UNIT 2

Electrical Symbols and Outlets

OBJECTIVES

After studying this unit, the student will able to

- identify and explain the electrical outlet symbols used in the plans of the single-family dwelling.
- discuss the types of outlets, boxes, fixtures, and switches used in the residence.
- explain the methods of mounting the various electrical devices used in the residence.
- understand the meaning of the terms *receptacle outlet* and *lighting outlet.*
- understand the preferred way to position receptacles in wall boxes.
- position wall boxes in relation to finished wall surfaces.
- make surface extensions from concealed wiring.
- determine the number of wires permitted in a given size box.

ELECTRICAL SYMBOLS

Electrical symbols used on an architectural plan show the location and type of electrical device required. A typical electrical installation as taken from a plan is shown in Fig. 2–1.

The *C.E.C., Part I* defines an *outlet* as a point on a wiring system where current is taken to supply utilization equipment.

A receptacle outlet is an outlet where one or more receptacles are installed (Fig. 2–2).

A lighting outlet is "an outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder" (Fig. 2–3).

A toggle switch is *not* an outlet, however, the term *outlet* is used broadly by electricians to include noncurrent-consuming switches and similar control devices in a wiring system when estimating the cost of the installation. Each type of outlet is represented on the plans as a symbol.

In Fig. 2–1 the outlets are shown by the symbols ⊖ and ⊹. The standard electrical symbols are shown in Fig. 2–4 to Fig. 2–10 (pages 14–18).

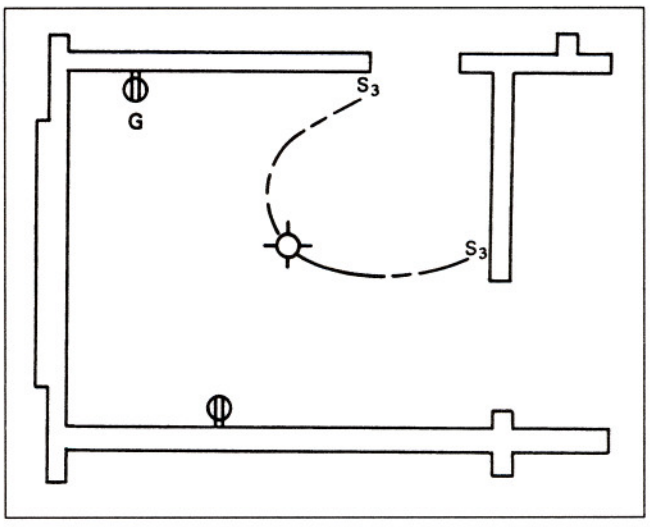


Fig. 2–1 Use of electrical symbols and notations on a floor plan.

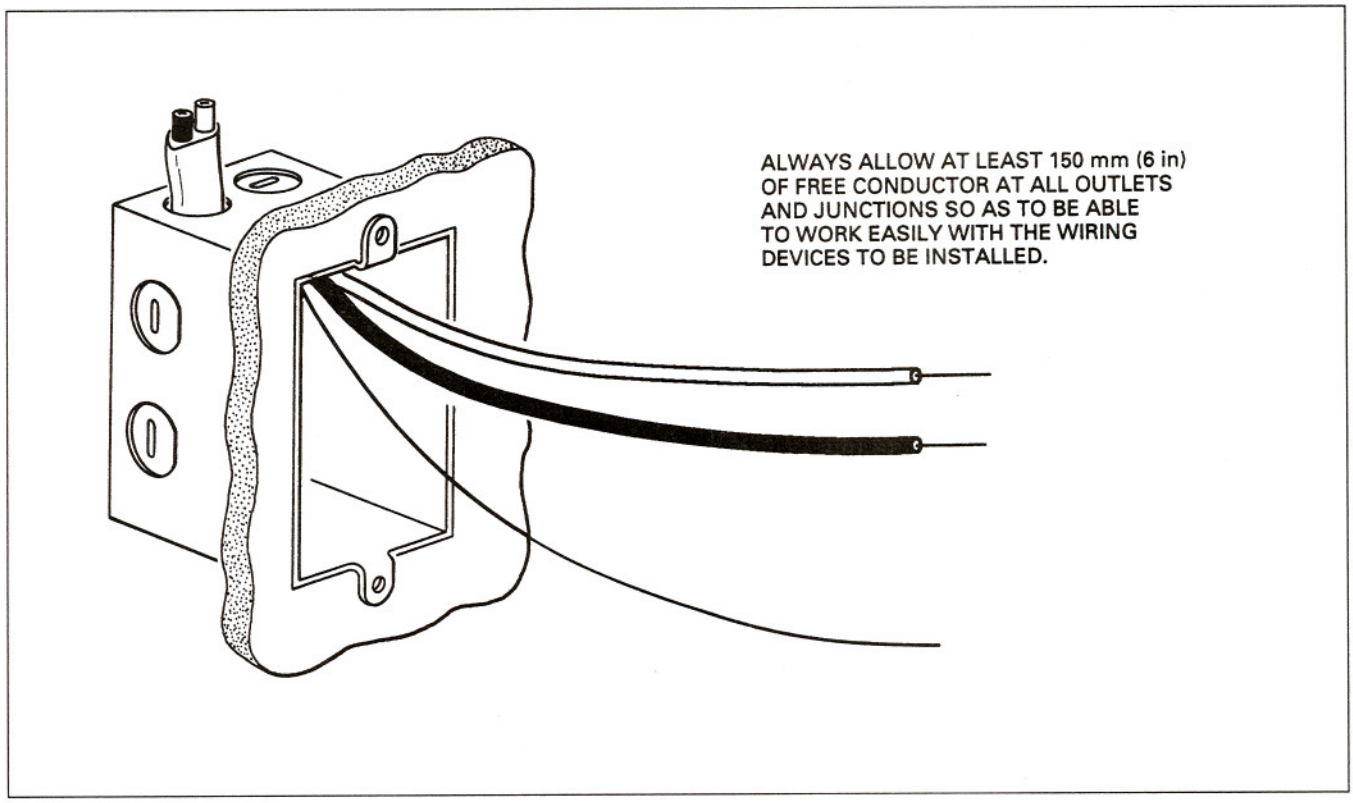


Fig. 2–2 When a receptacle is connected to the wires, the outlet is called a *receptacle outlet*. For ease in working with wiring devices, the *C.E.C, Part I* in *Rule 12–3002(4)* requires that at least 150 mm (6 in) of free conductor be provided.

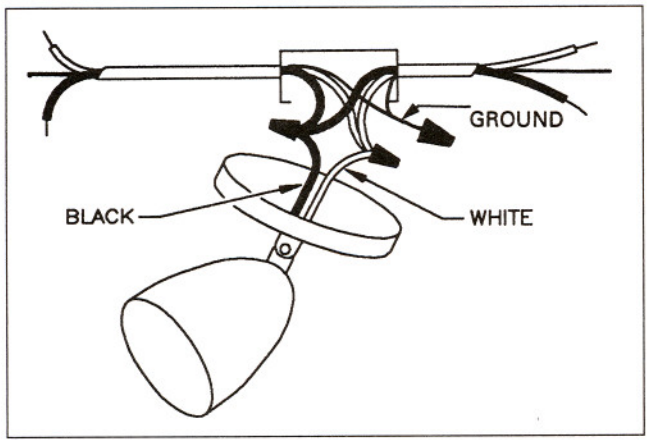


Fig. 2–3 When a lighting fixture is connected to the wires, the outlet is called a *lighting outlet*. The *C.E.C, Part I* requires that at least 150 mm (6 in) of free conductor be provided.

The dash lines in Fig. 2–1 run from the outlet to the switch or switches that control the outlet. These lines are usually curved so that they cannot be mistaken for invisible edge lines. Outlets shown on the plan without curved dash lines are independent and have no switch control.

A study of the plans for the single-family dwelling shows that many different electrical symbols are used to represent the electrical devices and equipment used in the building.

In drawing electrical plans, most architects, designers, and electrical engineers use symbols approved by the American National Standards Institute (ANSI) wherever possible. However, plans may contain symbols that are not found in these standards. When such unlisted (nonstandard) symbols are used, the electrician must refer to a legend that interprets these symbols. The legend may be included on the plans or in the specifications. In many instances, a notation on the plan will clarify the meaning of the symbol.

Figs. 2–4 through 2–10 (pages 14–18) list the standard, approved electrical symbols and their meanings. Many of these symbols can be found on the accompanying plans of the residence. Note in these figures that several symbols have the same shape. However, differences in the interior presentation indicate that the meanings of the symbols are different. For example, different meanings are shown in Fig. 2–10 (page 18) for the outlet symbols. A good practice to follow in studying sym-

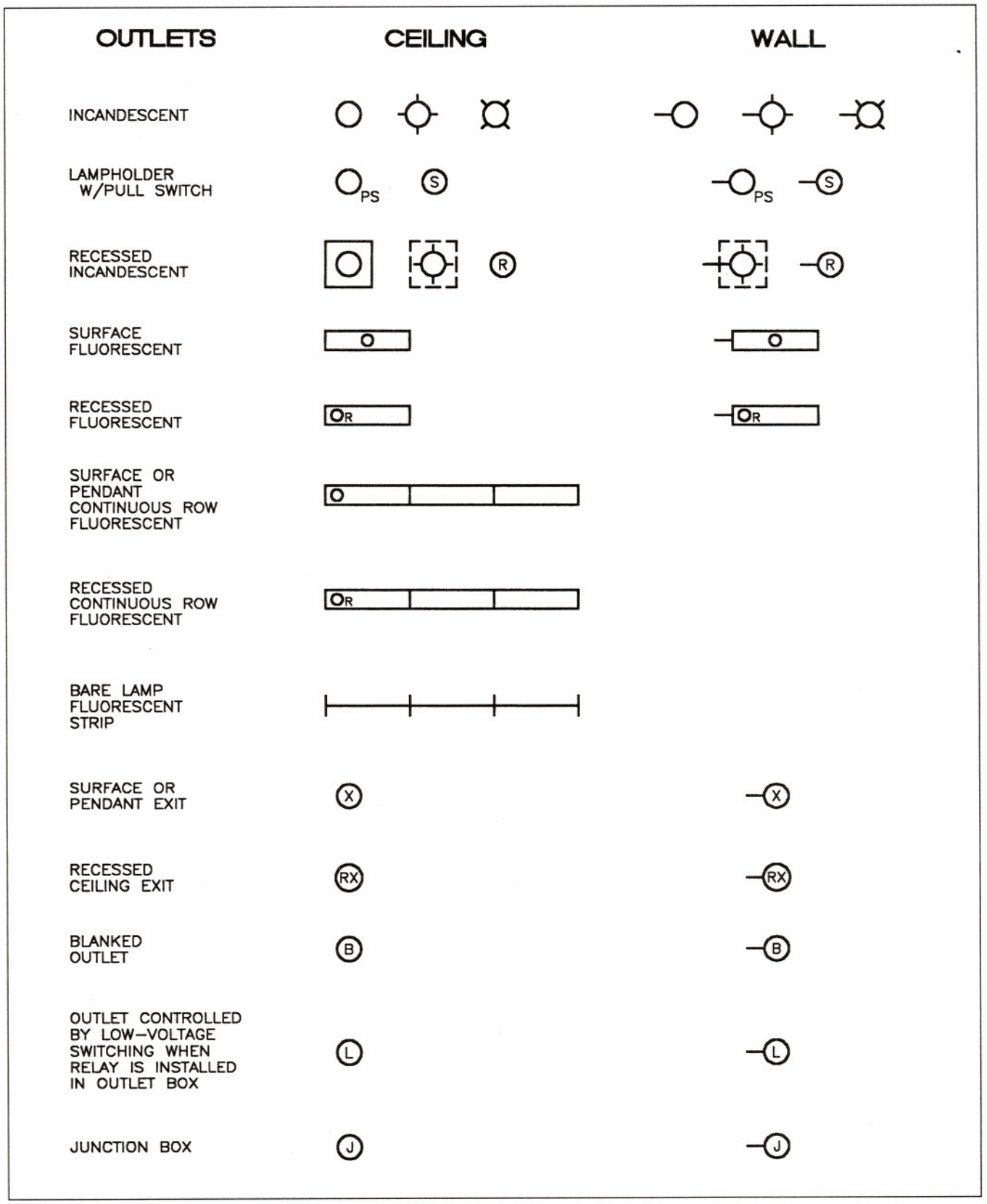


Fig. 2–4 Lighting outlet symbols.

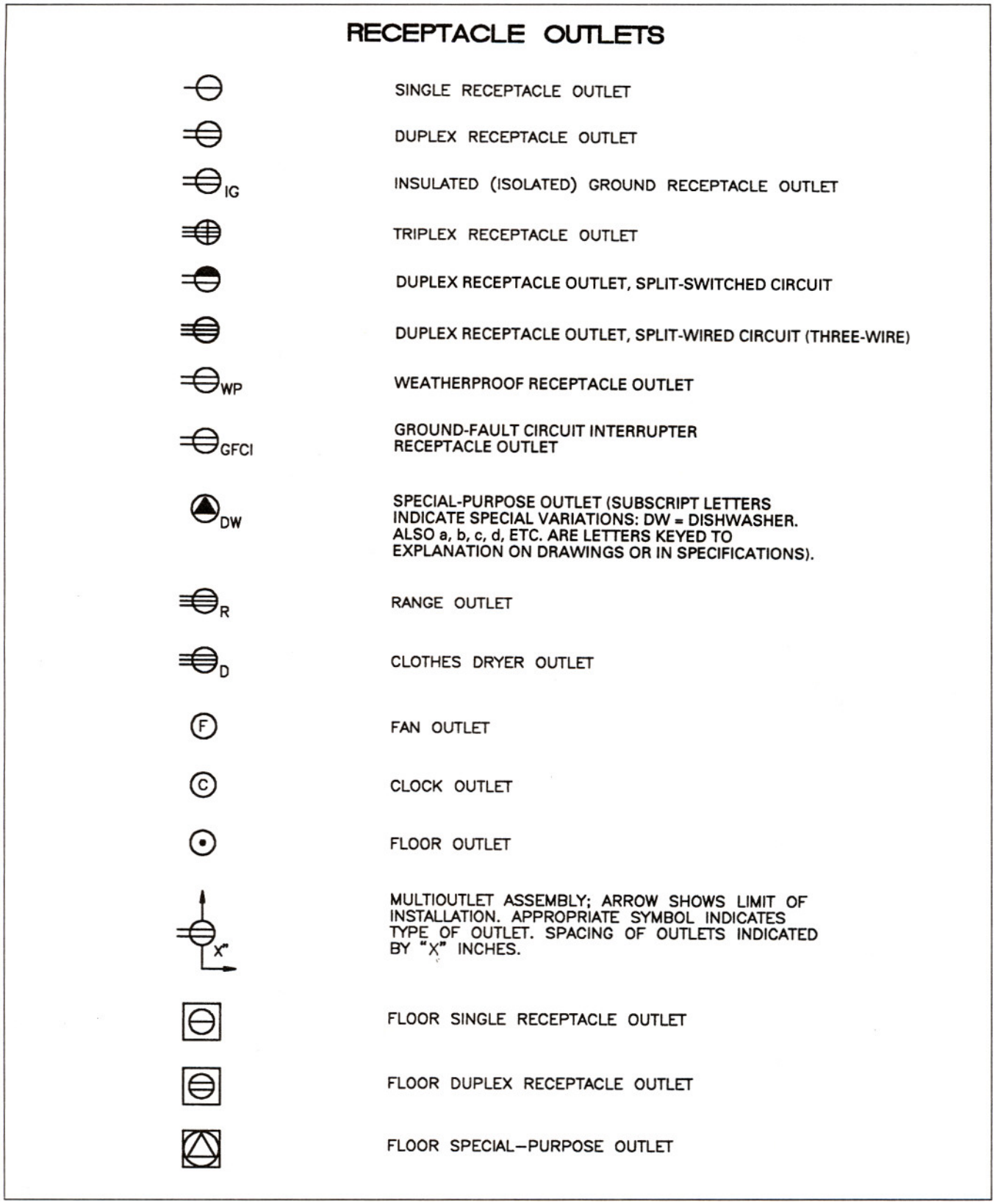


Fig. 2–5 Receptacle outlet symbols.

SWITCH OUTLETS

S	SINGLE–POLE SWITCH
S_2	DOUBLE–POLE SWITCH
S_3	THREE–WAY SWITCH
S_4	FOUR–WAY SWITCH
S_D	DOOR SWITCH
S_{DS}	DIMMER SWITCH
S_K	KEY SWITCH
S_L	LOW–VOLTAGE SWITCH
S_{LM}	LOW–VOLTAGE MASTER SWITCH
S_P	SWITCH WITH PILOT LAMP
S_F	VARIABLE–SPEED SWITCH
S_T	TIME SWITCH
S_{WP}	WEATHERPROOF SWITCH

Fig. 2–6 Switch outlet symbols.

bols is to learn the basic forms first and then add the supplemental information to obtain different meanings.

FIXTURES AND OUTLETS

Architects often include in the specifications a certain amount of money for the purchase of electrical fixtures. The electrical contractor includes this amount in the bid, and the choice of fixtures is then left to the homeowner. If the owner selects fixtures whose total cost exceeds the fixture allowance, the owner is expected to pay the difference between the actual cost and the specification allowance. If the fixtures are not selected before the roughing-in stage of wiring of the house, the electrician usually installs outlet boxes having standard fixture mounting studs.

Most modern surface-mount lighting fixtures can be fastened to an octagon box (Fig. 2–11 (page 19), top row) or an outlet box with a plaster ring using appropriate No. 8–32 metal screws and mounting strap furnished with the fixture (Fig. 2–11, third row).

A box must be installed at each outlet or switch location, *Rule 12–3002(1)*. There are exceptions to this rule, but in general they relate to special man-

CIRCUITING

1 2	BRANCH–CIRCUIT HOME RUN TO PANEL
///	THREE WIRES IN CABLE OR RACEWAY
////	FOUR WIRES IN CABLE OR RACEWAY, ETC.
//+	SOME DRAWINGS USE THIS METHOD OF CONDUCTOR IDENTIFICATION: EQUIPMENT GROUNDING CONDUCTOR: LONG LINE WITH DOT. NEUTRAL CONDUCTOR: LONG LINE. PHASE CONDUCTOR WITH SWITCH LEGS: SHORT LINE.
———	WIRING CONCEALED IN CEILING OR WALL
— — —	WIRING CONCEALED IN FLOOR
– – – –	WIRING EXPOSED
——o	WIRING TURNED UP
——●	WIRING TURNED DOWN
——— CO	CONDUIT ONLY (EMPTY)
—–—	SWITCH LEG INDICATION. CONNECTS OUTLETS WITH CONTROL POINTS.

AN ARROW INDICATES A BRANCH–CIRCUIT HOME RUN TO PANEL.
THE NUMBER OF ARROWS INDICATES THE NUMBER OF CIRCUITS.
IF THERE ARE NO CROSSHATCHES, THEN IT IS ASSUMED THAT THE RACEWAY CONTAINS TWO WIRES.

Fig. 2–7 Circuiting symbols.

ufactured wiring systems where the "box" is an integral part of the system. For standard wiring methods, such as cable or conduit, a box is usually required.

Outlet boxes must be accessible, *Rule 12–3016(1)*.

Be careful when roughing in boxes for fixtures and also when hanging ceiling fixtures to:

- nonmetallic device (switch) boxes.
- nonmetallic device (switch) plaster rings.
- metallic device (switch) boxes.
- metallic device (switch) plaster rings.
- any nonmetallic box, unless specifically marked on the box or carton for use as a fixture

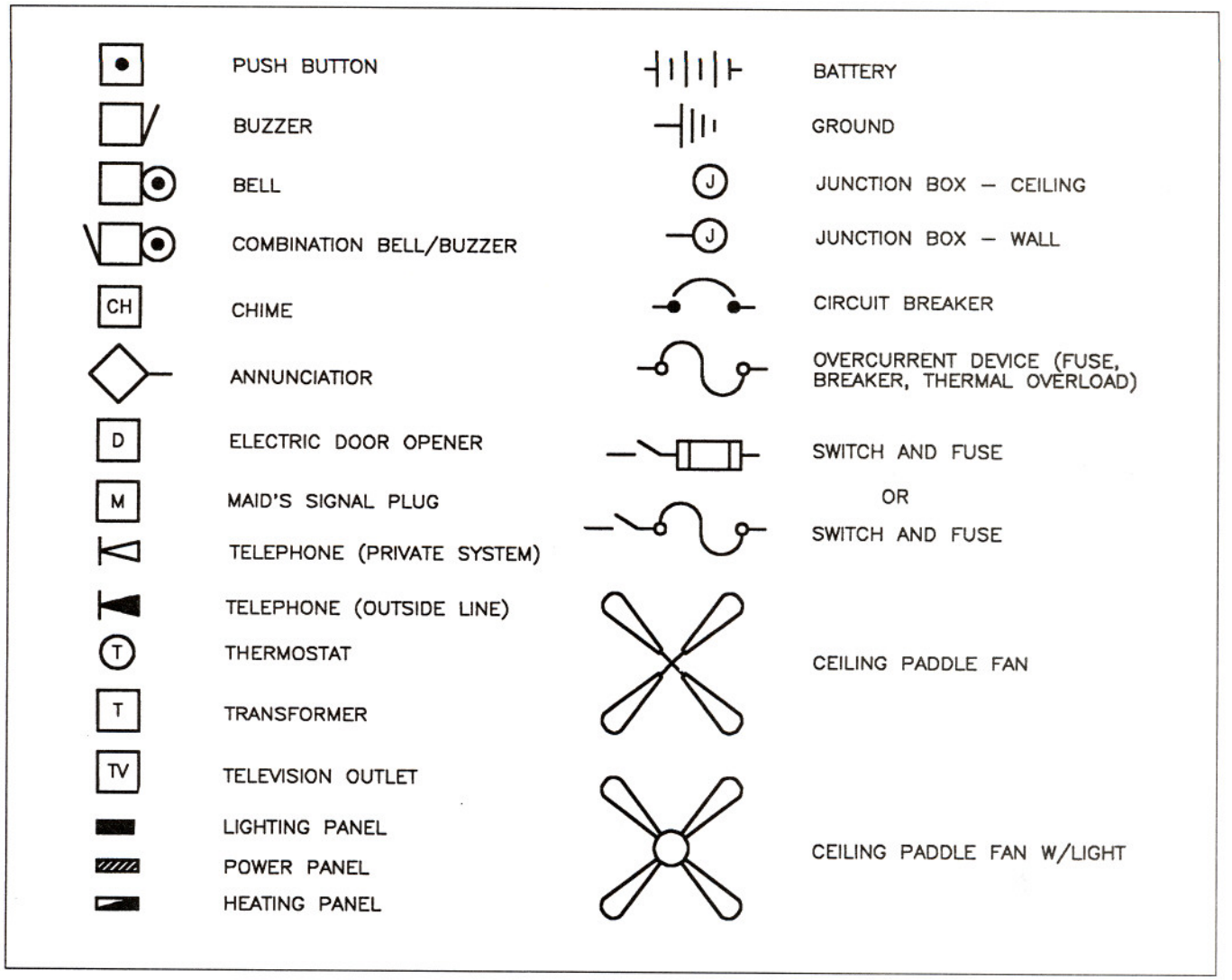


Fig. 2–8 Miscellaneous symbols.

support, or to support other equipment, or to accommodate heat-producing equipment.

Therefore, unless the box, device plaster ring, or carton is marked to indicate that it has been listed by CSA for the support of fixtures, do not use where fixtures are to be hung. Refer to Fig. 2–12 (page 20) and *Rule 12–1110.*

Be careful when installing a ceiling outlet box for the purpose of supporting a fan. See Unit 9 for detailed discussion of paddle fans and their installation.

If the owner selects fixtures prior to construction, the architect can specify these fixtures in the plans and/or specifications. Thus, the electrician is provided with advance information on any special framing, recessing, or mounting requirements for the fixtures. This information *must* be provided in the case of recessed fixtures, which require a specific wall or ceiling opening.

Many types of lighting fixtures are presently available. Fig. 2–11 (page 19) shows several typical lighting fixtures that may be found in a dwelling unit. Also shown are the electrical symbols used on plans to designate these fixtures and the type of outlet boxes or switch boxes on which the lighting fixtures can be mounted. A standard receptacle outlet is shown as well. The switch boxes shown with it are made of steel. Switch boxes may also be made of plastic, as shown in Fig. 2–12 (page 20). Other types of outlets will be covered in later units.

SYMBOL	NOTATION
(1)	PLUGMOLD ENTIRE LENGTH OF WORKBENCH. OUTLETS 18" O.C. INSTALL 48" TO CENTRE FROM FLOOR. GFCI PROTECTED.
(2)	TRACK LIGHTING. PROVIDE 5 LAMPHOLDERS.
(3)	TWO 40-WATT RAPID START FLUORESCENT LAMPS IN VALANCE. CONTROL WITH DIMMER SWITCH.

Fig. 2–9 An example of how certain *notations* might be added to a symbol when the symbol itself does not fully explain its meaning. The architect or engineer has a choice of fully explaining the meaning directly on the plan if there is sufficient room; if there is insufficient room, a *notation* could be used.

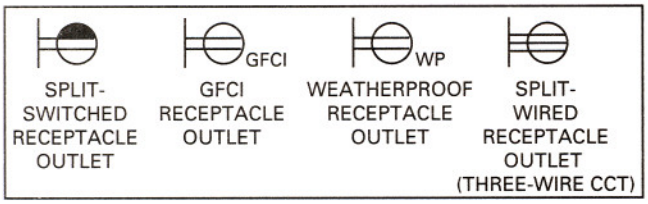


Fig. 2–10 Variations in significance of outlet symbols.

FLUSH SWITCHES

Some of the standard symbols for various types of switches are shown in Figure 2–13 (page 21). Typical connection diagrams are also given. Any sectional switch box or 4-in (102-mm) square box with a side mounting bracket and raised switch cover can be used to install these switches. Refer to Fig. 2–11.

JUNCTION BOXES AND SWITCH (DEVICE) BOXES *(RULES 12–3000 TO 12–3038)*

Junction boxes are sometimes placed in a circuit for convenience in joining two or more cables or conduits. All conductors entering a junction box are joined to other conductors entering the same box to form proper hookups so that the circuit will operate in the manner intended.

All electrical installations must conform to the *C.E.C., Part I* standards requiring that junction boxes be installed in such a manner that the wiring contained in them shall be accessible without removing any part of the building. In house wiring, this requirement limits the use of junction boxes to unimproved basements, garages, and open attic spaces because blank box covers exposed to view detract from the appearance of a room. Of course, an outlet box such as the one installed for the front hall ceiling fixture is really a junction box because it contains splices. Removing the fixture makes the box accessible, thereby meeting *C.E.C., Part I* requirements. Refer to Fig. 2–14 (page 21) and Fig. 2–15 (page 22).

Rule 12–3002(1) requires that a box or fitting be installed wherever splices, switches, outlets, junction points, or pull points are required (Fig. 2–14, page 21). However there are instances where a change is made from one wiring method to another. For example armoured cable to electrical metallic tubing (EMT), *Rule 12–3002*. Note that the fitting where the change is made must be accessible after installation, Fig. 2–16 (page 21).

Boxes shall be rigidly and securely mounted, *Rule 12–3014(1)*.

NONMETALLIC OUTLET AND DEVICE BOXES

The *C.E.C., Part I* permits nonmetallic outlet and device boxes to be installed where the wiring method is nonmetallic sheathed cable, *Rule12–524*. Nonmetallic boxes may be used with armoured cable or metal raceways, but only if a proper means is provided inside the boxes to bond any and all metal raceways and/or armoured cables together, *Rule12–3002(2)*.

The house wiring system usually is formed by a number of specific circuits. Each circuit consists of a continuous run of cable from outlet to outlet or from box to box. The residence plans show many branch circuits for general lighting, appliances, electric heating, and other requirements. The specific *C.E.C., Part I* rules for each of these circuits are covered in later units.

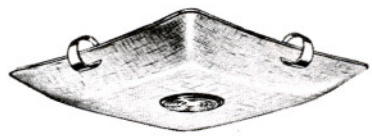
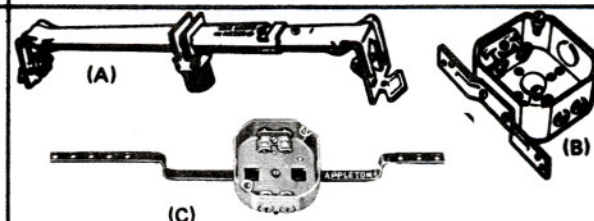
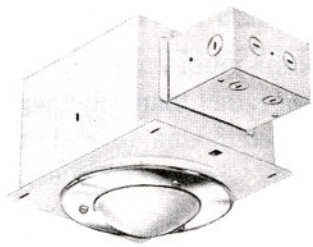
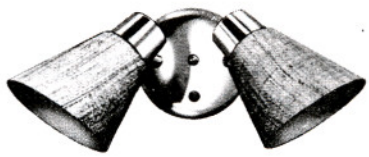
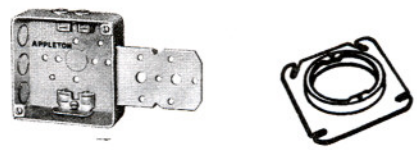
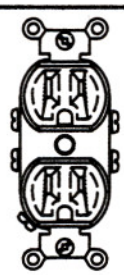
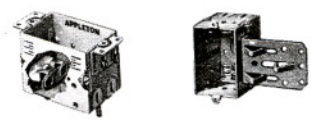
SYMBOL	TYPE OF FIXTURE OR OUTLET	OUTLET BOXES THAT MAY BE USED
OR CEILING OUTLET	 SURFACE MOUNTED	 (A) ADJUSTABLE BAR HANGER WITH FIXTURE STUD (B) OCTAGON BOX ON BRACKET (C) OCTAGON BOX AND OFFSET BAR HANGER BOXES ARE AVAILABLE WITH EITHER INTERNAL OR EXTERNAL CABLE CLAMPS.
CEILING OUTLET	 FLUSHED RECESSED TYPE	CABLE TERMINATES IN BOX THAT IS FURNISHED WITH FIXTURE. SPECIAL CODE RULES GOVERNING THE INSTALLATION ARE FOUND IN ***RULES 30-300*** THROUGH ***30-330*** OF THE ***C.E.C.,*** **PART 1.** SEE UNIT 8.
WALL OUTLET		 4" SQUARE BOX WITH SIDE BRACKET AND PROPER RAISED PLASTER COVER
DUPLEX RECEPTACLE OUTLET		 SECTIONAL SWITCH DEVICE BOXES

Fig. 2–11 Types of fixtures and outlets.

GANGED SWITCH (DEVICE) BOXES

A flush switch or receptacle outlet for residential use fits into a standard $3 \times 2 \times 2\frac{1}{2}$-in ($76 \times 51 \times 64$-mm) sectional switch box(sometimes called a *device box*). When two or more switches (or outlets) are located at the same point, the switch boxes are ganged or fastened together to provide the required mounts, Fig. 2–17 (page 23).

Three switch boxes can be ganged together by removing and discarding one side from both the first and third switch boxes, and both sides from the second (centre) switch box. The boxes are then joined together as shown in Fig. 2–17. After the switches are installed, the gang is trimmed with a gang plate having the required number of switch handle or receptacle outlet openings. These plates are called two-gang wall plates, three-gang wall plates, and so on, depending upon the number of openings.

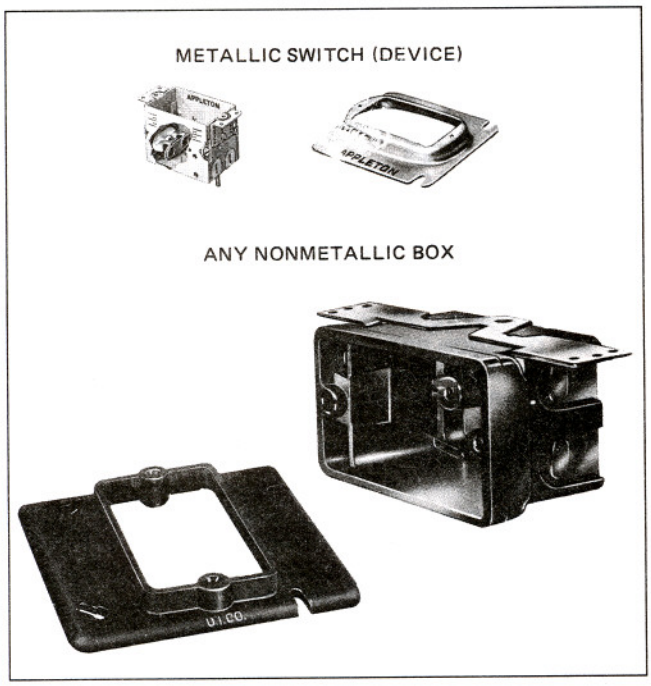


Fig. 2–12 Supporting (hanging) a ceiling fixture from these types of boxes is not permitted unless specifically marked on the box or carton.

The dimensions of a standard sectional switch box (3 × 2 in or 76 × 51 mm) are the dimensions of the opening of the box. The depth of the box may vary from $1\frac{1}{2}$ inches to $3\frac{1}{2}$ inches (38 to 89 mm), depending upon the requirements of the building construction and the number of conductors and devices to be installed. *Rules 12–3000* to *12–3038* cover outlet, switch, and junction boxes. See Fig. 2–18 (page 24) for a list of common box dimensions.

Rule 12–3018(1) states that boxes must be mounted so that they will be set back not more than 6 mm ($\frac{1}{4}$ in) from the finished surface when the boxes are mounted in noncombustible walls or ceilings made of concrete, tile, or similar materials. When the wall or ceiling construction is of combustible material (wood), the box must be set flush with the surface or project from it, Fig. 2–19 (page 25). These requirements are meant to prevent the spread of fire if a short circuit occurs within the box.

Ganged sectional switch (device) boxes can be installed using a pair of metal mounting strips, *Rule 12–3012(2)*. These strips may also be used to install a switch box between wall studs, Fig. 2–20 (page 26). When an outlet box is to be mounted at a specific location between joists, as for ceiling-mounted fixtures, an offset bar hanger is used (Fig. 2–11, page 19).

Rule 12–3012(5a) states that when a switch box or outlet box is mounted to a stud or ceiling joist by nailing through the box, the nails must be not more than 6.4 mm ($\frac{1}{4}$ in) from the back or ends of the box, Fig. 2–21 (page 26). This requirement ensures that when the nail passes through the box, it does not interfere with the wiring devices in the box. Some box manufacturers install the nail holes outside the box.

BOXES FOR CONDUIT WIRING

Some municipal electrical ordinances require conduit rather than cable wiring. Conduit wiring is discussed in Unit 18, and examples of conduit fill (how many wires are permitted in a given size conduit) are presented.

When conduit is installed in a residence, it is quite common to use 4-inch (102-mm) square boxes trimmed with suitable plaster covers. This type of cover is shown in Fig. 2–18 (page 24). There are sufficient knockouts in the top, bottom, sides, and back of the box to permit a number of conduits to run into it. Plenty of room is available for the conductors and wiring devices. Note how easily these 4-inch square outlet boxes can be mounted "back-to-back" by installing a small fitting between them. This is illustrated in Fig. 2–22 (2) and (3) (page 27).

Four-inch square outlet boxes can be trimmed with one-gang or two-gang plaster rings where wiring devices will be installed. Where lighting fixtures will be installed, a plaster ring having a round opening should be used.

Any unused openings in outlet and device boxes must be closed as per *Rules 12–3028* and *12–3026(1)(e)* of the *C.E.C., Part I,* using knockout fillers. See Fig. 2–23 (page 28).

The number of conductors allowed in outlet and device boxes is covered elsewhere in this text.

SPECIAL-PURPOSE OUTLETS

Special-purpose outlets are usually indicated on the plans. These outlets are described by a notation and are also detailed in the specifications. The plans included in this text indicate special-purpose outlets by a triangle inside a circle with subscript letters. In some cases, a subscript number is added to the letter.

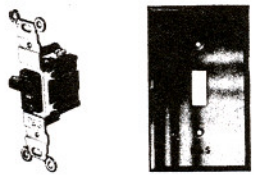
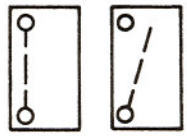
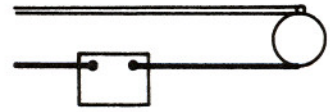
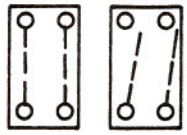
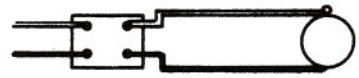
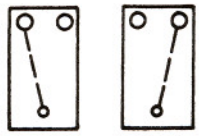
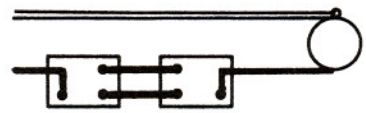
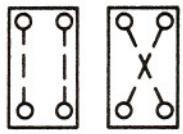
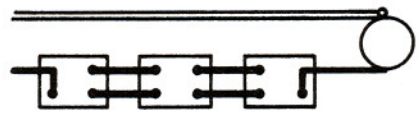
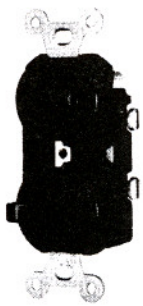
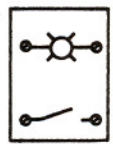
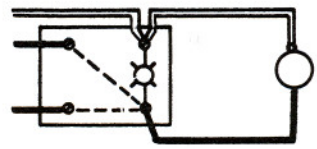
SYMBOL	FLUSH TOGGLE SWITCH	OPERATION	CONNECTIONS
S SINGLE-POLE		 ON OFF	
S_2 DOUBLE-POLE		 ON OFF	
S_3 THREE–WAY		 POSITION 1 POSITION 2	
S_4 FOUR–WAY		 1 2	
S_p SWITCH AND PILOT LIGHT		 FOR CONTROLLING LIGHTS FROM ONE POINT WITH PILOT LIGHT INDICATION	 ALSO AVAILABLE IN THREE-WAY TYPE OF CONTROLLING LIGHT FROM TWO POINTS WITH PILOT LIGHT INDICATION

Fig. 2–13 Standard switches and symbols.

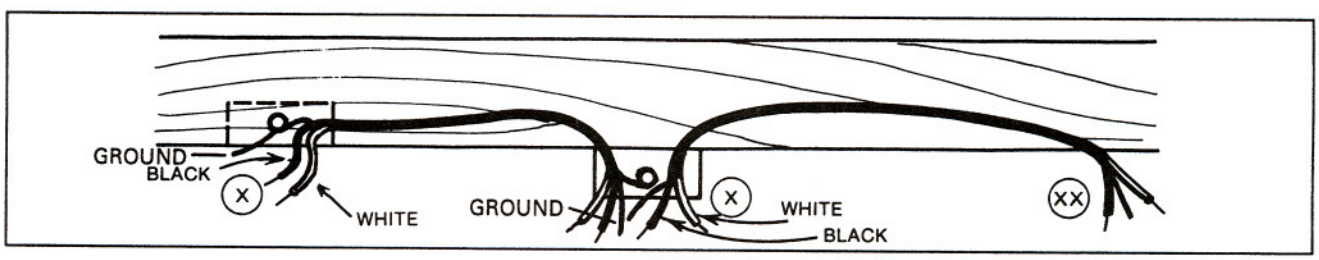
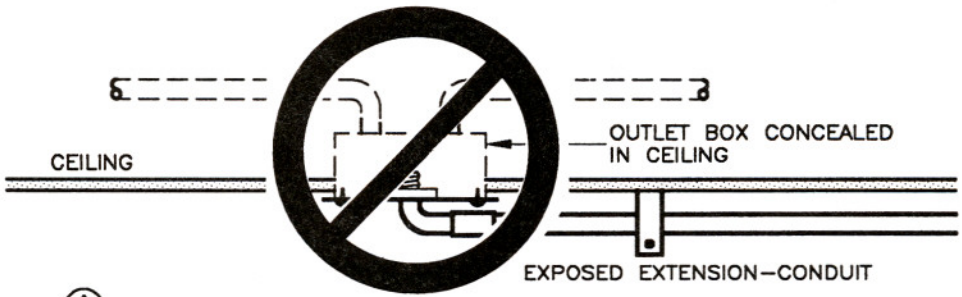
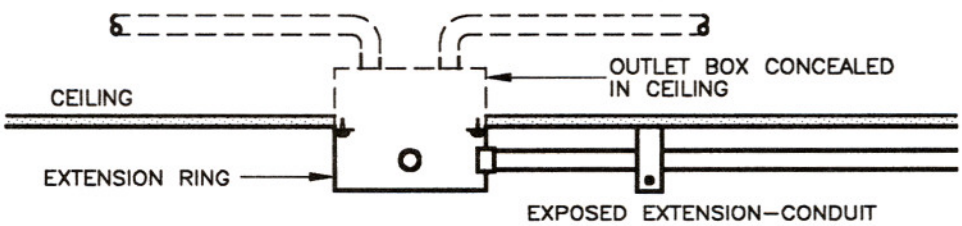


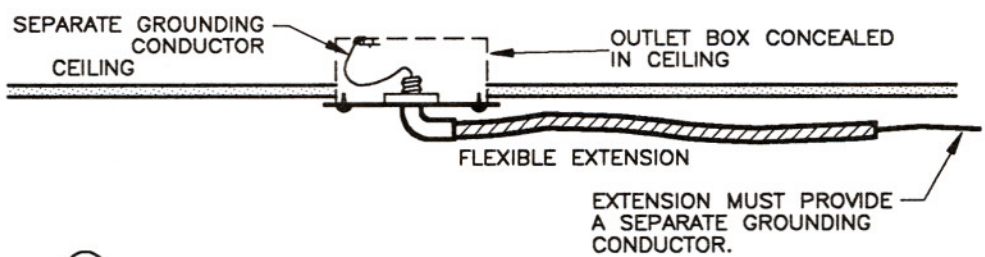
Fig. 2–14 A box (or fitting) must be installed wherever there are splices, outlets, switches, or other junction points. Refer to the points marked X. A potential *Code, Part I* violation is shown at point XX. However, this is only a violation if the cable is not supplying equipment with an integral connection box, or if the apparatus has not been approved as a connection box. *Rules 12–3002(1)* and *12–3016*.



Ⓐ VIOLATION. IT IS AGAINST THE CODE TO MAKE A RIGID EXTENSION FROM A COVER THAT IS ATTACHED TO AN OUTLET BOX, JUNCTION BOX, OR DEVICE BOX, *RULE 12-3028(1).*



Ⓑ THIS MEETS CODE. A BOX OR EXTENSION RING MUST BE MOUNTED OVER AND MECHANICALLY SECURED TO THE ORIGINAL BOX, *RULE 12-3028(1).*



Ⓒ THIS MEETS THE *C.E.C., PART I.* IT IS PERMITTED TO MAKE A SURFACE EXTENSION FROM A COVER FASTENED TO A CONCEALED BOX WHERE THE EXTENSION WIRING METHOD IS FLEXIBLE AND WHERE A SEPARATE GROUNDING CONDUCTOR IS PROVIDED SO THAT THE GROUNDING PATH IS NOT DEPENDENT UPON THE SCREWS THAT ARE USED TO FASTEN THE COVER TO THE BOX.

IT WOULD BE A CODE VIOLATION TO MAKE THE EXTENSION WITH A RIGID WIRING METHOD SUCH AS A CONDUIT THAT WOULD MAKE IT DIFFICULT TO GAIN ACCESS TO THE CONNECTIONS INSIDE THE BOX, OR IF A FLEXIBLE WIRING METHOD WAS USED BUT HAD NO PROVISIONS FOR A SEPARATE GROUNDING CONDUCTOR.

Fig. 2–15 How to make an extension from a flush-mounted box.

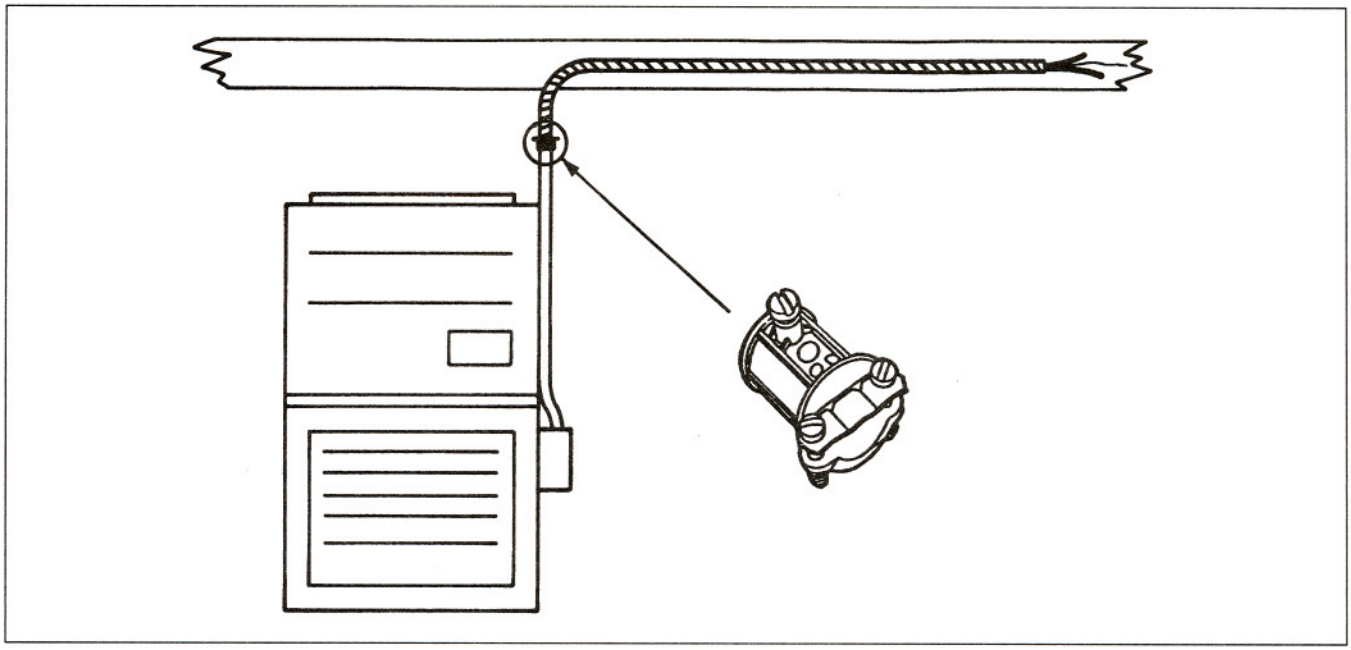


Fig. 2–16 ***Rule 12–3002(1)*** **permits a transition to be made from one wiring method to another. In this case, the armor of the Type AC cable is removed, allowing sufficient length of the conductors to be run through the conduit. A proper fitting as shown must be used at the transition point, and the fitting must be accessible after installation.**

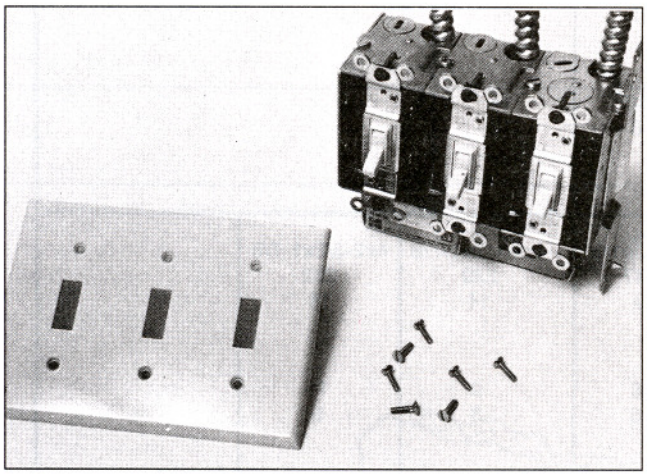


Fig. 2–17 Standard flush switches installed in ganged sectional device boxes.

When a special-purpose outlet is indicated on the plans or in the specifications, the electrician must check for special requirements. Such a requirement may be a separate circuit, a special 240-volt circuit, a special grounding or polarized receptacle, or other preparation.

Examples of special-purpose outlets include

- central vacuum
- weatherproof receptacle
- dedicated receptacle, perhaps for a home computer
- air conditioning
- clock receptacle

NUMBER OF CONDUCTORS IN A BOX

Rule 12–3036 dictates that outlet boxes, switch boxes, and device boxes should be large enough to provide ample room for the wires without having to jam or crowd the wires into the box. The *C.E.C., Part I* specifies the maximum number of conductors allowed in standard outlet boxes and switch boxes, Fig. 2–24 (page 28). A conductor running through the box is counted as one conductor. Each conductor originating outside of the box and terminating inside it is counted as one conductor. Conductors that originate and terminate within the box are not counted.

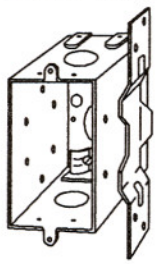
When conductors are the same size, the proper box size can be selected by referring to *Table 23*. When conductors are of different sizes, refer to *Table 22,* Fig. 2–25 (page 29).

Tables 22 and *23* do not consider fittings or devices such as fixture studs, wire connectors, hickeys, switches, or receptacles that may be in the box. For assistance in this case, see Fig. 2–26 (page 29). When the box contains one or more fittings (such as fixture studs or hickeys) the number of conductors must be one less than shown in the table for each type of device.

QUICK-CHECK BOX SELECTION GUIDE

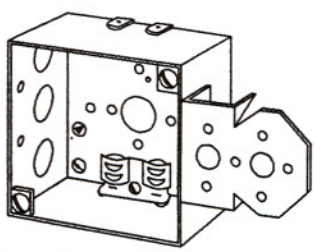
FOR BOXES GENERALLY USED FOR RESIDENTIAL WIRING

DEVICE BOXES



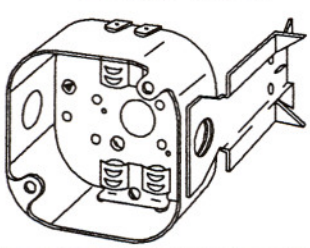
BOX SIZE		3x2x1-1/2	3x2x2	3x2x1-1/4	3x2x1-1/2	3x2x2
VOLUME	Millilitres	131	163	163	204	245
	Cu. In.	8.0	10.0	10.0	12.5	15.0
WIRE SIZE	14	5	6	6	8	10
	12	4	5	5	7	8

SQUARE BOXES



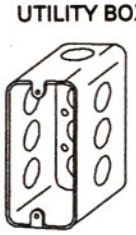
BOX SIZE		4x4x1-1/2	4x4x2-1/8	4-11/16x4-11/16x1-1/2	4-11/16x4-11/16x2-1/8
VOLUME	Millilitres	344	491	491	668
	Cu. In.	21	30	30	42
WIRE SIZE	14	14	20	20	28
	12	12	17	17	24

OCTAGON BOXES



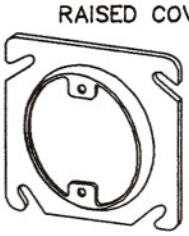
BOX SIZE		4x1-1/2	4x2-1/8
VOLUME	Millilitres	245	344
	Cu. In.	15	21
WIRE SIZE	14	10	14
	12	8	12

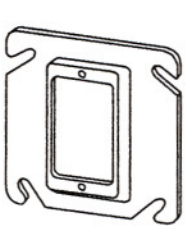
UTILITY BOXES

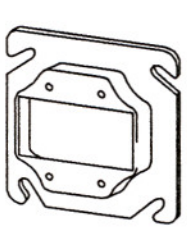


BOX SIZE		4x2x1-1/2	4x2-1/8x1-7/8	4x2-3/8x1-7/8
VOLUME	Millilitres	147	229	262
	Cu. In.	9	14	16
WIRE SIZE	14	6	9	10
	12	5	8	9

RAISED COVERS







WHERE RAISED COVERS ARE MARKED WITH THEIR VOLUME IN CUBIC INCHES, THAT VOLUME MAY BE ADDED TO THE BOX VOLUME TO DETERMINE MAXIMUM NUMBER OF CONDUCTORS IN THE COMBINED BOX AND RAISED COVER.

NOTE: BE SURE TO MAKE DEDUCTIONS FROM THE ABOVE MAXIMUM NUMBER OF CONDUCTORS PERMITTED FOR WIRE CONNECTORS, WIRING DEVICES, CABLE CLAMPS, FIXTURE STUDS, AND GROUNDING CONDUCTORS. THE CUBIC INCH (IN^3) VOLUME IS TAKEN DIRECTLY FROM *TABLE 23* OF THE *C.E.C., PART I.*

Fig. 2–18 Quick-check box selection guide.

Deduct two conductors for each device mounted on a single strap (switches, receptacles). The deduction of two conductors has become necessary because of severe crowding of conductors in the box when the switch or receptacle is mounted or when dimmer switches are installed. In most cases,

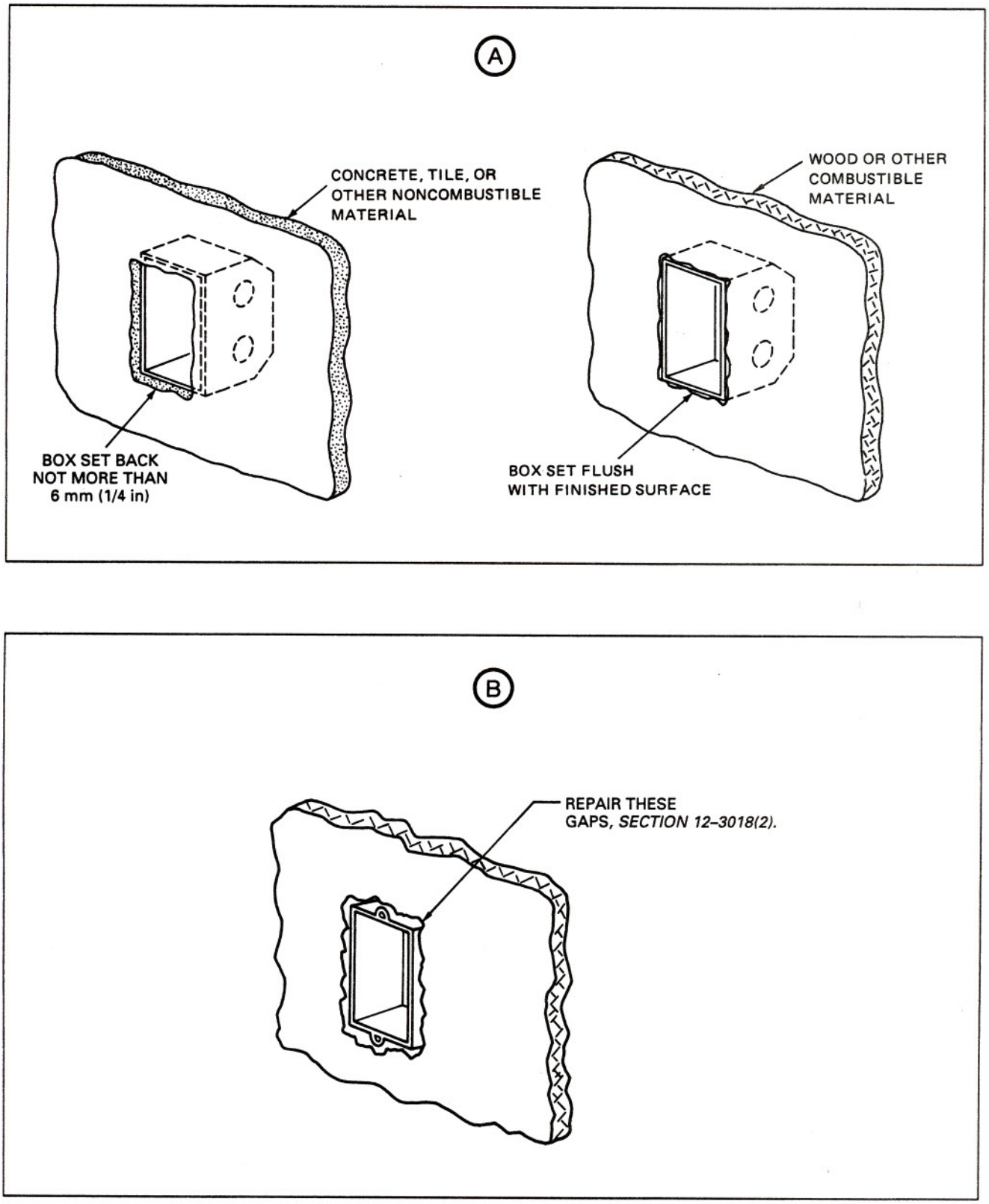


Fig. 2–19 Box position in walls and ceilings constructed of various materials, *Rule 12–3018.*

dimmer switches are larger than conventional switches.

Deduct one conductor for every two wire connectors. For example: for two or three wire connectors deduct one wire, for four or five connectors deduct two wires. *Note:* there is no deduction for the first wire connector because it will probably be used for the second ground connection. Be sure to

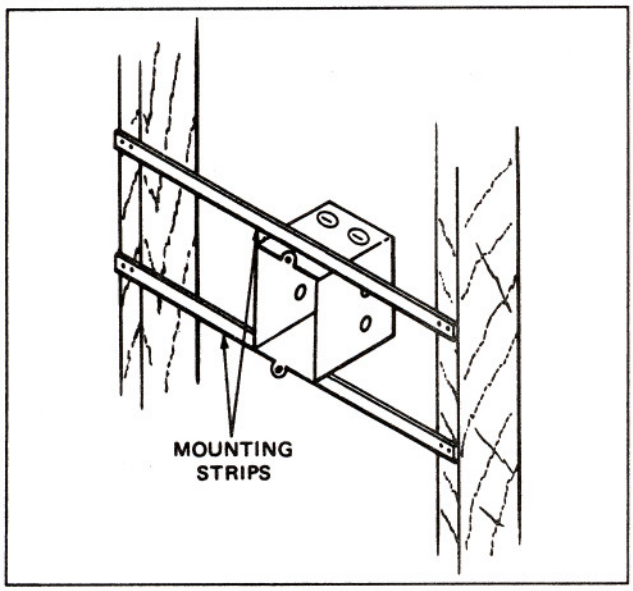


Fig. 2–20 Switch (device) boxes installed between studs using metal mounting strips. If wooden boards are used, they must be at least 19 mm ($\frac{3}{4}$ in) thick and be securely fastened to the stud, *Rule 12–3012(2).*

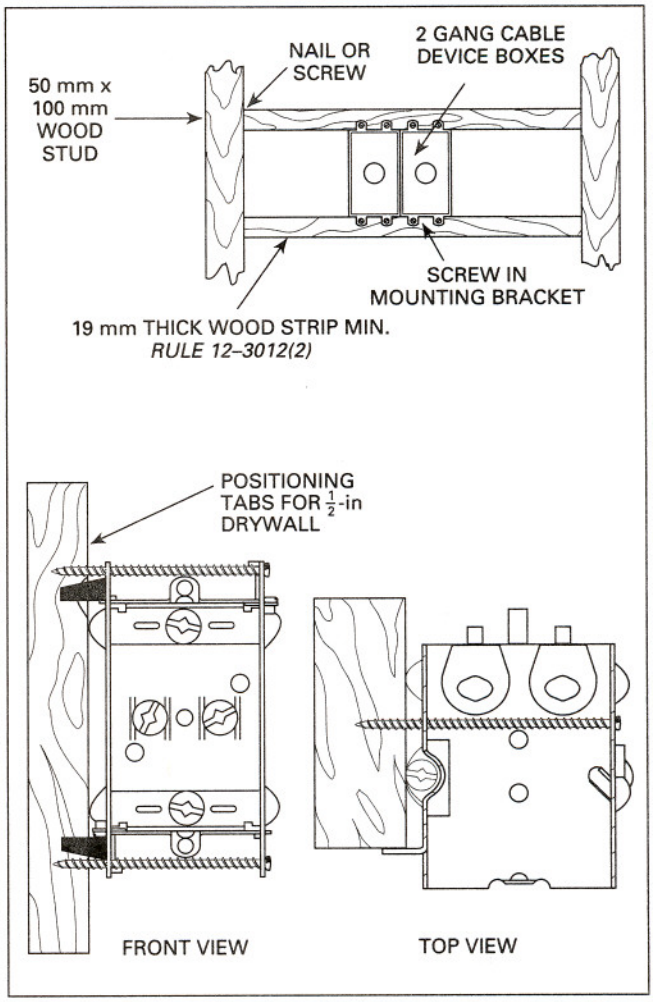


Fig. 2–20A A method of mounting sectional boxes to wood studs.

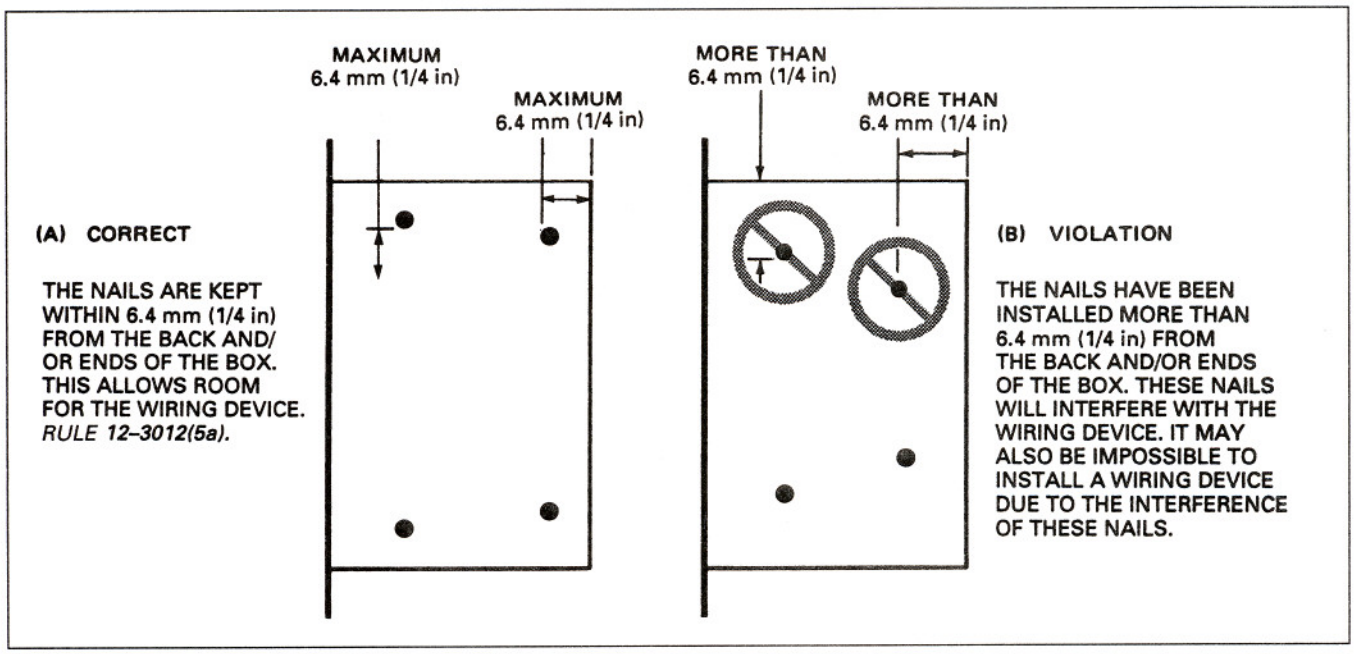
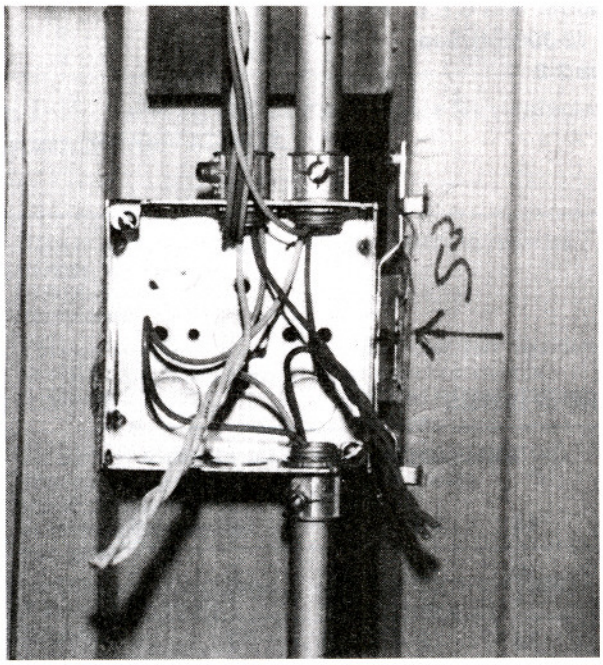
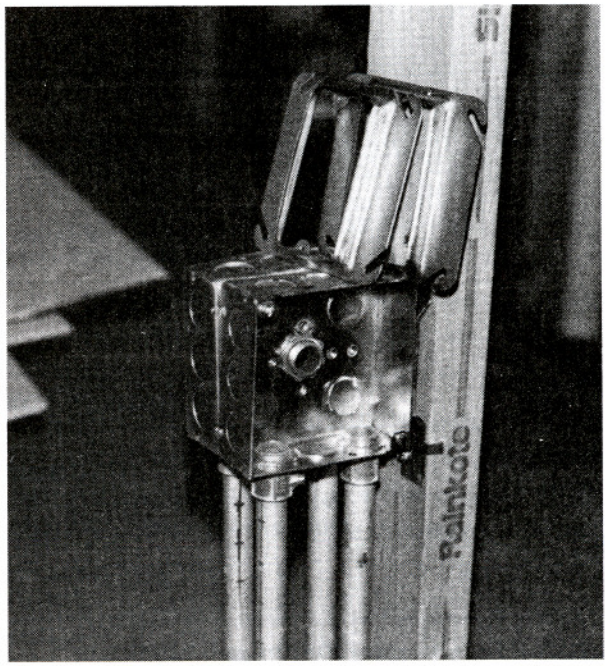


Fig. 2–21 Using nails to install a section switch box, *Rule 12–3012(5a).*

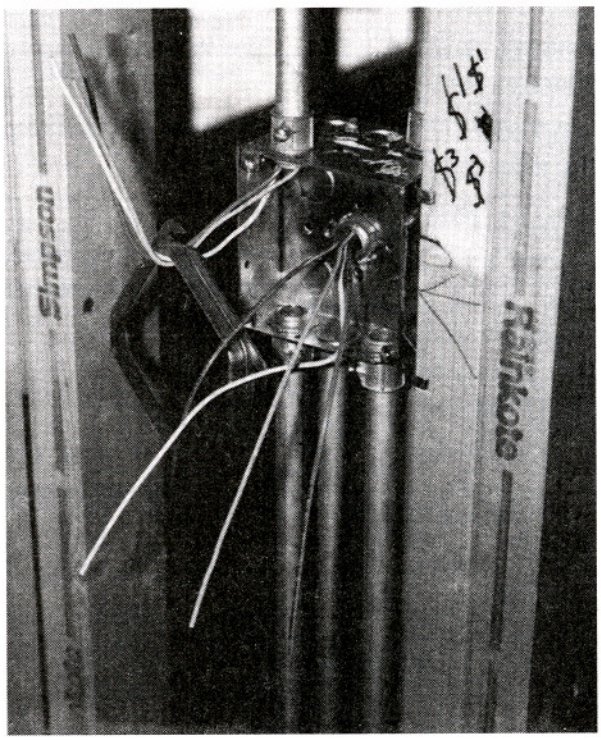
include all conductor sizes (Nos. 14, 12, 10, 8, and 6 AWG) when determining the size of the box to be installed. See Fig. 2–29 (page 30) and Fig. 2–30 (page 31) for examples of this *C.E.C., Part I* requirement, *Rule 12–3036(1).*



1.



2.



3.

Fig. 2–22 Boxes for conduit wiring.

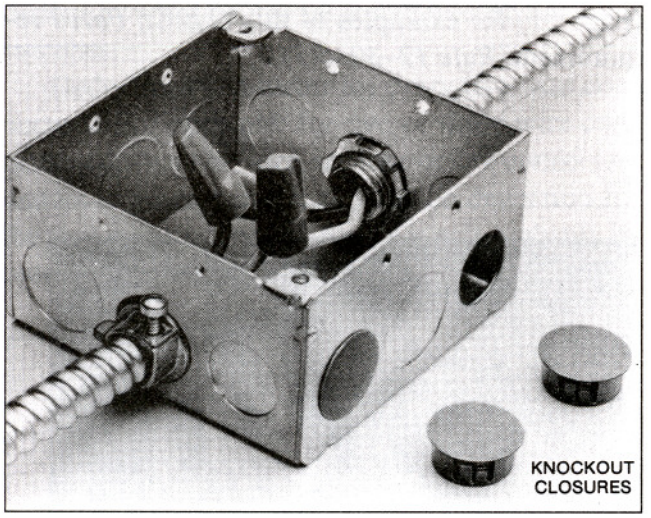


Fig. 2-23 Unused openings in boxes must be closed according to the *C.E.C., Part I, Rule 12–3026.* This is done to contain electrical short-circuit problems inside the box or panel and to keep rodents out.

WIRES MUST BE 150 mm MIMIMUM. See *C.E.C., Part I Rule 12-3002(4).* See Figure 2-2

TABLE 23
NUMBER OF CONDUCTORS IN BOXES

	Box Dimensions Inches Trade Size	Capacity Millilitre (Cubic Inch)	Maximum Number of Conductors Size AWG 14	12	10	8	6
Octagonal	4 x 1 1/2	245 (15)	10	8	6	5	3
	4 x 2 1/8	344 (21)	14	12	9	7	4
Square	4 x 1 1/2	344 (21)	14	12	9	7	4
	4 x 2 1/8	491 (30)	20	17	13	10	6
	4 11/16 x 1 1/2	491 (30)	20	17	13	10	6
	4 11/16 x 2 1/8	688 (42)	28	24	18	15	9
Round	4 x 1/2	81 (5)	3	2	2	1	1
Device	3 x 2 x 1 1/2	131 (8)	5	4	3	2	1
	3 x 2 x 2	163 (10)	6	5	4	3	2
	3 x 2 x 2 1/4	163 (10)	6	5	4	3	2
	3 x 2 x 2 1/2	204 (12.5)	8	7	5	4	2
	3 x 2 x 3	245 (15)	10	8	6	5	3
	4 x 2 x 1 1/2	147 (9)	6	5	4	3	2
	4 x 2 1/8 x 1 7/8	229 (14)	9	8	6	5	3
	4 x 2 3/8 x 1 7/8	262 (16)	10	9	7	5	3
Masonry	3 3/4 x 2 x 2 1/2	229 (14)/gang	9	8	6	5	3
	3 3/4 x 2 x 3 1/2	344 (21)/gang	14	12	9	7	4
	4 x 2 1/4 x 2 3/8	331 (20.25)/gang	13	11	9	7	4
	4 x 2 1/4 x 3 3/8	364 (22.25)/gang	14	12	9	8	4
Through Box	3 3/4 x 2	3.8/mm (6/inch)	4	3	2	2	1
Concrete Ring	4	7.7/mm (12/inch)	8	6	5	4	2
FS	1 Gang	229 (14)	9	8	6	5	3
	1 Gang Tandem	557 (34)	22	19	15	12	7
	2 Gang	426 (26)	17	14	11	9	5
	3 Gang	671 (41)	27	23	18	14	9
	4 Gang	917 (56)	37	32	24	20	12
FD	1 Gang	368 (22.5)	15	12	10	8	5
	2 Gang	671 (41)	27	23	18	14	9
	3 Gang	983 (60)	40	34	26	21	13
	4 Gang	1392 (85)	56	48	37	30	18

Fig. 2–24 *Table 23, Canadian Electrical Code, Part I.* See *Rule 12–3036.*

TABLE 22
SPACE FOR CONDUCTORS IN BOXES

Size of Conductor	Usable Space Required for Each Insulated Conductor	
AWG	Cubic Centimetres	Cubic Inches
14	24.6	(1.5)
12	28.7	(1.75)
10	36.9	(2.25)
8	45.1	(2.75)
6	73.7	(4.5)

Fig. 2–25 ***Table 22, C.E.C., Part I.*** **Space for conductors in boxes. See** ***Rule 12–3038.***

• If box contains NO fittings, devices, fixture studs, hickeys, switches, or receptacles	• refer directly to *Table 23.*
• If box contains ONE or MORE fittings, fixture studs, or hickeys...	• deduct ONE from maximum number of conductors permitted in *Table 23* for each type.
• For each device on a single strap containing ONE or MORE devices such as switches, receptacles, or pilot lights...	• deduct ANOTHER TWO from *Table 23.*
• For ONE or MORE isolated (insulated) grounding conductors...	• deduct ANOTHER ONE from *Table 23.*
• For conductors running through the box...	• count ONE conductor for each conductor running through the box.
• For conductors that originate outside of box and terminate inside of box...	• count ONE conductor for each conductor originating outside and terminating in box.
• If no part of the conductor leaves the box—for example, a "jumper" wire used to connect a receptacle, as illustrated in Figure 5-21...	• don't count the conductors

Fig. 2–26 Quick checklist for determining proper size boxes.

SELECTING A BOX WHEN ALL CONDUCTORS ARE THE SAME SIZE

EXAMPLE: A box contains one fixture stud and two cable clamps. The number of conductors permitted in the box shall be one less than shown in the table. (Deduct one conductor for the fixture stud.)

A further deduction of two conductors is made for each wiring device in the box, but if two more devices are mounted on the same strap they count as a single device. For example, if a switch and a receptacle are mounted on a single strap, only two conductors are deducted.

SELECTING A BOX WHEN CONDUCTORS ARE DIFFERENT SIZES (*RULE 12-3036(4)*)

When the box contains different size wires, do the following:

- Determine the size of conductors to be used and the number of each (e.g., 2 No. 10 and 2 No. 12).
- Determine if box is to contain any wiring devices (switch or receptacle), wire connectors, or fixture studs. This volume adjustment must be based on the cubic inch volume of the largest conductor in the box.
- Deduct one conductor for each pair (two) of wire connectors. For example, two or three equals one wire, four or five equals two wires. *Note:* if only one wire connector is used it is not counted.
- Deduct two conductors for each switch or receptacle that is less than one inch between the mounting strap and the back of the device.
- Make the necessary adjustments due to devices, wire connectors, and fixture studs.
- Size the box based upon the total volume required for conductors according to *Table 22.*

EXAMPLE: What is the minimum volume required for a box that will contain one switch, two No. 14 wires, and two No. 12 wires? What is the minimum volume required for a box that will contain one switch, two No. 14 wires, two No. 12 wires and three No. 33 wire connectors? The cable is armoured cable.

SOLUTION:

2 No. 14 AWG wires × 24.6 cm^3/wire = 49.2 cm^3
2 No. 12 AWG wires × 28.7 cm^3/wire = 57.4 cm^3
3 wire connectors
each pair counts as 1 wire = 28.7 cm^3
switch
each switch counts as 2 wires = 57.4 cm^3
Total volume = 192.7 cm^3

Therefore, select a box having a minimum volume of 192.7 mL of space. A 3 × 2 × 2½-in (76 × 51 × 64-mm) device box has a volume of 204 mL (12.5 in³) from *Table 23*, and this would be sufficient. The cubic inch volume may be marked on the box; otherwise refer to the second column of *Table 23,* entitled "Cubic Inch Capacity."

When sectional boxes are ganged together, the volume to be filled is the total volume of the assembled boxes. Fittings, such as plaster rings, raised covers, and extension rings, may be used with the sectional boxes. When these fittings are marked with their volume, or have dimensions comparable to those boxes shown in *Table 23*, their volume may be considered in determining the total cubic inch volume to be filled (see *Rule 12–3036(6)*). In some cases the volume listed in *Table 23* is not equivalent to the length × width × depth of the box. When doing calculations using boxes listed in *Table 23*, the volume found in the table must be used. Otherwise multiply L × W × D to find the actual volume of the box. For example, a 12 × 12 × 6-in (305 × 305 × 152-mm) box is not found in *Table 23*. Therefore the box volume is 12 × 12 × 6 = 864 in³ (14.1 L). Fig. 2–27 shows how a ¾-inch (19-mm) raised cover (plaster ring) increases the wiring space of the box to which it is attached.

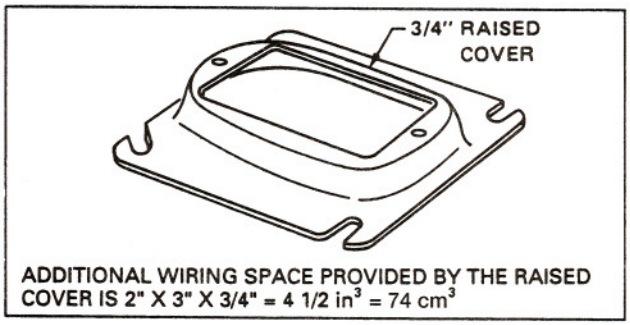


Fig. 2–27 Raised cover. Raised covers are sometimes called plaster rings.

Electrical inspectors have become very aware of the fact that GFCI receptacles, dimmers, and certain types of timers take up a lot more space than regular receptacles. Therefore, it is a good practice to install switch (device) boxes that will provide lots of room for wires, instead of pushing, jamming, and crowding the wires into the box.

EXAMPLE: How many No. 12 conductors are permitted in the box and raised plaster ring shown in Fig. 2–28?

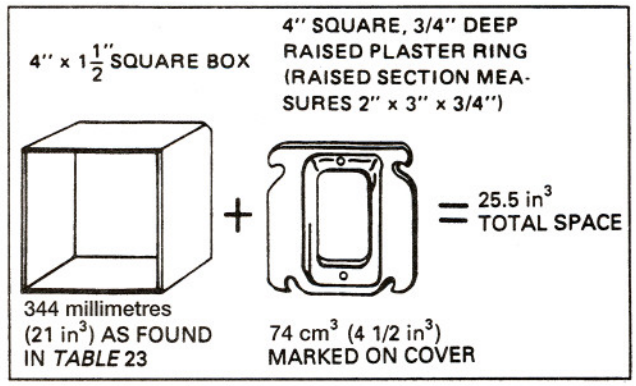


Fig. 2–28 Area of box and plaster ring.

SOLUTION: See *Rule 12–3036* and *Tables 22* and *23* for volume required per conductor.
This box and cover will take:

$$\frac{418 \text{ mL}}{28.7 \text{ mL per No. 12 conductor}}$$ = 14 No. 12 conductors maximum, less the deductions for devices and connectors, per *Rule 12–3036(2).*

Fig. 2-29 shows how transformer leads No. 18 AWG or larger must be counted when selecting a box.

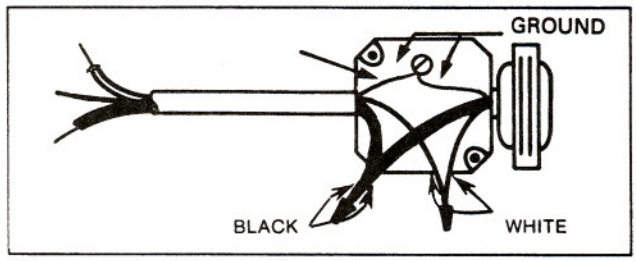


Fig. 2-29 Transformer leads No. 18 AWG or larger must be counted when selecting the proper size box, *Rule 12–3036(1).* In the example shown, the box is considered to contain four conductors.

Wire No. 16 or No. 18 AWG supplying a lighting fixture is not counted when sizing the box that the fixture is mounted on. This is stated in *Rule12–3036(1)(d).* Refer to Fig. 2-30.

Fig. 2–18, **Quick-check box selector guide** (page 24), shows some of the most popular types of boxes used in residential wiring, and can be referred to as you work your way through this text.

When wiring with cable, "feeding through" a

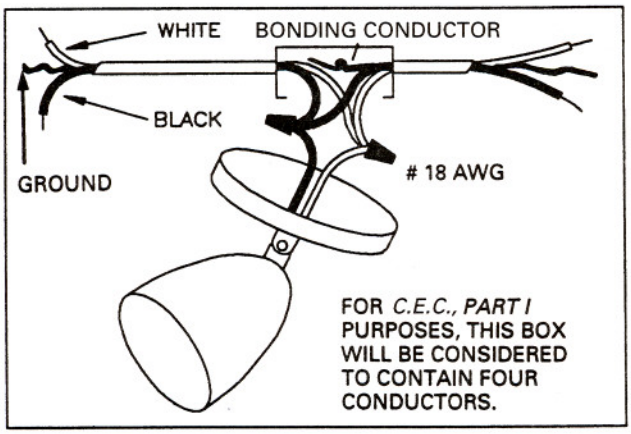


Fig. 2–30 Fixture wires are not counted when determining correct box size. The *C.E.C., Part I, Rule 12–3036(1)(d)* specifies that No. 18 and No. 16 AWG fixture wires supplying a lighting fixture, mounted on the box containing the fixture wires, shall not be counted.

box is impossible. But, when installing the wiring using conduit, it is possible to feed straight through a box. Only one wire is deducted for a wire running straight through a box.

BOX FILL

The following method can makes "box fill" easier to calculate when determining the proper size junction box or wall box to install:

1. Count the number of circuit wires.
2. Add one wire for fixture stud (if any).
3. Add one wire for each pair of wire connectors.
4. Add one wire for one or more isolated (insulated) grounding conductors (if any).
5. Add two wires for each wiring device.

Look up the total count in *Table 23* to find a box appropriate for the intended use that will hold the number of conductors required, as totalled above.

EXAMPLE: Six circuit conductors	6
One wiring device (switch)	+2
Three wire connectors	+1
Total	9

Therefore, select a box capable of containing nine or more conductors. See *Table 23*.

It is possible to select a smaller box when using EMT than when using the cable wiring method because it is possible to "loop" conductors through the box. These only count as one conductor for the purpose of box fill count. See Fig. 2–31 (page 32).

HEIGHT OF RECEPTACLE OUTLETS

There are no hard-and-fast rules for locating most outlets. A number of conditions determine the proper height for a switch box. For example, the height of the kitchen counter backsplash determines where the switches and receptacle outlets are located between the kitchen countertop and the cabinets.

The electric heat for the residence featured in this text is discussed in Unit 23. The type of electric heat could be

- electric furnace (as in this text).
- electric resistance heating buried in ceiling plaster or sandwiched between two layers of drywall material.
- electric baseboard heaters.

Let us consider electric baseboard heaters. In most cases, the height of these electric baseboard units from the top of the unit to the finished floor seldom exceeds 150 mm (6 in). The important issue here is that the manufacturer's receptacle accessories may have to be used to conform to the receptacle spacing requirements as covered in *Rule 26–702* of the *C.E.C., Part I.*

Electrical receptacle outlets are not permitted to be located above an electric baseboard heating unit. Refer to the section "Location of Electric Baseboard Heaters" in Unit 23. *Rule 26–702(3) Appendix B.*

The location of lighting outlets is determined by the amount and type of illumination required to provide the desired lighting effects. (It is not the intent of this text to describe how proper and adequate lighting is determined. Rather, the text covers the proper methods of installing the circuits for such lighting. If the student is interested, standards have been developed to guide the design of adequate lighting. The local electric utility company can supply information on these standards. The *Instructor's Guide* lists excellent publications relating to proper residential lighting.)

It is common practice among electricians to consult the plans and specifications to determine the proper heights and clearances for the installation of electrical devices. The electrician then has these

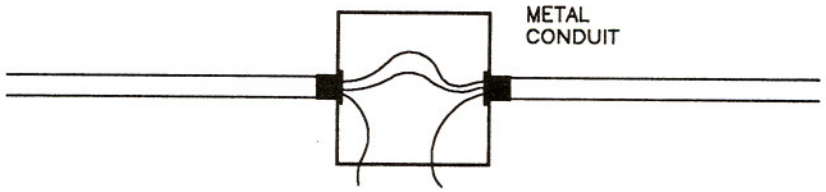


FIGURE A. CONDUIT: SINCE TWO CONDUCTORS ARE LOOPED THROUGH THE BOX, THE CONDUCTOR COUNT IN THIS ILLUSTRATION IS FOUR.

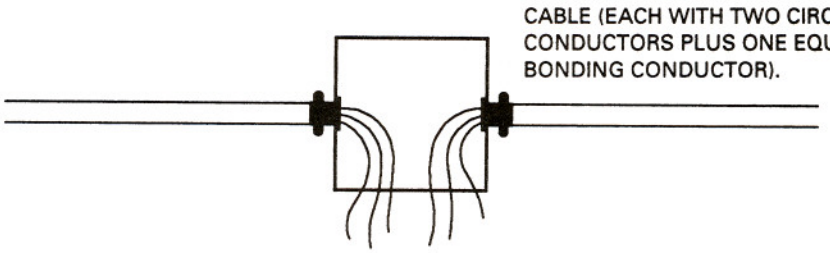


FIGURE B. CABLE, THE CONDUCTOR COUNT IN THIS ILLUSTRATION IS FOUR. THE TWO EQUIPMENT BONDING CONDUCTORS ARE NOT COUNTED.

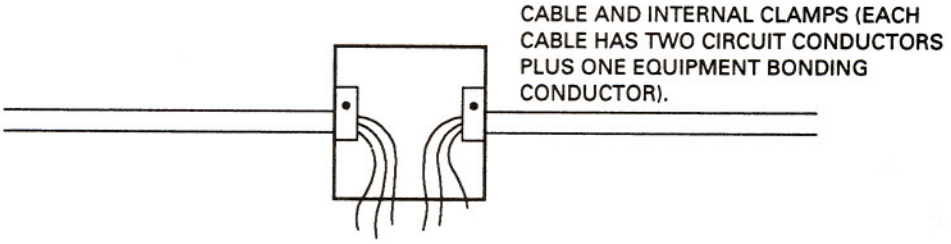


FIGURE C. CABLE AND A BOX WITH INTERNAL CABLE CLAMPS. THE CONDUCTOR COUNT IN THIS ILLUSTRATION IS FOUR. THE TWO EQUIPMENT BONDING CONDUCTORS ARE NOT COUNTED.THE TWO CABLE CLAMPS ARE NOT COUNTED.

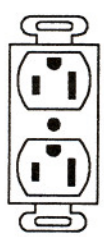
Fig. 2–31 Example of conductor count for both metal conduit and cable installations.

dimensions verified by the architect, electrical engineer, designer, or homeowner. This avoids unnecessary and costly changes in the locations of outlets and switches as the building progresses.

POSITIONING OF RECEPTACLES

Although no actual *C.E.C., Part I* rules exist on positioning receptacles, there is a concern in the electrical industry that a metal wall plate could come loose and fall downward onto the blades of an attachment plug cap that is loosely plugged into the receptacle, thereby creating a potential shock and fire hazard. Here are the options.

Recommended

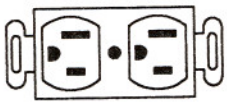


Grounding hole to the top. A loose metal plate could fall onto the grounding blade of the attachment plug cap, but no hazard would result.

Not Recommended

Grounding hole to the bottom. A loose metal plate could fall onto both the grounded neutral and "hot" blades, a potential hazard.

Recommended



Grounded neutral blades on top. A loose metal plate could fall onto these grounded neutral blades with no hazardous effect.

Not Recommended

"Hot" terminal on top. A loose metal plate could fall onto these live blades. If this was a split-circuit receptacle fed by a three-wire, 120 240-volt circuit, the short would be across the 240-volt line.

To ensure uniform installation and safety, and in accordance with long-established custom, standard electrical outlets are located as shown in Fig. 2–32. These dimensions usually are satisfactory. However, the electrician must check the blueprints, specifications, and details for measurements that may affect the location of a particular outlet or switch. The cabinet spacing, available space between the countertop and the cabinet, and the tile height may influence the location of the outlet or switch. For example, if the top of the wall tile is exactly 1.22 m (48 in) from the finished floor line, a wall switch should not be mounted 1.22 m (48 in) to centre. This is considered poor workmanship since it prevents the wallplate from sitting flat against the wall. The switch should be located entirely within the tile area or entirely out of the tile area, Fig. 2–33 (page 34). This situation requires the full cooperation of all trades involved on the construction job and a careful review of the architectural drawings before roughing in the outlets.

Faceplates

Faceplates for switches shall be installed so as to completely cover the wall opening and seat against the wall surface.

Faceplates for receptacles shall be installed so as to completely cover the opening and seat against the mounting surface. The mounting surface might be the wall, or it might be the gasket of a weatherproof box.

Faceplates should be level. In addition, a minor detail that can improve the appearance of the installation is to align the slots in all the faceplate mounting screws in the same direction. See Fig. 2–34 (page 34).

SWITCHES

	*Height above floor
Regular	1.17 m (46 in)
Between counter and kitchen cabinets (depends on backsplash)	1.12–1.17 m (44–46 in)

RECEPTACLE OUTLETS

	*Height above floor
Regular (not permitted above electric baseboard heaters)	300 mm (12 in)
Between counter and kitchen cabinets (depends on backsplash)	1.12–1.17 m (44–46 in)
In garage	1.22 m (48 in)

WALL BRACKETS

	*Height above floor
Outside	1.68 m (66 in)
Inside	1.52 m (60 in)
Side of medicine cabinet	1.52 m (60 in)

*Note
All dimensions given are from the finished floor to the centre of the outlet box. Verify all dimensions before roughing in.

Fig. 2–32 Outlet locations.

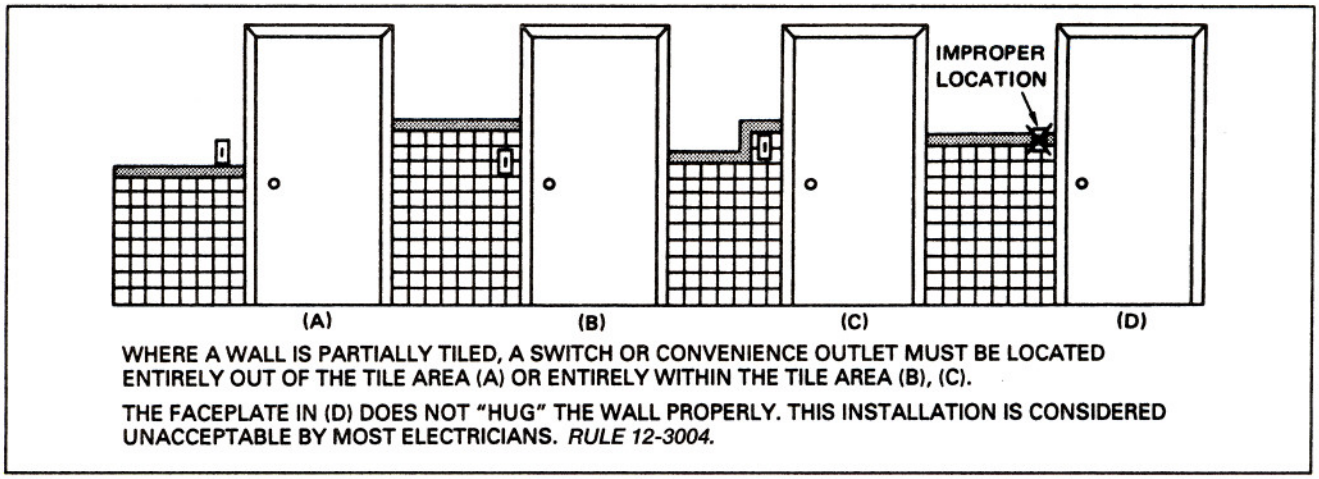


Fig. 2–33 Locating an outlet on a tiled wall.

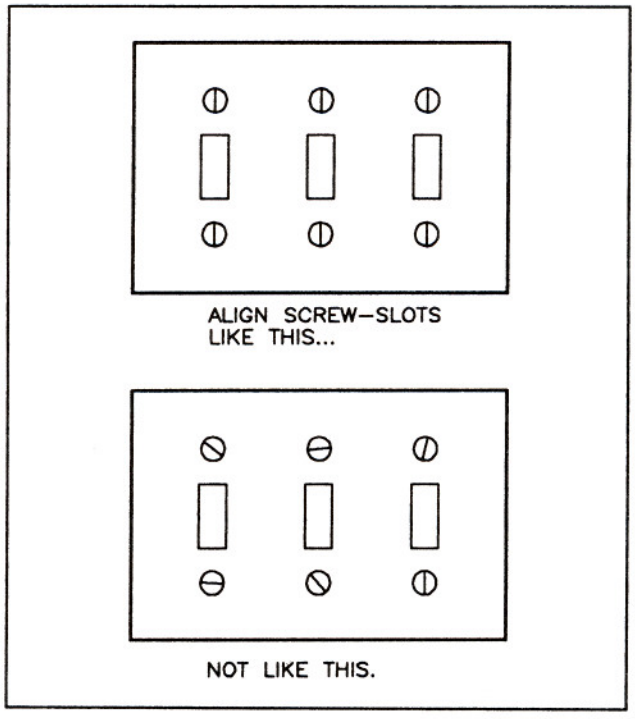


Fig. 2–34 Aligning the slots of the faceplate, mounting screws in the same direction makes the installation look neater.