Rewiring Your House

by Geoffrey Burdett

The modern home electrical installation consists of a number of circuits of various current ratings to meet the required total expected load in kilowatts. The current rating of each circuit is the maximum likely load demand which in aggregate gives the total maximum current demand on the installation. Most circuits originate at a combined mainswitch and fuse distribution board, termed a consumer unit.

The fuse distribution section of the consumer unit comprises a number of fuseways, one for each circuit. Although traditionally termed fuseways, in many instances miniature circuit breakers (mcb's) are fitted into the fuseways instead of fuse units, these generally being superior to the fuses they replace.

Although there are, or should be initially, at least the number of fuseways in the unit to meet circuit requirements plus others to add circuits as they are needed over the years this is often not the case.

Where only one circuit is added, it is common practice to fit what is termed a mainswitch and fuse unit, or switchfuse unit which is really a one-way consumer unit.

Such practice lacks foresight, and although only one circuit is added at the time it is better to allow for at least another circuit which means fitting a multi-way consumer unit. Whether a switchfuse unit or a multi-way consumer unit, this, with the existing consumer unit, is connected separately to the mains by the electricity board, usually via a service connector box.

Some installations have yet another consumer unit, for off-peak storage heating and water heating, time controlled by a time switch so that the circuits and appliances are energised only during the off peak period eg. about 7 hours overnight when electricity is supplied at about half price. See tariffs.

Circuit cables

Most houses are now wired in pvc flat sheathed cable. The cable termed twin and earth has two insulated current carrying conductors, one red, the other black, and an uninsulated copper earth conductor now called the circuit protective conductor (cpc) and formerly the earth continuity conductor (ecc), because it is electrically continuous throughout the installation and terminated at the central earthing point, the earth electrode. In some parts of an installation 3-core plus earth flat pvc sheathed cable is used, usually in switching circuits containing more than one switch for the one light or for different lights in the same area. eg 2-gang, 3-gang assembly etc.

The core colours of 3-core and earth cable are red, yellow, and blue respectively plus the uninsulated earth conductor. The colours have no significance in home wiring but represent the three colours of the phases of a 3-phase electricity supply system. When used on single phase circuits

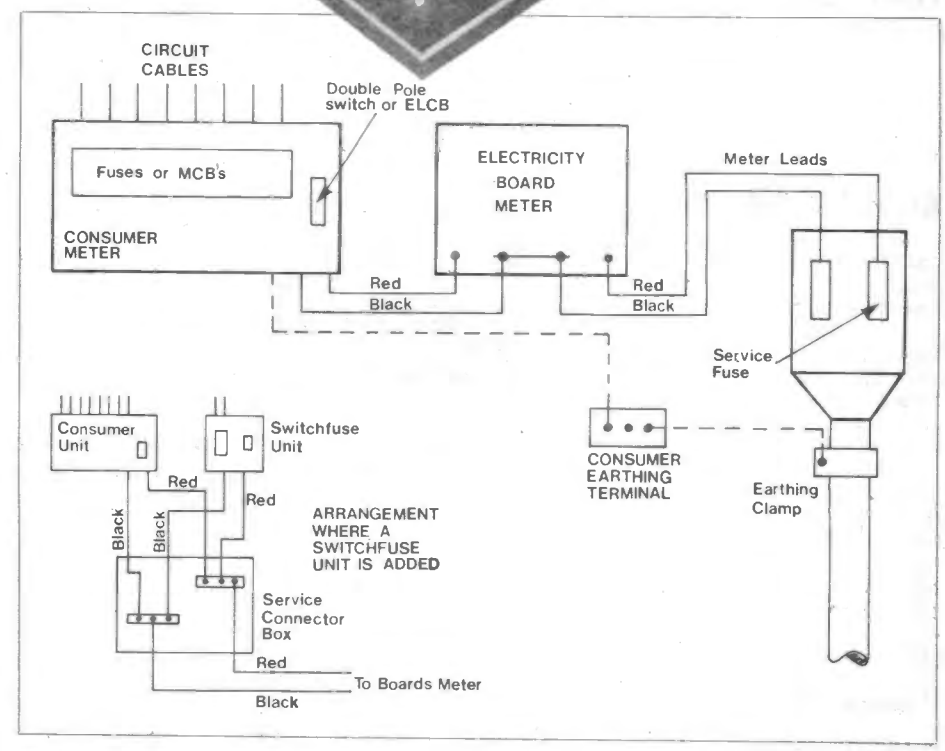

Figure 1. Arrangement at mains supply.

in the home for single pole switching the conductor ends should be enclosed in red sleeving or insulation tape as they are all live conductors.

Circuit cables are sold normally in 50m and 100m reels though they can be bought in shorter cut lengths where a limited amount only is required, this usually being the case with 3-core and earth cable and all the larger sizes of cables used in the home installation. Some homes are wired throughout in plastic conduit using non-sheathed pvc insulated cables in various colours. The cables are single-core and the colours are red, black and green/yellow striped, respectively.

The red is used for the live conductors, the black mainly for the neutral but is sometimes used as a live, suitably identified with red sleeving. The green/yellow conductor is the earth conductor.

Plastic conduit is also used in some twin & earth and 3-core & earth wiring, but as the cables are sheathed the conduit does not have to be continuous. It is used at switch drops and other vertical drops as well as in horizontal cable runs. Another form of enclosure for sheathed cables is plastic mini-trunking run vertically or horizontally on walls and ceilings.

Sizes of cables

The size of a cable is given as the cross section area in mm² of its current carrying conductor, the earth conductor in such composite cables usually being smaller since it carries current only to clear a fault. Earth conductors run independently are sized according to their cross section area in mm².

Circuit cables each have a specific size of current carrying conductor, the size determining the maximum current it is designed to carry without further rise in temperature. Possible voltage drop on long runs is also a factor considered when choosing a cable. The cable sizes used in home wiring circuits range from 1mm² to 10mm², with larger sizes for the connection of the consumer unit to the meter, these being termed meter leads or meter bights.

The 1.0mm² cable is used for lighting circuits, the 10mm² cable for cooker circuit cables. The intermediate sizes of cables for other circuits. See table 1 for the current ratings.

Circuit wiring accessories

In addition to the cables there are various components used in circuit wiring. The mounting box is among the most important wiring accessories, though often omitted. It is used for mounting socket outlets switches, fused connection units and a host of other accessories, these having open backs. The function of the box, in addition to being a ready mount for the accessory, is to enclose the unsheathed ends of cables, flex and connectors where used, in a non-combustible chamber.

There are two principal types of mounting box: moulded plastic and metal. The moulded plastic box is for mounting the accessory on surfaces and the metal box is for flush mounting the accessory, the box being sunk into the plaster or wall.

The boxes are of various sizes and depths. The most used box is the one-gang for mounting a single one-gang accessory. It is square in shape, approximately 87 x 87mm, the faceplate of the switch or other accessory being the same size. The metal box is slightly smaller at 86 x 86mm so that the accessory faceplate overlaps the box and covers the gap in the plaster.

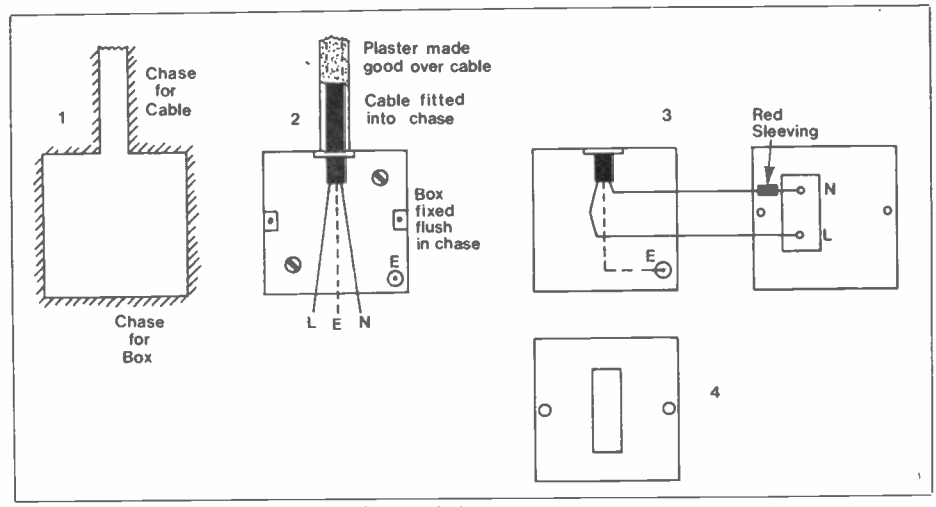

Figure 2. Sequence in fixing a flush lighting switch.

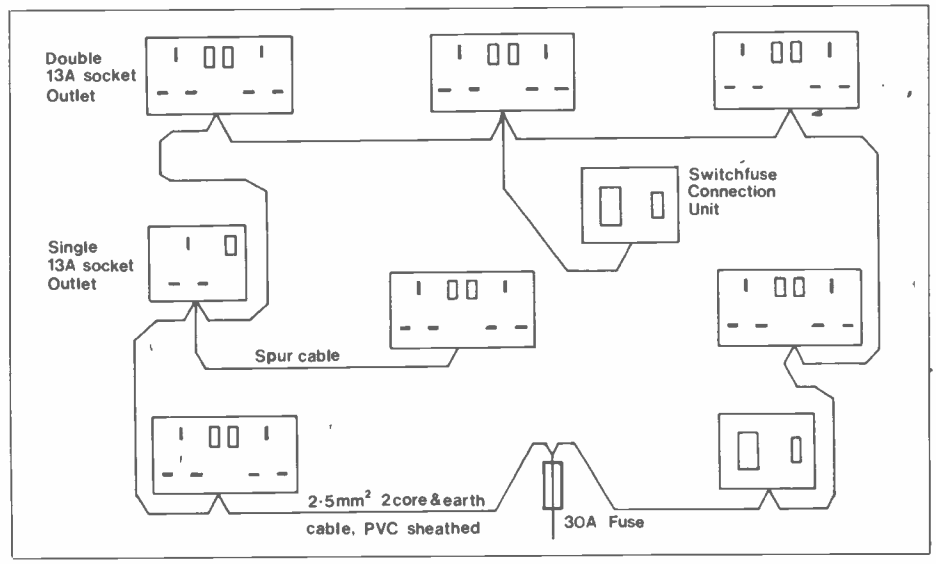

Figure 3. Ring circuit.

Depth of boxes

The boxes for lighting switches are plaster depth 16mm deep, and the plastic box 17mm.

For socket outlets the standard box has a depth of 25mm and deeper boxes where needed depending upon the accessory and the room needed in the box for cable connections. All have two or more screwed lugs for fixing the accessory, these being tapped M3.5 metric. Some lugs are adjustable for levelling the accessory after the box is fixed.

Socket outlets and plateswitches are actually flush fitting components, although surface mounted or flush mounted according to the type of box. Surface sockets are entirely different. They are self contained, and usually have an enclosed back for direct mounting on a suitable surface, the sheathed cable passing right into the accessory. Some versions are, however, mounted on a slim pattress block. There are also surface type switches, these usually being metalclad and sold complete with metal surface boxes. Whatever the type of box or accessory it is essential that the pvc

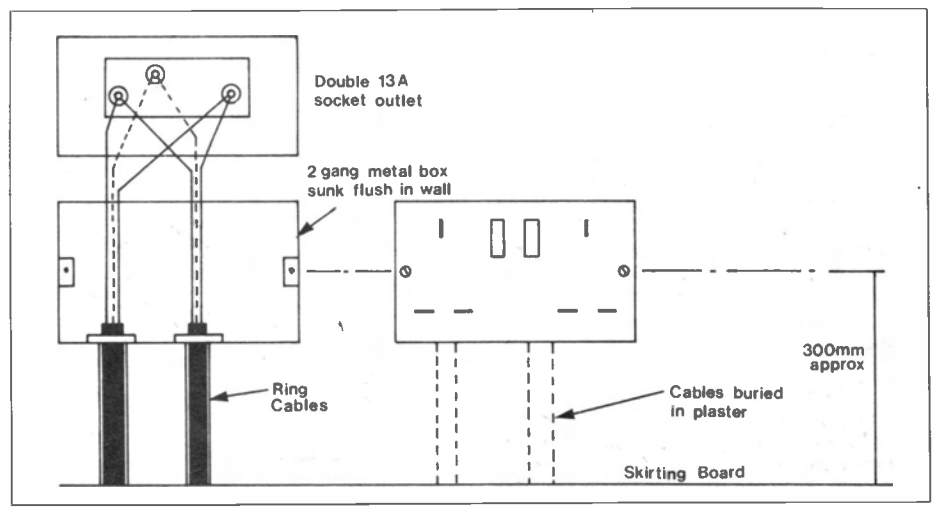

Figure 4. Fixing and connecting a ring socket outlet on the wall above a skirting board.

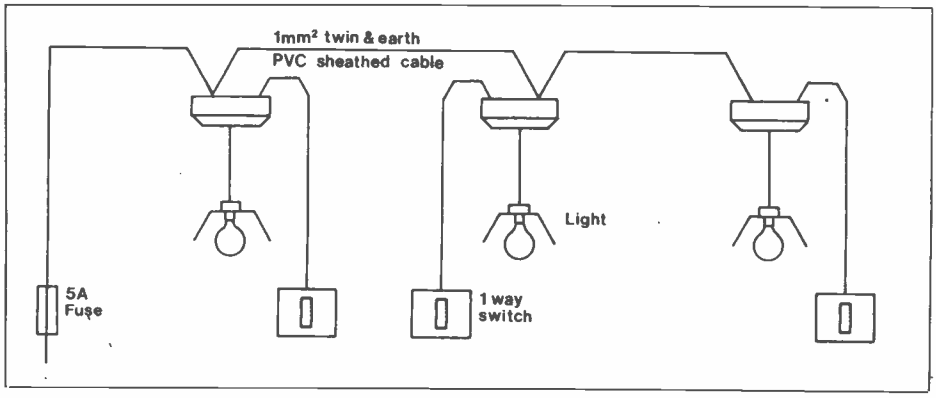

Figure 5. Lighting circuit wired on the loop-in system.

cable sheathing terminates within the accessory or its box.

The modern ceiling rose has no box and does not need one. It has an integral backplate, enabling it to be fixed direct to the surface of the ceiling. Thin plastic sections are knocked out of the backplate into which the sheathed cables are passed. Some batten lampholders and other ceiling fittings have an integral backplate, and need no box. However, most of the special pendant fittings do require a mounting box. This is a circular conduit box termed a BESA box, having a back outlet and fitted flush into the ceiling to support the ceiling plate and the fitting. Two screwed lugs are M4 metric. The box can be plastic, but where it is to support a fitting in excess of 3kg a metal box is necessary. The box is fixed to timber between joists, with a hole drilled to take the box outlet.

Most wall lights, as well as spotlights, also need to be mounted on boxes, to join the circuit wires to the flex wires and to contain the cable connector.

Lighting switches

The modern lighting switches are termed plate switches because of their faceplate, usually moulded plastic but sometimes metal. Most fit a one-gang slim or plaster depth box. The switch assembly can be a single switch, either 1-way, 2-way or intermediate, or it can comprise two or three switches in the one gang, these would all be 2-way switches which can be used for either one-way or two-way. Where four, five or six switches are required in the one position, a 2-gang faceplate and a 2-gang box are used.

Other switches

There is a whole range of switches used for other circuits including 20A double-pole, these requiring a deeper box. Cord operated switches used in the bathroom and bedroom are also made in one-way, two-way and double pole versions with and without neon indicator.

Socket outlets

The modern socket outlet used in the home installation is the 13A with fused plug having square pins, and has largely replaced the old round-pin 2- and 3-pin plugs and sockets of 15A, 5A and 2A current rating. As already explained, most sockets are of the flush type, either switched or non-switched, with or without neon indicator, in single and double versions.

Junction boxes

Junction or joint boxes used in home wiring systems are plastic, usually circular and have three or four terminals or banks of terminals. They are made in current ratings of 5A, 20A and 30A.

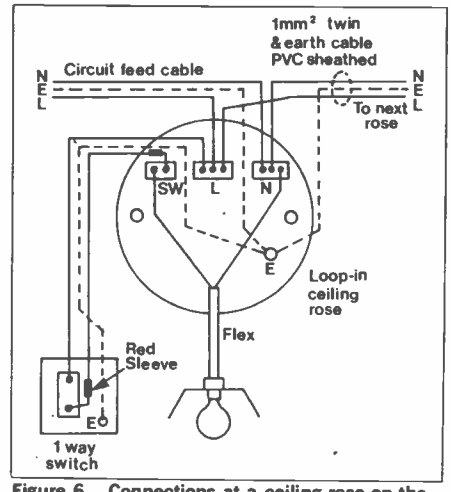

Figure 6. Connections at a ceiling rose on the loop-in system.

The ring circuit

A ring circuit, or ring final circuit to give it its official title, consists of a pvc flat sheathed cable starting at a 30A fuseway or mcb in the consumer unit, and runs throughout the various rooms, finally returning to the same fuseway terminals, forming a complete loop or ring, the connections being made at either the terminals of a ring socket or at a joint box.

Why a ring?

The ring circuit was designed in 1943/44 as a post war measure to enable dwellings to be equipped with an ample supply of socket outlets with the minimum of cable, when copper was in short supply. Before the advent of the ring a 15A socket outlet had to be supplied from a separate circuit, which meant 6 circuits for 6 15A socket outlets. However, abuse of the system over the years meant that sockets had been added to the original circuits, with subsequent danger from overload on the old wiring.

Therefore a circuit was designed to allow a number of power sockets to be supplied from a single circuit, which would save cable and require only one fuseway in the consumer unit, or fuseboard. The alternative was a radial circuit, which to supply a number of 13A socket outlets would mean a very heavy and costly cable. The cable would have to be of 30A current rating and its conductors would be too large for looping in and out of terminals of socket outlets. Ultimately the circuit in the form of a ring was devised using cable half the current rating at 15Amps. For about the same cost the cable supplying the ring would be nearly twice the length, cover a wider area, and be able to supply more socket outlets than a single run of cable.

Since each socket outlet connected to the ring cable would in effect be supplied by two cables (outgoing and incoming), this gave the circuit a current rating of 30A to match the circuit fuse or mcb. The size of the circuit cable was 7/.029 imperial which had a current rating of 15 amps, but was uprated to 21 amps, as is its metric equivalent 2.5mm² now used to wire ring circuits.

Local fusing at each outlet was made necessary because the circuit fuse is 30A and requires anything up to 60 amps to blow. The local fuse is in the plug, so that it protects the appliance and flex connected to it against short circuit current. The current rating (maximum) of a plug fuse is 13A which is the equivalent of a little over 3000 watts. The rectangular shape of the plug pins was chosen so that it could not be plugged into any other existing socket nor could any other plug be plugged into the 13A socket outlet.

The number of 13A outlets (sockets and fused connection units) which may be supplied from any one ring circuit is unlimited but the area in which the outlets are fixed must nox exceed 100m². The logic is that adding sockets within a given area does not itself increase the load or current demand but to increase the area is likely to, so far as space heaters are concerned.

Spurs

As mentioned, a spur is a cable branching off the ring cable at a convenient point, which can be the terminals of a ring socket or a 30A joint box inserted into the ring cable. Its principal purpose is to supply a socket outlet or a fixed appliance via a fused connection unit off the main route of the ring cable. This arrangement saves cable, but as it is a single length of 2.5mm² having a current rating of only 21 amps it may supply only one outlet. This can be either a single or a double socket or a fused connection unit. The number of spurs on a ring circuit must

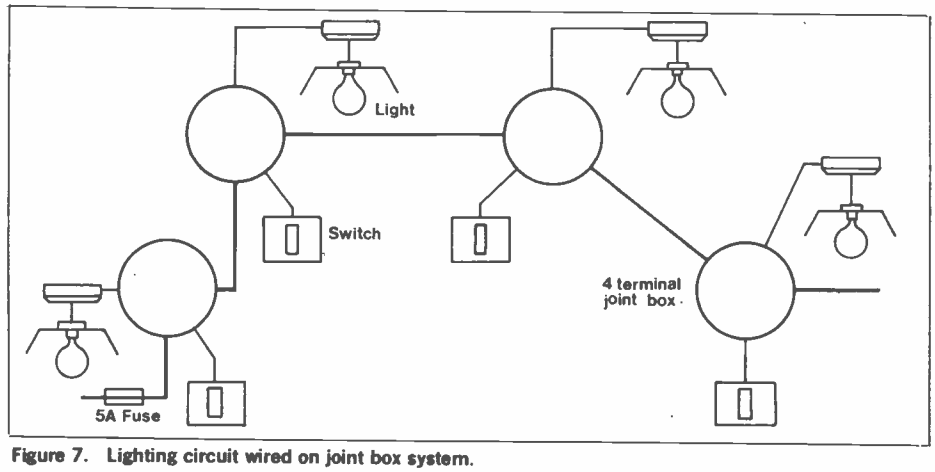

Figure 7. Lighting circuit wired on joint box system.

not exceed the number of socket outlets connected to the ring cable. Chiefly, spurs should be limited mainly for future extensions rather than to install initially, except where significant saving in cable can result.

Lighting circuits

A lighting circuit is a radial circuit, which means that the circuit cable terminates at the last light on the circuit and does not return to the fuseway to form a ring.

A ring is not necessary, since the cable is smaller, and can extend throughout the house if necessary, and the number of lighting points will still be consistent with the current rating of the circuit fuse or mcb.

There are two principal methods of wiring lighting circuits, or rather lighting points, and either or both methods can be used on any one circuit. These are the loop-in and the joint box methods.

Loop-in method

With the loop-in method the lighting circuit cable is run from a 5A fuseway in the consumer unit to each of the lighting points, starting at the nearest, looping out to the next, and so on until the last on the circuit, where the cable terminates.

Then, from each lighting point, a length of the same cable is run to the respective switch position, usually on the wall of the same room or area, eg hall or landing, and in some instances, such as in the bathroom, to a ceiling switch next to the access door. All the cable joints are made in the ceiling rose which also serves as a joint box with ready access in the same room.

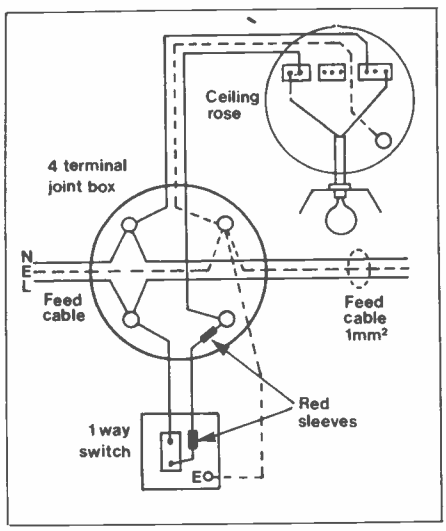

Figure 8. Joint box system.

Joint box method

With the joint box method the lighting circuit cable is run from the 5A fuseway to a series of 4-terminal 15A joint boxes, one for each light, and its switch situated in a convenient position between each light and its switch.

Then from a joint box two additional cables are run, one to the light the other to the switch, making a total of four cables, two feed cables plus the light and switch cables, except at the last joint box where there is only one feed cable. All joints are made in the joint boxes, which being situated in the ceiling voids or roof space are comparatively inaccessible, which is the main disadvantage of the joint box method. The main advantage is that less cable is normally used.

Mixed method

Although there are two methods, both can be applied to any one circuit, some lights being wired on the loop-in system, usually where ceiling roses are used. On other lights with no loop-in facilities, such as wall lights and some ceiling fittings and pendants, the joint box system is used with only one cable going to the light.

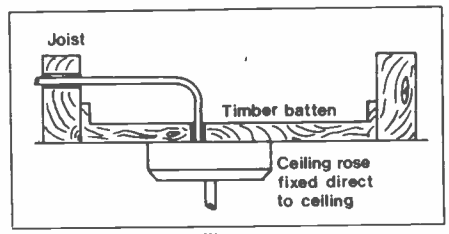

Figure 9. Fixing a ceiling rose.

In rewiring the loop-in system is usually employed, since the new cables are run under the floorboards with the minimum disturbance and there is no need to allow for the fixing of joint boxes. Where the circuit cables are run in the roof space for the upstairs lighting the joint box method is often used, with the joint boxes fixed between joists.

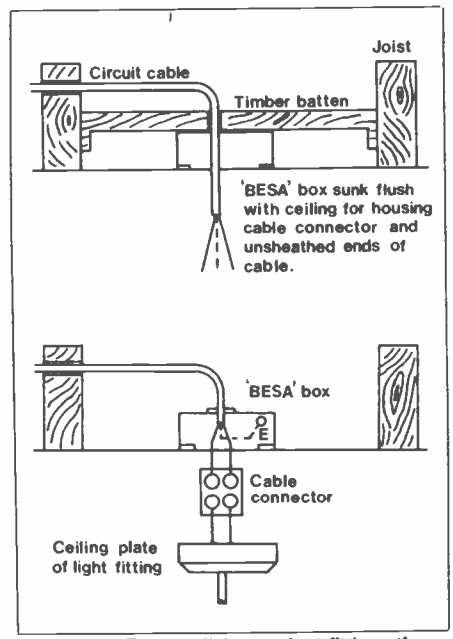

Figure 10. Fixing a light pendant fitting other than a ceiling rose.

Number of lights per circuit

A lighting circuit of 5A is on a 240V electricity supply equal to 1200 watts. This is the maximum which should be connected to the circuit. However regulations stipulate that a light containing a tungsten filament bulb is assessed at 100 Watts for any bulb, up to and including 100 Watts. Bulbs of higher wattage are assessed at the actual wattage. 12 bulbs at 100 watts each total 1200 watts, which is the maximum permitted. This means that the circuit may serve twelve lampholders, provided none contain bulbs of higher wattage than 100W. Where there are higher wattage bulbs the number of lampholders are reduced proportionately. With one or more 2- and 3-light fittings plus higher wattage bulbs the number of lights on a circuit should definitely not exceed eight, and preferably no more than six, so that the area affected by a fuse blowing is limited; this also allows for future additions of one or more lights on a circuit. A house of 3- or 4-bedrooms usually requires two lighting circuits but where wall lights and spotlights are included the number will be more.

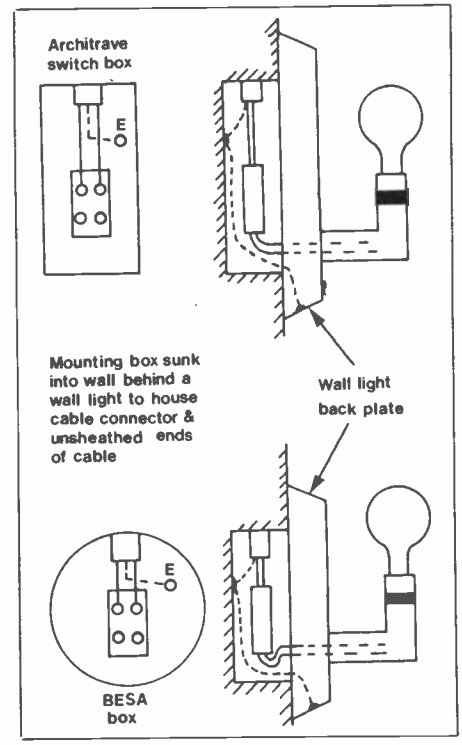

Figure 11. Mounting wall lights.

Fixed lighting, especially spotlights, can be supplied from a ring circuit via a fused connection unit fitted with a 3A fuse. Cable used for a lighting circuit is, as already explained, 1.0mm² twin & earth pvc sheathed with some sections wired in 3-core and earth pvc sheathed cable.

Installing lighting fittings

The simplest lighting fitting is the plain pendant comprising ceiling rose, flex and pendant lampholder. The ceiling rose of the wired pendant is connected to the circuit cables and fitted direct to the ceiling, with wood fixing between the joists to support it. See figure 9 for connections. Batten lampholders and some enclosed lighting fittings are similarly connected, but as already explained a special pendant having a ceiling plate is connected to a circular box fixed flush with the ceiling. The circuit wires are connected to the flex using cable connectors housed in the box. See figure 10.

Wall lights are fixed either to a round box or are mounted over an architrave switch box and fixed direct to the wall. See figure 11.

Fixing switches

A wall switch is fixed to a box mounted on the wall at a height of about 1.4m above floor level. For surface mounting a plastic box is used. This is fixed to the wall by two No.8 wood screws in holes drilled and plugged in the wall. A section of thin plastic is knocked out of the edge of the box and the cable threaded through. The end of the sheathing within the box is stripped off, and about 10mm of insulation from the end of each of the two insulated conductors. A piece of red sleeving or red pvc insulation tape is fitted over the end of the black wire, and the two conductors are connected to the two terminals of the one-way switch. The bared end of the earth conductor is enclosed in green yellow striped pvc sleeving and the conductor is connected to the earth terminal of the box. If a 2-way switch is used one conductor is connected to the common terminal of the switch, the other to the L2 terminal, and the switch fixed to the box with the Top on the faceplate at the top so that the rocker will be down to switch the light on.

For flush mounting the plastic box is fitted into a plaster depth chase cut into the plaster and, using No.8 wood screws, fixed to the wall in the two drilled and plugged fixing holes. For a cord operated ceiling switch the cable is passed through a removed section of thin plastic in the backplate, the ends prepared and the black conductor with red sleeving connected to the switch terminals and the sleeved earth terminal connected to the earth terminal on the backplate.

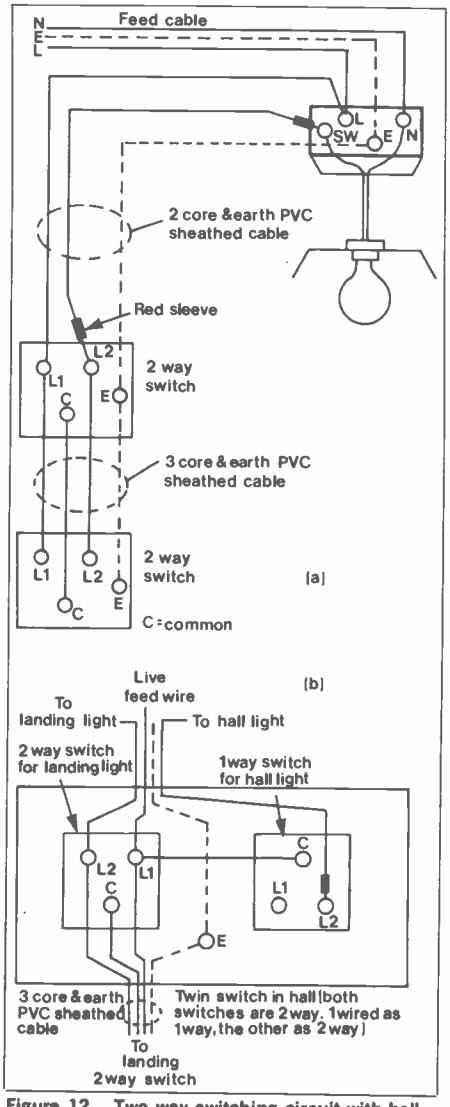

Figure 12. Two way switching circuit with hall and landing wiring.

Two-way switching

Where a light is to be controlled by two switches in different positions a 3-core and earth cable is run from the first switch position to the second switch position and a 2-way switch fixed at each. The connections at each switch are shown in figure 12.

Intermediate switching

Where a light is to be controlled by three or more switches in different positions intermediate switching is used. This is a 2-way switching circuit with a 2-way switch at each end and one or more switches fixed in intermediate positions between the two 2-way switches. One intermediate switch is needed for each extra switch position. An intermediate switch is an ordinary plate switch of the rocker type, but has four terminals instead of the two of a 1-way switch and three of a 2-way switch.

The 3-core and earth cable running between the two 2-way switches is cut at each intermediate switch and the yellow and blue wires connected to the terminals as shown in figure 13. The red wire running from the common terminal of one 2-way switch to the common terminal of the other 2-way switch is not connected to an intermediate switch, but because the cable is cut the conductor is jointed in the mounting box of the intermediate switch so that it is continuous from one 2-way switch to the other.

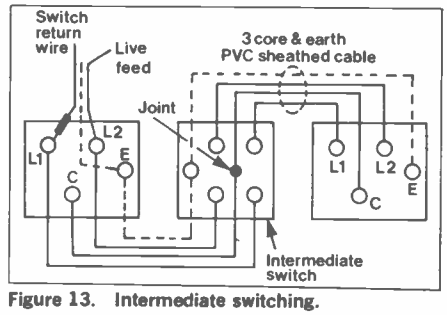

Figure 13. Intermediate switching.

Dimmer switches

Where a light is to be controlled by a dimmer switch instead of a rocker switch the dimmer switch replaces the rocker switch without any need for modification in the wiring. Most dimmer switches fit the shallow or plaster depth switch. They are made in one and two-gang assemblies, to fit a one-gang box and control more than one light.

Where the light is fluorescent a dimmer switch cannot be used,though there are special dimmers and fluorescent fittings that can be used, but an extra switch wire has to be run from the switch to the fluorescent lighting fitting.

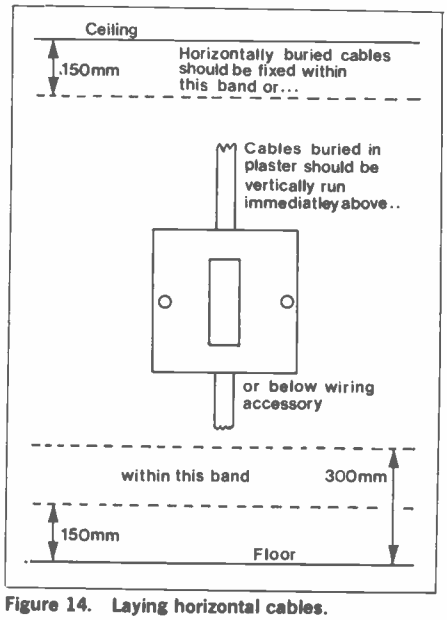

Figure 14. Laying horizontal cables.

In a roof space where polystyrene granules are used for heat insulation pvc sheathed cables must be situated where they do not come into contact with them, as the pvc is adversely affected by it. If it is not possible to avoid the insulation the cables should be enclosed in plastic conduit. Generally cables in the roof space should be situated away from walkways and the cold water storage cistern where they are likely to be disturbed.

Running circuit cables

The various circuit cables are normally run in the void between the ceiling and floorboards above the ground floor of a 2-storey house. These cables serve the lighting points and switches in the room below. Ring circuit cables supply socket outlets in the first floor rooms, and cables to an immersion heater and other apparatus are also run in this void. In the roof space are mainly lighting cables feeding the lights and switches in the rooms below, though the cable to the shower in the bathroom is sometimes run in the roofspace to a ceiling switch in the bathroom.

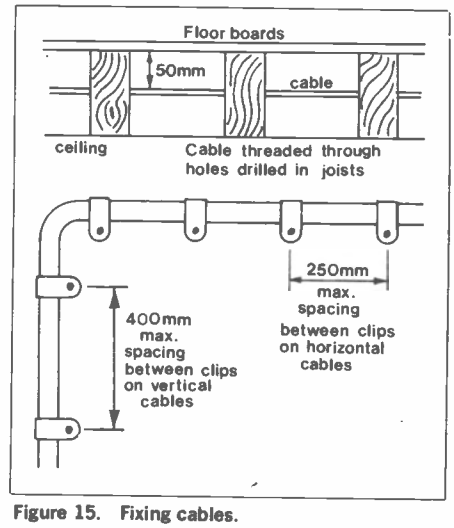

Figure 15. Fixing cables.

On the ground floor cables are run in the void below the floorboards where it is a suspension floor, but if the floor is solid cables may be run in conduits before the screed is laid, otherwise they are run behind skirting boards. PVC sheathed cable may in fact be run anywhere along the house structure, fixed to the surface or buried in the plaster without the need for protection from the risk of mechanical damage.

Cables clipped to the surface must have fixings not more than 250mm apart for horizontal runs and not more than 400mm apart for vertical runs. Where cables are buried in the wall they should as far as practicable be run vertically exactly above or below the switch or socket outlet they feed so that anyone later fixing shelves will know where to expect them. Where horizontal buried cables cannot be avoided they should be run in a band 150mm from the ceiling or between 150mm and 300mm above floor level. Where cables are run under floors and cross joists they must be threaded through holes drilled in the joists not less than 50mm below the tops of the joists.

It is neither necessary nor desirable to enclose pvc sheathed cables in conduit where buried in the wall since they are unaffected by plaster, and the extra chopping away can damage the wall structure. In houses under construction it is usual to enclose them so they stay in place and are not damaged by the plasterer's float during plastering.

Permission to wire

No permission is required in Britain to carry out home electrical installation work, though where the house is rented permission may be necessary from the owner. Neither electricity boards nor local authorities or any other official body has any jurisdiction in respect of wiring. The work should however conform to the IEE Wiring Regulations published by the Institution of Electrical Engineers and recognised as a code of good wiring practice by all official bodies, including electricity boards and government departments. The regulations,

contrary to popular belief, are not statutory, and an electricity board has no powers to refuse connection to its mains of an installation, or parts of it, which do not strictly conform to the current IEE wiring regulations, but a board can and will refuse connection to its mains of any installation which is dangerous and as such does not conform to the Electricity Supply Regulations. These are statutory and are quoted in the application form signed by a consumer when requiring a supply of electricity.

An installation conforming to IEE Wiring Regulations is deemed to satisfy the requirements of the Electricity Supply Regulations and the electricity board must connect it to the mains. In these circumstances the board must connect the installation, whether carried out by a recognised contractor or by the householder himself.

From a contractor the board requires a test certificate, and may waive its own test and inspection. The householder who is unable to complete a test certificate can expect the board to test the installation through they are not obliged to do so. The test is at the option of the electricity board and is mainly to satisfy them that the installation will not adversely affect the supply to other consumers. It is important to note that good workmanship using correct material is necessary to conform to the regulations.

Electricity tariffs

A tariff is the means by which an electricity board calculate the amount to charge a consumer for electricity and the service provided. Basically, all tariffs consist of a fixed quarterly charge plus a charge for each unit of electricity consumed. Most domestic tariffs are of this type, though where a lot of electricity is consumed during off-peak times the charge for the electricity may be reduced, or even halved. A popular off-peak domestic tariff is the Economy 7 which provides electricity over a 7-hour night period at a cheaper rate.

Electricity consumed is registered on a 2-rate meter, and all electricity consumed during the 7-hour period is cheaper, whereas in some former off-peak tariffs only the electricity consumed by storage heaters qualified for the cheaper rate.

Even though the cheap rate now applies to all electricity consumed during the off peak period it is not usually financially beneficial to adopt the tariff, because the day time rate is higher than the standard rate per unit on the ordinary tariff. It is therefore advisable to have the tariff temporarily for at least two quarters (one summer the other winter) so that a comparison may be made.

*These current ratings apply where the cables are clipped direct to the surface. Ratings are lower for enclosed cables and some other situations, but are all suitable for the circuits specified.

Circuits	Fuses	Colours
Lighting	5A	White
Ring	30A	Red
Immersion heater	15A	Blue
Storage heater and 20A Radial Circuit	20A	Yellow

Current ratings of house wiring cables

The various cables used in house wiring with their sizes, current ratings, and the principal circuits in which they are used are as follows:

Cable size mm²	Current rating* amps	circuits
1.0	16	lighting
1.5	20	lighting and 15A single socket circuits
2.5	28	ring circuits and 20A radial circuits
4.0	36	radial circuits (30A)
6.0	46	cooker circuits, shower unit circuits
10	64	cooker circuits
16	85	meter leads
25	108	meter leads