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PRACTICAL ELECTRICAL RE-WIRING & REPAIRS

BY

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C O N T E N T S

CHAPTER ONE

WHEN AND WHY DOES RE-WIRING BECOME NECESSARY?

If you live in a house over 25 years old, which has never been re-wired, the state of its electrical system may range from inefficient to downright dangerous. Why should this be?

Part of the answer is given by a casual glance around an average house at the number of electrical and electronic appliances in everyday use. It is no exaggeration to estimate that there are from five to ten times the amount commonly found in 1950, when it was quite usual to find only one or two sockets at the most in most rooms. Indeed, going back another fifteen years some council houses were being built with just one socket to serve the entire premises! Obviously, over the years many extra points have had to be installed to cater for the ever-increasing demands. And there's the rub. All too often these extra points have been tacked on to existing cables, which may end up with a potential loading far in excess of their capacity. Alternatively large numbers of adaptors are used, which is most undesirable. Since the few sockets are seldom handy for all the equipment, long trailing extension leads abound. Frequently these are hidden under carpets, where they constitute a fire hazard.

In addition to this the current consumption (wattage) of many appliances has risen sharply since 1950. Then, an electric kettle would be rated from 500 to 750 watts. Now the figure is four times greater – 2,500 to 3,000 watts. But still people expect them to work from the same 5 amp socket that was perfectly o.k. years before. The compactness of modern heaters tends to disguise their increased loading. A small turbo-fan heater consumes three times the power of a large old-fashioned one bar fire. Likewise, washing machines, toasters, cookers, and so on, have all "grown up". Thus wiring which was adequate when installed becomes, as stated, at best inefficient, at worst, dangerous, if only for these reasons. There are, however, other important considerations.

The rubber insulation used for so many years perishes with age. This process is accelerated by the heating effects of over-loading, and it goes on largely out of sight. Often the first indication is fuse-blowing caused by someone innocently changing a light bulb; in doing so the insulation on the flex to the lamp-holder literally flakes off, allowing the two conductors to touch. When this occurs, treat it as a friendly warning that something far more serious is probably developing.

Have a good look around the fuse boxes. If you are new to the house these will give a good idea of the age of the wiring. Old installations are characterised by having numbers of seperate fuse boxes (in contrast to the modern single consumer unit) dotted around on wood blocks.

Should you find that some of the boxes are made of iron, and have curly single cables emanating from them, you possess a truly vintage system. Switch off the fuse boxes and gently knead the insulation of the cables between your fingers. If it is hard and brittle, and flakes away, the chances are that the unseen rest of it is dodgy, too. A further check, whilst the mains are off, is to remove the top of a couple of light-switches, and to undo the fixing screws; this will enable them to be pulled out and the state of the cables behind investigated. Bad insulation should not be "temporarily" repaired with tape. Out of sight is out of mind, and the next reminder could be a fire.

Another most important aspect which must not be ignored is the effectiveness or otherwise of the earthing system. Understandably, many people have only a hazy idea of the purpose of earthing, and do not appreciate that their very lives may depend upon it in certain conditions. For them, a brief explanation may be of use.

The mains supply has two "poles" (cables), live and neutral. The latter is connected to earth very efficiently by the Supply Authority. (The term earth here means our planet, and not something like a window-box, as has been imagined before now!) Thus there is no appreciable difference in voltage between the earth and the neutral main, which may be handled by skilled electricians without ill-effect. With the live pole there is a different story. This has a voltage of 240 with respect to earth, so that anyone coming into contact with it would receive a shock, the severity of which depends upon their distance from earth. A person standing on a wooden floor in a bedroom would have a far better chance of survival than someone on the stone floor of a kitchen.

It will be seen that where appliances made of metal are in use, the accidental connection of the live main to the metalwork would result in its becoming highly dangerous, even fatal, to a person touching it. To prevent just this sort of accident the idea of earthing metal appliances was evolved. The familiar third wire in the mains lead (green or green/yellow) connects the metalwork via the three-pin plug to a wire which is in turn connected to earth at or near the fuse box. Now when the live main touches the metal a very heavy current flows, causing the supply fuse to the socket to blow, and removing danger to the user.

This is fine in theory, but in practice things can still go wrong if the domestic earth connection is not effective. At one time the cold water pipe was regarded as highly suitable for earthing purposes, but due to the spread of non-metallic (plastic and asbestos) water mains it can no longer be relied upon. A bad earth here is worse than useless, as a short to live main could make all the water taps in the house, and even the neighbours' "live" to the touch. This perilous situation can be obviated completely by the use of an Earth Leakage Trip or a Board's Earth, both of which are discussed in more detail in Chapters two and seven.

Even into the 1930s houses were being wired with no provision at all for earthing. The sockets had only two pins, which would of course make such a system instantly recognisable, were it not for the fact that in many cases they have been replaced by modern types – but still without an earth connection. When the previously mentioned iron fuseboxes are to be found, it is most important to remove and check modern-looking three-pin sockets.

Another feature of old wiring systems was the method of using seperate fuses and cables for each socket. This entailed having (typically) a four-way splitter fuse box in addition to the old single way iron type. The sockets were rated at two, five, ten, or fifteen amps, according to the appliance they were to supply. This has what now seems the obvious disadvantage of limiting the use of individual appliances to certain locations; attempts to overcome this by fitting larger sockets in place of the lower-rated types could once again lead to over-loading of cables. Alternatively an unwitting person might fit a heavy-current device such as a multi-bar fire with a two or five amp plug, with similar unpleasant results.

Old-fashioned sockets and wall-switches were generally large and unattractive to modern eyes. They were frequently badly sited and after years of use have become uncertain in operation.

In the interests of convenience, appearance, and above all, of safety, it is highly desirable that old wiring systems should be replaced completely. Do not delay if at all possible; not only is it potentially dangerous, but certainly expensive, as the price of cable and accesories rises constantly in common with most other goods.

CHAPTER TWO

WHAT YOU HAVE TO DO, AND WHAT YOU NEED TO DO IT

For professional electricians very precise and detailed requirements for wiring are given in what may be termed their bible – or to give it its full title, The Institution of Electrical Engineers' Regulations for the Electrical Equipment of Buildings. This is a book running to over 200 pages, happily not all concerned with domestic premises, written in a mixture of technical and legal jargon which makes it difficult to be understood by the layman. This book has been written with the Regulations very much in mind, so that the techniques and practical work described will comply with them, but as much as possible avoiding the "blinding with science" approach.

Copies of the Regulations will most likely be available at Public Libraries, should you wish to study them in depth. For the moment I will quote just the First Note to Part One in its entirety:

"Good Workmanship and the use of proper materials are essential for compliance with these regulations."

The well known makes of cables, accessories, etc, are made to conform with relevant B.S.S. Use them, and "proper materials" are ensured. You have only then to install them carefully and conscientiously to fulfill your side of the bargain. Don't forget that the Regulations have not been made up at the whim of a group of high-powered Engineers! They have been compiled and revised over many years to assist electricians to abide with the various Acts of Parliament which have been passed since the late nineteenth century. The Inspectors from the Supply Authorities who will examine your installation also work to the Regulations, so it follows that strict adherence will considerably increase the likelyhood of your wiring passing first time.

Some requirements in more detail

Earthing, of course, is of great concern to the Institute of Electrical Engineers (I.E.E.). Completed installations must be tested to ensure that a short from live to earth will either blow a fuse or otherwise cut off the supply. In adverse conditions, as referred to in chapter one, an earth leakage trip may be necessary to do this. The E.L.T., as it is commonly called, is an automatic switch connected in the main leads from the meter to the consumer unit. It also contains an operating coil which is connected to the earth wiring in the house on one hand, and to an earth rod on the other. The slightest of shorts from live to earth will send enough current through the soil for it to activate the tripping mechanism and cut off the mains. It will remain off until manually reset, and then only after the initial fault has been cleared. A test button is provided to simulate an earth fault; it should be used frequently to make sure that the trip does work. Failure to do so must be investigated.

All cables and apparatus must be capable of carrying the maximum load that they might be expected to have imposed. In other words, when a 13 amp socket, for instance, is installed, the cable to it must jolly well be rated for that current. (Not, as I once discovered in a certain place, twin flex!) The wiring must be insulated effectively, and joints made properly.

Fuses or circuit breakers have to operate at overloads related to the current rating of the cables in the various circuits. A provision that seems rather quaint nowadays is that fuse boxes must be designed to prevent the scattering of hot metal when they come into operation. No doubt this was once an everyday hazard domestically, as it may well be even now in factories and the like. The alarming prospect of a shower of white-hot metal being emitted from the fuses is not likely to materialise if a good consumer unit is used, and the correct fuse wire fitted.
Where single-pole switches are used, as with nearly all power sockets, they must break only the live pole of the supply. The vast majority of such switches are marked by the manufacturers to ensure that this is done. The exception is the light switch, and the wiring must be carefully carried out to avoid switched neutrals. More of this in the text later.

Metal work which is in any way capable of becoming live must be earthed. Domestically this is probably confined to the odd length of conduit and/or the slip tubing which was formerly used to protect wiring under floor boards. In places likely to be damp or wet, which are equipped with electrical apparatus (e.g., a bathroom with a water-heater), the earthing circuit has to be connected both to the heater and to the water-pipes. In addition, gas pipes must be bonded to the earth system.

Fittings exposed to the elements (e.g., outside lights) must be suitable weather-proofed.

All the various circuits and apparatus on the premises must be capable of being switched off easily to avoid danger. (For instance, the fuse box should not be hidden behind a pile of junk in a stairs cupboard. Vital seconds could be lost here if an electrical fire occurred.)

No additions must be made to existing installations, even temporarily, without due regard to the current rating of the cables, and their condition. So don't run a lot of extra sockets from an existing one without checking up first. Note that this also applies to the supply mains. A major addition to the load, such as a storage heater circuit, could seriously over-run cables installed many years previously.

These then are some of the basic requirements which have to be met if your installation is to be passed by the Inspector, and is to give long and trouble-free service. But this is, of course, only half the story. We now have to translate these into terms of lifting floorboards, channelling walls, re-plastering, and so on. And for this you will need certain tools.

It will be assumed that you already possess the basic tool set of hammers, screw-drivers, pliers, tenon and hack saws, side cutters, mallet and wood chisels. Items not so frequently found in the average tool box, but essential for the job, are: a 2lb or 1kg lump-hammer, a bolster chisel with a 2 or 2½" blade, and a long thin (⅜ - ½") chisel for channelling behind skirting boards and picture rails.

Another tool which you may feel is worth acquiring is an electricians' flooring saw. This has a short stiff blade with a pronounced curve on one side and a few inches of straight teeth on the other. The curved side is used to start a cut in a floor board which cannot be lifted immediately. When it has cut its way through most of the board the short straight section is employed to complete the cut at either side.

It must not be forgotten that once the boards have been taken up, the joists beneath have to be drilled in many cases to take the cables. Since the Regulations demand a space of at least 2½"(50mm) between the top of the joists and the holes you will need to get into the floor space with your power drill. For this job I use a Wolf ½" chuck model, which though on the large side, seems to fit in pretty well anywhere. I buy ordinary wood bits, as used with a hand brace, and cut off the squared end to enable them to be fitted into the Wolf chuck. Not only are these much cheaper than standard metal-drilling bits, but they also drag themselves through the wood, a great help when you are in an awkward spot. In addition they are flexible enough to stand a little bending, something that a metal bit will not tolerate – it will snap like a carrot.

Talking of drills, a good No. 10 masonry drill for fixing switch boxes and the like to walls is needed. For drilling walls to take cables a large masonry drill about 10-12 inches long by ½" diameter is invaluable, but they are rather expensive if you have no regular need for them.

Materials for each section of the re-wiring job will be dealt with at the beginning of the appropriate chapters. Obtaining them can be done in several ways. You could, for instance, walk into a High Street shop with a list, and leave the rest to them. Not recommended. There is no recommended retail price for cable for a start, and shops with high overheads have no option but to charge what to them is an economic price. Then you could approach a small jobbing electrician, who might oblige you (a) if he is overstocked at the time and (b) if he is not the type to resent not having the job to do himself. Possibly the best idea is to get a copy of "Exchange & Mart" and browse through the pages devoted to wiring accesories. Some of the prices are very reasonable indeed, but do be careful to buy only British-made materials. This may sound rather old-fashioned nowadays, when to "buy foreign" is supposed to be the clever thing to do; nevertheless, as far as switches, sockets, fuseboxes, etc, etc, are concerned, those produced in the UK are far superior to imported types. The major manufacturers have for the most part been in business for many years, and their products are of consistently high quality. Don't "spoil the ship for a ha'porth of tar" by using very cheap, inferior accessories. Compare the prices for the various items you need, and if possible obtain all from one supplier, as a large order may result in a useful discount.

Where do I start?

With all the necessary materials to hand, and the prospect of some spare time in view, a decision has to be made as to what job comes first. A lot depends on the hours you will have free for working, and on the time of year. Obviously, the best combination is a week or two's holiday in high summer. The long hours of daylight and the reduced need to keep the family supplied with light, heat and television are of great assistance. In these circumstances it is probably immaterial whether the lighting or power circuit is tackled first. If, however, spare time is limited to evenings and weekends, or if the nights are long, I would always prefer to re-wire the lights first. This may surprise you, so I will elaborate: Generally speaking the lights will not take so long as the power to re-wire. If the latter is left intact some sort of lighting will always be available via table lamps and so on plugged into the existing sockets. Also, power tools can be freely used, along with electric fires in cold weather. And you won't have TV-hungry small fry hanging around muttering "when will it be ready?". I normally leave all the old power points working until there are enough new ones installed to satisfy the immediate demands.

The immersion heater is best worked in with whichever other job takes you near the route of its wiring. It would be pointless to delay tackling it if its cable could be run through the same joists as those used for a lighting circuit.

The item I always leave to last is the cooker. Not only does this avoid alienating the woman of the house by upsetting her routine, but it also leaves at least one socket (The one on the cooker control box) available for power tools, etc., should all the rest have to be disconnected in one go.

In the following chapters we will discuss in depth the planning and installation of the new circuits, in the order suggested.

CHAPTER THREE

THE LIGHTING CIRCUITS

Three principal systems of light wiring are to be found in older houses. The first is normally confined to premises in which electricity was put in to supplant some other form of lighting. Known as surface wiring, the cables were clipped directly to the walls, ceilings, etc., and covered by wooden channelling. Switches and ceiling roses, which tended to be large and knobbly, were mounted on wooden blocks, resulting in their being even more prominent.

As time went by and house-owners demanded a tidier job, the wiring on the walls was sunk into the plaster, and that on the ceilings transferred into the floor or roof space. The accessories remained more or less unchanged, however.

Finally, in the 30s, houses were being built with electric lighting included in the specification. The wiring was carried in slip tubing, i.e., light steel tubing joined by elbows, tees, and so on, installed in the ceilings and walls prior to plastering. With this method flush type switches started to be used and to enhance the neatness still further.

The cables used in slip tubing were seldom of multi-core type, as is common today. Single 3/.029 with rubber and cloth insulation was virtually universal. Quite often one finds that only one colour of cable was used throughout, with a fine disregard for the principle of switching only the live pole. Latterly colour coding for live and neutral was used, a vast improvement.

To discover whether or not your house is wired in slip tubing, you have only to venture your head through the customary trap-door into the roof space, and shine a torch around. The really keen electricians would carry the slip tubing even round here, and the network of pipes will be instantly recognisable. The less fussy would content themselves with using the tubing for runs down to the various switches, and would drape the wires negligently across the joists. In this case the ends of the tubes are to be seen sticking up out of odd places around the roof space.

Whichever you find, you should be greatly pleased because its presence means that your work will be made much easier. In the hope that you have been fortunate, we shall first discuss the use of the old tubing as an aid to rewiring, and then go on to work involved in fitting flush wiring in place of the previous surface type.

Before all that, however, let's check up on the cable and accesories that will be needed.

Shopping list for the lights

The vast majority of the light circuit will be carried out in what is called 1 square millimetre twin and earth, usually abbreviated to 1.0mm T & E. This has taken the place of the old 3/.029 T & E, used up to only a few years ago. The new metric size cable is much smaller physically than the one it replaces, and as the conductors are solid instead of stranded, it is much stiffer. This helps a lot when it has to be pushed under floor boards or through slip tubing.

You could, by a lot of hard work, calculate how much 1.0mm will be needed, but since it is more often than not sold in reels of 50 and 100 metres, the exercise is rather pointless. 50 metres is about right for an average sized semi, and 100 for larger detatched houses.

For two-way switching a small amount of 1.0mm three-core and earth will be required. It is worth measuring this run in advance as it will be better to pay a little over the odds for a length cut from a reel rather than have far more than you will need. An aid to finding the necessary amount will be found later in the text.

Two methods of connecting the switches and the light fittings together will be used, looping-in, and joint boxes. All the ceiling roses should be of the four-terminal type for looping in, to save time sorting them out on the job, although for most of the down stairs lights four-terminal 20 amp. joint boxes will be used, (one for each light). As discussed later, one six-terminal joint box will take the place of three four-terminal types, so you may find it better to obtain a few.

Most of the switches will be of the single-gang, one-way type, flush fitting. For two-way systems one-gang, two-way switches are called for, unless one end of the two-way circuit can be combined with another switch, or even two. Two and three gang switches of the same overall size as single types are obtainable; in each case all the individual switches are of the two-way variety.

The switches are mounted in steel boxes. Ask for plaster-depth types with sliding lugs for the switch retaining screws, and an earth terminal. Occasionally a switch may have to be fitted on a surface, and for this plastic boxes of similar depth to the steel ones are used.

For the bathroom, shower, etc., pull-switches must be used. For this application they need be only one-way. When employed in bedrooms to give two-way switching between door and bed-head the appropriate type will be needed.

All switch-boxes, ceiling roses, and so on have to be earthed. This is why twin and earth cables are specified. The earth wire in T & E is bare, so to obviate shorting it is covered by PVC sleeving, coloured green. This is obtainable in 50/100 metre hanks at a reasonable price, and the one size will handle cables from 1.0mm up to 6.0mm, in other words, all that you will need domestically.

When wiring has to be buried into plaster it should first be covered with metal or plastic channelling, obtainable in various widths to suit one or more cables of different sizes.

Most handy men have a fair selection of wood screws by them. For fastening switches into walls 1" or 1¼" no. 8s are called for; ceiling roses need up to 2" 8s depending on the thickness of the plaster. A few ½" or ¾" 6s are useful for screwing down joint boxes.

For working in dark corners, and, of course, in the roof space, an inspection lamp is invaluable. As an alternative a long length of flex with an ordinary lampholder may be used, but this is a lot more susceptible to accidental damage. If you are working in the roof space alone it's not a bad idea to put a spare bulb handy just inside the trap door.

If you are unlucky enough to have to delve through a thick layer of glass fibre to get at the slip tubing or wiring in the roof-space, I strongly recommend that you should wear gloves, preferably of thick rubber. Particles of the fibre worked into the skin cause itching which can be merely annoying or downright painful depending on the sensitivity of your skin. And scratching only drives it in further!

Whilst on the subject of the roof space, if it has lain undisturbed for many years it will be indescribably dirty, so wear either a boiler suit or very old clothes when in there, and don't omit some kind of headgear!

Making a start

Without a doubt the best place to start rewiring the lights is on the top floor. Although conditions in the roof space may not be exactly congenial, the absence of floor boards makes the installation of new cable very straightforward. (Unless, of course, some bright person has laid down boarding and covered it with junk, in which case you are in for some removal work!) In common with most aspects of rewiring, two pairs of hands are better than one here. It would just about be possible to manage by yourself, but the constant running up and down steps that this would involve would make it a long and tedious process. So try to get yourself an assistant with whom you are used to working, and ensure that you both know exactly what the task in hand will demand of you.

The first job of all is to switch off the fusebox controlling the upstairs lights. This can readily be determined by turning a light on, and switching off each fuse box in turn until you find the right one. Don't rely on leaving it merely switched off, but remove the actual fuse carriers and put them somewhere out of the way, thus eliminating the possibility of someone turning on the current whilst you are working on the circuit.

Next, you can both go upstairs and remove all the old switches and ceiling roses, but none of the old wires should be drawn out as yet. This done, one of you must get up into the roof space for the next stage.

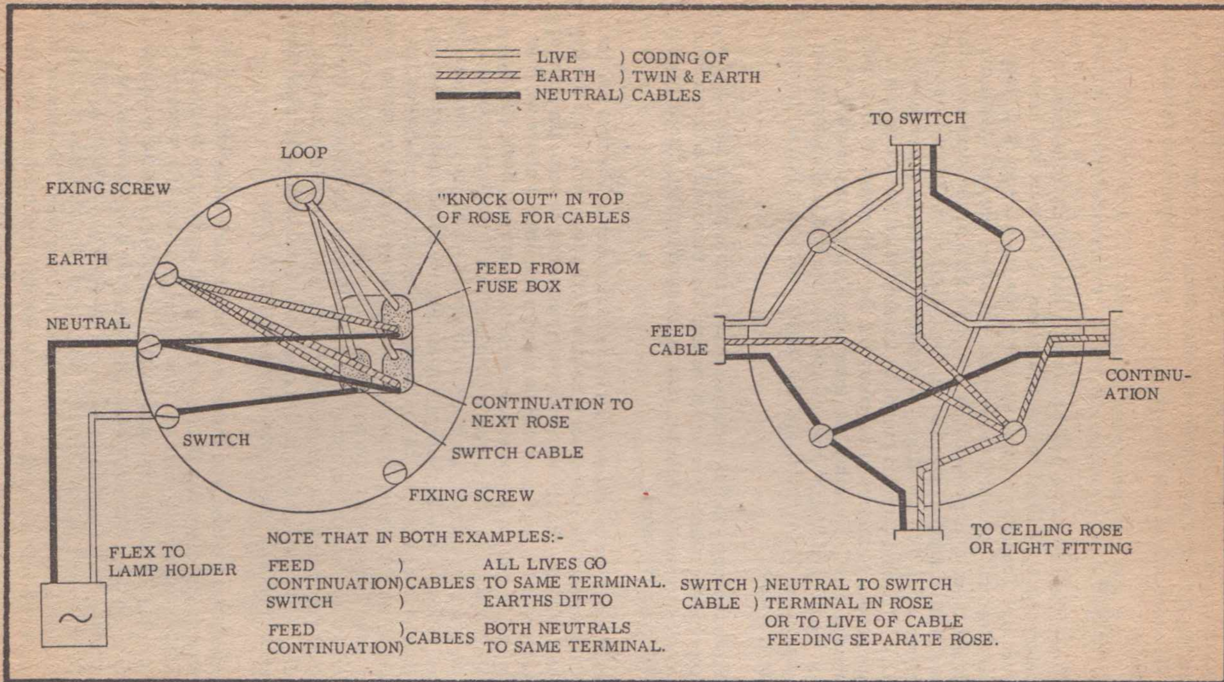
Looping-in

This is the method we shall be using for the upstairs lights. The first celing rose to be fitted will be that nearest to the main feed from the fuse box. The latter is wired straight to the terminals marked "loop" and "neutral". Another cable which will supply the next ceiling rose is also taken to these terminals, and so on until all the roses have a live and neutral supply. Note that the loop terminal will either have a red sleeve, or be set deep within its insulation to comply with regulation C19 – "... that terminal cannot be touched when the ceiling rose is dismantled to the extent necessary for the replacement of the associated flexible cord". The other two terminals of the rose are marked "flex", or "cord", and "earth" respectively. The live lead to the lampholder goes to the flex terminal, and the neutral lead shares that of the neutral supply wire.

From the loop and flex terminals in each rose a cable is taken to the appropriate switch. Thus it will be seen that there will be three cables running to most of the roses, plus the lampholder flex. The diagram will make this clear.

Now you have to translate this into practical terms. The first task for the person in the roof-space is to identify the feed wires from the fuse box. With the slip tubing which we are assuming to exist, the point of entry into the roof-space will be more or less directly above the fuse-boxes. Search for a tube so located, almost certainly flush with the brickwork. If the full tubing system has been fitted in the roof-space there will be a removable elbow at this point which should be unscrewed. It should now be possible to grasp the wires leading downwards. Have your assistant watch the wiring to the light fuse whilst you tug gently on these wires. With any luck you should be able to move them a little. They should now be removed from the fusebox and one of them drawn up through the tubing into the roof-space. Occasionally the feed to the upstairs lights was fed into that of the ground floor, and not directly to the fusebox. In this case a board will have to be lifted directly above the fuses and the connections cut at the join.

Whichever the case, you should now have a single cable which can be used to pull a new length of 1mm. twin and earth up to the roofspace. Make a strong, neat joint and tape it over to prevent the wires from snagging themselves on rough parts of the tubing. One person should feed the cable into the tube as the other pulls it up. It should be unrolled from the reel properly to avoid kinking. Draw enough up into the roof-space to reach the first rose, cut off the old cable, and poke a six-inch length of the new through the existing hole. The assistant should mark this with red insulating tape to identify it as the feed cable. He


LIVE) CODING OF
EARTH) TWIN & EARTH
NEUTRAL) CABLES
LOOP
FIXING SCREW
"KNOCK OUT" IN TOP OF ROSE FOR CABLES
EARTH
FEED FROM FUSE BOX
NEUTRAL
CONTINUATION TO NEXT ROSE
SWITCH
SWITCH CABLE
FIXING SCREW
FLEX TO LAMP HOLDER
TO SWITCH
FEED CABLE
CONTINUATION
TO CEILING ROSE OR LIGHT FITTING
NOTE THAT IN BOTH EXAMPLES:-
FEED) CONTINUATION) CABLES SWITCH) ALL LIVES GO TO SAME TERMINAL. EARTHS DITTO
FEED) CONTINUATION) CABLES BOTH NEUTRALS TO SAME TERMINAL.
SWITCH) CABLE) NEUTRAL TO SWITCH TERMINAL IN ROSE OR TO LIVE OF CABLE FEEDING SEPARATE ROSE.

then returns to the fuses and cut the new cable from its reel, leaving ample for connection into the new consumer unit when it is fitted.

While he is doing this, you will have had time to discover the tubing leading to the switch associated with the light you're working on. There may be two or three wires in this tube, since a rather different form of looping-in was used in those days. While your assistant holds one of the wires firmly with pliers, draw the rest out. Then attach the new cable as before and pull sufficient through to reach the rose, and push another short length through. This need not be marked, signifying that it is a switch wire. The assistant then cuts the cable at the reel again, and pushes the free end up through the hole in the ceiling to you, above. You take enough to reach to the next rose, and both ends of this length are marked with red tape as feeds. Then the next switch wire is drawn up, and so on, until the last rose is reached. At this there will be just the one feed cable and one switch cable. Once you have got the hang of this, the cables can be installed very rapidly, the limiting factor being the speed at which the assistant can move a set of steps from one room to another!

When there is an upstairs bathroom, and this has had a wall switch previously, ignore it and take the switch wires to a conveniently sited hole for a pull-switch. It should be in such a position that at least one of the fixing screws will bite into a joist, and that the cord will not catch on the door when it is opened.

Not all the lighting points may be straightforward. Some may be in the form of chandaliers or globe fittings not using a ceiling rose. The easiest way of tackling these is to use a four-way joint box above the ceiling, wiring it in the same way as you would the rose. A two or three core flex can then be run down to the fitting as required. (Fittings made wholly or partly of metal should be earthed).

The light above the stairs will almost certainly have two-way switching in the hall and on the landing. Draw a switch cable through the tubing to the upper switch position, and leave it for the moment. Installing the two-way switching will be dealt with in detail later.

Providing you now have cables sticking out of the walls and ceilings in all the right places, you may descend from the roof-space and continue the installation rather more comfortably!

Preparing roses for fitting

To eliminate as much fiddling work as possible when perched on the top of steps, I make up pendants (lampholder, rose, and flex) in advance, leaving the feed and switch wires to be connected later.

The top of the rose will have some knock-out sections which are removed to admit cables. Tap out as many sections as needed and thread the cables through, taking care not to lose the tape identifying the feeds. Remove about two inches of the outer sheaths, then carefully bare the individual live and neutral wires back for about ¼", and screw them into the appropriate terminals. Earth wires are, of course, already bare, and a length of the sleeving should be slipped over them, again leaving ¼" uncovered. Fasten them all into the terminal provided. Incidentally, terminal screws should always be tightened firmly, but not to the extent where they bite deeply into the wires and weaken them. Press the wires neatly into position in the rose where there is no danger of the cap fouling them when it is fitted. The rose now has to be screwed to the ceiling.

The previous fitting was more than likely fastened on to a wooden block, which was in turn screwed to the ceiling. These blocks are now redundant, but usually at least one of the screw holes left can be used for the rose. Depending on the thickness of the plaster, 1¼" or 1½" screws should be long enough for the job.

Fitting switches

The original switches may have been on similar wooden blocks to those used for the old roses, or set flush into the wall in small wooden boxes. Blocks are useless and should be removed altogether, but it is possible to make use of the old boxes on occasion. To accomodate the new switch a plaster depth metal box has to be fitted into the wall. Hold it into position and draw round it with a pencil or felt tip pen. Then, using the bolster chisel and lump hammer, cut into the marks. The plaster can be eased out from the centre in one or two lumps, with any luck, leaving a clean hole for the new box. Where there have been old wooden boxes, break the sides out, leaving the back fastened into the wall. This will usually accept small woodscrews and hold the new box securely.

If you have managed to cut the plaster neatly enough, the overlap on the new switch should effectively hide the metal box. Sometimes the nature of the plaster prevents a neat cut being made, and it will crumble away in places to leave unsightly gaps around the box. In this case, it should be made good before the switch is fitted. Polyfilla may be used for this purpose, but if large amounts are needed it is cheaper to obtain a few pounds of pink plaster from a builers' merchants. For applying it, I use a wallpaper stripper and/or a putty knife. These two tools can be bought very cheaply and are always handy. It takes a little practice to mix the plaster with just enough water to make a smooth creamy consistency; it mustn't be sloppy, or it will drip down the wall, and if it's too hard it will be difficult to smooth it properly. When you have plastered around the box, leave it to harden before proceeding with wiring the switch, and carry on elsewhere.

When the box is ready to accept the switch, examine the latter to see if its terminals are at the top or bottom, or otherwise spaced out. Cut the cable to suit, leaving enough earth wire for it to be taken round the edge of the box to the earth terminal, clear of the other cables. Don't forget to use sleeving. With some makes of switch the wires enter from the rear, making it important to cut away only just enough insulation for the proper fitting of them into the terminals. Failure to observe this precaution could result in a bare wire touching the metal box. This in turn would cause a fuse to blow, or the earth leakage trip to throw out, and tracing the offending switch might require the removal of all those you have fitted!

Back-to-Back Switches

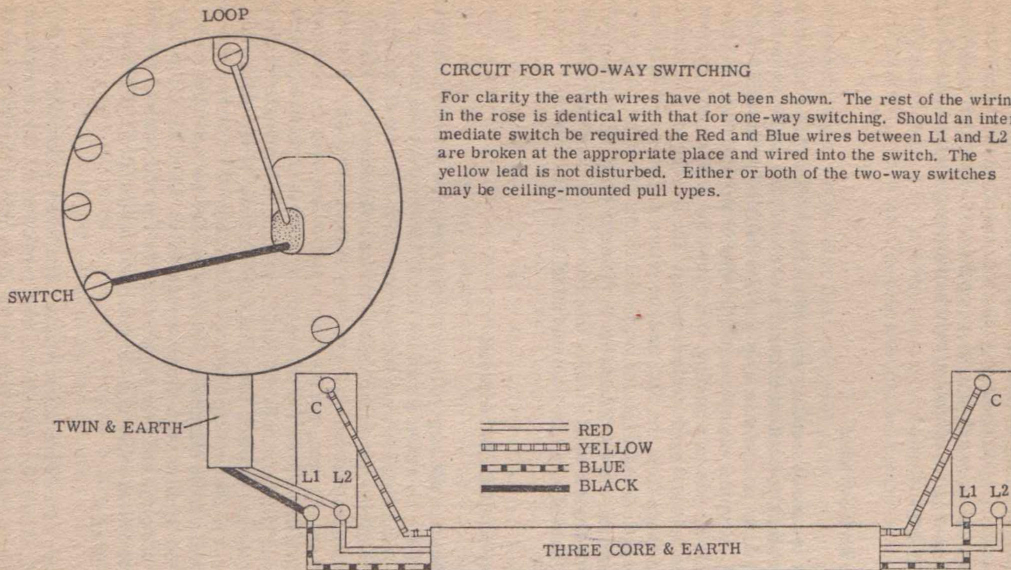
In order to save unnecessary runs of tubing, in suitable places switches are fitted back-to-back on either side of a wall; the cables to both are brought down on one side, only and one switch fed through a hole in the wall. A typical example would be where two bedrooms have their doors side by side on a landing. When rewiring such an arrangement only one twin and earth cable is needed. The live feed to the second switch is taken from the first, and the return to the second light made with a length of red single, or single and earth. The latter will earth the second switch box by connection to the earth terminal in the rose. If non-earth single is used a length of green wire, or bare wire suitably sleeved, should be taken from one metal box to the other.

Two-way switching in bedrooms

This is perhaps not as popular as it once was, now that bedside lights are common. However, it can still be useful where such lights are located some distance from the bedroom door. The use of three core and earth cable (mentioned earlier) makes installation only slightly more complicated than with a one-way system. Obviously, 2 two-way switches are required, one normally a pull switch over the bed-head. The switch cable from the ceiling rose goes to the two fixed contacts of the pull switch, usually marked L1 and L2. It is immaterial which one has the red or black wire. The third terminal of the pull switch is connected to the moving contact, and marked "C". The two-way wall switch will also be marked in this manner. The two switches must be connected together with three-core and earth, L1 to L1, L2 to L2, C to C, using red and blue to join onto the red and black of the twin and earth switch cable, and the yellow to couple the Cs together.

How it works

Looking at the diagram, you will see that when both switches are in the position, either Common to L1, or Common to L2, no current can flow from the live feed to the lamp. Only when one of the switches is changed over is the circuit completed. Plainly, this can be done at either end, and a further operation of a switch will break the circuit once more.



CIRCUIT FOR TWO-WAY SWITCHING

For clarity the earth wires have not been shown. The rest of the wiring in the rose is identical with that for one-way switching. Should an intermediate switch be required the Red and Blue wires between L1 and L2 are broken at the appropriate place and wired into the switch. The yellow lead is not disturbed. Either or both of the two-way switches may be ceiling-mounted pull types.

In cases where the wall switch is placed back-to-back with a single way switch, the latter may still be fed from the live wire of the three-core cable.

Switching the stairs light

You will recall that we left a piece of T & E dangling where the upstairs two way switch is to be fitted. From this point another length of three-core has to be run to the down-stairs switch, wired in the same way as mentioned above. Sometimes the lower switch may be conveniently incorporated in a two or three gang unit which can also control, say, the porch and hall lights. For this reason it is best to leave the fitting of the downstairs switch until you are ready to tackle all the ground floor lights. The T & E should meanwhile be taped up for safety.

Starting on the down stairs lights

This presents a far more formidable job than that on the upper floor, but once again the slip tubing will come to your aid in no uncertain manner. This allied with certain crafty methods and a little good luck will lighten your task considerably.

The first thing to do is to find the tubing. Lift the carpet or lino on the landing and look for signs of boards having been taken up previously. If done to the letter, they will have been screwed down, but it's more likely that a few nails have been knocked in at intervals. If there are screws, remove them before tapping the blade of the bolster chisel into a joint near one end of the board to be lifted. Prise it a little, then transfer the chisel (or use another if you have one) to the other side of the board and prise again. Repeat this process along the length of the board until it may be easily removed. Resist the temptation to heave it up summarily, as this can cause splitting. If you are unlucky enough to discover no previously lifted boards, choose one roughly central as regards the width of the landing, and preferably with both ends visible. Before it can be prised up the tongue and grooving has to be cut out. This too is done with the bolster chisel, by tapping it down into the joints on either side of the board. You will have to make it penetrate about an inch each time in order to do the job properly. On a long board this is a protracted and tedious operation, but one vitally necessary if undue damage to the floor is to be avoided. Should it be impossible to find a suitable board with both ends free, cut the tonguing out for about a yard and prise up sufficient of it to observe if the slip tubing lies beneath. If it does, remove as much tonguing as possible and lift the board further. Hopefully, this will reveal enough of the tubing for our purpose. The board may be propped up, if this will allow sufficient hand-room under it, or alternatively cut off. The easiest way of doing this is to wedge the board up with a screwdriver placed transversely under it, and to saw it with a small tenon. Saw in front of the screwdriver so that the weight of the board tends to open the cut.

Always try to saw above the centre of a joist, so that each end of the cut board has something to rest on. This again is occasionally difficult due to the position of the nails in the board, or some other reason. The cut may then be made close to one side of the joist and a block of wood nailed onto the latter to take the weight of the board when it is replaced.

Sometimes it may be necessary, or expedient, to cut a board before it is lifted, e.g., where both ends are under skirting boards, or where cutting is preferable to getting up a fitted carpet. The flooring saw is invaluable here. The middle of the curved blade is applied to the centre of the board to be cut, as near over the top of a joist as the nails will allow. When the sawcut is so deep that the blade starts to bite into the boards either side, the short straight cutting edge on the reverse of the blade is used for finishing off. The rest of the job is as for any other board.

Once sufficient boards have been lifted, it is to be hoped that the backbone of the sliptubing will be visible. I use this term because the usual system was to have a main piece of tubing running almost the length of the house, parallel with, and under the landing, from which were teed off other tubes leading to the ceiling roses and switches. As it is virtually impossible to pull a new cable around the right angle bend of a tee joint, or an elbow, these have to be removed. For instance, a tube leading to a downstairs switch will probably have a tee joint into the main tube, a short length of tubing to the side of the landing, followed by an elbow connecting it to the vertical run. Unscrew the tee joint first and pull the short length free. If the main tube is lifted from its fastenings there will almost certainly be enough free play to facilitate this. The wires should then be cut near the main tube. The elbow joint is loosened off next to allow it and the short tube to be removed together. You should be left with a useful length of old wires with which to pull through the new.

Hopefully, all the light and switch wires will pull through reasonably easily. However, there are snags which can be encountered. Instead of a tube going directly to a light, it may have one or more elbow joints, which would render it useless as regards pulling through. Again, if the run down to a switch tended to stand proud of the wall too much, a plasterer might well have flattened it a little to make his work easier, and thus trapped the wires within. In cases like these you would have to resort to the techniques used in replacing old surface wiring, which will be dealt with later.

It will be fairly evident that the looping-in type of wiring, which was so convenient for the upstairs lights, will be quite impracticable for those downstairs, as it would require two or three lots of twin and earth to be drawn through the slip tubing to each rose. In its place we use the joint box system, which is very similar if you regard the joint box as you did the roses when wiring the feed and switch wires, and treat the cable leading to the light as the same as the flex from the rose to the lampholder. The old electricians used a form of looping-in which sometimes involved switching the neutral wire, if that happened to be handier! – which explains why there are often three or four old single wires to be drawn out of the tubing to the rose.

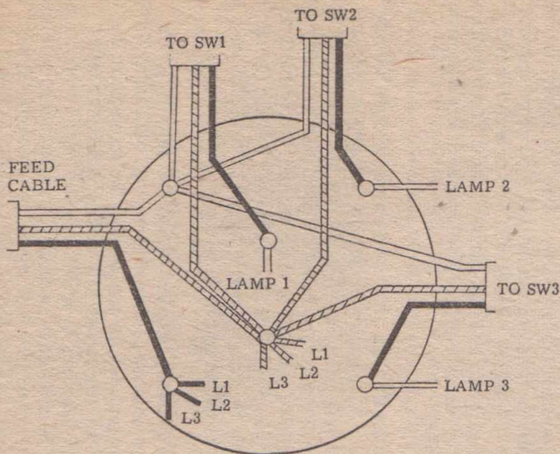
If a seperate four-way joint box is to be used for each light, half a dozen will be needed for an average semi. For only a very slight addition to the length of the various cables, just two six-way boxes can serve the purpose. This may be surprising until you recall that in each four-way box, three terminals will always be used for the live, neutral and earth of the feed cable, leaving only one terminal for the return wire from the switch. In the six-way box three terminals are available for switch wires. They are thus often to be preferred on grounds of cost and convenience.

The preliminary work is much the same as for upstairs – remove the fuses, then all the old fittings. Draw up your feed cable and take it into a joint box. Draw further cables from the ceiling holes and the switches. It should be reasonably easy to distinguish these by their different routeings, but if in doubt mark them with tape to identify light from switch wires. The diagram shows the method of wiring both four and six way boxes. In essence it is much the same as with the roses used upstairs, with the twin and earth supplying the light fitting taking the place of the flex to the lampholder.

Now is the time to complete the two-way switching of the stairs light. It may be that the lower switch is directly below the upper; alternatively the cable may have to run along the landing for a short distance before it drops down. Whichever the case, if you save and measure one of the old single wires, you will know just how much three-core and earth to buy. Add six inches at either end for ease of handling when the switches are fitted.

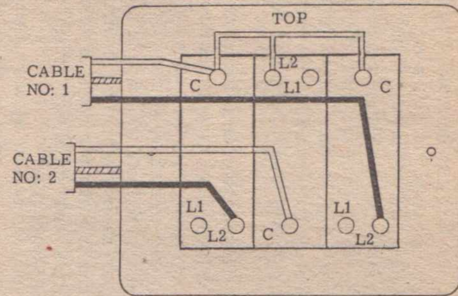
It was remarked earlier that the lower two-way unit might be combined with another. Two or three gang switches are available in the same overall size as single gang units, and they fit into the same metal boxes. If there are several switches in the hall it's a good plan to choose the site which is most convenient and to scrap the rest. Once the three-core and earth has been drawn through to the two-way switch, its live cable can be used to supply the other gangs. A length of twin and earth will be sufficient to act as switch return wires for two other lights.

The slip tubing was generally installed in slots cut into the joists. Because the cables within are protected from, say, nails being driven in when the boards are replaced, its use satisfies the regulations, and it may be re-used for the new cables. The task of pulling the latter through could prove daunting, in which case you might prefer to use the tubing only where absolutely necessary, the redundant sections being taken out. You must then drill the joists to take the cables. To fully comply with the regulations it would appear that all the sections of tubing that are used must be bonded together and earthed. One way



How a six terminal joint box may serve three switches and lights.

For clarity connections to lamps are shown in abbreviated form.



Connections to a typical 3-gang switch. Cable No: 1 carries the live feed and should be identified with red tape.

Connections to a 2 - gang switch are similar but one three core and earth cable is used.

All earths go to the terminal in the metal box.

of achieving this would be to save all the elbows and tee joints and slip them over the ends of tubes so that an earth wire can be fastened on with the same screw which tightens the fittings. These earth wires can be bonded to the nearest joint box earth terminal.

The wiring of the joint boxes completed, the switches have now to be fitted in the same manner as upstairs. When doing this give consideration to the desirability of extra lights, since this can often be simplified by using more multi-gang switches. For instance, if wall lights are to be installed in a lounge, they could be independantly controlled from one position. Again, the switch for the kitchen light could be ganged with one for a pantry, or for an outside light for the rear of the house. Another item which can be very useful is the dimmer switch, which fits directly into a standard metal box and allows the brightness of the light to be controlled over a wide range. N.B. that most dimmer switches are suitable only for filament lighting; alternative types for fluorescent tubes are available to special order.

Whilst mentioning fluorescent lighting, remember that it has great advantages over filament lamps in terms of light output and economy. A 100 watt bulb in a kitchen can be replaced by a single 40 watt fluorescent fitting, giving considerably lower running costs. The circular decorative fittings can be used in lounges and dining rooms instead of chandaliers, with even more dramatic savings. It is not uncommon for a 32 watt fitting to take the place of a three-bulb chandalier using three 60 watt lamps. The life of a fluorescent tube is far greater than that of a filament lamp – at least five times as long. Economies like these soon off-set the greater initial cost of fluorescent lighting.

Outside light fittings are available in many different styles, from purely functional bulkhead units to the expensive decorative wrought-iron and coloured glass type. Whichever you decide to use, the installation is much easier if done whilst the floorboards are still up. It is usually possible to drill the outside wall at joist level, to enable the cable to the outside light to pass straight under the floor and to a convenient joint box. If absolutely necessary the light may be switched outside the house, but as expensive waterproof switches must be used, employing the ganged switch method has much to recommend itself.

When all the switches have been fitted all that remains to be done is the wiring of the two feed cables into the consumer unit, ready for testing.

From surface to flush

But now we must consider the lot of those who are faced with the task of replacing old surface wiring. As far as the circuitry is concerned there is, of course, no difference from that done with the aid of the old slip tubing, but the installation is changed from the word go. You will recall that the first in the roof-space was to draw up a new feed cable. A new method for this has to be devised, and it will depend very much on the position of the consumer unit. Should it be under the stairs, or in a back pantry, it is often possible to get the new cable up into the floor space inconspicuously without recourse to channelling the plaster. Where the fuses are in a hall behind the front door (a favourite spot in old houses) there is nothing for it but to use the hammer and chisel! Since the remainder of the cables will also use this route, the channel may be cut wide enough to accomodate them all. To protect the cables when they are clipped to the wall, they are covered with metal or plastic "channeling", available in various widths to suit the different cables. A length of the appropriate channelling makes an ideal ruler with which to mark the wall, as it is just the right width. Hold it firmly in position from the ceiling down to the consumer unit, and draw down each side with a felt tip pen.

Note. If you have the slightest reason to suspect that you may be following the route of old cables, switch off all the fuse boxes before proceeding further.

The plaster is cut with the bolster chisel. If this has become blunt due to chopping out brickwork for switch boxes, touch it up on a grind-stone to ensure a clean cut. Tap firmly into the plaster with the chisel, for the full length of each line, whereupon it should be ready for scraping out with a suitable implement. The best is an old chisel just wide enough for the channel. Draw it down the plaster two or three times until the bare brickwork is revealed. Next a hole is made in the ceiling capable of taking the channelling. When the time comes for this to be fitted an inch or so can be pushed up into the floor space to assist in holding it firm.

The next task is to get from the floor space into the roof space. If there is an airing cupboard, or a built in wardrobe reaching from floor to ceiling, the cable could be taken up within and completely concealed with a minimum of effort. On the other hand, where a two-way switch is to be fitted on the landing the plaster will have to be channelled from top to bottom, so it might as well be made to accomodate the feed cable as well.

With a feed established into the roof space the looping in may proceed, with the difference that the switch wires are poked through holes in the ceiling, as close as possible to the brickwork. With this kind of wiring the back-to-back system becomes even more advantageous, as only one channel is required for two rooms. Do the cutting on the side of the wall which will be least conspicuous, or where it will avoid disturbing prized decoration on the other side.

The same methods are also applicable down stairs. A few minutes thought before any cutting is done can be well repaid in terms of time, mess, and cable saved.

After the switch boxes have been fitted, and the channelling nailed (into the mortar) over the cables, the walls are replastered. When you come to do this you will appreciate the care spent in cutting out a minimum of plaster. Let it all harden thoroughly before fitting switches, lest you disturb any and have to do the job again.

Where there are thick wallpapers, or vinyls, not too securely pasted on, it is often possible to cut them with a sharp knife and to bend back a strip about four inches wide, prior to cutting the channell. This strip can be stuck back when the new plaster has dried, effectively hiding it. Thoughtful little touches like this are much appreciated by the ladies of the house!

Extending two-way switching

In large houses the ordinary two-way system with switches at the top and bottom of a staircase may not be sufficient. Further switching at the end of a landing, or at the top of a second flight of stairs, may be needed for maximum convenience. In this case so-called intermediate switches are used.

The intermediate switch looks similar to a two-way unit, but has four terminals, arranged in two pairs. If we imagine the three core cable which joins the normal two-way switches at some point, and cutting through the wires which go to the L1 and L2 terminals, each pair of cut ends would then be taken to one pair of terminals on the intermediate switch. When this is operated the effect is to reverse the L1 and L2 connections, i.e., one position will join L1 and L2 on one two-way switch to the same on the second; in the other position L1 will go to L2 and vice versa. The effect of this is just the same as if one of the two-way pair were operated – if the light was off it will go on, or again vice versa. Reference to the diagram will make this much clearer.

In theory there is no limit to the number of intermediate switches which can be installed. The largest number I have personally used is a mere two, but even this enabled me to switch the stairs lights in a rambling Victorian house at four points.

Note that only the L1 and L2 wires are cut. The wire joining the "common" terminals remains intact throughout its length.

CHAPTER FOUR

RE-WIRING THE POWER POINTS

Radial or Ring?

In Chapter One reference was made to the old system of having a seperate fuse and cable for each socket, which might be of from 2 to 15 amps rating depending on the appliance it was intended to serve. Modern practice is to use sockets of a standard rating – 13 amps – and to fit fuses of appropriate amperages in the plug tops. It would be perfectly practicable to rewire the old power circuits in the same manner, one fuse to one socket, with new cable and outlets, but it would be a long job, very expensive in terms of time and materials. A development of this system, known as radial wiring, is rather more economical. A single 20 amp fuse, via 2.5mm twin and earth, can supply up to six 13 amp sockets in any one room not exceeding 30 square metres (say about 15 feet by 18 feet) which is not a kitchen. The sockets are wired one from another. Six on one cable may at first seem rather excessive, but a moments thought shows it to be perfectly in order. 2.5mm cable is rated at 23 amps when unenclosed in conduit, that is, just over 5½ kW. It's extremely unlikely that anyone would use that amount of power in one room! And if they did, the fuse being lower rated than the cable, would blow before any overheating of the wiring took place. In certain situations, therefore, the radial circuit may be of interest. Unfortunately, in a kitchen, where a large number of sockets is essential, the number of sockets on 2.5mm is restricted to two. For any more, up to six, the more expensive 4.0mm cable has to be used, with a 30 amp fuse. This combination allows loads of up to 7¼ kW to be drawn. To sum up, in small houses with few rooms, or for bed-sitters, the radial circuit may have its uses. For larger premises a different, and far more flexible system is used.

It is the ring circuit, so called because a cable goes from the fuse board to the first socket, from there to the next, and so on, to finally return to the fuse, where it is connected to the same fuse as the outgoing cable. Thus each socket is supplied in effect from two cables. For areas of up to 100 square metres the number of sockets is unlimited, so for a small house one ring is sufficient for all the power points required. For larger houses two rings may be installed, giving a load capacity of 15 kW. This ought to be sufficient, unless you happen to live in a mansion!

In addition to the sockets wired directly into the ring, you may also have what are termed spurs, a branch wire connected in at the fuse board, a socket, or a joint box installed for the purpose. These are unfused spurs, to be wired with the same cable (2.5mm) as the ring, and capable of supplying two single sockets or one twin-gang socket. Fused spurs are fed from special switch fuses similar in size to a single 13 amp socket. These fused spur boxes are connected directly into the ring, and have a maximum rating of 13 amps. The cable from them to a single socket, or to a fixed appliance such as a small water heater need only be of 1.5mm section.

The total number of spurs is governed by a simple rule – they must not exceed the total number of sockets or fixed appliances directly on the ring. It's important to remember that a two-gang socket is counted as two seperate sockets for this purpose.

From the above it will be seen that the ring circuit offers considerable advantages over the radial in many ways. It not only permits more sockets to be installed initially, but also may have others wired in later with no danger of overloading the cables.

Shopping list

As mentioned earlier, the standard cable for ring mains is 2.5mm twin and earth. This is fairly expensive, so an accurate estimation of the length required is more worth while than with the lighting circuit. Doing this is bound up with planning the best route for the ring, which will be dealt with in more detail later.

When obtaining your 13 amp switch sockets don't spoil the ship fora ha'porth of tar by getting the cheapest available. Experience shows that low prices and low quality go hand in hand in this instance, and replacing failed sockets soon brings disillusionment!

Non-fused spurs, where not takenffrom the fuse board, or from the terminals of a switch socket, require the use of 30 amp. three terminal joint boxes. The fused spur boxes referred to earlier are largely optional, except where fixed appliances are concerned. These, by the way, are defined in the Regulations as "... intended to be fixed to a supporting surface, or used in only one place". Infra-red bathroom heaters obviously come into this category along with items like heated towel rails and tubular heaters. It may also be convenient to use fuse spur boxes for appliances which must not be accidentally unplugged, such as deep freezers and heated aquaria. Tot up how many fused and unfused spurs you are likely to need and purchase accordingly, erring on the generous side.

Both switch sockets and fused spurs may be mounted in steel boxes, for flush fitting, or in plastic boxes when it is required to convert to surface mounting. Both types come in various depths, but the ones you need are 28mm for steel and 30mm for plastic.

You will already have green sleeving, and the various small hardware items as detailed in the chapter on lights. Some plastic cable clips complete your shopping list.

Planning the route

The worst thing you can do when installing a ring main is to start off haphazardly. There may be a dozen possible routes for the cables, of which only one scores as regards ease of working and economy of materials. Time spent investigating different ways and means is never wasted. Obviously only a general guide to this can be given here as there are so many variables from one house to another, but the principles and methods discussed should hold good for most domestic premises.

The first item to have a direct bearing on the route is the position of the fuse board in the house. In houses fed by underground mains it will usually be found at the nearest point to the street, i.e., in the region of the front door, and probably mounted fairly near the floor. Overhead mains, as found in country districts, are normally taken into the house high up on the most convenient downstairs wall. Having the fuse board near the ceiling is very handy as regards most of the wiring in the house excepting the downstairs ring, unless this too is to be taken around in the floor space and dropped down the walls to the sockets. If the downstairs floors are solid, with no cavity beneath, this method may well be the easiest to use. On the other hand, where means exist of getting under the floors a low-level fuse will facilitate wiring the downstairs sockets, and may well enable the light feeds, etc., to be taken out of sight to a more convenient place for their ascent to the floor and roof spaces. Sometimes part of a house has cavity floors and part solid, a frequent arrangement being that the entrance hall and kitchen are tiled, whilst the other rooms have wooden floors. When the fuse board is in the hall the ring should be taken up to the floor space, down to the first socket, and thence to the floor cavity for the remainder of the downstairs run, after which it has to return upstairs and to the fuse board. This system is also very convenient in smaller houses where only a single ring is to be installed.

The best place for the initial dropping of the cable from the floor space is on the shaded side of a chimney breast, which is also a favourite spot for mounting a socket out of sight. The cable can be channelled into the plaster, loop into a mounting box, then be channelled again to the skirting board. Once under the floor the cable must find its way into the next room, so plan its route to include as many sockets as possible. Should you need one on the opposite side of the room, make this a spur. Carry on around the ground floor in this way. The eventual return upstairs can often be made in the same way as the descent. The upstairs sockets will not require vast amounts of channelling even when mounted at the recommended height of 1 metre above floor level, but even this can be reduced still further by using the back-to-back technique whenever possible.

Be generous with the number of sockets you plan to install, particularly in the kitchen, where a busy housewife needs to have a lot of appliances running simultaneously.

When you have worked out your route and obtained the necessary amount of cable and other materials you should be able to start on the practical work with your plan of campaign clear in your head – again half the battle.

Wiring the ground floor. 1, from beneath

If there were such a place as an ideal building to wire, it would probably be a bungalow with wooden flooring throughout, and a nice deep cavity from which one could merely push the cables up through holes to the sockets above! Floor cavities certainly exist in many houses, but they are seldom commodious; and threading the cable up to the sockets can be not entirely straightforward on occasion!

The existence of a floor cavity is often revealed by the presence of air bricks in the outside walls. To verify the matter, a board has to be lifted, preferably in a place not habitually trodden upon. If a short end is not available, prise up enough for a torch to be shone down. Whilst any cavity is suitable for the threading of cables with fish wires, a depth of at least a couple of feet is desirable as working space, unless you are particularly slender and untroubled by claustrophobia! Presuming that the investigation is encouraging, a trap door must be cut in the floor, starting with the board already raised. Prop it up and saw it off above the next joist to the end. With this out of the way an ordinary hand saw can be used to cut out two more sections of boards. Hold the blade at roughly 45 degrees to the floor to give a vee shaped end to the boards. This will make a rather more solid and draughtproof joint when they are replaced. You are now ready to descend and thread the cables around the room, apart from one small snag. Builders usually make little skeleton walls beneath the middle of floors to help bear the load on the joists, and one of these may prevent your taking a direct path around the cavity. In cases of dire necessity two or three bricks can be temporarily removed to give enough room to crawl through.

With someone in the cavity, an assistant has to pass the free end of the 2.5mm down to him, from as near to the fuse board as possible. No difficulty should be experienced in channelling the plaster behind the skirting board, but actually getting into the cavity may require drilling of the floorboards, which normally extend under the skirting. Another point to remember is that where the skirting and floorboards are at right angles there is almost certain to be a joist hard up against the wall, possibly leaving insufficient space for a cable to pass between. The best way around this is to take the electric drill into the cavity and bore up through the joist from about two inches down, at such an angle that the bit will break through behind the skirting. To get the cable through this angled hole it may be necessary to use a drawing wire. A steel coat hanger, as supplied by dry-cleaners, straightened out is ideal for the job. It will also be a great help when cables have to be passed through the floor space upstairs.

Where the skirting lies parallel with the floorboards the joists will be at right angles to the wall, giving ample spaces between them where only the boards themselves will need drilling.

The old sockets which are to be removed were more than likely screwed onto the skirting, and you may be tempted to follow suit with the new ones, rather than channel the plaster. This is not to be recommended. Few skirting boards are deep enough to give a reasonable clearance beneath a modern socket. This results in the flex in the plug being bent out nearly at right angles when inserted, with consequent risk of damage to the insulation. In addition you will once again condemn the user of the socket to having to bend almost double to switch it on and off, which is especially tiring for older folk. Siting sockets at the recommended height of 1 metre will assist and encourage the good habit of switching them off at night after use. So while the cavity worker is clipping the cable to the undersides of the joists, the assistant can be cutting the plaster behind the skirting ready for the two lengths of 2.5mm which will have to be pulled up. It will probably be easier to measure and cut the cable, rather than to attempt to draw a loop through the 1 mited space.

Where a spur is to be fitted continue the ring via a 30 amp joint box screwed onto a joist. The spur cable in this case is unfused and must also be 2.5mm. Don't forget to put sleeving on to the earth wires in the box.

When the time comes to continue the ring into the next room, you will most likely find your way barred by a 4½ inch wall from foundation level. Look for any holes made for the old wiring, or for plumbing which can be used, provided that no hot water pipes are involved. Should you have to make your own way through, the easiest method is the use of the electric drill and a ½ inch diameter masonry bit. Drill into the mortar, not the brickwork.

The next task will be the cutting of another trapdoor into the floor of the second room. The wiring should not need further discussion.

The kitchen

Because kitchens so often have tiled floors, it is frequently necessary to adopt different methods for getting the cables to the sockets. One way is to bring the 2.5mm up from the cavity in an adjoining room and thence through a hole drilled in the party wall. It may then be possible to channel the kitchen wall to continue the ring to the other sockets; if not, some or all may have to be treated as spurs. The situation is aggravated by the presence of fitted cupboards, etc., and worst of all by the complete tiling of walls. In the latter case drilling the walls is the only answer, even if they happen to be on the outside of the house. The cable should then be taken from the cavity via a specially drilled hole or convenient air brick, and clipped as inconspicuously as possible along the wall. PVC covered cable is completely impervious to the effects of weather, but to protect it against mechanical damage it must be covered by metal channelling.

The same techniques are used when sockets are fitted in outside buildings attached to the main part of the house.

2, from above

Wiring the ground floor from above entails channelling down to each socket. As a sort of compensation for all this work, it will normally be possible to install the upstairs ring at the same time, by lifting only one lot of floor boards.

Routing the cable under the boards from its point of entry near the fuse boxes should not prove too difficult. If it is run at right angles to the joists these must be drilled at the regulation 2 inches minimum from the top. When it has to be threaded in the space between joists, the stiffness of 2.5mm cable is of great assistance. Over long distances the process is aided by the use of the aforementioned fish wires. A loop should be made in the end of the 2.5mm, and a shepherd's crook type of bend at the end of the fish wire. To see what you are doing under the boards a hand mirror at an angle and a good torch are required. Be warned, however, that it takes a good deal of practice to operate a fish wire when observing it in a mirror, as all one's movements seem to act backwards! A snag often encountered is the fitting of cross-bracing in the centre line of the floor. It takes no little patience to negotiate a cable through the small triangular spaces in the bracing; in extreme cases it may prove necessary to lift a nearby board to achieve the aim.

It has been previously said that chimney breasts are ideal locations for sockets because the required channelling is less obvious. Something which must be borne in mind when preparing to run a cable down from the floor space is that the dimensions of the chimney breast are seldom identical below and above the downstairs ceiling, the difference being most likely about 4½ inches – the tickness of one brick. So a hole made in the down stairs ceiling close by the brickwork could be a puzzling distance away upstairs. Worse, the builders may have surrounded the chimney breast upstairs with timber to carry the floor boards, in which case the hole in the ceiling will have to be made two or three inches out into the room, and the ceiling itself channelled to take the cable.

Another hazard on the way down is the old fashioned picture rail and/or plaster coving. In both cases very careful excavation with an old wood chisel is required.

Since half the sockets must be directly on the ring, reserve the spurs for the really awkward ones. Fused spur boxes will be needed if you intend to install wall-mounted heaters in the kitchen or downstairs bathroom. In both instances the boxes must be mounted high up out of the reach of wet hands, so working from above is an advantage here. It's also useful if a high level socket has to be fitted to supply a window-mounted extractor fan. Don't forget that the method of drilling the walls and running externally to a socket is just as easy from above as from below.

Another method which I have used with great success, albeit mainly when fitting additional sockets in newer houses, is to take advantage of cavity walls to completely avoid channelling and subsequent making-good. The system is in itself simple, but it requires the taking of accurate measurements.

The position of the socket is marked on the wall downstairs, and its distance from the nearest corner of the room noted. (Generally speaking this is only applicable to outside walls.) At an exactly similar distance in the floor space a hole is cut in the wall large enough to admit a weight and strong cord into the cavity. This is lowered until is quite obviously reaches ground level. The cord should be tied to a large object to prevent its being all drawn into the hole during the next operation. The large masonry bit is now used to drill into the cavity at the socket position. A fish wire with a small hook, cranked slightly is passed through the hole and twirled around until, hopefully, it picks up the cord. I have seldom encountered much difficulty in this. The cord is drawn up from the bottom of the cavity, and although the weight will probably be too large to come through the hole, you should have an ample amount to grip. The cable is tied on securely to the loop, and for good measure the joint is taped as well, whereupon it can be pulled gently upwards into the floor space. This is best done with someone feeding the cable into the hole in the wall. The weight is drawn back and the cord and cable separated. All that remains to be done downstairs is to cut out the plaster for a steel box, and to fit the socket to it. When wiring houses professionally I use this method as a kind of party trick, which never fails to amaze and delight the customer as a new socket appears as if by magic!

Although, as said earlier, the method is mainly used on outer walls, there are cavity inner walls to be found from time to time, and it's well worth investigating the possibility before undertaking a long channelling job.

The upstairs sockets

Carrying on the theme of cavity walls for a moment, these are often to be found on upper floors, in the version known as lath and plaster. These are basically a framework of timber with either the old fashioned cladding from which they get their name, or in more modern houses faced with plaster board. In either case they are useless for our "party trick" because the wooden frame runs both horizontally and vertically. Nevertheless they can have their uses where the socket is not to be fixed higher than about a foot from floor level. I know this sounds like a direct contradiction, of a recommendation made only a few pages ago, so I had better qualify this statement. Sockets fitted either side of a bed for reading lamps, tea-makers, etc., are usually fitted low down at the request of the user, who does not want them to be in full view with flexes drooping down. Also the appliances mentioned, to which we ought to add the all-night electric blanket, do not have to be switched off at the socket for obvious reasons.

Fitting sockets for these purposes in lath and plaster walls has been made much easier in recent years by the introduction of a plastic box made especially for the purpose. This has the classic attributes of an invention of being simple and efficient – and also being inexpensive. The box has two spring-loaded lugs positioned on the sides in such a way that they can be pressed back within it as it is inserted into a hole in the plaster board, etc. This hole must be cut accurately with a pad saw or sharp knife to provide a close fit for the box. With the latter flush to the surface of the wall the lugs are sprung out to grip the inner surface. Their grip is increased as the socket is screwed home, until the box is fixed firmly. To get the cable up to the box the part of the framework which rests on the floor will have to be drilled, and since this is hardly possible from beneath, the hole must be made at an angle from about 2 inches above floor level, using a ½ inch wood bit. Once the cable is threaded through to the box there will be only a small amount of re-plastering to do to hide the damage.

This method is naturally applicable to back-to-back working, the only proviso being that the boxes may have to be offset from each other in walls of little depth.

Other bedroom sockets are frequently required for electric heaters, so they should be mounted as far away as possible from the bed. Where there are chimney breasts these should be used, and the standard 1 metre height adhered to. Mention has already been made of the possibility of finding timber surrounding chimney breasts. This will require the use of the wood bit at an angle to get through to the back of the skirting.

Always important to the housewife is the provision of a socket on the landing for her vacuum cleaner. To save her aching back this too should be at the standard height.

Bathrooms

Wherever the bathroom is situated, there is an absolutely clear and unequivocal regulation which must be obeyed. It is that no sockets for portable appliances are to be allowed with the sole exception of the special shaver sockets made to B.S.3052. A room which has been converted to house a bath or shower must have any sockets previously fitted removed. The only part of a fixed appliance (wall heater) which may be touched is the cord which operates the switch. Where there is an airing cupboard in the bathroom with the hot water tank within, any immersion heater must be permanently connected and the switched placed in a position remote from wet hands.

The importance of these rules cannot be overstressed. An electric shock is nasty at any time, but where the recipient is in contact with water the results can be grave, or fatal.

Some years ago a lady told me of an experience which exemplifies the above. She had taken a portable electric fire into her bathroom; on stepping out of the bath she reached down to move it and received a severe shock. Unable to relax her grip on the fire she fell to the floor with it jammed against her thigh. Her screams soon attracted her husband, but fate had played another trick. The presence of visitors in the house had caused the woman to lock the bathroom door, something she never normally did. Her husband had to break the window to get in, and not a moment too soon. Miraculously she survived the shock, but sustained terrible burns from the fire, and will carry the scars to her grave.

"Better be safe than sorry" is a motto applicable to all domestic wiring, but seldom more so than when a bathroom is concerned.

B.S.3052 Shaver sockets are obtainable for domestic use in a size comparable with a normal 13 amp socket, but there the resemblance ends. The heart of the shaver socket is a small, very high grade transformer which effectively isolates the mains input from the actual pins of the socket. The transformer delivers 240 volts at sufficient power for shavers only; the voltage is isolated from earth also, which means in practice that unless one went to the extreme of deliberately grasping both pins of the razor plug as it entered the socket the chances of getting a shock are eliminated.

A fixed appliance becoming steadily more popular is the "instant" water heater, as used to supply a shower. These units have a lot to commend themselves regarding their small size, ease of installation, and running costs. Because they consume power only while water is being drawn through them, a family of five persons can each have a ten minute shower for less than 5 pence. At a conservative estimate this is less than a fifth of the cost of having five reasonably hot baths supplied by a conventional immersion heater. The initial cost of the instant heater is recouped very quickly at this rate.

Fitting one of these heaters is not beyond the ability of a handyman who has had some experience of plumbing with compression fittings. It is beyond the scope of this book to describe that part of the work in detail, but the following points, which affect the electrical operation of the unit, must be borne in mind.

Inside the unit is a switch operated by the water pressure. Therefore the tap controlling the unit must be on the supply side. If it were fitted on the outlet side the unit would be permanently switched on with no flow of water to stop the heating element reaching a dangerously high temperature. It would become red hot and be destroyed within seconds of the power being switched on.

Plumbing joints in the supply to the unit must not be made with jointing compound such as "Boss White". The effects of this being carried into the unit by the water are so serious that the makers consider its use to invalidate the guarantee. If any difficulty is experienced with compression joints P.T.F.E. tape must be used to seal the threads.

Units are supplied with various ratings, up to about 5kW. I find that a 3kW unit is perfectly satisfactory for a shower. This wattage can be taken in perfect safety from a ring main, via a fused spur box. The latter should be placed outside the shower or bathroom. A very suitable box for this job is the type carrying the legend "Water Heater", and having a built-in neon lamp to show when it is switched on.

The unit itself obviously has to be mounted near the shower base, an arrangement which is perfectly safe provided that the cover is well fitted – and that it is unlikely to be used by persons whose irresponsibility borders on the suicidal. I say this because not far from me lives a gentleman who had a shower fitted by a very competent specialist firm. Regrettably the unit failed whilst his teenage son was taking a shower. Without further ado the youth took a penknife from his trouser pocket, unscrewed the cover, and attempted adjustments within – with the mains still switched on. Once again a miracle saved his life, but the extensive burns he received required treatment for many months afterwards. With this incident in mind, and having sons of my own, I contrived to fit my heater behind the shower unit, which is made of translucent plastic. This completely screens the heater from view, but allows the warning neon lamp to glow through.

Heated towel rails

These useful appliances are often of the oil-filled type. Once heated the oil is slow to cool, so that in conjunction with a thermostat the heating element draws current for limited periods. The maintenance of an even temperature is of course essential to prevent scorching of the towels. The oil-filled panel radiator works on exactly the same principle.

Being totally enclosed, these heaters are extremely safe. To permit their use in the bathroom, however, the rules concerning portable appliances must be observed. They should be fastened to the wall or floor and the connecting flex taken out to a fused and switched spur box fitted on the outside of the bathroom wall. Here too a warning neon light is recommended. Either the wall or the floor may be drilled to take the flex, whichever lends itself to making the neater job.

Heat and light fittings

Perhaps these appliances should have been dealt with in the chapter on lighting circuits, since they are wired in place of the bathroom light. The usual form is of a circular infra-red heating element surrounding a central lamp housing, both backed by a circular reflector which is screwed to the ceiling. Separate pull cords are provided to enable the lamp and the heater to be used independently. The latter is rated at about 750 watts, i.e., a current demand of just over 3 amps. Whilst this is well within the capacity of 1.0mm cable, it would represent over half the full load on the light fuse. Therefore separate light circuits for ground and upper floors are more suitable for these appliances.

Electric clocks

The correct way to wire in an electric clock is via a special clock connector plug and socket, which incorporates a 3 amp fuse. They are obtainable in either flush or surface mounting types. The flush variety can be fitted in the wall immediately behind the clock itself, so that no unsightly flex is seen. The feed cable (1.0mm) is channelled into the plaster and taken to the nearest source of power. Because the current consumed by a clock is negligible it may be connected to either the lighting or ring circuit as convenient.

CHAPTER FIVE

IMMERSION HEATER CIRCUITS

The immersion heater is probably the one domestic electrical appliance destined to cause more upsets and arguments than any other, mainly on grounds of running costs. When a large electricity bill arrives it is almost traditional for the disgruntled husband to blame it on his wife's indiscriminate use of the immersion heater. Admittedly they are not cheap to run – about 5 pence per continuous hour at today's prices – in some respects, but the convenience of having hot water must be worth that, at least. A cynic might say that certain sections of the public will cheerfully pay 50 pence or more per day to get lung cancer, but will jibe at giving one tenth of that amount for a hot bath!

By bringing the hot water tank, the heater, and its wiring up to date you can effect useful savings in running costs, as well as making it electrically safer. Firstly, let us consider the feed to the heater. Because it consumes a fair amount of power (3kW, or 12.6 amps for a modern one) the heater has its own separate fuse and supply cable. This is well inside the maximum quoted for 1.5mm, but due to the requirement to maintain the voltage at full load, in practice it should not be used for runs over 15 metres in length. Above that, and up to about 30 metres, 2.5mm should be used. It's not unusual to find old heaters wired up with 3/.029, which was really only suitable for lengths of around 13 metres; above this the voltage drop could have a marked effect on the performance of the heater. For this reason simply changing the feed cable can increase the actual wattage of the heater, and shorten the time taken for it to do its job. (For every 10 volts lost the wattage is reduced by 126). So when planning the route of your cable, keep it as short as possible!

It was common practice in years gone by to take the supply cable directly to the airing cupboard, and there connect it to the heater by either a fairly massive switch, or sometimes a 15 amp socket and plug. Where the airing cupboard is in a bathroom this arrangement constitutes a hazard, as wet hands may be used to switch on or off. My own inclination is to fit the heater switch in a handy place downstairs, to avoid needless running about, but nevertheless I find that some women still prefer to switch on at or near the hot tank. With this remote from the bathroom a neat arrangement is to cut a hole in the side of the cupboard just large enough to admit the "works" of a flush water heater switch, leaving an ample amount of wood or hardboard for the rim to bear against. An ordinary metal box is employed to secure it. The feed cable, and that to the heater itself have to be threaded through holes in the metal box and connected into the switch before it is clamped home using the normal fixing screws and holes. The best type of switch is that with a warning neon lamp built in, to give at-a-glance indication of its being "on".

If the switch is mounted away from the airing cupboard, take the cable from it to a 30 amp joint box mounted as near as possible to the heater terminal block.

In either case the cable from switch or joint box to the heater must be of the heat-resistant type. It's dear to buy, hence the object of getting as close as possible with normal cable. Butyl rubber insulation is o.k. up to 85 degrees C., and silicone rubber to 150 degrees, the 1.5mm size being used in both instances.

Next a look at the heater itself. The most common type is that having an overall length of about 27 inches, screwed into a boss soldered, or otherwise fixed to the top of the tank. Where the rating, which is quoted on the heater or its cap, is below 2.5kW, it will be worth while changing it to a more powerful type, as explained above.

To unscrew the heater a correct size of spanner must be used – not stilsons. The water pressure must be removed from the hot tank by operating the valve in the supply pipe from the cold tank. Then a bucket full of water should be drawn off at the release valve to be found near the boiler downstairs. Note that opening the hot taps will not do! Due to the length of the heater it may be necessary to remove some of the clothing slats often found above the tank.

Normally a new sealing gasket will be supplied with the replacement heater. Make sure that no trace of the old one remains on the flange to spoil the joint, and coat all the surfaces with a little "Boss White" or similar compound. Screw the heater down firmly, but don't go mad. Open the feed valve and watch for dribbles of water around the joint; they may not appear until the heater has been brought into use.

The thermostat fits into a tube in the body of the heater. There are two types, short and fat, and long and thin. Both normally have a small dial calibrated in degrees surrounding an adjustment screw. A usual temperature is 140°F, as this is about the most that hands can tolerate. However, in very hard water districts a higher temperature (160–170) is said to assist in protecting the element from "fur".

Considering the widespread publicity that had been given to the subject, it is surprising how many hot water tanks are still not lagged. This is the greatest single factor in keeping down costs. The better the lagging applied to the tank the sooner will it heat up, and the longer will it retain its heat. Especially made jackets are available at a cost which will soon be repaid in the saving in electricity. Even if you feel that you can't afford one of these, for goodness sake fit something, even if it be only an old eiderdown or some blankets, around the tank. Several layers of old newspapers, topped with an overcoat from a jumble sale were fitted in the first house I owned; it was evident on feeling the outside of this concoction just how efficient it was in reducing heat loss. It certainly didn't warrant replacement whilst I lived there.

An argument which will probably continue until that happy day when we all have solar heating, is whether it is more economical to leave the immersion heater switched on permanently, relying solely on the thermostat to control the heat, or to use the manual switch as and when hot water is required. My own leaning is toward the former, as I maintain that it takes less electricity to keep the water at a constant temperature after intermittent use than it does to heat the tank up from cold at intervals. I believe that the Electricity Boards upheld this view, though I am perfectly prepared to concede that this might have been in their own interests! Of course, the individual requirements of different households is bound to affect the position. A young wife with a number of small children will need hot water right through the day, whilst a married couple who both work may need none from 8 a.m. until late afternoon. Their needs could best be met by having a time switch set to come on for an hour or two before these times, while there would seem little point to the young housewife's ever switching her heater off, even at night.

Off-peak water heating

The entire subject of off-peak electricity will be dealt with later in this book, so for the moment we will confine its discussion to its connection with water heating in general.

As you will probably know, a few years ago the Electricity Boards introduced a "White Meter" scheme, whereby all the current used outside the peak hours was charged for at a lower price. This was an alternative to the long-standing arrangement with a separate meter for off-peak electricity which could only be used for space and water heating. The white meter could be of greatest advantage to those persons needing to use a lot of electricity during the night over and above the usual storage heater demand. Water heating obviously comes into this category, although to their credit the Boards pointed out that the savings would be small unless a larger-than-usual hot tank were to be installed. To do this would cost a great deal of money, so on balance it would appear that unless you intend doing a lot of cooking and other household work at night the white meter offers very little advantage over the conventional off-peak system, particularly now that the hours have been reduced as demand has risen.

Those persons lucky enough to be getting the old style of off-peak, with daytime boost period(s) are well advised to have the immersion heater wired into the circuit. Should this not be sufficient then for their requirements it is possible (and very reluctantly admitted to be legal by the Boards) to fit a change over switch which automatically selects the low-priced current when available, then reverts to the normal circuit outside off-peak hours.

So, as you will see, the advantages or otherwise of using off-peak electricity for your water heating will vary enormously according to individual demands. The over-riding consideration must be whether the limited hours can provide the amount of water you need, or alternatively, would the projected savings in electricity rapidly amortize the cost of a larger tank, or extra equipment? Only you can answer this, and then only after careful consideration. It would also help if you were some sort of clairvoyant. How different might be the number of all-electric houses if consumers could have foreseen five years ago the staggering rise in the cost of supplies? But who can say if alternative fuels might not exceed these costs in the not so distant future? One thing is for sure. Electricity whether generated by coal-fired boilers, atomic fission, or wave movements, will always be with us. This may not be true of oil or natural gas.

Dual-range immersion heaters

It is possible to obtain dual-element heaters which will heat either the top few inches of the tank, or most of it, as desired. These may be controlled at the tank, by a switch built in the heater itself, or from a two-way switch downstairs marked "sink"/"bath". Once again the advantages or otherwise are a very personal matter. I remember that the instruction booklet with the first one I ever installed, many years ago, was refresingly candid, saying that in certain circumstances no saving at all would be possible. I liked the honesty of the manufacturers, and the quality of their product is unquestionable. If you occasionally need to use sinks – full of hot water, and a bath rarely – then the dual heater could be for you. On the other hand your needs might be met by a small capacity water heater mounted near the sink. Think about it.

Alternatives to immersion heaters

There are three types of alternatives to the immersion heater. First there is the storage water heater, of from 2–5 gallons capacity. These are plumbed into the water supply and have automatic valves and switches to maintain water level and temperature as hot water is drawn off. They are remarkably efficient and economical where there is a constant demand for small quantities of hot water.

Secondly we have the small geyser type, commonly holding about 1 gallon. They normally have a flexible hose for connection to a tap, and possibly an audible warning device to give notice of boiling. The time taken to achieve boiling point from cold is fairly rapid even at full capacity. They are ideal for washing-up, or making large quantities of tea or coffee, for filling numbers of hot-water bottles, or in any circumstance where the demand is not large, but is beyond the capacity of an electric kettle.

Thirdly comes the instant water heater, as already referred to in the chapter on bathrooms. They are excellent in many ways, but because the flow through them is restricted, they take rather a long time to fill even a small sink. They are, however, ideal for places like hairdressing salons where they may be used with spray attachments with great success.

Each of the above can offer, in its own way, advantages in cost and performance over the immersion heater except where there is a demand for large amounts of hot water. If this demand can be made to coincide with the off-peak hours, and the immersion heater used on the cheaper rate, very substantial savings are possible. It is a goal well worth pursuing.

CHAPTER SIX

ELECTRIC COOKER CIRCUITS

The normal ratings for cooker circuits have been for many years 6.0mm (7/.044 in pre-metric days) cable with a 30 amp fuse. This suffices for the average cooker plus the assumed load on the socket which is usually incorporated in the cooker control unit. The ratings are arrived at by an interesting formula, which assesses the current demand as follows:

The first 10 amps of the full loading of the cooker, plus
30% of the rest of the loading, plus
5 amps for the socket.
Our average cooker will draw a maximum of 35 amps, giving:
10 + 8.3 + 5 = 23.3 amps assumed load.

Whilst a larger model with 4 rings, large oven, warming drawer, rotisserie, and all that jazz will draw 55 amps, or:

10 + 15 + 5 = 30 amps.

So on the face of it the 30 amp circuit is quite sufficient. But would it be so in practice? Surely it would not be unreasonable to expect the owner of a large cooker to be using it at 60% of full load at least for a family dinner? This alone is well over 30 amps, and if she should plug in her 12.6 amp hi-speed kettle to the cooker box, bingo! a fantastic overload. No danger, you may say, the fuse will blow before the cable can overheat. You try explaining that to a harrassed housewife fiddling with fuse wire while the dinner spoils on the cooker!

So, what do we have to do? Install heavier cable at great expense, and a larger fuse? Fortunately not. A study of the regulations reveals that the normal rating of 6.0mm, 35 amps, may be multiplied by 1.33 where close excess-current protection can be assured. This is provided by special fuses complying with B.S.88 (Class P or Q1) or B.S.1361, or by miniature circuit breakers to B.S.3871. All these are supplied by the manufacturers of consumer units and may be readily obtained. The 35 amp rating multiplied by 1.33 gives 45 amps, a much more reassuring figure for the large cooker.

Incidentally, the definition of close excess-current protection is rather intriguing. It is simply protection which will cut off the supply within 4 hours at 1.5 times the rated load. Coarse protection, as provided by the familiar re-wirable fuse, will not operate within 4 hours at the same overload. This must be a powerful argument against the dangerous practice of fitting heavier-than-normal gauges of fuse wire to accommodate extra loading on a power circuit. An old 15 amp cable having been given a 30 amp fuse = a 300% overload potential = a 999 call to the fire brigade.

Installation notes

6.0mm cable is the dearest that you will use domestically, so it behoves you to take the shortest route from the fuses to the cooker! When it follows the same path as that of the ring main, or the immersion heater wiring, do not try to use the same holes in joists, etc., but make fresh ones. This avoids bunching and the possibility of mutual heating of the cables that this can cause.

The cooker control box may be obtained in flush fitting or surface mounting type, with built-in neon warning lamps if desired. The normal practice is to have a 13 amp socket integral with the box, but non-socket types are to be had if need be (refer to an earlier paragraph!).

As always, the flush-fitting units are by far the more attractive. The steel boxes have for a long time been of a standard size, so an old unit with, say, a 15 amp round-pin socket may easily be replaced with a 13 amp model. Cutting brickwork out for a new flush installation is a long and arm-aching job, as you need to go in about 2 inches. It's best to check before hitting the first blow on the chisel that there will be sufficient depth of brickwork to accommodate this chasm. Single-brick (4½ inch) walls are definitely not recommended; nor are those made of breeze blocks or similar materials. With these it is far better to stick to the surface mounting method.

The connection of the cooker to the box should be made with 6.0mm also. Make the length of this sufficient for normal movement for cleaning and servicing, but not over-long (maximum 2 metres).

Small cookers

There are many small cookers on the market intended for small flats, etc., which have a maximum rating of 3kW. This enables them to be run from a standard 13 amp socket with no special control gear, but do not extend the cable supplied with the cooker to reach this socket. If the cooker just can't be moved closer, install a socket especially for it. A taped joint operating at high current is a definite fire risk.

More than 1 cooker?

The regulations allow the use of 2 cookers in any one room on a 30 amp circuit when the formula quoted earlier indicates that the assumed load will not exceed this figure. If, for any reason you have 2 cookers installed in your house in different rooms (a flat for Granny?), each must have its own 6.0mm feed and appropriate fuse. The assumed loading may then well exceed 60 amps, in which case the Supply Authority must be informed so that they in turn may ensure that their cables will handle this demand.

Returning to the 2 cookers in one room, a single control box may supply both appliances provided neither is more than 2 metres distant from it. So if you must have 2 cookers, mount them side by side!

CHAPTER SEVEN

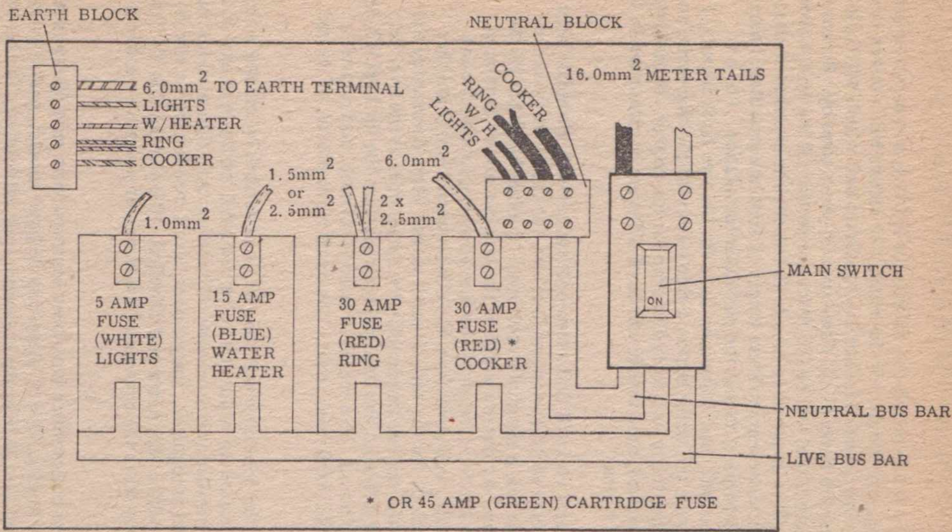
THE FUSE BOARD AND ITS ACCESSORIES

Having by now completed the circuits for lighting, power, water heating and cooking, you should now have near the meters half a dozen new cables awaiting connection into the consumer unit which will replace the accumulated ranks of old fuse boxes of years gone by. Because the two ring main cables will be fed from one section of the unit, a five-way type will be required to handle all the circuits mentioned above. As supplied, consumer units are empty of fuse holders, these being purchased separately to suit the particular installation. For our example you will need 2 five-amp fuses for the two light circuits, 1 fifteen-amp for the water heater, a thirty-amp for the ring main, and either another thirty or a forty-five amp for the cooker. If the larger rating is specified, note that it will be of different construction to the lower rated types.

Inside the unit you will find a two-pole switch with terminals large enough to take up to 16mm single cables, for the input from the meter. Near this is situated a multi-way terminal block for all the neutral wires. Across the width of the box is a row of terminals attached to the top section of the fuse contacts, to take the live wires. Finally, well away from the other connections is another multi-way block for the various earth wires. When connecting the cables, use the neutral terminals in the same order as the live, i.e., the farthest left-hand live terminal matches with the farthest left-hand neutral, and so on. This makes it easier to identify and remove a specific cable if the need arises. The earth wires should, of course, be sleeved.

Entry into the consumer unit may be from behind, by cutting a largish hole in the board on which it is to be mounted, or through any of the sides. The smaller units are made of bakelite, with thin sections ready to break out as required. Larger ones have a wooden frame which can be cut with a tenon saw and chiselled. When doing this it's best to keep away from the corners of the frame, or you may weaken it severely.

The old fuse boxes which have been removed were most likely mounted on wooden blocks. One of these may be large enough, and in good enough condition to take the consumer unit without any further work. Otherwise a suitable board should be rawlplugged to the wall with thin battens interposed to stand it off about half an inch. Make the board sufficiently large to hold a bigger consumer unit than at present envisaged, just in case extra circuits are needed in future, and for an earth trip if needed.



A TYPICAL CONSUMER UNIT (4-WAY)

The feed cables from the meter to the consumer unit are known as meter tails. For the loads anticipated for our example the full 16mm size are needed, but before these are measured up and connected the method of earthing should be determined. Should the trip be necessary the tails will be connected to it first, and thence to the meter. Where an earth terminal exists at the meter board it's pretty safe to assume that it can be re-used. A phone call to the Planning Engineer at your local Electricity Board will establish for certain if this is so, or if a terminal can be fitted if there is none at present. The cost of having it fitted varies from area to area, but should in any case be much cheaper than the earth leakage trip which is otherwise necessary. Trips are nearly always required in rural areas.

Besides the four large terminals on the trip for the meter tails there are two smaller ones, marked "E" and "F" respectively. "E" is connected to an earth rod driven into the ground outside the house. The rod should be at least four feet long, of copper or copper-clad. Rods obtained commercially often have threaded ends to which a steel spike and cap can be screwed to assist in driving into hard ground. The rod should not be sited near other earthed objects, e.g., water pipes. Also note that you are not about to transfix a drain or gas pipe as you hammer downwards!

The joint to the earth rod should be either soldered or made with a proper clamp. The latter is normally supplied with the rod, as is the special label which has to be attached to or near it. The wording is: "Safety Electrical Earth – Do Not Remove", in letters not less than 4.75mm high. The cable to be used for connecting the rod to the trip should be 2.5mm green single.

Another length of the same cable connects the "F" terminal to the earthing block in the consumer unit. Why "F"? It stands for "Frame", which may or may not date back to when trips were used solely for protecting machinery.

The gas and water pipes must be bonded to the electrical earth, preferably where they enter the building. The bonding must be done with 6.0mm cable. The connection into the electrical earth should not be made before the latter is itself complete, either by way of the trip or Earth Terminal. Regulations D11 and D30 state this very clearly, and I mention this because it has been my experience that certain Electricity Boards have tried to insist that the installation should be done in the reverse order, i.e., that the bonding into the earth should be done prior to their workmen installing an earth terminal. The reason for this is obscure, and certainly indefensible, because it could lead to a water or gas pipe becoming live.

Your part of the work will terminate with the fitting of the consumer unit and/or trip. The whole installation has then to be inspected by the Board, and if found to be satisfactory, it will be connected into the meter. Broadly speaking, the tests will be for:

1. Verification of polarity, to ensure that all the switches are in the live pole, and so on.
2. The effectiveness of the earthing system.
3. Instulation between live and neutral, and between live and earth.
4. For continuity of the ring circuit.

Should any of these prove to be unsatisfactory, it will have to be made good before the supply is connected. To obtain a test you must obtain the appropriate form from the Board's offices and complete it. They usually want 48 hours notice of when the installation will be ready for testing, and they also ask for the name of the contractor who did the wiring. You will of course enter your own here. They'll also ask what form the earthing is to take, so if the answer is "Board's Earth Terminal", append a note to the effect that you want them to install one. You will probably be asked to pay in advance for this. If you have just taken over the house you will also have to fill in an application for supply form. This will indicate to the Board what is to be your maximum demand for electricity, enabling them to arrange for larger main fuses, meter, etc., if required.

CHAPTER EIGHT

OFF-PEAK ELECTRICITY

Many years ago the demand for electricity dropped so sharply at around midnight that it was difficult, if not impossible, to operate the generating stations economically. There used to be stories of electricity being deliberately sent to waste to enable reasonable loadings to be maintained. In these circumstances was born the storage heater. The idea was to sell the otherwise surplus electricity at or below half price to charge heaters which would release the heat gradually throughout the day. As further reductions in demand were common at mid-morning and afternoon half-price "boost" periods were also available to supplement the main overnight charge. I do not wish to boast when I say that at the time I gloomily forecast that the off-peak would become a peak if the intensive sales-drive succeeded; nor do I take any pleasure in having been proved correct. The initial 14-hours (8 at night, 3 in morning, 3 in afternoon), were reduced to 11 by eliminating the morning boost first, then down to 8 by cutting out the afternoon period. The sole benefit to the consumer of this, as far as I can see, is that to compensate for the reduction in charge hours the heaters have had to be made more efficient, and in the process, smaller physically.

There is nothing particularly novel or complicated about the storage heater, by the way. The Romans used precisely the same idea 2000 years ago when they placed huge blocks of stone above fireplaces to store heat; and generations of country folk went to bed with a common house-brick wrapped in flannel to preserve the heat it had absorbed in the coal-fired oven during the evening. The electrical storage heater is in essence a powerful element embedded in a stack of bricks, with a cladding of glass-fibre to restrict the radiation of heat. In practice there is also some kind of thermostat to prevent overheating, and a safety device which will cut off the supply should all else fail. It's usually a fuse in the true meaning of the word – a link made of a special alloy which melts at a higher-than-safe temperature.

The early heaters were of prodigious size and weight. As denser materials were developed for the bricks the size went down dramatically, if not the weight. Features like bi-metallic strip-operated louvres to release the heat quickly when desired, and fans to blow it around, were introduced.

To restrict the supply to the heaters, they are wired on completely separate circuits and fuses, these being controlled by a time switch. This is normally hired from the Board for about 50p per quarter, and is set by their engineers to suit the slightly different off-peak hours allocated in different localities.

Unfortunately, the huge increases in the price of electricity over the last few years has caused the popularity of storage heaters to decline sharply. Even so, they have a lot of advantages which may outweigh the running costs in certain circumstances. Firstly, they are by far the easiest form of central heating to install, and being, at least technically, portable they do not cause the house rates to rise. Secondly, they are the safest type of heater, since there are no exposed elements, flames, or fumes. Power cuts which render hot-water radiators useless when the pump won't work leave storage heaters unaffected, because few cuts take place in off-peak hours. For rooms which need to have a constant background heat, and where the presence of flammable materials has to be considered, the storage heater still has a lot of offer.

Should you decide to install some heaters, it's worth studying for sale columns in your local paper. Very often reasonably new examples are to be had for a fraction of their original price. It's perfectly possible to acquire four heaters, and to install them, for around £50. At this price you could burn an awful lot of electricity before reaching even the installation costs of other systems, let alone fuel bills!

To install four heaters you will need a four-way consumer unit with 15 amp fuses, and four switched outlet boxes. If a trip is used for earthing the normal circuits, another will be needed for the off-peak. The runs of cable from the fuses to the outlet boxes may be in 1.5mm for up to 25 feet; above that distance 2.5mm must be used to avoid exceeding the permissible 6 volts drop at full loads. As with the water-heater cables, avoid bunching those to the heaters with others. Rating factors apply when groups of cables are in close contact. Two together have their ratings reduced by 20%, three by 30%, four by 35%, and so on.

The switched outlets are mounted either flush or in plastic boxes, whichever is simplest. Because they need to be touched only rarely they can be fitted in a low, inconspicuous position. From the outlet to the heater itself 1.5mm flex with silicone rubber insulation must be used. This is rated at 15 amps at between 35 and 120 degrees centigrade.

Heaters are best installed near inner walls, where the heat can be absorbed to best effect. A clear space of 2–3 inches is usually recommended, to achieve which spacers are fitted at the rear of the heater. But perhaps you are wondering how on earth you could move the heaters to their appointed places.

Dismantling, servicing, and re-building heaters

Because of their great weight, storage heaters are nearly always supplied new in kit form, to be assembled on site. It's possible to man-handle complete heaters from one home to another if strong assistants and suitable transport are available. Otherwise it's alot easier to dismantle and reassemble.

The heaters should have been switched off for a day or so before dismantling to allow them to cool completely. The outer casing is normally sectionalised, and held in position by self-tapping screws with Phillips heads. Once it has been removed, you are strongly recommended to don leather or industrial gloves to prevent particles of the glass-fibre insulation from getting into your skin. The itching from these drives you mad, and the more you scratch the worse it becomes, so be warned. The fibre is normally in pre-formed boards an inch or so thick. These will be brittle, so handle them gently and lay them flat on newspaper. Ensure that you will be able to reassemble them correctly by making notes of their positions. The bricks may now be removed. The top row will no doubt have the same lengthwise shallow trough as the lower rows, but in this instance it will be unoccupied. The removal of these will reveal the element lying in the next trough. Ease the bricks out from beneath it starting from the middle, to avoid stretching it. Continue doing this until all the bricks are out. They can be re-assembled in any order. With any luck this process will have been completed without actually having to disconnect the element. If it was fitted correctly initially it should retain sufficient flexibility to move around in transit without damaging itself.

Repairing elements

It will be appreciated that the dismantling procedure is equally applicable to servicing as well as transporting heaters. In either case where the element is found to be broken, examine it to determine the cause. In most cases it can be attributed to local overheating, the result of incorrect or careless installation. When supplied new the element is tightly coiled. It should have been measured and divided into as many sections as required (one less than the number of rows of bricks), then stretched out to the proper length. It's when this isn't done correctly that the trouble starts. If the turns aren't equally spaced those closer together get much hotter and eventually burn out. Where this has occurred in only one place a repair is practicable; where general cramping of turns is found more than likely the whole element will have become excessively brittle, and repair in one place will probably be followed by breaks elsewhere.

To repair simple breaks two methods are feasible. The whole idea is to make a joint which is electrically sound and which will not itself overheat. To achieve this either a small nut and bolt, with washers, should be used to clamp the broken ends together, or alternatively they can be pushed into the centre portion of a flex connector, the type with a brass barrel and two grub screws. In this case the broken ends should overlap, so that each screw bears on both wires. Elements repairs in this way stand a good chance of lasting years longer.

While the heater is apart check around the various terminals for signs of overheating and/or damaged insulation. The former is often the result of the terminal screws not being tight. The overheating makes the wire and its insulation very brittle, to the point where jarring of the heater can make it come adrift from the terminal altogether. When insulation itself needs to be replaced it must be of the heat-resistant spun-glass type.

When reassembling the heater there is usually a thick panel of glass fibre to be refitted in the base, followed by others upright at the rear and sides. After this the first row of bricks is fitted. The element should then be strung along the trough in the top of the bricks. At one end it will have a short straight section where it rises to the next row; the first brick of this should be slid sideways into position to retain the element in the trough and in its upright attitude simultaneously. The procedure is repeated until all the bricks are back in position, after which the fibre panels to the front and top are replaced.

It's now the turn of the outer casing to be slipped on. Take care whilst doing this that no wires are trapped against it. With the case safetly screwed on the heater is ready for test. If any kind of test-meter is available the resistance between live and neutral leads should be checked. A typical reading would be 40 ohms for a small heater down to 20 or so for large models. Next the resistance of the element to earth has to be proved to be extremely high, in the order of megohms. Finally the continuity of the earth wire to the metalwork must be assured. If all this is o.k., the heater can be wired back into its switched-outlet. Unfortunately, unless you are fortunate enough to have an afternoon boost period, you will have to wait until midnight to find out if all is well. An ear pressed to the heater when the current starts to flow will detect the twanging of the element as it starts to warm up and expand.

When put back into service heaters should have the heat control turned to maximum for the first day or so, then reduced to the desired level.

CHAPTER NINE

WIRING TO OUTBUILDINGS

Putting lights and a power point or two in a garage or workshop involves more than just clipping a cable along a wall, or dangling it between the house and the outbuildings. There are a number of regulations which must be complied with if the job is to be 100% safe.

For instance, if a cable is to be clipped to a wall on the outside, it must be in conduit, or be of a special construction suitable for the purpose (e.g. lead-covered). This is to prevent as far as possible damage to the insulation which could result in electric shock.

Where the outbuilding and the house are quite seperate you have the choice of running the cable over- or under-ground. Many house-owners will opt for the extra work of digging a cable trench in the interests of tidiness. Ordinary PVC cable is suitable for the run provided that it is enclosed in either a pipe or a duct. The latter could be the tough PVC tubing commonly used for sink wastes, etc. set into a good thickness of concrete. This would probably be cheaper and easier to work with than the alternative of steel water piping. If you do use this it should be earthed for safety, but it must not be used as an earth conductor, i.e. an earth wire of some sort must connect the earthing in the outbuilding to that in the house. Twin and earth cable will satisfy this requirement except in certain circumstances which will be discussed later.

The minimum depth of the cable is 18" (500 mm if you work in metrics). Where ground is subject to cultivation this should be increased to 24" (600 mm). If the ducting can be carried right into the building(s) before the cable emerges, so much the better, but if this cannot be arranged conduit, steel piping, or metal capping must be used to protect it up to the point of entry.

Overhead Wiring

Where the distance involved is less than 12 feet (3m) PVC cable can be used unsupported, provided that precautions are taken to prevent damage by chafing or twisting. For this distance conduit supported at either end may be used to carry the cable, provided that the conduit is in one complete length.

Unsupported cables are subject to a minimum height requirement of 12 feet (3.5m); conduits can be a little lower, at 10 feet (3m). These minima are for places inaccessible to vehicles. In all other situations the height requirement is 17 feet (5.2m), and this figure holds good for the overhead systems to be next discussed.

For longer distances overhead two methods are open for use. One is to employ single cables stretched between insulators. This is good for spans of up to 100 feet (30m). The other is to use the standard twin and earth supported by what is called a catenary – a steel wire to which the cable is fastened. There is no upper limit recommended for this system.

In a modest sort of installation where, for instance, the overheads have to supply a couple of lights, and perhaps a socket for a deep freeze, this latter method is ideal. 2.5m twin and earth is rated for this job in the same way as for when it is clipped to a surface and un-enclosed, that is, 21 amps. This gives an ample safety margin. Two single 2.5mm cables would be rated slightly higher at 23 amps, and might be rather cheaper to buy. They would be well suited to supplying a workshop where power tools and some form of electric heating are to be used. No., I haven't forgotten the earthing. Over long distances an earth connected into the house circuit might become inefficient, and with power tools no risks should be taken. By the nature of things one has to grip them well in use, which would considerably increase the seriousness of a shock from them. The best plan is to fit an earth leakage trip in the workshop with its own earth rod. This will afford great protection and is well worth the extra cost involved.

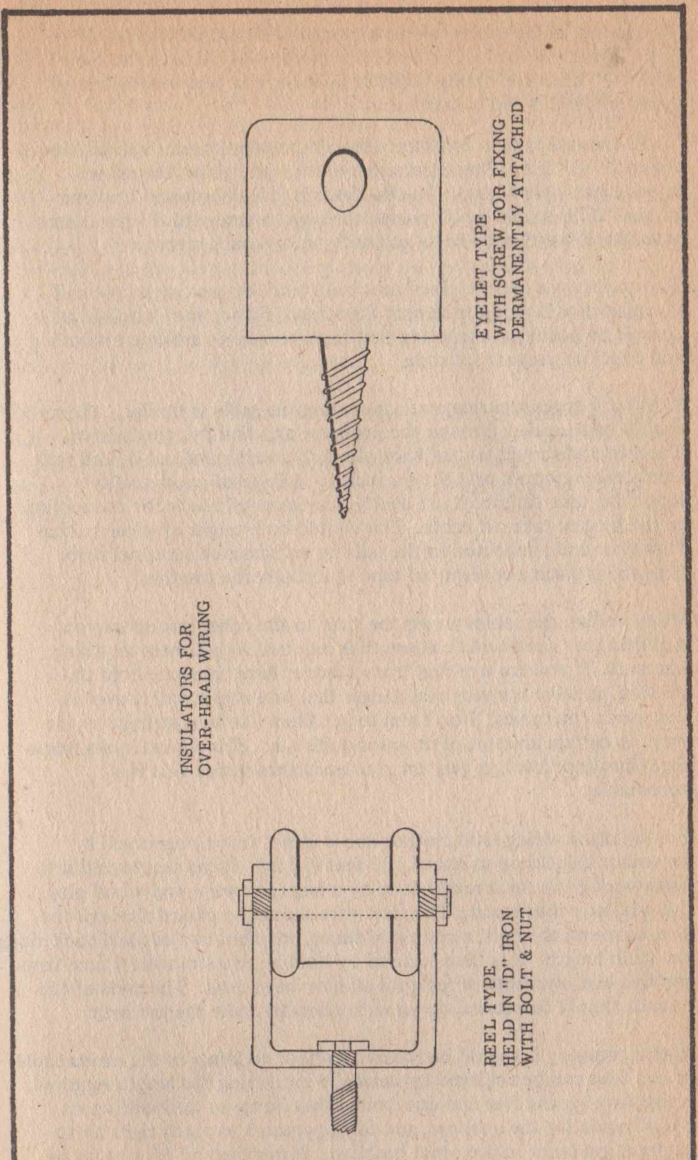
Protecting the outside wiring

The outbuilding has to be considered as a separate installation as regards fuses. A switch-fuse should be fitted near the main supply in the house, and a small consumer unit in the outbuilding. The supply fuse must have a rating appropriate to the cable size. (E.g. for 2.5mm, 20 amps). Outside the unit might have one 5 amp fuse for the lights, and two 15 amps for switch-sockets.

In certain cases where electric motors rated at more than those of small power tools are to be used, the cables could be subject to overloading during the starting period. The manufacturers ratings as stated on the identification plate of the appliance should be studied, and the cable size increased if necessary.

Practical Work

In order to use the cable at its optimum rating, it should be taken outside as soon as convenient after leaving its fuse box. If this can be done by drilling the wall close to the fuse board, so much the better. Remember to cap the cable with steel channelling where it is vulnerable to mechanical damage. Even if you intend to run the overheads in single cables, the initial will also be in twin, or twin and earth. As mentioned earlier, the underground cables will need protection all the way above the surface. The overhead will probably be o.k. without capping once you have reached a height of eight feet.



INSULATORS FOR
OVER-HEAD WIRING

To support single cables two insulators will be required at either end. There may be had in the reel pattern, which have to be used with "D" irons and fixing bolts, or in the eyelet type having a large screw integral in the construction.

To fit the reel type in brickwork suitable rawlbolts are required, one for each "D" iron. The latter are mounted one above the other, about eight inches apart. The insulator is placed between the arms of the "D" iron and a bolt passed through to secure it. Fitting onto woodwork is either by bolts and nuts, or by coach screws.

The eyelet type may be fixed into brickwork by making a hole and plugging it with wood to accept the screw. Fitting into wood is, of course, no problem, excepting that there should be sufficient width and depth to prevent splitting.

With both types securing and connecting the cable is similar, Some 18" should be threaded through the insulator and tied in a single knot. The free end should be laid back along the main span and bound with thin steel or copper wire for six inches. A layer of good quality insulating tape finishes it off neatly, leaving a tail ready for connection to the feed or take-off cable. This should be brought up close to the insulators and connected to the tails by an insulated terminal strip. This too is given a covering of tape to exclude the weather.

When pulling the cables across the span to the other insulators you will find that considerable strength is required to get them anything like taut. If you are working from a ladder have someone hold the bottom, as there is a very real danger that you might pull it over as you strain the cables. Don't aim to get them like bow strings, by the way. A certain amount of droop is quite o.k. This always looks worse from insulator level, so rely on your assistants advice that it is acceptable.

For catenary wiring steel clothes line is ideal. Ironmongers sell it in various lengths up to about 100 feet (30 m). It can be secured into brickwork either by a rawlbolt or by a large screweye and wood plug, and similarly into wood. The steel wire should be passed through the eye, or round the bolt, a couple of times, and about a foot laid back along the main length. It is then secured by binding one strand at a time from the free end over both wires until all have been used. The ends of the strands should be pressed down with pliers to make the job neat.

With a catenary it should be the aim to have no joints in the mains cable at all. This can be achieved by carefully measuring the length required, or by drawing the free end out from either house or outbuilding via a hold made for the purpose, and taking enough to reach right up to termination point in the other building. It can then be clipped up to the fastening of the catenary. The latter should be attached at only this end for the time being. A loop should be formed in the cable before it is fastened to the catenary to prevent any tension being placed upon it. It should then be taped along the length of the catenary at six-inch intervals. Most of this work can be done at ground level. When completed the catenary and cable combined have to be drawn up to the other fastening place. This again is almost impossible to do single handed. The assistant's job here will be to hold up the catenary with a line prop while you lash it into position. The mains cable can be clipped down to the entry point, leaving you with the reel inside for running to the fuseboard or consumer unit as the case may be.

If you anticipate using a lot of power in the outbuilding, it would be as well to inform the supply Authority in case their main fuse and/or cable should need to be strengthened.

You might also wish to keep an eye on the amount of electricity used in the outbuilding. Check meters can be obtained at quite reasonable prices, for fitting on the fuseboard in the outbuilding. It could be very useful during domestic disputes concerning the size of the electricity bill!

CHAPTER TEN

REPAIRS TO DOMESTIC ELECTRICAL APPLIANCES

To be able to successfully repair domestic appliances, you need to own, or be able to borrow, a simple test-meter capable of measuring resistance. Not only will this help you to trace open-circuits (breaks) in elements, wiring, etc., but it will also indicate shorts from one pole of the mains to the other, or to earth- a very vital consideration before and after reassembly.

Some repairs are inevitably outside the scope of the amateur. These will be indicated where applicable in the following pages. Nevertheless a large number of faults can be remedied by the handyman at a useful saving in cost. We'll examine various appliances in alphabetical order.

Blankets. We've started on a bad one. They are best left to the specialist firms, via your electrical dealer, when the fault lies in the blanket itself or the control gear. Even so, it's always worthwhile to check for intermittent breaks in the mains lead at the plug end. Undo the wires from the terminals and pull on each in turn, gently. A stretchy feeling indicates that the actual conductor is broken inside the insulation. Normally chopping a few inches off the lead and remaking the connection to the plug is sufficient.

Boilers. By which we mean the heated wash-boiler which used to be a round thing standing on little legs. It's now more likely to be square and have rollers rather than legs, but inside, the works will be much the same. There are normally groups of six or eight elements clamped to the bottom of the boiler tub, rated at 500W and 375W respectively to give a total of 3kW in either case. The failure of one or more of these elements will be indicated by an increase in boiling time, and also visually by a marked difference in colouring of the tub above the good and bad units. Although they do usually fail one or two at a time, it's a good idea to replace the lot at one go to avoid another repair in the near future.

Replacing the elements is a fiddling job. There are nuts to hold them to the tub, and nuts and bolts to connect them to the switch, dozens all told. Note that the elements are wired in a certain sequence to obtain series and parallel connection for low, medium, and high settings on the switch. Make sure that this sequence is followed when reconnecting the new ones. Not only must the electrical terminals be tight, but it is also vital that the elements be clamped firmly to the tub. Failure to ensure this will lead to overheating and consequent burning out.

Boilers incorporating water pumps need occassional attention to these as well. The pump is usually driven by a small motor not unlike that of a record player. Its bearings will appreciate a drop or two of oil, as will the pulley bearing on the pump itself. Be sparing with the oil, for if it finds its way on to the pulleys the drive belt will slip badly.

Some pumps have a removable side plate to enable the impellors to be cleaned out. It's always worth doing this because a surprising amount of lint anf fluff works its way into the pump over the years.

Clocks. Mains electric clocks are generally very reliable and trouble-free. About the worst thing that can happen is for the motor coil to turb out or otherwise go o/c. The first check on a clock that has stopped is to hold it to the ear. If the coil is intact there will be a slight but quite perceptible hum (with the clock plugged in, of course!) If this is absent remove the clock connector from its socket and measure the resistance across the wires from the clock. It should be rather high, in excess of 1000 ohms normally. An open circuit reading hers should be followed by a check directly on the terminals inside the clock, in case the mains lead should have gone o/c. Note at the same time if the coil looks as though it's been getting hot. An open circuit coil almost certainly means a new clock, unless you have the facilities and/or the patience to rewind it yourself. To have it done commercially would not be worth while.

When the motor hums but does not turn it could be due to lack of lubrication at the armature bearings. Try the effect of a very small amount of thin oil at these points. And I mean small. It's said that there is enough oil in one small tin to lubricate all the watches in England, so be warned!

Some clocks have an annoying habit of grunting to themselves in the night hours. This can sometimes be remedied by oiling, or by tightening the small flat spring which controls the end-float on the armature.

Battery driven clocks come in two main types. Some are more or less spring-driven with an intermittent spring tensioning device powered by a 1.5v cell. These are identified by their clonking sound which they emit every few minutes. Other types are transistorised, with a coil, the hairspring and balance wheel, and the transistor forming a stable low speed oscillator. In all cases the battery should be checked first, and then the connecting springs, etc. Once a battery has been left in too long, and has leaked some of its contents over the connectors, corrosion is inevitable. Carbon tetra-chloride or a similar cleaning agent should be used to clean off nasty deposits (in a well-ventilated place, if you value your health), really difficult portions being scraped away with a pen-knife. It's a good idea to smear the newly cleaned contacts with Vaseline or Electrical Silicone Grease.

The transistor(s) can be tested in situ by the standard method of reading the resistance from base to emitter and to collector in turn, hoping to obtain roughly the same readings. These will be obtained with the meter probes arranged positive or negative to base for PNP or NPN transistors respectively. With the leads reversed the readings will be much higher, sometimes up to infinity, so long as the transistor is o.,. Similar readings both ways, or low readings between collector and emitter indicate faults. Whether replacements would be available is a different matter altogether, but you might like to experiment with a low power device such as the BC108 as an alternative to scrapping your clock.

Unless you number watchmaking amount your skills, you would be advised to leave the rest of the works well alone.

Clothes Driers. Can be of the static or "tumbling" type. The former often goes under the generic name of Flatley, after the originator of the breed. It consists quite simply of a metal box with an element in the bottom, and slats at the top to hold the clothes. There may be a thermostat or a switch to vary the temperature. These are of robust and reliable construction and unlikely to give trouble themselves; but as with most heating appliances the connecting wires become brittle after a while and break away from the terminals. These should always be checked by a gentle pull, as the disconnection may not be immediately apparent.

The elements are also sturdy affairs. Single breaks can be repaired by the nut-and-bolt or terminal strip method, taking care when doing so to ensure ample clearance between the joint and nearby metalwork.

Tumbler Drivers have a rotating drum for the clothes and, most likely, a timing device to control the drying period, in addition to the heating element. This of course can be checked, and if necessary replaced or repaired as with any other element. Faulty timers are best replaced by new units. Motors are generally long-lived, unless there has been severe overloading due to jamming of the drum, etc. Please refer to the section "Motors".

Convector Heaters. Are basically very similar to the Flatley type of clothese drier discussed in the last section. The faults and repair action mentioned are applicable too.

Cookers. These are my unfavourite repair job on account of the vast amounts of fat, grease, and dirt which they attract and subsequently deposit on one's hands and clothes. They come in many sizes from the table-top models for bed-sitters to the split-level, rotary-spit, eye-level grill, and multi-oven contraption for dream kitchens. Older cookers generally had solid cooking plates and low level grills. The control switches in very old types had low/medium/high settings; the "simmerstat" came later. More up-to-date models have the quick-heat rings, usually, but not always, with simmerstats. Grills also can have either type of control. An important difference between new and old cookers is that nowadays the rings and grills have to be unscrewed and small connectors removed for servicing. The old types merely un-plugged. As always the wiring must be checked first when a ring or grill fails. Switches and simmerstats are the next in line. Only when these have been proved to be o.,. by checking across the terminals with the meter should the rings, etc., be disturbed.

Rings and grill elements have just two pins when controlled by a simmerstat, and three or more when by switch. (Plus an earth pin in certain cases). Meter readings of 20-50 ohms should be obtained between pins depending on the wattage of the element. A fairly common fault is for the latter to short to the metal covering, causing fuses to blow, or earth leakage trips to operate. Such a short may not always register on the meter, due to its developing only when the element is hot. If there have been complaints about one particular ring causing trouble, examine it carefully for tell-tale burn marks, or pin holes at the point where shorting has taken place.

Most elements can still be replaced from the ranges of specialist manufacturers. It's often possible to modernise an old cooker by fitting quick heat rings in place of the old solid plates.

Ovens nowadays have tubular heating elements of similar construction to the quick heat rings, but formed into a semi-rectangular shape. Older cookers had fireclay heaters rather like the old fashioned electric bar fires. The testing of these follows conventional practice. Both types have more or less the same control system, a combined switch/thermostat with a thin copper pipe connected to a heat sensitive bulb embedded in the heat insulation around the oven elements. When these give trouble a replacement is the only answer.

For cookers incorporating fan heaters or motors driving spits, please refer to the appropriate sections.

Drills. In my experience a large proportion of drills never actually wear out, but are brought to an untimely end by gross over-loading. The average small drill is perfectly o.k. if used intermittently with ample rest periods to allow it to cool down.

Long periods of duty such as when the drill is used to drive hedge-trimmer or sanding attachements almost inevitably lead to overheating, followed by a breakdown in insulation in the field coils or armature. Failure of either or both of these is then swift. You'll hardly need any test gear to diangose this fault, merely your own nose! The aroma of burned-out windings is quite unique and unmistakable. For further details refer to the "Motors" section. (Especially brush replacement).

Mains leads are always suspect when a drill suddenly stops functioning, in particular at the point of entry into the machine. The switch gives trouble only rarely. Standard tests will soon reveal the faults here. Spare parts when needed are normally obtainable from the appropriate dealer, except in the case of some imported drills, which can present a problem in this respect. Also the cost of repairs against the cost of a new drill is worth considering.

Fans. Ar long-lived appliances simply because the amount of use they receive in a British climate is small! The domestic type usually has an induction motor which is quiet in service and which will require sparing use of an oil can at infrequent intervals as the sole maintenance operation. Otherwise check for mains lead trouble caused by its being coiled up for long periods.

Fan-heaters. Are much of a muchness as regards design and performance. They are generally, in domestic form, small rectangular boxes containing a heating element and a tangential fan driven by an induction motor. Three levels of heat are usually provided by a control switch, together with one or more "cold" settings for the fan alone. It:s also common practice to have a thermal cut-out to prevent dangerous overheating should the fan fail on a heat setting. The elements are sturdy affairs supported at intervals by ceramic insulators to form several parallel rows. Jarring of the heater when hot can cause turns on adacent rows to touch. This will cause either an immediate burn-out, or local over-heating causing failure later on. Clearances should be carefully checked if joining of the element is contemplated. The fan motor bearings, and those on the fan itself can benefit from a little oil, the need for which is evidenced by slow running and a tendency fo the element to glow red, instead of its normal black heat. The control switch, in addition to varying the wattage of the heating element, often varies the fan speed by inserting series resistors to slow it down in the "low" and "medium" positions. These are standard 10 watt radio resistors obtainable from dealers. The actual resistance will differ from one make of heater to another, but will be stamped on the components.

They should be checked with the meter if the fan fails only on the lower settings, bearing in mind that some disconnecting will have to be done to avoid false readings due to the heating element's resistance being effectively in parallel. Also ensure that this fault is not due to lack of lubrication preventing the motor from developing enough power at low settings to drive the fan.

Since fan heaters suck in cold air to be heated, they also draw in fluff and dust. This can eventually build up sufficiently to restrict the air flow to the point where the thermal cut-out operates frequently. Dusting out with a soft paint brush, avoiding damage to the element, is the answer.

Fires. This name is convetionally understood to include all types of heater (apart from bathroom heaters) which directly radiate or reflect heat from elements operating at red-heat. The original fires had the "bar" type of element, in which the wire was stretched around a rectangular fire-clay former. This has been largely superseded by the "rod" element of about ¾" diameter and upwards of 8" in length. The still later infra red type has an external former for the wire in the shape of a silica glass tube of some ¼" bore and 18" or more long. This also provides the infra-red effect.

Fires come in single, double, and (rarely) triple element models. The last two naturally incorporate switching with the attendant likelyhood of connecting wires coming adrift. All fires, but older ones in particular, are heir to troubles due to the heat striking back at the mains lead where it enters. Later fires aren't quite so bad because the reflectors are more efficient and the cable better shielded anyway. It's always worth checking mains leads, particularly as regards earthing.

As fire elements are thinner than those in fan and storage heaters, etc. and unlike them run at red heat, they become frail after years of service and not worth repairing. Replacements for the rod type are widely available, but be careful when purcahsing to get the exact size you need, as a casual measurement can be deceiving. For the bar type, and for infra red tubes, provided that the glass is intact, the same replacement element is suitable. It's called a fire spiral and costs around 20 pence. It comes in a small packet with its turns compressed for you to stretch out to suit your former. With the bar type you must check the number of rows the wire traverses and divide the element up accordingly. For instance, if the bar has four rows and the element is 20" long unstretched, you will divide it into four lengths of 5" apiece by bending it at right angles at these intervals. It's then carefully stretched out row by row and pressed into the bar. There will be a straight length at either end for connection to terminals mounted on the bar.

To replace the element in an infra-red tube, remove all traces of the old one (burned-off bits can stick to the inside) and push a thin piece of wire through it. Fasten this on the new element and draw it carefully through, being careful not to over-stretch it. The straight bits are twisted around terminals which fit over the ends of the tube, and which also fasten the whole thing into the fire itself. It's especially important to space the turns equally here since a "hot spot" could cause the glass to break.

Fridges and freezers. Most of these contain sealed units which are just not repairable except by specialists. Indeed, even they often replace the whole unit rather than work on it. The one kind of fridge that can be serviced at home is the boiler type. This has a small heating element enclosed in a tube to, paradoxically, effect the cooling process. It may be possible to obtain a replacement element if you sound out the specialist suppliers. When one of these fridges fails for no apparent reason a well-known trick is to stand it upside-down for a day or so. This quite often brings it back to normal, for reasons I am not able to explain!

Sometimes fridges lose their refrigerent gas. At one time this was not too expensive to have put right, but the effect of inflation on this as with so many things have made a prior estimate of the cost an absolute must.

Hair-dryers. The basic principle of all hair-dryers is to have a small motor driving a fan to propel air through or past a heating element. Professional and older domestic models may have brush motors which with their higher fan speed allow the use of more powerful elements than those found in the more common induction motor models.

The most common fault is failure of the element, especially if the dryer is handled roughly when hot. Spares are obtainable for well-known makes, but imported ones may be very hard to come by, rendering a repair necessary to keep the appliance going. It's not too easy to join the thin wire of a hair-dryer element, but if you are dexterous enough to manage it, using a small nut and bolt, you will often be rewarded by a reasonable period of extra service.

A fault peculiar to older Morphy-Richards dryers was the failure of the series capacitor for the induction motor. This component was fitted into the handle of the dryer, and had a rather unusual value of capacity, to be found marked on the case. Exact replacements may not be available, so a near value in a Radio/TV type of 300 volts AC working is the next best thing.

Irons. The days of the old-fashioned electric iron which weighed about seven pounds, and no heat control, and was plugged into a light socket, are long past. The first controllable irons were introduced in this country before World War 2, and to the credit of the original design, have changed but little in essentials since that time. The control depends upon the action of a bi-metal strip- two dissimilar metals of widely differing heat/expansion characteristics bonded together. When heated the metal which expands more than the other is restrained by the latter, causing both to bend in direct relationship to the temperature. In practice the strip is mounted on the sole plate of the iron, as centrally as possible. As it bends up when the iron first warms up it operates a switch to cut off the current at a predetermined heat. The control knob turns a cam which in turn allows the strip to bend more or less before it works the switch, thus pre-setting the desired heat level. With the current off the iron cools and the strip straightens until it pulls the switch "on" again. The accuracy of the temperature control by this method is surprisingly good. By placing a low value resistor (called the shunt) in series with one pole of the mains where it joins the element a few volts are made available to light a pilot bulb. This glows only when the iron is actually drawing current.

Elements are readily available for well-known makes of irons, but unfortunately in almost all cases the control switch has to be removed to get at the element fixing screws. This entails disturbing the calibration of the system, which can't really be set up again properly without the aid of a "pyrometer". This is specialised thermometer reading up to four- or five-hundred degrees fahrenheit. It has a sensing-plate upon which the iron is rested, and a lamp to indicate when the current is on or off. A small nut on the bi-metal assembly is turned to regulate the temperature at which the iron is switched off, as shown on the dial of the pyrometer. Certain manufacturers will not guarantee replacement elements unless they are set up in this way. In cases of severe necessity a rough check can be made by noting as accurately as possible the setting of the control nut, and duplicating this when reassembling the iron. The lady of the house will soon inform you if this results in under- or over-heating!

Kettles. Can be fairly divided into two broad classes – Russel-Hobbs and the rest. The first-named are of course the original and best known automatic kettle, whose element is switched off at boiling point by the actual steam impinging on a heat sensitive device. Both the element and the switch are of specialised construction and the manufacturers prefer replacements and repairs to be done by authorised dealers.

Virtually all other kettles have the familiar metal or plastic tubular shroud enclosing a two-pin and earth connector. The elements for these are readily available from most electrical shops. They come in at least two different sizes of neck diameter, so take the fixing shroud with you to ensure that you get the correct one. The difference is minimal, so don't trust to guesswork. There should be a set of washers with the element, or they can be obtained separately if need be. When you have removed the old element make sure that no bits of "fur" are left ready to drop between the flange on the new one and the body of the kettle. One of the washers is softer than the other, and this is the one that goes inside the kettle. The harder one is then placed over the neck of the outside and the shroud tightened up by hand only. Unless the kettle has been damaged around the aperture for the element a good joint is assured without undue force being used. There may, however, be a need to re-tighten slightly after the first filling with water.

Replacement elements are also available for most kettles with a heat sensitive switch built in, thus converting them to automatic operation.

Motors. So many household appliances depend upon electric motors that these warrant a section to themselves. There are two main types, brush and induction. The former are usually of medium size and are found in drills, vacuum cleaners, spin dryers, and the like where high rotational speeds are required. They are also suitable for AC or DC operation, although nowadays the domestic use of DC mains has ended in this country.

This type of motor has three main electrical parts, the field coils, which supply the necessary magnetism, the armature, which does the actual rotating, and the brushes which supply the electricity to it. These are made of compressed carbon, with a flexible copper lead moulded in one end. This passes through a light spring and is held by a soldered washer. When the brush is in the holder the spring and lead perform the dual function of connection to the supply (via the field coils) and of maintaining steady pressure onto the armature to ensure good contact. This is why worn brushes cause motors to lose power, become intermittent, and to finally stop altogether. After long use they wear down to a fraction of the correct length and the spring can no longer maintain pressure, even if the contact surface of the brush remains effective. It sometimes happens that one of the brushes will wear more quickly than the other, but they should both be replaced at the same time.

The armature has a number of windings, each being connected to a pair of copper contacts on what is called the commutator. There may be twelve windings, resulting in twice that number of contacts, or segments as they are called. Each nas to be insulated from the others, normally by mica strips. After long use, aggravated perhaps by worn brushes, the copper segments wear down and spark badly as the armature rotates. This causes a process of mutual destruction to take place which rapidly escalates to the point where a new armature, and brushes of course, are needed. To protect the motor from this expensive trouble the brushes should be checked at reasonable intervals for signs of wear. It should be borne in mind that a spin dryer, for instance, used several times a week, will sustain more wear in a month than a drill, used occasionally at weekends, would in a year.

The field coils suffer when the motor is subjected to long and heavy over-loading – the sort of thing that occurs when a small drill is used to drive a power attachment for unreasonably extended periods. The wire with which the coils are wound is insulated by enamel, and whilst this is normally very reliable, excess heat can cause it become brittle and to flake off. Only two turns touching each other will trigger another destruction cycle with the same quick finale.

If ever there was a perfect example of prevention being better than cure, the brush motor is it. Commonsense precautions and considerate handling would eliminate very many breakdowns. There are certain obvious symptoms of impending trouble which are ignored at one's peril. Loss of power; Erratic starting and running, buzzing noises; evident overheating of hand tools; smells of fumes; any of these heralds disaster and to continue using the appliance in these circumstances is to invite a costly repair bill.

Replacement electrical parts are available for some of the well known makes. In other cases only complete motors are supplied. Where spares are to be fitted by yourself, check the motor mechanically as well, paying particular attention to the bearings. If they are worn, replace them; otherwise make sure that they are properly lubricated before re-assembly. Some have a felt oil pad which must be given a generous helping to last it a long while.

Induction motors are used mostly for very small and very large appliances, the extremes being the electric clock on one hand and the washing machine on the other. The speed of the induction motor is directly related to the frequency of the mains – they are a strictly AC only device – and is much slower than that of a brush motor. It is this frequency/speed relationship which makes the induction motor so suitable for clocks and record-players. The UK standard of 50Hz is accurately maintained by the generating stations, so the armature rotates as near constant speed as makes no difference.

One great advantage of the induction motor is its silence when running, even with the largest domestic cypes in washing machines and freezers. This is largely due to the absence of a commutator and brushes, which are inherently noisy in operation. Not all induction motors are exactly alike; they vary in detail for different applications. For instance, clock motors are not always self-starting, but have a little lever to flick the armature over initially. Record players, tape recorders, etc., have of course instant-start types. Washers and fridges have to start on full-load conditions, so their motors have additional starting windings to assist them. A heavy initial current flows through these windings, which explains the "thump", sometimes accompanied by visible dimming of light bulbs, when one of these appliances is first switched on. In some motors there is a centrifugal switch which disconnects the start winding once full speed is reached; in others the job is done by a large capacitor (condenser) mounted on or near the motor itself.

These motors are extremely reliable, and burn-outs are rare indeed. Faults are likely to be confined to lack of lubrication (especially in smaller types), or to failure of the starting capacitor in the large models. Record player motors have little starting torque, and a dry bearing can prevent its running altogether. A little thin oil in each of the two bearings will work wonders, but take great care not to get any on to the drive shaft or pulley, or slipping is inevitable.

Starting capacitors can be tested with the meter on the ohms range. A good one will allow the needle to flick over momentarily and then to drop back towards infinity. A reading of some thousands of ohms may be considered o.,., as there is often a built-in resistor to discharge the capacitor when it is idle. A very low resistance indicates an internal short, and the capacitor must be replaced by one of the same capacity and voltage rating.

Care should be taken to ensure that the water hoses in washing machines are in good condition, and the fixing clips kept tight. Reliable as they are, motors can't be expected to put up with a deluge of water now and again!

Shavers. Are not things to go poking about inside. Servicing of the works should be entrusted to a specialist. The cutting heads, however, are not difficult to replace and this job can be approached with confidence. The better manufacturers have world-wide service organisations from whom spares can be obtained, or who will effect repairs.

P.S. Don't use battery driven shavers unless you are very rich. The price of one set of batteries will run a mains shaver for more years than you are likely to need it!

Tea-makers. Also not recommended for home repair, except for the usual minor faults; frayed and intermittent cables and the like.
The tea-maker is an ingenious piece of kit, embodying four seperate switches, two automatic, two manual. The first of the latter is operated to switch on the built in bedside light, the second to switch it off, and to prepare the kettle for action. The first automatic switch is that incorporated in the clock. This actually switches the kettle on at the predetermined time. When the kettle has boiled and ejected its contents into the tea-pot, its reduced weight allows the other automatic switch to operate and turn the current off. This last switch is situated beneath the small tray on which the kettle rests. It sometimes happens that the action is too abrupt, resulting in only half a kettle full of water being sent into the tea-pot. This can be rectified by a slight adjustment of the setting screw to be found in the base of the appliance. It can be got at by removing the bottom cover.

Old tea-makers sometimes develop the feared grunting associated with worn electric clocks. Since this appliance is normally placed near the bed, the noise is more annoying than with wall mounted clocks. Please refer to that section for possible cures.

Toasters. There may still be some of the old manual "do-it-yourself smoke-signal kit" models about, but the vast majority are of the familiar "pop-up" automatic variety. The control system of these is rather more complicated than might be first thought. In the better makes it is replaceable as a unit, to avoid a complicated setting-up procedure having to be done in the home or work shop. The way the four elements are wired is unusual, too. Instead of each being rated at 240 volts, a 120 volt winding is used, with two being connected in series on each side of the toaster. If one element should fail it is essential that all four are changed. This is not in itself a difficult job, even if it is a little expensive, but unfortunately the very long-evity of these appliances acts against eventual repair. By the time one has to replace the elements the chances are the steel framework in which they fit will have become eroded by heat to such an extent that it breaks up when disturbed. This makes the purchasing of a new appliance worth considering as and when the old one fails.

Washing Machines. The simple type is epitomised by the little Hoover model of some years ago. It had a robust motor in the base driving an agitator in the tub by means of a vee belt and pulleys. Maintenance was restricted to oiling the agitator shaft and very occasionally replacing the drive belt. Alas, those days are no more. The modern washing machine is so sophisticated that only the most minor repairs (faulty mains leads, etc.) are open to the layman. Certainly he should not attempt anything more on an automatic washer. The older twin-tub machines are much easier to tackle. They often had brush motors which to me seemed rather under-powered for the job, and consequently susceptible to overloading with its inevitable results. Replacement motors are still available from specialist firms, should more than just new brushes be required. Drive belts again are not difficult to acquire and fit, nor the various hoses.

There are often lots of earth leads on washing machines, interconnecting the motors with different parts of the frame. It's essential to see that all these are put back as they were found if you have to disturb them, otherwise safety cannot be guaranteed. Machines which incorporate heater draw a lot of current from the mains, and a really good quality plug should be fitted, not a rubber one made in the far East. These just are not good enough to stand constant high loads without heating up around the terminals. Unbreakable versions of British-made plugs are available where this type is to be preferred.

APPENDIX

I.E.E. REGULATIONS RELEVANT TO WORK DESCRIBED IN THIS BOOK

Note:– the following are reproduced by kind permission of the I.E.E., to whom the author expresses his thanks.

Chapter One-Water-pipe earths. "Neither gas nor water pipes, separately or jointly, shall be used as the sole earth electrode of the installation." (D34(ii)).

Chapter Two-Various. "On completion of an installation or an extension or major alteration, tests should be made, with suitable instruments, to verify as far as practicable that the requirements of Regulations 1 to 10 have been met, that the insulation of all conductors and apparatus is satisfactory, and that the earthing arrangements are such that in the event of an earth fault the faulty circuit or sub-circuit or apparatus is automatically disconnected from the supply so as to prevent danger". (Part 1, Note 2). "All electrical conductors shall be of sufficient size and current rating for the purposes for which they are to be used" (a)). "Every electrical joint and connection shall be of proper construction as regards conductance, insulation, mechanical strength, and protection" (1(d)). "Every electrical circuit and sub-circuit shall be protected against excess current by fuses, circuit breakers, or other similar devices which –

(i) will operate automatically at current ratings which are suitably related to the safe current ratings of the circuit, and

(ii) are of adequate making and breaking capacity, and

(iii) are suitably located and of such construction as to prevent danger from overheating, arcing, or the scattering of hot metal when they come into operation, and as to permit ready renewal of fuse elements without danger.

"Where the earth-fault-leakage current from a circuit due to a fault of negligable impedance from a live conductor to earthed metal is insufficient to operate the circuit breakers, or other similar devices provided so as to comply with regulation 2(a), the circuit shall be protected against the persistance of earth-leakage currents liable to cause danger by an earth-leakage circuit-breaker or equivalent device". (2)

"Every single-pole switch shall be inserted in the live conductor only, and any switch connected in the conductor connected with earth shall be a linked switch and shall be arranged to break also all the live conductors". (3)

"Where metalwork, other than current-carrying conductors, is liable to become charged with electricity in such a manner as to create a danger if the insulation of a conductor should become defective or if a defect should occur in any apparatus –

(i) The metalwork shall be earthed in such a manner as will ensure immediate electrical discharge without danger, or

(ii) other adequate precautions shall be taken to prevent danger."(4)

"Effective means, suitably placed for ready operation, shall be provided so that all voltage may be cut off from every circuit an every sub-circuit and from all apparatus, as may be necessary to prevent danger."(5) "All apparatus and conductors exposed to weather, corrosive atmosphere, or other adverse conditions, shall be so constructed or protected as may be necessary to prevent danger arising from such exposure." 7(a).

"In a situation which may be normally wet or damp, where electrical apparatus is present and might give rise to danger, and where there are substantial exposed metal parts of other services (such as water and gas pipes, sinks and baths), and earth-continuity conductor of the electrical installation shall be effectively connected electrically and mechanically to all such metal parts and to any exposed metalwork of the electrical apparatus which is required by Regulation 4 of these Regulations to be earthed."(9)

"No addition, temporary or permanent, shall be made to the authorised load of an existing installation, unless it has been ascertained that the current sating and condition of any existing conductors and apparatus (including those of the supply undertaking) which will have to carry the additional load are adequate for the increased loading, and that the earthing arrangements are also adequate." (10)

Chapter Three-Earthing at lighting switches and points:–

"At every lighting point an earthing terminal shall be provided and connected to the earth-continuity conductor of the final sub-circuit." (D6) "An earthing terminal, connected to the earth-continuity conductor of the final sub-circuit, shall be provided at every lighting switch position unless this takes the form of an earthed metal box having a means of fixing the switch-plate in reliable electrical contact with the box." (D7). Looping-in:–

"A ceiling rose shall not be connected to the fixed wiring in such a manner that one of its terminals remains live when the associated switch is off, unless that terminal cannot be touched when the ceiling rose is dismantled to the extent necessary for the replacement of the associated flexible cord." (C19). Holes in joints:–

"Where cables are installed under floors they shall be run in such positions that they are not likely to be damaged by contact with the floor or its fixings. Where a cable traverses a wooden joist under floorboards, it shall do so by means of a hole so drilled that every part of the cable when installed is at least 50mm measured vertically from the top of the joist; or alternatively the cable shall be protected by enclosure in steel conduit securely fixed or by equivalent mechanical protection." (B26)

Chapter Four. No. of spurs:– "For ring final sub-circuits complying with Regulations A30-33, the total number of spurs shall not exceed the total number of socket-outlets and stationary appliances connected directly in the ring." (A38). Bathrooms:–

"In a room containing a fixed bath or shower, there shall be no socket-outlets and there shall be no provision for connecting a portable appliance except as provided by regulation D19 for electric shaver supply units." (D18). "In a room containing a fixed bath or shower, electric shavers shall be connected only by means of a shaver supply unit complying with B.S.3052, The earthing terminal of the shaver supply unit shall be earthed in accordance with Regulation D20." (D19). "For compliance with Regulations D16-19 the modifications must include the removal of all socket-outlets and replacement of all portable appliances by fixed appliances except as provided by Regulation D19 for electric shavers". (Note to D15). "Every switch or other means of control or adjustment shall be so situated as to be normally inaccessible to a person using a fixed bath or shower. This requirement does not apply to electric shaver units installed in accordance with Regulation D19 or to insulating cords of cord-operated switches. No stationary appliance having heating elements which can be touched shall be installed within reach of a person using the bath or shower." (D17).

Chapter Six. Two cookers:– "In domestic premises, a final sub-circuit having a rating exceeding 15 amperes but not exceeding 30 ampers when determined in accordance with Regulation A27, may supply two or more cooking appliances where these are installed in one room." (A28)

Chapter Seven. Siting of earth rods:– "The earth electrode used with any voltage-operated earth leakage circuit-breaker shall be placed outside the resistance area of any parallel earth which may exist, for example where a water-heater is installed." (D26). "Every connection of an earthing lead to an earth electrode or other means of earthing shall be readily accessible and soundly made by use of soldered joints or clamps. A permanent label, indelibly marked with the words 'Safety Electrical Earth-Do Not Remove', in a legible type not less than 4.75mm high, shall be permanently fixed at the point of connection." (D33). Bonding:–

"The consumer's earth terminal required by Regulation D2 shall be bonded to the metalwork of any public gas services and any water services on the consumer's premises in accordance with Regulations D11-13". (D10). "Before the consumer's earth terminal is bonded to the metal work of any gas or water service, connection of the earthing terminal to an effective means of earthing complying with Regulations D34 or D24-26 shall be completed." (D11). "Pipes such as gas or water pipes, or members of structural metalwork, shall not by themselves constitute an earth-continuity conductor, but it is admissible to bond them to the earth-continuity conductor where this is necessary for compliance with Regulations D10-14, provided that such bonding is not carried out prior to the connection of the earth-continuity conductor to an effective means of earthing complying with the requirementsof Regulation D20." (D30).

Chapter Nine. Depth of underground cables:– "Cables should be installed at a depth of at least 500mm". (Note to B125). Control:–

"Where a consumer's installation comprises installations in two or more detached buildings, seperate means of isolation complying with the requirements of Regulation A2 shall be provided in each building." (A5). Catenary wire earthing:– 'All metalwork of wiring systems (other than current-carrying parts), including cable sheaths and armour, conduit, ducts, trunking, boxes, and catenary wires shall be connected to the appropriate earth-continuity conductors. This regulation does not apply to isolated metal parts referred to in Regulation D9" (D3).

The foregoing is, of course, only a selection of all the regulations affecting domestic premises. As mentioned earlier in the main text, should you wish to study them thoroughly, copies may be available in libraries. Larger bookshops will probably stock them if you decide to purchase, or in cases of difficulty you could write to the I.E.E. at Savoy Place, London W.C.2.

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