1

BASIC CONSIDERATIONS

The design and installation of security and fire-alarm systems employs a wide variety of techniques, often involving special types of equipment and materials designed for specific applications. Many systems operate on low-voltage circuits but are installed similarly on conventional electrical circuits for light and power. All installations, when used in buildings, must conform to applicable National Electrical Code (NEC) requirements (especially those codes covered in Chaps. 6 and 7 of the NEC), local ordinances, and instructions provided by security and fire-alarm system manufacturers and design engineers.

CLASSIFICATION OF SIGNAL CIRCUITS

A signal circuit used for a security or fire-alarm system may be classified as *open circuit* or *closed circuit*. An open circuit is one in which current flows only when a signal is being sent. A closed-circuit system is one in which current flows continuously, except when the circuit is opened to allow a signal to be sent.

All alarm systems have three functions in common: detection, control, and annunciation (or alarm) signaling. Many systems incorporate switches or relays that operate when entry, movement, pressure, infrared-beam interruption, and other intrusions occur. The control senses the operation of the detector with a relay and produces an output that may operate a bell, siren, silent alarm such as telephone dialers to law enforcement agencies, or other signal. The controls frequently contain ON/OFF switches, test meters, time delays, power supplies, standby batteries, and terminals for connecting the system together. The control output usually provides power on alarm to operate signaling devices or switch contacts for silent alarms. See the diagram in Fig. 1-1.

An example of a basic closed-circuit alarm system is shown in Fig. 1-2. The detection, or input, subdivision in this drawing shows exit/entry door or window

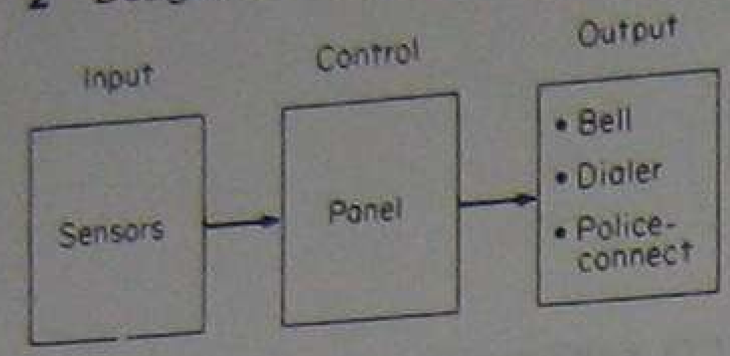

FIGURE 1-1. Basic subdivisions of an alarm system.

contacts. However, the detectors could just as well be smoke or heat detectors, switch mats, ultrasonic detectors, etc.

The control subdivision for the system in Fig. 1-2 consists of switches, relays, a power supply, a reset button, and related wiring. The power supply shown is a 6-V nickel-cadmium battery that is kept charged by a plug-in transformer unit. Terminals are provided on the battery housing to accept 12-Vac charging power from the plug-in transformer which provides 4- to 6-V power for the detection (protective) circuit and power to operate the alarm or output subdivision.

Figure 1-3 shows another closed-circuit system. The protective circuit consists of a dc energy source, any number of normally closed intrusion-detection contacts (wired in series), a sensitive relay (R_1), and interconnecting wiring. In operation, the normally closed intrusion contacts are connected to the coil of the sensitive relay. This keeps the relay energized, holding its normally closed contacts open against spring pressure—the all-clear condition of the protective circuit. The opening of any intrusion contact breaks the circuit, which de-energizes the sensitive relay and allows spring force to close the relay contacts. This action initiates the alarm.

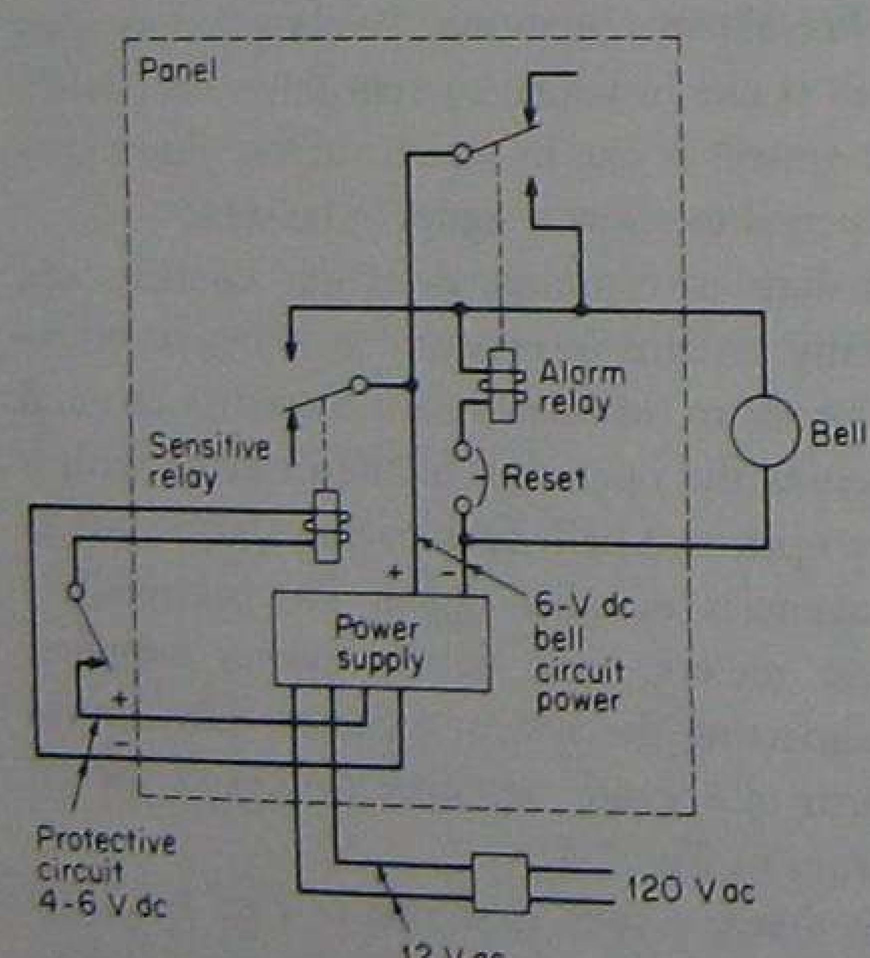

FIGURE 1-2. Basic closed-circuit security alarm system.

The key-operated switch shown in the circuit in Fig. 1-3 is provided for opening the protective circuit for test purposes. A meter (M) is activated when the switch is set to CIRCUIT TEST. The meter gives a current reading only if all intrusion contacts are closed. All three sections of the switch (S_1, S_2, S_3) make contact simultaneously as the key is turned.

Opening of intrusion contacts is not the only event that causes the alarm to activate. Any break in protective-circuit wiring or loss of output from the energy source has the same effect. The circuit is broken which de-energizes the sensitive relay and allows spring force to close the relay contacts, thus sounding the alarm. Any cross or short circuit between the positive and negative wires of the protective circuit also keeps current from reaching the relay coil and causes dropout which again sounds the alarm.

Other components of the alarm circuit in Fig. 1-3 include a second energy source, an alarm bell, and a drop relay (R_2). When the keyed switch is at ON, dropout of the sensitive relay R_1 and closing of its contacts completes a circuit to energize the coil of drop relay R_2. Closing of the drop relay's normally open contacts rings the bell and latches in the drop-relay coil so that R_2 stays energized even if the protective circuit returns to normal and opens the sensitive relay's contacts. As a result, the bell continues to ring until the key switch is turned away from ON to break the latching connection to the R_2 coil.

Drop relays often have additional contacts to control other circuits or devices. The extra contacts in the circuit in Fig. 1-3 are for turning on lights, triggering an automatic telephone dialer, etc. But the main two functions of the drop relay

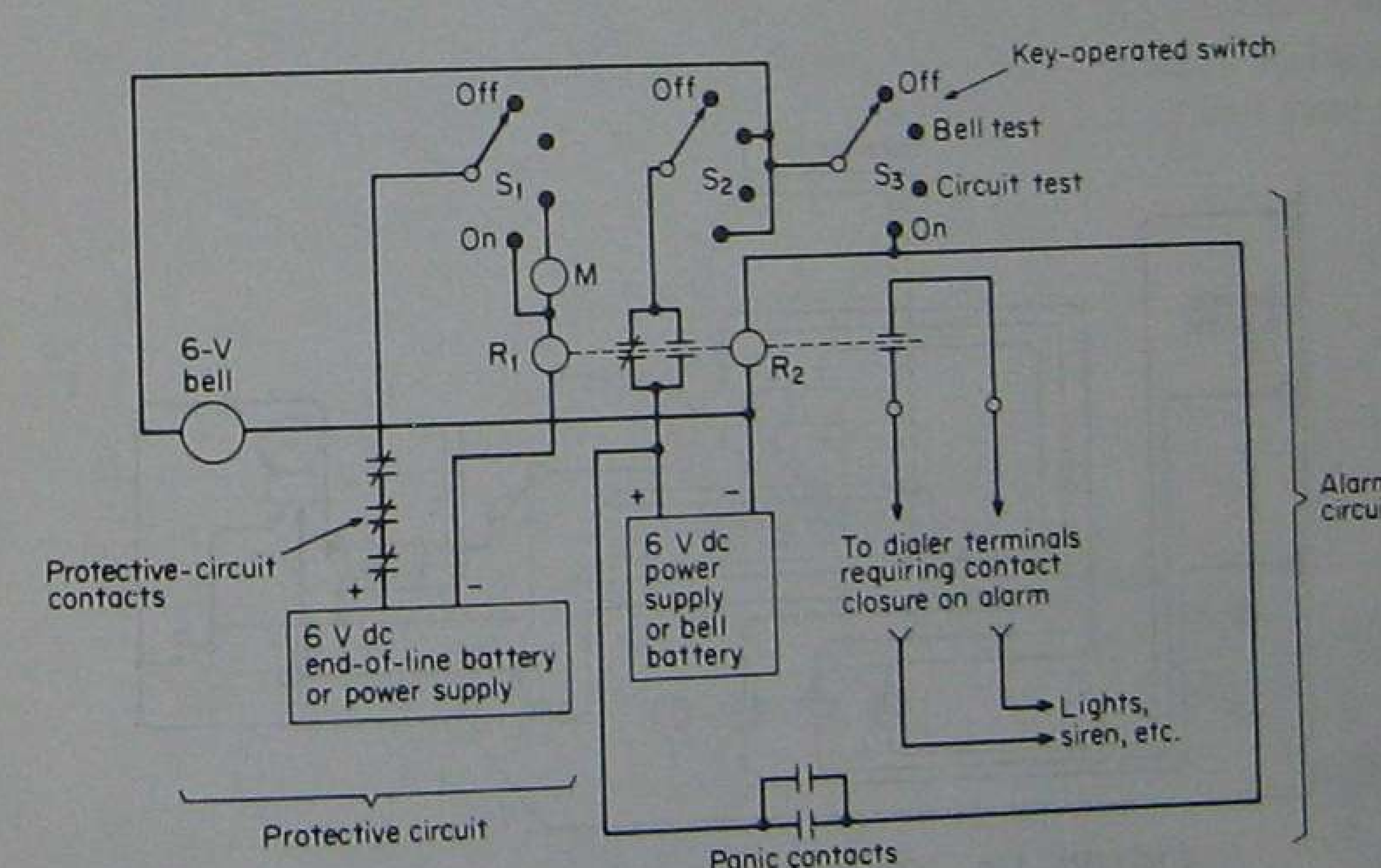

FIGURE 1-3. Closed-circuit security alarm system.

are actuation of the alarm and latching the coil to keep the circuit in the alarm condition.

Almost all burglar systems use a closed-loop protective circuit, so only a very brief description of an open-circuit system will be given here. In general, the system consists of an annunciator connected to a special design contact on each door and window and a relay so connected that when any window or door is opened it will cause current to pass through the relay. The relay, in turn, will operate to close a circuit on a bell, horn, or other type of annunciator which will continue to sound until it is shut off, thereby alerting the occupants or law enforcement agencies.

The wiring and connections for the open-circuit system are shown in Fig. 1-4. This wiring diagram shows three contacts, but any number can be added as needed. Closing any one of the contacts completes the power circuit through the winding of the proper annunciator drops, the constant-ringing switch, the constant-ringing relay, the alarm bell, and the bell-cutoff switch. The current through the winding of the constant-ringing relay operates to complete a circuit placing the alarm bell directly across the battery or other power source so the bell continues to ring until the cutoff switch is opened. At the same time, current in another set of wires operates a relay that closes an auxiliary circuit to operate other devices, such as lights and automatic telephone dialer.

A spring-type contact for open-circuit operation is shown in Fig. 1-5. This device is set in the window frame so that cam *c* projects outward. When the window is raised, the cam pivots and is pressed in and makes contact with spring *s*, which is insulated from the plate by a washer at the lower end and is held free

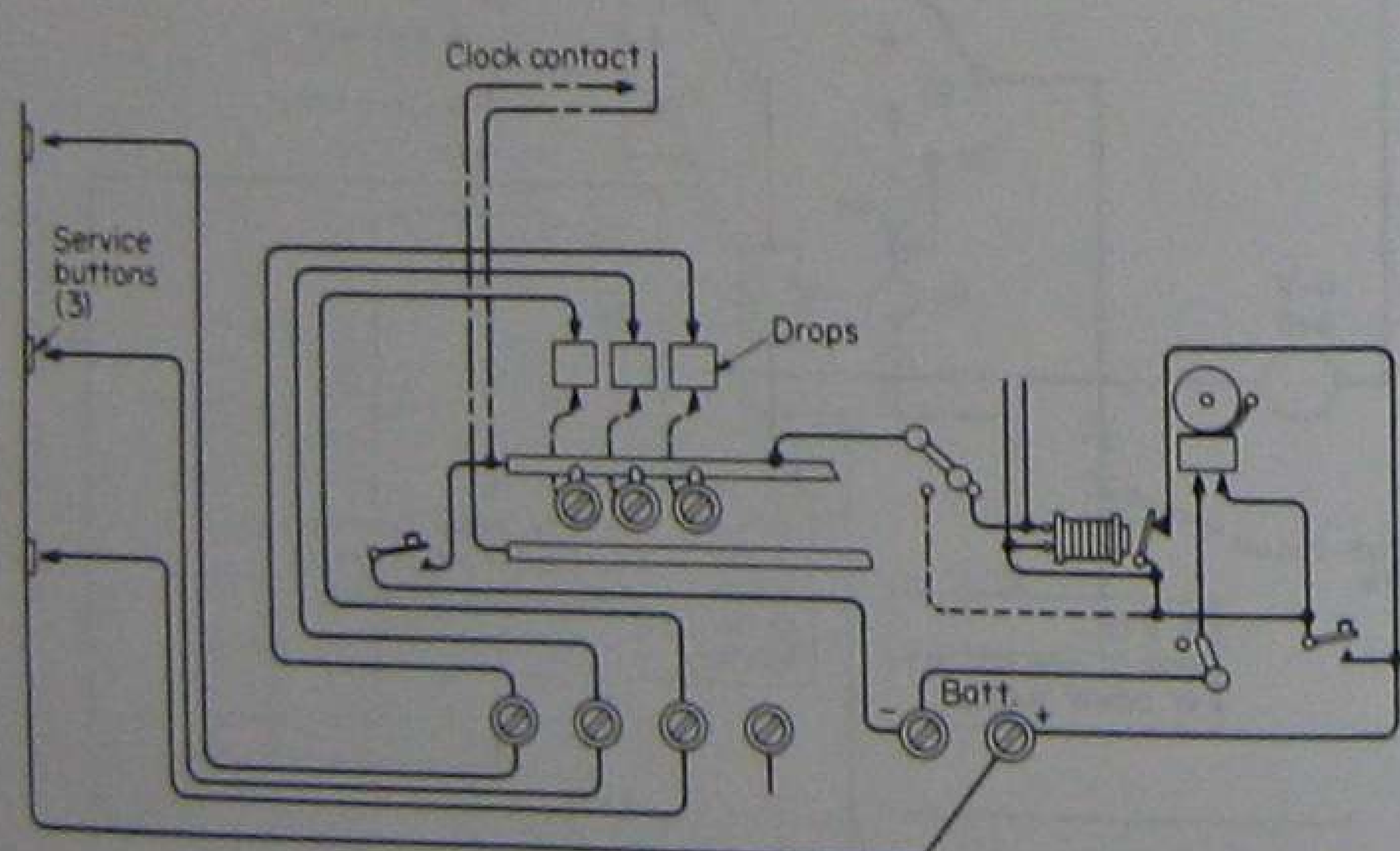

FIGURE 1-4. Open-circuit security alarm system.

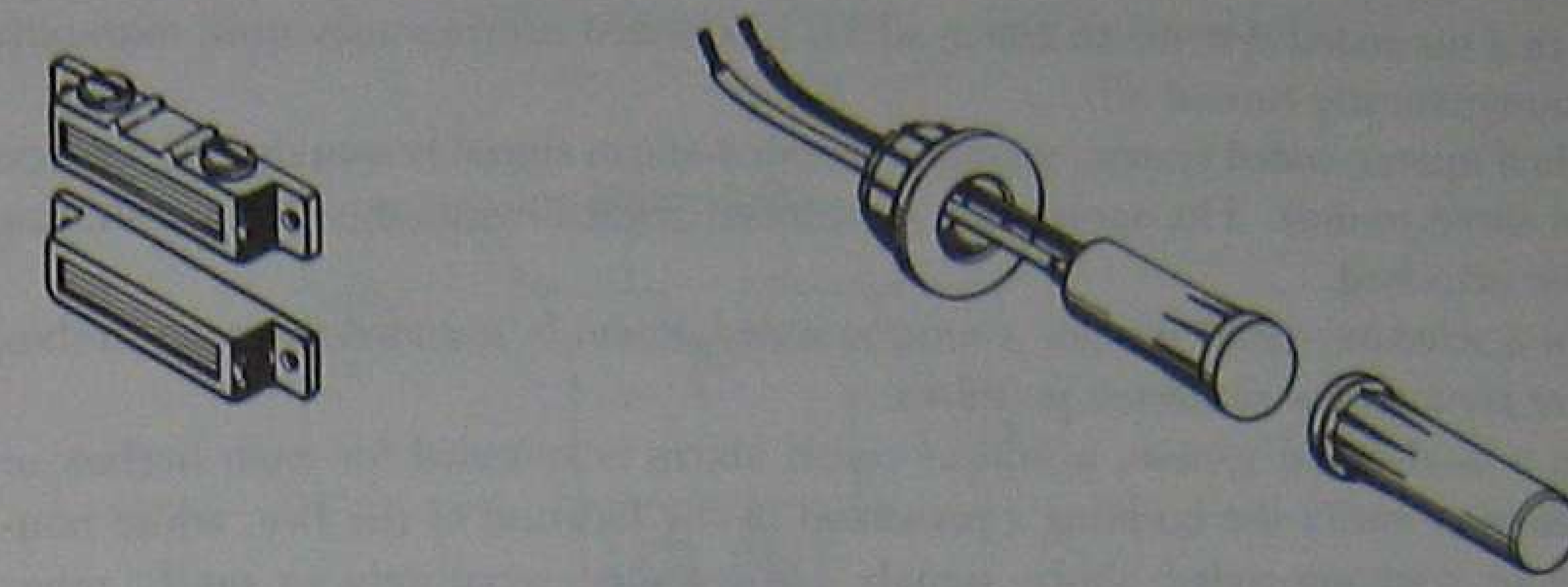

FIGURE 1-5. Spring-type contact for open-circuit operation.

from *c* by the insulating wheel *w*. This contact is connected in series with the power source and the annunciator; that is, one wire is connected to the plate and the other to the spring. An old type of door contact for an open-circuit system is shown in Fig. 1-6.

FIRE-ALARM SYSTEMS

A fire-alarm system consists of sensors, a control panel, an annunciator, and the related wiring to connect the components. Fire-alarm systems generally may be divided into four types: noncoded, master-coded, selective-coded, and dual-coded.

Each of these four types has several functional features so designed that a specific system may meet practically any need to comply with local and state fire codes, statutes, and regulations.

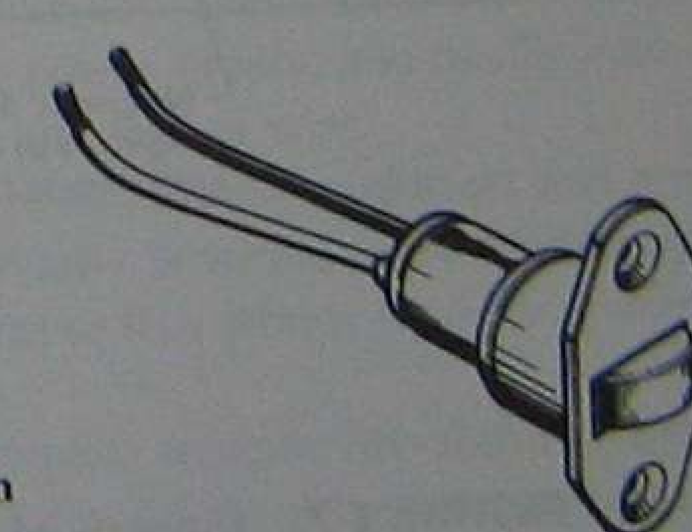

FIGURE 1-6. Old type of door contact for an open-circuit security system.

In a noncoded system, an alarm signal is sounded continuously until manually or automatically turned off.

In a master-coded system, a common-coded alarm signal is sounded for not less than three rounds. The same code is sounded regardless of the alarm-initiating device activated.

In a selective-coded system, a unique coded alarm is sounded for each firebox or fire zone on the protected premises.

In a dual-coded system, a unique coded alarm is sounded for each firebox or fire zone to notify the building's personnel of the location of the fire, while non-coded or common-coded alarm signals are sounded separately to notify other occupants to evacuate the building.

A fire-alarm system riser diagram is shown in Fig. 1-7. Basically, if any smoke detector senses smoke or if any manual striking station is operated, all bells within the building will ring, indicating a fire. At the same time, the magnetic door switches will release the smoke doors to help block smoke and/or drafts. This

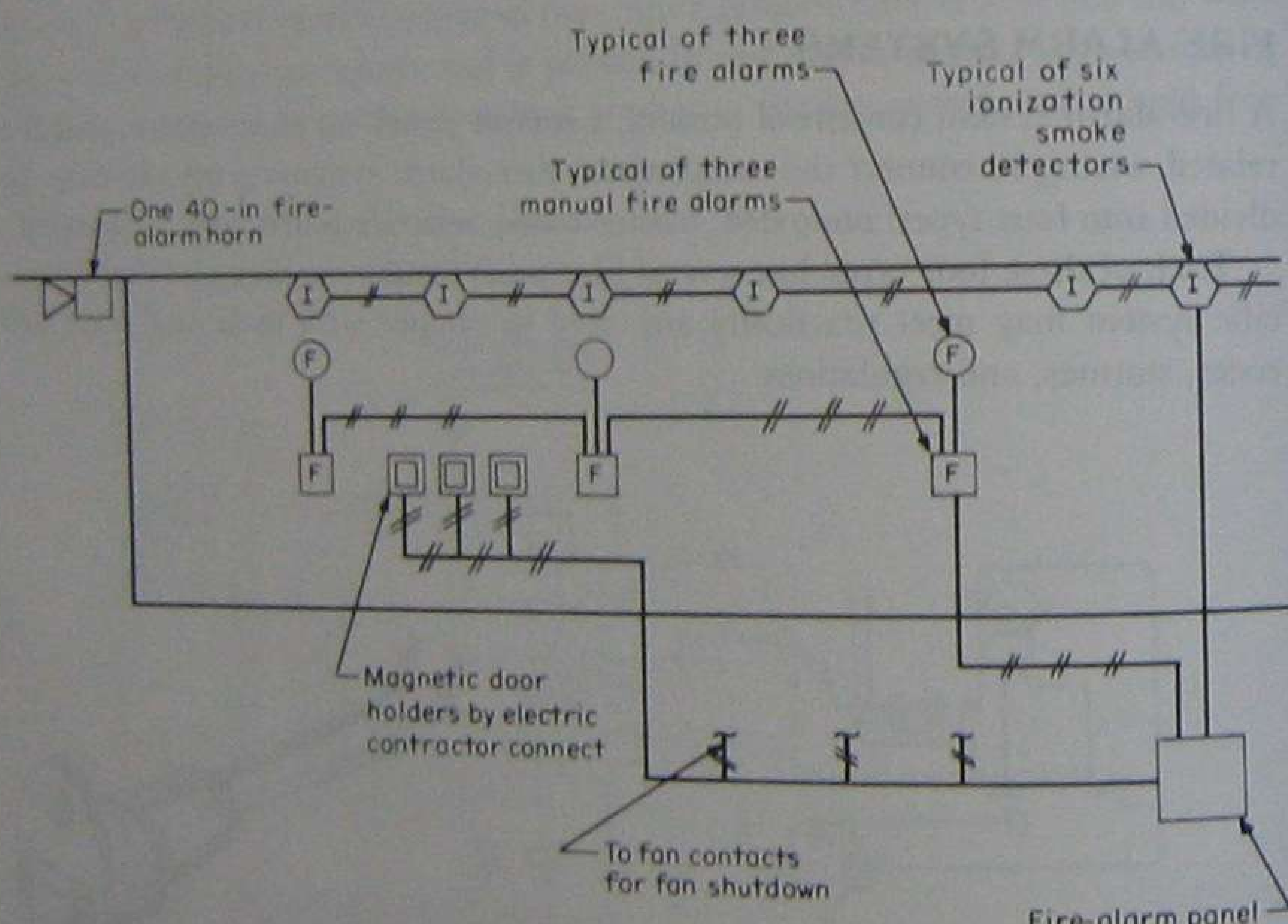

FIGURE 1-7. Diagram of a fire-alarm system riser for a courthouse.

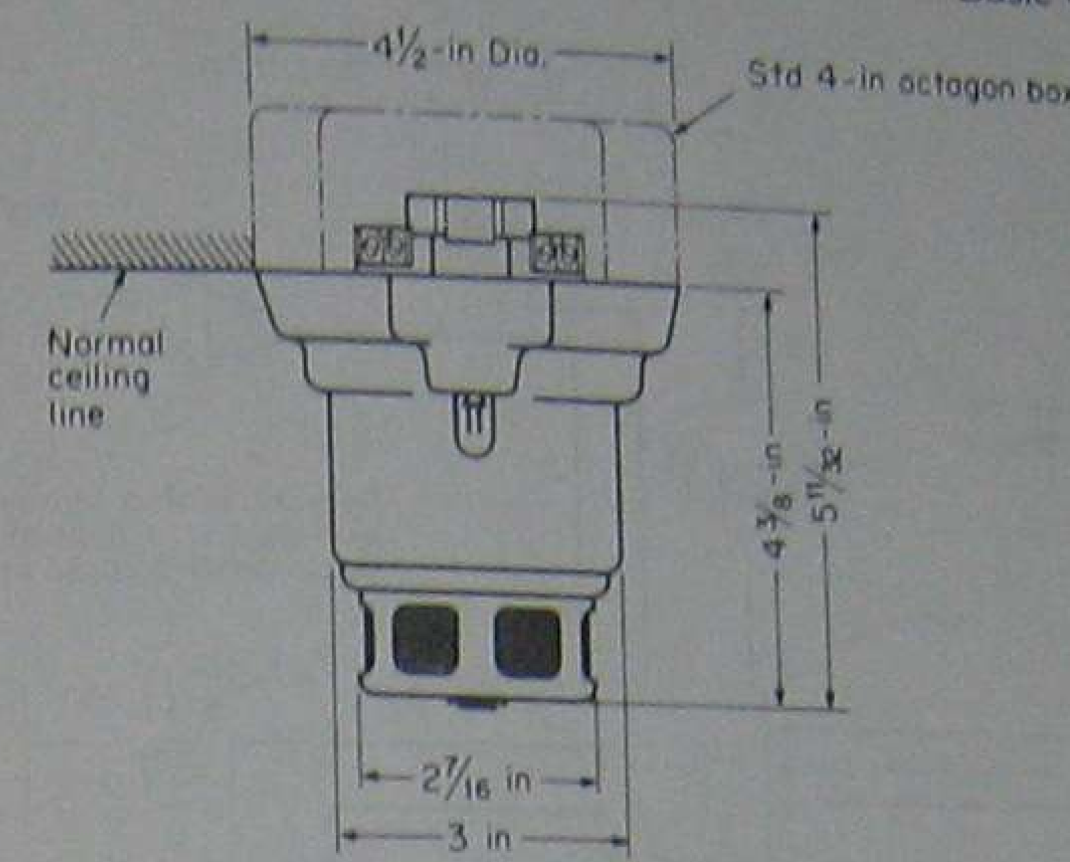

FIGURE 1-8. Ionization smoke detector.

system is also connected to a water-flow switch on the sprinkler system. If the sprinkler valves are activated causing a flow of water in the system, the fire-alarm system will again go into operation energizing all bells and closing smoke doors.

Ionization smoke detectors (Fig. 1-8) may be used in place of conventional smoke detectors or they may be used in combination with smoke detectors. The ionization smoke detectors are more sensitive than the conventional smoke detectors.

COMPONENTS OF SECURITY/FIRE-ALARM SYSTEMS

Wire sizes for the majority of low-voltage systems range from no. 22 to no. 18 AWG. However, where larger-than-normal currents are required or when the distance between the outlets is long, it may be necessary to use wire sizes larger than specified to prevent excessive voltage drop. Voltage-drop calculations should be made to determine the correct wire size for a given application—even on low-voltage circuits.

The wiring of any alarm system is installed like any other type of low-voltage system; that is, locating the outlets, furnishing a power supply, and finally interconnecting the components with the proper size and type of wire.

Most closed systems use two-wire no. 22 or no. 24 AWG conductors and are color-coded to identify them. A no. 18 pair normally is adequate for connecting bells or sirens to controls if the run is 40 ft (12 m) or less. Many, however, prefer to use no. 16 or even no. 14 cable.

A summary of the various components for a typical security/fire-alarm system is depicted in Fig. 1-9. The following list gives a description of these components.

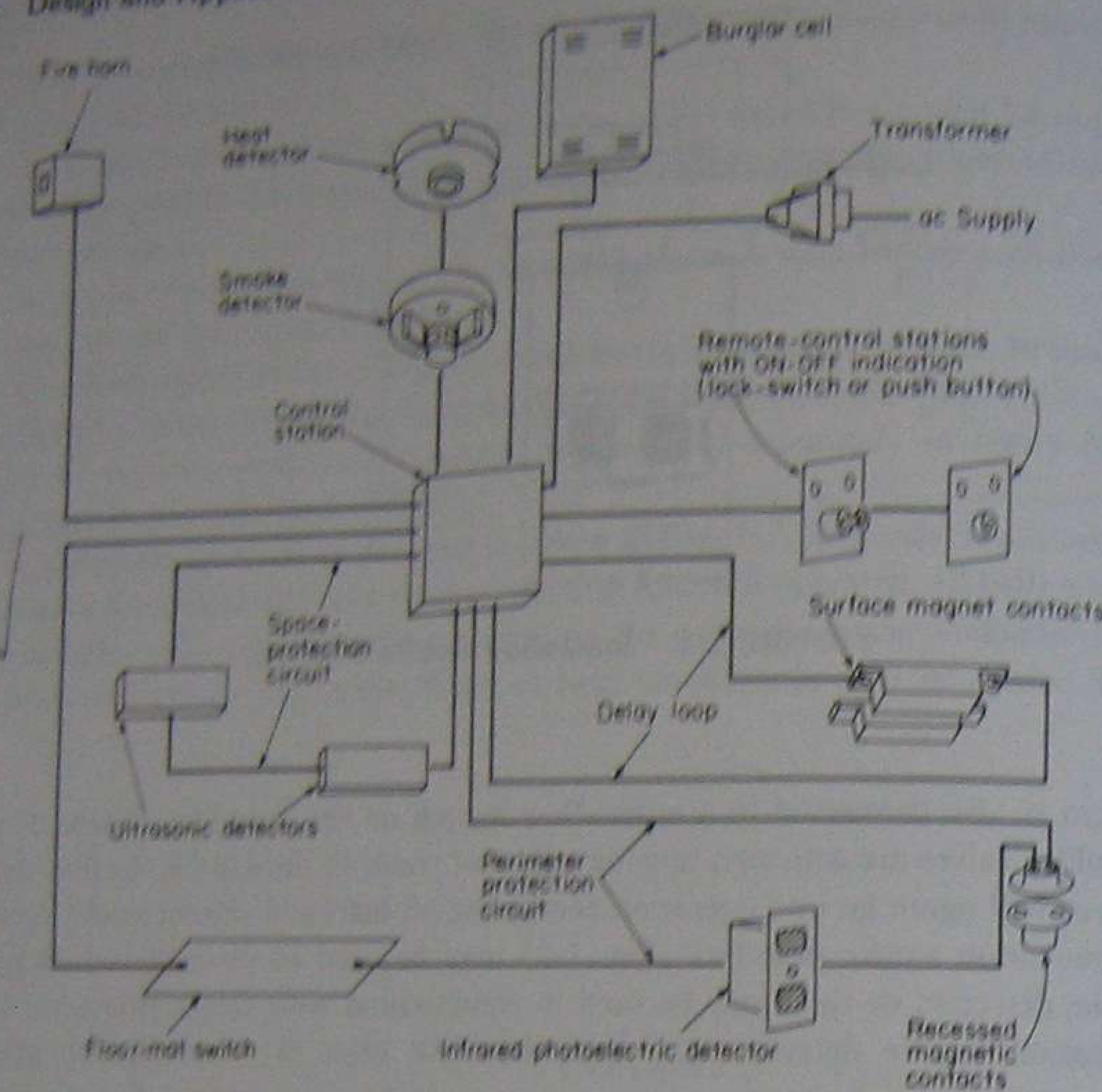

FIGURE 1-9. Various components for a typical security/fire-alarm system.

Control Station: This is the heart of any security system since it is the circuitry in these control panels that senses a broken contact and then either sounds a local bell or horn or omits the bell for a silent alarm. Most modern control panels use relay-type controls to sense the protective circuits and regulate the output for alarm-sounding devices. They also contain contacts to actuate other deterrent or reporting devices and a silent holdup alarm with dialer or police-connected reporting mechanism.

Power Supplies: Power supplies vary for different systems, but in general they consist of rechargeable 6-Vdc power supplies for burglar-alarm systems. The power packs usually contain nickel-cadmium batteries that are kept charged by 12-Vac input from a plug-in or otherwise connected transformer to a 120-V circuit. The better power supplies have the capability of operating an armed system for 48 hours or more without being charged and still have the capacity to ring an alarm bell for 30 minutes or longer. Power supplies are obviously used in conjunction with a charging source and supply power for operation of the alarm system through the control panel.

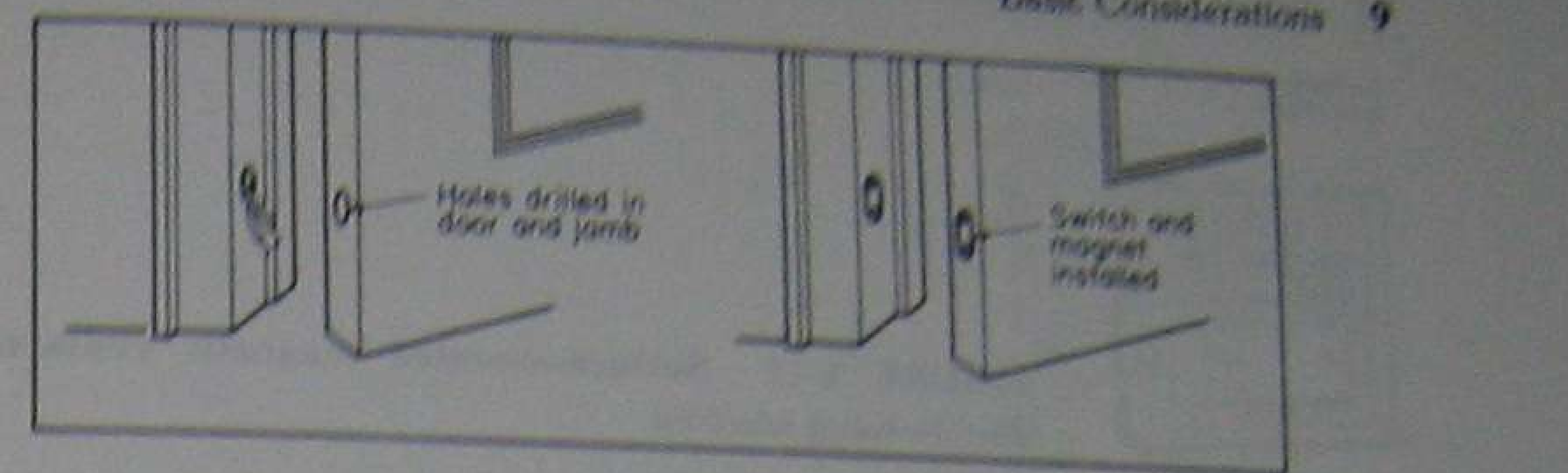

FIGURE 1-10. Recessed magnetic contacts in door.

Recessed Magnetic Contacts in Door (Fig. 1-10): Holes are drilled in the door and in the casing, one directly across from the other, and a pair of wires from the positive side of the protective circuit is run out through the switch hole. The switch and magnet are then installed with no more than a ⅛-in (0.3 cm) gap between them.

Recessed Magnetic Contacts in Casement Window (Fig. 1-11): A switch and magnet are installed as in the door, preferably in the top of the window and underside of the upper window casing, where they will be least noticeable.

Surface-Mounted Magnetic Contacts on Double-Hung Window (Fig. 1-12): A switch is mounted on the window casing with a magnet on the window casing and a magnet on the window. As long as the switch and magnet are parallel and in close proximity when the window is shut, they may be oriented side-to-side, top-to-side, or top-to-top.

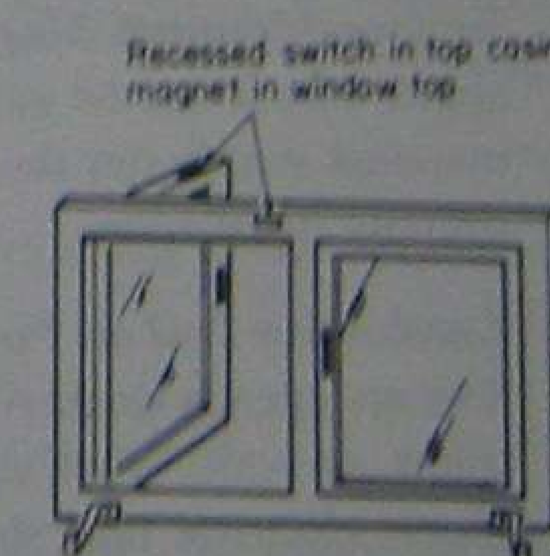

FIGURE 1-11. Recessed magnetic contacts in casement window.

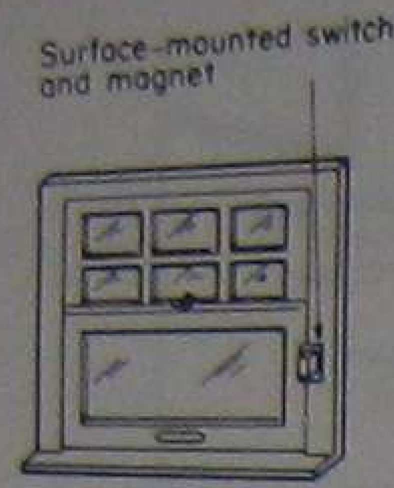

FIGURE 1-12. Surface-mounted magnetic contacts on double-hung window.

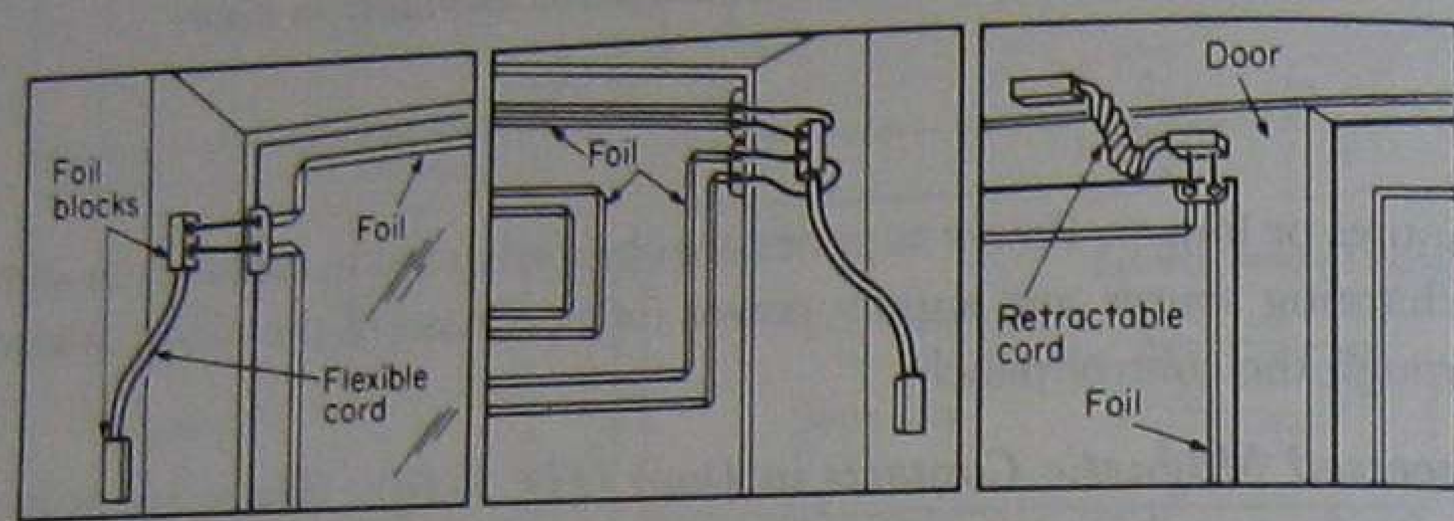

FIGURE 1-13. Conductive foil on glass doors.

Conductive Foil on Glass Doors (Fig. 1-13): A self-adhesive foil block (terminator) on the door is connected to a similar unit on the door frame by a short length of flexible cord to allow for door movement. The foil is connected in the positive conductor of the protective circuit and is adhered to the glass parallel to and about 3 in (7.6 m) from the edge of the glass, using recommended varnish. Breaking the glass breaks the foil and opens the circuit. To provide more coverage, a double circuit of foil may be taken from the foil block. Coiled, retractable cords are available for use between foil blocks to allow for sliding-door travel.

Complete Glass-Door Protection (Fig. 1-14): A glass door with a glass transom may be protected by a combination of magnetic contacts and foil.

Surface-Mounted Magnetic Contacts on Door (Fig. 1-15): Where appearance is not the most important consideration, the use of a surface-mounted switch (on the door frame) and a magnet (on the door) will simplify installation.

Conductive Foil on Picture Windows (Fig. 1-16): Where a window does not open, a single run of foil is connected to a foil block on the glass, frame, or wall. When the foil crosses over a frame member, a piece of plastic electrical tape should be used to provide an insulated crossover surface for the foil.

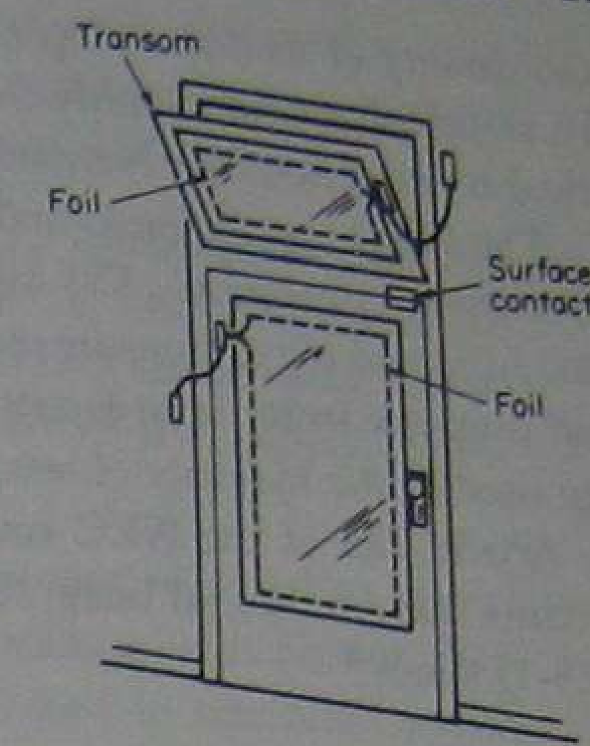

FIGURE 1-14. Complete glass-door protection.

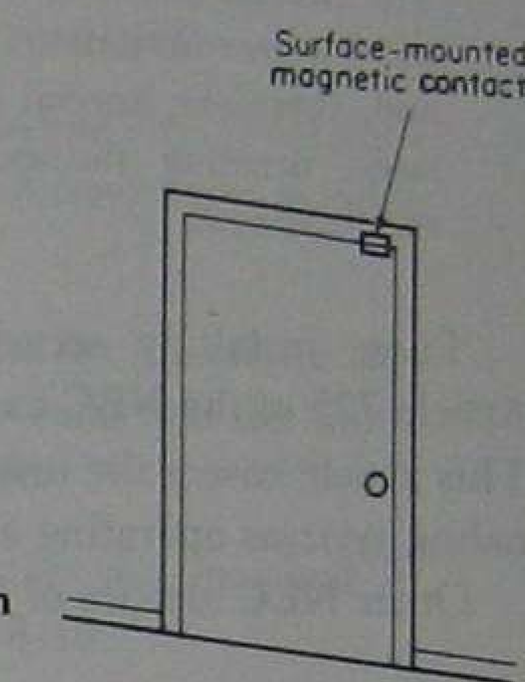

FIGURE 1-15. Surface-mounted magnetic contacts on door.

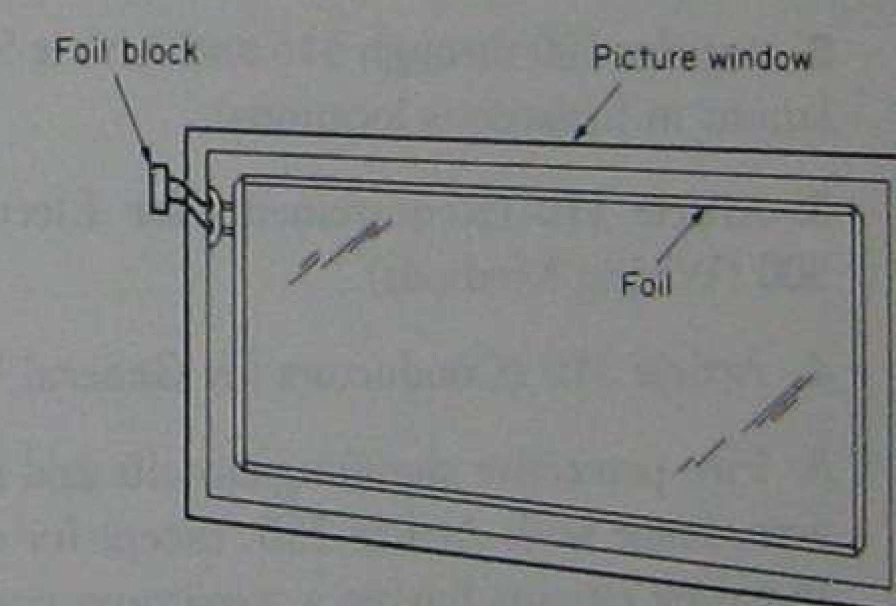

FIGURE 1-16. Conductive foil on picture windows.

These and other components are discussed in more detail in the chapters to follow.

NATIONAL ELECTRICAL CODE REQUIREMENTS

Because of the potential fire and explosion hazards caused by the improper handling and installation of electrical wiring, certain rules in the selection of materials and quality of workmanship must be followed, as well as precautions for safety. To standardize and simplify these rules and provide some reliable guide for electrical construction, the National Electrical Code (**NEC**) was developed.

The **NEC** is published (and frequently revised) by the NFPA (National Fire Protection Association), 470 Atlantic Avenue, Boston, MA 02210. It contains specific rules and regulations intended to help in the practical safeguarding of persons and property from hazards arising from the use of electricity, including low-voltage used in the majority of security/fire-alarm systems.

Article 725 of the **NEC** covers remote-control, signaling, and power-limited circuits that are not an integral part of a device or appliance. The **NEC** (Section 725-1) states:*

> The circuits described herein [Article 725] are characterized by usage and electrical power limitations which differentiate them from light and power circuits and, therefore, special consideration is given with regard to minimum wire sizes, derating factors, overcurrent protection, and conductor insulation requirements.

Those installing security/fire-alarm systems should become familiar with Article 725 of the **NEC** as well as Article 760, Fire Protective Signaling Systems. This article covers the installation of wiring and equipment of fire protective signaling systems operating at 600 volts or less.

Other **NEC** articles of interest to security/fire-alarm installers include:

1. Section 300-21 (Spread of Fire or Products of Combustion).
2. Articles 500 through 516 and Article 517, Part G (dealing with installations in hazardous locations).
3. Article 110 (Requirements for Electrical Installations) and Article 300 (Wiring Methods).
4. Article 310 (Conductors for General Wiring).
5. Fire-protective signaling circuits and equipment shall be grounded in accordance with Article 250, except for dc-power limited fire protective signaling circuits having a maximum current of 0.03 amperes.*
6. The power supply of nonpower-limited fire-protection signaling circuits shall comply with Chapters 1 through 4 and the output voltage shall not be more than 600 volts, nominal.*
7. Conductors of no. 18 and no. 16 size shall be permitted to be used provided they supply loads that do not exceed the ampacities given in

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Table 402-5 and are installed in a raceway or a cable approved for the purpose. Conductors larger than no. 16 shall not supply loads greater than the ampacities given in Tables 310-16 through 310-19.

8. When only nonpower-limited fire-protective signaling circuits and Class 1 circuits are in a raceway, the number of conductors shall be determined in accordance with Section 300-17. The derating factors given in Note 9 to Tables 310-16 through 310-19 shall apply if such conductors carry continuous loads.*
9. Where power-supply conductors and fire-protective signaling circuit conductors are permitted in a raceway in accordance with Section 760-15, the number of conductors shall be determined in accordance with Section 300-17. The derating factors given in Note 8 to Tables 310-16 through 310-19 shall apply as follows:
   a. To all conductors when the fire-protective signaling circuit conductors carry continuous loads and the total number of conductors is more than three.
   b. To the power-supply conductors only when the fire-protective signaling circuit conductors do not carry continuous loads and the number of power-supply conductors is more than three.
10. Where fire-protective signaling circuit conductors are installed in cable trays, comply with Sections 318-8 through 318-10.

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2

CONTROLS

Devices used to control security/fire-alarm systems vary from simple toggle switches to complex systems utilizing components such as relays, timers, magnetic contacts, and so forth. This chapter is designed to acquaint the reader with some of the control circuits normally found in security and fire-alarm systems.

FIRE-ALARM SYSTEMS

Fire-alarm systems for commercial and industrial use usually fall into four basic categories: noncoded, master-coded, selective-coded, and dual-coded. Each of these four systems has several functional features to accommodate a building's needs and to satisfy local and state fire codes, statutes, and regulations.

In a noncoded system, an alarm signal is sounded continuously until manually or automatically turned off.

In a master-coded system, a common-coded alarm signal is sounded for not less than three rounds. The same code is sounded regardless of the alarm-initiating device activated.

In a selective-coded system, a unique coded alarm is sounded for each firebox or fire zone on the protected premises.

In a dual-coded system, a unique coded alarm is sounded for each firebox or fire zone to notify the owner's personnel of the location of the fire, while noncoded or common-coded alarm signals are sounded separately to notify other occupants to evacuate the building.

One of the best ways to understand the control function of the various fire-alarm systems is to analyze existing systems. For example, Fig. 2-1 shows a partial floor plan of a nursing home. This portion of the floor plan shows the fire-alarm panel, smoke detectors (designated SD), striking stations, gongs (bells), and mag-

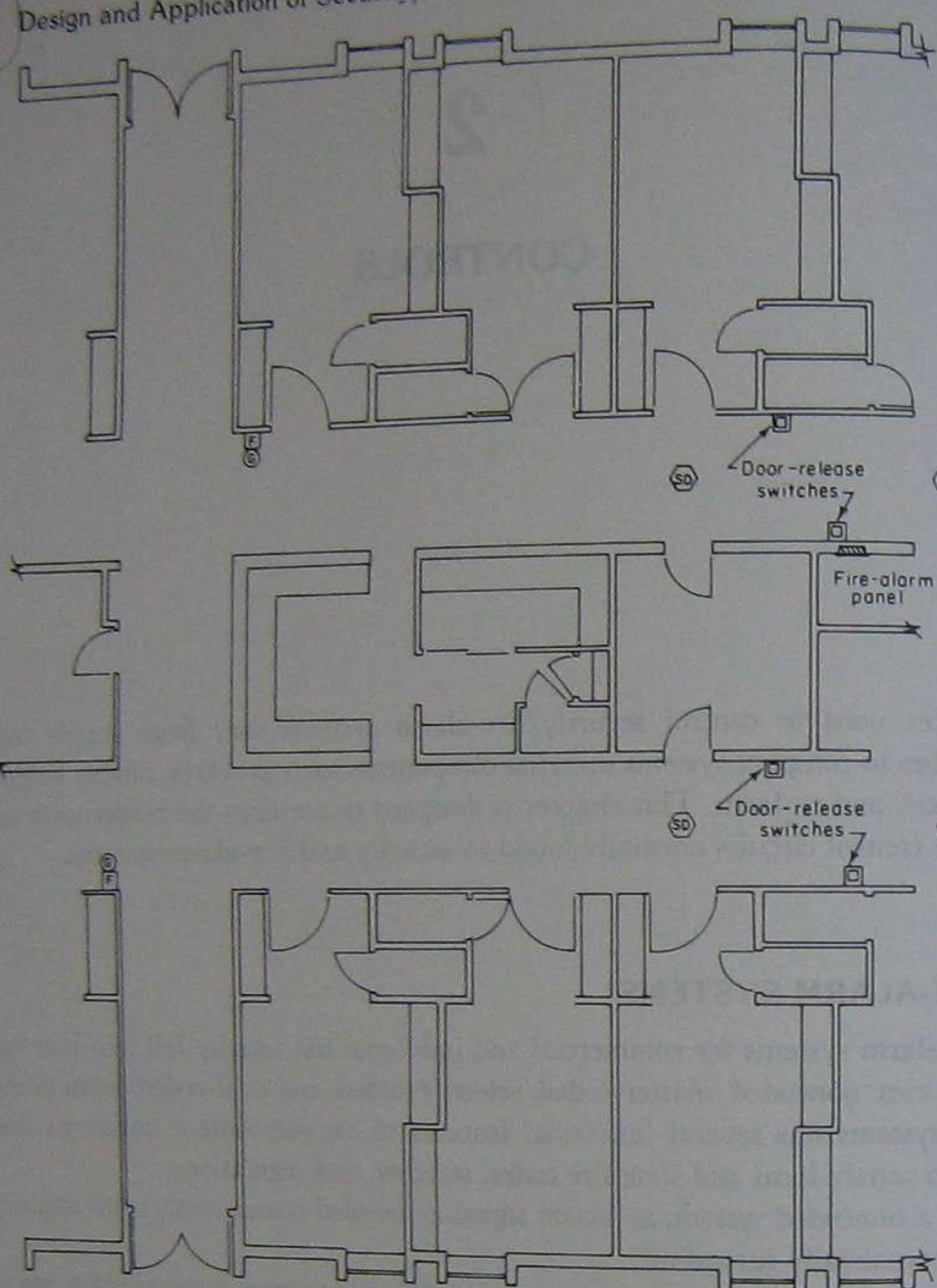


FIGURE 2-1. Partial floor plan of a nursing home showing the fire-alarm system.

netic door-release switches. The fire-alarm riser diagram in Fig. 2-2 shows all devices connected to this system, along with the wiring for each.

Basically, if any smoke detector senses smoke or if any manual striking station is operated, all bells within the building sound, indicating a fire. At the same time, the magnetic door switches release the smoke doors to help block smoke and/or drafts. This system is also connected to a water-flow switch on the sprinkler system. If the sprinkler valves are activated causing a flow of water in the system, the

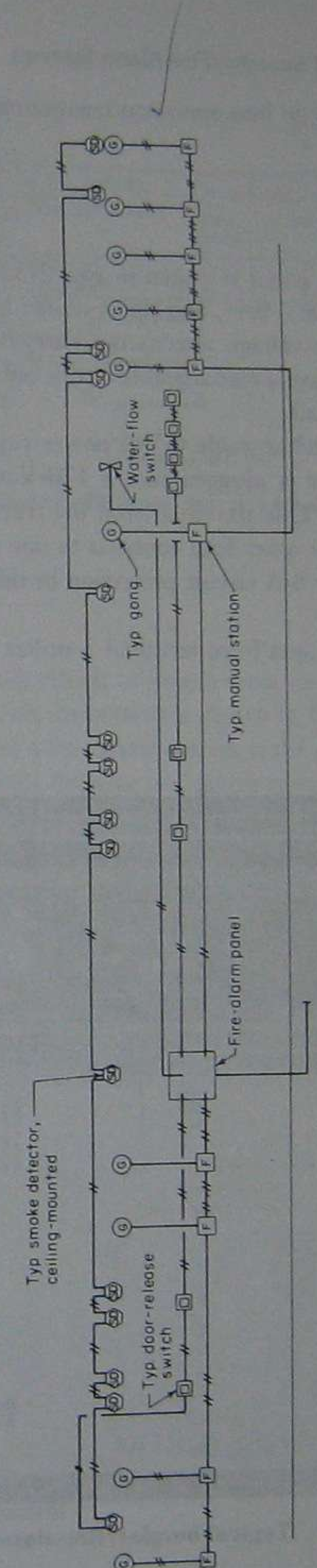


FIGURE 2-2. Fire-alarm riser diagram for the system shown in Fig. 2-1.

fire-alarm system will again go into operation energizing all bells and closing all smoke doors.

CONTROL PANELS

A typical burglar/fire-alarm panel is shown in Fig. 2-3. This particular panel is designed for combined burglar-, fire-, and panic-alarm systems. This panel, and most others, operate on low-voltage alternating current from a plug-in transformer. Many systems also have a rechargeable or dry cell battery pack for backup power should the ac source fail.

A wiring diagram for a rechargeable 6-Vdc power supply is shown in Fig. 2-4. Note that the transformer is plugged into a 120-Vac outlet which provides 12Vac on its secondary side. One terminal from the transformer connects to the charging circuit (1) while the other lead connects to one side of the battery (B_1). Fuse F_1 and resistor R_2 offer 6-A circuit protection in this case. R_2 also provides short-circuit protection.

The protective-circuit contacts from terminal 5 utilize a 100-Ω, 2-W resistor

FIGURE 2-3. Typical burglar/fire-alarm panel.

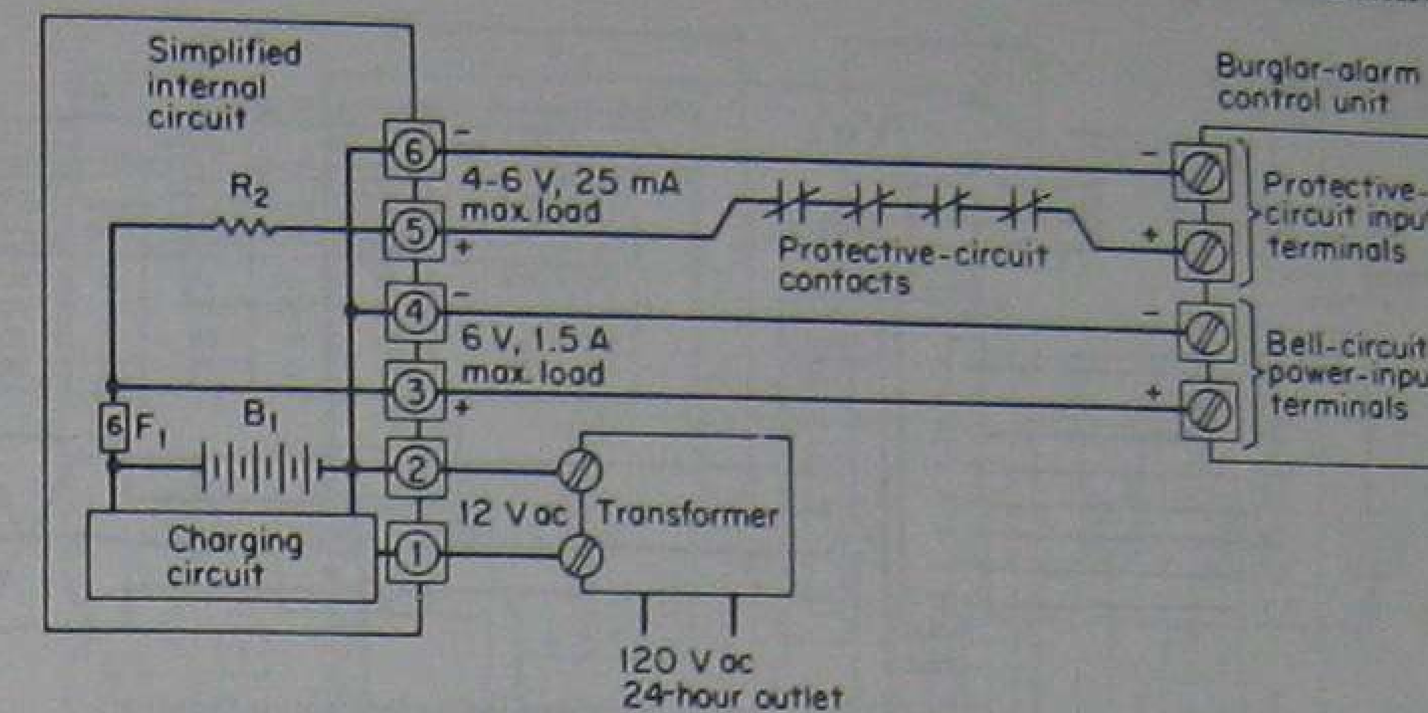


FIGURE 2-4. Wiring diagram for a rechargeable 6-Vdc power supply.

in the positive feed to each circuit to keep a cross on any one zone from affecting other zones. A detail of this connection is shown in Fig. 2-5.

Obviously, the heart of a fire-alarm system is the master control panel. To this panel are connected various detector and alarm circuits, as shown in Fig. 2-6. In this case, the primary power is taken from an unswitched three-wire 120/240 Vac distribution line. The initiating and alarm circuits are connected to the neutral

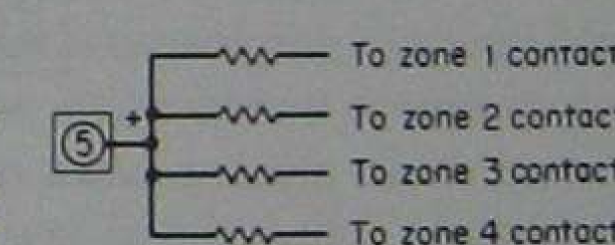


FIGURE 2-5. There are 100-Ω resistors connected in the positive feed to each circuit to keep a cross on any one zone from affecting other zones.

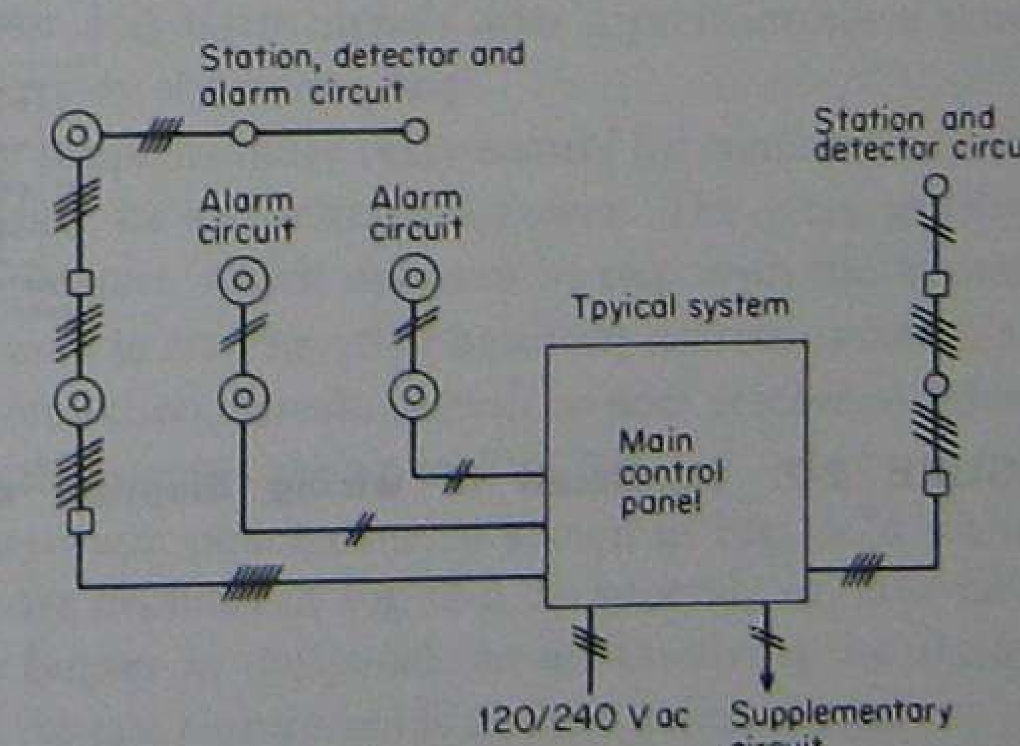
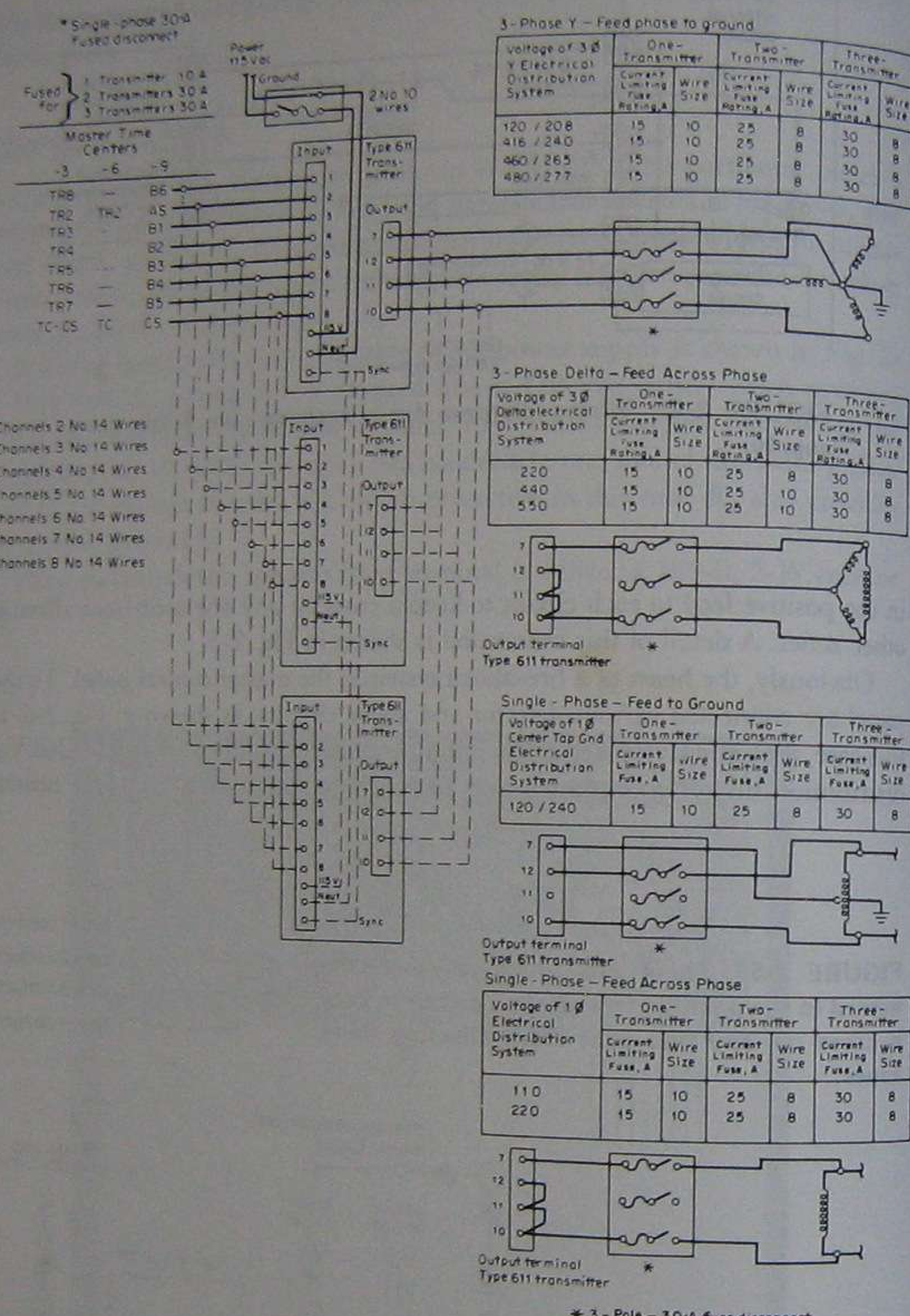


FIGURE 2-6. Wiring diagram of a master control panel.



3-Phase Y – Feed phase to ground

Voltage of 3Ø Y Electrical Distribution System	One-Transmitter		Two-Transmitter		Three-Transmitter	
	Current Limiting Fuse Rating, A	Wire Size	Current Limiting Fuse Rating, A	Wire Size	Current Limiting Fuse Rating, A	Wire Size
120 / 208	15	10	25	8	30	8
416 / 240	15	10	25	8	30	8
460 / 265	15	10	25	8	30	8
480 / 277	15	10	25	8	30	8

3-Phase Delta – Feed Across Phase

Voltage of 3Ø Delta electrical Distribution System	One-Transmitter		Two-Transmitter		Three-Transmitter	
	Current Limiting Fuse Rating, A	Wire Size	Current Limiting Fuse Rating, A	Wire Size	Current Limiting Fuse Rating, A	Wire Size
220	15	10	25	8	30	8
440	15	10	25	10	30	8
550	15	10	25	10	30	8

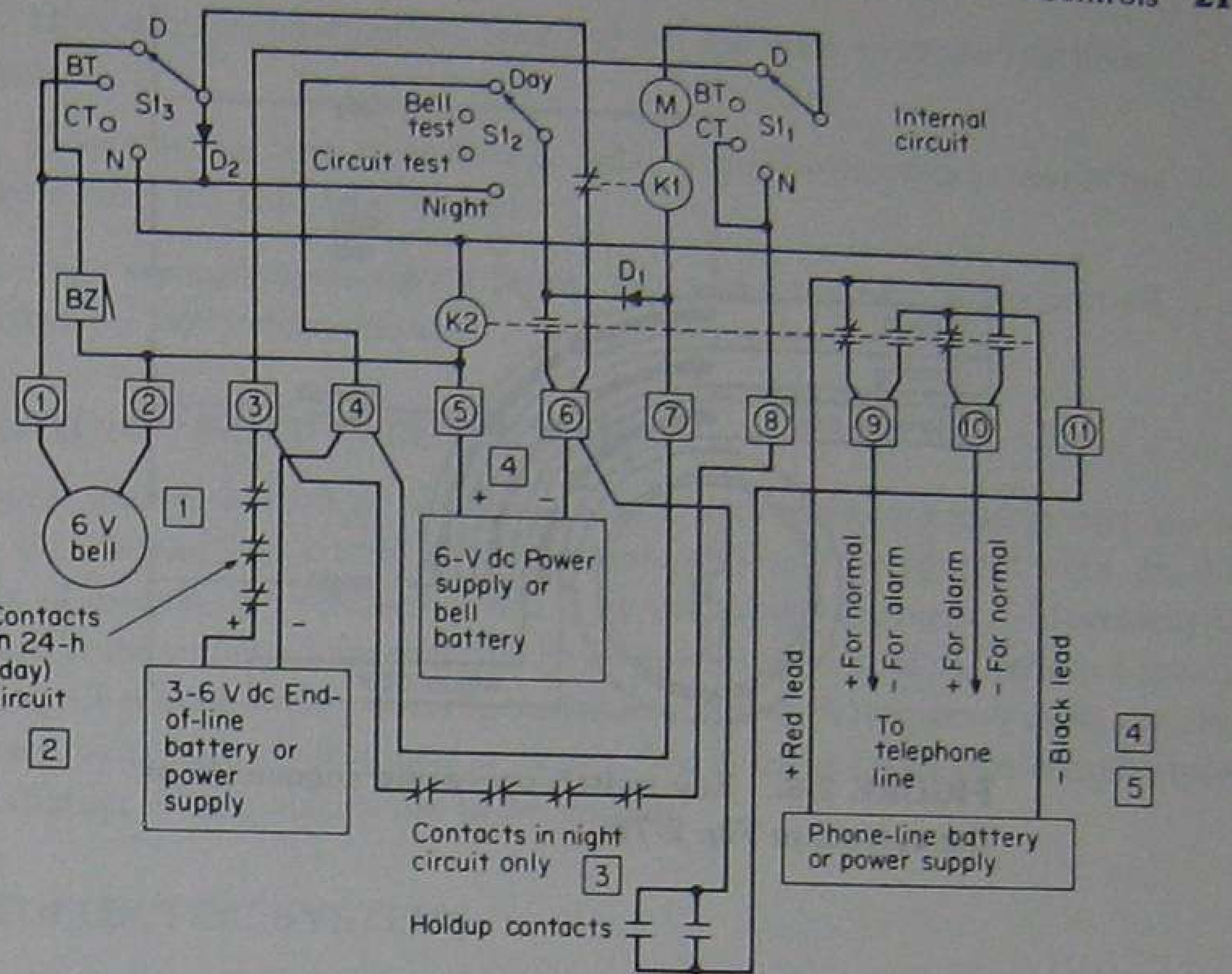
Single-Phase – Feed to Ground

Voltage of 1Ø Center Tap Gnd Electrical Distribution System	One-Transmitter		Two-Transmitter		Three-Transmitter	
	Current Limiting Fuse, A	Wire Size	Current Limiting Fuse, A	Wire Size	Current Limiting Fuse, A	Wire Size
120 / 240	15	10	25	8	30	8

Single-Phase – Feed Across Phase

Voltage of 1Ø Electrical Distribution System	One-Transmitter		Two-Transmitter		Three-Transmitter	
	Current Limiting Fuse, A	Wire Size	Current Limiting Fuse, A	Wire Size	Current Limiting Fuse, A	Wire Size
110	15	10	25	8	30	8
220	15	10	25	8	30	8

FIGURE 2-7. **(*a*) Detail of wiring diagram of a master control panel.**



(*b*) Schematic drawing of a day-night police panel.

ground and to one leg of the main circuit. The trouble-indicator circuits are connected to the neutral ground and to the opposite leg of the circuit.

When an automatic detector or manual station is activated, the contacts close to complete a circuit path and apply 120 Vac to the alarm control circuits in the main panel. This includes a synchronous motor on some systems, which immediately operates cam assemblies that cause the alarm circuit switch contacts to make and break in a code sequence (if a code sequence is used). Additional cam-controlled switches stop the motor and alarm signals after a predetermined time lapse and actuate the alarm buzzer on the main panel.

Most control panels contain a supplementary relay control for connection to an external auxiliary circuit providing its own electrical power. The relay usually has a single-pole double-throw contact, which operates in step with the master code signal. The circuit may be used to activate other auxiliary alarms or controls, such as a city fire-department connection, fan shutdown, or door release. A schematic wiring diagram of a typical system is shown in Fig. 2-7.

A schematic drawing of a day-night police panel is shown in Fig. 2-7*b* while key switch operating sequences are depicted in Fig. 2-8. In general, any DAY circuit contact opening sounds the buzzer in the panel but does not ring the alarm bell or disturb police. A holdup contact closure sends a silent police alarm.

On the BELL TEST circuit, the bell can be rung for a test to check the power

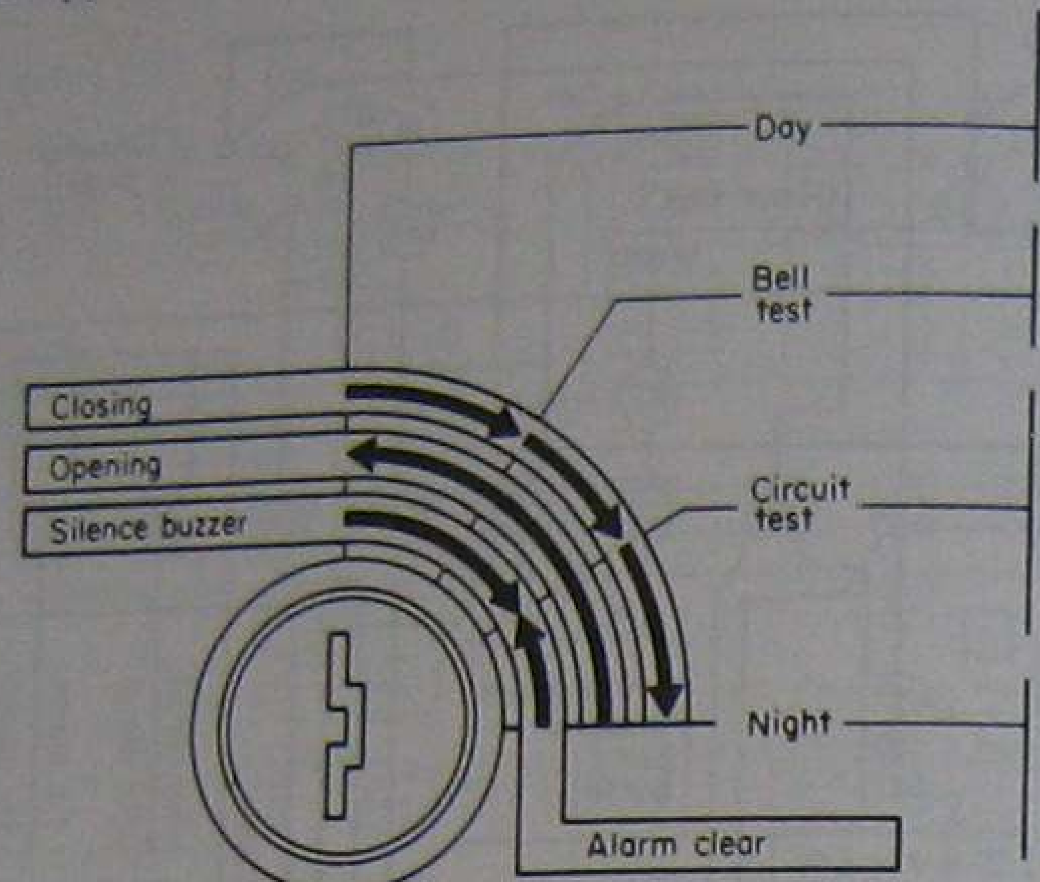


FIGURE 2-8. Key switch-operating sequences of the system in Fig. 2-7*b*.

source and wiring without disturbing the police, but the holdup circuit remains armed during this test.

During the CIRCUIT TEST sequence, the holdup circuit remains armed and the meter shows the current through DAY and NIGHT circuits combined when all contacts are closed. A reading on this particular circuit should be from 2 to 6 mA.

Any contact opening (or cross) in the DAY or NIGHT circuits rings the alarm bell and sends the police alarm. This alarm latches on until the key switch is turned back to CIRCUIT TEST or beyond.

ENTRY/EXIT DELAY MODULE

Solid-state entry/exit delay modules eliminate the need to install a shunt lock across any entry/exit door contacts in a security system. Door contacts are connected to the module, which in turn is wired into the protective circuit. Separately adjustable exit and entry delay periods allow the user to turn the system on and leave and then enter and shut the system off without causing alarms.

The module is installed in the alarm system control cabinet as shown in Fig. 2-9. It operates on current from the system's bell battery or power supply and is controlled by the switch functions available in any conventional control unit. It works like a normally closed contact in the negative side of the protective circuit, with all the protective contacts except the entry/exit door contacts wired into the positive side of the circuit. Opening of any positive-side contacts causes an instant alarm, but the module opens the negative side to cause an alarm *only* when one of the following occurs:

1. Door contacts have opened once and are still open when the exit delay expires.
2. Door contacts open after the exit delay expires when there was not an exit during the exit delay period.
3. Door contacts open after a proper exit and the system is not shut off before the entry delay expires.

ULTRASONIC MOTION DETECTORS

Ultrasonic detectors work by flooding an area with ultrasonic energy and monitoring the "sound" that returns to the detector from the covered area. In the absence of motion, the received sound is all of a single frequency. Movement of an object in the protected space shifts the frequency of some of the reflected sound, changing the output of the receiving transducer. But such frequency shifts can also be caused by certain environmental factors that must be taken into consideration at installation if false alarms are to be avoided.

PHOTOELECTRIC SYSTEMS

A photoelectric transmitter is shown in Fig. 2-10*a* and the receiver is shown in Fig. 2-10*b*. Each requires a 12-Vac input for operating power. This type of system is intended for continuous operation, regardless of whether the alarm system to which it is connected is on or off. Clicking of the receiver relay is thus a normal indication whenever the invisible infrared beam is broken or restored.

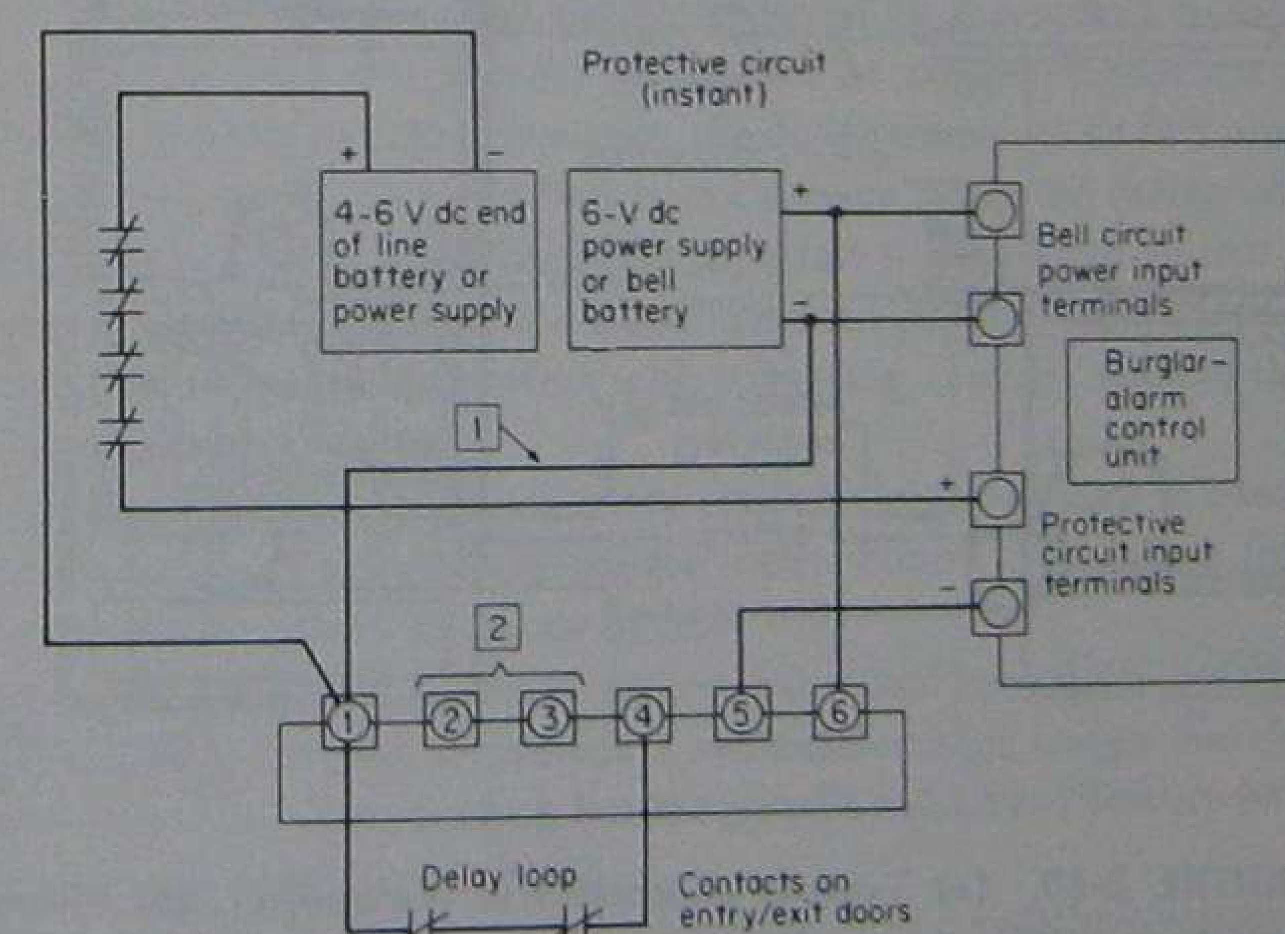


FIGURE 2-9. Connection detail of entry/exit delay module.

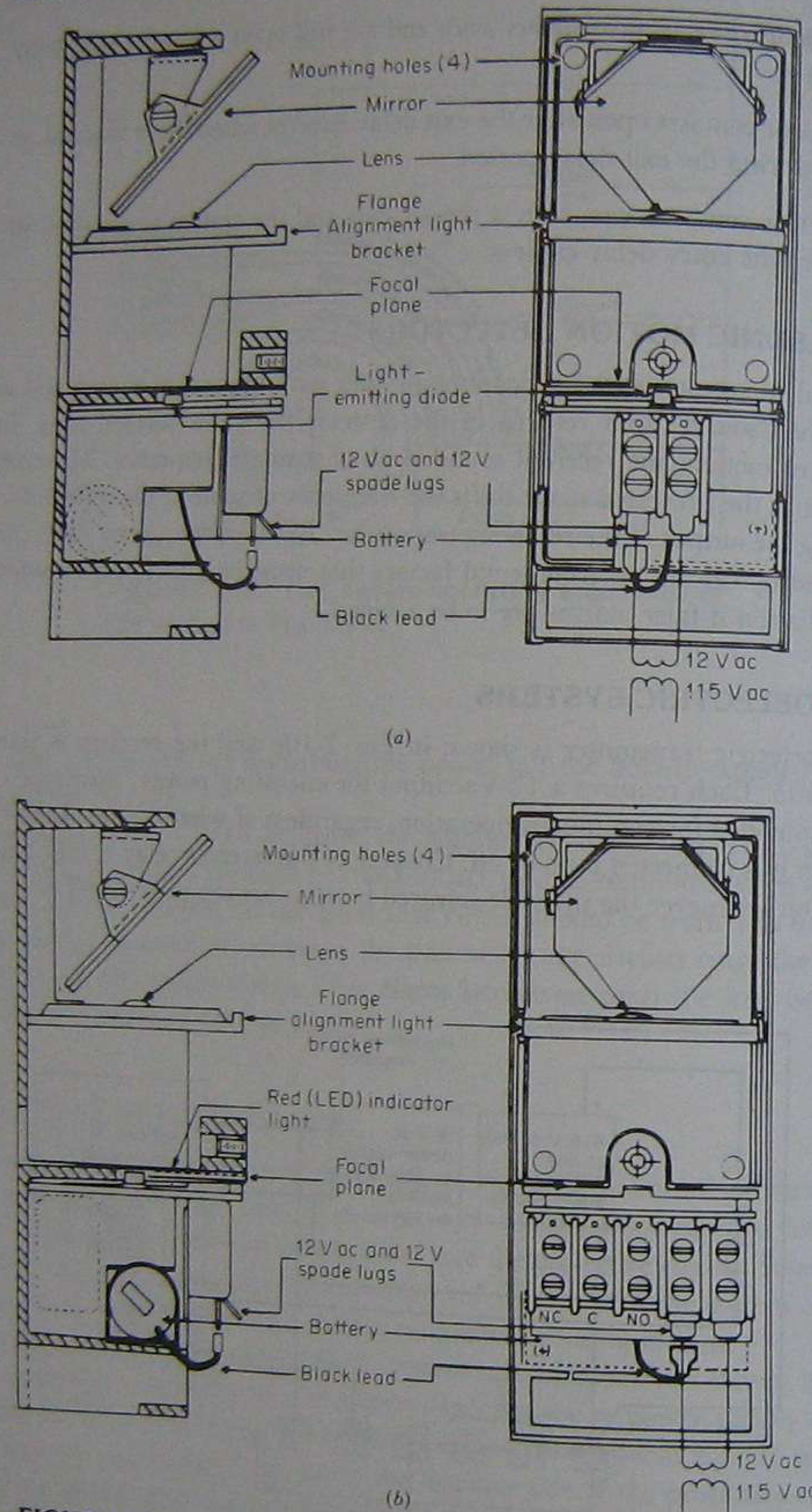


FIGURE 2-10. *(a)* **Typical photoelectric transmitter.** *(b)* **Photoelectric receiver.**

TELEPHONE DIALERS

A schematic wiring diagram of a typical telephone dialer is shown in Fig. 2-11. The dialer's two cooperating channels permit two distinct dialing and message programs. Although labeled as, and most commonly used for, separate burglar and fire alarms, the two channels can be connected and programmed for any application: medical emergency, heating-system failure, freezer warmup, water-pressure failure.

It is important to understand the priority relationship between the two channels before making trigger connections. The priority arrangement ensures transmission of the vital fire-alarm program (or other priority program on the FIRE channel) in three ways:

1. If the dialer is already operating on the BURGLAR channel when the FIRE channel is triggered, the dialer immediately switches to FIRE-channel transmission.

2. When FIRE-channel priority seizure has occurred, the dialer overrides its normal end-of-cycle stop and runs for another full cycle. This ensures transmission of the entire priority program, even if the FIRE-channel takeover occurred near the end of a BURGLAR-channel cycle.

3. Even if the dialer has stopped after transmitting the full BURGLAR-channel program and the burglar-alarm input is still present, an input on the FIRE channel causes immediate transmission of the FIRE-channel program.

Each of the dialer's channels can be triggered by a switched dc voltage, a dry contact closure, or a dry contact opening. The trigger inputs may be either momentary or sustained. In either case, the dialer transmits its full program, then stops and resets itself. An input that is still present when the dialer stops must be removed briefly and then applied again to restart transmission on that channel. A sustained input does not make the dialer transmit or interfere with normal use of the telephones, nor does it interfere with triggering and operation of the dialer on its other channel.

When available, an appropriate dry contact closure should be used instead of a switched voltage for the dialer-trigger input. Figure 2-12 shows the preferred connections for a typical telephone dialer.

Where the contacts of a police-connect panel are needed for polarity reversal, the contacts may be used to provide a switched-voltage trigger for the dialer as shown in Fig. 2-13. This hookup lets the panel's BELL TEST feature be used without causing any dialer transmission.

When using the bell output of an alarm panel as a switched-voltage trigger for the dialer, always run the trigger wires directly from the dialer input terminals to

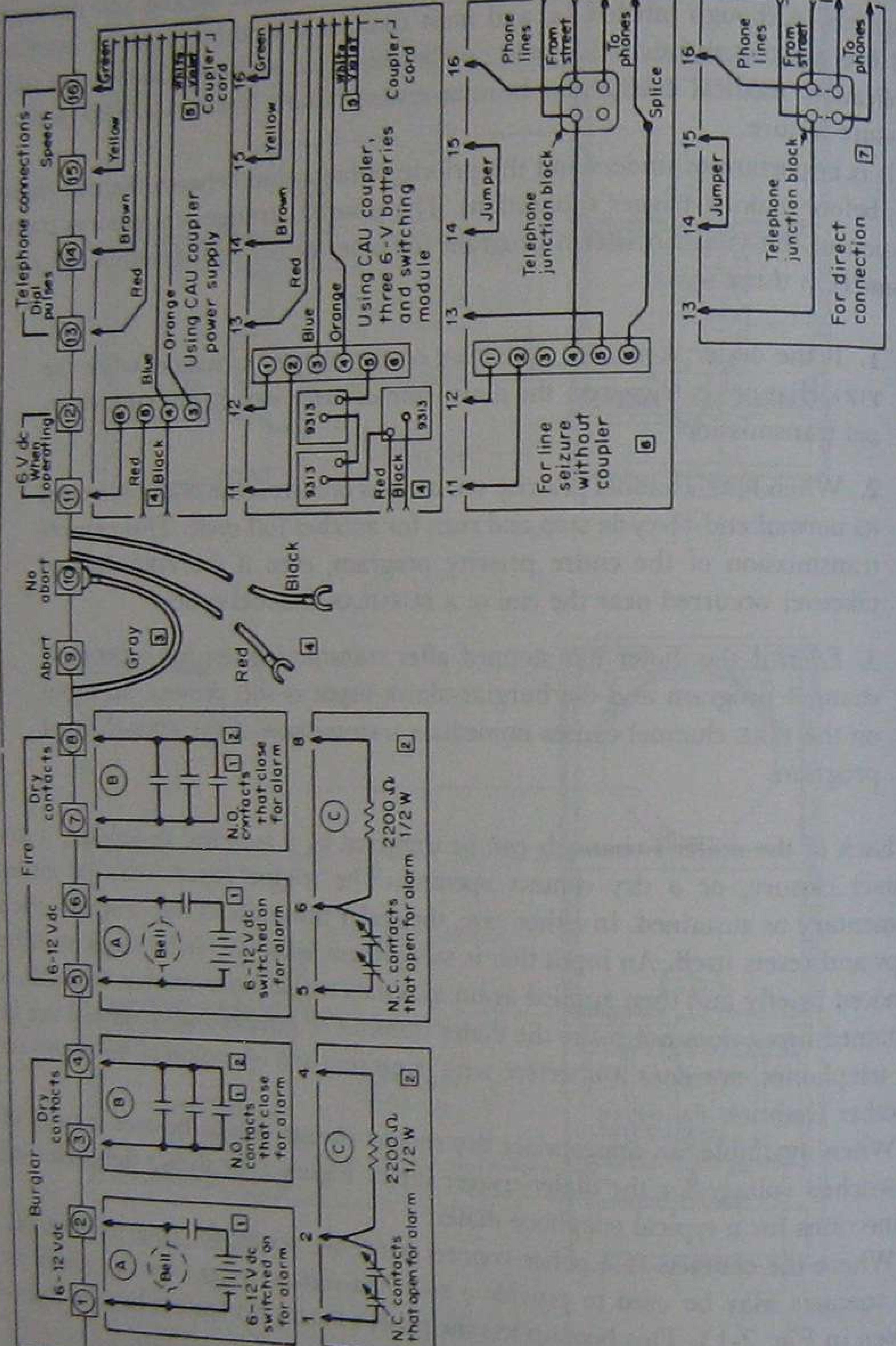


FIGURE 2-11. Schematic wiring diagram of a typical telephone dialer.

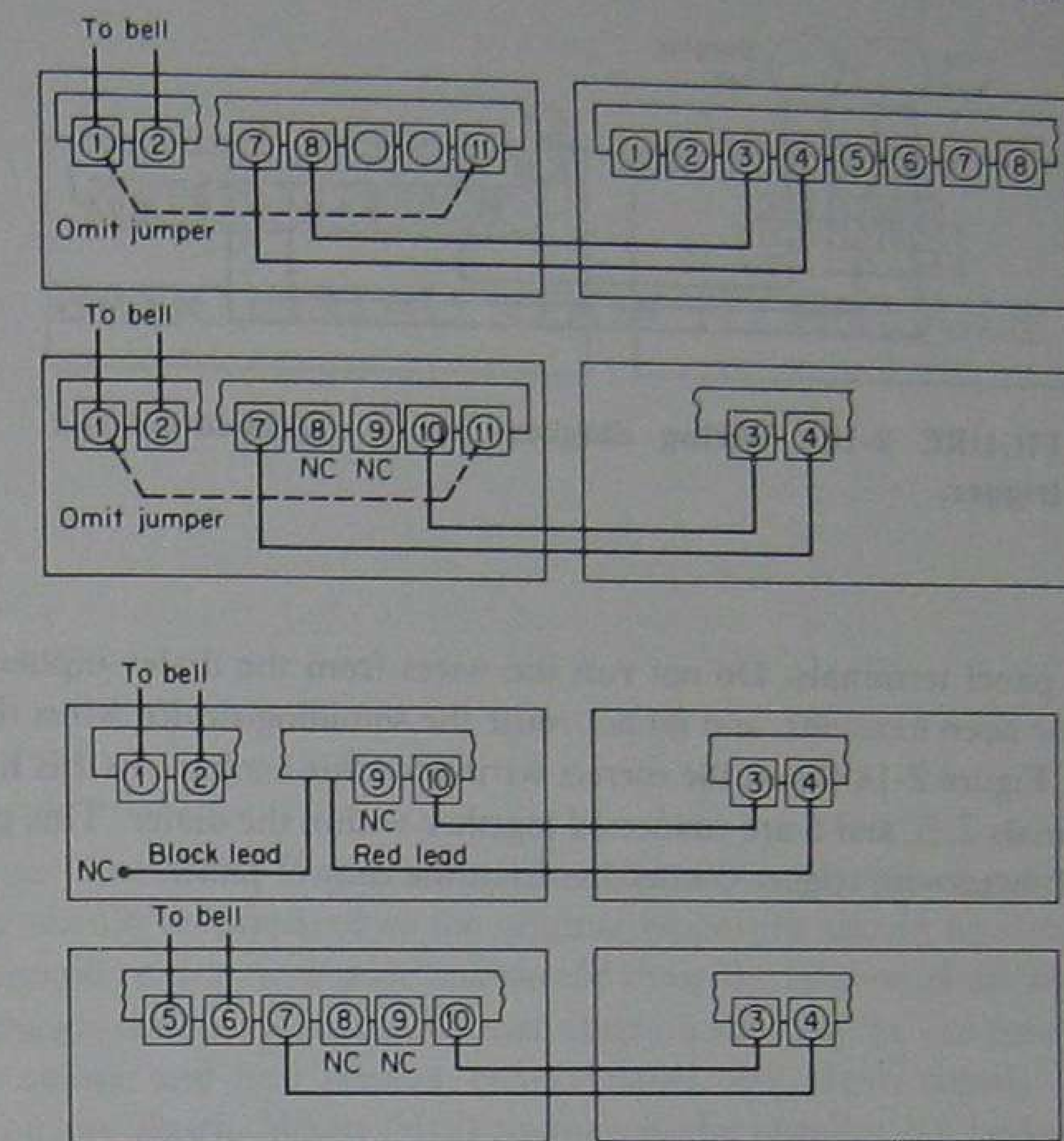


FIGURE 2-12. Preferred connections for a typical telephone dialer.

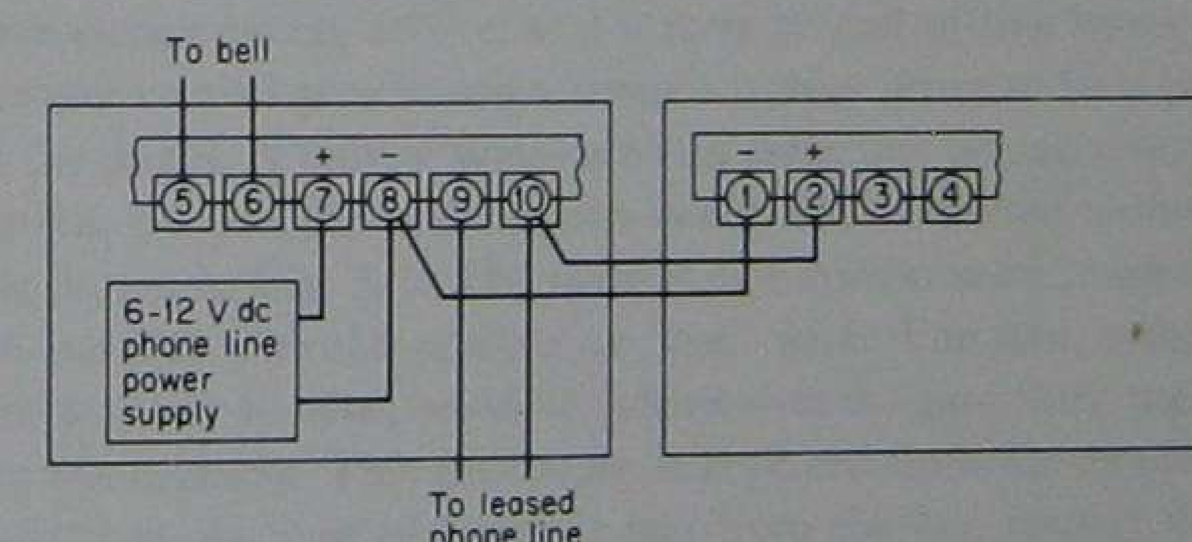


FIGURE 2-13. A switched-voltage trigger connected to a telephone dialer.

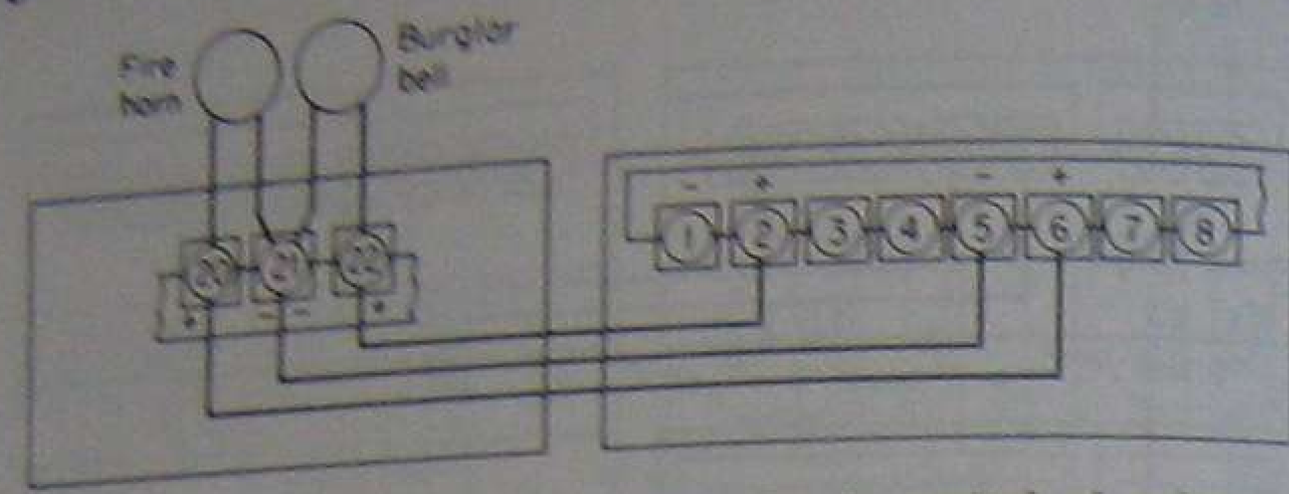


FIGURE 2-14. Wiring diagram for a switched-voltage trigger.

control the panel terminals. Do not run the wires from the dialer inputs to the bell, horn, or siren locations, and do not route the sounding-device wires through the cabinet. Figure 2-14 shows the correct wiring for this hookup. In this hookup, dialer terminals 2, 5, and 6 are connected together within the dialer. This permits a simplified three-wire trigger connection from the control panel.

3

BASIC INSTALLATION TECHNIQUES

Before the installation of a security/fire-alarm system is started, a sketch of the building should be prepared or the original blueprints should be obtained. This sketch should be drawn to scale and should show the location of all windows and doors, chases, closets, etc. A simple riser diagram showing the various components such as smoke and heat sensors, control panel, and alarm signals should also appear on the sketch. When this is completed, the installer can begin the design of the security/fire alarm system (see Chaps. 5 and 6).

INSTALLATION BASICS

The installation of a protective security/fire-alarm circuit should always start at the protective-circuit energy source, as if it were an end-of-line battery—a battery remote from the control panel—even though it may actually be a power supply installed in the panel. A pair of wires are run from this power source to the first contact location, but just the positive wire is cut and connected to the two contact terminals as shown in Fig. 3-1. The neutral or common wire is not cut, but continues on in parallel with the positive or "hot" wire. The pair is then run on to the next contact—be it door, window, sensor—and again only the hot wire is connected to the contacts. This procedure is repeated until all contacts are wired in series, and then the pair of wires is run from the last contact device on the system to the protective-circuit terminals in the panel. Although the markings will vary from manufacturer to manufacturer, the terminals for the starting connections will read something like LOOP POWER OUT, while the terminating terminals will read IN or a similar term.

A simple circuit of the wiring connections just described is shown in Fig. 3-2. Obviously, the system would operate with just a single-wire, positive-leg circuit run from contact to contact, with the negative power-supply terminal connected

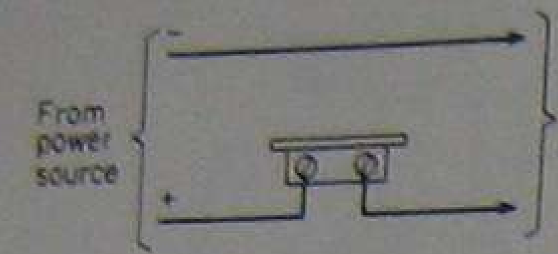


FIGURE 3-1. Contacts are connected into the positive wire only. Break positive wire only at door contacts.

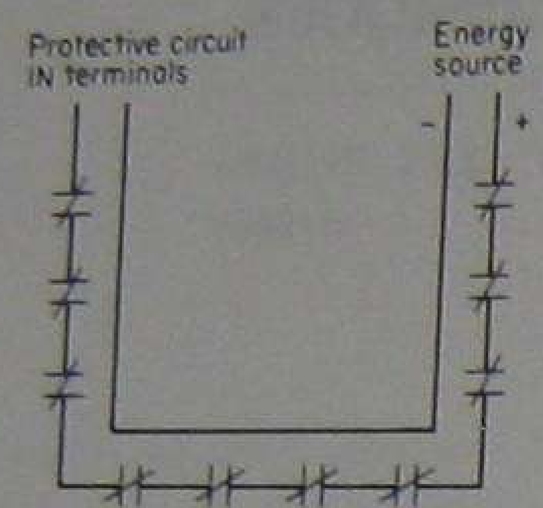


FIGURE 3-2. Negative conductor is run with positive conductor to all contacts even though the system would operate with just a single-wire, positive-leg wire run from contact to contact.

directly to the negative protective-circuit terminal within the cabinet. However, manufacturers discourage this practice, since troubleshooting a single-wire circuit can be extremely time-consuming and the single wire is more vulnerable to defeat by an intruder with no trouble symptoms occurring to warn the user of the loss of protection.

An exit/entry delay relay is sometimes used on security systems so that authorized personnel may exit and enter (using their door keys) without activating the alarm. However, a shunt switch is more often preferred (see Fig. 3-3). The purpose of the shunt lock is to enable an authorized person with a key to shunt out the contacts on the door used for entry/exit, allowing him or her to enter or leave the premises without causing an alarm when the alarm system is turned on. The

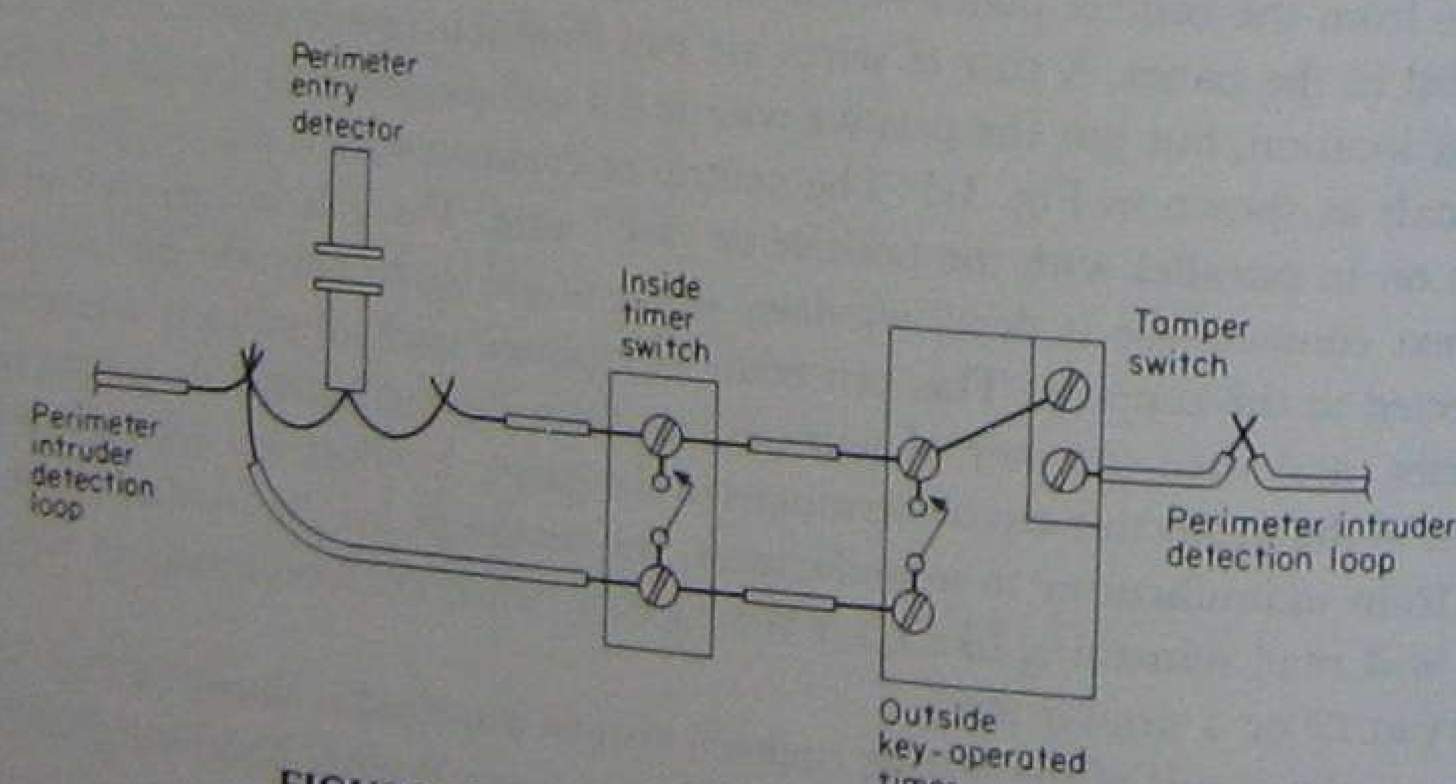
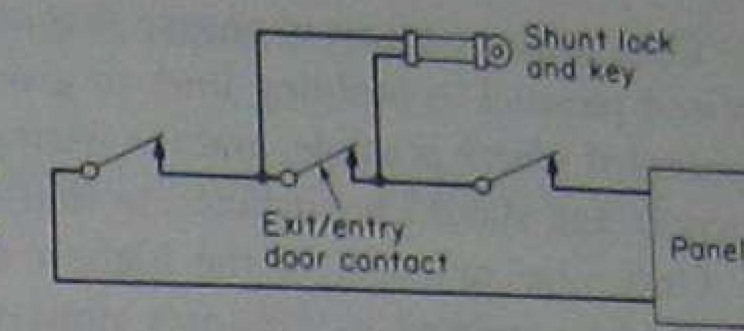


FIGURE 3-3. Typical shunt switch circuit.

FIGURE 3-4. Wire the shunt lock switch to the magnetic contacts as shown.



shunt lock does extend outside the protected premises, however, and it is a potential weak link in the system. Following the two procedures suggested below makes defeat of the shunt lock much more difficult.

1. Install the shunt lock at the door that is most brightly illuminated and most readily visible to passersby.

2. Wire the shunt lock switch to the magnetic contact terminals as shown in Fig. 3-4. This arrangement traps the lock, so that any attempt to pull it out to gain access to its terminals will break the positive side of the protective circuit and cause an alarm to sound.

Contacts used to signal the opening of doors, windows, gates, drawers, etc., are usually mounted on the frame of the door or window, while the magnet unit is mounted on the door or window (moving part) itself. The two units should be positioned so that the magnet is close to and parallel with the switch when the door or window is closed. This keeps the shunt lock actuated, but opening the door or window moves the magnet away and releases the switch mechanism.

As long as the faces of the switch and magnet are parallel and in close proximity when the door or window is closed, they may be oriented side-to-side, top-to-top, or top-to-side. Mounting spacers may be used under the units if necessary to improve their alignment and proximity.

Terminal covers are available for most makes of door contacts to give the installation a more finished look and also to protect the terminal connections against tampering.

The wiring of any alarm system is installed like any other type of low-voltage signal system; that is, one must locate the outlets, furnish a power supply, and finally interconnect the components with the proper size and type wire.

QUALITY OF WORKMANSHIP

Since most security/fire-alarm systems are operated on low-voltage circuits, many installers might not pay as strict attention to the quality of the workmanship and materials as they would when installing conventional electrical wiring for lighting and power. Security/fire-alarm systems are worthy of the best materials and the best workmanship and strict attention to quality work should always be given.

Care must be taken to ensure that all visible components are installed adjacent to and parallel to building lines to give a neat appearance. All wiring should be concealed where possible, and the wiring that must be exposed should have square corners and should be installed so that it is as inconspicuous as possible.

Only new material of the highest quality should be used and this material should be approved by UL or a similar testing agency. Remember that the protection of the owner's building and its contents are dependent—to a great extent—on the quality of the security/fire-alarm system installed.

INSTALLING SYSTEMS IN EXISTING BUILDINGS

Many changes and advances in developing complete security/alarm systems for building operation and protection have taken place in the past few years. Numerous existing buildings are currently having security and fire-alarm systems installed—either to replace their obsolete systems or to provide protection they never had.

The materials used for installing a complete alarm system in an existing building are essentially the same as those used in new structures. However, the methods used to install the equipment and related wiring can vary tremendously and require a great deal of skill and ingenuity. Each structure is unique.

When concealed wiring is to be installed in a finished existing building, the installation must be planned so that the least amount of cutting and patching is necessary. In most cases, this means giving special consideration to the routing of conductors. Unlike the wiring of a new building where the installer would try to conserve as much material as possible, the amount of material used (within reason) is secondary in existing buildings. The main objective in security/fire-equipment installations in existing buildings is to install the wiring in the least amount of time with the least amount of cutting and patching of the existing finishes of the building.

Prior to any actual work on an existing building, the contractor or his installers should make a complete survey of the existing conditions in the areas where the security system will be installed. If the majority of the work can be done in exposed areas (as in an unfinished basement or attic), the job will be relatively simple. On the other hand, if most of the wiring must be concealed in finished areas, there are many problems to be solved. The initial survey of the building should determine the following:

1. The best location for the alarm control panel.

2. The type of construction used for exterior and interior walls, ceilings, floors, etc.

3. The location of any chases that may be used for routing the conductors and the location of closets, especially those located one above the other, for possible use in fishing wires.

4. The material used for wall and ceiling finishes—plaster, drywall, paneling, etc.

5. Location of moldings, baseboards, etc., that may be removed to hide conductors.

6. Location of decorations or other parts of the building structure that cannot be disturbed.

7. Location of any abandoned electrical raceways that new alarm-system wires might be fished into. Don't overlook similar possibilites. For example, old abandoned gas lines were recently used to fish security-system wires in an old building in Washington, D.C.

8. The location of all doors and windows, coal chutes, and similar access areas to the inside of the building.

As indicated previously, the most difficult task in running wires in existing buildings is the installation of concealed wiring in finished areas with no unfinished areas or access to them in the area in question. In cases like these, the work is usually performed in one of two ways, namely, by deliberately cutting the finished work so that the new wiring can be installed. Of course, these damaged areas must be patched once the wiring is installed. The second way is to remove a small portion of the finished area (only enough to give access to voids in walls, ceilings, etc.) and then fish the wires in. The removed portions are then replaced after the wiring is complete.

Where outlet boxes are used, they should be designed for installation in the type of finish in the area. Means of securing the boxes to some structural member—like mounting ears or holding devices—should also be given consideration.

Another method of providing outlets in a finished area is to remove the existing baseboard and run the conductors in the usual groove between the flooring and the wall and then replace the baseboard. This method requires less work (cutting and patching) than most other methods when the finished area must be disturbed. There is also a type of metal baseboard on the market which may be installed along the floor line and used as a raceway. Most types are provided with two compartments for wires—one for power and one for low-voltage wiring. Using this metal baseboard provides a simple means of routing wires for security/fire-alarm systems with very little cutting or patching. In most cases, wires can be fished from the baseboard up to outlets on the wall, especially if they are under 3 ft. (0.9 m) above the floor. However, if this is not practical, matching surface molding can be installed to blend in very nicely with the baseboard.

When a lot of cutting and patching is required in a finished area, many installers like to hire a carpenter to do the work. The carpenter may know some tricks that will help the alarm-system installers get the system in with the least amount of difficulty. Also, any cutting or patching will be done in a professional manner.

Before doing any actual cutting of an existing building to install security/fire-alarm components, the installer should carefully examine the building structure to ascertain that the wires may be routed to the contacts and other outlets in a relatively easy way. It is possible that a proposed outlet location, for example, could be moved only a foot or two to take advantage of an existing chase. Perhaps a smoke detector or similar component was originally located in a ceiling with insulation, which would make the fishing of cables very difficult. If the detector could be located on a ceiling containing no insulation, the job would be greatly simplified.

When cutting holes in ceilings for outlets, a drop cloth or paper should be spread underneath to catch all dust and dirt. Sometimes an old umbrella can be opened and hung upside down under the spot in the ceiling where the hole is being made to catch the debris and keep it off the rugs and furniture.

Holes for wires and components can be cut through plaster with a chisel, through wood with a keyhole saw after first drilling two or four pilot holes, and in brick or other masonry with a masonry chisel or rotary hammer. To locate the exact spot to cut these openings, it is best to first cut a very small hole in the center of the spot where the larger one will be made. This hole may then be used to locate the area between studs or—in the case of very old homes—the cracks between the plaster laths. It is then possible to shift the mark for the outlet openings so that all obstacles can be avoided and to provide proper anchoring of the outlet box or component.

There are a number of ways to pull and fish wires into walls and openings in finished buildings and, with a little ingenuity and careful thought, workers should be able to solve almost any problem of this kind that they may encounter.

When pulling wires into spaces between the joists in walls, a flashlight placed in the outlet box hole is often a great help when feeding the wires in or catching them as they are pushed near the opening. Under no circumstances should a candle or other open flame be used for this purpose. If one must see farther up or down the inside of a partition, a flashlight and mirror used in combination as shown in Fig. 3-5 is a great help. Many installers like to make their own mirror

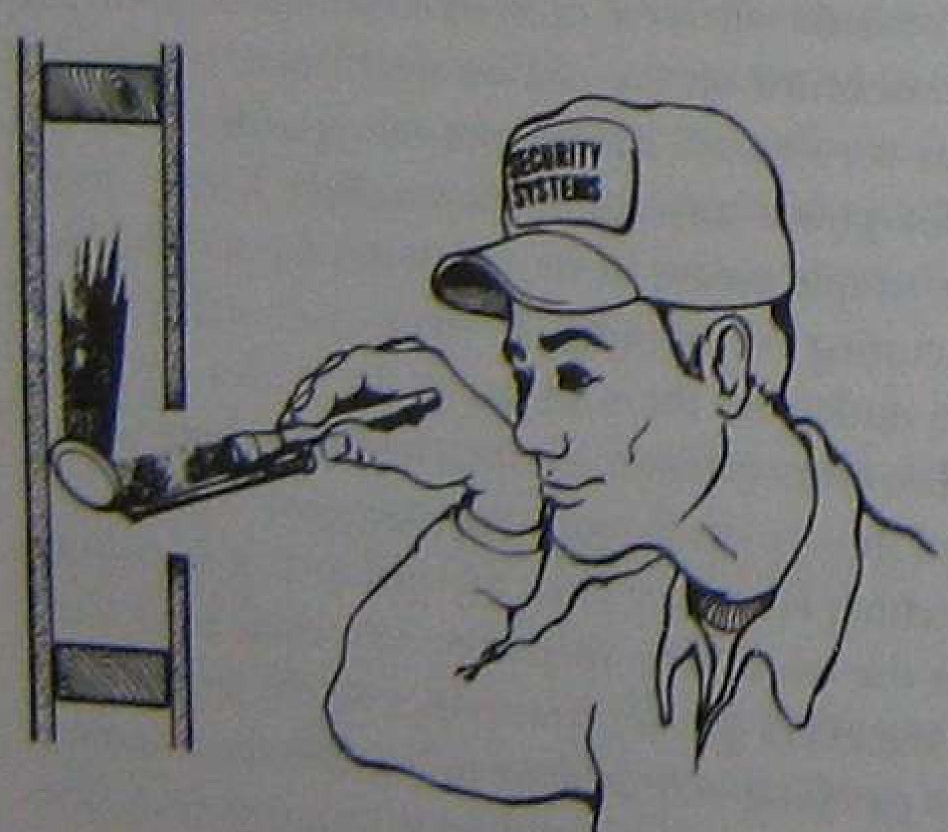


FIGURE 3-5. A flashlight and mirror used in combination are useful for viewing conditions inside of partitions.

by gluing a small 2- x 3-in (5- by 8-cm) compact mirror on a handle resembling a wooden tongue depressor. Any type of small flashlight may be used.

Where it becomes necessary to remove floor boards during a security/fire-alarm installation, it should be done with the greatest of care so that the edges are not split. Split edges make a poor appearance on the finished job when the boards are replaced. Special saws may be purchased for cutting into floors or other surfaces without drilling holes to start the saw. Then if the tongue (on tongue-and-groove boards) is split off with a thin sharp chisel driven down in the crack between the boards, the board from which the tongue was removed can be pried up carefully without damaging the rest of the floor.

NEW INSTALLATION TECHNIQUES FOR EXISTING STRUCTURES

A few years ago, the Diversified Manufacturing and Marketing Co. (Burlington, NC 27215) patented a system which attaches a drill bit to a long flexible spring steel shaft and is known as D'versiBit. This system makes it possible to manipulate easily a drill bit in walls to accomplish complex installation maneuvers in existing buildings. The D'versiBit can be inserted into the wall cavity through a small opening and positioned accurately for drilling from midwall to attic or basement, from windows and doorways to basement or attic, etc. The development of this system makes penetration and cable retrieval a much simpler operation than it used to be. Following is a list of tools available for use with the D'versiBit system.

Bits: The three types of bits available for this system are shown in Fig. 3-6. The auger bit (Fig. 3-6*a*) is for starting and drilling a clean entrance hole, the combination bit (Fig. 3-6*b*) is designed for greater durability, and the masonry bit (Fig. 3-6*c*) has a carbide tip for drilling in cement blocks and plaster. All three of these bits are designed for use with standard drill motors.

Alignment Tool: The special alignment tool shown in Fig. 3-7 provides total control of the flexible shaft, and may be used to hold the bit and shaft steady and true toward any desired destination.

Line Recovery Devices: After the drilling is completed, the system quickly converts to a line recovery system using the grips as shown in Fig. 3-8. These grips attach to holes located in the bit tip or in the shaft end. This feature enables even one person to quickly fish wires or cables through partitions.

Shaft Extensions: The standard lengths of the flexible shaft are 54 in (135 cm) and 72 in (180 cm), but shaft extensions (Fig. 3-9) are available to provide extra distance drilling capabilities. One or more can be attached in special situations, such as from the basement to a smoke sensor in the attic.

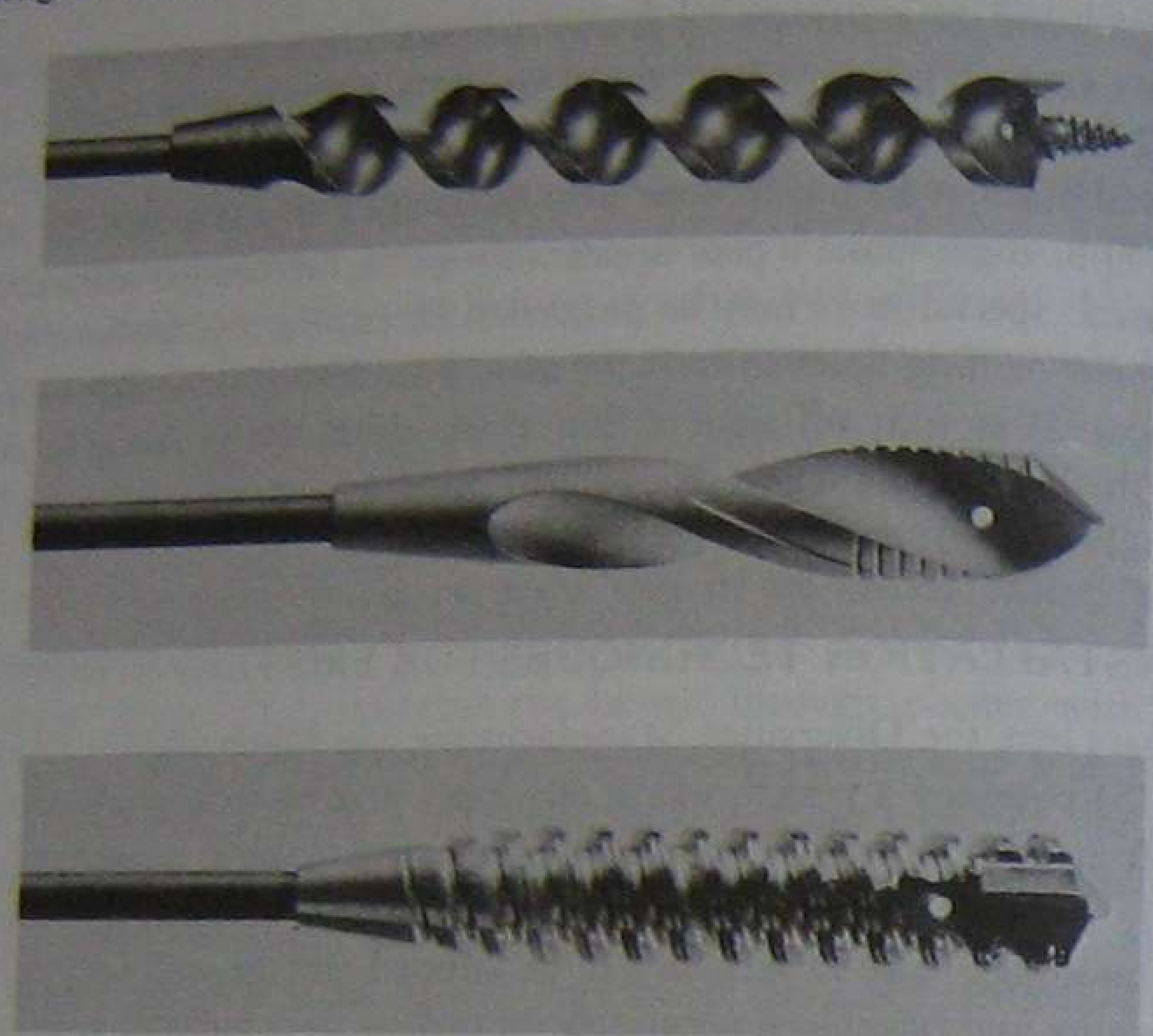


FIGURE 3-6. Three types of bits available for the D'versiBit system.

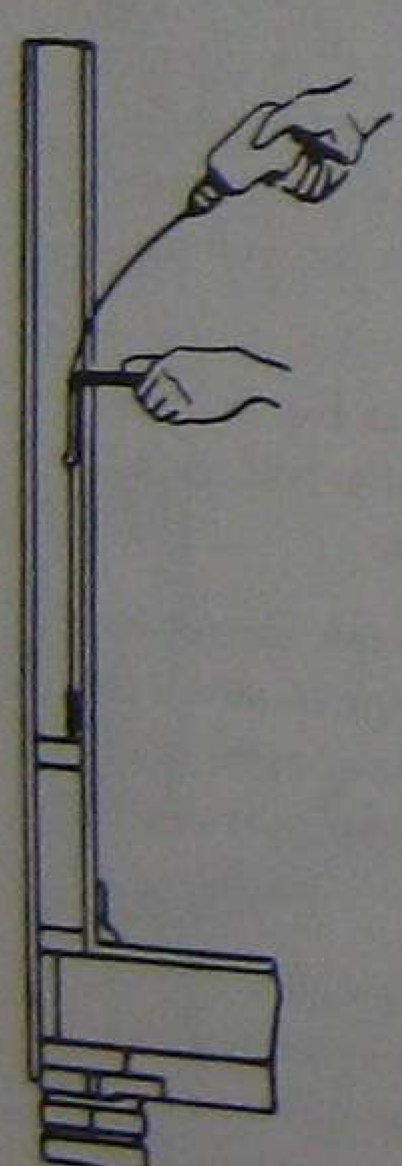


FIGURE 3-7. Special alignment tool provides total control of the flexible shaft.

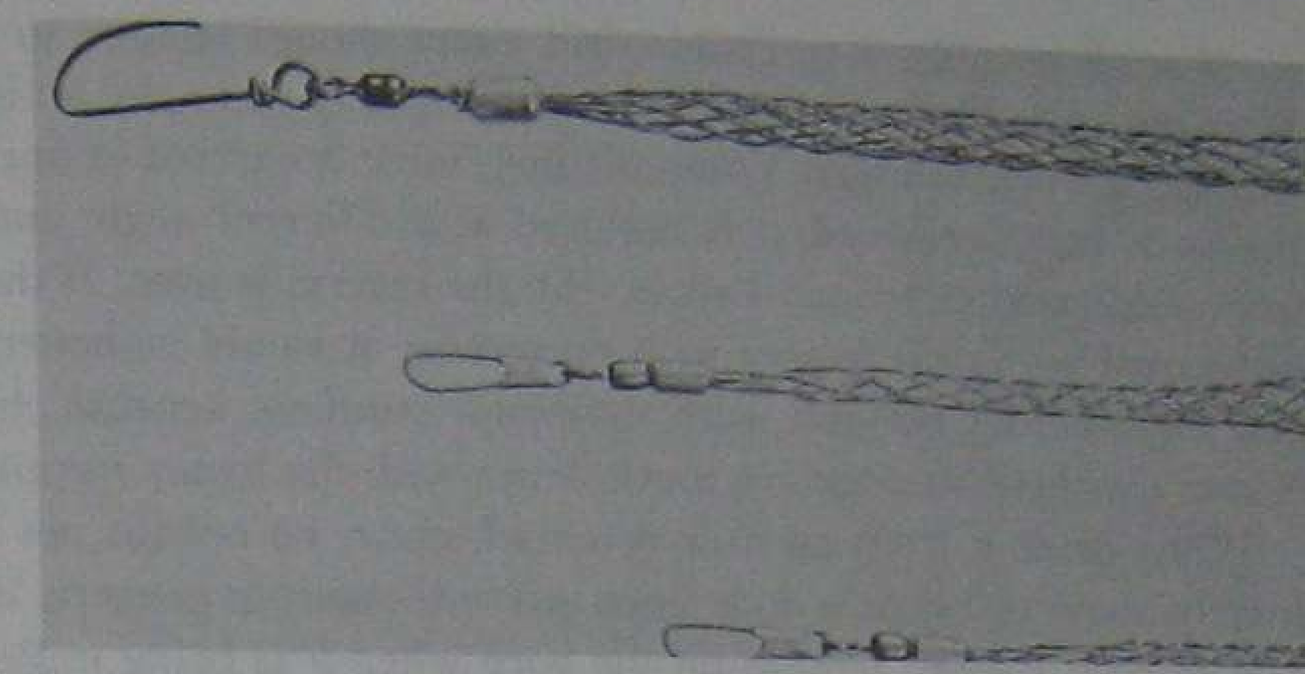


FIGURE 3-8. **Line recovery devices.**

FIGURE 3-9. **Shaft extension.**

The basic shaft is 3/16 in (0.5 cm) which will accommodate both ⅜-in (0.9 cm) and ½-in (1.3-cm) drill bits in the three styles mentioned previously. For larger bits—such as ¾ in (1.9 cm) and 1 in (2.5 cm) sizes—a ¼-in (0.6-cm) shaft is required. This larger shaft reduces the flexibility for complex drilling.

Operation Procedures

When drilling with the flexible shaft of the D'versiBit, run the drill motor only when actually drilling. Never run the drill when sliding the bit up or down in the wall cavity as wires—either signal wires or existing electric power wiring—may be cut during the process. Also make certain that the bit is sharp since a dull bit is one of the greatest causes of bit breakage.

If at all possible, a reversible drill motor should be used to withdraw the bit from the wall. The motor should be running only when the bit is actually passing through a wood member. When drilling, force is exerted in one direction. When the bit is being removed, it is removed at a different angle and force is exerted from a different direction. This is why the reverse is used. If the flexible shaft is being used with drill motors with no reverse, it would be better to exert force to pull the bit from the hole with the motor running, because chances of an easy recovery without damage are much better with the motor running.

When drilling from an attic or crawl space, be certain not to select an area directly above or below a door since this will result in property damage. It is also good to keep a slight tension on the wire when it is being pulled from overhead so that it will not get tangled with the bit and become damaged.

The shaft should not be bowed any more than absolutely necessary to accomplish the job. Excessive bowing will decrease the life of the flexible shaft. Drill motors, of course, should be adequately grounded or else have insulated handles.

Practical Applications of the D'versiBit

Assume that an outlet box for an infrared photoelectric detector is to be installed above a countertop in a residential kitchen to sense entry of unauthorized persons through the kitchen door. If, upon investigation of the space inside of the partitions, it is found that a 2- by 4-in (5- by 10-cm) wood member (fire-stop) blocks the route from the outlet hole to the basement area where the alarm control station is located, an alignment tool must be used.

The flexible shaft containing a drill bit is placed through a cut outlet-box opening and then the special alignment tool is attached to the shaft as shown in Fig. 3-10. By keeping the alignment tool in the same position on the shaft and by lifting the handle, the shaft will bow back toward the operator. As the bit is lowered into the wall cavity, the operator can feel the bit strike the inside wall. When the bit is aligned correctly on the wooden member, the alignment tool is removed while keeping downward pressure on the bit so that it will not slip out of place, and the hole is drilled through the fire-stop. This hole will then act as a guide for drilling through the floor plate as shown in Fig. 3-11.

In the case of a wall cavity without fire-stops or purlins, the alignment tool is used to snap the bit back to the inside wall (Fig. 3-12) at which time downward pressure on the drill motor will keep the bit point in place and cause the shaft to bow. Power and pressure is then transmitted from the back wall which allows proper angle drilling to miss the joist boxing.

After the bit has penetrated into the basement area as shown in Fig. 3-13, the operator has access to the hole in the drill bit itself for attaching the recovery grip and pulling the wire up to the outlet location—all without damage to existing finishes.

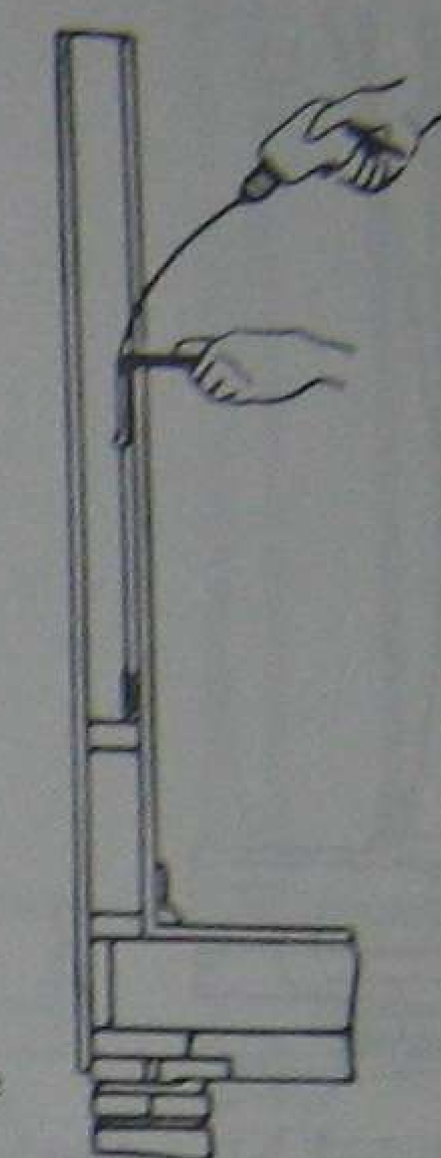


FIGURE 3-10. The alignment tool is attached to the shaft ready for operation.

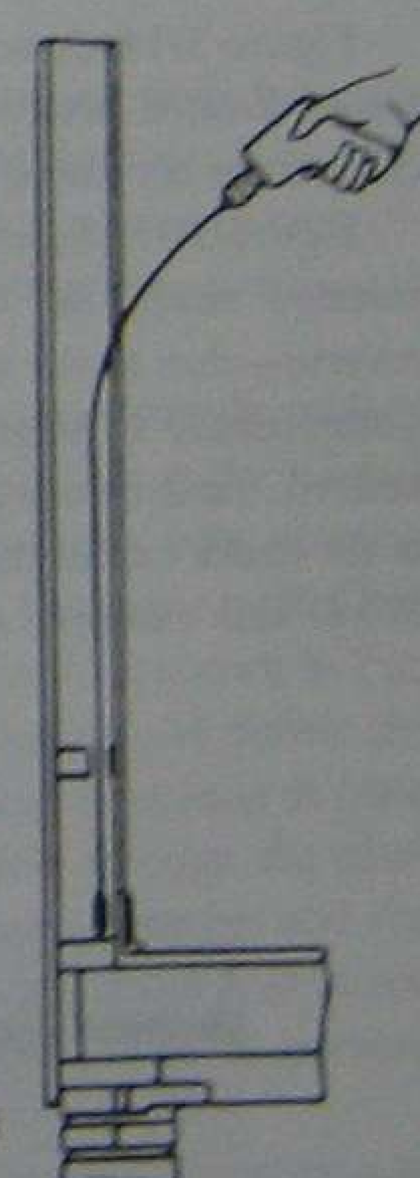


FIGURE 3-11. The first hole cut acts as a guide for drilling through the floor plate.

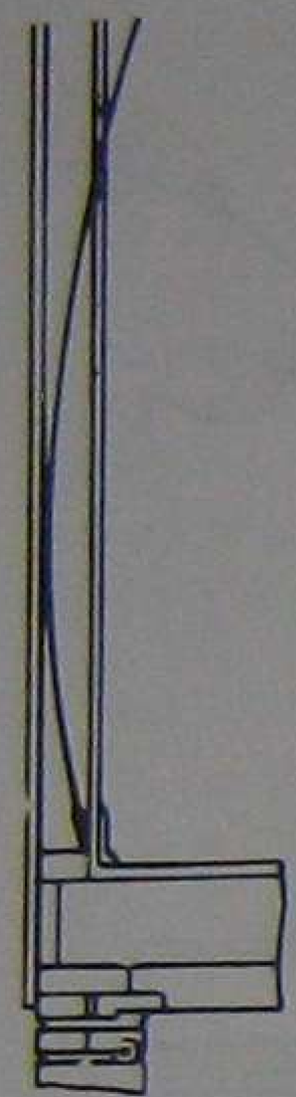


FIGURE 3-12. **Alignment tool used to snap the bit back to the inside wall.**

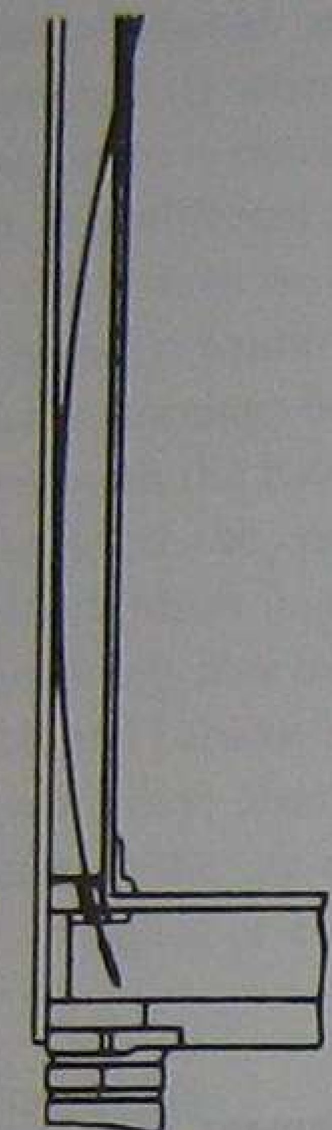


FIGURE 3-13. **Bit has penetrated into basement area.**

Figure 3-14 shows how the recovery grip is attached to the bit tip eyelet. The swivel located between the cable and the head of the grip prevents the wire or cable from becoming twisted during the fishing process.

Figure 3-15 shows the grip after it has been attached to the bit tip with the line inserted ready for recovery. The operator then operates the drill motor in reverse—due to the angle of the pull—applies a slight pull, and the wire can be pulled easily through the holes due to the reverse cutting action of the bit. If desired, the drill motor can be removed from the shaft and a recovery grip attached to the chuck end of the shaft for pulling the wires downward toward the basement. While this example shows the method of routing wires or cables from an outlet

FIGURE 3-14. **Recovery grip attached to the bit tip eyelet.**

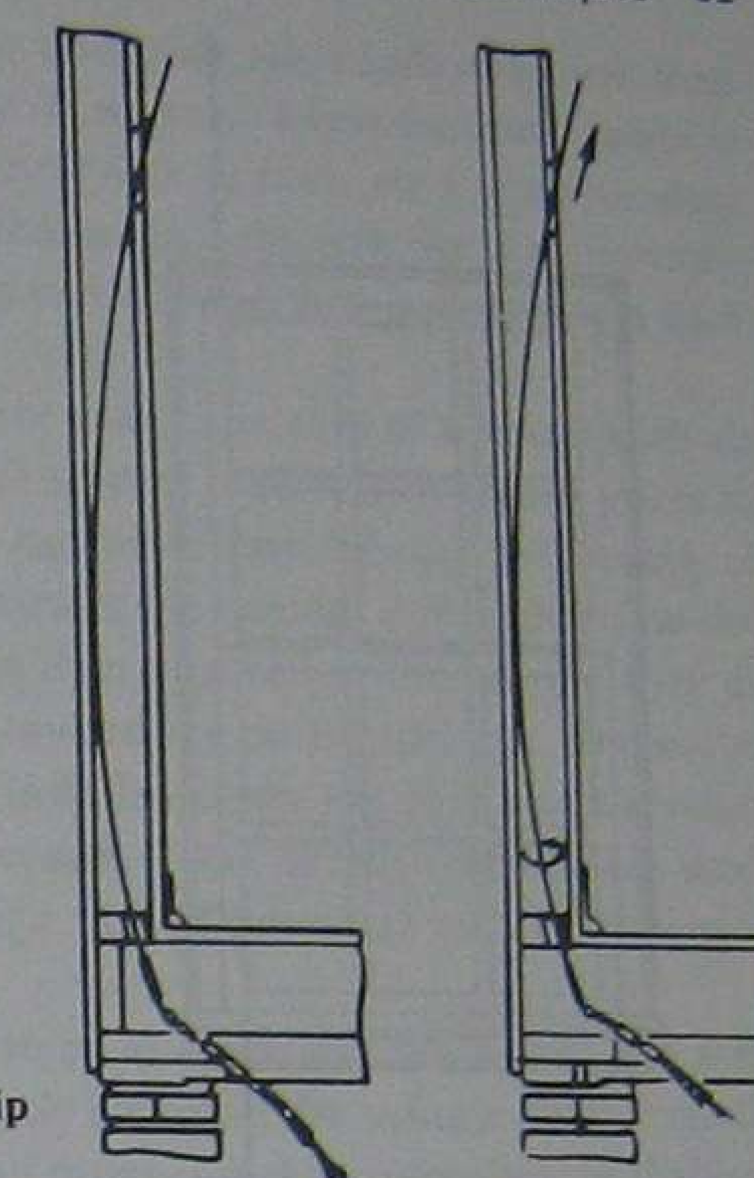


FIGURE 3-15. **Grip attached to the bit tip with the line inserted ready for recovery.**

to a basement, the same procedure would apply for drilling from an outlet opening to an attic space.

To install contacts on windows for a burglar-alarm system, drill from the location of the contact through the casement, lintels, and plates with a ⅜-in (0.9-cm) shaft. Attach a recovery grip to the end of the bit, insert the wire to keep the grip from becoming tangled, reverse the drill motor, and bring the wire toward the operator as the bit is being withdrawn.

Burglar-alarm contacts or door switches installed at doors are simple projects when one uses the flexible shaft. First cut or drill the entrance hole in the normal manner and then insert the flexible shaft with bit into the entrance hole, slanting the bit as much as possible in the desired direction of travel. Continue by drilling through the door casing and floor jamb into the cavity of the wall as shown in Fig. 3-16. The drill is then stopped until it strikes the next stud which will deflect the bit either up or down, depending on the direction of the drilling. Continue to push the bit until it strikes the top of the bottom plate and then drill through the plate into the basement or attic. The recovery grip is then attached to the bit and the wire or cable may be drawn back toward the operator by reversing the drill motor and keeping a slight tension on the wires as they are being pulled to prevent tangling.

With conventional tools, the routing of wires from one outlet to another—as shown in Fig. 3-17—requires either channeling the wall, using wire mold, or

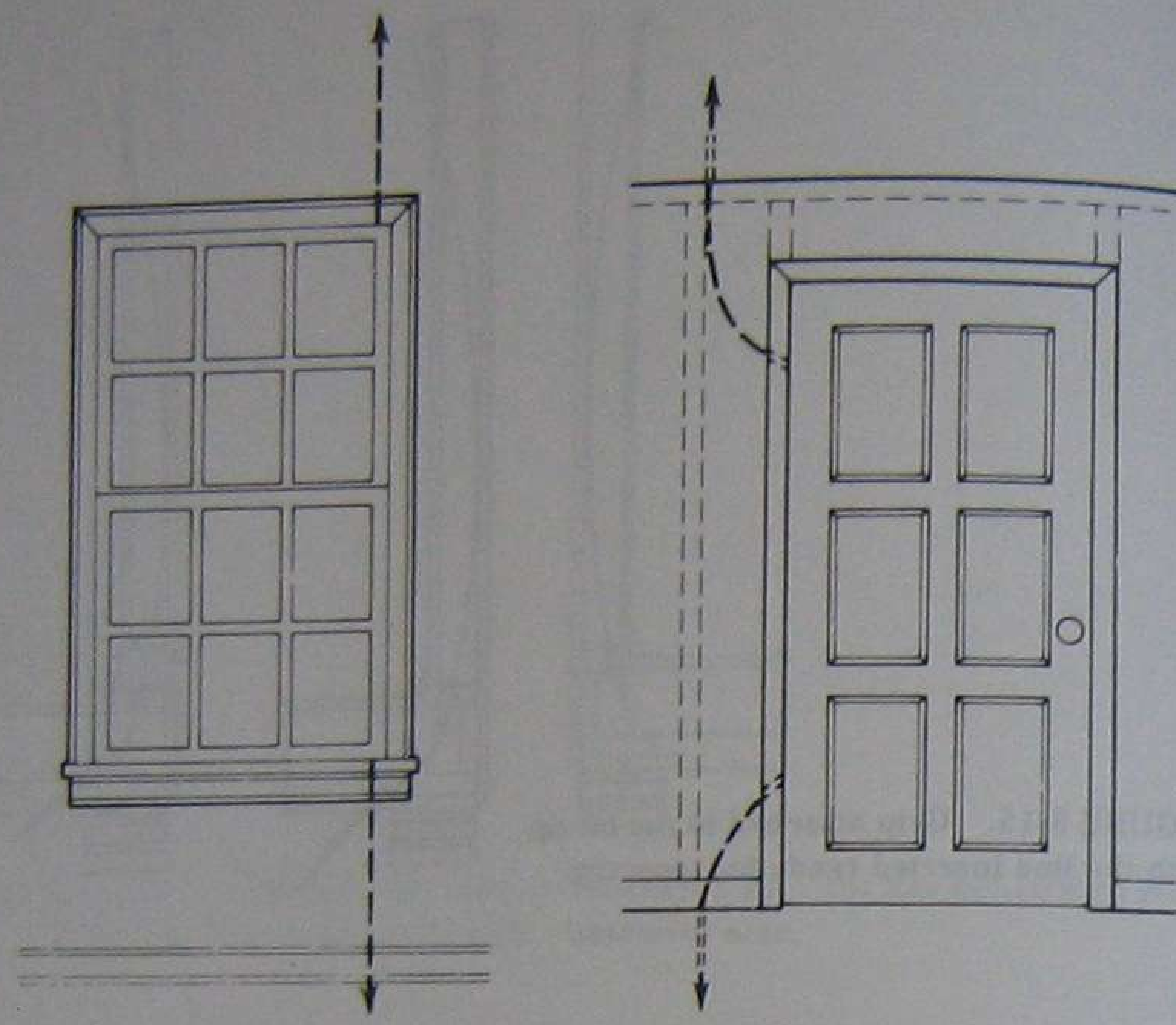


FIGURE 3-16. Drilling through the window casing (*a*) and door jamb (*b*) into the cavity of the wall.

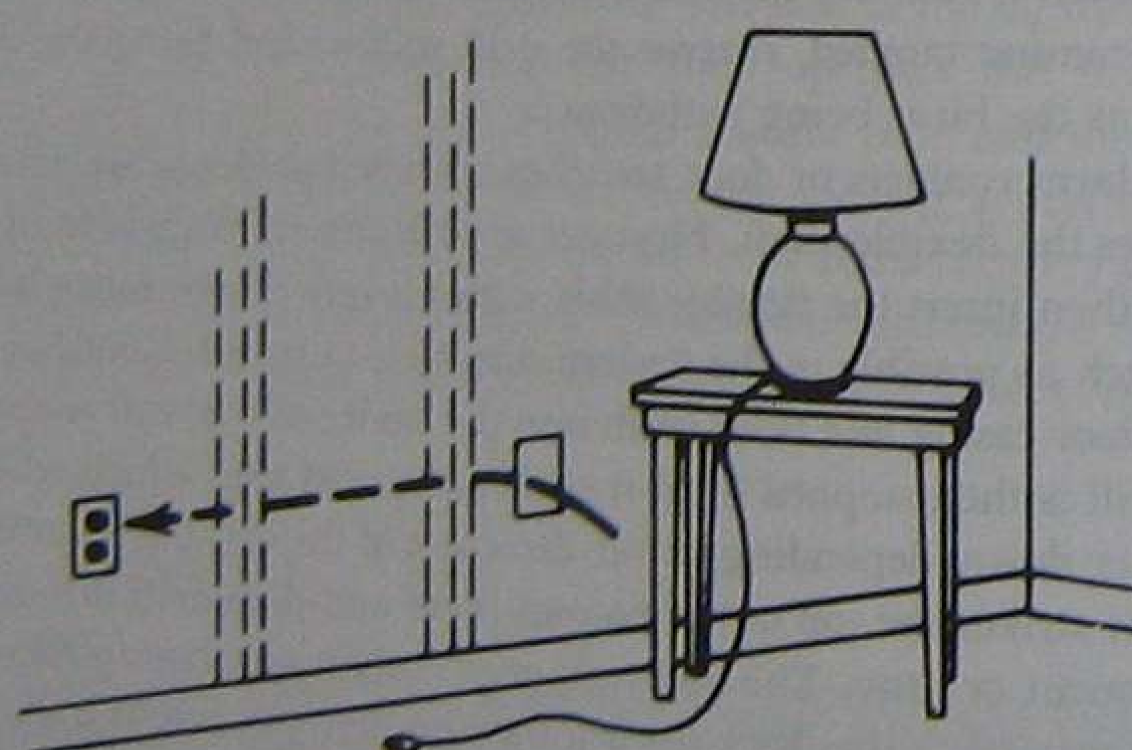


FIGURE 3-17. How wires must be routed when one uses conventional tools.

running the wires down to the baseboard, removing the baseboard, and then installing the wires behind it. Instances like these occur when the crawl space is too shallow for workers to crawl into or the house is built on a concrete slab. However, with the flexible shaft, it is possible to drill through the wall horizontally through several studs (if the operator is careful) and then pull the wires back through the holes to the openings.

The installation of an outside annunciator under the eave of a house with an extremely low pitch to the roof would cause several problems in getting wires to the outlet. With the flexible shaft, a hole can be drilled through the boxing as shown in Fig. 3-18. As soon as the bit penetrates the boxing, it is pushed into the attic as far as it will go. A recovery grip is then attached to the bit, the wire or cable inserted, and then pulled backward toward the outlet opening. The outlet box and annunciator (horn, bell, etc.) are installed under the eave and the other end of the cable is connected to the alarm system. Also, because the flexible shaft is more rigid than the conventional fish tape, it will penetrate attic insulation if any exists.

If it becomes necessary to install wiring in an attic and run cable from this area to the basement, the installation can be greatly simplified by using a flexible shaft. First drill through the top plate into the wall cavity—making sure that the drilling is not being done above a window or doorway or any other obstruction such as existing wiring, ductwork, etc. Once through the top plate, the drill motor is turned off and the bit is pushed into the cavity of the wall as far as it will go. If no fire-stops are encountered, the bit is pulled back and an extension is attached to the shaft. With the extension installed, the bit is again lowered into the wall cavity until a fire-stop is encountered. The bit is then positioned and used to drill through the wooden member. Once the wooden member is penetrated, the drill

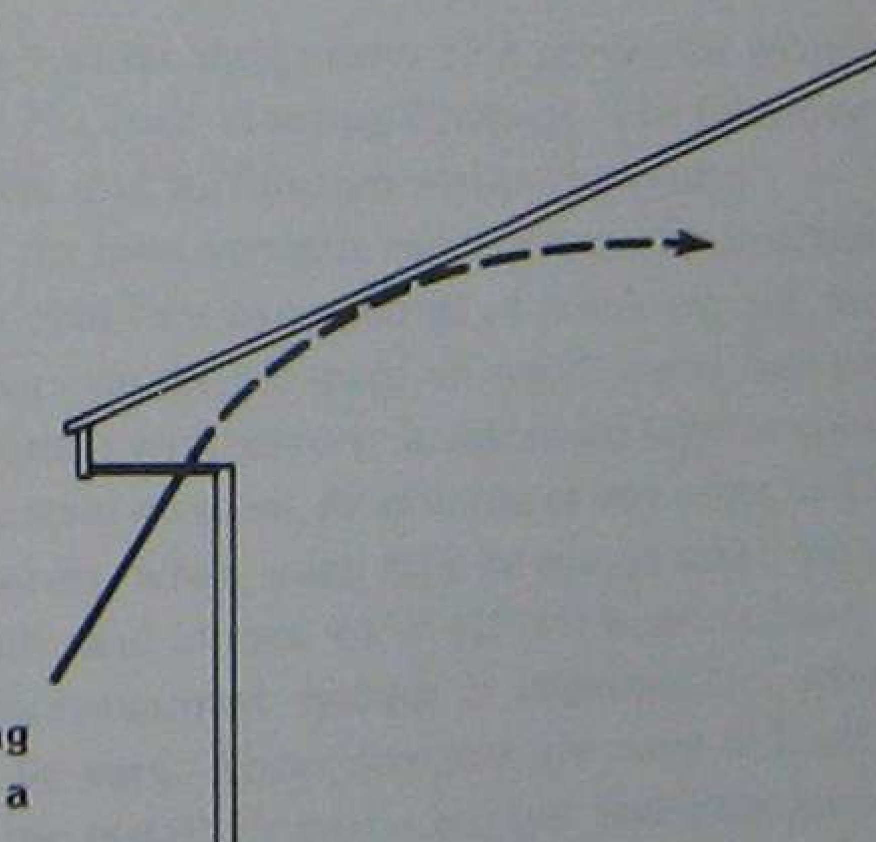


FIGURE 3-18. Method of drilling a hole through boxing by using a flexible shaft.

motor is again stopped and the bit is lowered further until the bottom plate is reached. Continue drilling through the bottom plate in the basement or crawl space. Fasten the appropriate recovery grip, insert the wire or cable, and pull up the wire with the flexible shaft. The drill motor should be reversed only when the bit is passing through one of the wooden members.

Those who use this device often are certain to discover many other useful techniques for installing wiring in existing structures.

4

SELECTING EQUIPMENT

Dozens of manufacturers in this country offer security/fire-alarm systems with a wide selection of accessories to fill practically any need. The selection of a particular system for a given application will usually depend upon the following factors:

1. The type of building to be secured.
2. The allotted budget.
3. The availability of the equipment.
4. Service available.

RESIDENTIAL EQUIPMENT

The diagram in Fig. 4-1 illustrates various components of a residential security/fire-alarm system as distributed by NuTone Housing Products. The following is a brief description of each component and its function within the system.

The surface magnetic detector is the most versatile entry detector for residential alarm systems and should be considered first as a method of protecting any movable door or window. These detectors can be mounted on wood, metal, and even glass, if necessary. They can be mounted with screws, double-sided tape, or epoxy. Obviously, the tape and epoxy are useful on glass, aluminum, or any other surface where screws cannot be used. However, when using tape or epoxy, make certain that the surface is clean, dry, smooth, and at least 65°F (18°C) when applied.

Where the appearance of surface-mounted systems is objectionable, recess-mounted magnetic protectors may be used. These detectors are more difficult to install—requiring greater care on the installer's part—but few problems develop if the following precautions are adhered to:

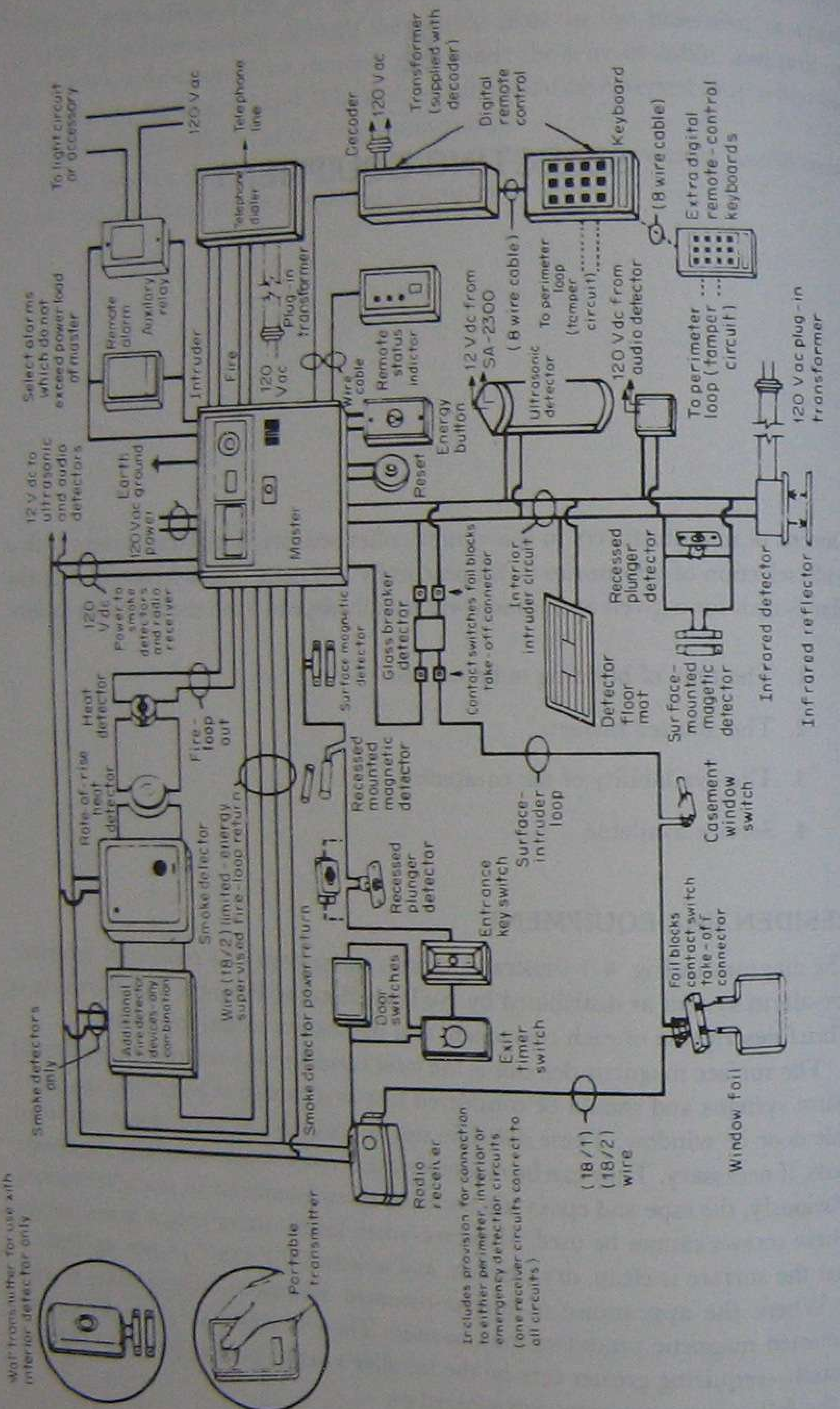


FIGURE 4-1. Various components of a residential security/fire-alarm system.

1. Be careful not to damage or destroy any weatherproofing seal around windows, doors, or other openings.

2. If a recessed-mounted entry detector is installed in the window sill, you must prevent water seepage to the switch by applying a sealant under the switch flange and around the switch body.

3. When drilling holes to accept each half of the detector, be sure the holes line up and there is no more than ¼-in (0.6-cm) space between the two sections of the detector.

4. Be certain there is enough space between the window and its frame (or door and its frame) when each is closed; that is, there must be enough space (usually equaling ¹⁄₁₆ in or 0.16 cm) for the protrusion of both sections when they meet.

5. If the window frame is not thick enough to accept the magnetic section of the detector, the detector can be mounted in the side frame.

The recessed plunger detector shown in Fig. 4-1 is mounted so that the door or window will contact the plunger at the tip and push the plunger straight in. Therefore, the area of the window or door that depresses the plunger should have no slots, cutouts, or step-downs into which the plunger might slip. The area should also be hard and free of rubber or vinyl that might be weakened by the plunger and consequently allow the plunger to open. For protecting doors, plunger-type detectors should only be mounted in the door frame on the hinge-side of the door.

In cases where it is difficult to protect a window or door by mounting any of the direct-type detectors, the area directly inside the door or window can be protected with interior "space" detectors, such as a floor-mat detector (Fig. 4-2) or an ultrasonic motion detector (Fig. 4-3).

Floor-mat detectors are easily concealed under rugs at doors, windows, top or bottom of stairways, or any other area onto which an intruder is likely to step. A light pressure on the mat triggers the alarm.

There are also rolls of super-thin floor matting that can be cut to any desired length. These rolls can be used on stair treads and in areas near sliding glass doors or other large glass areas, entrance foyers, etc. In households with unrestricted

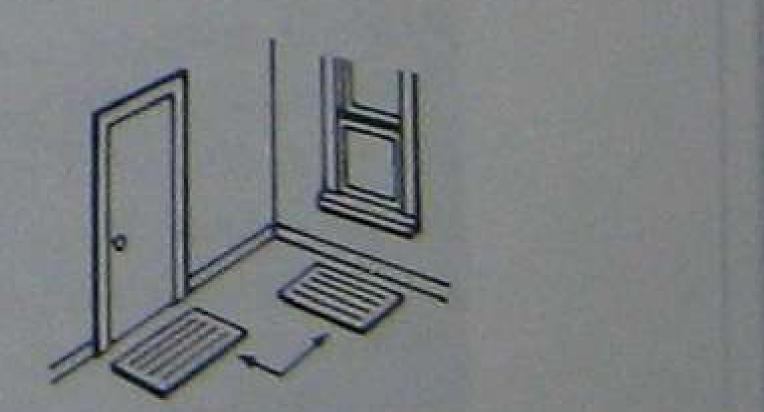


FIGURE 4-2. Floor-mat detector.

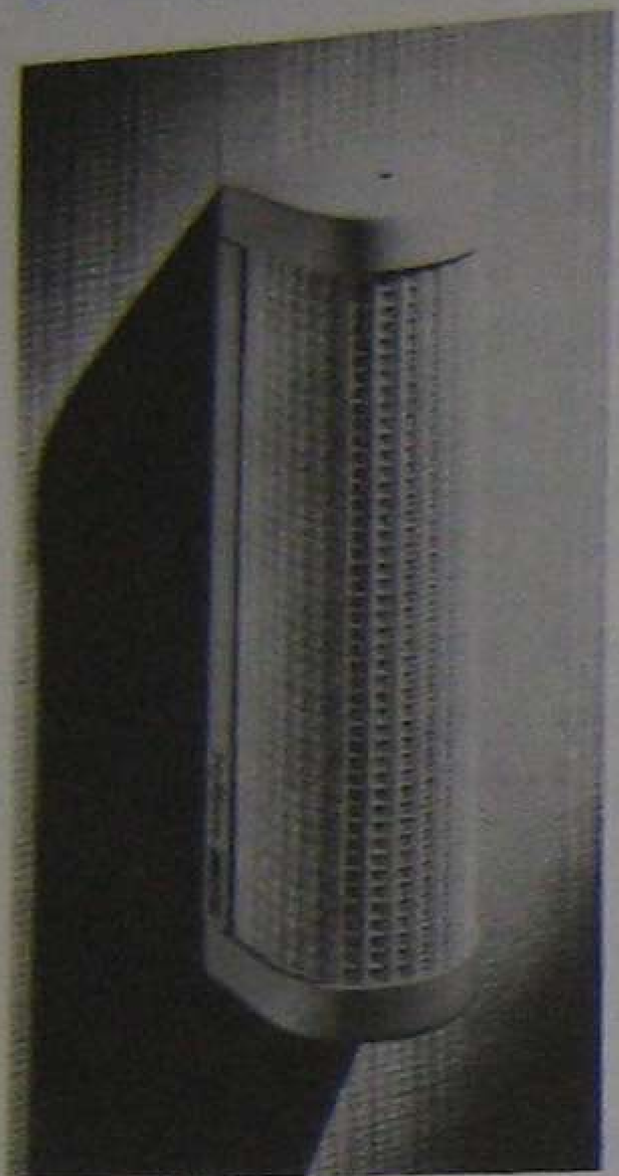


FIGURE 4-3. Ultrasonic motion detector.

pets, these mats are almost useless since the pets roam around the home and are certain to step on one of the mats and trigger the alarm.

Other space detectors include ultrasonic motion detectors, audio detectors, and infrared detectors. Care must be used with any of these units because the protected area is limited both in width and depth—depending upon the particular unit.

The ultrasonic motion detector can be used in large glass-walled rooms that might otherwise be difficult to protect and in hallways or entries or in virtually any area an intruder would have to pass through in moving about a home. They are especially useful as added protection (when conventional detectors are used also) to monitor a "valuables" room or area.

Most ultrasonic motion detectors are designed for mounting on either the wall or ceiling. It emits inaudible high-frequency sound waves in an elliptical pattern that ranges from 12 ft (4 m) to 35 ft (11 m) by 5 ft (2 m) by 20 ft (6 m) for most residential models. When an intruder moves within the secured area, movement interrupts the established pattern of sound waves and sounds the alarm.

Some designs of motion detectors can be rotated up to 180° for maximum coverage of the area being monitored as shown in Fig. 4-4.

Another type of motion detector is the *audio detector* (Fig. 4-5). This type senses certain sharp sounds known to be present in forced entry, such as wood splintering or glass breaking. When these sounds are received through the unit's miniature microphone, the detector triggers the control unit to sound an alarm.

Audio detectors are best utilized in areas which are seldom used, such as an

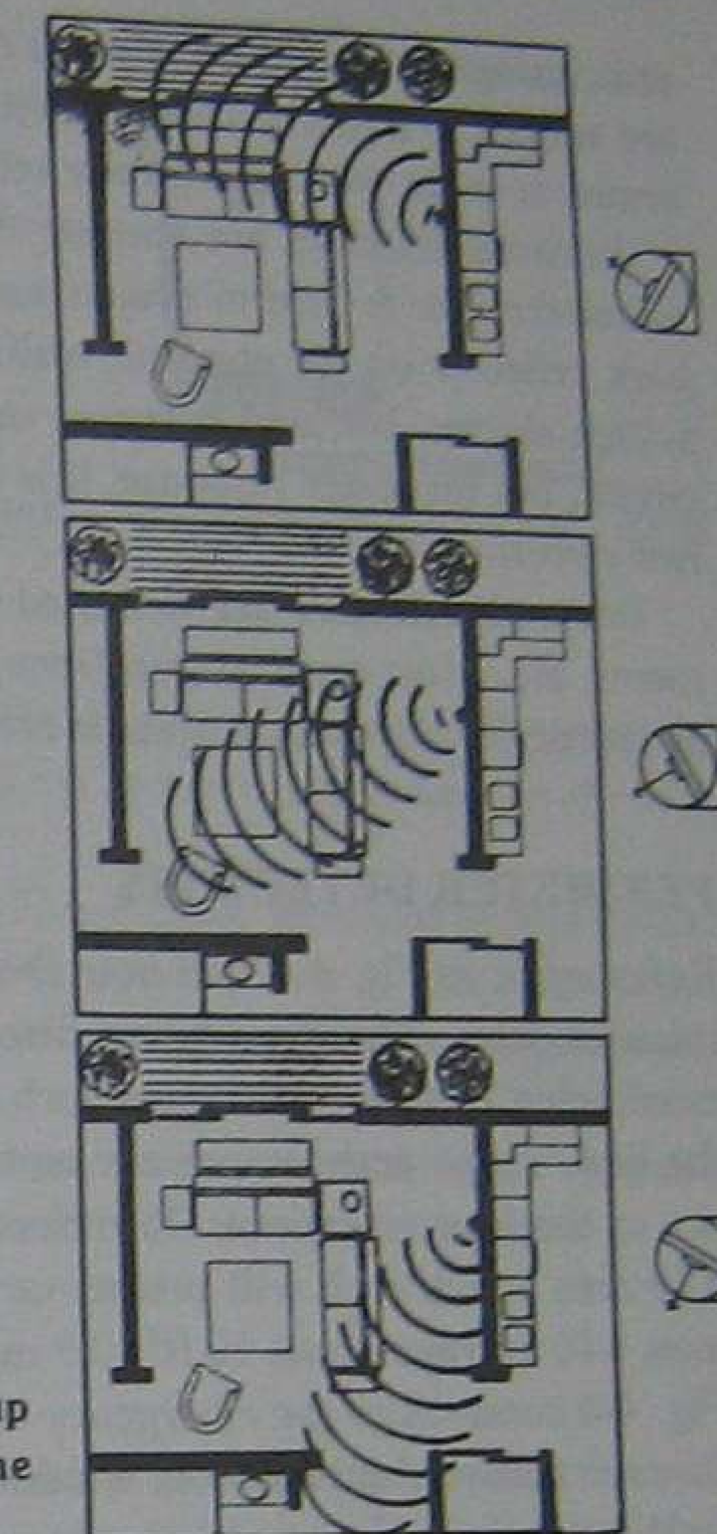


FIGURE 4-4. Motion detector rotating up to 180 degrees for maximum coverage of the area being monitored.

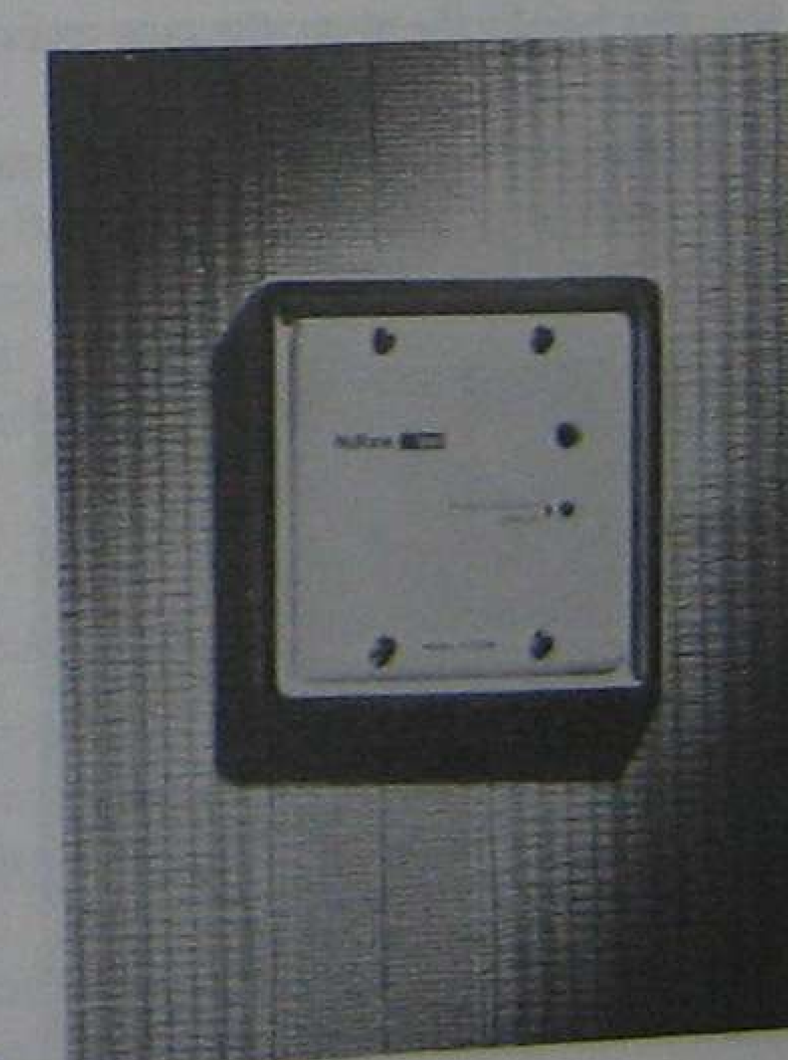


FIGURE 4-5. Audio detector.

attic, garage, or closed-off wing. It can be used in other areas, but when such areas are subject to much daytime activity, it is recommended that the detector only be armed at night when the family retires or is away from home.

Infrared detectors are another type of motion detector. A combination transmitter-receiver is used to project an invisible pulsating beam at a special bounce-back reflector on an opposite wall. Any interruption of the beam activates the system alarms. Infrared detectors can be wired to either the perimeter or interior circuit, but for faster response, it is recommended that it be connected to the interior circuit.

Infrared detectors are designed for indoor areas such as entries, hallways, rooms, etc. Most cover a span from 3 ft (1 m) to 75 ft (23 m), so it may be used in practically any indoor area or room.

PERIMETER DETECTORS

Refer again to Fig. 4-1 and note the various detectors available on the perimeter intruder loop. The glass-break detector, for example, is an excellent means of monitoring large areas of glass such as sliding glass doors, picture windows, and the like. These detectors, as the name implies, respond only to glass breaks and not to shock or vibrations. Therefore, they are relatively free from false alarms. The area which each will protect varies from manufacturer to manufacturer, but most will average about 10 ft^2 (0.9 m^2) of protection. A small cube like the one in Fig. 4-6 connects to the emergency circuit and the supervised perimeter circuit if they are mounted on movable windows.

Window foil tape is used mostly in commercial and industrial buildings but are sometimes used in residential systems—especially on basement windows. If an intruder breaks the glass, the tape tears, opening the circuit, and causes the alarm to sound.

Where the building construction makes it difficult to install wires, radio con-

FIGURE 4-6. Glass-break detector.

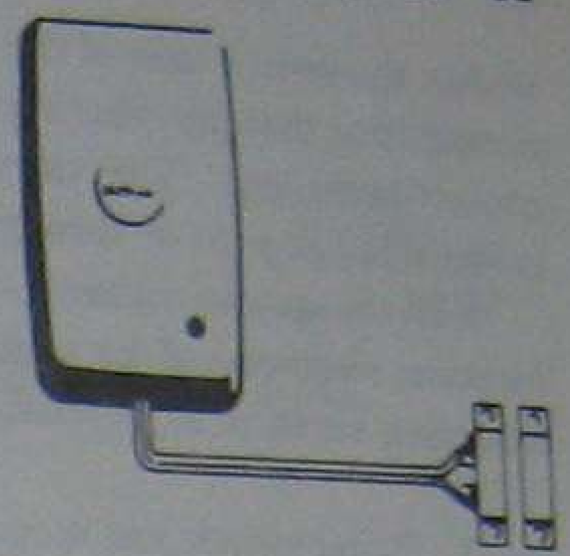


FIGURE 4-7. Wall-mounted radio transmitter.

trolled intruder detection systems are available. Such systems are also useful for linking outbuildings in a range of 150 ft (46 m) or more, depending on the type used.

Wall-mounted radio transmitters (Fig. 4-7) are easily mounted behind drapes at windows, above doors, and similar locations. Any number of transmitters can be used and each can be wired to an unlimited number of detectors as previously described.

When a detector senses forced entry, the transmitter sends a signal via radio waves to the radio receiver. It signals the control unit to sound an alarm.

FIRE-ALARM SYSTEMS

Most residential smoke detectors are photoelectric so that when abnormal smoke accumulates, they automatically activate the system alarms. Heat detectors are also used with smoke detectors in critical areas to help assure full coverage of the home. They activate the alarm when the preset temperature limit is exceeded, causing the contacts to close.

Another type of heat detector is sometimes referred to as a "rate-of-rise" type since it detects abnormal heat from either flash or slow-burning fires. Pneumatic rate-of-rise elements sense any rapid change in temperature, such as 12 to 15 degrees per minute, and sound the alarms. Also, if the fixed temperatures of the detectors are exceeded, the fusible alloy melts, closes the contacts, and activates the alarms.

COMMERCIAL SECURITY/FIRE-ALARM SYSTEMS

Security/fire-alarm systems used for commercial applications are similar to the ones previously described for residential use except that for the former, heavier-duty components are normally used along with additional equipment, such as automatic telephone dialers.

Magnetic contacts are used on doors and windows in closed-protective circuits, in direct-wire systems, and also in open-circuit applications. Movable elements within the switch unit of the magnetic contacts usually consist of a single flexible contact arm that provides a solid metal circuit path from the terminal screw to the contact-point end. The circuit continuity should not depend upon conduction across a hinge joint or through a coil spring.

When magnetic contacts are mounted on either noncoplanar or ferromagnetic surfaces, magnet and/or switch units should be held away from their respective mounting surfaces as necessary to:

1. Bring switch and magnet into close proximity when the door, window, etc., is closed.
2. Reduce the shunting effect of ferromagnetic materials so that positive switch pull-in occurs when the magnet approaches to within ⅛ in (0.3 cm) of the switch.

Mechanical contacts are used as emergency, panic, or fire-test switches. Ball contacts (Fig. 4-8) and plunger contacts (Fig. 4-9) are used in both closed- and open-circuit applications.

FIGURE 4-8. Ball contacts.

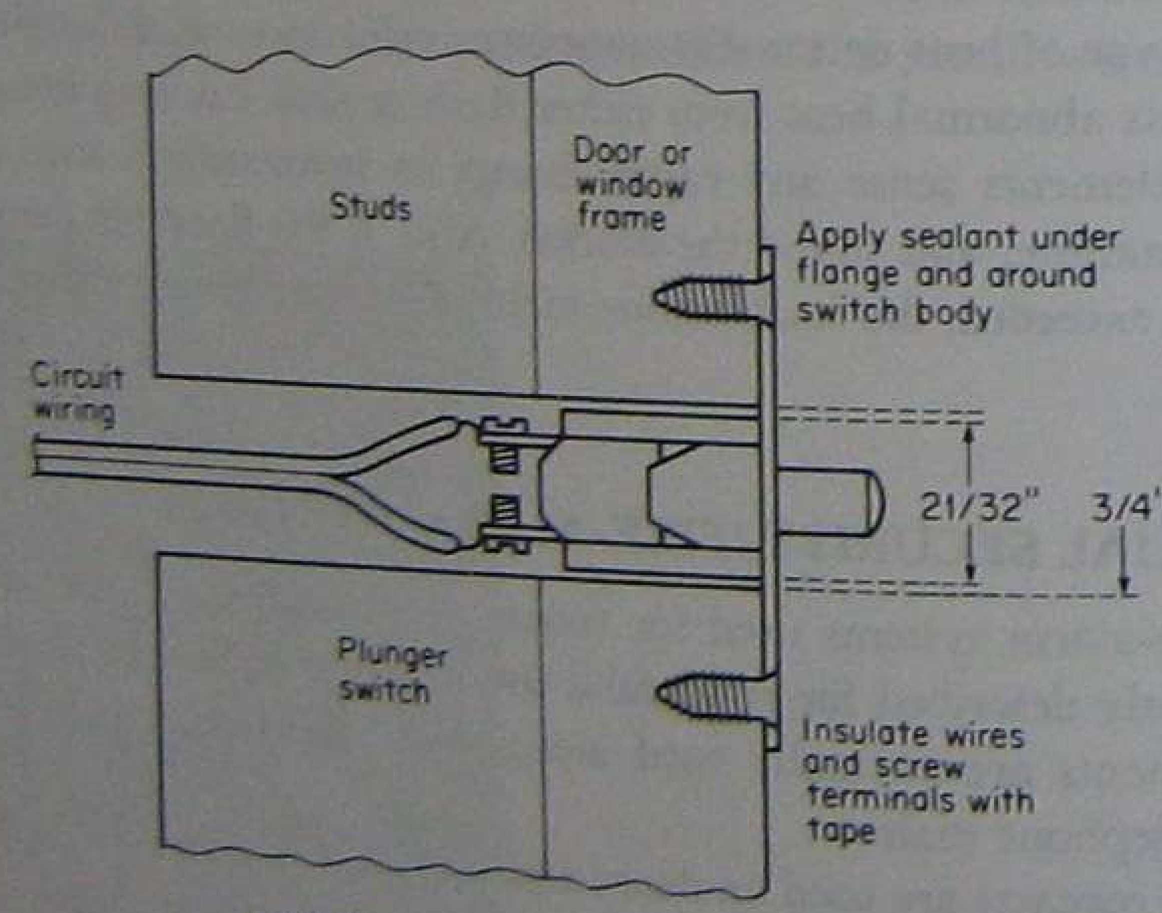


FIGURE 4-9. Plunger contacts.

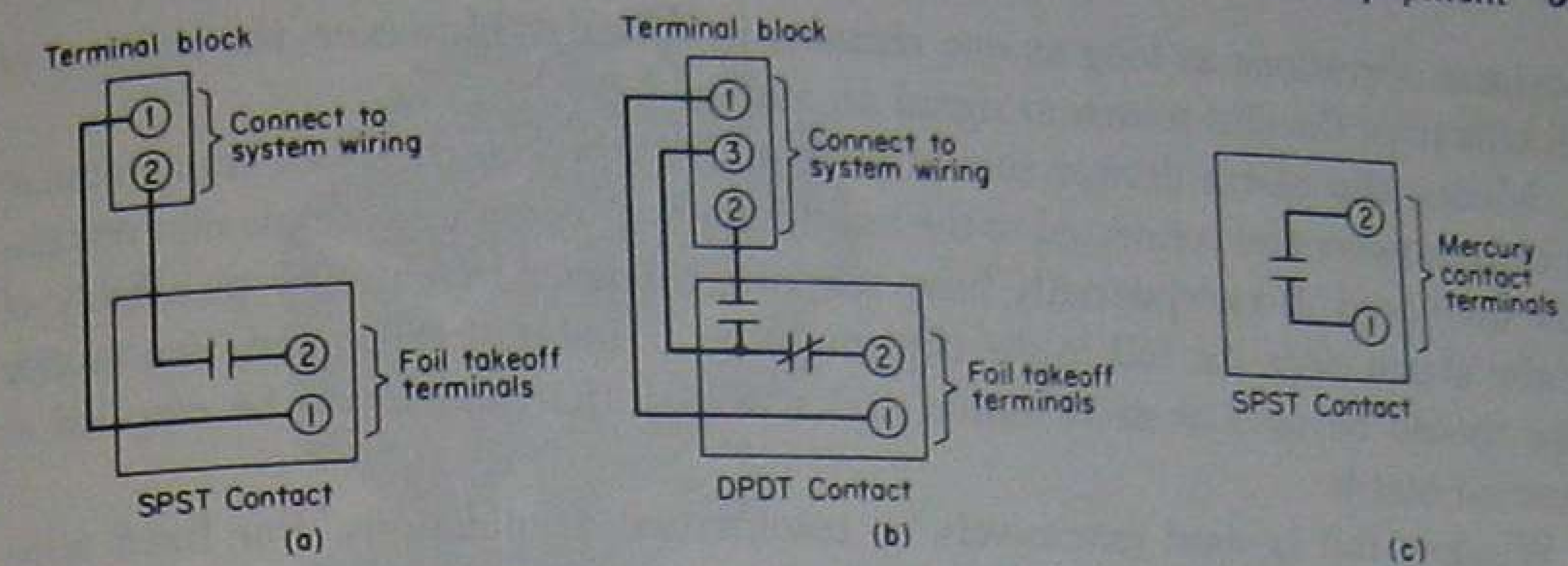


FIGURE 4-10. Wiring diagram of mercury contact connections.

Mercury contacts are sometimes used in low-energy alarm or signal systems to detect tilting of any horizontally hinged window, door, cover, access panel, etc. Due to the different items to be protected, it is best to install mercury contacts that can be adjusted to sensitivity after installation.

For combined detection of either opening or breakthrough, cord-mounted contacts with foil connected to takeoff terminals should be used. Wiring diagrams of mecury contact connections are shown in Fig. 4-10.

Holdup switches are usually installed under counters or desks in banks or stores, where an employee observing a holdup may be able to signal for help.

In banks and similar places where large amounts of money are exchanged, a money-clip alarm device is sometimes used. This device automatically triggers an alarm when all bills are removed from a cash drawer. A bill inserted in the clip (see Fig. 4-11) holds its switch in the normal position. Additional bills on top of the clip keep it concealed. Bills may be added or removed as required for normal

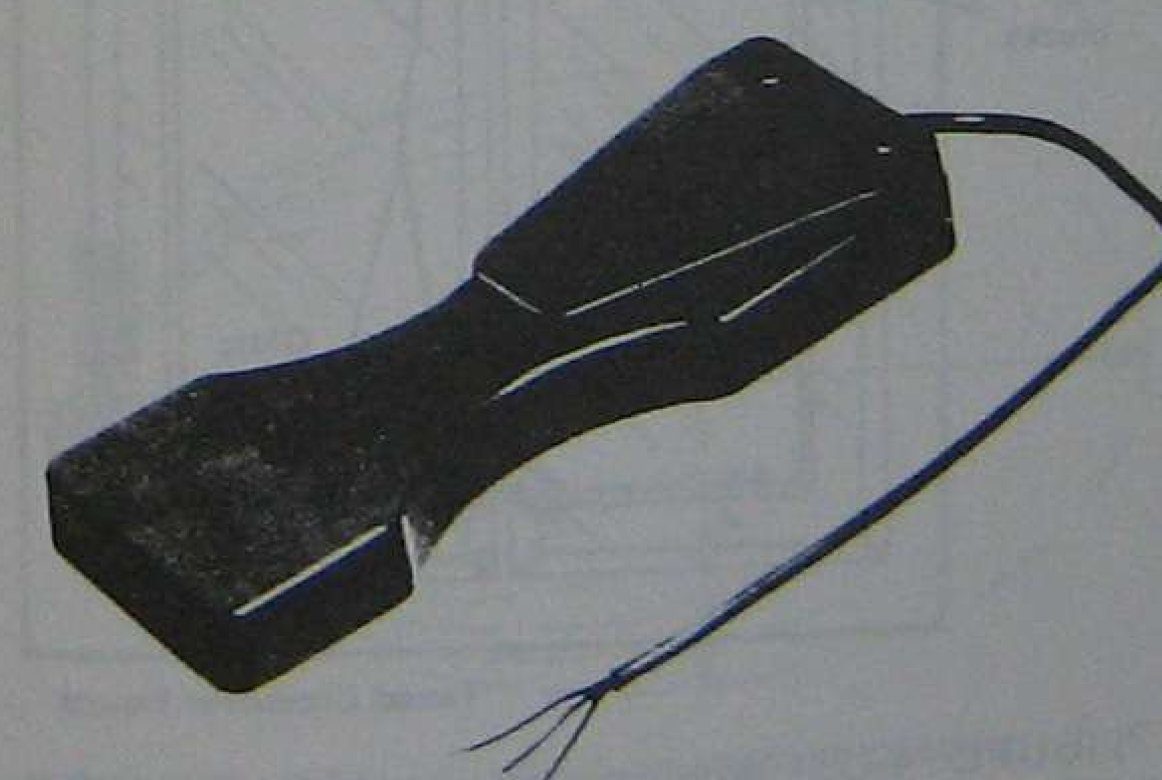


FIGURE 4-11. Money-clip alarm device.

business operations as long as one remains in the clip. However, the removal of all bills trips the clip switch to signal an alarm.

Money-clip alarm devices should be installed in the largest bill compartment of cash drawers and connected to the building alarm system by means of a retractable door cord. If exceptionally busy working conditions create the possibility of a false alarm since the bill in the clip might be accidentally removed, two money clips should be used at each station and wired so that both must be emptied to cause an alarm.

Window foil is used extensively in commercial applications. For fixed windows, the connections to the building alarm system is usually made through foil blocks as shown in Fig. 4-12. For movable windows and doors, a retractable door cord (Fig. 4-13) must be used.

Ultrasonic motion detectors for commercial applications are essentially the same as the ones described for residential use. However, the range of detection is sometimes extended on the units designed for commercial use. For example, a typical coverage pattern of a motion detector manufactured by Conrac is shown in Fig. 4-14. Note the coverage here is 15 ft (5 m) wide by 30 ft (9 m) deep.

Commercial telephone dialers are available that dial emergency numbers and deliver voice messages. Most distinguish between burglar and fire-alarm channels. A typical wiring diagram is shown in Fig. 4-15.

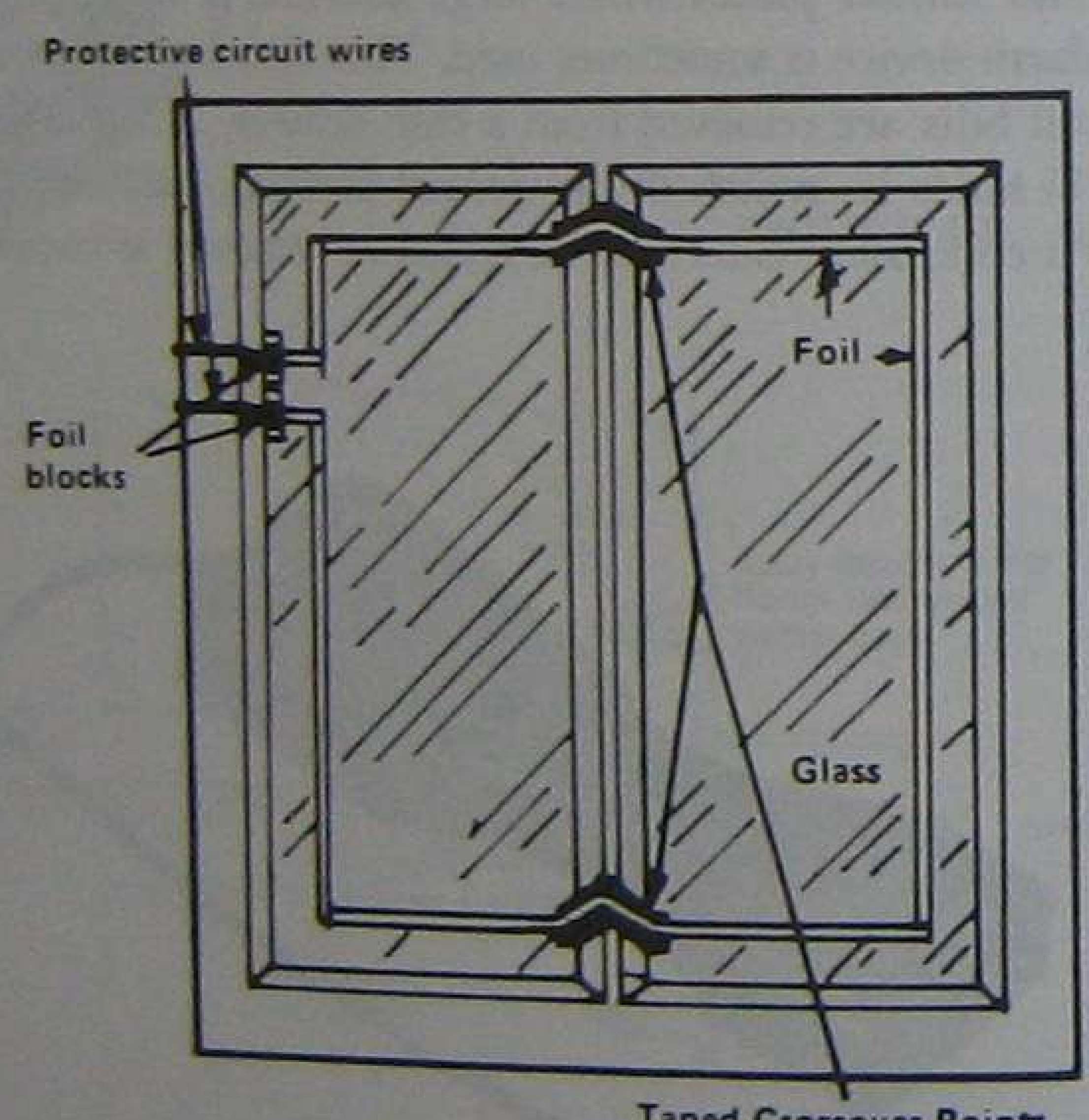


FIGURE 4-12. Window foil connected to foil blocks.

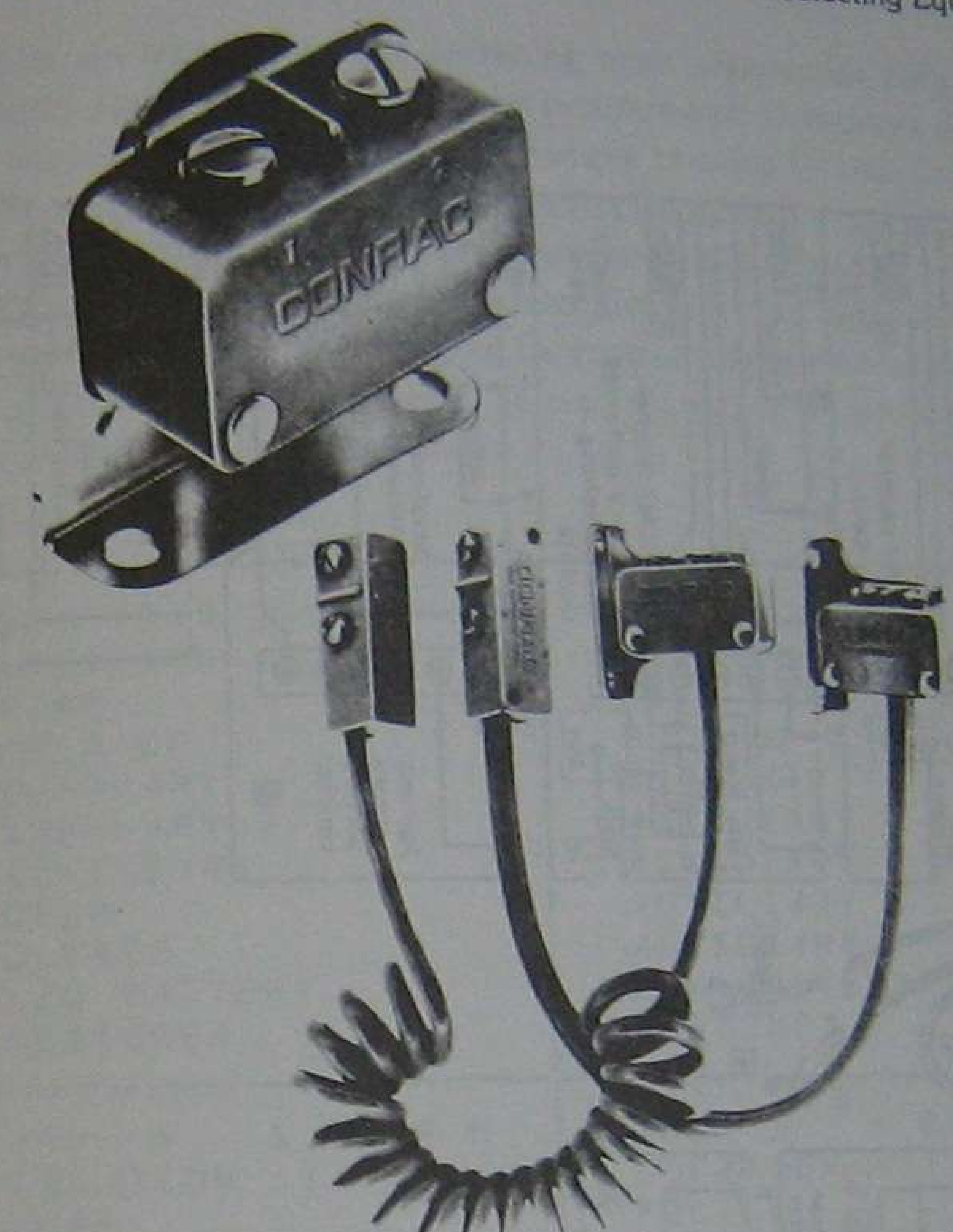


FIGURE 4-13. Retractable door cord.

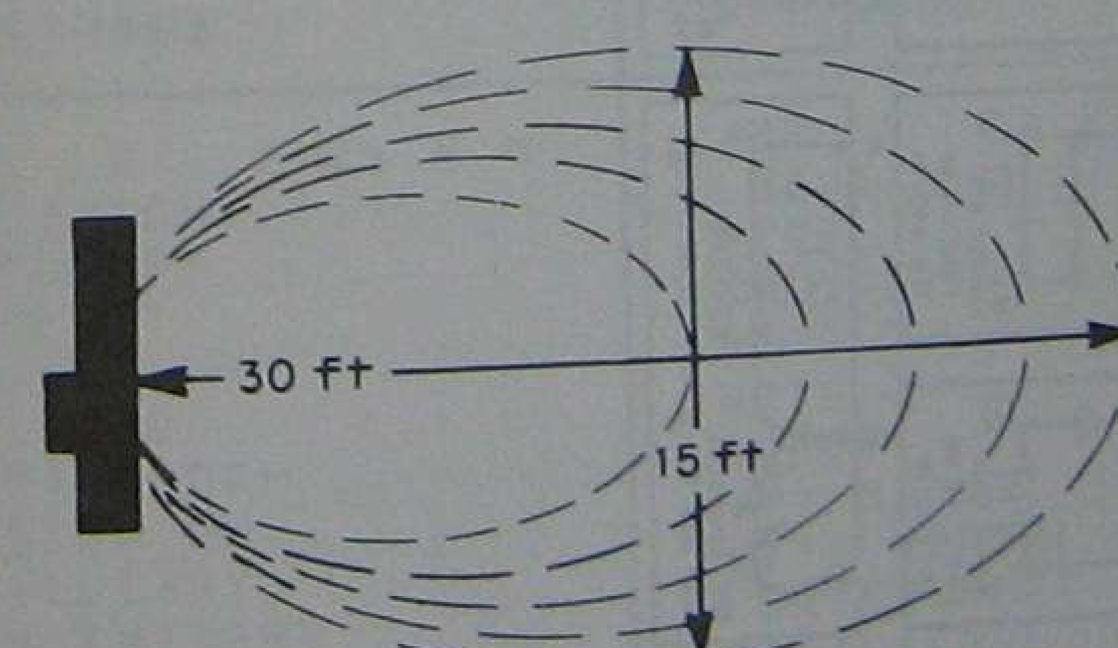


FIGURE 4-14. Typical coverage pattern of a motion detector.

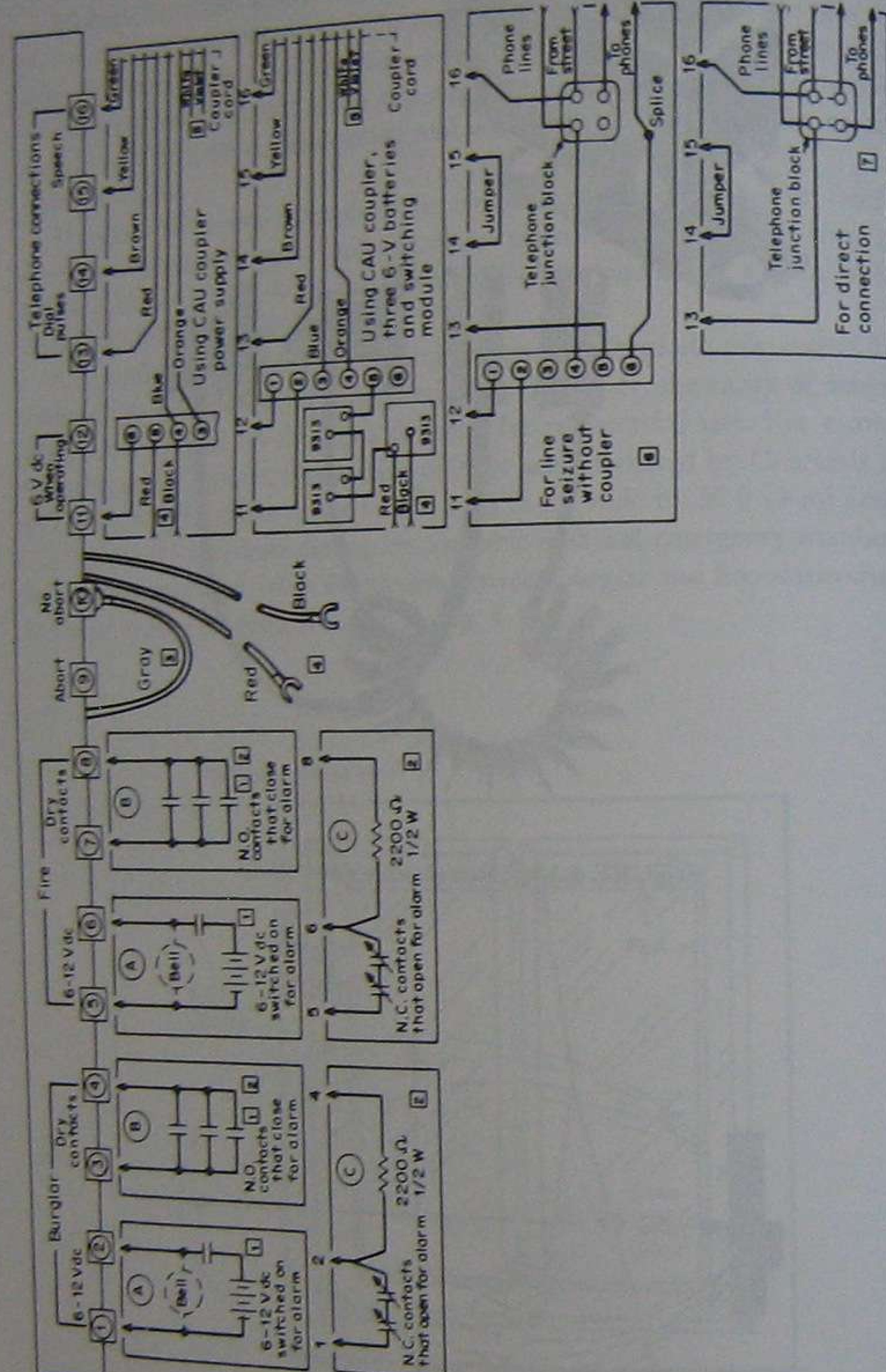


FIGURE 4-15. Wiring diagram of a commercial telephone dialer.

Digital alarm transmitters are becoming more popular for both commercial and industrial applications. They can be programmed on memory chips to meet the exact requirements of any business. Sample printing formats for one digital-alarm system manufactured by Adcor Electronics is shown in Fig. 4-16. In this model, each line (corresponding to an alarm code) is limited to 13 characters. A blank space between two words on the same line will take up one character.

These units are specifically designed for central-station monitoring of commercial and small industrial buildings. The unit consists of a transmitter, a special module, and a subscriber control station.

DEC 2 2 02 A M LOCATION 1111 FIRE HOLD-UP BURGLARY 1 BURGLARY 2 AUXILIARY OPEN CLOSED LOW BATTERY RESTORED	JAN 3 2 02 P M LOCATION 1111 FIRE HOLD-UP BURGLARY AUXILIARY 1 AUXILIARY 2 AUXILIARY 3 AUXILIARY 4 LOW BATTERY RESTORED
APR 4 5 05 P M LOCATION 1111 FIRE HOLD-UP BURGLARY 1 BURGLARY 2 SUPERVISORY OPEN CLOSED LOW BATTERY RESTORED	DEC 3 4 04 P M LOCATION 1111 POLICE FIRE SECURITY 1 SECURITY 2 CONTROL ARMED ROBBERY BURGLARY LOW BATTERY RESTORED
DEC 2 2 05 P M LOCATION 1111 BURGLARY FIRE PANIC FAILURE SYSTEM OFF SYSTEM ON AUXILIARY LOW BATTERY RESTORED	APR 7 6 26 P M LOCATION 1111 FIRE HOLD-UP NITE 1 NITE 2 SUPER DAY NORMAL NITE NORMAL LOW BATTERY RESTORED

FIGURE 4-16. Sample printing formats for digital alarm system.

The Adcor module has three input zones as follows:

Zone A: Two-wire, closed-circuit input generally used for a foil circuit. This zone may be 24-hour or key-controlled by the subscriber control station.

Zone B: Three-wire, closed-circuit and open-circuit input for perimeter doors and windows. This zone is armed and disarmed by the subscriber control station. It can be connected to the detector contacts so that an open or a crossed circuit will produce an alarm.

Zone C: Three-wire, closed-circuit and open-circuit input for internal protection devices, such as ultrasonic motion detectors, infrared beams, passive infrared detectors, etc. They may be wired so that either an open or a crossed circuit will produce an alarm. Six output leads are provided from the module to trip the control as follows:

1. Zone A open
2. Zone B open or crossed
3. Zone C open or crossed
4. System armed (closed—night)
5. System disarmed (open—day)
6. Alarm circuit restored

Zones A and B may be connected to the same channel of the transmitter, thus using only five channels for the module. If this is done, a daytime foil break will be reported as "perimeter alarm—day." The sixth channel may then be used for 24-hour reporting of fire alarm, holdup alarm, or equipment supervisory monitoring. A holdup alarm may also be connected to the same channel of the transmitter as Zone C. If this is done, a holdup would be indicated as "interior alarm—day."

When the subscriber leaves, an interior alarm will be tripped (which will be reported) and the perimeter door circuit will be tripped (which will be reported). A restore signal will be reported only when all three zones have returned to normal.

The subscriber control station consists of an ace key switch and two LED's mounted in a stainless steel plate. One LED indicates that all three zones are good. When the subscriber turns the key to arm the system, the second LED comes on, indicating that the transmitter is reporting the closing signal. This LED goes out when the signal is received at the central station.

Because the transmitter can report multiple signals on the same call, it is practical to locate the subscriber control station near the exit door. Thus, if the subscriber arms the system and leaves immediately, the closing (interior alarm), perimeter alarm, and restore signal will all be transmitted on a single call. This will take about 30 seconds (including dialing time). The receiver at the central station will be tied up for about 15 seconds after it answers the call.

Surveillance cameras are being used extensively in banks and stores to prevent holdups, pilferage, and burglaries. Since thieves are notoriously camera-shy, the presence of a surveillance camera is often sufficient to make a would-be robber change his mind. If a business should be robbed, a surveillance camera provides sharp evidence to aid police and court.

Most surveillance cameras can be adjusted to take individual still pictures at preset intervals to keep a continuous eye on the premises. The Super 8 Kodak Surveillance camera, for example, provides continual recorded surveillance for up to 180 hours with each 100 foot roll of film. There are up to 7200 individual photographs to assist in positive identification and apprehension. This camera can be activated by a switch on the camera, by remote control, or automatically by a relay from the external alarm system.

INDUSTRIAL EQUIPMENT

Industrial security/fire-alarm systems are essentially the same as those used for commercial applications. There are, however, a few additional systems that are used more in industry than elsewhere.

Vibration detectors are often used on industrial buildings to detect vibrations caused by forced entry. Such detectors have been used on a variety of construction materials such as hollow tile, plaster and lath, brick, concrete, metal ceilings, and wood. Once mounted in place, they may be adjusted with a set screw for the desired sensitivity.

Some factories maintain a security fence equipped with fence-guard detectors. This type of detector will detect climbing, cutting, or any other penetration of the fenced area. Most of these detectors operate on standard closed-circuit controls as described previously.

Fence-guard detectors use a vertical-motion detector that is sensitive to movement created by climbing or cutting the fence. Normal side motions such as wind or accidental bumping do not affect the detector and cause false alarms. They are normally mounted about midway up the fence, and every 10 ft (3 m) of fence length. Most of these devices set off the alarm if they are tampered with or if the wire is cut. They may be connected to a control panel and the alarm will "sound" in the form of a bell or horn, or it will silently dial the local law-enforcement agency.

The only other type of detector encountered in this particular survey was the outdoor microwave detector which was used for protecting large outdoor areas like car lots, construction sites, and factory perimeters. In operation, a solid circular

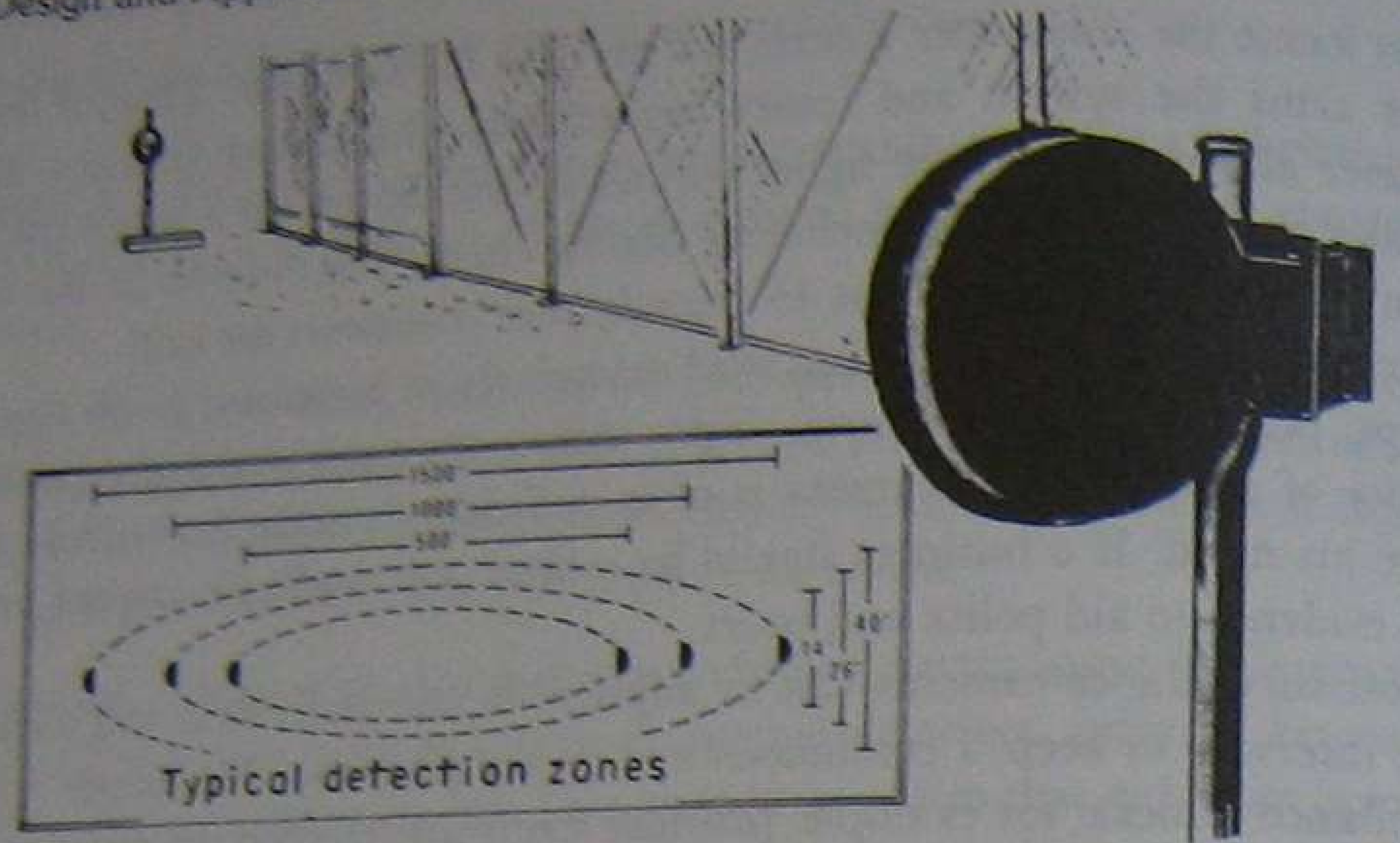


FIGURE 4-17. A solid circular beam of microwave energy extends from a transmitter to the receiver over a range of up to 1500 ft (457m).

beam of microwave energy extends from a transmitter to the receiver over a range of up to 1500 ft (457 m) (for some brands). Any movement inside of this beam (see Fig. 4-17) will activate the alarm.

THERMISTOR SENSOR

The continuous linear thermal sensor is a small-diameter coaxial wire which is capable of sensing temperature changes along its entire length. The sensor is made up of a center conductor and an outer stainless steel sheath. The center conductor is electrically insulated from the outer sheath by a ceramic thermistor material as shown in Fig. 4-18.

Since the thermistor has a negative coefficient of resistance, the electrical resistance between the center wire and the outer sheath decreases exponentially as the surrounding temperature increases (see Fig. 4-19).

The changing resistance is monitored by one of several control panels which then can actuate extinguishing systems or any other electrically controlled devices.

Such sensors have a diameter of approximately 0.080 in (0.2 cm) and therefore have a small mass which permits them to sense changes in temperature rapidly. They can sense temperatures from 70°F (21°C) up to 1200°F (649°C), if the thermistor material is properly selected.

Since electrical resistance is measured across two wires (center and sheath), the sensor has the ability to detect a high temperature on a short wire as well as a lower temperature on a longer one.

The elements are mounted by clamps spaced along their lengths and the detectors, being all solid state, have only two electrical failure modes: open-circuit and short-circuit. Both of these conditions can be caused only by mechanical means and are minimized by rigid mounting. Figure 4-20 shows the construction and mounting details.

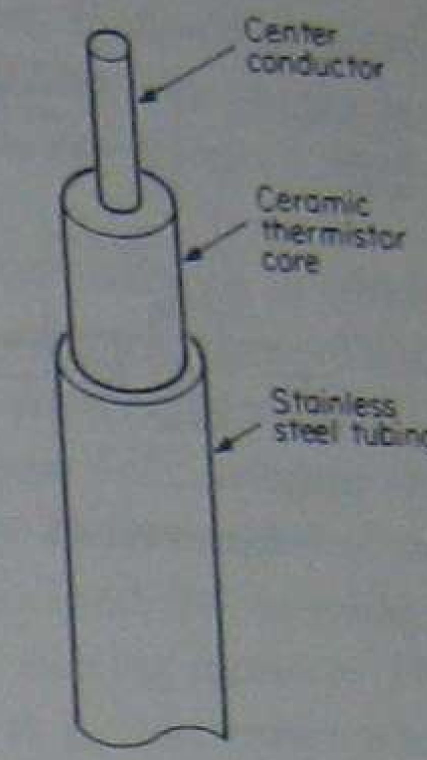


FIGURE 4-18. Structure of heat-sensor cable.

ULTRAVIOLET-RADIATION FIRE DETECTORS

Ultraviolet-radiation fire detectors combine large-scale integration circuit techniques with an ultraviolet detection assembly to form a simple, yet flexible, fire-detection system.

The basis of this type of system is a gas-detection tube employing the Geiger-Mueller principle to detect radiation wave lengths extending from 2000 to 2450 angstroms (Å) (1 Å = 10^{-8} cm). Figure 4-21 displays the tube's radiation sen-

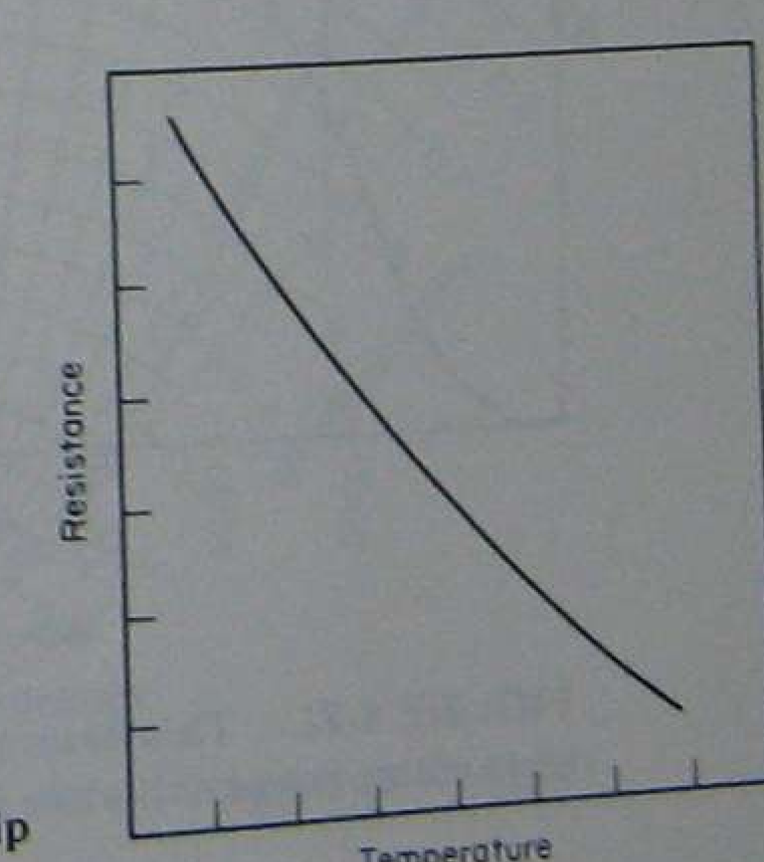
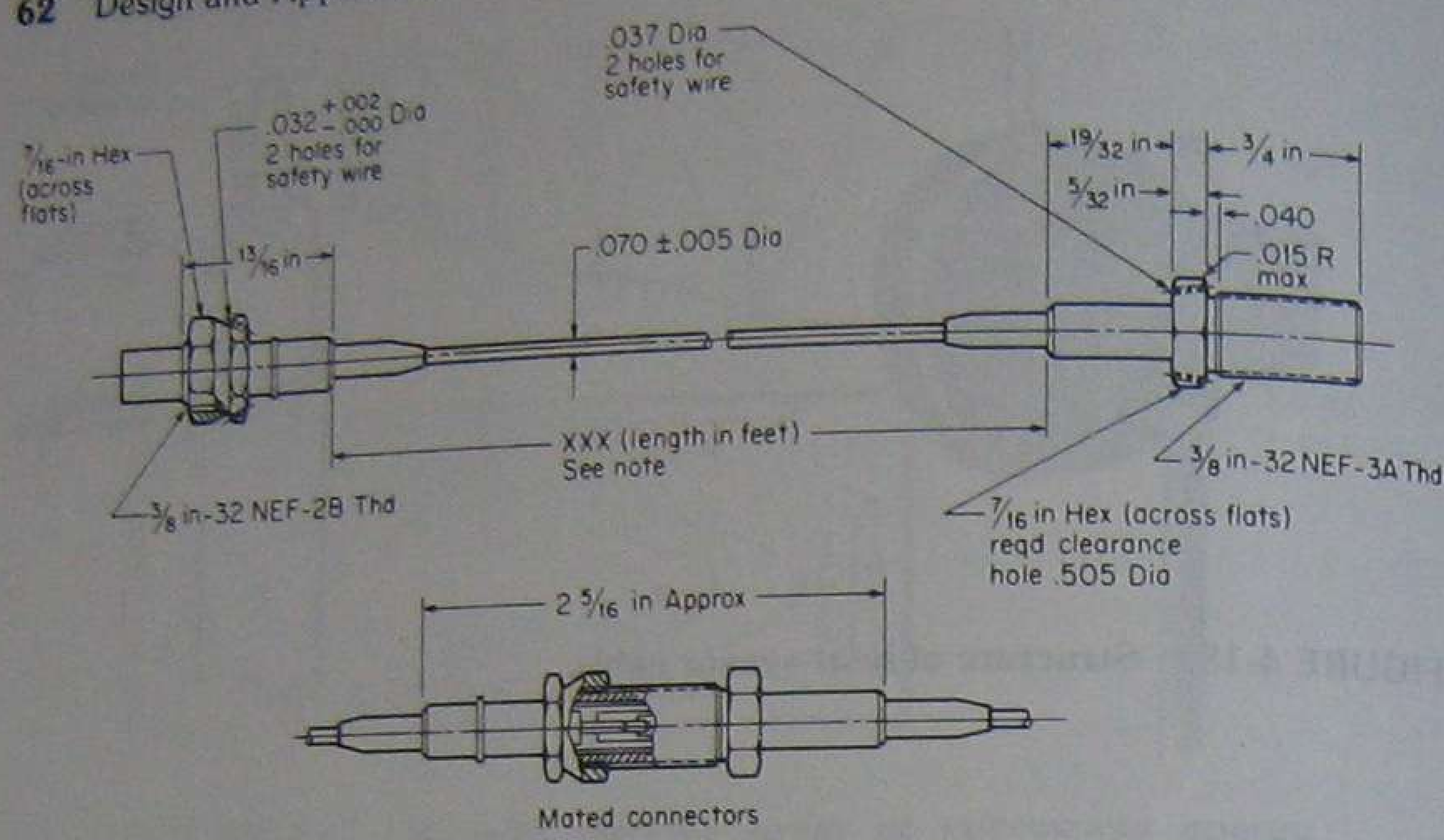


FIGURE 4-19. Curve showing relationship of resistance to temperature.



Note:
Any length of sensor may consist of one or more discrete lengths.

FIGURE 4-20. Using connectors to supply desired length of sensor cable.

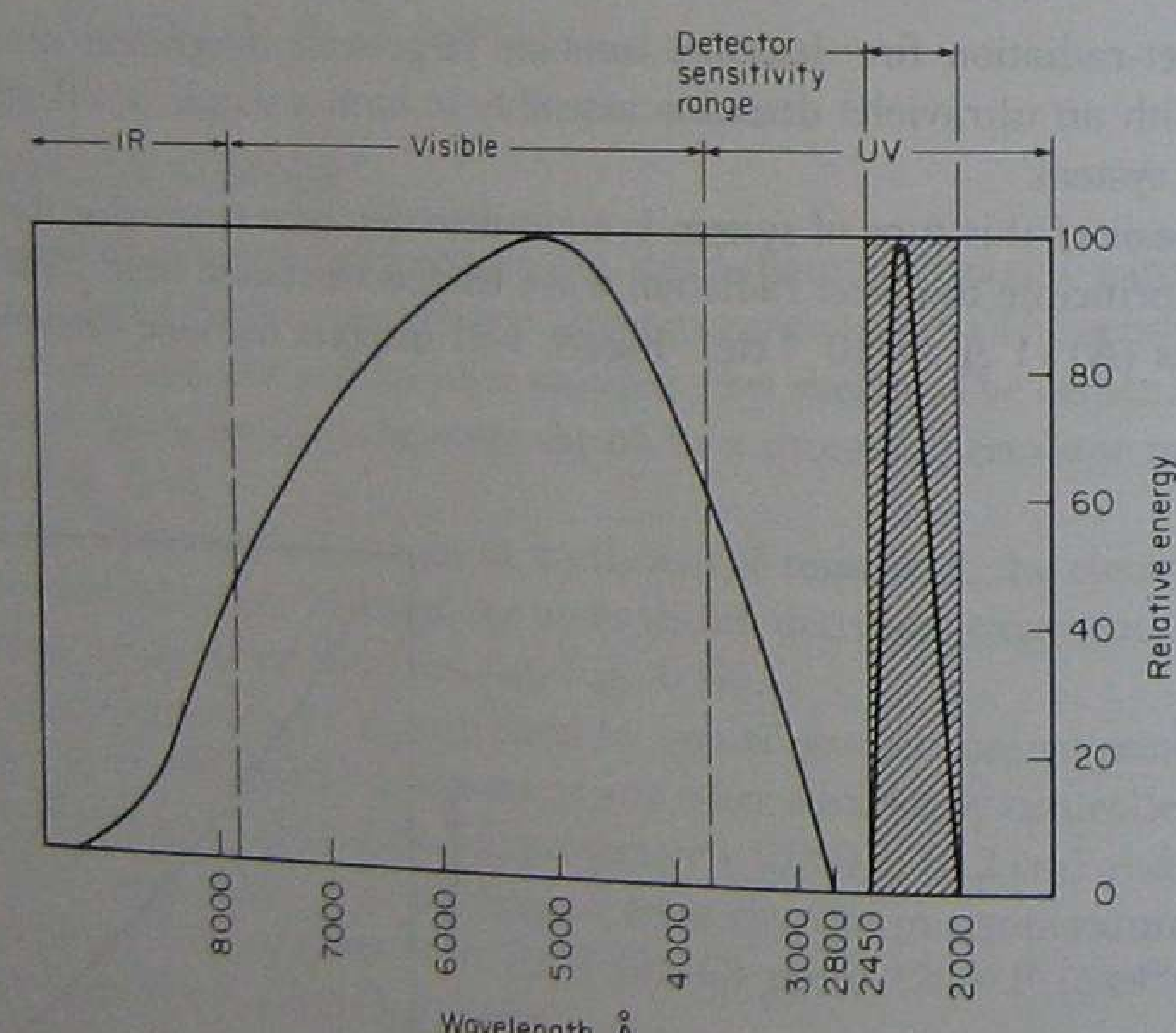


FIGURE 4-21. This detector has maximum sensitivity in the ultraviolet range.

sitive area and compares this area to other forms of radiation. It should be noted that visible radiation does not extend into the detector's sensitive area. Similarly, radiation from artificial lighting sources does not extend into the detector's sensitive area.

Welding arcs and lightning strikes, however, will generate radiation to which the detectors are sensitive and precautions must be taken to minimize these effects.

The ultraviolet-radiation detector's focus of sensitive points is a 60-degree spherical cone whose apex lies at the detector tube. Figure 4-22 indicates the relationship between viewing angle and relative sensitivity. The sensitivity of the detector tube is a characteristic of its cathode material and is fixed, but its voltage-pulse output rate varies both with flame size and flame viewing distance. The pulse output rate is directly proportional to flame size; that is, it increases when larger flame fronts are presented to the detector. The pulse output rate is also inversely proportional to the distance of the flame front from the detector tube—the pulse output rate decreases as the distance from the detector tube to the flame front increases.

To illustrate, a 1 ft^2 (0.09 m^2) hydrocarbon fire will cause a pulse output rate of 3 pulses per second at a viewing distance of 30 ft (8 m). This same fire will

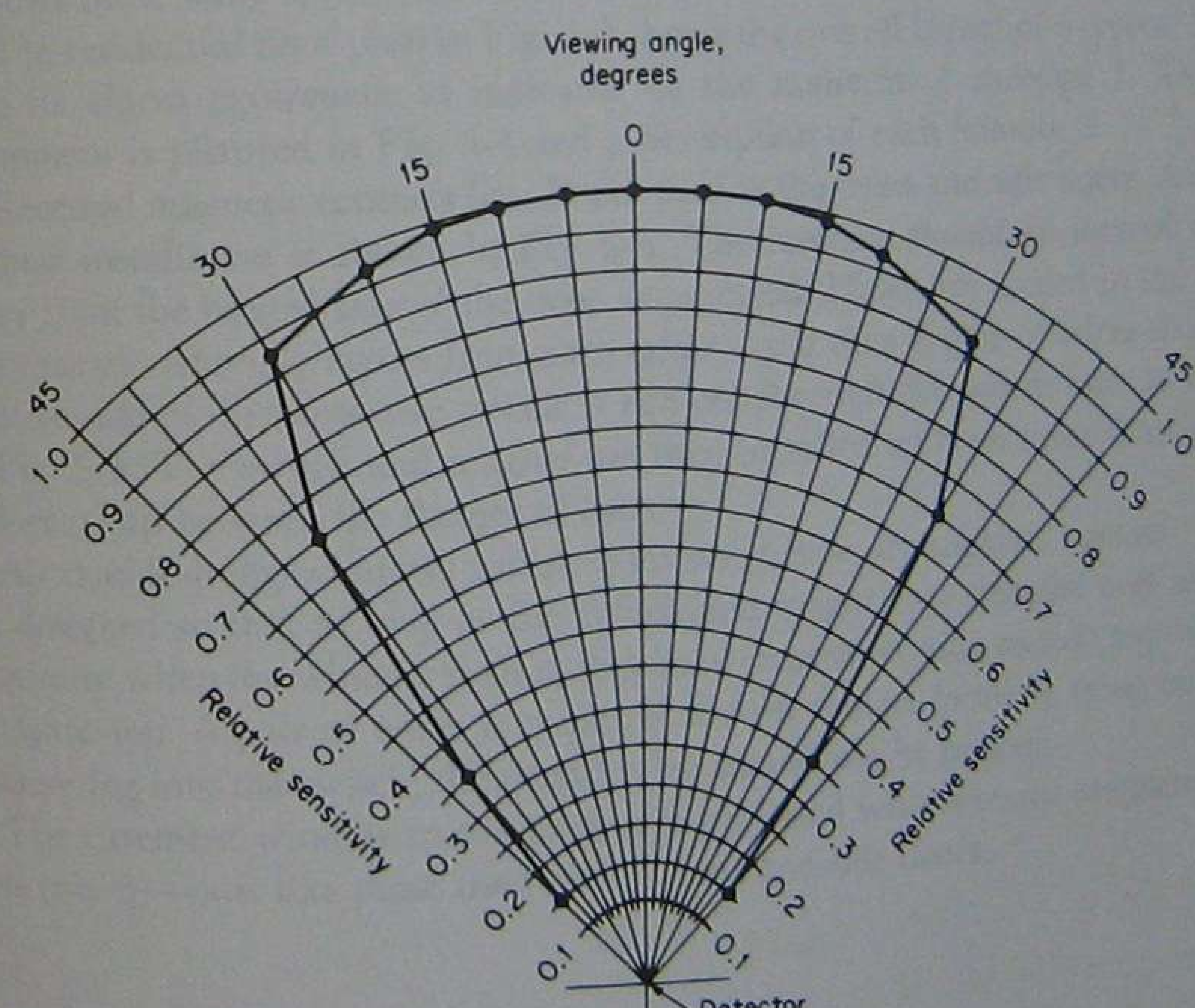


FIGURE 4-22. Viewing angle of ultraviolet motion detector.

cause a tube pulse output rate of 20 pulses per second at a viewing distance of 20 ft (6 m). In a like manner, 1 ft² (0.09 m²) flame front must be located at a distance of 5 ft (1.5 m) to create a pulse output rate of 30 pulses per second, a 16 ft² (1.4 m²) fire will create the same pulse output rate at a distance of 25 ft (7.6 m), and so forth.

5

DESIGN OF RESIDENTIAL SECURITY/FIRE-ALARM SYSTEMS

A wide variety of alarm systems and accessories are available to take care of almost every conceivable residental application. For example, the pictorial diagram in Fig. 5-1 shows several accessories available for residential application. Figure 5-2 shows these same accessories in an actual installation.

The residential floor plan in Fig. 5-3 shows the overall layout of a typical home with its alarm equipment as indicated by the numerals 1 through 7. Typical equipment is pictured in Fig. 5-4 and a description of each follows.

Recessed magnetic contacts (no. 3) are used at the front and side doors. A detail of their installation is shown in Fig. 5-5. The contacts should be located as far away from the hinged side of the door as practical. Holes are drilled in the doors and casings—directly across from each other—and then a pair of wires from the positive side of the protective circuit is run out through the switch hole as shown in Fig. 5-5. The switch and magnet are then installed with no more than a ⅛-in (0.3-cm) gap between the flanges of each.

All double-hung windows utilize a different type of magnetic contact. These are designed so that as long as the switch and magnet are parallel and in close proximity when the window is shut, they may be oriented side-to-side, top-to-side, or top-to-top. A pair of wires is required at each contact location, tying only the positive leg into the switch; the negative leg should not be broken.

The casement window in the kitchen is protected with recessed magnetic contacts (no. 3)—just like those used on the front and side doors.

BEGINNING THE DESIGN

The first decision to be made and the hardest to determine is what the system must accomplish, that is, identify the threat—whether it is personal risk encoun-

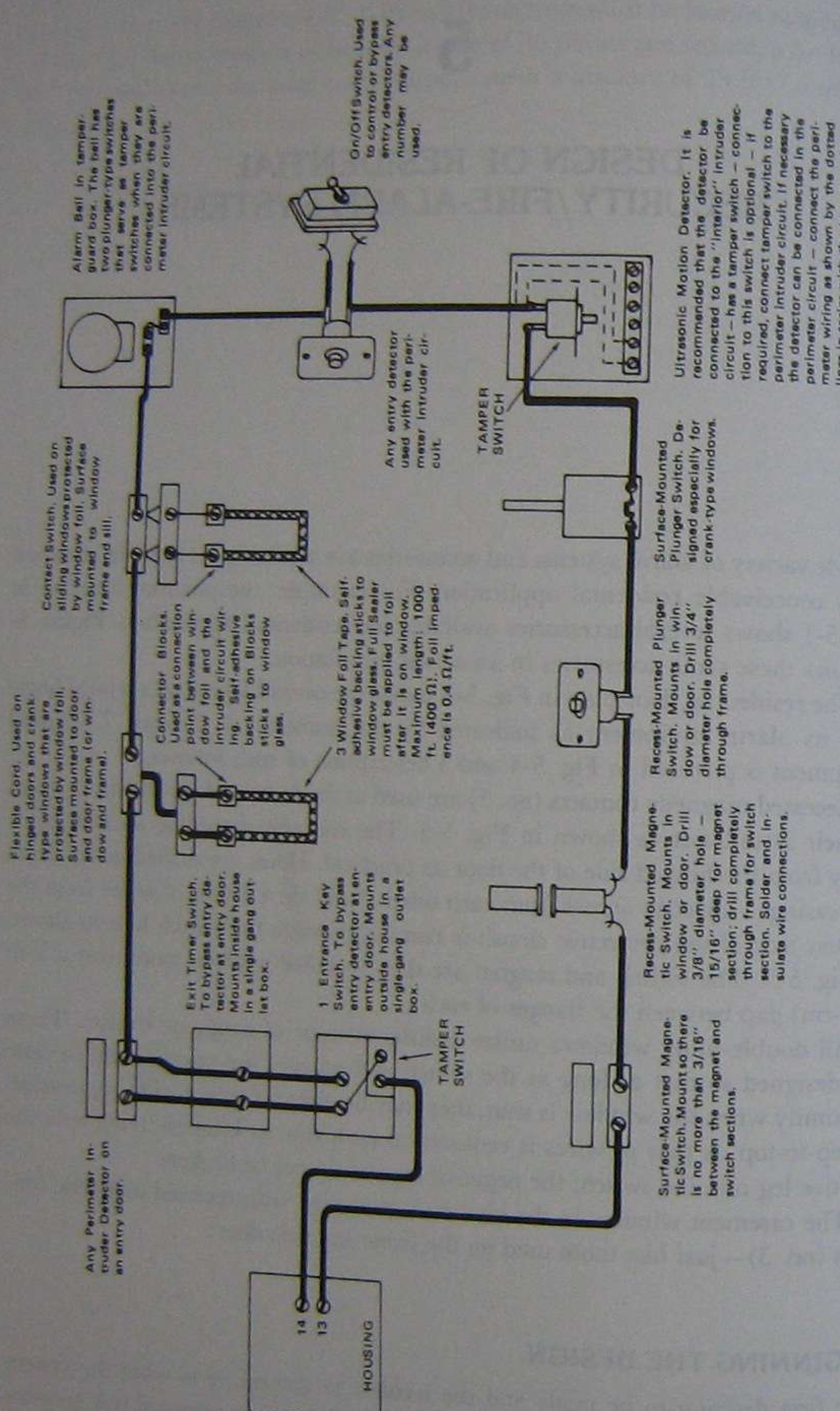


FIGURE 5-1. Several security/fire-alarm accessories available for residential applications. (See Fig. 4-1.)

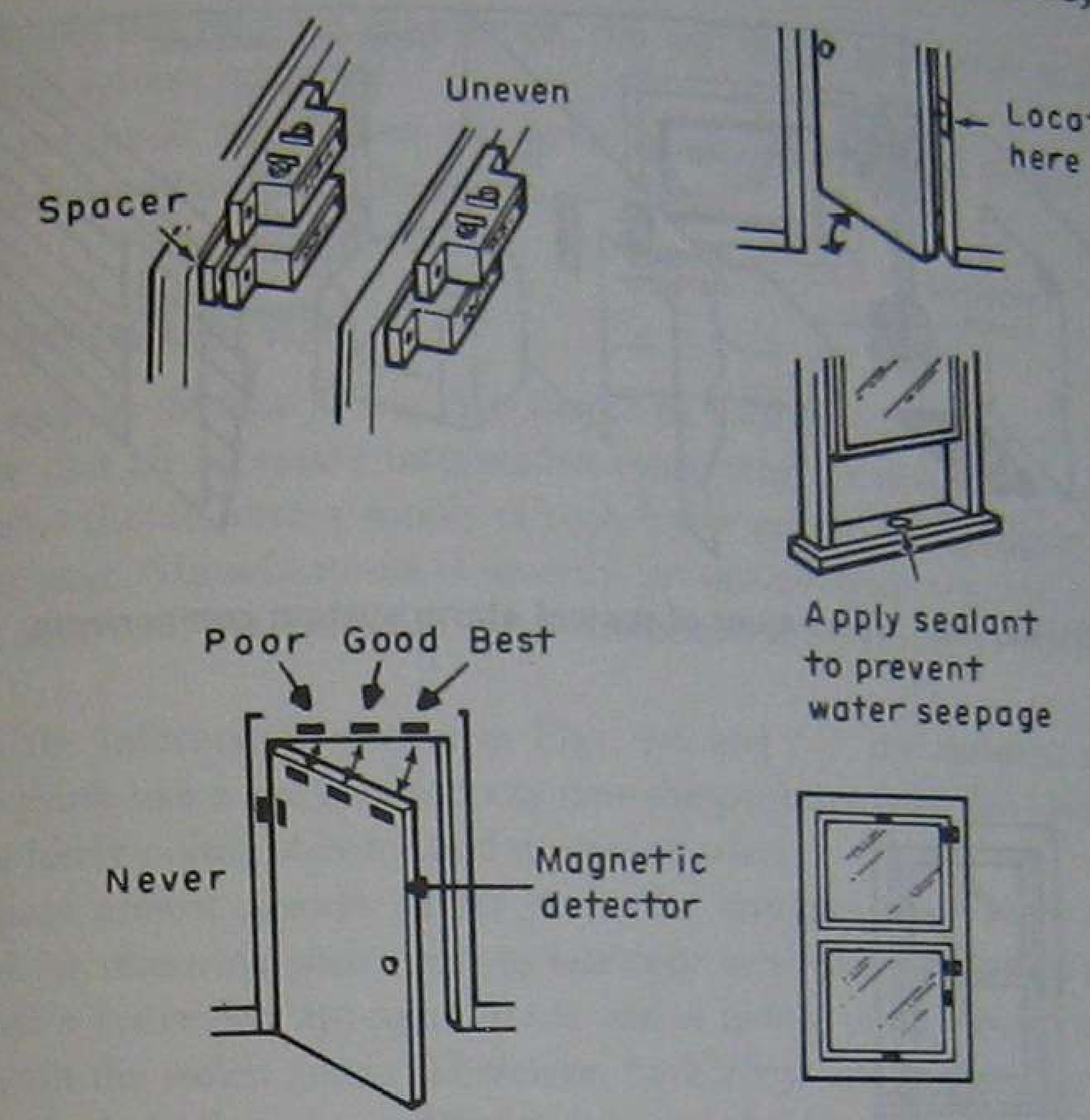


FIGURE 5-2. Practical application of the accessories shown in Fig. 5-1.

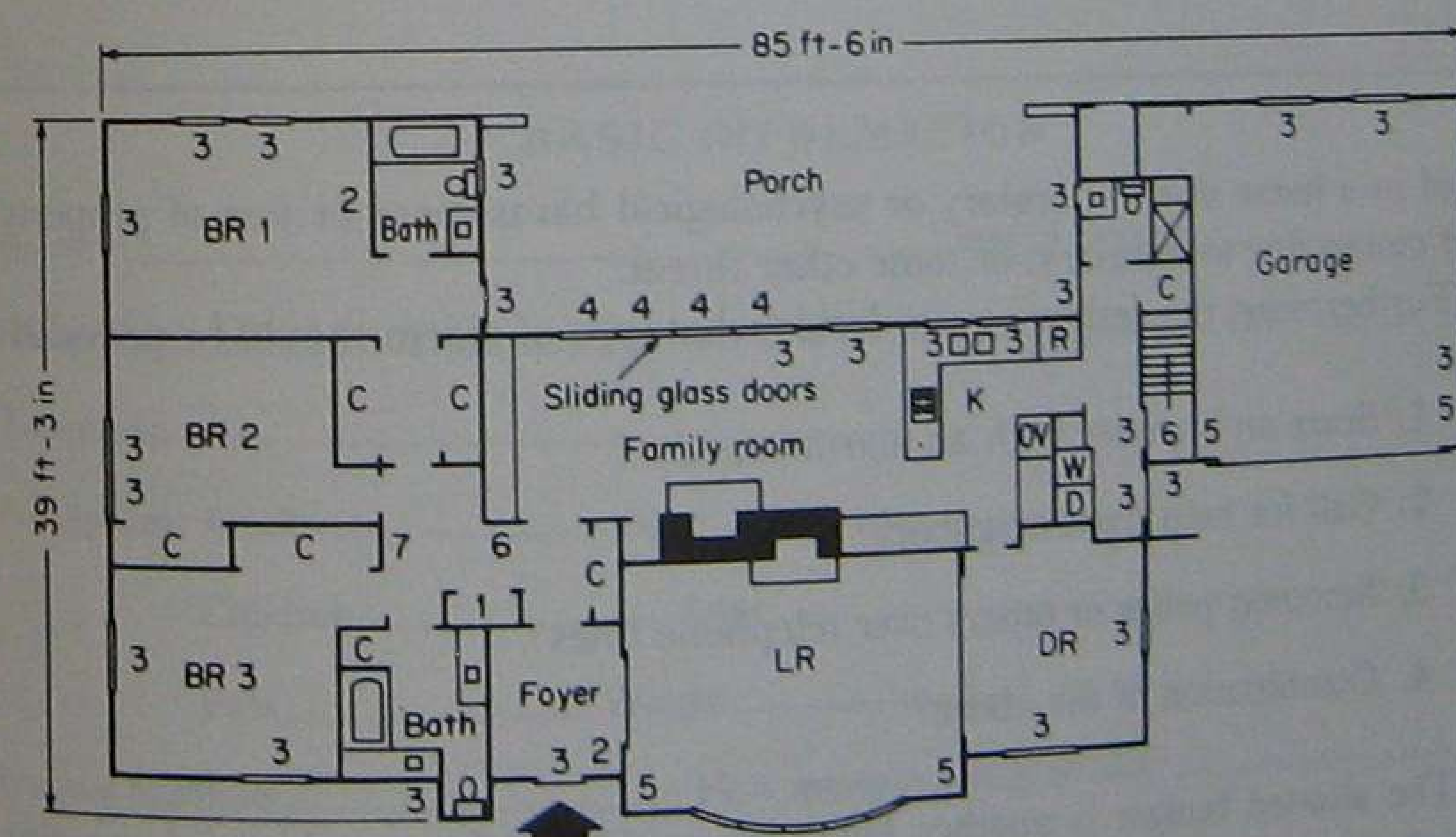


FIGURE 5-3. Residential floor plan showing the overall layout of a security/fire-alarm system. Key: 1 = Control panel; 2 = remote station; 3 = magnetic contacts; 4 = glass-break detectors; 5 = photoelectric detectors; 6 = smoke detector; 7 = fire horn.

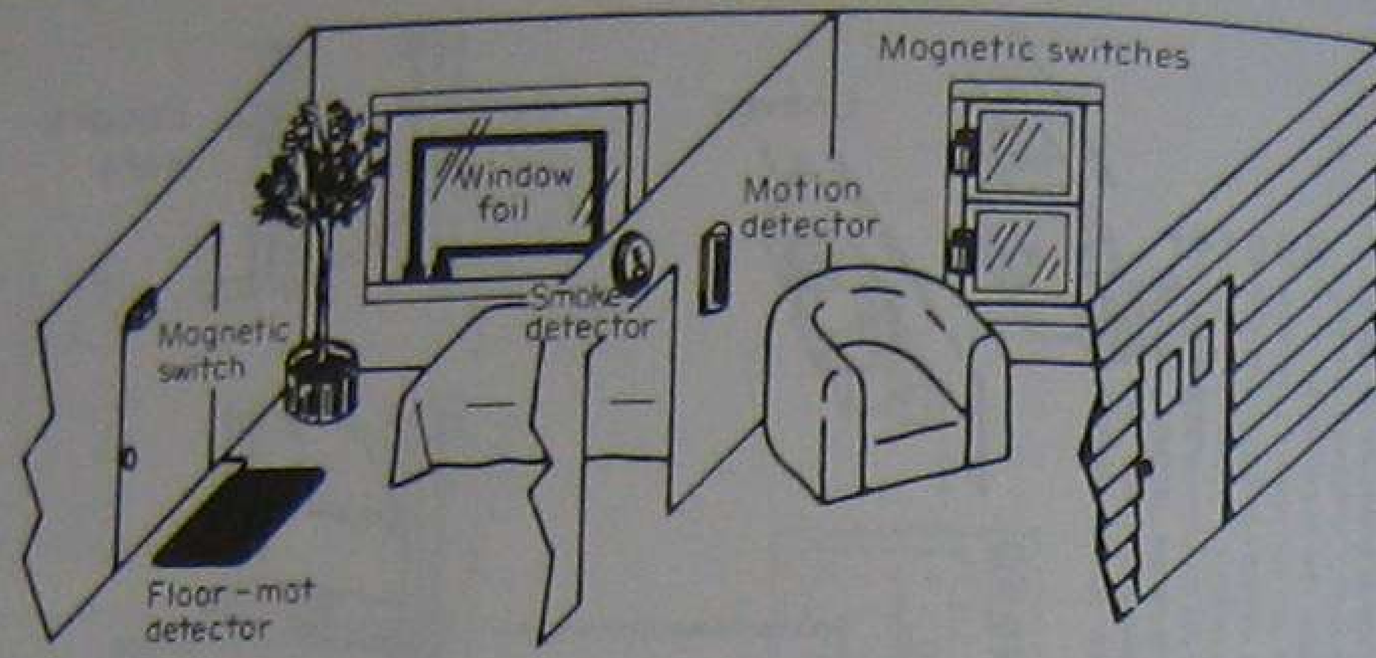


FIGURE 5-4. Placement of typical alarm system components.

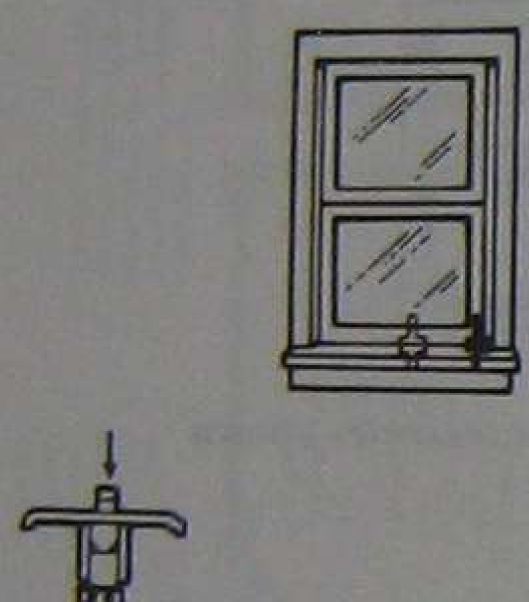


FIGURE 5-5. Installation detail of recessed magnetic contacts.

tered in a home due to burglary or psychological harassment or loss of property and money due to burglary, or some other threat.

Furthermore, the designer must decide what type of alarm should be provided.

1. Scare an intruder with an alarm sounder?
2. Call for help from neighbors?
3. Summon police or others over telephone lines?
4. Combination of the above?

The allotted budget is another factor to consider. Many residential security fire-alarm systems can be installed for less than $1000 while others may run into the thousands of dollars. The best way to determine the amount of protection needed is to consider the threat of personal risk or bodily injury and the possible loss of property. Then determine how much this protection is worth to the home-

owner. When this figure is determined, you will have a good guide to how much of an alarm system is needed.

With the threat determined, the system goals and a general budget figure for the system cost established, the design may begin.

BASIC INFORMATION

A form such as the one in Fig. 5-6 should be used by the contractor or installer to ensure that all necessary information concerning the design will be obtained. Contractors should have a supply of such forms printed with their letterhead on top of the page. Manufacturers of security/fire-alarm equipment also furnish such forms at little cost. You will also need the information included in the form in Fig. 5-7.

With the information shown in Figs. 5-6 and 5-7, the designer should now begin to think like a burglar and examine the premises from this viewpoint. List the most likely points of entry and determine why.

Burglars almost always prefer doors for entrance since doors are usually required for removing such items as television sets from the home. Furthermore, they need a concealed approach route and a hiding place for the vehicle to be loaded with the stolen goods. Therefore, back alleys and hidden carports are the obvious vehicle hiding places. With this knowledge in mind, choose the most vulnerable door in the building as deserving the best physical and burglar-alarm protection. A dead latch and dead-bolt locks should be used on a solid wood or steel

BASIC INFORMATION

Name ______ Date of Survey ______

Street ______ City ______ Zip ______

Telephone ______

Family size: Adults ______ Ages ______

Children ______ Ages ______

Pets ______ Weight ______

Normal bedtime ______ How many in family smoke? ______

Name of closest relative ______ Telephone ______

Name of insurance agent ______ Company ______ Tel. ______

FIGURE 5-6. Form used for initial survey of project.

CONSTRUCTION INFORMATION

Age of home: ______ Lot size: ______ Ft. wide ______ Ft. deep ______

Acre(s) ______

Building measurements: ______ Ft. long ______ Ft. wide ______ Ft. high ______

Walls: Wood ____ Shingle ____ Stone ____ Brick ____ Metal siding ____

Other ______________________________

Interior walls: Wood ____ Plaster ____ Plasterboard ____

Flagstone ____ Brick ____ Fiberboard ____

Other ______________________________

Ceilings: Wood ____ Plaster ____ Plasterboard ____ False ____ Acoustic ____

Other ______

Roof: Wood shingle ____ Tar paper ____ Tile ____ Asphalt shingle ____

Rock ____ Slate ____ Pitched ____ Flat ____ Multistory ____

Other ______________________________

Floors: Wood ____ Concrete ____ Tile ____ Flat stone ____ Carpet ____

Other ______

Attic: Full ____ Partial ____ None ____

Attic crawl space: Good ____ Average ____ Poor ____ None ____

Crawl space under house: Good ____ Average ____ Poor ____ None ____

Basement: Full ____ Partial ____ None ____ Basement dimensions: ______ x ______

Garage: Attached ____ Free standing ____ Garage dimensions: ______ x ______

Garage walls: Wood ____ Unfinished ____ Plasterboard ____ Brick ____

Stone ____ Other ______________________________

Type of insulation:

Walls:______ Floor: ______ Ceiling:______ Basement: ______

FIGURE 5-6. Form used for initial survey of project. (*Continued*)

INTRUSION SECURITY INFORMATION

Law-enforcement agency ______ Telephone ______ Response time ____

Distance to neighbor on:

Right ______ ft. Left ______ ft. Front ______ ft. Rear ______ ft.

Type of public lighting: Street ____ Flood ____ Other ______ None ____

Type of private lighting: Front ____ Side ____ Rear ____

What lights are left on at night? ______________________________

Visibility onto property from street:

Good ____ Average ____ Poor ____ Why? ______________________________

Hours home is normally vacant: ______________________________

Number of entrances:

Doors ______ Sliding glass doors ______ Windows ______ Other ______

Doors: Wood ____ Metal ____ Glass ____ Single ____ Double ____ Hollow ____

Solid ____

Door frames: Wood ____ Metal ____ Aluminum ____ Other ______

Locks: Single-key ____ Sliding-bolt ____ Double-key ____ Dead-bolt ____ Padlock ____

Night latch ____ Other ______ When last rekeyed? ______

Windows: Sliding ____ Double-hung ____ Single-hung ____ Casement ____

Louver ____ Fixed ____ Other ______________________________

Glass: Single-strength ____ Double-strength ____ Plate ____ Frosted ____

Tempered ____ Thermal pane ____ Other ______________________________

Storm windows? Yes ☐ No ☐

Glass framing: Wood ____ Metal ____ Other ______________________________

Grilles or Screening: Standard screens ____ Iron bars ____ Other ______

Garage door: Single ____ Double ____ One-piece overhead ____

Sectional overhead ____ Swing out ____ Other ______________________________

Outbuildings: Number ____ Type ______________________________

FIGURE 5-7. Form to obtain intrusion security information.

steel door with no windows in it, if possible. If this point of entry is a sliding glass door, care must be taken so that the door cannot be lifted out of the track and the door should be capable of being securely key-locked and pinned into the closed position using appropriate hardware.

Obviously, this most vulnerable entry point must be alarmed with the best equipment available. Similarly, other doors of the home must have some sort of protection.

Windows should be analyzed in a similar manner to doors. In most premises there are one or more windows which may face a side yard, a fence, or a wall where no casual observer is likely to see someone making forced entry. First, protect the window from being forced open and then install a dependable security system.

Most security systems use a closed-loop protective circuit where a pair of wires is connected to the alarm control and is then run around the perimeter of a building and finally returned to the alarm control panel. Closed-circuit detectors are connected in series in this loop. A small current flows through the wiring and detectors and any interruption of this current by the detector operation (cutting the wires or shorting the wire pair together) will sound the alarm. Restoring the loop to its original condition, such as closing the alarm door after entry, will not stop the alarm condition. Only operating the appropriate control will do this.

Magnetic contacts or switches are by far the most commonly used detection devices for openings such as windows and doors. They consist of two pieces—a magnet and a magnetically operated switch enclosed in plastic cases. The magnet is mounted on the edge of the door while the switch section is mounted directly adjacent to the magnet on the door frame. When the magnet is located near the switch section, the switch is turned on and electricity flows through the switch contact. Moving the magnet away from the switch, such as opening a door, turns the switch off.

Since this is a closed-circuit system, the current through the loop will cease and the alarm will sound on opening. Magnetic switches are very successful because they are noncritical in alignment between the magnet and switch section and are extremely reliable in operation. Many switches are rated for hundreds of millions or even billions of switch operations. There is little mechanical motion in this switch, so replacement will be extremely infrequent under the worst of circumstances. By their nature, they are free from false alarms and are easy to troubleshoot and replace in the event one fails.

Magnetic contacts are also the best method of protecting windows and other openings. To protect glass from breakage in windows or sliding glass doors, a special lead foil is the common means of protection. This foil is put in series with the same burglar circuit that connects the doors and windows. The alloy in the foil is of such composition that any break in the glass will break the foil and thereby set off the alarm.

It may also be advisable to include an extra door switch or two on some of the interior doors that are likely to be opened in the event an intruder somehow penetrates the perimeter circuit. Such doors might include those to a gun closet, fur storage vault, or just between two rooms that have to be traversed to find any valuable property. The intruder is likely to have his guard down at this point and not to be looking for such a switch. Motion detectors—such as ultrasonic, infrared, audio, etc.—are also good insurance for the interior circuit.

Routing the circuit wires around the perimeter in an effective manner is one of the most important parts of a security/fire-alarm system. A pair of either 22-AWG or 24-AWG wires should be run all the way around the home from the control panel and then back. All detectors are then connected to this perimeter loop.

Wire concealment can be a major problem for the installer. If the house is under construction, the pair of wires can be located at some set distance within the partitions and walls. The installer can then cut into the wall at this distance when the walls are finished to get to the wires for the final connections. For existing construction, much fishing is necessary to route the wires to the various detectors, but Chap. 3 gives several solutions to these problems.

Concealment is important for aesthetic reasons, for making it impossible for the intruder to locate the presence of the system, and for reliability in the sense of minimizing damage to the wires.

RESIDENTIAL FIRE-ALARM SYSTEM

Heat and smoke detectors should be included in any residential security/fire-alarm system. They are generally connected to the system as shown in Fig. 4-1. The fire-detection circuit should be fully supervised as required by UL (Underwriters Laboratory). The circuit itself should act as a detector in the event of a malfunction; that is, a trouble bell or buzzer should activate in the control unit to alert the occupants of the situation.

The primary location for installing smoke detectors is outside each bedroom area. Since fire travels upward, the top of each stairwell is another important location. The National Fire Protection Association (NFPA) also recommends that smoke detectors be installed on each living level of a multistory house.

Heat detectors should be installed in each enclosed living area including bathrooms, closets, attics, and basements. Any number of detectors can be used with most fire-alarm systems.

Rate-of-rise heat detectors should be mounted on the ceiling not less than 6 in (15 cm) from a side wall. Exact detector location can be determined by an evaluation based on good engineering judgment, supplemented if possible by field tests.

The chart in Fig. 5-8 shows some of the heat/smoke detectors supplied by NuTone. The model number, a description of each component, suggested use, and dimensions are given to assist designers of security/fire-alarm systems.

For further information on the design of residential fire alarm systems, contact the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA

HEAT-SMOKE DETECTOR SELECTION GUIDE
(Use with NuTone SA-2300 or S-2100 Security Alarm Systems)

Model no.	*Description*	*Suggested use*	*Specifications*
S-120	135°F fixed-temperature heat detector	Surface-mount on ceiling in ordinary living areas with normal room temperatures.	1¾ in diameter, ¾ deep Distance range: 10 ft in all directions. Detector covers area up to 20 x 20 ft.
S-121	200°F fixed-temperature heat detector	Surface-mount on ceiling in areas where temperatures are higher than normal: furnace or boiler rooms; attics.	
S-122	Rate-of-rise/135°F fixed-temperature heat detector	Surface-mount on ceiling in ordinary living areas with normal room temperatures.	4½ in diameter, 1⅜ in deep Distance range: 25 ft in all directions. Detector covers area up to 50 x 50 ft.
S-123	Rate-of-rise/200°F fixed-temperature heat detector	Surface-mount on ceiling in areas where temperatures are higher than normal: furnace or boiler rooms. Note: Use S-121 or S-125 in areas where temperatures consistently exceed 150°F.	
SA-124	135°F fixed-temperature heat detector	Surface-mount on ceiling in ordinary living areas with normal room temperatures.	1¾ in diameter, ¾ in deep Distance range: 15 ft in all directions. Detector covers area up to 30 x 30 ft.
SA-125	200°F fixed-temperature heat detector	Surface-mount on ceiling in areas where temperatures are higher than normal: furnace or boiler rooms; attics.	
S-245	Smoke detector	Surface-mount on 4-in square or octagonal wiring box, primarily outside bedrooms.	5½ in square x 2⅜ in deep
S-245H	Smoke detector with 135°F heat sensor		
S-240	Smoke-detector supervisory module for S-2100 *only*	Installs in wiring box at location of last smoke detector in series.	2 in x 2 in x 1 in

FIGURE 5-8. Application of heat/smoke detectors.

02210, and request a copy of NFPA no. 72E, Standard on Automatic Fire Detectors.

While no regularly scheduled maintenance is necessary for most heat/smoke detectors, periodic cleaning of the detection chambers may be required when detectors are located in abnormally dirty or dusty environments.

PRACTICAL APPLICATIONS

To better understand the procedures necessary to design a suitable residential security/fire-alarm system, the floor plan of a two-story residence is shown in Fig. 5-9. The obvious starting place for the design of the system is at the normal

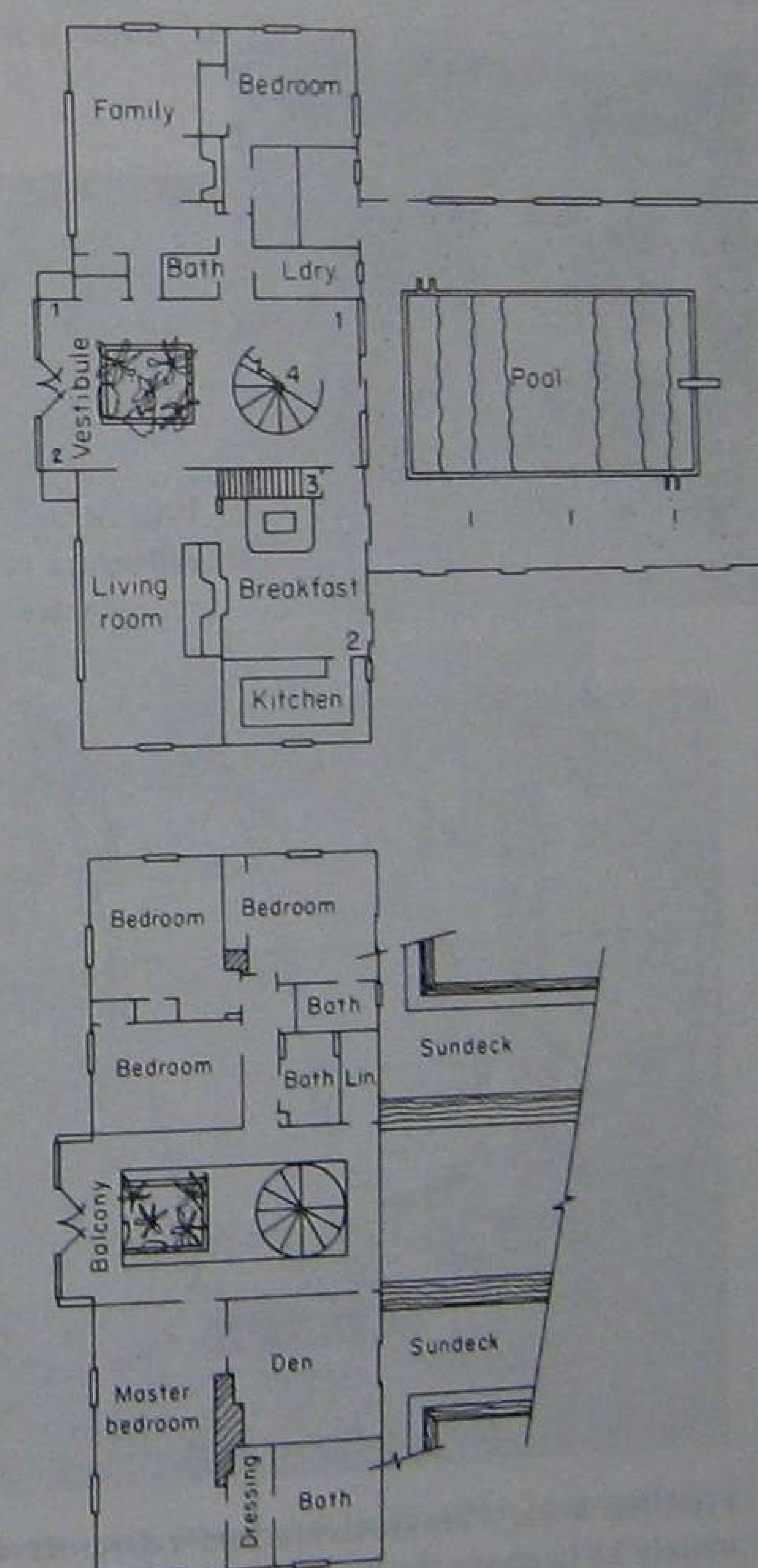


FIGURE 5-9. Floor plan of a two-story residence.

entrances, such as the front doors opening into the vestibule and the sliding glass doors in the rear of the house opening into the vestibule and breakfast/kitchen areas. These types of entries may be protected by several methods, but in this case, infrared photoelectric entry detectors seem to be the best.

For example, transceivers are positioned at the locations indicated by the numeral 1 and reflectors are located at the locations indicated by the numeral 2. Each of these items resembles a conventional quadruplex receptacle as shown in Fig. 5-10. The centers of these outlets are located approximately 18 in (45 cm) above the finished floor so that an intruder will break the beam as shown in Fig. 5-11.

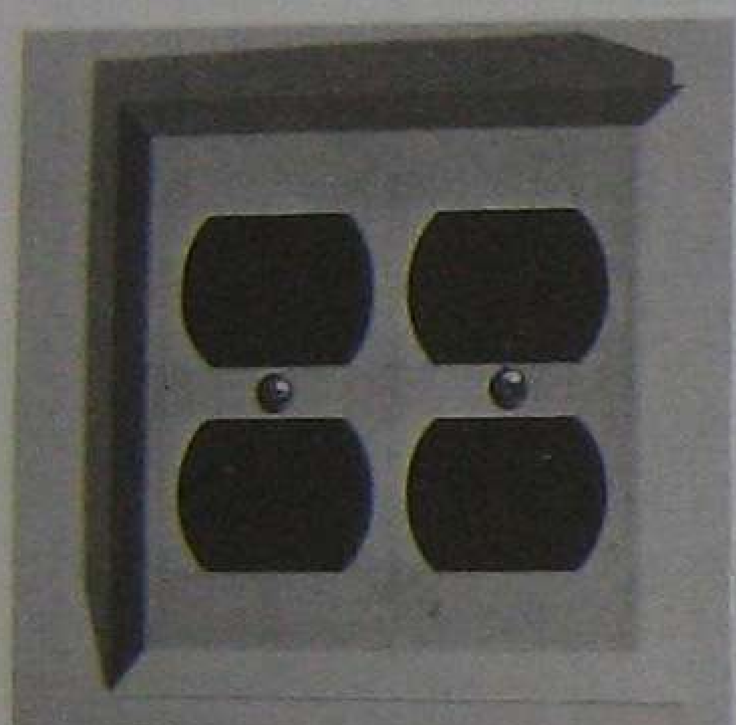


FIGURE 5-10. Transceivers and reflectors resemble ordinary quadruplex receptacles.

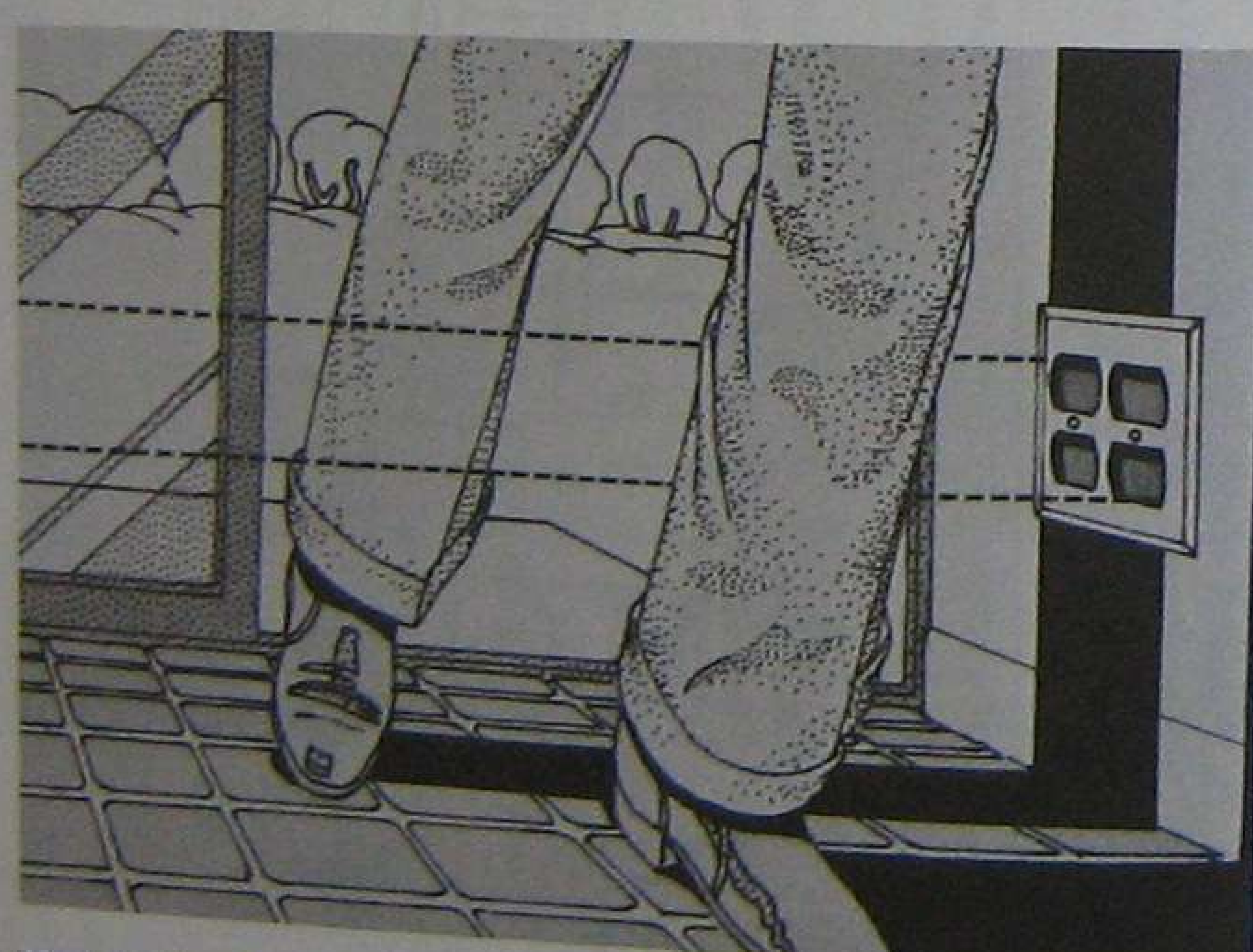


FIGURE 5-11. Transceivers and reflectors are located approximately 18 in above the floor so that an intruder will break the beam.

Note that the infrared photoelectric entry detectors guarding the rear entries protect three separate doors since the transceiver is located in the vestibule and aimed at a reflector mounted in the end of a kitchen cabinet.

This distance may seem great, but as long as there are no obstacles between the transceiver and reflector (furniture, plants, etc.) and the distance is no more than 75 ft (23 m) apart, the system will function properly.

At the top of the basement stairs, a floor-mat entry detector (indicated by the numeral 3) is positioned. The mat is shown in Fig. 5-12 and should be concealed by a scatter rug, as shown in Fig. 5-13. Floor-mat detectors should also be located on stairways (numeral 4), as shown in Fig. 5-14. They may also be located in other interior locations that are likely to be used by intruders.

The items described thus far may be termed interior protection. Now, perimeter protection must be provided to ensure an intruder-proof home. Window foil

FIGURE 5-12. Typical floor-mat entry detector.

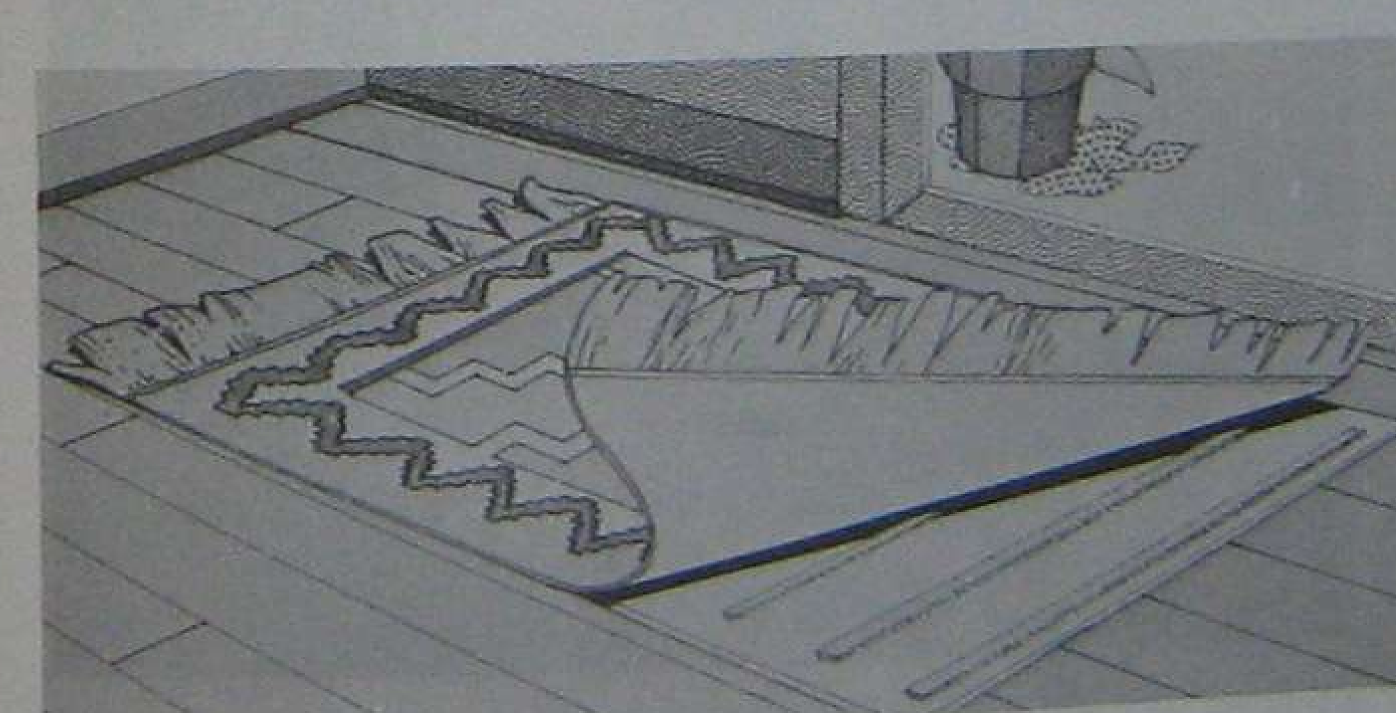


FIGURE 5-13. A scatter rug is a good medium for concealing floor-mat entry detectors.

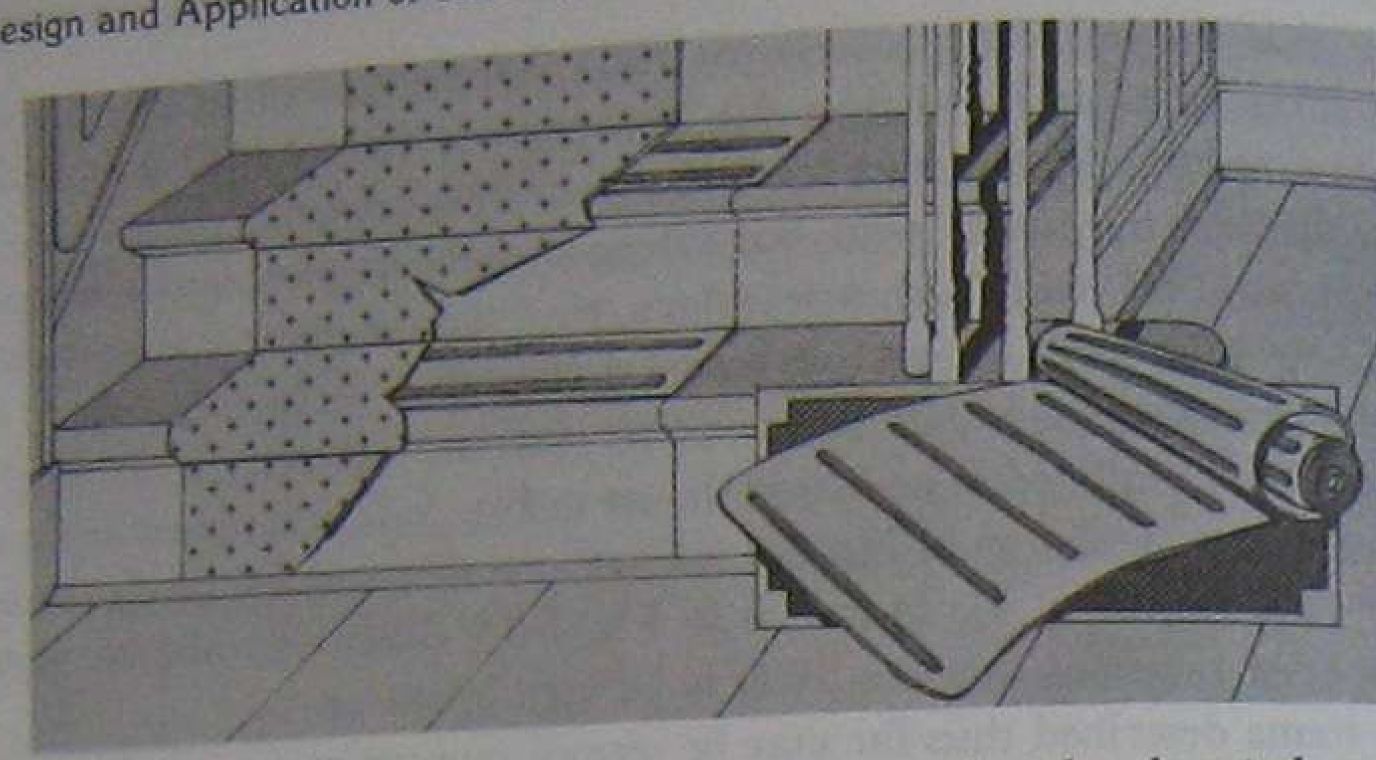


FIGURE 5-14. Floor-mat detectors may also be located on stairways.

(Fig. 5-15) should be used on all windows and possibly the rear sliding glass doors. Doors may be protected by recessed magnetic detectors (Fig. 5-16) or recessed plunger detectors, as shown in Fig. 5-17. Figure 5-18 shows some possible locations for this type of detector.

Of course, the system will need a delayed-entry control as shown in Fig. 5-19

FIGURE 5-15. Window foil should be used on all windows as well as on sliding glass doors.

FIGURE 5-16. Doors may be protected by recessed magnetic detectors.

and some means of sounding an alarm. A bell (Fig. 5-20), horn (Fig. 5-21), or telephone dialer (Fig. 5-22) may be used. The wiring of all of these units is performed as discussed previously.

If the security/fire-alarm system is operated by conventional house current, you should have a battery backup system. Also, the designer should consider some possible causes of false or unwanted alarms, as presented in the following list:

1. Severe electrical storms.
2. Faulty smoke detector.
3. Faulty wiring: wire connections, staple cutting through insulation, insulation broken by severe bending, closely spaced bare wires which may touch if jarred by vibration of refrigerator, washer, dryer, furnace, etc.
4. Electrical transients from heavy-duty appliances, such as refrigerators, relays, etc.

FIGURE 5-17. Recessed plunger detectors may also be used for door protection.

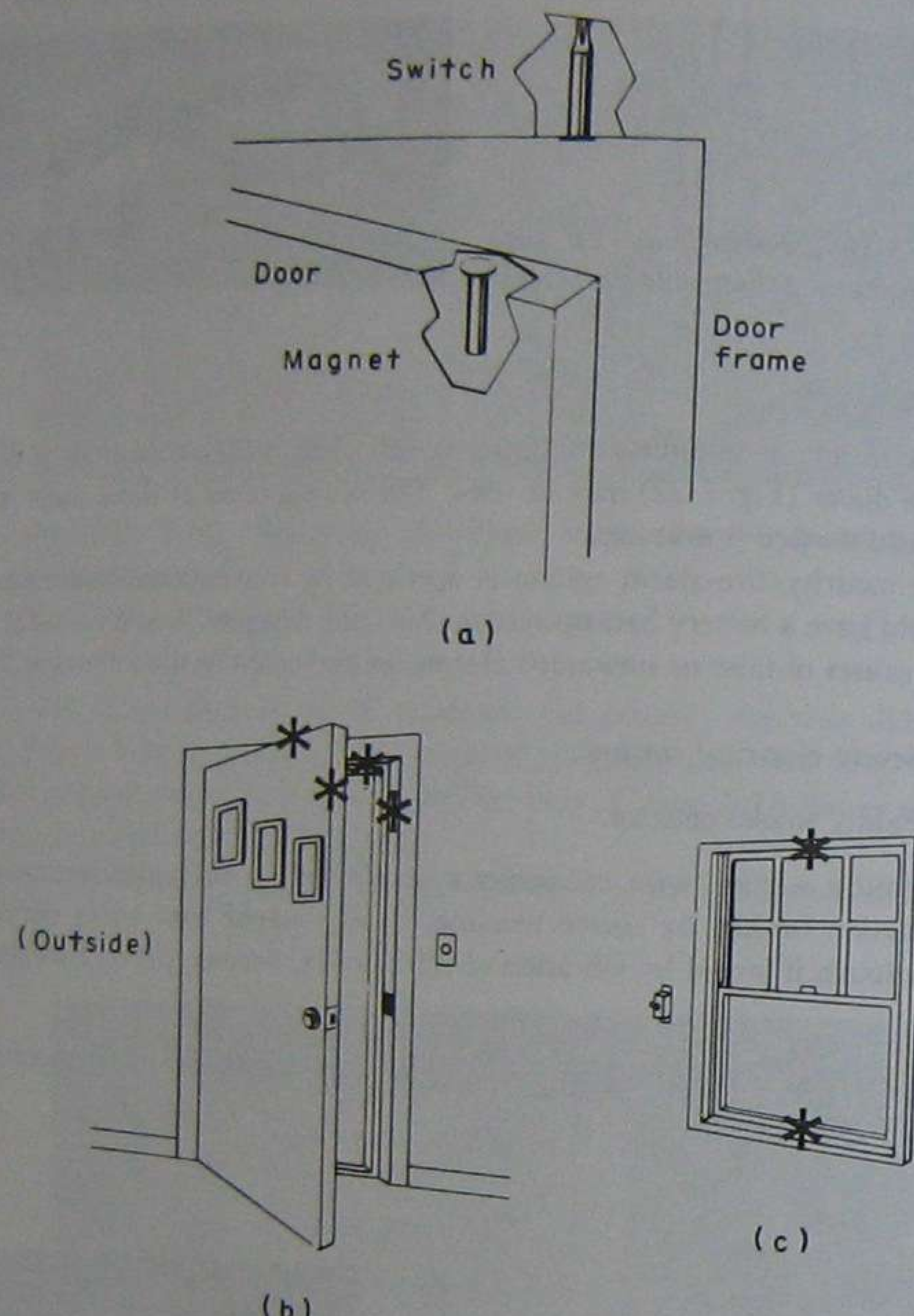


FIGURE 5-18. Some of the possible locations for recessed magnetic entry detectors.

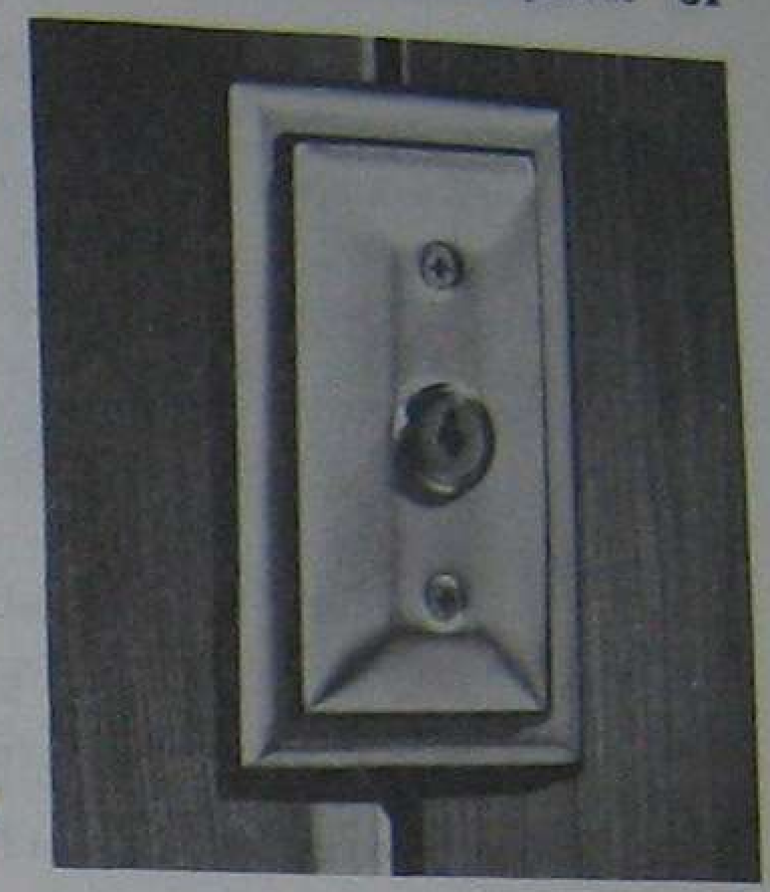


FIGURE 5-19. A key-operated delayed entry control.

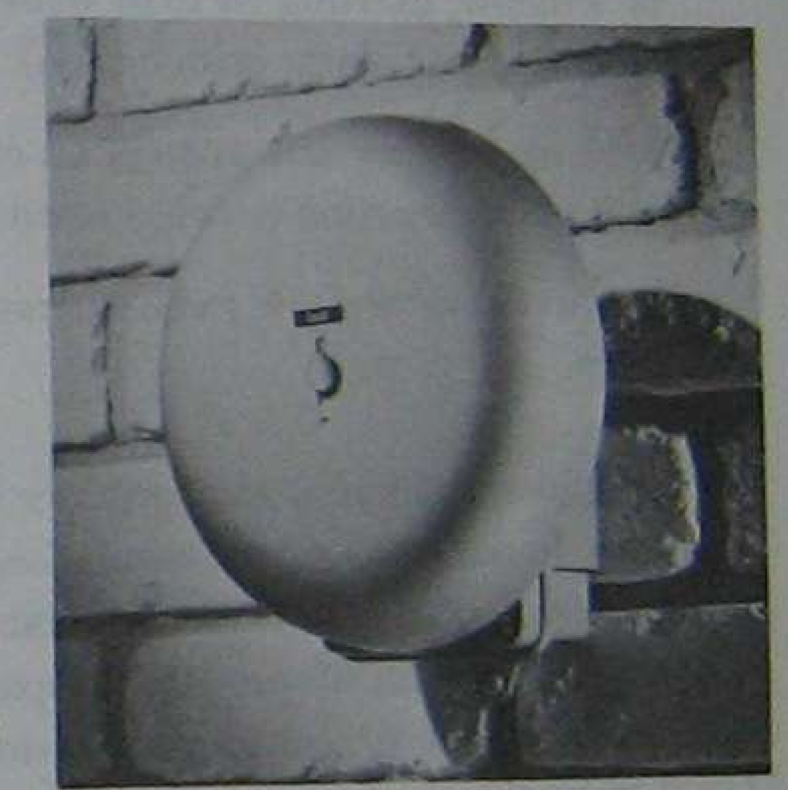


FIGURE 5-20. A bell may be used as a means of sounding the alarm.

FIGURE 5-21. A horn is often used to alert neighbors that an intruder is on the premises.

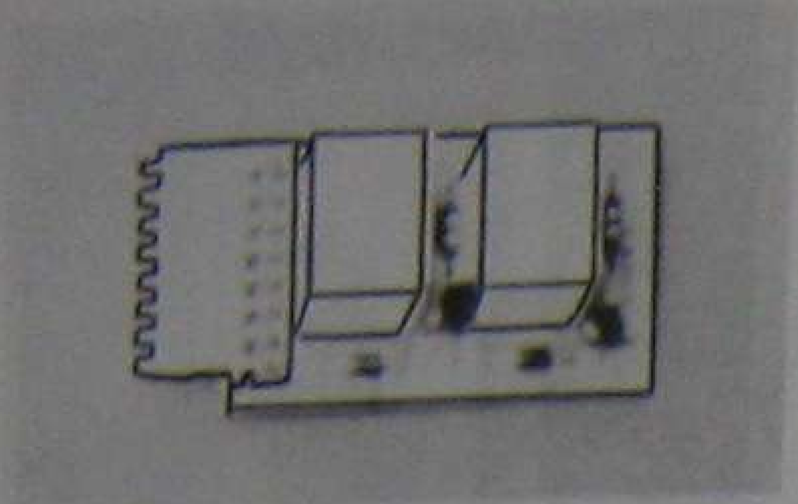


FIGURE 5-22. A telephone dialer is one means of notifying law-enforcement agencies without scaring off the intruder.

5. The use of low-temperature heat detectors in a high-temperature environment, such as attic and furnace room.

6. Concentration of sunlight on a heat detector or smoke detector.

7. Accidental activation of an intruder detector (opening protected door or window, exerting 70 lb or more of pressure on floor mat, depressing an emergency alarm push button).

8. A momentary activation of an entry detector switch on the perimeter or interior detection circuit, caused by a severe vibration.

9. Shortwave or C.B. radio operating with excessive power near your home.

Standpipes, fire hoses, and sprinkler systems are required in many commercial buildings. In many states, the regulations are controlled by the state fire marshall.

In general, a Class II service fire standpipe requires a minimum residual pressure of not less than 65 psi at the topmost outlet. Standpipes should be located in noncombustible fire-rated stair enclosures; in multistory buildings exceeding 275 ft in height, the fire protection standpipe system must be zoned accordingly.

Fire standpipe risers must be designed so that a stream of water can be brought to bear on all parts of all floors within 30 ft of a nozzle. The nozzle, in turn, is connected to not more than 100 ft of riser-attached hose.

For Class II service, fire standpipes shall be provided with 1½-in hose connections on each floor. However, a fire standpipe in excess of 100 ft in height shall be a minimum of 6 in in size at its base. Furthermore, at least one fire department hose valve shall be provided at each floor level for fire department use in any building under construction.

The number of standpipes in each building will determine the minimum water flow. For example, a building with nine standpipes—conforming to Class III fire protection service—must have an automatic fire pump providing at least 2500 gpm. A 750-gpm capacity fire pump for a standpipe system may be provided with three 2½-in hose wall outlets at ground level for fire department use. Fire

standpipes under 50 ft high shall be a minimum of 2 in in diameter. However, many local codes require a minimum size of 4 in in diameter for fire standpipes, so always check the local codes and ordinances before beginning the design and certainly before anyone starts construction.

In buildings with combined systems, designed to be completely sprinklered, with risers sized by hydraulic calculations, the contractor must submit complete calculations to the authority having jurisdiction.

Ordinary Hazard (Group 3) occupancies are defined as buildings that have a high quantity and/or high combustibility of contents. Such occupancies include woodworking businesses, feed mills, and the like.

Sometimes during modifications to an existing fire protection system, it becomes necessary to remove all or a portion of the system from service. When all or any portion of a standpipe system is out of service for any reason, the local fire department shall be notified.

When a standpipe system has been out of service for a number of years, before it is filled with water and restored to service it shall be tested with air at a pressure not exceeding 25 psi to determine its tightness.