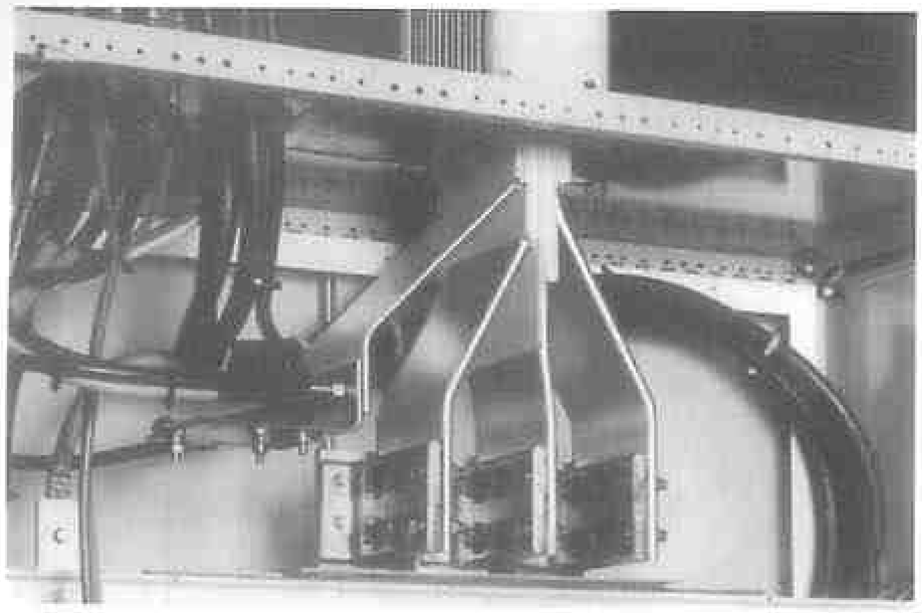


Fig. 7.19(a) *A typical busway system* MM CABLES

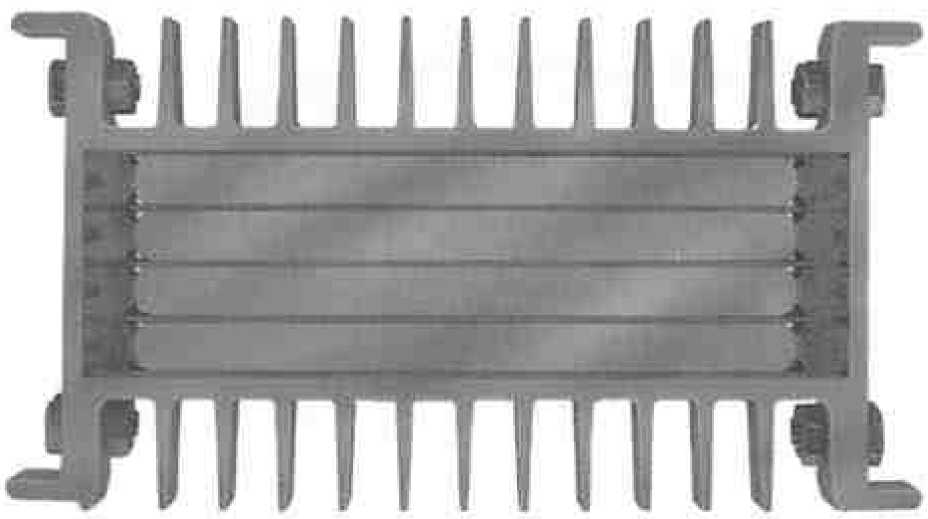


Fig. 7.19(b) *Cooling fins increase heat dissipation* MM CABLES

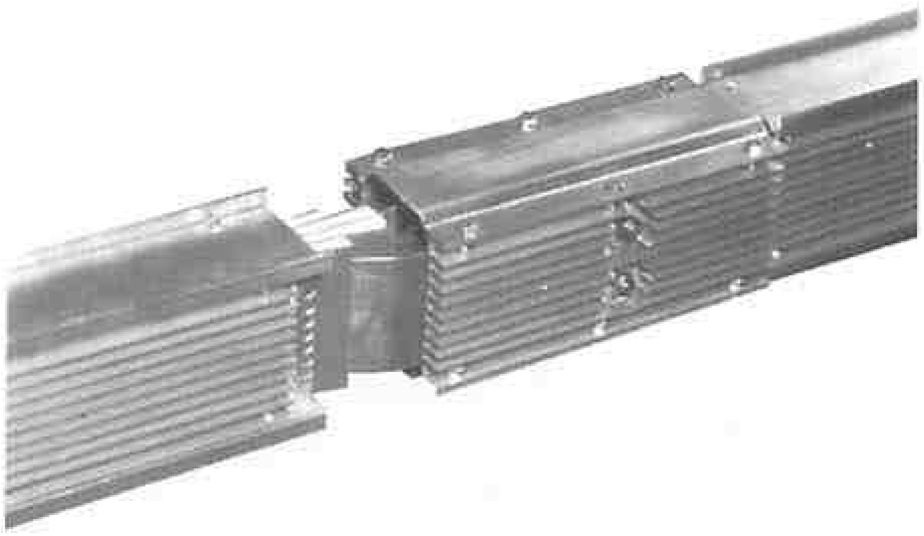


Fig. 7.19(c) *High-capacity joint* MM CABLES

may be used as an earthing medium. Current capacities of up to 10 kA are possible with this system.

Busways must comply with AS 3439.2—1994: *Particular Requirements for Busbar Trunking Systems (Busways)*, prepared by the Standards Australia/Standards New Zealand Committee EL/6.

Busways are classified by the Standard according to

- whether they are indoor or outdoor types,
- their rated voltage, and
- their continuous current ratings.

Also specified in the Standard are

- preferred values of rated voltage and current,
- short-time withstand currents,
- peak-withstand current ratings, and
- short circuit current ratings (see AS 3000, *Clause 3.32.2*).

Service conditions, design, construction criteria and tests are also covered by AS 3439.2, which should be consulted for details by an electrician concerned with the installation of busways.

It is seen that any busway installed must be fabricated by a reputable manufacturer to comply strictly with the Standard. All relevant data must be marked on a nameplate or plates, preferably with the AS mark as an assurance that it has been produced by a manufacturer licensed under the 'certification mark' scheme operated by Standards Australia.

Busway systems are not permitted for use on voltages above 650 V, and are covered by *Clause 3.32.*

It is now common to find busways being used in shopping complexes as unmetered mains and for variable consumer needs in leasehold premises. Labour costs can be reduced by the use of feeder and rising mains busways.

Feeder systems range from 300 A to 5000 A and are available in both copper and aluminium, totally enclosed with either ventilated or ventilated and insulated conductors.

Take-offs for the feeder systems are available from 20 A to 1200 A in high-rupturing-capacity (HRC) combination fuse switches or circuit breakers. They are usually of a bolt-on type.

A rising main feeder often proves advantageous where space is at a premium in the service ducts of high-rise buildings (see Fig. 7.20). They usually require only one fixing per 3 m length and can incorporate expansion joints and integral fire barriers, thus eliminating cable ladder, multiple cable runs and lengthy and time-consuming cable ties.

7.5 Track systems and flat cable assemblies

Both these systems are similar to trunking and busway systems in that they consist of manufactured channels or modules with take-off plugs that may be installed at convenient positions along the run.

A typical track system (see *Clause 0.5.93*) comprises an extruded anodised aluminium section enclosing a plastic extrusion carrying the active and neutral conductors. A copper earth conductor, which is an integral part of the aluminium extrusion, is provided. Prewired take-off plugs or adaptors provide the connection facility (see Fig. 7.21(a)).

Flat cable assemblies (see *Clause 0.5.20*) consist of a channel housing in which a special flat cable is laid.

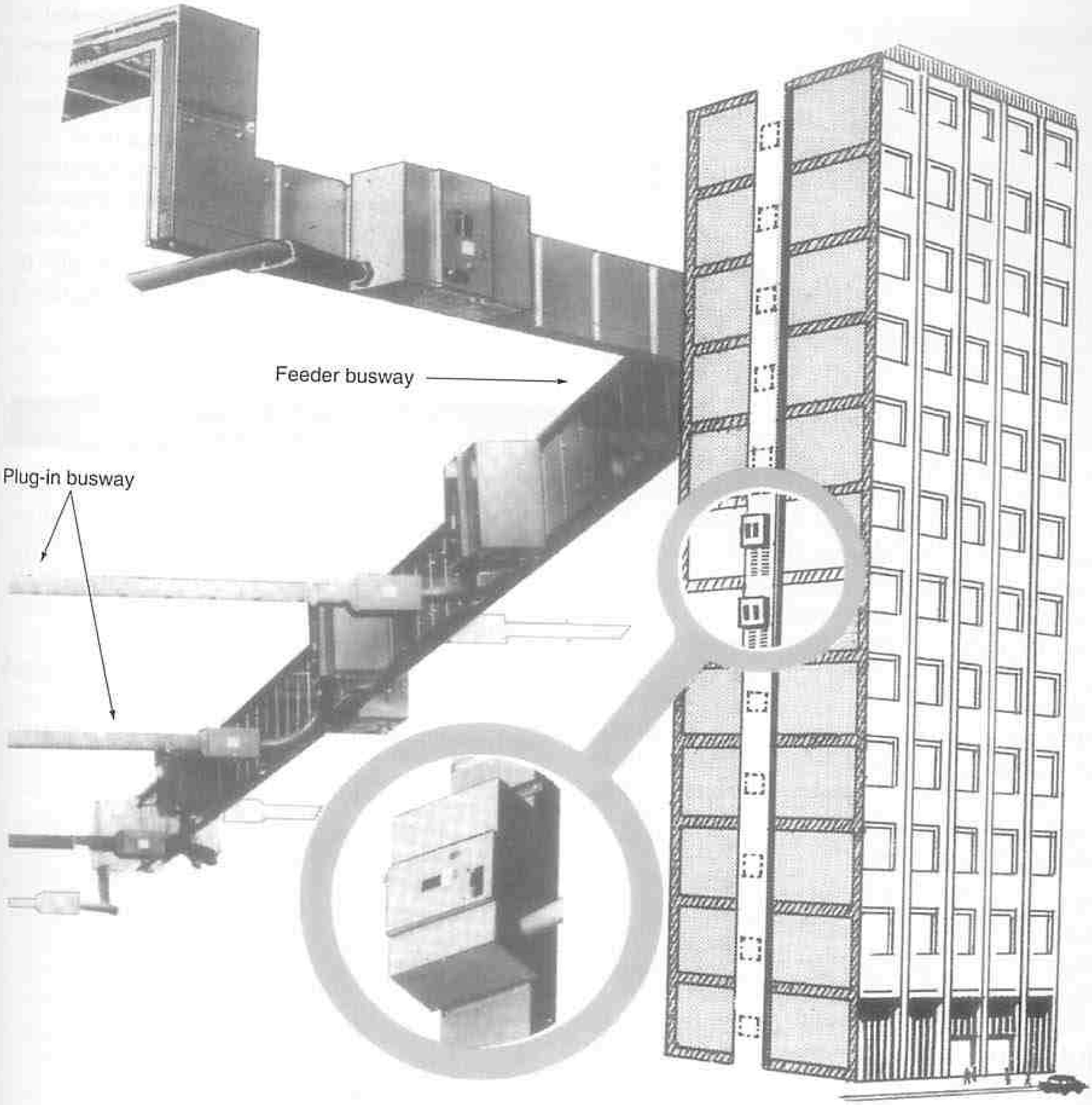


Fig. 7.20 *Feeder busway for high-rise building. Inset: typical horizontal take-off feeder* VASS ELECTRICAL INDUSTRIES

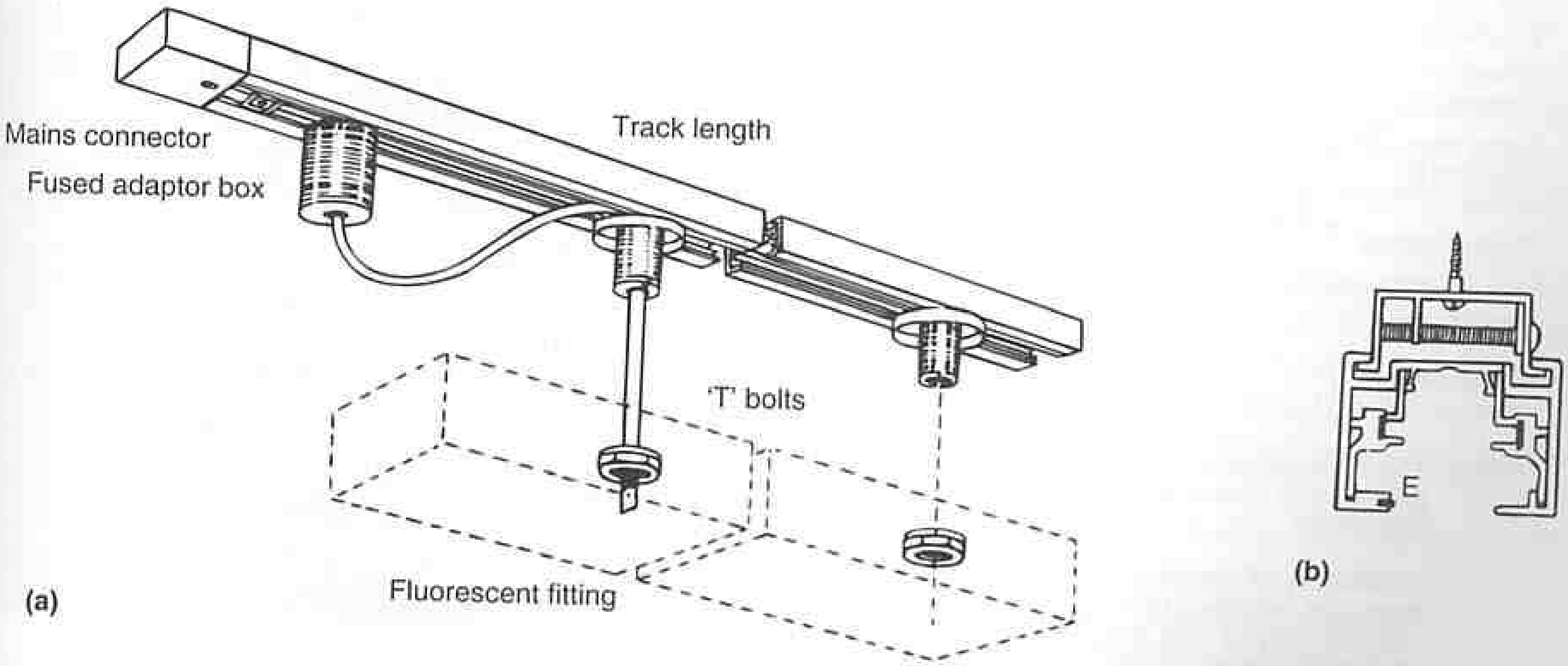


Fig. 7.21 **(a)** *Typical track system;* **(b)** *End view of track extrusion module*

The take-off plugs for the system make contact with the flat cable conductors by contacts that penetrate the cable sheath in a manner similar to that of a festoon-type lampholder. The makers of both systems claim that the use of standard channels and accessories, luminaires and take-off plugs reduces both the prime cost and installation costs and provides a flexible system for alterations or additions.

There are many features common to both systems, some of which are:

- Neither system is suitable for use on supplies higher than low voltage.
- Neither system is permitted where mechanical damage or the action of corrosive fumes could occur, nor is their use permitted in certain special situations (see *Clauses 3.33* and *3.34*).
- Both systems must be installed so that they are exposed to view throughout their length.
- Both systems have continuous earthing conductors to which the channel or track is earthed and which provide the earth connection for the take-off plugs.
- Only accessories that are expressly designed for use in the specific system may be used.
- For both systems there is no limit, other than current-carrying capacity, to the number of points that may be installed.
- Protection for both systems must be provided by overload circuit breakers.

Some points on which the systems differ are:

- Whereas the track system may be connected to a circuit containing lighting points only or to a separate subcircuit, each circuit of the flat cable assembly is to be regarded as a final subcircuit.
- The track system is erected as a series of complete modules or sections in which the conductors are integral to the track (see Fig. 7.21(b)). In the flat cable assembly the channel housing is erected as a complete system (see *Clause 3.33.2.2*) **before** the flat cable assembly is inserted into the housing.
- The track system design is mainly for two-wire low-voltage or extra-low-voltage lighting circuits.
- Flat cable applications include low-voltage equipment, and the flat cable may contain up to three active conductors together with the neutral.

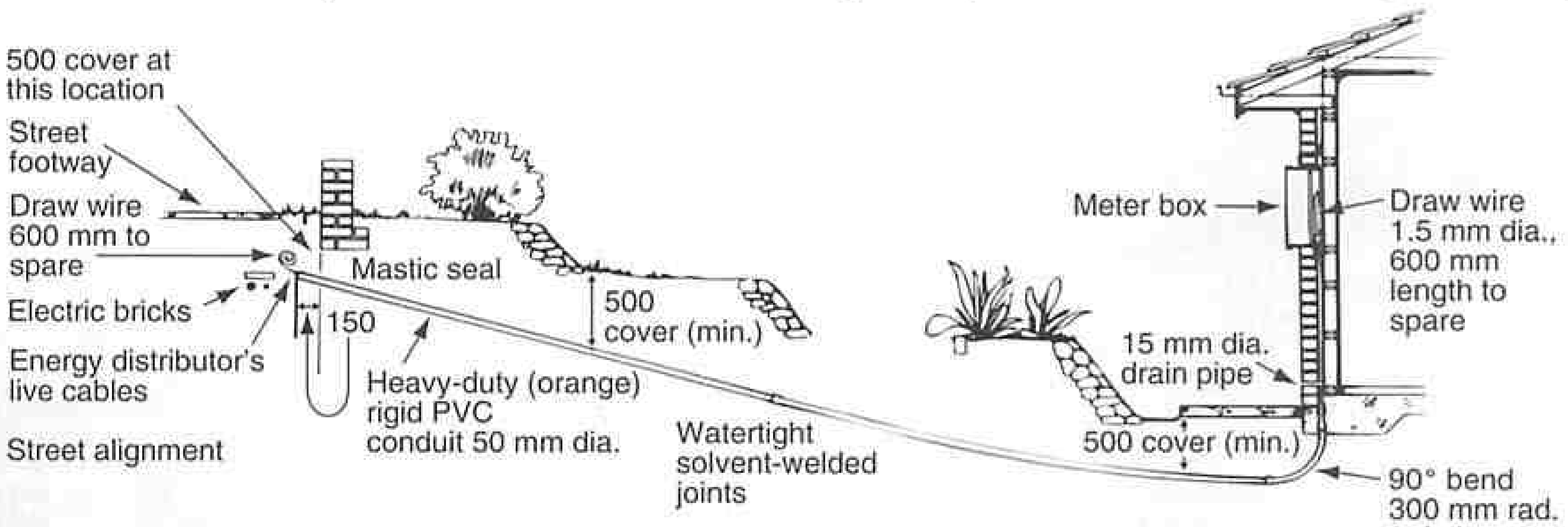
Both systems often vary in design and should be installed in accordance with the manufacturer's instructions.

7.6 Underground wiring systems

In the densely populated areas of a large city, most of an energy distributor's low- and high-voltage reticulation is underground. Low-voltage reticulation and service mains are also commonly installed underground in many housing estates. On consumers' installations, underground wiring is often employed for the wiring to outbuildings, advertising signs and outside lighting, and for submains. In commercial and industrial installations, extensive underground wiring systems are also commonly used.

The energy distributor's reticulation is its own domain and responsibility; but if underground service mains are required, they are usually installed by the electrical contractor in accordance with the distributor's specified requirements (see *Clause 0.5.78* and Fig. 7.22, which illustrates typical requirements).

The electrician is usually concerned with wiring on a consumer's premises, to which *Clause 3.16* relates. This Rule sets out the various forms of acceptable enclosures, the depth of laying and protection required, and any other provisions relevant to underground wiring.



Notes: The drainage provision is not required if the floor of the premises is above street level. All dimensions are in millimetres.

Installation of underground supply services will vary from one supply area to another depending on the relevant service and installation rules of the particular energy company.

Fig. 7.22 *Underground service to a single domestic dwelling* ENERGY AUSTRALIA

Decisions on the type of cable to be used, the form of the enclosure and the cable route are made 'on the job', and are largely influenced by cost and the type of terrain under which the cables will be laid (see Fig. 7.23). For example, a lead-sheathed and armoured cable might well be considered for a 100 m underground submain in a factory yard, whereas single-insulated PVC conductors in heavy-duty underground conduit would be suitable for a 10 m underground feed from a house to a post lantern light in a garden.

Table 3.6 of AS 3000 lists ten cable types that may be used, and by cross-reference it classifies the acceptable forms of enclosure as category A, B or C. Once the cable type and enclosure have been decided on, the depth of laying is obtained from *Table 3.7* (see also Fig. 7.25).

Where types of cables and enclosures not specified in *Table 3.6* are considered by an energy distributor to provide a degree of safety from fire and shock not less than the types covered by the Rules, it may approve their use for underground work

Category A systems

Any of the ten listed cable types may be used in the specified non-metallic enclosure of AS 3000 *Table 3.6*, column 2. The choice, however, is usually heavy-duty

Fig. 7.23(a) *Heavy-duty rigid unplasticised PVC conduits and ducts for an underground service*

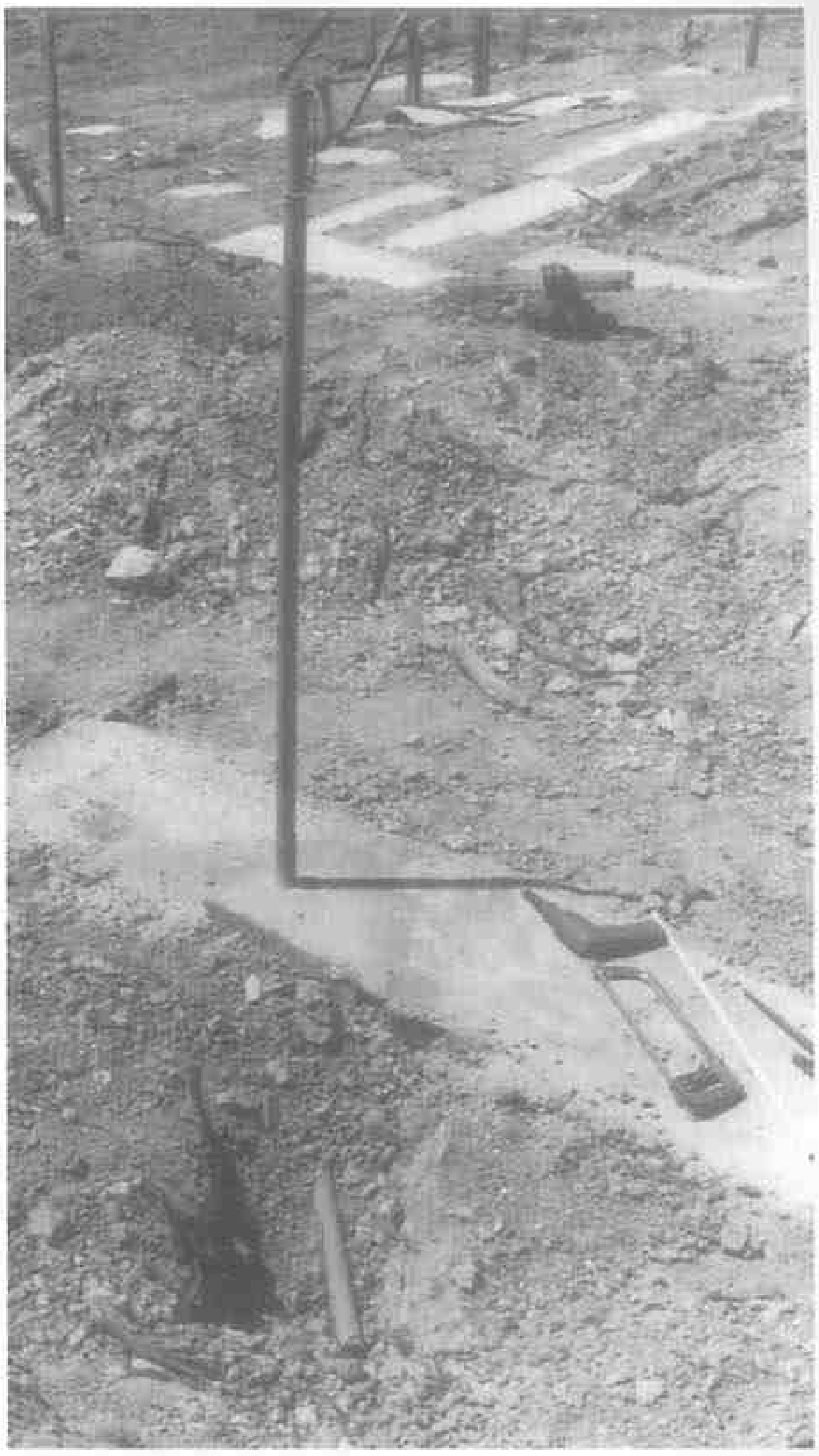


Fig. 7.23(b) *Conduit for a consumer's underground mains, placed before concrete pour*

rigid PVC underground conduit (standard colour orange) that has been manufactured in accordance with AS/NZS 2053—1995. The most economical type of cable for this enclosure is single-insulated PVC. If water pipe is used, unsheathed cable or unarmoured lead-covered cable, with or without sheathing or serving, is **not** to be used, as the rough interior surface of the pipe may damage the cable.

If terracotta (drainpipe), fibrous cement pipe or ducting, or light-duty rigid unplasticised PVC conduit is the chosen enclosure, the only cables not allowed are unsheathed (single-insulated) ones, but the enclosure for the cables must itself be enclosed in concrete or otherwise protected.

Although *Clause 3.16* does not require it, some energy distributors do provide further mechanical protection for heavy-duty rigid unplasticised PVC (underground) conduit. Figure 7.23(a) shows electrical distribution conduits and ducts enclosed in concrete. For depth of laying, refer to Figures 7.24 and 7.25.

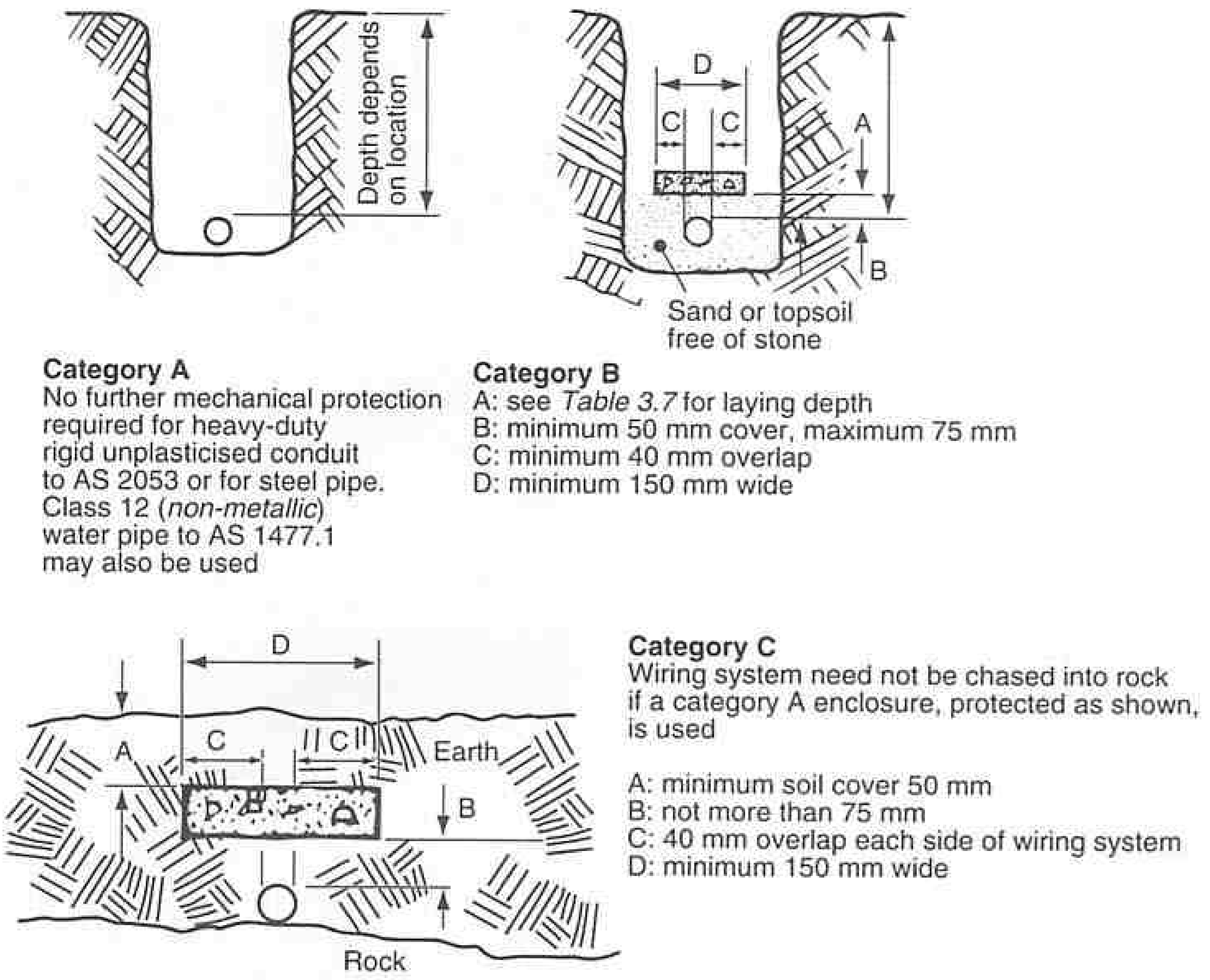


Fig. 7.24 *Underground enclosures*

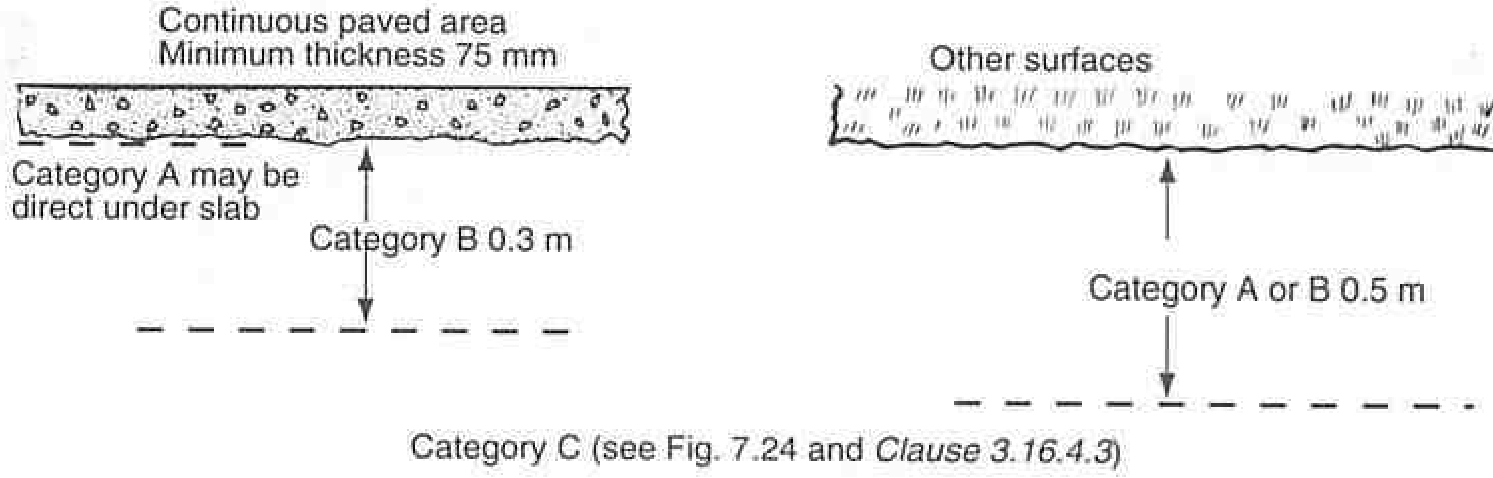


Fig. 7.25 *Depth of laying underground wiring*

Note that the current rating of an underground cable is affected by soil temperature, depth of laying, conductor size, whether the cable is buried in the ground or in an underground duct, and whether it is single-core or multi-core. Refer to *Clauses B4.2.3* and *B4.2.4* of *Appendix B*, AS 3000, and *Tables 25 to 29* of AS/NZS 3008.1.1.

Category A and C systems: in rock

In category C, the wiring system is chased into rock and covered to a depth of 50 mm by a fine aggregate concrete. Only cable types (c), (f), (i) and (j) of category C, *Table 3.6* (AS 3000), are allowed in the channel, but any of the enclosed category A systems may be used. This means that, if rock has been encountered on the surface or before the necessary depth of the cable trench has been attained, the rock may be chased to give a clearance of 50 mm **above** the wiring system and the channel filled with fine aggregate concrete.

An acceptable alternative to chasing the rock is to install a category A system on top of the rock and provide further protection by using a continuous pour of 75 mm thick concrete. The concrete must overlap the category A system by 40 mm on each side and be not less than 150 mm wide. It must also be placed not more than 75 mm above the wiring system and be covered by at least 50 mm of soil.

Figure 7.24 illustrates some options for installing underground enclosures.

Category B systems

These systems, whether in the enclosures of columns 6 and 7 of *Table 3.6* or laid direct in the ground, must

all be embedded in not less than 50 mm of sand (preferred) or fine topsoil free of stone and then covered by another 50 mm of the material. In addition to this, mechanical protection must be provided, as indicated in *Clause 3.16.4.2*, and minimum depths maintained as specified in *Table 3.7*. Forms of mechanical protection and depths of laying underground wiring systems are illustrated in Figures 7.24 and 7.25.

Only MIMS cable with serving is permitted to be buried direct in the ground (see *Table 3.6*, column 8), due to the usually unknown nature of the soil, which may, for example, contain a concentration of acids or alkalis. Provided that the cable is PVC-served, the sheath of the MIMS cable may be used as an earthing conductor. If a separare earthing conductor is buried direct in the ground, it also must be of the insulated type (see *Clause 5.5.4.5*).

Other cable types that may be buried direct in the ground are listed in column 8 of *Table 3.6*. Note that they are still classed as a category B system and thus require further mechanical protection (see Fig. 7.24).

All underground wiring systems must be arranged and spaced so as not to interfere with other services. This is particularly applicable to telecommunications services, where interference due to inductive effects may occur.

7.7 Undercarpet wiring systems

An undercarpet wiring system is one that is installed directly on top of structural floors, beneath modular carpet tiles. It is usually an integrated system of power, telephone and data communications wiring and is specifically designed for installation in industrial and commercial offices (see Fig. 7.26). All cables are manufactured in flat configuration, and the power wiring uses flat copper strip conductors rather than the circular conductors used in other wiring systems and in telephone and data undercarpet wiring. The communications wiring system is also available as a fibreoptic building-wire system designed for undercarpet use. Only the power wiring system is described here.

Undercarpet power wiring

In Australia, undercarpet wiring is subject to the requirements of *Clause 3.36* of AS 3000 and may be used only for final subcircuits in non-domestic installations. Each circuit must be protected by an overcurrent circuit breaker. There is no limit to the number of points on a circuit, provided that they are connected to an undercarpet wiring system only. In other cases, the number of points is restricted by the size of the smallest live conductors, in accordance with *Clause 2.12* of AS 3000.

To permit easy access for alterations, additions and maintenance, undercarpet wiring may be installed only under carpet tiles having a maximum size of 1 m × 1 m. It may not be installed under broadloom carpet or any other type of floor covering, and this must be counted as one disadvantage of the system. The main advantages of the system are that it eliminates floor chasing and drilling, thus maintaining floor fire rating and structural strength, and that it is easy to install, no special tools being required for termination.

Clause 3.36.2.2 requires that the system be installed as a total system in accordance with the manufacturer's instructions, using specified component parts and installation tools. One manufacturer markets a five-core cable; this clause restricts its use to a dedicated circuit and prohibits interconnection between a five-core and a three-core system. Each manufacturer of undercarpet

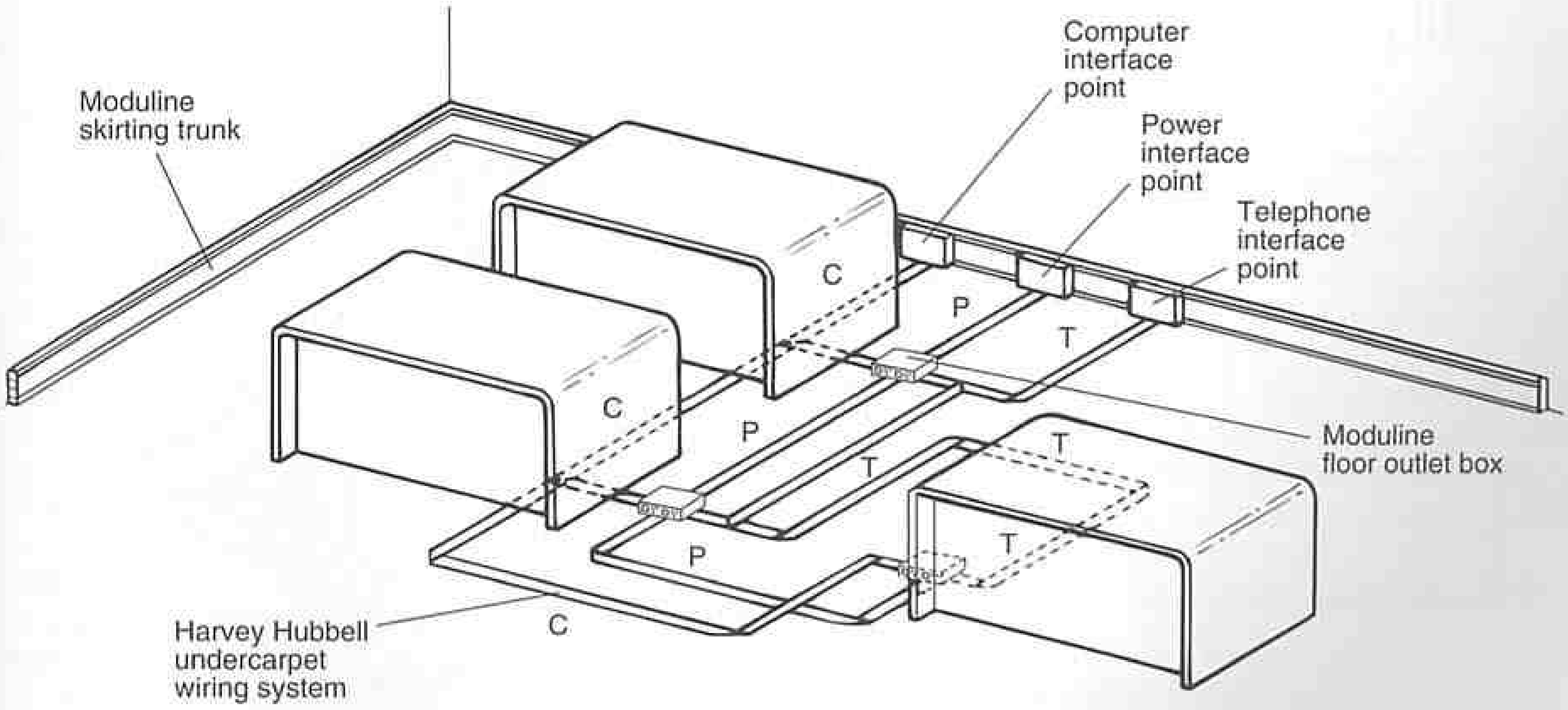


Fig. 7.26 *Typical layout for an undercarpet wiring system* MODULINE

wiring normally issues comprehensive instructions for cable installation, and it is assumed here that you will obtain these and seek the manufacturer's advice before attempting your first installation.

Installation

Only a brief description of installation procedures and precautions is included in this book, and only the Harvey Hubbell system of undercarpet wiring marketed by Moduline Pty Ltd is illustrated. This system utilises a colour-coded three-core cable, consisting of flat copper conductors rated at 20 A 300 V, enclosed in an integral plastic insulating shield. The cable is 50 mm wide and 0.864 mm thick.

The cable is laid over an abrasion-resistant PVC strip, 80 mm wide and 2 mm thick, which is installed on the floor surface. Essential mechanical protection and an earthed screen for the cable are provided by an earthed galvanised steel top shield that is 114 mm wide and 0.254 mm thick. A 50 mm pressure-sensitive tape is used to secure the PVC strip, the cable and the top shield to the floor (see Fig. 7.27).

Undercarpet wiring should never be installed while other building operations are in progress, in order to avoid mechanical damage to the cables. Ideally, it should be installed just before the laying of the carpet tiles.

Prior to installation, the whole floor area, not just the cable routes, must be thoroughly cleaned of all debris, dust and grit. The floor surface should also be free of holes and have no sharp edges that could penetrate the cable insulation. The cable should be laid on areas that have been smoothed with a float; if this is not possible, an additional metal shield must be installed underneath the cable. This shield must then be bonded to the top shield, using a special crimping tool available from the cable supplier.

After the floor has been cleaned, a check should be made that the adhesive tape to be used to secure the system adheres readily to the floor surface. If the concrete surface is powdery, it will have to be sealed; a plastic paint applied with a brush or roller and allowed to dry should suffice.

Once the floor outlets have been positioned, the PVC liner strip is laid along the planned cable routes and fixed down with adhesive tape. The cable is then laid out along the PVC liner, and tape is fixed across the cable at 2 m intervals. The cable run starts at a special transition device that accepts the three-conductor cable and enables its connection to standard cable.

Undercarpet cable is too expensive and unsuitable for runs back to distribution boards; it is permitted only for undercarpet use. The transition device has specially designed drill screws that pierce the cable and thread into a nut and cause insulating piercing terminals to make electrical contact with the conductors. The same device is used in conjunction with floor-mounted outlets designed for use with the system, and for joining two cables; stripping of the cable is never necessary (see Fig. 7.28).

At a change of direction in the cable route, the cable is simply folded over at the corner and pressed down with a piece of flat timber (see Fig. 7.29).

Floor outlets are installed in sequence along the cable route, floor-box mounting plates being fixed to the floor and installed in such a way that earth continuity of the top shield is maintained. In the floor box illustrated in Figure 7.28, segregated compartments (not

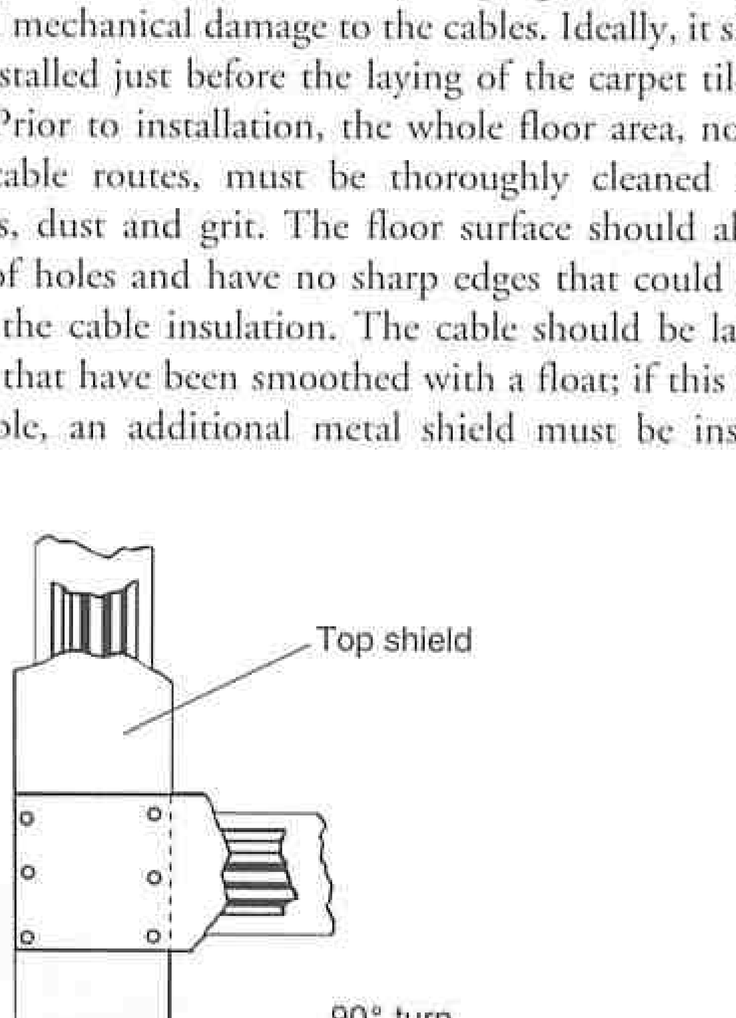


Fig. 7.27 *Installation of earthed metal top shield* MODULINE

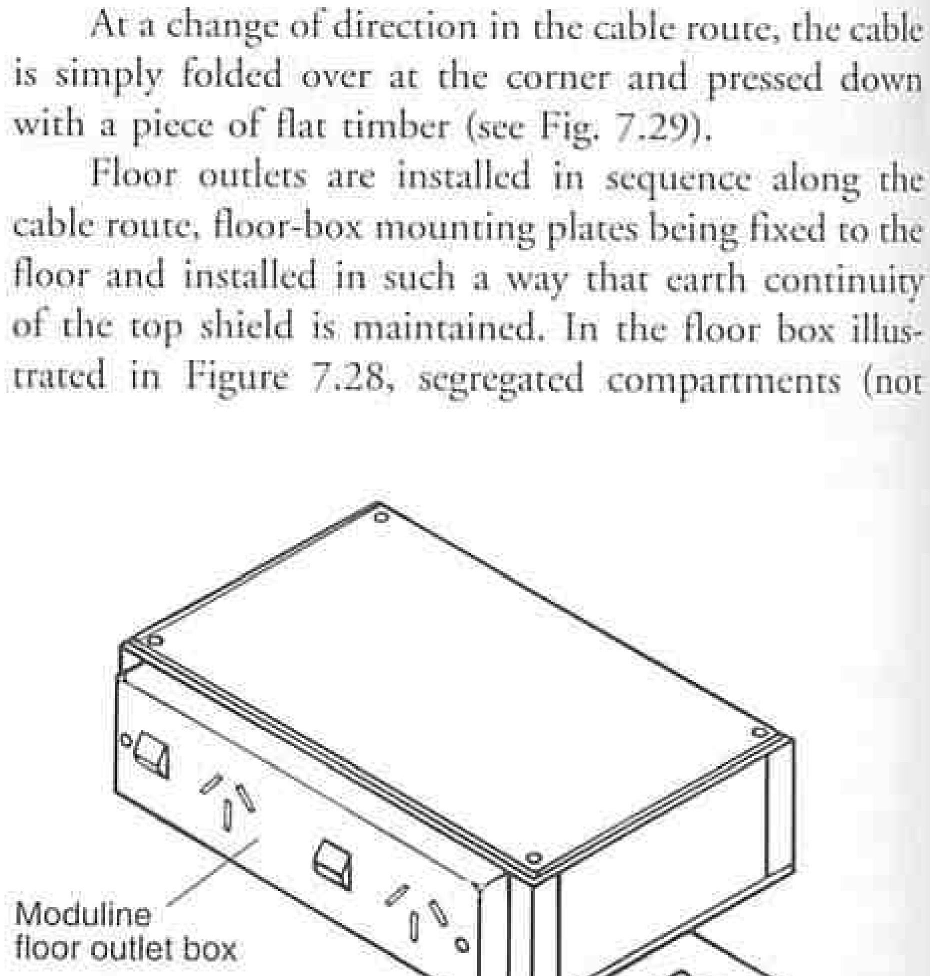


Fig. 7.28 *Installation of floor box* MODULINE

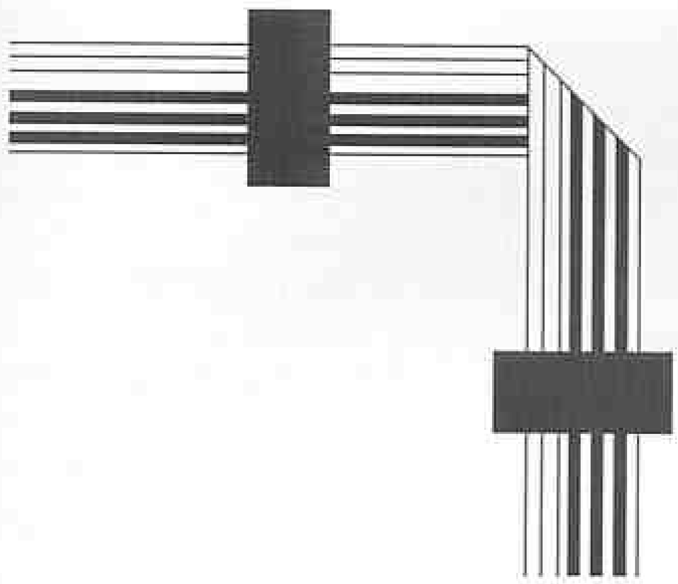


Fig. 7.29 *Folding cable at a change of direction* MODULINE

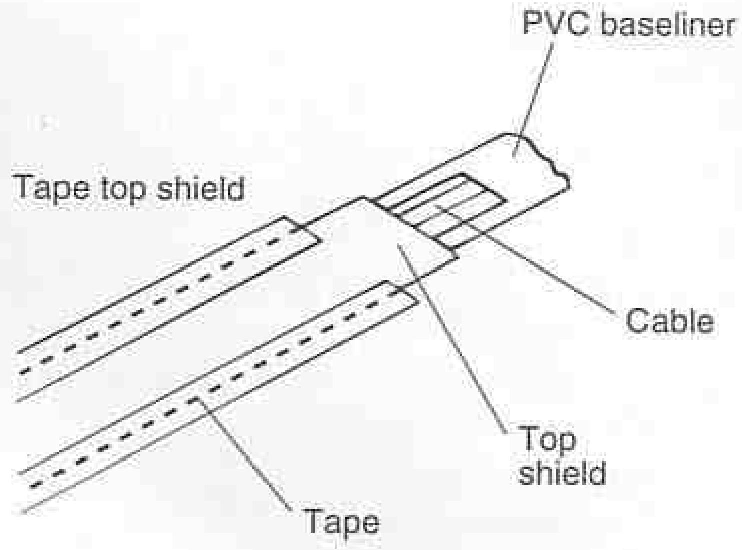


Fig. 7.30 *Taping to exclude dirt and grit* MODULINE

shown) are provided for telephone and data terminations.

The metal top shield is installed after each segment of cable installation is complete. At each change of direction and at joints in the shield, the special crimping tool is used to ensure earth continuity. Because the shield provides continuous earthed protection over the cable, it is essential that the earth connections are properly made at each transition device, including those at floor outlets.

In order to exclude dirt and grit from the finished shield and cable run, both edges of the top shield are taped to the floor, the tape centre being positioned in line with the shield edge (see Fig. 7.30).

Where an undercarpet wiring run is to be connected to standard cables in a skirting trunk, such as the one illustrated in Figure 7.11, the normal transition device is used in conjunction with special fittings obtainable from the cable supplier. The procedure is straightforward provided that the manufacturer's instructions are followed.

SUMMARY

- Factors to be considered in selecting a particular cable system are: the type of building structure; appearance of the completed installation; ambient temperature; mechanical hazards that may damage the wiring; hazards associated with the environment and initial and ongoing cost of the installation.
- The advantages of open wiring are:
  - the lower cost than sheathed or enclosed systems, and
  - that the whole system is readily accessible for repairs, maintenance, alterations and the like.
- The disadvantages are:
  - its poor appearance, and
  - that the system occupies more space than other systems.
- Insulated conductors used as an open-wiring system are installed to comply with *Clause 3.18*.
- Bare conductors installed as open wiring must comply with *Clause 3.17*, and are usually limited to use as collector wires for cranes and trains, busbar wiring on switchboards, substations and extra-low-voltage applications such as electroplating installations.
- Bare or insulated conductors supported above the ground are classed as aerial conductors (*Clauses 0.5.5* and *0.5.6*).
- The major part of the electricity supply and distribution system is by bare aerial conductors.
- Aerial wiring systems must comply with the requirements of *Clause 3.14*, while *Appendix D* provides aerial line data for determining pole or post size, span length and clearances.
- Low-voltage aerials are terminated using shackle-type insulators (see Figs 7.5 and 7.7).
- Cable supported by a catenary wire must have stranded conductors, be double-insulated, and if installed outside must be a type suitable for exposure to direct sunlight (refer to *Clause 3.15*).
- A catenary wire must not be less than 7/1.25 hard-drawn copper or galvanised mild steel.
- 'Cable trunking' is an enclosure for housing and protecting electrical cables and conductors (*Clause 0.5.94*).
- Trunking systems are manufactured in a range of designs, including:
  - metal and PVC trunking with removable lids for installation overhead and wall mounting, and
  - metal trunking with compartments for segragation of power, telecommunications and other systems, and for incorporation into the building structure and finishings. These include systems designed for skirting and office partition troughing, service columns used in conjunction with office partitioning, and underfloor troughing systems.
- Cable trunking must be installed to comply with *Clause 3.31*.
- Perforated cable tray and ladder systems are used to support sheathed cables in commercial and industrial installations.
- A cable 'duct' is a closed passage formed underground or in a structure into which cables are drawn.
- A pipe of 75 mm diameter or greater is classified as a duct (*Clause 0.5.40*).
- Busway systems:
  - consist of solid copper or aluminium conductors supported by barriers at intervals in a formed duct or trunk;

- are used for distribution to high-demand concentrated loads such as machines in a manufacturing plant, reducing the number of distribution boards and submains, or as unmetered mains and rising mains in commercial installations;
- are provided with plug-in take-off boxes incorporating fuses or circuit breakers for supplying each outgoing circuit;
- must comply with AS 3439.2—1994 and be installed to comply with *Clause 3.32* of AS 3000.

- Track and flat cable assemblies:
  - consist of manufactured channels or modules with take-off plugs similar to busway systems;
  - are not suitable for supplies higher than low-voltage.
- Track systems are confined to low- and extra-low-voltage lighting applications, and must be installed to comply with *Clause 3.34.*
- Flat cable assemblies can be used to supply low-voltage equipment, and must be installed to comply with *Clause 3.33.*
- Underground wiring systems are used extensively by energy distributors for distribution in densely populated areas of cities and housing estates.
- Underground wiring systems are classified in categories A, B and C, each of which specify a selection of cable types that may be used with particular enclosures, the minimum depth at which the cable must be laid, and additional protection requirements.
- Underground wiring systems must be installed to comply with *Clause 3.16.*
- Undercarpet wiring is a complete system of cable assembly and accessories, and may be used only for final subcircuits in non-domestic installations under carpet tiles having a maximum size of 1 m × 1 m.
- It has the advantage of:
  - eliminating floor chasing and drilling and thus maintaining floor fire ratings and structural strength, and
  - being easy to install; no special tools are required for termination.
- Undercarpet wiring must be installed to manufacturer's instructions and to comply with *Clause 3.36.*

REVIEW QUESTIONS

Where the answer to a review question is numerical or requires reference to the SAA Wiring Rules, *the answer is given at the back of the book. These questions are marked ★.*

★ **1.** What do you understand by the term 'electrical installation'?

2. What is implied by the term 'wiring system'?

3. In what manner does ambient temperature affect the choice of a wiring system?

4. List some environmental situations that would require special wiring systems.

5. When choosing a wiring system, what economic factors must be considered?

6. What type of wiring system would you consider to be unsuitable for the electrical installation in a church? Give reasons.

7. Give an example of a situation where bare conductors on insulators would be a suitable wiring system.

★ **8.** What are the differences between a cable duct and a cable trunk?

★ **9.** Is aerial wiring covered by the same Rules as those relating to bare conductors run as open wiring?

★**10.** Would an open-wiring system be permissible in a theatre if kept at a height exceeding 4.5 m from the floor?

★**11.** State a wiring situation in which cable trunking should not be installed.

★**12.** May electrical accessories be attached direct to a cable trunk?

13. Provision is made, in many types of cable trunk, for the inclusion of telephone, signalling, radio, communications and other circuit wiring. How is this achieved?

★**14.** What distinguishes a busway system from a cable trunking system?

15. Name two types of underfloor cable duct systems used in large concrete buildings.

16. State one suitable application for a busway system.

★**17.** Are all parts of a bathroom classed as being in a damp situation?

★**18.** The easiest and most direct route for a run of 25 mm heavy-duty PVC conduit is through a controlled-atmosphere room operating at a temperature of −18°C. Is this permissible?

★**19.** Is a standard batten-type fluorescent luminaire permitted in a coolroom?

20. State two suitable types of multicore aerial cable that are available for service lines.

★**21.** What is the minimum depth in the ground for:
(a) a category A system beneath a roadway?
(b) a category B system beneath a concrete path?

22. State the designation and colour of thermoplastic rigid conduit suitable as a category A enclosure.

★**23.** If terracotta pipe is used as an enclosure for underground wiring, what type of added mechanical protection must be provided?

★**24.** What restrictions are placed on the installation of undercarpet wiring?

★**25.** Is it permissible to use a single run of five-core undercarpet cable to supply two circuits?

26. At what stage of building construction is undercarpet wiring normally installed?

8

TPS wiring systems

In this chapter you will learn about thermoplastic-sheathed (TPS) wiring systems, including:

- characteristics of TPS wiring systems
- basic TPS circuit wiring techniques
- installing methods and requirements
- prefabricated loom-wiring systems.

8.1 Introduction

PVC-insulated PVC-sheathed cables, commonly known as TPS (thermoplastic-sheathed) cables, form the basis of the most widely used wiring system in domestic and commercial premises. This chapter describes the features of TPS wiring and installation practices that help to ensure that the wiring is installed efficiently and that the installation complies with the regulations.

8.2 Characteristics of TPS wiring systems

Both tough rubber-sheathed (TRS) and TPS cables, when used with all-insulated accessories, form a double-insulated wiring system (see *Clause 0.5.58*).

In situations where mechanical damage was not a hazard, the old lead-sheathed cables and plain conduit wiring were first superseded by TRS cable and later, after the development of plastics, by TPS cable. The latter wiring system is now perhaps the most popular system for use in domestic installations, and it is widely used in factory and commercial installations, where both flat and circular TPS cable is often employed. The installation of TRS and TPS cables is covered by *Clause 3.20*, with cross-references.

The main reasons for the current popularity and widespread use of the TPS wiring system, compared with most other systems, are:

- It is quickly and easily installed for surface work.
- Its use as a concealed wiring system is even more convenient and labour-saving.
- If used with all-insulated accessories, it forms a complete double-insulated system.
- Mainly due to the above advantages, its installation cost is usually less than that of other systems.

TPS cable is available with or without an earthing conductor enclosed in the same sheath as the other circuit conductors. Cable with an enclosed earthing conductor simplifies the installation of circuits such as general-purpose outlets (GPOs) in parallel, light outlets, motors and other equipment required to be earthed.

TPS cable does, however, have some disadvantages; for example, it is prone to mechanical damage during installation if not handled carefully, it may be subject to damage by rodents, and it must be protected against mechanical damage in some situations. It is also unsuitable for use in a 'draw-in' system similar to single PVC-insulated cables in conduit.

The PVC sheath is chemically inert to most environments, and only those chemicals listed in section 9.4, Chapter 9, for PVC conduits are deleterious. Note also that an electrician must always be alert for any environment that is suspect; be cautious and consult the manufacturer if in doubt regarding a particular application.

Applications include underground wiring, if suitably protected; and because the cable is classed as being 'weatherproof' it may be used in certain situations external to buildings or run as catenary wiring inside or outside buildings.

TPS cable exposed to direct sunlight should preferably be sheathed with a material that has been stabilised against the effects of ultraviolet rays.

Characteristics of a double-insulated fire-rated cable are described in some detail in Chapter 10.

8.3 Basic TPS wiring techniques

The loop-in type of wiring circuit is the one most used, and modern ceiling roses, batten holders and switches have one or more looping terminals provided for this purpose. A system where active and neutral feeds loop from accessories instead of junction boxes is preferable throughout, but sometimes junction boxes are necessary or economical, or are installed to permit later extensions.

At this point you should refer to Chapter 6, in which circuits for 'looping in' are illustrated. Figures 6.7 and 6.8 represent the two most common methods used in TPS wiring of lighting circuits, and the method of Figure 6.7 is the one used in conjunction with the wiring layout shown in Figure 8.1.

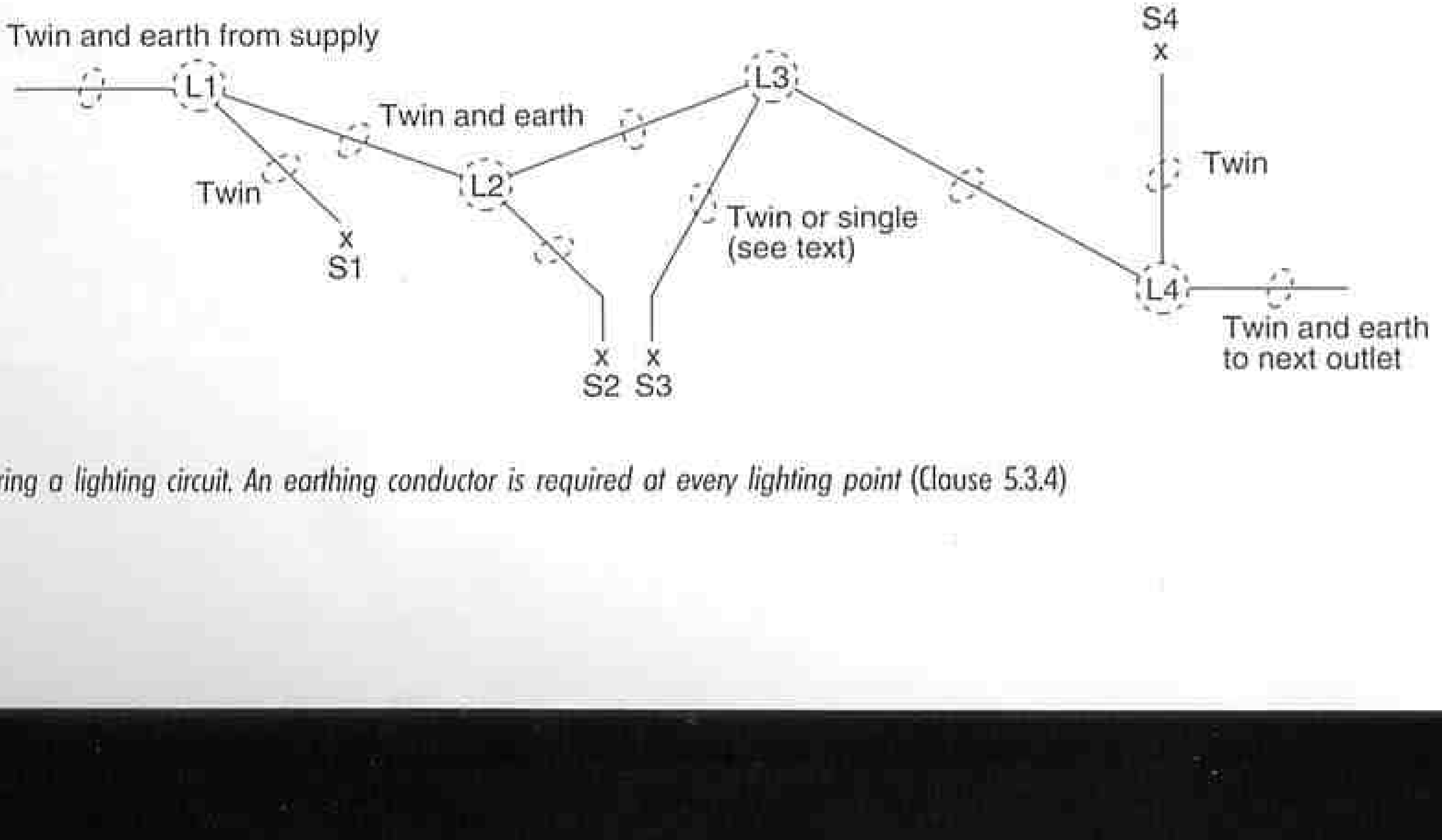


Fig. 8.1 *Wiring a lighting circuit. An earthing conductor is required at every lighting point* (Clause 5.3.4)

Twin and earth 1 mm^2 cable is looped between light outlets, and twin cable is used from the light outlet to the switch position. The cables need not be specially marked for identification when connecting up, as the switch run is the only two-core cable used.

The adjacent switches S2 and S3 of Figure 8.1 could be connected by two 1 mm^2 two-core cables, as shown in Figure 8.2(a), or by a two-core and a single-core cable, as shown in Figure 8.2(b).

Where looping is done from switch to switch, the method indicated by Figure 6.8 of Chapter 6 may be applied. Alternatively, twin and earth cable may be used throughout the circuit to maintain the required earth at every lighting point, as shown in Figure 8.3. In this case, the twin and earth cable from each switch to the light that it controls will need to be identified.

Basic circuits illustrated may be used for either surface or concealed work, with variations to suit the type of building construction and other wiring conditions.

Three-core and three-core with earth are popular cables for wiring three-phase motor circuits where the TPS system of wiring is being used.

8.4 Installing TPS cables

The general approach to the installation of a TPS wiring system has commonsense rules similar to those for other systems; that is:

1. Cable runs should be planned for speedy installation and the economical use of material. Appearance will also be a factor in surface work.

   The usual fixing accessories for TPS cable are pin clips of soft brass in four sizes, suitable for

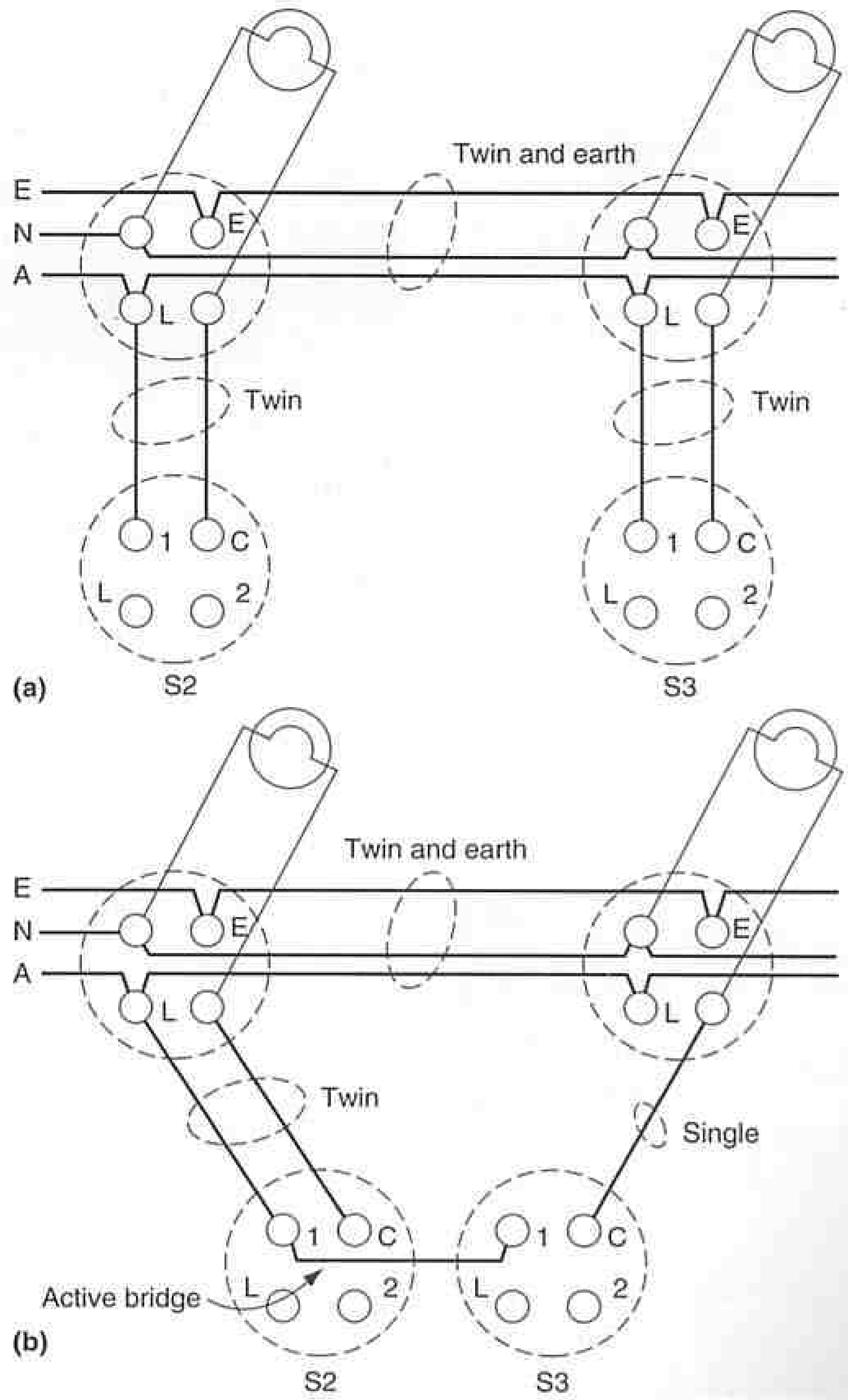


Fig. 8.2 *Two methods of wiring using looping at lights:* **(a)** *where switches are apart;* **(b)** *where switches are adjacent*

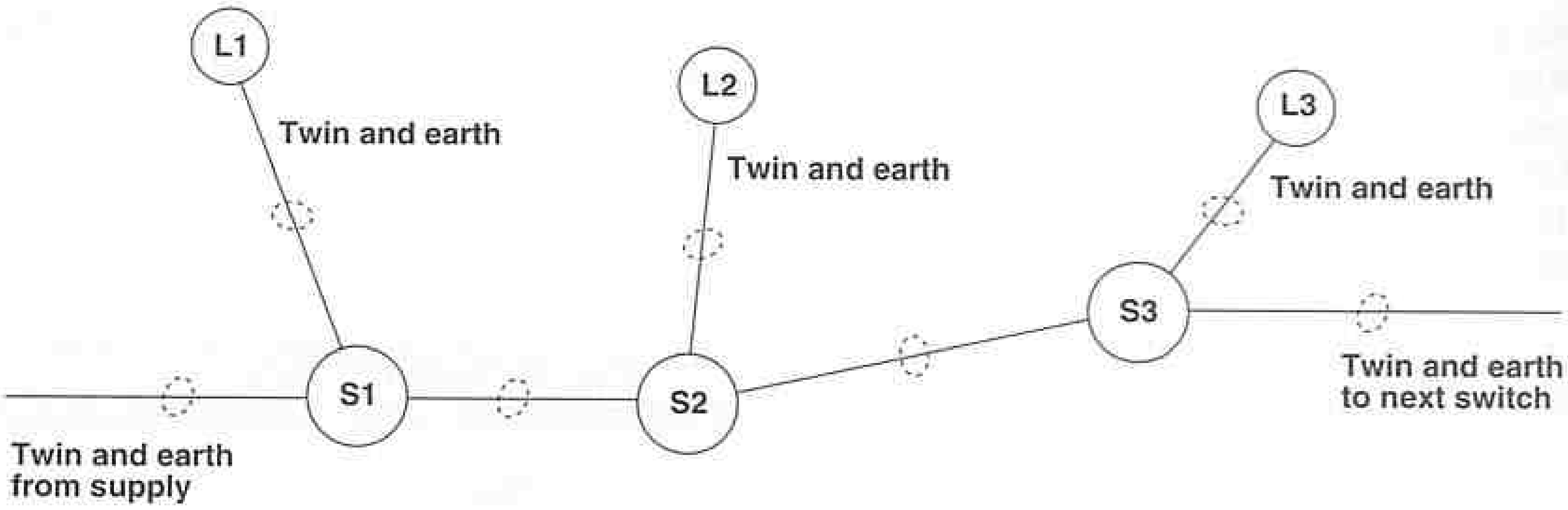


Fig. 8.3 *Wiring a lighting circuit looping at switches*

different cable sizes (aluminium clips also are made for special purposes), plastic cable clips as shown in Figure 8.4(b) and nylon cable ties (see *Clause 3.20.3.6* 'Means of fixing').

2. If the wiring is on the surface, installed in a position where it is likely to be disturbed (*Clause 3.20.3.2*), and metal pin clips are to be used, these may be installed in short sections and the cable then clipped in, making sure that it is installed with no sharp twists or bends in the cable run. Alternatively, the more commonly used plastic cable clips or other fixings, such as cable ties, may be used. It is usually best practice to use metal pin clips on long runs, where you can install the clips for the whole run prior to fixing the cable. This reduces the risk of damage to the cables, which is more likely when they are installed and fixed at the same time.

   With concealed wiring, any fixing necessary is done as the cable is placed in position.
3. When all the cables are fixed and secure, and the wiring into equipment is complete, the final connections are made at junction boxes, switchboards and equipment, and the installation is prepared ready for service.
4. Before the system is put into service, final testing is carried out.

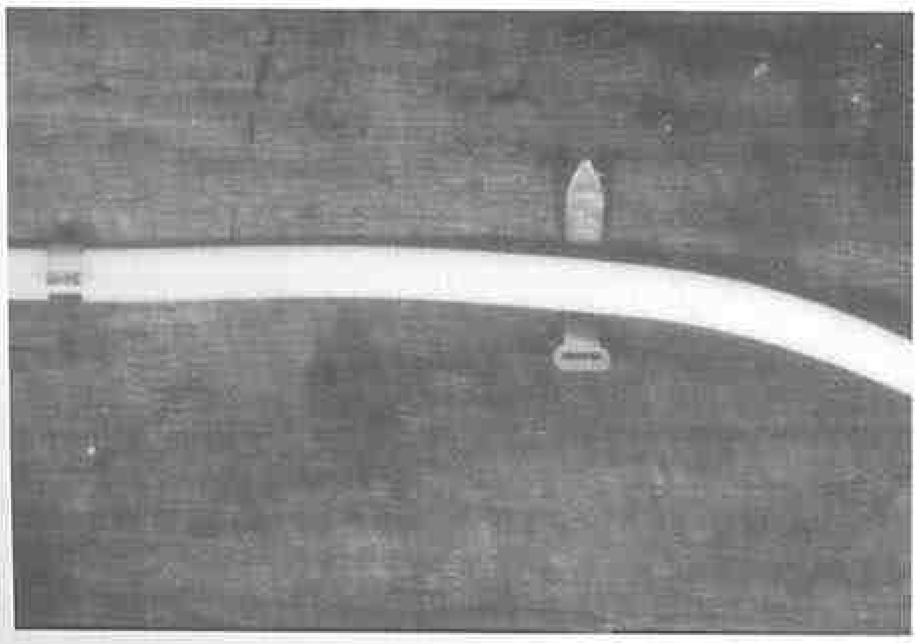


Fig. 8.4(a) *Metal pin clips for TPS cable* UTILUX

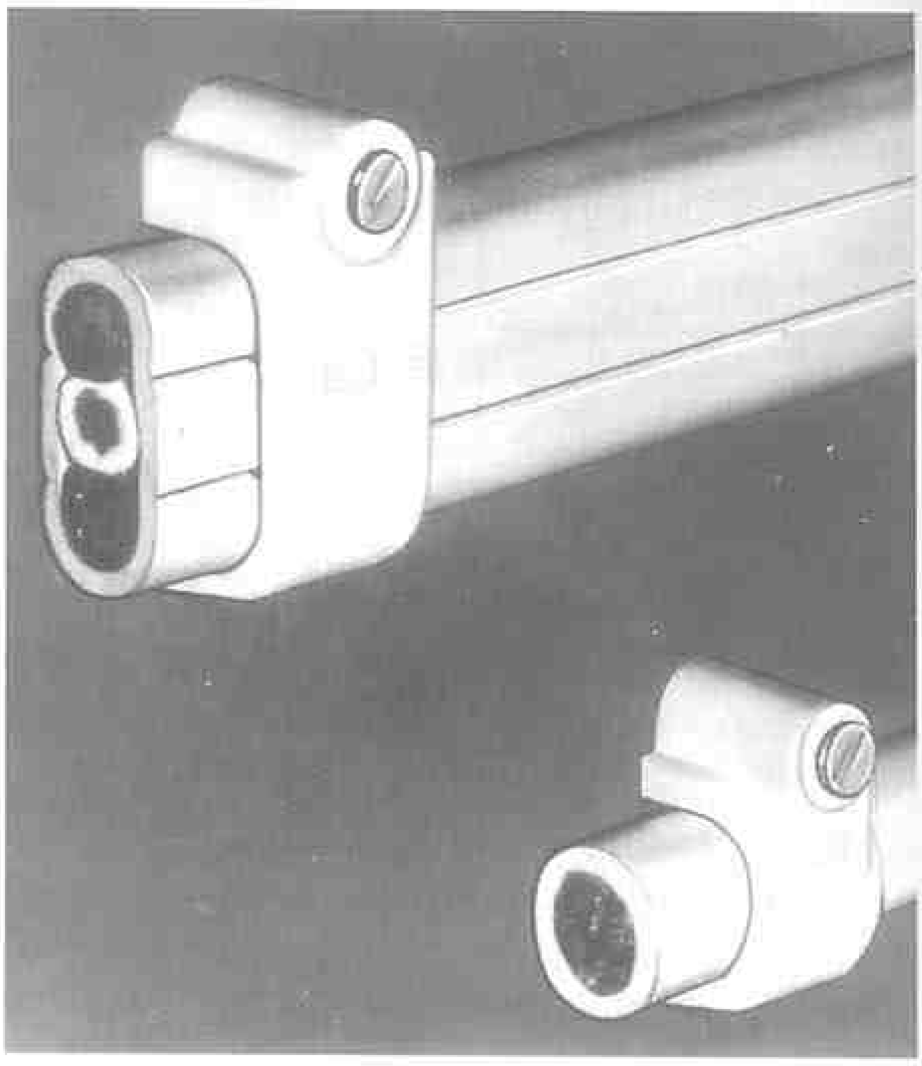


Fig. 8.4(b) *Plastic clips for TPS cable* SPINAWAY CABLES

Although essentially a surface system, TPS wiring may be concealed in roof spaces or cavities or between a floor and an uppermost ceiling. Unless protected mechanically by a suitable enclosure, it must not be buried in concrete, but it may be buried in cement or plaster for vertical runs not exceeding 3 m in length above or below the accessory being supplied in the same room (refer to *Clause 3.20.2.1(b)(ii)*).

One factor to be considered when installing TPS cable is that the current-carrying capacity of a cable is influenced by environmental conditions, such as ambient temperature and ventilation. The effects of surrounding or partially surrounding the cable with thermal insulation may also need to be considered. Other factors dependent on the method of installation of the cable and directly affecting the current rating of the cable are:

- the number of circuits

- whether single-core or multicore cable is used
- the type of enclosure
- the spacing between cables, circuits and the wall or adjacent surface
- whether the cable is run vertically or horizontally.

Figure 8.5(a) shows circular non-armoured, PVC-insulated, PVC-sheathed cables installed on a vertical cable-support system in groups; their current-carrying capacity would be considerably increased if they were spaced further apart (see *Para. B4.3.2(f)* of AS 3000). Construction of this type of TPS cable is shown in Figure 4.11, and circular steel-wire-armoured, PVC-insulated, PVC-sheathed cable is illustrated in Figure 4.7 of Chapter 4.

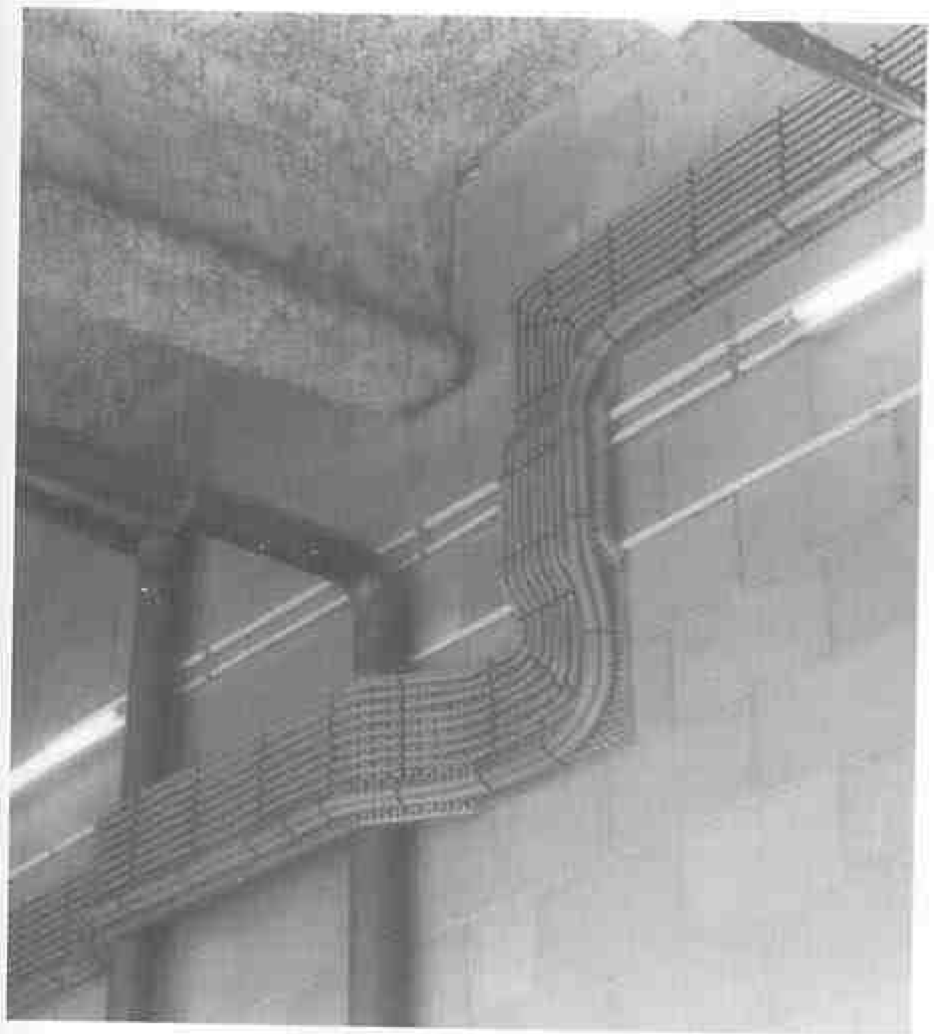


Fig. 8.5(a) *Cables installed in groups. Mutual heating reduces current-carrying capacity of cables*

Fig. 8.5(b) *Cables positioned clear of thermal insulation and to avoid the effects of mutual heating, with consequent derating of current-carrying capacity*

The four circuits in the background of Figure 8.5(b) have been installed to avoid the effects of mutual heating and positioned so that they will not be surrounded or partially surrounded by thermal insulation. Refer to Chapter 16, Volume 2, for a discussion of the selection of suitably rated cables and the use of the tables of AS 3000 and AS/NZS 3008.1.1.

For surface work, or where the cable is **likely to be disturbed**, the maximum distance between fixing is 0.3 m, or twenty times the smaller diameter of the cable, whichever is the greater (see *Clause 3.20.3.2*). Figure 8.6 shows cables installed in a garage without a ceiling.

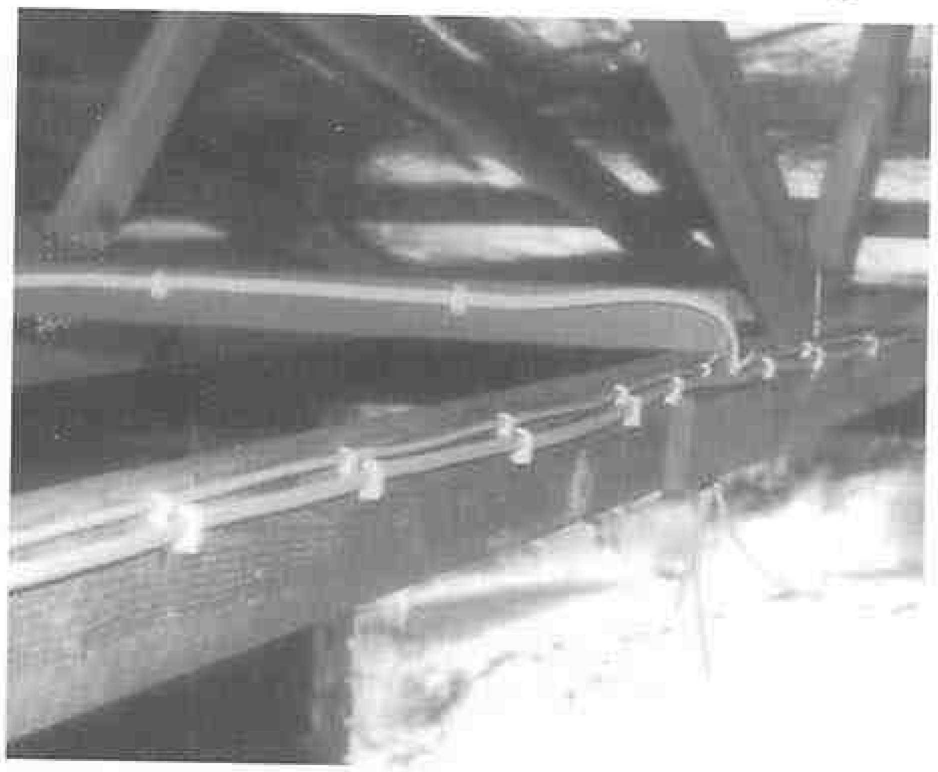


Fig. 8.6 *Cables 'likely to be disturbed'*

If the cable is installed in a ceiling space having an access space exceeding 0.6 m in height, it must be fixed so as to prevent appreciable sagging of the cable, typically fixed at maximum intervals of 1.2 m. This fixing is not required if the cable is laid on a continuous horizontal surface on which a person may not stand, such as the ceiling of Figure 8.8(c). Where TPS cables cross the tops of ceiling joists or other structural members, mechanical protection, say in the form of wooden battens, must be provided.

All the wiring runs in Figure 8.7 and some in Figure 8.8 are in positions **not likely to be disturbed**. No fixing is required if the cables are laid on a continuous horizontal surface; otherwise, support (not necessarily fixing) is required at intervals not exceeding 2 m.

The wiring installed in the suspended ceiling of Figure 8.7(d) is considered to be in a position 'not likely to be disturbed'. The reason for this is that, in practice, the ceiling modules are removed only on rare occasions, to enable access for plumbing or electrical repairs or modifications. Refer to *Ruling C.739/91* to *Clause 3.20.3.3* in *Doc. 3000 R/1—1991, Rulings to SAA*

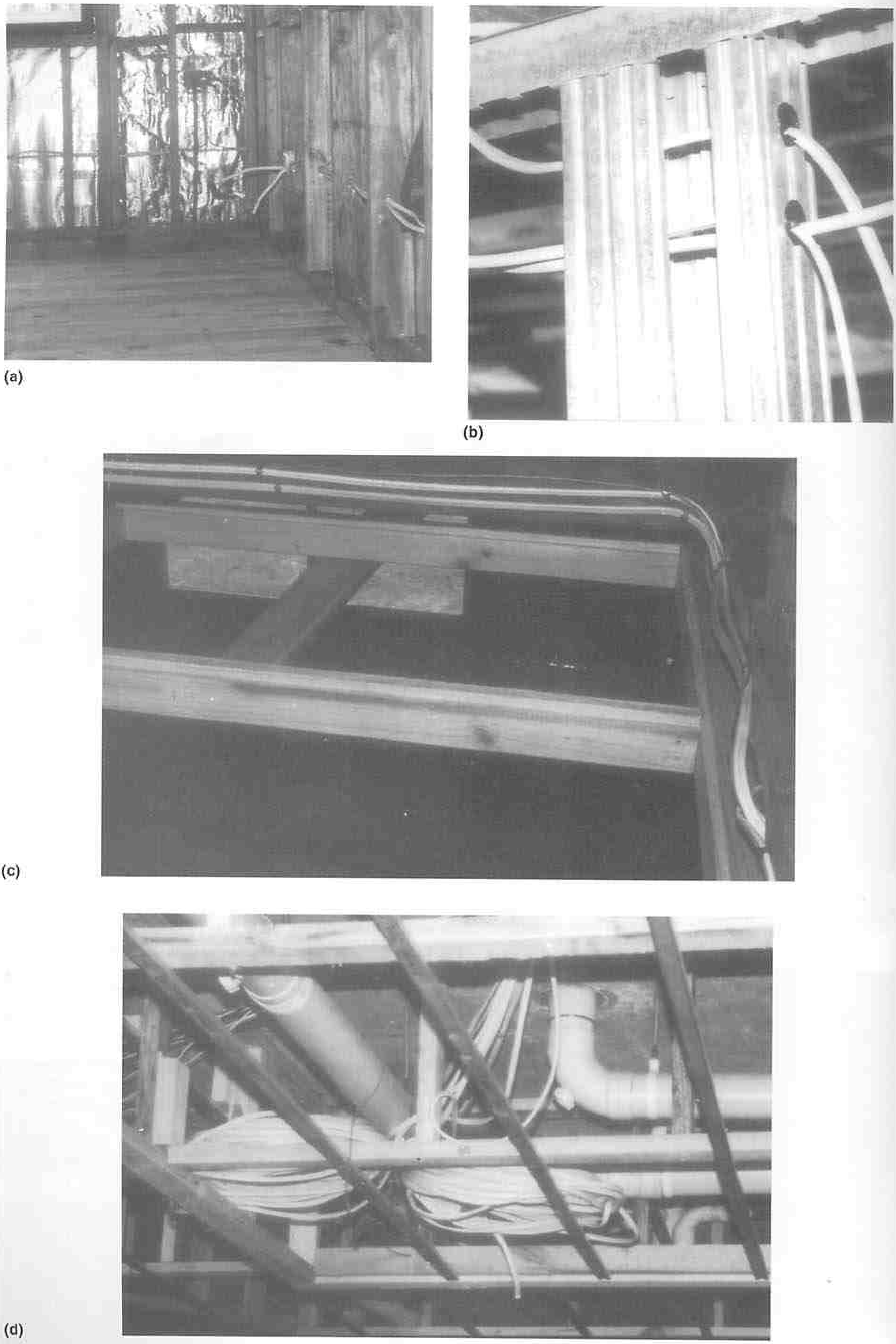


Fig. 8.7 *Methods of installing TPS cables 'not likely to be disturbed':* **(a)** *through or in the space between wall studs;* **(b)** *through grommets provided in steel-framed walls;* **(c)** *on timber work in a ceiling;* **(d)** *in a suspended ceiling*

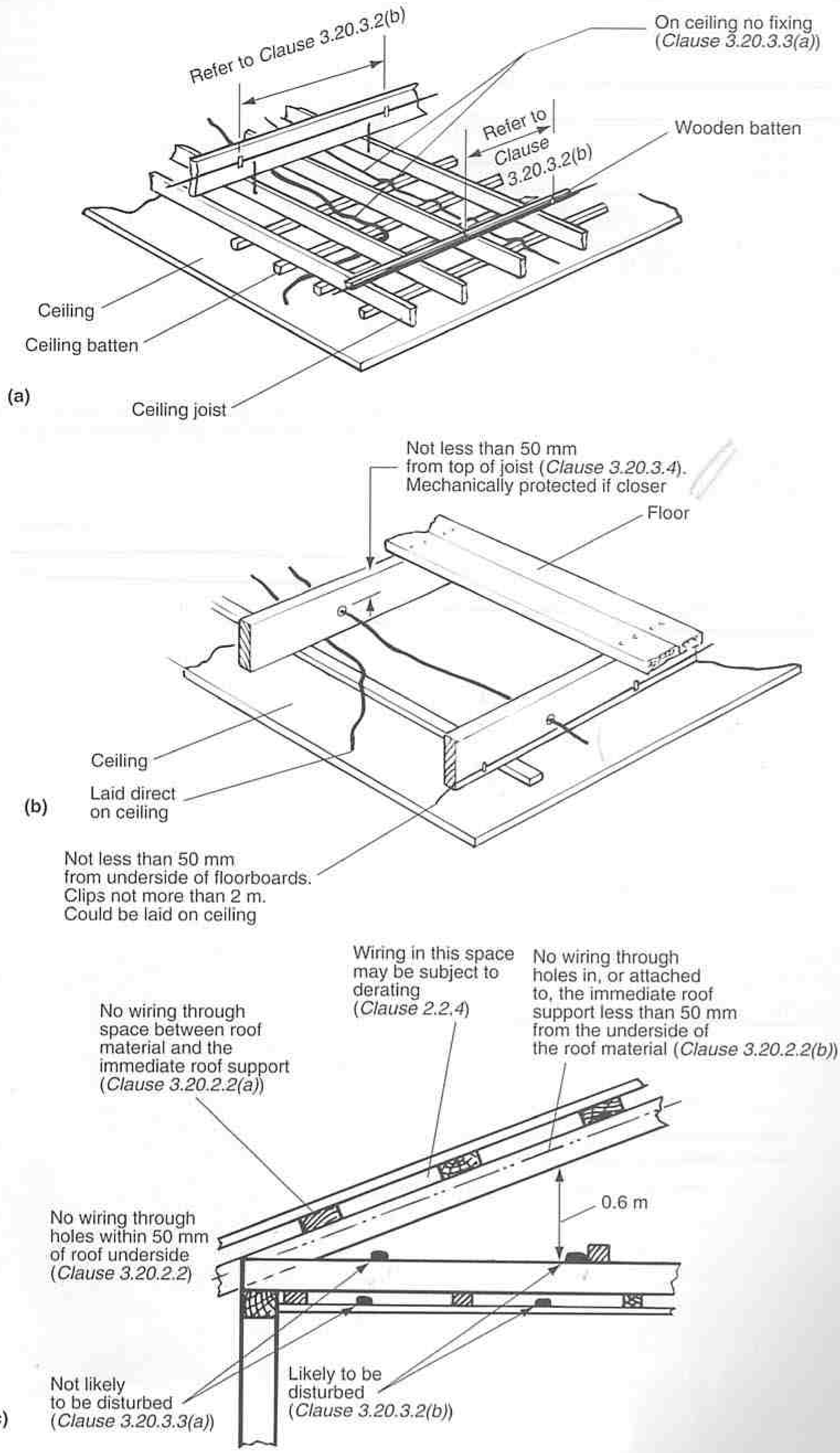


Fig. 8.8 *TPS wiring:* **(a)** *in a ceiling space;* **(b)** *between a floor and an uppermost ceiling;* **(c)** *between ceiling and roof*

Wiring Rules (AS 3000—1991). This document is published by and obtainable from Standards Australia.

Where wiring is installed in the space between the roofing material and the rafter of Figure 8.8(c), it may be subject to derating (see *Clause 2.2.4*). When the temperature in this space is not known (the usual scenario), V75 cable may be treated as if it were partially surrounded by thermal insulation (see *Ruling C.706/91* to *Clause 2.2.2* for further details). Cable ratings are treated in Chapter 16 of Volume 2.

Another case of 'cables not likely to be disturbed' is shown in Figure 8.9, where the cable is supported on wall ties; alternatively, it could have been laid on the wire vermin barrier at the bottom of the cavity wall. Using wall ties to support cables is not permitted in Victoria. In any case, taking the cable through, say, every third stud is good practice. This avoids cable touching the outside wall, and the risk of moisture transmission to inside cladding. The cable clip on the right-hand stud has been used to provide the necessary segregation of the telephone wiring from the power wiring.

Refer to *Clause 3.20.3.3*, and note the requirement for fixing intervals of 7.5 m for unarmoured and 3 m for armoured sheathed cables, in the case of cables installed vertically. Note also the provisions of *Clause 3.20.3.5* to prevent excess mechanical pressure on the cable where there is a change of direction.

Consider too the precautions to be adopted, as outlined in *Clause 3.20.3.4*, for installation of the cable when it is run, for example, in the space between the floor of one storey and the ceiling of the storey below. Again the precautions are against mechanical damage to the cable, due to traffic on the floor or to nails used in the fixing of flooring.

Some spaces in which the installation of TPS wiring is restricted are included in Figure 8.8(c).

Because TPS cable is considered to be weatherproof, it may be installed on the exterior of a building, provided that it is protected from mechanical damage by virtue of its height or position (see *Clause 3.20.2.2*). Manufacturers of TPS cable do not recommend white or coloured sheathing for exterior work; they recommend sheathing material that has been stabilised against the effects of ultraviolet rays.

The installation of TPS cable using catenary support and its use underground are dealt with in sections 7.3 and 7.6 respectively of Chapter 7.

8.5 Loom-wiring systems

Loom wiring

This is a system in which the TPS cables are installed in the space between the underside of a concrete floor slab or roof structure and a false or suspended ceiling, for the supply of plug-in lighting units. One system utilises the socket outlet illustrated in Figure 8.10, which is fixed to the underside of the floor slab or beam at each preselected lighting position.

At floor level the cable is cut to correspond with the intervals between socket outlet positions, and the ends are then prepared and connected to the socket outlets. Thus the whole of the wiring loom or 'harness', including switch drops where required, is made up at floor level with considerable saving of labour. Material is also saved, as the cable 'tails' usually left at each accessory position in an in-situ installation are eliminated.

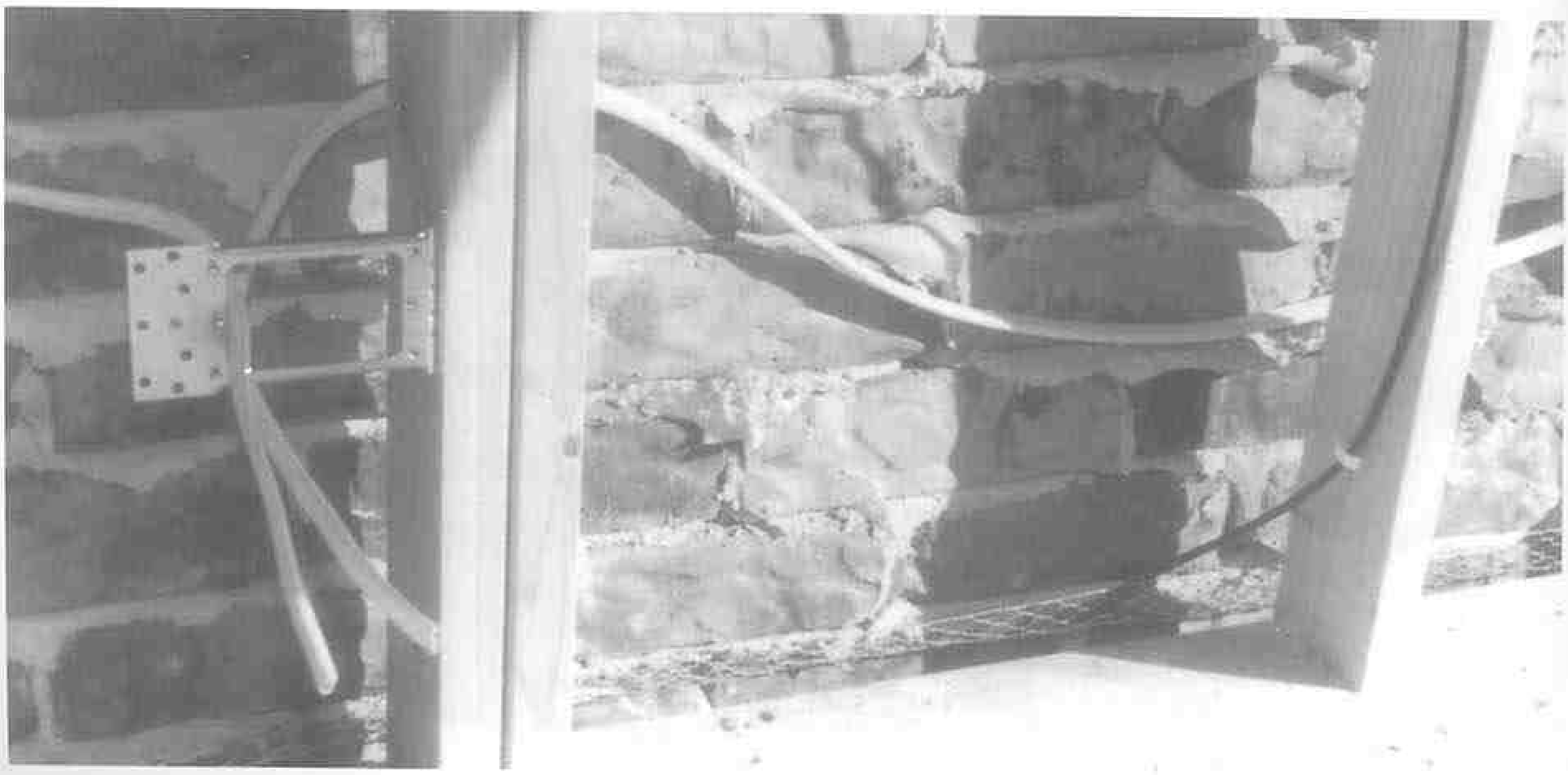


Fig. 8.9 *Cables supported on wall ties (not permitted in Victoria)*

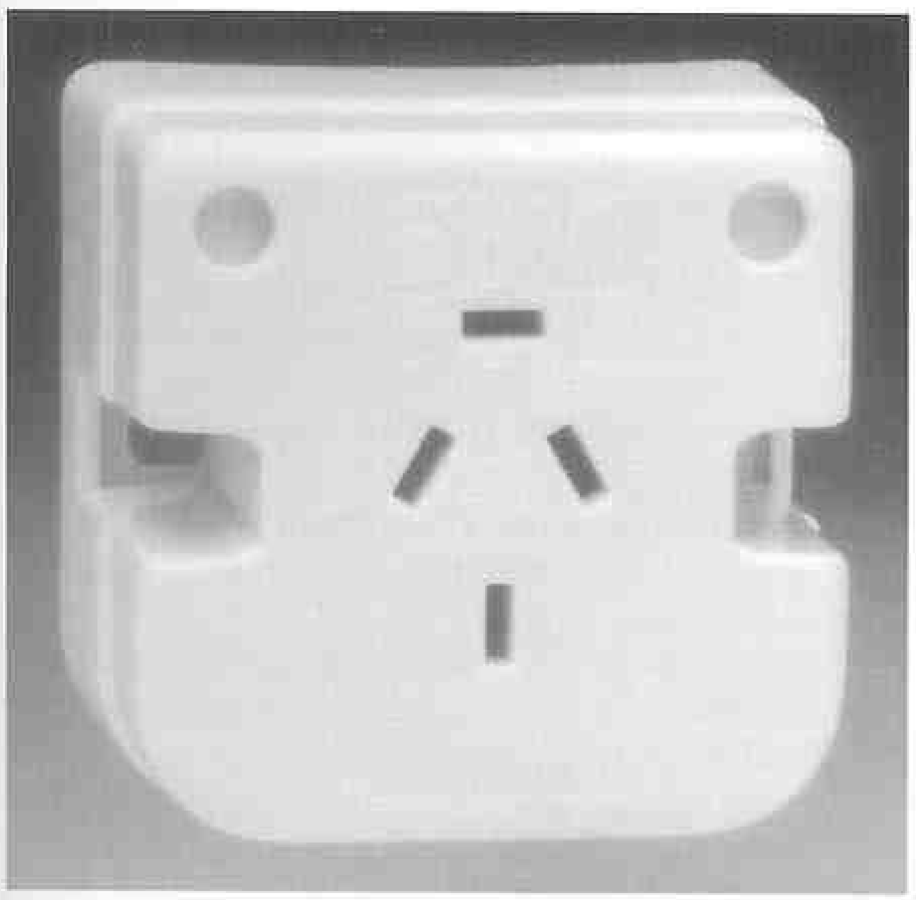


Fig. 8.10 *Four-pin socket outlet designed for loom-wiring system*

After the complete harness is made up, it is lifted into position and the socket outlets are mounted at their preselected positions in the false ceiling. Any switch drops are then run to the preselected switch positions and the luminaires installed and plugged in.

Typical commercial loom-wiring system

HPM Industries manufactures four-pin plugs and socket outlets (see Fig. 8.10) intended for use with a four- or five-wire loom for commercial lighting, including emergency lighting, and for dimming fluorescent luminaires. They may also be used in a system designed to reduce lighting levels by switching selected lamps in a luminaire. For example, a five-wire loom may be used in conjunction with four-pin socket outlets and a three-lamp luminaire; one lamp may be left on continuously and the other two switched on when required. Circuits for this and other applications are available from the manufacturer, which describes the wiring arrangements used with its products as a 'smart system'. Some typical circuits are shown in Figure 8.11.

Note that the plug base of Figure 8.10 is also available as a twin-socket outlet, and that both may be used with a normal three-pin plug if required.

TPS systems are thus seen to be popular to the extent that they have virtually replaced many older types of wiring. Systems using TPS wiring harnesses indicate a modern approach to both reducing labour costs and conserving material, with the advantage of a flexible system for repairs, alterations or additions. Accordingly, TPS loom-wiring systems are finding many applications, mainly in commercial buildings.

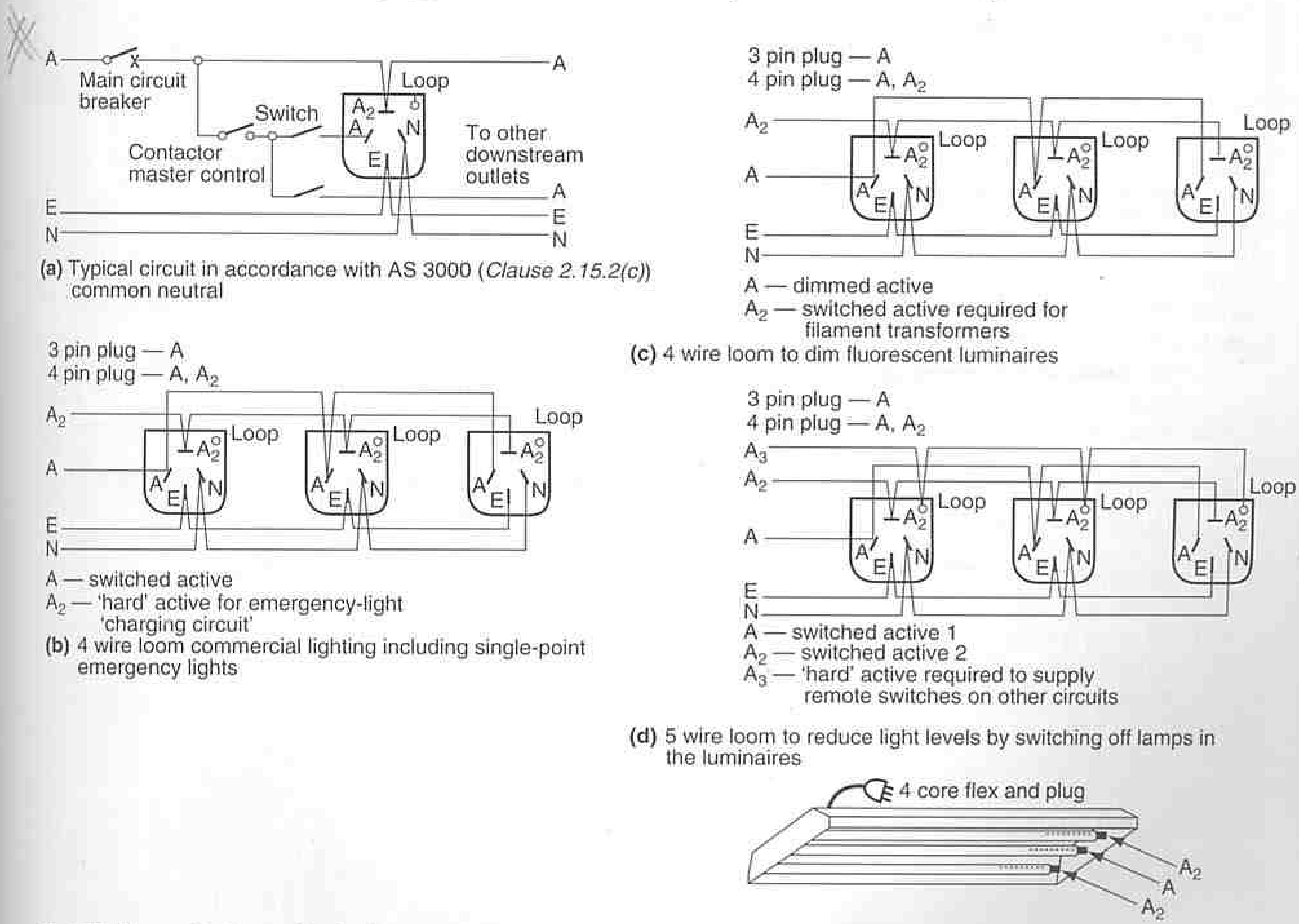


Fig. 8.11 *Some typical loom-wiring circuits* HPM INDUSTRIES

SUMMARY

- Thermoplastic-sheathed (TPS) wiring is the most commonly used wiring system in domestic and commercial installations.
- Advantages of TPS wiring systems are:
  - They are easy to install.
  - They can be used as concealed wiring.
  - They can be used with all-insulated accessories, forming a double-insulated system.
  - They cost less than other systems.
- Disadvantages of TPS wiring systems are:
  - They are prone to mechanical damage during installation if not handled carefully.
  - They are subject to damage by rodents.
  - They must be protected against mechanical damage, which restricts their use.
- TPS cables are used in loop-in-type wiring circuits, with most accessories supplied with looping terminals, eliminating the need for junction boxes.
- A typical TPS loop-in circuit is a twin and earth 1 mm^2 cable, looped between each light point; a twin cable is installed from the light points to the switch position.
- Three-core and three-core-and-earth TPS cables are used for three-phase motor circuits.
- The general installation approach is:
  - Plan cable runs.
  - Where necessary (*Clause 3.20.3.2*), cables are fixed with metal pin clips, plastic cable clips or nylon cable ties.
  - For surface wiring likely to be disturbed, metal pin clips may be installed in short sections. Alternatively, plastic cable clips or other fixings may be used.
  - On long runs, where fixing is required, it is better practice to install pin clips for the whole run before fixing the cables.
  - Once cables are fixed and secure and the wiring into equipment is complete, all final connections are made.
  - The completed wiring is then tested before being put into service (refer to Chapter 11 for the tests required and how to test).
- TPS cabling may be concealed in roof spaces and wall cavities.
- The cable must be protected from mechanical damage by a suitable enclosure.
- Burying the cable directly in concrete is prohibited, and there are restrictions on burying the cable in cement and plaster (*Clause 3.20.2*).
- The current-carrying capacity of the cable will be affected by the installation method and environmental conditions (*Paras B4.2 and B4.3* of AS 3000).
- Loom wiring is a system in which TPS cables are installed in the space between the underside of a concrete slab or roof structure and a false ceiling, for the supply of plug-in lighting units.
- The wiring loom or 'harness' is made up at floor level, then fixed into position. This results in considerable savings in labour and materials.
- Four- and five-wire looms are used where emergency lighting, dimming of fluorescent luminaires or selective switching is required. Special plugs and socket outlets are available for this purpose (see Fig. 8.11 for typical circuit arrangements).

REVIEW QUESTIONS

Where the answer to a review question is numerical or requires reference to the SAA Wiring Rules, *the answer is given at the back of the book. These questions are marked* ★.

★ **1.** Could a section of thermoplastic-sheathed (TPS) cable be installed along a wooden skirting board? Give reasons for your answer.

★ **2.** What is the maximum distance specified for fixing TPS cables where they are used for surface wiring?

★ **3.** A TPS cable is to be dropped a vertical distance of 11 m in a cavity. What provisions are necessary for:
(a) support of the cable weight in the vertical drop?
(b) prevention of mechanical damage where cable is run over a sharp brick on the cavity edge?

★ **4.** TPS wiring is to be run across ceiling joists in an accessible ceiling space. What measures should be taken for mechanical protection of the cables?

★ **5.** Is it permissible to bury TPS cable in:
(a) a concrete floor?
(b) a cement-rendered wall?
(c) a floated plaster wall?

6. State some applications for TPS cable.

7. What circumstances would warrant the use of cable trays as a cable support system?

★ **8.** Name two positions in a roof space where TPS wiring is prohibited.

9. State four distinct advantages of TPS systems.

10. State three disadvantages of TPS systems.

11. What are three chemicals that could affect the PVC sheath of TPS cable?

12. State the recommended sheath type for TPS cable exposed on the exterior of a building.

13. Where is loom wiring used?