivoted soft iron armature, connected in its circuit. To one end of the armature is fixed a a contact blade, and to the other end a spring which pulls the armature away from the end of the core of the electromagnet. Under normal working conditions of the lamp the current passing round the windings does not magnetise the core sufficiently to attract the armature to it. Should the arc become too long, or fail, the pressure across the shunt coil rises, and the current through the windings of the electromagnet is now strong enough to cause the magnetic attraction of the core to pull the armature to the end of the core, causing the contact blade to short circuit the arc circuit through a resistance which is equal to that of the arc. The pull on the armature is further increased by the action of the auxiliary winding on the electromagnet, which is now energised by the current passing through the alternative path which completed the circuit.

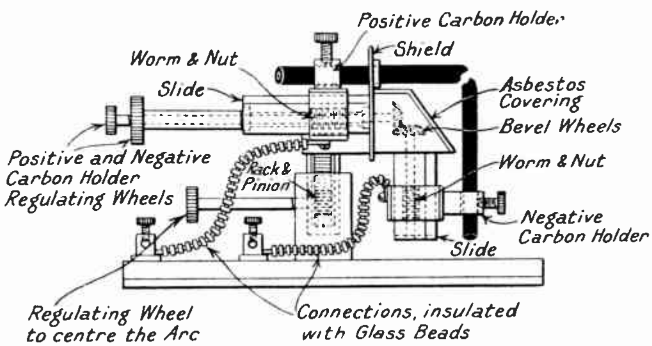


Fig. 6.—HAND-OPERATED PROJECTION ARC.

The carbons are brought together at an angle of 90° and by keeping the negative carbon just below the positive, very little light is cut off from the crater and the end of the positive carbon. Each carbon holder has a separate worm and nut motion operated by a regulating wheel.

The arc may be raised or lowered for centring purposes by a rack and pinion motion, operated with a regulating wheel. Copper flexible connections, insulated with glass beads, connect the carbon holders to the terminals which are mounted on, but insulated from, the sliding metal base. The sliding base is fitted in the lantern or projector case.

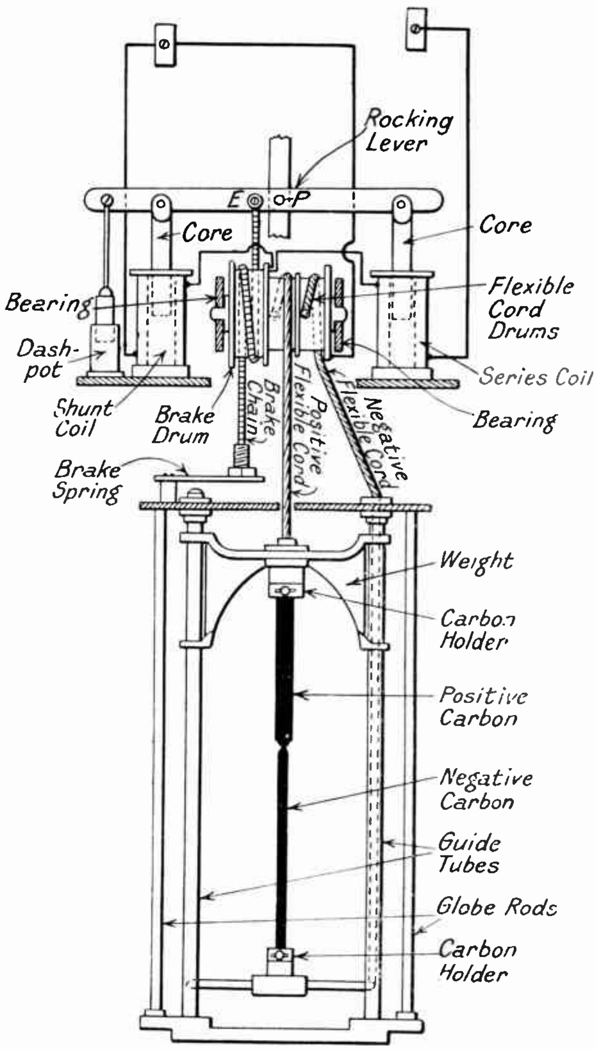


Fig. 7.—CONSTRUCTION OF A CROMPTON DIFFERENTIAL ARC LAMP.

near woodwork, the resistance frame should be separated from it with asbestos. All woodwork or combustible material should not be less than 24 in. measured vertically above, or 12 in. below, and 6 in. measured in any other direction from the resistance. There should be no soldered connections to the resistance.

Arc Lamp Mechanisms.

An arc lamp is fitted with a mechanism which will strike the arc and maintain it at a correct length, to give stable conditions of burning and the maximum flux of light.

This mechanism may be automatic or hand regulated.

Arc lamps used for lighting and photographic purposes are generally fitted with automatic mechanism, and those which are used for projection work are fitted with hand-regulating mechanism.

The operation of the automatic mechanism depends upon the electro-magnetic action of solenoids.

Flame Arc Lamps.

The flame arc is produced by two carbons which meet at an acute angle inside an inverted saucer-shaped iron bowl called the economiser, which is lined with fireclay. The spreading of the arc into a flame is produced by the magnetic field of a solenoid, whose windings are connected in series with the air.

The characteristic colour of a flame arc is produced by providing the carbons with a core containing flame-producing salts. The yellow arc is produced by using calcium fluoride, the white arc with cerium fluoride, and the red arc with strontium fluoride.

Owing to the high resistance of the carbons, a zinc or brass wire is placed through the centre of the core: this wire reduces their resistance.

The rate of consumption of the carbons is greater than those in an ordinary open type arc, and is about $1\frac{1}{2}$ in. per hour, and to reduce the amount of trimming the carbons are made about 24 in. long.

The flame arc produces a large amount of ash and emits corrosive fumes; they should not be used for indoor lighting unless there is plenty of ventilation.

Magazine Flame Arcs.

Owing to the rapid burning of the carbons, flame arc lamps are sometimes fitted with a magazine which contains from 6 to 10 pairs of carbons. A new pair of carbons automatically replaces the pair which are consumed, and the ends of the burnt carbons are ejected.

Enclosed Arc Lamps.

The supply of air to this type of arc is limited by enclosing it in an inner glass globe. The length of the arc may be increased and a much better distribution of light is obtained than that obtained with the open type arc.

The arc lamp requires a higher voltage, about 80 volts, and the consumption of carbons is reduced. This type of arc is specially suitable for photographic work and blue printing, the rays of the arc having a strong action upon photographic plates and papers.

The Magnetite Arc Lamp.

This is a flame arc lamp and does not use carbon electrodes. The negative electrode is a thin walled tube of iron, which is packed with a mixture of chromium, titanium and iron oxide. The mixture is the flame producing material. This positive electrode is a copper alloy rod. Good ventilation is necessary for the efficient burning of the arc. This lamp is made for use on small current circuits.

Crompton Differential Arc Lamp.

Fig. 7 shows the construction of a Crompton differential arc lamp. A rocking lever pivoted at P carries two vertical soft iron cores so arranged that they freely move up and down the inside of two solenoids. A brake chain is fastened to the lever at E, and after passing twice round the brake drum, is fixed at its lower end to a spring.

To the brake wheel are attached two drums which are insulated from each other and the wheel, but turn with it. The whole is centred between two bearings. A flexible copper cord is attached to one drum and wound round it in a certain direction, and its lower end connected to the positive or top carbon holder. The negative or lower carbon holder is connected to another copper flexible cord, its end being attached to the second of the drums and wound round it in the opposite direction to that of the flexible connected to the positive carbon holder. When the brake wheel is turned in one direction the carbons separate, and in the other direction, they come together.

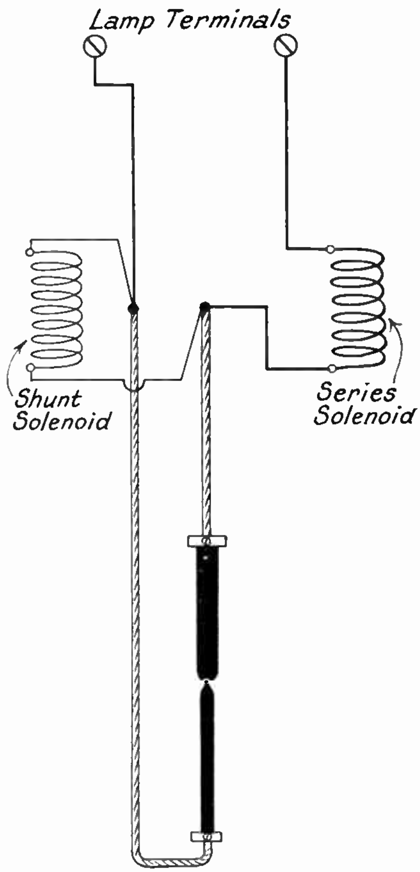


Fig. 8.—Internal Connections of the Crompton Differential Arc Lamp.

The Action of the Lamp Mechanism.

When current is switched on the current passes round the series coil and on to the drum on which is wound the copper flexible connected to the positive carbon holder, through the carbons to the other drum and back to the negative terminal of the lamp.

In doing so the core is sucked into the inside of the series coil causing the rocking lever to tilt, raising E and tightening the brake chain. The brake wheel is given a slight turn and the carbons separate. The arc is now struck and as it continues

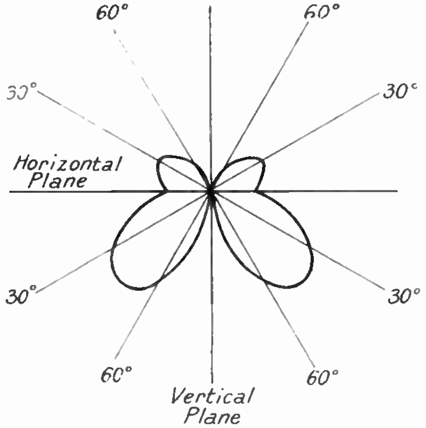


Fig. 9.—LIGHT DISTRIBUTION CURVE FOR AN OPEN-TYPE D.C. ARC WITH THE POSITIVE CARBON UPPERMOST.

The maximum intensity of the light is given at an angle of 45° downwards from the horizontal plane about the arc. All light in a vertical direction downwards is cut off by the negative carbon.

to burn its resistance increases. The pressure across the shunt coil now increases and the core of this solenoid is sucked in which causes the lever to tilt back again, slackening off the brake chain, the carbons feed together again and the arc is adjusted to its normal length. This action is repeated as the carbons are consumed and thus the arc is maintained.

A plunger fixed to the end of the rocking lever works up and down a dash pot and maintains a smooth movement of the lever when it is tilted.

This lamp is self focusing due to the relative positions of the arc and the globe always remaining the same. Fig. 8 shows the internal connections.

ARC LAMP FIXTURES & SUSPENSIONS

Arc lamps should be so fixed that it is impossible for them to swing into contact with any metal work connected to earth. The lamp as a whole must be insulated from earth, and the suspension hook is generally passed round a groove in a substantial porcelain bobbin, which is suitably fixed on the top of the lamp case. When arc lamps are fixed in positions exposed to the weather, the terminals must be adequately protected from rain, etc., and the cable connections to them should be protected with extra wrappings of proofed tapes, which must be coated with anti-sulphuric enamel.

Arc Suspension Cord.

In some cases it may be necessary to lower the arc to ground level for trimming and cleaning. The arc lamp suspension cord is carried over pulleys from the suspension position, across the ceiling, and down the wall, and the end wound on a drum which is fixed on the wall at a convenient height. The circuit cables to the arc are terminated in a special suspension box fitted on the ceiling, and which is provided with two annular metal rings insulated from each other and from the box. The ends of the cables are connected to the rings. The terminals of the arc lamp are connected to two laminated spring contact blades, which are fixed in a vertical position on the top of the arc lamp case. The contact blades are insulated from each other and the fixing to the case; they are so spaced from each other that when the arc lamp is wound up into its suspension position, they make contact with the annular rings fitted inside the suspension box.

Arc Lamp Suspension Height.

Arc lamps should not be suspended at a

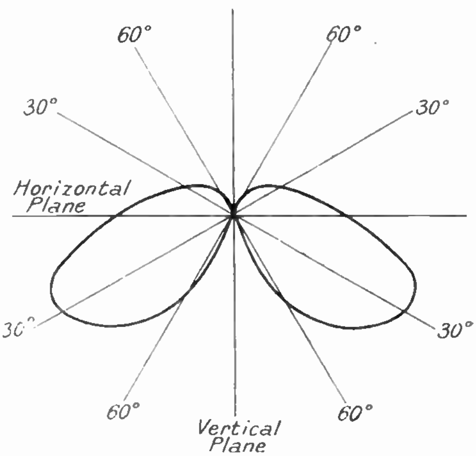


Fig. 10.—LIGHT DISTRIBUTION CURVE FOR AN ENCLOSED TYPE D.C. ARC WITH THE POSITIVE CARBON UPPERMOST.

Most of the light flux is projected in the lower hemisphere and a better distribution of light is obtained than that from an open-type arc.

height less than 8 ft. from the ground, and should be screened to prevent risk of contact with persons.

Arc Lamp Globe Guards.

The globes should be provided with a metal cage guard which will prevent pieces of hot carbon or broken glass falling from them.

Trimming and Cleaning Arc Lamps.

The carbons of an ordinary arc lamp will burn for about 8 hours, after which they will require to be renewed. The operation of renewing the carbons of an arc lamp is called "trimming," and this will have to be done at regular intervals, the time between intervals depending upon the daily hours of burning. Neglect to trim an arc lamp will mean failure of the arc, and possibly burnt carbon holders especially if the holders are able to meet each other.

Remove the burnt ends of the carbons and carefully clean all traces of carbon dust and ash from the carbon holders and guide rods; if the arc is of the flame type, particular attention should be paid to the cleaning of the economiser. The new pair of carbons should be cleaned and all traces of dust removed from them. Fix the positive or top carbon securely in the holder, tightening up the clamping screw, and note that the carbon will be in perfect alignment with the negative or lower carbon holder. The negative or bottom carbon is now fixed securely in its holder, and the end of the carbon should be fully covered by the end of the positive or top carbon. Test the carbons, by separating them, to ensure they will have sufficient striking distance.

The globe is cleaned with soap and water and carefully dried with a clean cloth; any refractory ash or dirt which has been deposited on the globe may be removed with a weak solution of nitric acid and water, 100 parts of water to 1 part of acid.

The globe is now replaced and the lamp switched on for a few minutes to ensure correct burning.

MAINTENANCE OF ARC LAMPS.

Arc lamps should be overhauled at regular intervals, the time between each overhaul depending upon the conditions

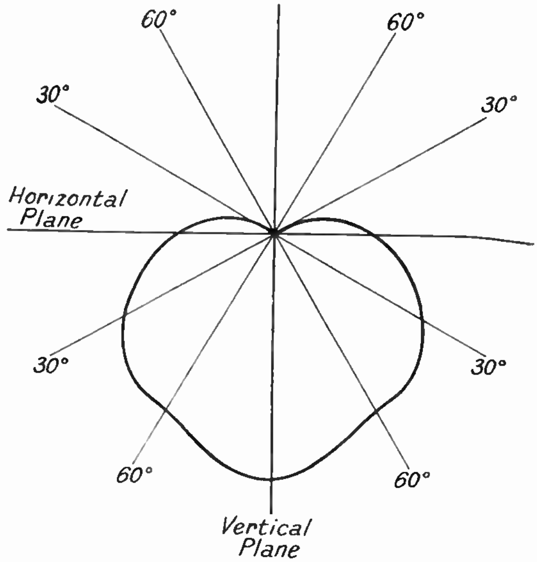


Fig. 11.—LIGHT DISTRIBUTION CURVE FOR A FLAME ARC.

No light is cut off by the negative carbon and a good general distribution of light in the lower hemisphere is obtained.

under which the lamp is used, and the hours of burning.

The globe of the lamp is removed and the cable connections to its terminals disconnected; if the lamp is connected direct to the circuit wiring, note the polarity of the cables and the lamp terminals, to ensure correct connecting after the overhaul.

The suspension cord and hook is now taken off the lamp case by removing the pin which holds the porcelain suspension bobbin, and the lamp is taken away to the workshop or place where it will be overhauled.

Hang the lamp up to a suitable suspension hook by a stout cord, and remove the case of the lamp, so as to expose the mechanism and internal connections.

All the connections should be carefully examined and tested for being tight, binding screws being tightened up where found loose.

Remove all dust from the mechanism, pivoted rocking levers, solenoid cores and windings with a sash tool, and finish off by cleaning with a soft cloth.

All bearings should be lubricated with a trace of clock oil, and levers tested for smooth action. Examine the working of the dash pot plunger. Test the lifting mechanism of the carbon holders and examine the condition of the copper flexibles and their connections to the carbon holders. The carbon holder clamping screws should not be too tight: ease them, if necessary, by running down the threads with a suitable die.

Clean the guide rods, examine the insulation of the terminals and note that the mica insulating washers are not broken or cracked.

Give the insulating covering of the solenoid windings a coat of shellac varnish and the outer case and frame of the lamp a suitable coat of paint.

Examine the condition of the suspension gear and steel cord: the cord should be renewed if the strands are rusted or frayed. Lubricate the bearings of the suspension cord pulleys, and the winding drum. Examine the safety catch of the drum and test it for good working order.

Testing the Lamp after Overhauling.

Fit the correct size of carbons in the holders of the lamp and connect the terminals of the lamp in series with an ammeter and suitable variable resistance to a supply. Switch on the current, and adjust the resistance until the correct burning current for the lamp passes through the circuit. Examine the arc through a blue coloured glass and note whether it is burning correctly and quietly. If the arc is too short or too long, adjust the lifting mechanism until the correct length of arc is obtained. Allow the arc to burn for two hours and check the rate of consumption of the carbons.

Examine the annular metal rings in the suspension box and clean them if they are burnt or dirty. Adjust the spring laminated contact blades to ensure they will make good contact with the annular rings when the lamp is wound up in its suspension position.

PRACTICAL NOTES ON V.I.R. CABLES

1. Differences in Dielectric Composition of 600 meg. and 2,500 meg. grade V.I.R. Cables, and Reasons Why it is Inadvisable to Use 2,500 meg. grade unless Voltage Demands it.

The difference in these two grades lies principally in the greater percentage of rubber in the 2,500 megohm grade cable. The additional rubber in the mixing gives higher insulation resistance. On the other hand, india-rubber is an unstable material, subject to deterioration with time. The greater the percentage of rubber in the dielectric, the more liable is this deterioration to take place, particularly with high temperatures.

Should comparatively low insulation resistance only be necessary, as is usually the case (i.e., for, say, 240 v. circuits), 600 megohm grade cable may safely be specified; and if the cable has to withstand high temperature continuously, it is preferable to install this grade.

2. Relative Advantages of Ordinary V.I.R. Cab Tyre and " Ite " Cables in Damp, Hot and Dry Situations, also Paper Insulated Cables for Sub-mains.

The usual and well-tried construction of rubber dielectric consisting of 3 layers—pure, separator and jacket vulcanized together—has not proved altogether satisfactory under certain special conditions. Under such circumstances a modified rubber dielectric, under various proprietary names, usually known as " ites "—is frequently used.

It must be understood that ordinary V.I.R. insulation consists of rubber compounded with certain ingredients, such as zinc oxide, french chalk, sulphur and certain colouring pigments, etc., forming, therefore, a highly intricate mixture or compound usually containing, say, from 40 per cent. to 60 per cent. rubber. On the other hand, in the case of the " ite " cables, the mixing referred to above has been modified as a result of modern experience, and ingredients of a bituminous nature have been introduced in place of certain other constituents. These are said to fill the pores of the rubber, rendering it less hygroscopic, less liable to oxidation and less liable adversely to affect the tinning of the conductor. It does not, however, follow that the percentage of rubber is less in the so-called compound or "ite" insulation than in ordinary V.I.R. insulation. In fact, it may well happen that an "ite" cable may contain more rubber in its insulation than ordinary V.I.R. cables.

The "ite" material, toughened somewhat, may be used as a sheath for cables and has greater weather resisting properties than ordinary T.R.S owing to its anti-oxidising nature, which renders it less liable to harden and crack. Its mechanical strength and elasticity, however, are not so great as those of ordinary tough rubber.

There is very little to choose between ordinary V.I.R. taped and braided cable run in conduit and V.I.R. insulated cab tyre sheathed cable run on the surface in hot and dry situations. It is desirable, however, that in such situations the cab tyre (or tough rubber) should be protected from the atmosphere by braiding and suitably compounding it on the outside.

The "ite" cable, although better able to withstand hot and dry situations, is, owing to its mineral rubber content, liable to soften somewhat and could, with advantage, also be protected by braiding and suitably compounding.

Objections raised against Paper Insulated Cables.

Paper insulated cables are very suitable for sub-mains. The objections usually urged against this type of cable by contractors or others responsible for an installation are largely due to lack of understanding of the full characteristics of modern paper insulated cables. Such objections are :—

(*a*) That the ends require the use of sealing boxes.

(*b*) That long vertical lengths are subject to leakage of oil at the lower end and even to bursting of the lead due to fluid pressure.

For the low voltage usually associated with sub-mains, sealing boxes can sometimes be omitted and if the cable end is properly prepared, taped and varnished it may be relied upon to last many years without giving any trouble whatsoever.

With regard to (*b*), the paper itself holding the oil in suspension obviates the possibility of fluid pressure at the base of a building of a height at all likely to be encountered in this country, particularly if the cable is drained. To ensure freedom from leakage of oil at the lower end of a vertical run, the cable should be specially drained of all surplus oil by means of suitable plant, in the course of manufacture.

3. Is Pure Rubber an Advantage in V.I.R. Insulation ?

This question is wrapped up with that of the tinning of the copper conductor. It was originally supposed that the tinning of the conductor prevented free sulphur, present in the rubber, from attacking the copper and that the layer of pure rubber assisted in this by acting as a separator. It is now known that the reverse takes place, i.e., that copper reacts on the rubber and eventually destroys it. The tinning of the copper prevents this action. On the other hand, free sulphur in the rubber will, in the presence of moisture, form sulphuric acid, attack the tin and dissolve it away, thus leaving the copper free to attack the rubber. The layer of pure rubber is actually more easily attacked than the vulcanized rubber and is, therefore, under some circumstances, actually detrimental to the cable. It does not serve as a satisfactory separator between the vulcanized rubber and the conductor, since sulphur is found to migrate freely through the pure rubber, hence it would appear that the layer of pure rubber could well be dispensed with.

On the other hand, where high insulation is required, a layer of pure rubber is useful since the insulation resistance of pure rubber, as expressed in megohms per mile, is considerably higher than that of the vulcanized india-rubber.

Thanks are due to Messrs. Johnson, Phillips, Limited, the well-known cable manufacturers, for the above information supplied by one of their cable experts.

THE INSTITUTION OF ELECTRICAL ENGINEERS

THE Institution of Electrical Engineers was founded in 1871 as the Society of Telegraph Engineers. With a modest beginning of 71 members in the first year of its existence, it has to-day (1932) 14,883 members, composed of the following classes :—

Honorary members ..	13
Members	1,970
Associate Members ..	5,820
Companions	115
Associates	1,540
Graduates	2,500
Students	2,925
	14,883

Founders of the Institution.

The actual founders of the Institution were Major (afterwards Sir Francis) Bolton and Captain (afterwards Major-General) C. E. Webber, R.E., who had in their enterprise the active co-operation of the two Varleys (Cromwell and Alfred), Lord Lindsay (afterwards the Earl of Crawford and Balcarres), Captain (later Colonel) E. D. Malcolm, R.E., C.B., C. W. (later Sir William) Siemens and Robert Sabine.

That the Institution would increase in numbers and multiply its activities was clearly seen by its founders, as is evidenced by the words of almost prophetic vision used by Cromwell Varley, the distinguished electrical pioneer, in a speech which he made at the opening meeting of the society on February 28th, 1872, when he said : " This society, I assume, will gradually, by natural selection, develop more into an electrical society than into a society of telegraphy proper ; and the moment it is understood that all papers on electricity or bearing directly upon the development of electrical science are admitted, it at once takes the science out of the narrow groove into which it seemed to be drifting, into the most extensive of all grooves, because it will be found ultimately to embrace every operation in nature."

Early Days.

In its early days the Society of Telegraph Engineers was necessarily concerned mainly with telegraph matters, but as the science of electricity developed it changed its name in 1880 to " The Society of Telegraph Engineers and Electricians " with the object of indicating more clearly its scope and the eligibility of persons engaged in all or any branches of electrical science for membership of the Society. A further change of name was made in the year 1888 to " The Institution of Electrical Engineers " in consequence of the great development which took place about that time in the application of electricity to lighting and heavy engineering, the term " electrical engineer " being substituted as embracing all classes of members of the Institution.

Granting of a Royal Charter.

In 1921 the Institution was granted a royal charter of incorporation, and its objects, as set out in its charter, may be summarised as follows :—

" To promote the general advancement of electrical science and engineering and their applications, and to facilitate the exchange of information and ideas on these subjects by means of meetings, exhibitions, publications, the establishment of libraries, the giving of financial assistance to inventors and experimenters, and any lawful deed conducive to the attainment of its objects."

The membership of the Institution consists of honorary members, members, associate members, who are known as corporate members ; and companions, associates, graduates, students, who are known as non-corporate members.

Honorary members are persons distinguished by their work in electrical science or engineering or whom the Institution desires to honour for special services rendered to it.

Those who belong to the class of member (M.I.E.E.) or associate member (A.M.I.E.E.) are entitled to the designation "Chartered Electrical Engineer."

CONDITIONS FOR MEMBERSHIP.

The following abbreviated particulars of the conditions for membership may be useful to those who contemplate making application for election into the Institution or for transfer from one class of membership to another :—

Member.

Must have had five or seven years' superior responsibility as an electrical engineer, and have been an associate member for at least three years.

Associate Member.

Must pass the graduateship examination or possess an exempting qualification or (if permitted to do so by the council) submit a satisfactory thesis in lieu of examination and have had from two to five years' experience in a position of responsibility as an electrical engineer. The council may, in special circumstances, waive the examination or thesis in the case of candidates over 40 years of age.

Companion.

This class is limited to those who, while not electrical engineers, hold important positions connected with electrical work, in commerce, finance, law or science.

Associate.

Similar responsiblity to that required for an associate member, for a minimum of five years ; no examination or thesis is required for admission to this class.

Graduate.

Must be at least 21 years of age and pass the graduateship examination or hold an exempting qualification approved by the Institution.

Student.

Must be a student of electrical engineering, or apprentice, pupil or assistant to a corporate member and under 28 years of age.

The Institution numbers, or has numbered, among its members practically every person of note in the electrical engineering profession and is to-day a powerful influence in the promotion of its objects. The Government recognise it as the representative body of British electrical engineers.

Principal Activity.

The principal activity of the Institution is the holding of meetings for the reading and discussion of papers. In addition to the ordinary meetings, there are meetings of special sections to discuss papers on wireless engineering and on meters and instruments, including protective apparatus. Further, fortnightly informal meetings are held throughout the session.

Local Centres and Sub-Centres.

With a view, as far as possible, to giving members in the provinces and abroad facilities similar to those enjoyed by London members, the Institution has established local centres and sub-centres with headquarters at Birmingham, Bristol and Cardiff, Dublin, Dundee, Glasgow, Leeds, Liverpool, Loughborough, Manchester, Middlesbrough, Newcastle-on-Tyne, Portsmouth and Southampton, Sheffield and Swansea. Centres are also in existence at Buenos Aires and Shanghai.

There are also eight students' sections for the reading and discussion of papers by students, their headquarters being at London, Birmingham, Edinburgh and Glasgow, Leeds, Liverpool, Manchester, Newcastle-on-Tyne and Sheffield.

The Institution has its own building on the Victoria Embankment, which it purchased in 1909 from the Royal Colleges of Physicians and Surgeons, an entirely new lecture theatre being built, with a seating capacity of 450.

The Reference Library.

The Institution possesses the finest collection in the world of works on electrical science and engineering, the number of volumes being about 16,500. This collection constitutes the reference library, but in order to provide facilities for those who are unable to consult it personally, there has been established a comprehensive lending library for the use of its members. The Institution also has the custody, under trustees, of the Ronalds' library, consisting of some 6,000 volumes and pamphlets, mostly of early dates. Further, the Institution is the possessor of the very fine library of the late Dr. Silvanus Thompson, which was purchased by a number of his friends in 1916 and presented to the Institution.

Outstanding Classic Papers.

Members have the privilege of attending its meetings and of receiving its very valuable journal, reference to which will show that it has always been in the van of electrical science and invention and of their applications, and all the great advances made during the last 60 years or so have been recorded in its pages. As notable among the more classic papers which have made history in the development of electrical engineering, the following deserve special mention: "Induction Between Parallel Wires," by O. Heaviside; "The Theory of Alternating Currents and Magnetism," by John Hopkinson; "Self-induction and Magnetism," by David Hughes; "Meters and Motors," by Ayrton and Perry; "Measuring Instruments," by Lord Kelvin; "Magnetism," by Gisbert Kapp; and "Oscillatory Discharges," by Sir Oliver Lodge.

Publications.

Other publications of the Institution are the wiring regulations for the electrical equipment of buildings and similar regulations for the use of electricity on ships. These regulations, which have been of the utmost value to the electrical industry and the public in ensuring satisfactory results, including safety from fire and shock, are, of course, not intended to take the place of detailed specifications or to instruct untrained persons.

"Science Abstracts."

In addition, the Institution publishes "Science Abstracts," which appears monthly in two sections, namely, Section A (Physics) and Section B (Electrical Engineering), and consists of full abstracts from the leading scientific and technical journals and the proceedings of learned societies of the whole world, so presenting in a form convenient for immediate reference a complete and concise record of the progress of physical science and electrical engineering. This publication is supplied to members of the Institution at rates of subscription considerably below those paid by the general public, and in the case of students and junior graduate members of the Institution, the subscription is as low as 5s. per annum for one section only or 7s. 6d. for both.

The Institution is a substantial contributor to the funds of the British Electrical and Allied Industries' Research Association and to the British Standards Institution, formerly known as the British Engineering Standards Association.

Where to Apply for Membership.

Those desirous of seeking membership of the Institution should apply to the Secretary, Savoy Place, London, W.C. 2, for particulars and application forms.

ELECTRICAL TARIFFS

By H. W. Johnson

TARIFFS IN OPERATION.

The Flat Rate.

THIS is the simplest tariff and is readily understood by the public. A fixed rate per unit of energy taken by the consumer is made. Energy for lighting is charged at a higher rate than energy taken for power purposes, because lighting is generally only required at times of the day when the demand on the supply station may be heavy, whereas energy for power purposes may be required at times when the demand is much lower. In addition to the charge per unit some supply companies make a meter rent charge. A consumer who requires energy for lighting and power purposes will therefore have two meter rents, one for the lighting meter and another for the power meter. There is generally a minimum charge made per quarter for energy, the charges for the energy taken during that quarter are less than this minimum charge. This minimum charge and the meter rents represent the consumer's share of the preparation costs of the supply station, and is independent of the energy consumed.

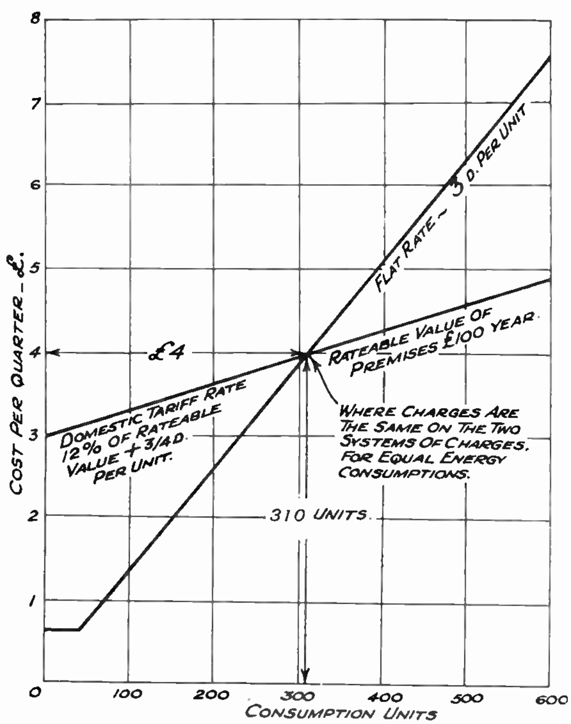


Fig. 1.—Chart showing Comparative Charges for Energy Consumption on a Single Flat Rate and a Domestic Tariff Rate.

Example of the Quarterly Charge for Energy on the Flat Rate System.

	s.	d.	
Lighting rate	0	4	unit.
Power rate	0	1	unit.
Meter rent	2	6	quarter.
Minimum charge per quarter exclusive of Meter rents	15	0	

Date Meter readings.	Lighting.	Power.
Jan. 5th	495	1258
April 6th	538	1410
Units consumed	43	152

Total charge for the quarter, including meter rents $= \frac{43 \times 4}{12} + \frac{152 \times 1}{12} + 5$ shillings
$= £1.\ 12s.\ 0d.$

Discounts for Large Consumers.

Large consumers are often given discounts on all energy taken over a certain amount during the quarter, or sometimes a falling rate is given as the consumption increases beyond certain specified amounts. Stores which use energy for shop window lighting after closing hours for advertising purposes are often given a two-rate tariff, the lower rate operating after a certain hour in the evening when the demand on the supply station is diminished. A two-rate tariff meter will be installed and the change, from one set of dials reading the units consumed at the higher rate to the other set of dials reading the units at the lower rate, will be made with a time switch.

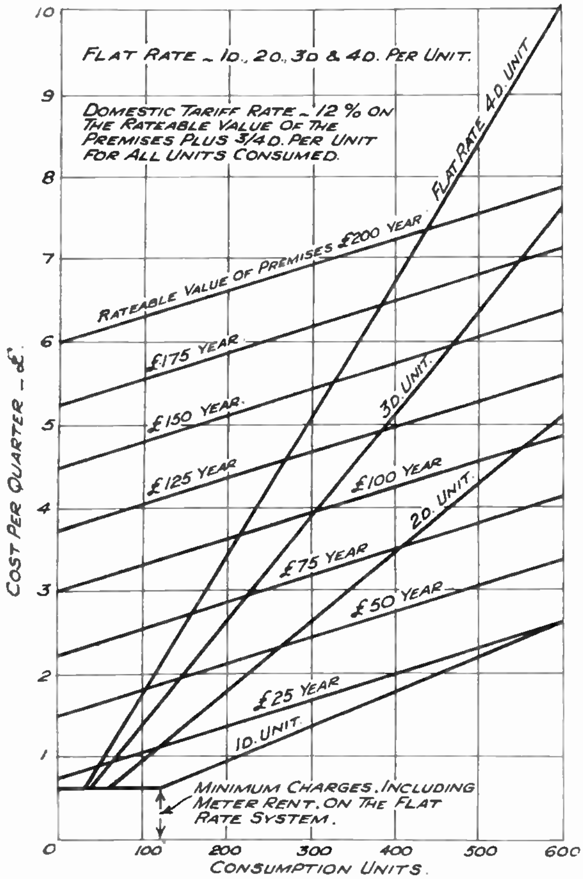


Fig. 2.—CHART SHOWING COMPARATIVE CHARGES FOR ENERGY CONSUMPTION OF VARIOUS SINGLE FLAT RATES AND DOMESTIC TARIFF RATES.

The Domestic Tariff Rate.

The charges made on this system are generally based on the rateable value of the consumer's premises and, in addition, a small charge per unit of energy taken. Twelve per cent. of the rateable value of the premises plus $\frac{3}{4}$d. per unit consumed is an average charge on the domestic tariff rate.

Consumers who adopt this rate in preference to that of the flat rate are compelled to consume a certain amount of energy in order that they may have full advantage of the rate. Only one meter is required as no distinction is made whether the energy is required for lighting or power; of course, the fixed charge on the rateable value of the premises is such that it would be almost impossible for the consumer to use the energy which must be taken for lighting purposes only.

Example of a Quarterly Charge on the Domestic Tariff Rate.

Charge.—12 per cent. of the rateable value of the premises + $\frac{3}{4}$d. unit for all energy taken.

Premises.—Rateable value £100 per year; energy for all purposes 800 units.

$$\text{Quarterly charge} = £3 + \frac{800 \times 3}{4 \times 240} = £5\ 10s.$$

A problem which often confronts a prospective consumer is to decide how many units must be consumed in order that the domestic tariff rate may be adopted with advantage. It is assumed that the consumer will have a normal lighting consumption, no matter which tariff will be adopted.

Calculation of Minimum Number of Domestic Heating and Power Units per Quarter, in Order to Obtain any Advantage from the Domestic Tariff Rate.

FLAT RATE CHARGES.	D.T.R. CHARGES.
Lighting, 4d. unit. Domestic Power, 1d. unit. Meter rent, 2s. 6d. per meter.	12 per cent. on the rateable value of the consumers' premises + $\frac{3}{4}$d. unit for all energy taken.

Rateable value of Premises, £100 per year; normal lighting consumption per quarter, 100.

Let x = No. of domestic power units to be taken in order that the D.T.R. may be adopted.

Cost per quarter on the Flat rate = Lighting charges + Domestic Power charges + Meter Rent = $(100 \times 4) + (x \times 1) + 60$ pence.

Cost per quarter on the D.T.R. = 12 per cent. of rateable value of premises + charges for all energy = $(240 \times 3) + \frac{3}{4}(100 + x)$ pence.

When the charges are equal

$$(100 \times 4) + (x \times 1) + 60 = (240 \times 3) + \tfrac{3}{4}(100 + x)$$
$$400 + x = 720 + 75 + \tfrac{3}{4}x$$
$$(x - \tfrac{3}{4}x) = 775 - 460 = 315$$
$$\tfrac{1}{4}x = 315$$
$$x = 1{,}260 \text{ units.}$$

The consumer must therefore take more than 1,260 units for domestic power purposes in order that he may adopt the D.T.R. with advantage.

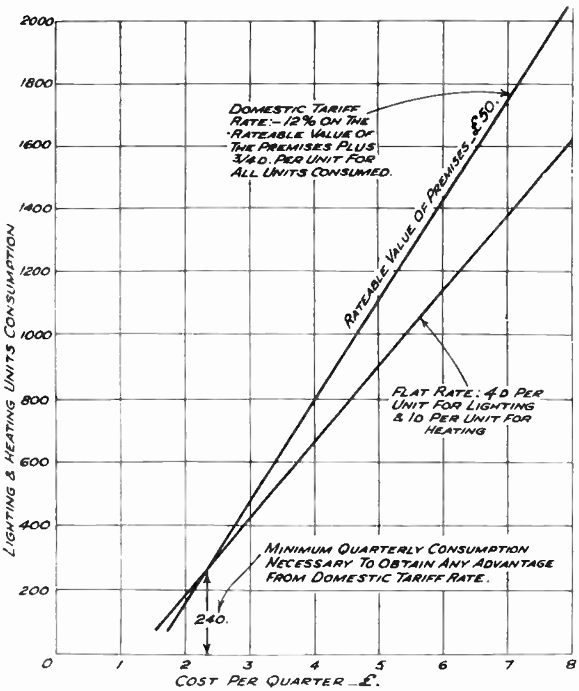


Fig. 3 (*Right*).—Chart showing Comparative Charges for Energy Consumed for Heating and Lighting on a Double Flat Rate and a Domestic Tariff.

Each system has a normal consumption of 80 lighting units per quarter.

The Maximum Demand System of Charging.

This system was first introduced at Brighton by Mr. Wright. The principle of charging on this system consists of charging the consumer on his maximum demand, and the units consumed. The demand charge ensures that the consumer will pay his share of the preparation costs of the supply station, and his charge for units consumed pays for the maintenance costs of the station. Two instruments are required for making the charges, namely, a maximum demand indicator which will give a permanent record over a stated period of the highest demand the consumer has made on the supply, and an energy meter which records his consumption of units during that period.

The rate is generally expressed as a fixed charge per KW of maximum demand over the stated period, plus a charge per unit of energy taken. A variation of this may be a charge for all units consumed at the maximum demand rate for a specified number of hours per quarter, these units are calculated at a special rate, plus an additional charge for all units above this calculated number at a lower rate. This variation is generally offered to large power consumers and will specially discourage them from taking a heavy demand for short periods, and on the other hand it

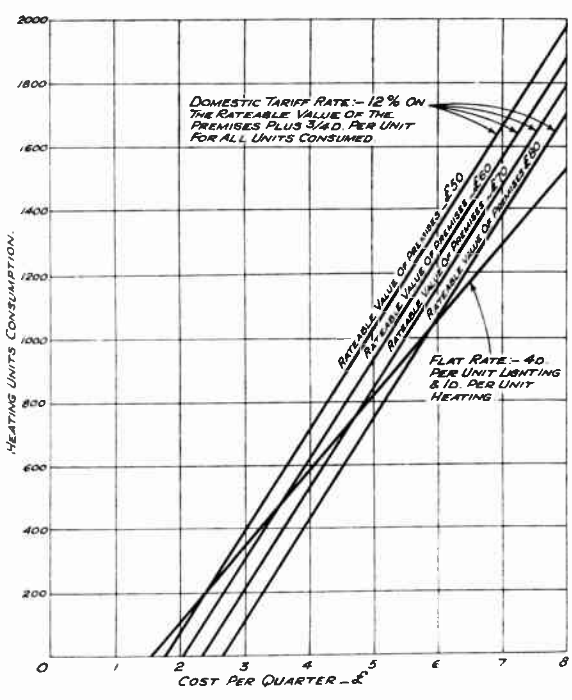


Fig. 4 (*Left*).—Chart showing Comparative Charges for Heating Energy Consumption on Various Double Flat Rates and Domestic Tariff Rates, each System having a Normal Lighting Consumption of 80 Lighting Units per Quarter.

will be advantageous to those whose demand is steady and continuous.

Calculation of Quarterly Charges on a Maximum Demand Tariff.

Charge.—£2 per KW of max. demand per quarter, plus ½d. per unit taken.

Max. demand meter reading = 4 KW, consumption 5000 units.

$$\text{Total cost} = £(4 \times 2) + \frac{£5000}{480}$$

$$= £8 + £10.\ 8s.\ 4d.$$

$$= £18.\ 8s.\ 4d.$$

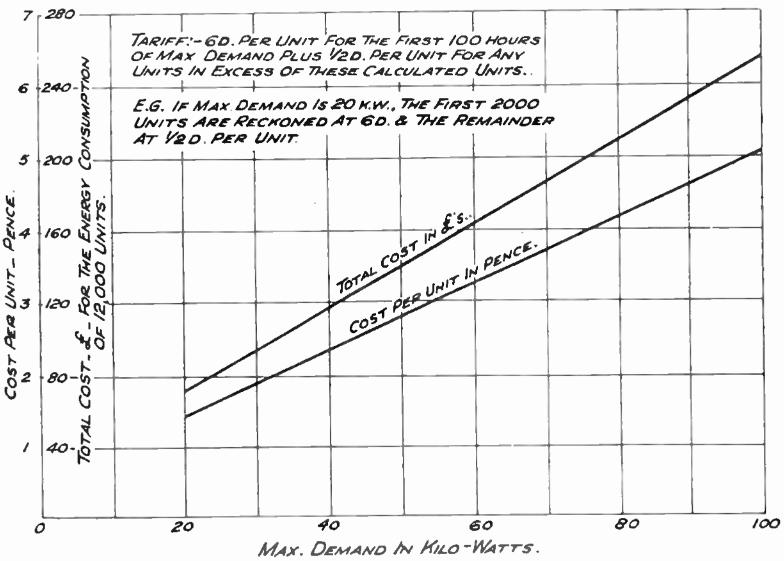


Fig. 5.—Chart Giving the Total Charges for Energy at Cost per Unit on a Maximum Demand Tariff with a Consumption of 12,000 Units.

Charge.—6d. per unit for the first 100 hours at the max. demand rate, per quarter plus ½d. per unit for all units in excess of these calculated number of units.

Max. demand meter reading = 4 KW, consumption 5,000 units.

Units at the max. demand rate = 4×100

Cost of these units at 6d. per unit = $\frac{£4 \times 100}{40} = £10.$

Units in excess of these at ½d. per unit .. .. = $(5000 - 400) = 4,600.$

Cost of these .. = $\frac{£4600}{480} = £9.\ 13s.\ 9d.$

Total cost .. = £10 + £9. 13s. 9d.

= £19. 13s. 9d.

A problem which the consumer may have to decide will be to know what the consumption will have to be in order to adopt a maximum demand rate in preference to a flat rate. Assuming the maximum demand is 4 KW and the rates offered are (*a*) A flat rate of 2d. per unit (*b*) A maximum demand rate of 6d. per unit for the first 100 hours at the maximum demand rate, per quarter, plus ½d. per unit for all units in excess of these calculated number of units.

Calculation of Consumption.

Let x = consumption in units per quarter.

Cost of units on the flat rate = $2x$ *pence.*

Units at the max. demand rate = $4 \times 100 = 400$.

Cost of max. demand units = $400 \times 6 = 2400$ pence.

Units in excess of max. demand units = $(x - 400)$.

Cost of these excess units = $\frac{(x - 400)}{2}$ pence = $\frac{1}{2}x - 200$ pence.

Total cost of units on the max. demand rate = $2400 + (\frac{1}{2}x - 200)$ pence.

$= 2200 + \frac{1}{2}x$ pence.

When the charges on the tariffs are equal $2x = 2200 + \frac{1}{2}x$

$1\frac{1}{2}x = 2200$

$$x = \frac{2200 \times 2}{3}$$

$$= \frac{4,400}{3} = 1,466 \text{ units.}$$

Therefore the consumption must be more than 1,466 units.

A charge on the estimated demand only, is sometimes made, irrespective of the amount of energy taken. This charge generally applies only to small lighting consumers, whose consumption does not justify the expense of installing and quarterly reading of a meter. The supply company make a statement of the various lamps which are installed, and from the total power they take, the estimated demand is obtained.

THE CATHODE RAY OSCILLOGRAPH

By C. A. Quarrington
(of A. C. Cossor, Ltd.)

The cathode ray oscillograph tube is so wide in its application that it becomes extremely difficult adequately to define it, but, broadly speaking, it is a device whereby a wave form or electrical movement can be thrown in visible form on to a screen. For example: if an ordinary source of A.C. is applied between one pair of plates and some form of time base on the other pair, the actual wave form will be shown on the fluorescent screen and amplitude frequency and actual form can be observed.

Investigation of Higher Frequencies.

Fig. 1 shows the type of oscillograph tube on which the foregoing remarks are based, which is one recently designed by A. C. Cossor, Limited, of London, N.5, and is the subject of a patent application. This tube which, incidentally, is entirely British has many unique features, the chief among which are the very low interplate capacity, making possible investigation of higher frequencies than has hitherto been possible, the sharpness and brilliance of the spot and the low gun voltage at which the tube will work. In addition, the price makes it within the reach of any private investigator.

Fig. 1.—The Cossor Cathode Ray Oscillograph.

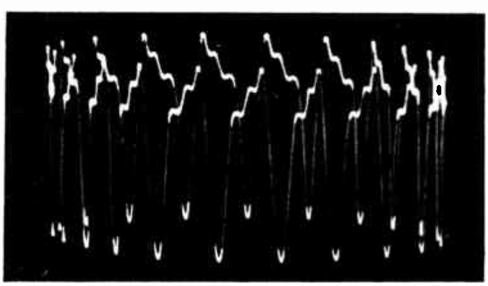


Fig. 2.—Showing the Complicated Image that is Possible with the Cathode Ray Oscillograph.

This is a comparison between two frequencies, 50 cycles and 1,050 cycles, the latter having very strong harmonics.

Reference to Fig. 3 will show that the filament is enclosed in a round tubular shield. This is called the focussing shield, and should not be confused with an anode.

How the Beam is Focussed.

The filament is heated to a suitable temperature, and a beam of electrons is thrown off and drawn by the gun through the hole in the bottom of the gun electrode. This beam of electrons is controlled by the potential applied to the focussing screen so that the width of the beam can be narrowed to a pin point by means of suitable negative potential, assisted by the small quantity of rarified gas with which the tube is filled to a pressure of the order of 2×10^{-4} mms.

The Fluorescent Screen.

Further reference to Fig. 3 will show that if the beam is correctly focussed it will pass in a vertical line between the two pairs of deflector plates and continue onwards until such time as it impinges on the fluorescent screen. It should be mentioned that the fluorescent screen is composed of a material which has the property of glowing when bombarded by electrons. The screen in this particular tube is such that slight afterglow is present, which assists persistence of vision, making it possible to observe transients which would be too rapid without this persistence. The feature of the screen used is that a highly brilliant image is obtainable with gun voltages as low as 500, but the tube will stand 3,000 volts without distress. There is also another type available without afterglow for use with photographic apparatus.

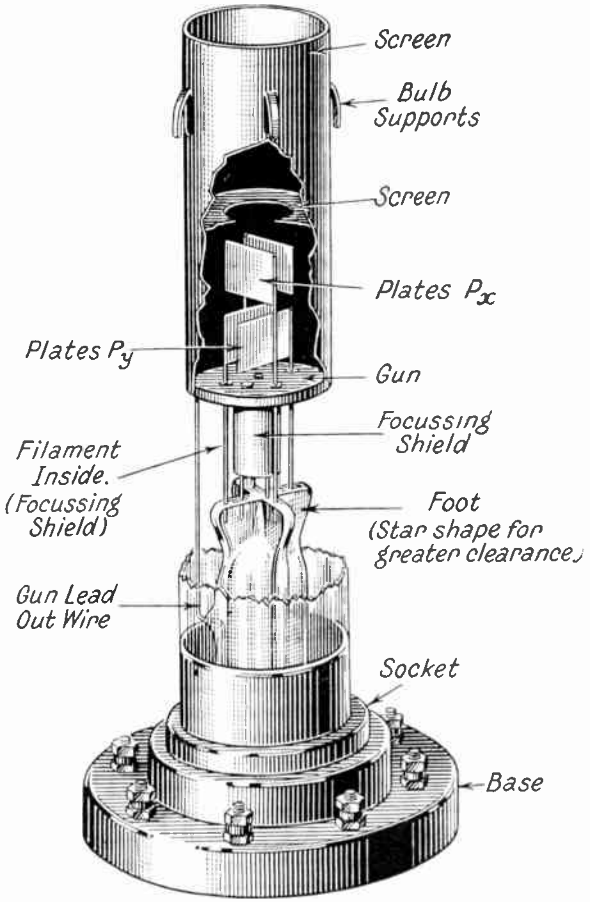


Fig. 3.—How the Cathode Ray Oscillograph is Constructed.

Continuing the investigation of the actual working principles, it has been made clear how the beam is focussed and directed on to the fluorescent screen, and it now becomes necessary to see how the beam can be controlled so that it makes a visual representation of differences in potential.

How the Beam can be Controlled.

The beam, on its upward travel, goes centrally between the two pairs of deflector plates. As the beam is composed of negative electrons it would be attracted by a positive plate and repelled by a negative plate. Thus, if an alternating potential is applied to a pair of plates the spot will travel backwards and forwards in a straight line making, if it travels fast enough, a line of apparently solid structure which will indicate the amplitude of the oscillation. Therefore, even if its frequency were unknown, the voltage could be measured by comparing the length of the line against a similar line set up by an oscillation of known amplitude.

Amplitude against Time.

When studying wave form it is usually necessary to compare the rise in voltage against time, and it will therefore be necessary to bring the second pair of plates into use by applying a suitable time base, which might reasonably consist of suitably attenuated A.C. mains. As the pairs of plates are at right-angles, the spot will be dragged in two directions, one being dependent upon time and the other upon amplitude, and as there is only one spot it must take the direction of the mean difference between the two forces, which will result in its tracking the familiar form of graph illustrative of alternating current, i.e., amplitude against time. There are numerous applications which are dealt with below, the one above being used to demonstrate the action of the tube.

Applications Requiring a Time Base.

The uses of the tube can be divided into two broad classes, namely, where a time base is required and where a time base is not required. The former class includes practically all general studies of wave form. Across one pair of plates, say, the Px pair, is placed a time base potential of known behaviour so that the spot will travel backwards and forwards in a straight line in a known manner. The voltage under investigation will now be applied to the other pair of plates, usually referred to as Py, in a manner which has already been indicated.

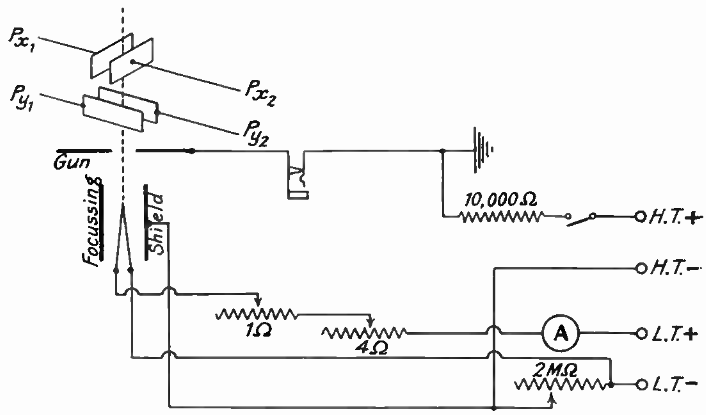


Fig. 4.—STANDARD CIRCUIT FOR USING THE OSCILLOGRAPH.

Sometimes it is convenient to use the A.C. mains as a time base, but more generally it should be linear, in the sense that the spot makes its excursion at a uniform speed, and returns rapidly to its beginning. Investigations requiring a time base split themselves up into two subsections—periodic, including studies of alternators, transformers and ripple on direct current, and transient phenomena which includes sparks, atmospherics and the making and breaking of circuits, etc.

Applications not requiring Time Base.

The applications of the tube to electrical engineering fall very largely into this group, as it includes the synchronisation of alternators, studies of phase relationship, frequency comparisons and monitoring, in addition to observations of valve characteristics, input and output of amplifiers, radio direction finding, R.F. standardisation and provides a voltmeter or ammeter with an amazing frequency range ; this latter is made possible as the beam has practicable negligible inertia.

Monitoring.

The cathode ray tube may advantageously replace the usual volume indicator used for monitoring, radio broadcasting, gramophone recording and talking picture recording. The speech voltage that is required to be monitored should be put across either pair of plates, and the resulting line observed. Its length will vary in relationship to the voltage imposed, and by observation it can be kept within the predetermined limits ; as the top of the bulb is clear glass, markings can be made with a glass pencil to indicate limit. In this direction a time base may prove useful, as it is easier to observe the extent to which the wave form will rise.

Voltmeter or Ammeter.

The cathode ray tube is a very convenient form of voltmeter when the frequency being measured is unknown. The difference of potential to be measured is applied over one pair of plates and the length of the line measured and reproduced by a controllable source of known frequency which can afterwards be measured.

Should it be desired, for any reason, to measure D.C. the displacement of the spot should be measured, as obviously no continuous line will appear. For measuring current a pair of coils would have to be rigged up so that the beam is deflected magnetically, and the same procedure adopted as for measuring voltage.

Synchronisation of Alternators.

The cathode ray tube provides a particularly attractive method of alternator synchronisation. Suppose that the output voltage of alternator No. 1 (phase 1 if

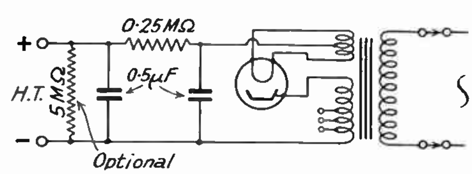


Fig. 5.—THE SIMPLE FORM OF ELIMINATOR MADE POSSIBLE BY THE LOW CURRENT.

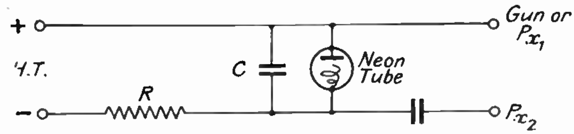


Fig. 6.—SIMPLE CIRCUIT FOR PRODUCING A TIME BASE (NOT TRULY LINEAR).

polyphase) is suitably stepped down and applied to plates P*x* of the oscillograph, and that alternator No. 2 is similarly applied to the plates P*y*.

If alternator No. 1 is running and No. 2 is idle, the spot will trace a straight line in the direction of a line running at right angles to the plates P*x*. If No. 2 is now started up, the resultant pattern goes through some very peculiar convulsions until synchronisation is approached; the pattern then ranges between the following extremes—

1. A straight line at 45° in, say, the positive quadrants indicating synchronism, correct phase and equal voltage.
2. A straight line in the positive quadrants at an angle other than 45° indicating unequal voltages but correct phasing and synchronism.
3. A narrow ellipse with long axis in the positive quadrants indicating small differences in phase.
4. A straight line or narrow ellipse with long axis in the negative quadrants indicating phase opposition.
5. A more or less circular figure indicating phase quadrature.

Screening the Tube.

Naturally, great care must be taken to see that stray fields do not affect the beam, and obviously some method must be used to screen the tube. It is suggested that a convenient method would be to fit the tube into a section of iron drainpipe, capped at the lower end and being some twelve inches longer than the tube. The chief operating data of the particular tube is as follows:

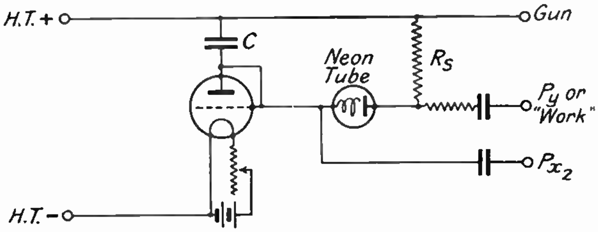


Fig. 8.—SIMILAR CIRCUIT AS FIG. 7, BUT ADAPTED FOR SYNCHRONISING TIME BASE WITH WORK.

The Cathode Ray Oscillograph—	
Filament current (amps)	0.7-1.1
Filaments voltage	0.4-0.8
*Gun voltage	300-3,000
*Shield voltage	0 to—200
Gun current (microamps)	10-200
†Electrical sensitivity	$\frac{350 \text{ mms. per volt}}{V}$
†Magnetic sensitivity	$\frac{8l \text{ mms. per gauss}}{\sqrt{V}}$

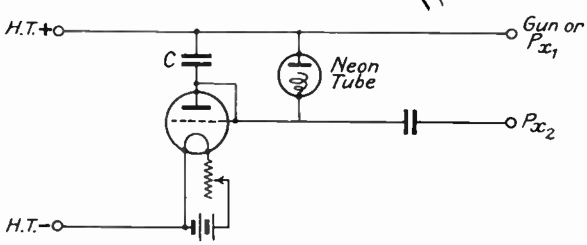


Fig. 7.—IMPROVED CIRCUIT GIVING MORE EXACTLY LINEAR TIME BASE.

Interelectrode capacity between opposite plates	1.5 μμF.
Interelectrode capacity each plate to gun	6 μμF.

*Relative to filament. 500 volts on gun is ample for most visual purposes, but tube will stand 3,000 without distress.

†Here V = gun voltage and *l* is length of beam passing through magnetic field (mms.).

Standard Circuit for Cathode Ray Tube.

Fig. 4 shows the standard circuit arrangement for using a cathode ray tube. It will be seen that the gun is earthed and that therefore the filament and shield circuits are live to earth and must be suitably insulated. For heating the filament an ordinary 2-volt accumulator is adequate, but particularly delicate adjustment of current is necessary and the use of 2 rheostats in series, one having a resistance of 4 ohms and the other 1 ohm is suggested. A filament ammeter, as shown in the diagram Fig. 4, is highly desirable.

Negative shield bias may be

free bias taken off the return space current as shown, for which purpose a good potentiometer of about 2 megohms is needed; alternatively a conventional 50,000 ohms potentiometer and battery may be used.

Using a Simple Eliminator.

The high tension current is negligible, so a very simple eliminator is possible with resistance smoothing, Fig. 5 indicating the connections. It is preferable to insert a protective resistance of, say, 10,000 ohms in the positive H.T. lead. Finally, with regard to the deflector plate circuit, this is clearly a matter of circumstances, the only general rule is that deflector plates should have a metallic connection to the gun. Plates not being used can either be shorted to gun or shorted to a bias battery if it is desired to centralise the picture.

Time Base Circuits.

Figs. 6, 7 and 8 show very interesting circuits for producing the time base, and doubtless have other quite different applications. The circuit, Fig. 6, shows a neon tube in conjunction with resistance and condensers. When the voltage across the condenser C reaches the striking voltage of the lamp a discharge occurs, and if the resistance R is not too low, the condenser will discharge to the breaking voltage of the lamp; it will then immediately start to recharge to the striking voltage, and so the process continues. The striking and breaking voltage is in the region of 200 and has a difference of about 30 volts, which is a convenient amplitude for the time base. This circuit does not give an absolutely linear time base, but has the advantage of simplicity.

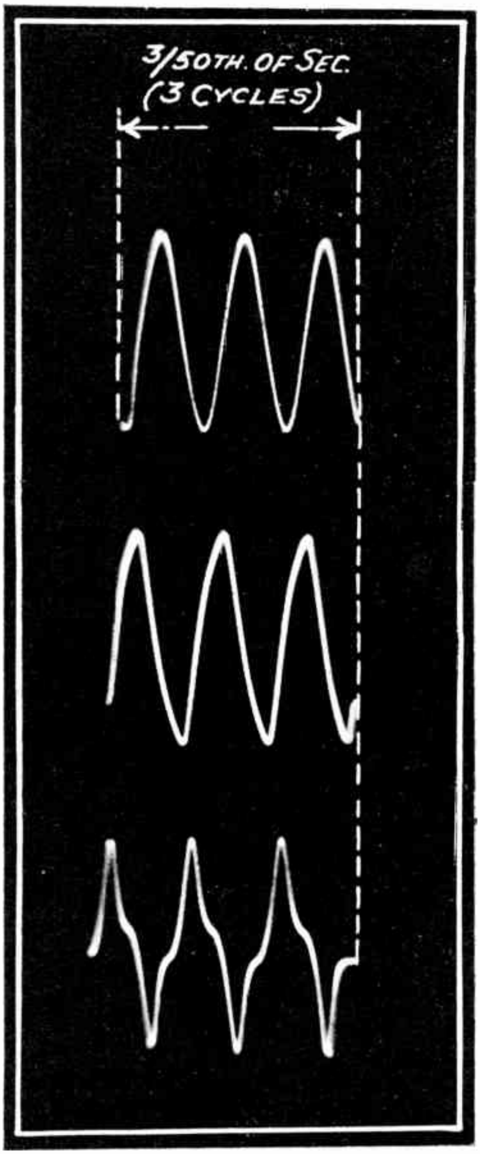


Fig. 9.—THREE IMAGES OBTAINED WITH THE CATHODE RAY OSCILLOGRAPH.

Top: Voltage wave-form of mains. Centre: Resulting primary current wave-form, showing iron hysteresis effect (iron underloaded). Bottom: Resulting primary current wave-form as in centre, but with iron overloaded.

Calculating the Period of the Time Base.

The period of this time base is :—

$$CR \frac{V_n}{V_b - V_m}$$

V_b is the H.T. voltage.

V_m is the mean voltage of the neon lamp.

V_n is the difference between the striking and breaking voltages.

(The units are farads, ohms, volts and seconds.)

When a more perfectly linear time base is required Fig. 6 can be modified by the substitution of the resistance R for a constant current device, such as, a saturated diode. The period of this time base is :—

$$C \frac{V_n}{I_s}$$

Where I_s is the saturated current supplied by the diode. A convenient diode is a triode with plate and grid connected together, a bright emitter valve being preferable.

Synchronising the Time Base to the Work.

Finally, we may add to either of the last two circuits a refinement of great importance, namely, a device for synchronising the time base to the work. Fig. 8 shows this arrangement applied to Fig. 7. Between the condenser and the neon lamp is placed a resistance Rs: this should be made as high as possible without unduly slowing down the "flyback" of the spot.

Many other arrangements will naturally have to be made to suit various circumstances which may arise and for details of the actual method on physically handling the tube, reference should be made to the instructional handbook supplied with each oscillograph.

TWO POINTS ABOUT LEAD-COVERED CABLES.

1. Action of Lead-covered Cable when the Sheathing is not Earthed.

Should there be a leak from conductor to sheath there is danger :—

(*a*) of a shock to an individual who might simultaneously be in contact with earthed metal and with the sheath.

(*b*) of fire at, say, a point where the sheath may be in proximity to a gas or hot-water pipe, even though this spot is remote from the position of the actual fault.

(*c*) of electrolytic action causing corrosion of the lead.

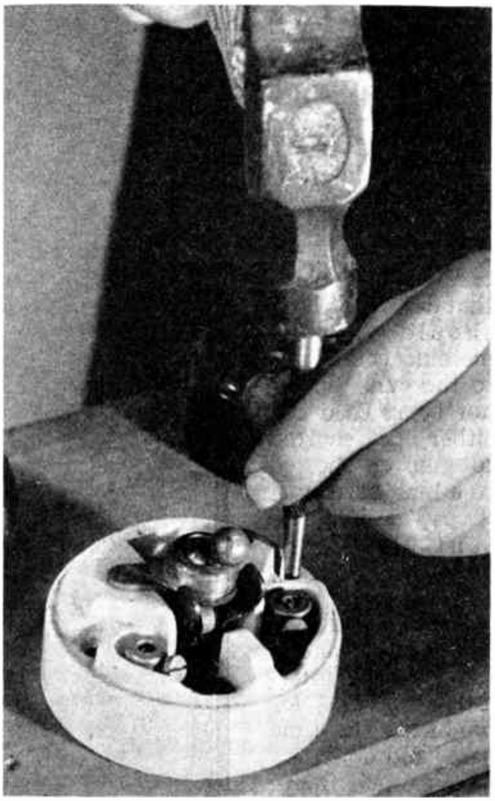
2. Action on Lead Covering when drawn into Conduit.

The lead sheath is liable to be damaged through drawing into conduit, is difficult to get round bends and, unless the conduit is perfectly straight throughout, this practice is not recommended.

A long sheath of lead-sheathed cable lying in conduit is apt to suffer from inter-crystallisation fracture of the lead should vibration be present. Cases have been known where, in the course of time, the lead has been hammered completely through by vibration. Electrolysis, or lead corrosion, through drawing into a pipe, is unlikely to take place, although not unknown where condensation has taken place inside the pipe.

Thanks are due to Messrs. Johnson, Phillips, Limited, the well-known cable manufacturers, for the above information supplied by one of their cable experts.

A BROKEN SCREW HEAD.



When a screw head becomes broken in an inaccessible position it is usual to drill the screw completely away, but before doing this the method illustrated above may be tried. Make a row of dents along the screw head with a pointed punch and hold a screwdriver on the line of dots. A sharp blow with the hammer will sometimes produce a sufficiently deep slot to allow the screw to be turned out in the ordinary way.

SPECIAL STEELS AND IRONS

FOR ELECTRICAL WORK

By A. W. Judge, A.R.C.Sc., D.I.C., Whitworth Scholar

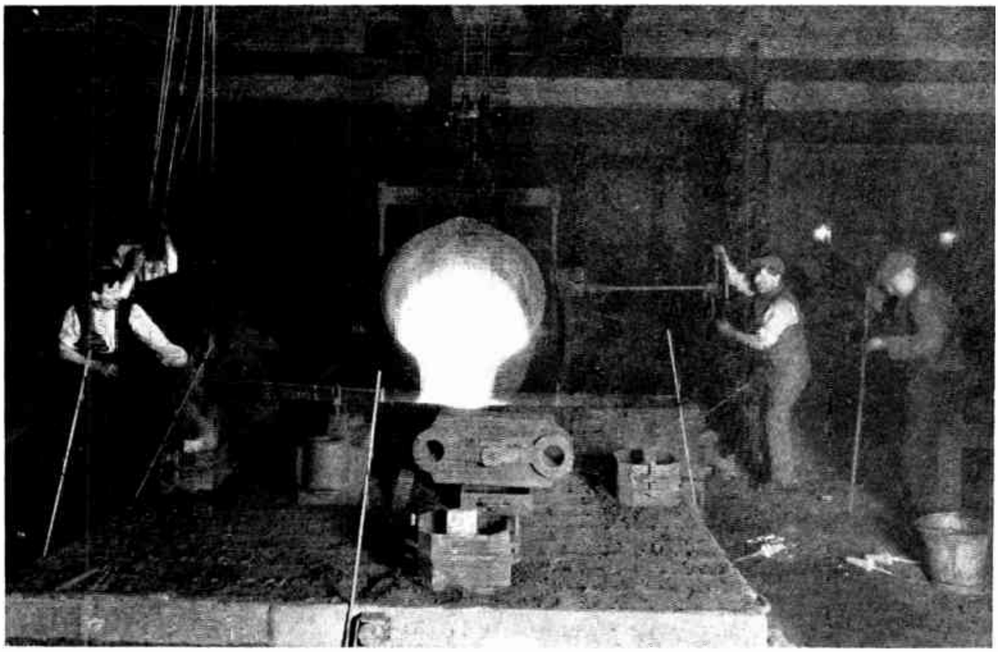


Fig. 1.—Pouring a Large Nomag Casting. (*Ferranti, Ltd.*)
This metal is easy to cast and machine so that it is particularly useful for the castings of electrical machinery where its non-magnetic properties are a special advantage.

A NUMBER of important iron alloys are now used in electrical engineering for various purposes.

These alloys may broadly be divided into two classes, viz.: (1) Magnetic and (2) Non-magnetic ones. Here it should be noted that steels are alloys of iron with small percentages of carbon and other elements.

The magnetic irons and steels include those which are capable of being magnetised only when placed in the vicinity, or field of a magnet; immediately they are removed from the magnet they lose their magnetism.

These metals are of great importance in electrical work, for armature stampings of dynamos, motors, transformers and chokes. Their purpose is to collect the greatest possible amount of magnetic effect from the magnets or coils near them; in other words, they must have a high permeability to magnetism, so as to concentrate as many magnetic lines of force within their bulk, as possible.

Among the more important irons of high permeability are the practically pure irons, very low carbon irons and certain iron alloys with silicon and nickel; we shall refer to the latter at a later stage in this article.

Amco iron is a special type of low carbon iron noted for its high magnetic permeability under normal magnetising forces. In addition, it possesses good mechanical properties; for example, it has a tensile

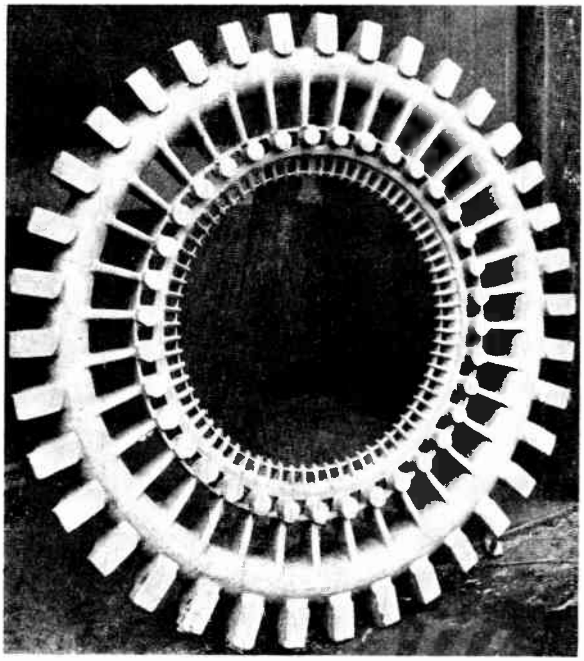


Fig. 2.—AN ALTERNATOR END RING IN NON-MAGNETIC CAST IRON. (*Ferranti, Ltd.*)
This ring is 5 ft. 6 in. in diameter and weighs 5¾ cwt.

breaking strength of about 22 tons per square inch.

Electrolytic iron is a very pure form of iron obtained by an electro-deposition process. This iron has excellent magnetic permeability. It is one of the best known metals for absorbing the magnetism produced with very low magnetising forces; it is rather expensive to obtain, however.

Hypernik is an alloy containing equal parts of iron and nickel. It is superior to Armco iron in magnetic permeability, and is much used in electrical machinery for armature and transformer cores, etc.

Permalloy is a more recent nickel-iron alloy developed in America. It contains about 80 per cent. nickel and 20 per cent. iron. It is superior to iron in its magnetic susceptibility and will give high magnetic absorption for low values of the magnetising force. Thus at extremely low magnetising forces it has about 30 times the permeability of pure iron.

Permalloy is being rapidly developed for submarine telegraph cables and for similar purposes where very low magnetisations are concerned. Its use on transatlantic cables has enabled the rate of sending to be increased fivefold.

Mechanical Properties of High Nickel Steels.

The following mechanical properties of forged or rolled bar of high nickel steels, supplied by Messrs. Brown Bayley's Steel Works, Ltd., may be of interest. The tensile tests were obtained with British Standard test pieces (2 in. by .564 in. diameter), while the Izod impact figures also relate to the test piece standardised by the Air Board and the B.E.S.A. :—

	Type of Steel.	
	25 per cent. Nickel Steel.	40 per cent. Nickel Steel.
Yield Point (tons per sq. inch) ..	18.4	20.5
Maximum Stress (tons per sq. inch)	38.0	37.7
Elongation (per cent.)	48.5	43.5
Red. of Area (per cent.)	63.2	68.0
Izod Impact Value (ft. lbs.) ..	118	101

Stalloy.

This is an alloy of iron with some 3 to 4 per cent. of silicon. It has a higher

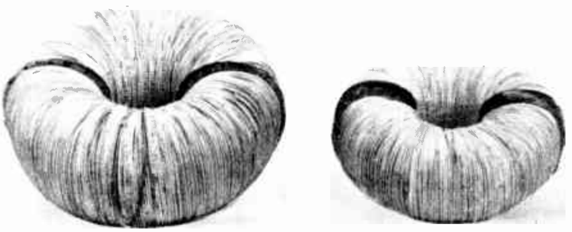


Fig. 3.—NICKEL IRON ALLOY CORE (SMALL) "BECALLOY" COMPARED WITH ORDINARY SILICON IRON CORE (LARGE) AS USED IN "LOADING" COILS FOR TELEPHONE CABLES. (*General Electric Co., U.S.A.*)

magnetic permeability under low magnetising forces than iron, and it has very low losses such as eddy current and hysteresis ones.

Stalloy is very widely used for parts such as telephone and loud-speaker diaphragms, for electrical machinery and instruments. It is made by Messrs. Joseph Sankey, Ltd., of Bilston, Staffs.

Steels for Permanent Magnets.

Having described the better-known magnetic irons and alloys of the non-permanent class, we now pass on to those metals which require to retain the maximum amount of magnetism permanently. These metals all belong to the steel class. The earlier magnets used for electrical work were made of a high carbon steel, such as tool steel, properly hardened and magnetised. This steel has now been superseded by certain alloy steels, notably Tungsten, Chromium and Cobalt steels, or steels containing two or more of the latter elements.

Tungsten Steel.

This is an alloy of iron with about 0.7 per cent. of carbon and 5.5 to 6.5 per cent. of tungsten. To obtain the highest and most permanent magnetic qualities it is necessary to heat-treat this alloy steel.

Tungsten steel is widely used for the permanent magnets of magnetos, dynamos and electrical instruments.

Chromium Steels.

A number of magnet steels of recent origin contain chromium in addition to tungsten or cobalt. These steels are known under such commercial names as *Cobaltchrom*, *Chromium-Tungsten* and *Chromium-Cobalt*.

Cobalt Steels.

An excellent magnet steel is one containing about 0.4 to 0.8 per cent. of carbon, 30 to 40 per cent. cobalt and the rest iron; was discovered by the Japanese Professor Honda in 1917. Although difficult to magnetise, it finally gives a very high degree of retained, or permanent, magnetism.

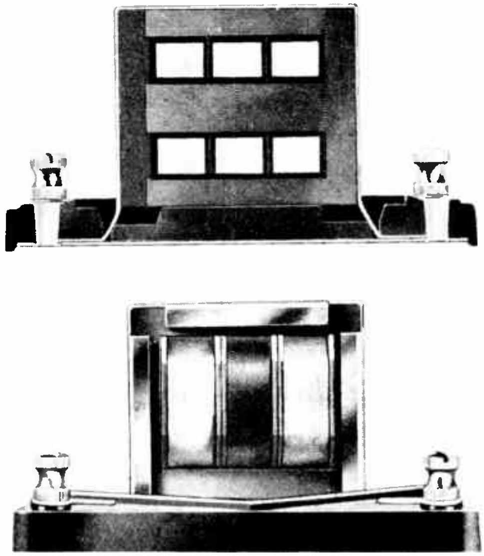


Fig. 4.—Section of Mullard Transformer Made with Nickel-Iron Core.

Top view shows nickel-iron alloy plates built around the primary and secondary windings. Bottom view shows exterior of windings.

Some Miscellaneous Iron Alloys.

Among the many other iron alloys used in electrical work special mention may be made of the following :—

Silicon Steel.

This steel contains from 3 to 4 per cent. of silicon. It belongs to the non-permanent magnetic iron class, an example of which has been referred to under the name of Stalloy. It is used for armature stampings for electrical work.

Manganese Steel.

Discovered by Sir Robert Hadfield, manganese steel possesses the somewhat remarkable property, when suitably heat-treated, of being *non-magnetic*. It has, therefore, many applications, such as for the cover-plates of lifting magnets, for ships' fittings used near the compasses, and for other purposes where a non-magnetic metal of good mechanical strength is required. It is extremely hard and very difficult to machine.

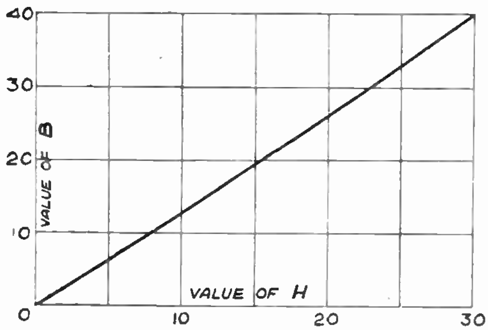


Fig. 5.—B/H CURVES FOR NON-MAGNETIC STEEL. (*Brown Bayley's.*)
Average value of $\mu = 1.3$.

Non-magnetic Cast Iron.

A special type of cast-iron known as "No-mag" now on the market is non-magnetic. It has the same non-magnetic properties as gun-metal, combined with the high resistance properties of cast-iron. By the use of this alloy magnetic leakage is largely removed, whilst the hysteresis and eddy current losses are minimised.

This metal is easy to cast and machine so that it is particularly useful for the castings of electrical machinery and for all electrical castings where its non-magnetic properties are a special advantage.

No-mag is slightly tougher than ordinary cast-iron; it is about 50 per cent. more expensive, however.

Fig. 5 is a graph showing the magnetic properties of a practically non-magnetic steel. The actual data refers to one containing about 12 per cent. manganese, but very similar results are obtainable from other steels; i.e., those containing about 6 per cent. manganese together with about 16 per cent. nickel, and also the austenitic chromium nickel stainless steels containing 16 to 20 per cent. chromium and 8 to 12 per cent. nickel.

Stainless Steels.

Stainless steel contains about 12 to 14 per cent. of chromium and, apart from its non-rusting properties, it has certain useful magnetic qualities. Thus, certain grades of stainless steel made by Messrs. Firths, of Sheffield, provide good material for permanent magnets. Such magnets, on account of their non-corrosive properties, are particularly useful in exposed places. It is interesting to note that *Staybrite*, a rustless iron made by the same firm, in the fully softened condition is *practically non-magnetic*, and may be used in a similar manner to the manganese steel previously mentioned.

Faraday and the Discovery of Alloy Steels.

In view of the importance of steel in electrical work it may interest many readers to know that Michael Faraday, in addition to his discoveries of the action and laws of electro-magnetic induction, was also a pioneer in the discovery of alloy steels. Sir Robert Hadfield in his book "Faraday" (Chapman and Hall, 21/-) deals with Faraday's metallurgical researches with special reference to their bearing on the development of alloy steels. Sir Robert Hadfield records the result of his examination by means of present-day facilities and apparatus of a series of 79 steels made by Faraday between 1819 and 1824. The large amount of information contained in this book will be found of particular value to anyone interested in research work in connection with metals.

HOW TO MAKE A VARIABLE CHOKE

By H. W. Johnson

General Arrangement.

A TAPPED coil is wound on a vulcanised fibre tube, which is supported on a teak base, with wooden supports. The tappings of the coil are connected to a sliding regulating switch, which is mounted on a slate panel. The panel is supported by two wrought iron brackets, which are fixed to the teak base.

The coil is provided with a laminated iron wire core, which is moved inside the windings with a handle when it is desired to increase the choking effect. The number of turns of the coil winding in use may be altered by moving the brush contact blade over the contact studs and bar to the desired position.

When 800 turns of the coil are in use and the iron core is fully inside the windings, the lights, when fed from 110-volt A.C. mains, will be blacked out. With 1,440 turns of the coil in use and the iron core fully in, the lights, when fed from a 220-volt A.C. mains, will be blacked out.

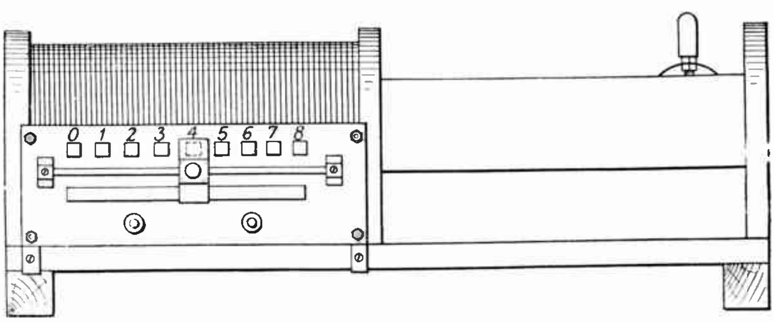


Fig. 1.—How the Variable Choke Looks When Completed. This is suitable for dimming stage lights, etc., on 110 and 220-volt A.C. mains, and is suitable for a load of 1.5 kilowatts.

Making and Winding the Tapped Coil.

The vulcanized fibre tube is cut to length, drilled for the tube ends and support, and slotted to allow of the core to be moved in or out of the winding. The holes are drilled and countersunk on the inside to admit $\frac{3}{8}$ in. 5's countersunk head brass screws. The tube ends and the centre support are cut to the given dimensions. The ends are dovetailed to ensure a firm fixing to the baseboard.

The centre support is now driven into the correct position, its outer edge being $12\frac{1}{8}$ in. from one end of the tube and there wedged tightly in position. The tube end is then fixed in position on this end of the tube and secured to it with three $\frac{3}{8}$ in. 5's copper headed brass screws. The edges of the tube end and the centre support should be in alignment.

Mounting the Tube in the Lathe for Winding on the Wire.

Make two circular wooden plugs 3 in. long and tapering from $3\frac{1}{8}$ in. to 3 in. diameter, and drive them tightly into the ends of the tube. Place the tube between the lathe centres; one plug is gripped in the chuck, whilst the other will revolve about the centre in the movable headstock. The plugs are removed when the coil is completely wound.

The Wire to be Used for the Coil.

Thirty-two pounds of No. 14 S.W.G. double cotton covered copper annealed wire, approximately 500 yds. in length,

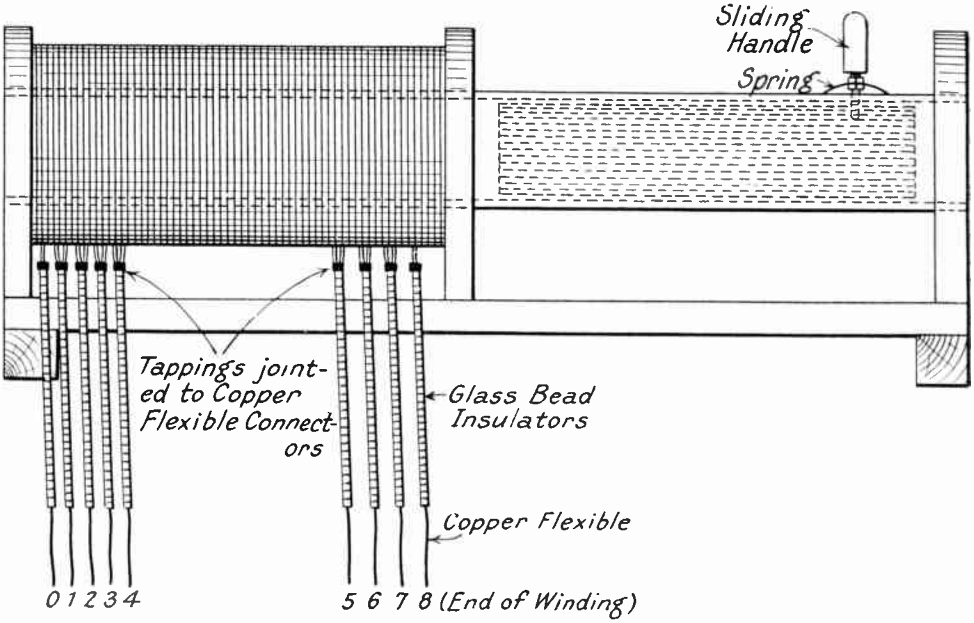


Fig. 2.—THE COMPLETED COIL AND MOVABLE IRON CORE FITTED TO THE BASEBOARD.

will be required. This wire will be delivered on a drum and should be mounted on a spindle so as to be free to rotate when wire is drawn off.

Winding the Coil.

Fasten the end of the wire to the surface of the tube at the inner edge of the tube end with a piece of stout twine, allowing 12 in. of the end to be free for making the connection to the regulating switch. Wrap 2 in. of this free end from the surface of the tube with empire tape, which is secured in position with Chatterton's compound.

The lathe spindle should be geared down to its slowest speed, and the winding on of the wire to the tube is commenced. Keep the wire taut and straight as it is wound on the tube, and the successive turns close together in order to get on 120 turns per layer. At the 100th turn, stop the lathe and bind this turn down securely to the surface of the tube; bring out a loop 12 in. long from the tube at this point and again bind the commencement of the next turn down to the tube. Insulate 2 in. of this loop with empire tape in the same manner as the end of the wire at the commencement of the winding. The winding is now continued until the first layer is complete; the last turn of the layer is bound tightly to the tube. Give the complete layer a coat of shellac varnish and allow 15 minutes to dry. The winding is continued, taking out the loops for connection to the regulating switch at the correct number of turns, as given in Fig. 7, and binding down the successive layers as they are completed. The various loops should be marked with a numbered label for identification when connection is made to the switch.

Bring all the tappings in numbered order on the underside of the completed winding, and bind them into position with a winding of stout cotton cord which is taken completely over the last layer from one end of the coil to the other. This cord will protect the insulation of the last layer from

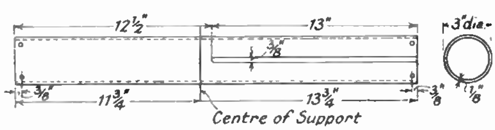


Fig. 3.—THE VULCANISED FIBRE COIL TUBE.

This article on How to Make a Variable Choke is continued in Part 39. Ready July 8th. Order your copy to-day.

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