Introduction to Electrical Blueprints

26110-05

Bayside Power Station

Bayside Power Station in Tampa, Florida, is the result of a decision to reconfigure an existing facility from coal to natural gas. This project integrated seven new combustion turbines and seven heat-recovery steam generators into two of the plants' existing steam turbines to reliably and cost effectively produce 1,800 megawatts of power. By using natural gas along with high-efficiency, state-of-the-art controls, emissions are significantly reduced, and growing energy needs will be met well into the future.

26110-05
Introduction to Electrical Blueprints

Topics to be presented in this module include:

Overview

The electrician on a job is usually handed a set of blueprints and a book or list of specifications for the job before conduit is installed, wire is pulled, or equipment is mounted. A set of blueprints tells the electrician how the customer wants the building wired. Specifications spell out the type and quality of material, components, and equipment that the customer wants, and provides specific instructions for installing them. Blueprints and specifications together create the roadmap to a successful installation and a satisfied customer.

An electrician must be able to read any set of blueprints, even though the style may vary from designer to designer. Standardized symbols are used throughout the industry to represent types of material, raceways, conductors, equipment, and circuit connections. It is the electrician's responsibility to accurately interpret a set of blueprints, and to be familiar with the standardized numbering system used in specifications to identify electrical components and their installation.

Objectives

When you have completed this module, you will be able to do the following:

1. Explain the basic layout of a blueprint.
2. Describe the information included in the title block of a blueprint.
3. Identify the types of lines used on blueprints.
4. Identify common symbols used on blueprints.
5. Understand the use of architect's and engineer's scales.
6. Interpret electrical drawings, including site plans, floor plans, and detail drawings.
7. Read equipment schedules found on electrical blueprints.
8. Describe the type of information included in electrical specifications.

Trade Terms

Architectural drawings
Block diagram
Blueprint
Detail drawing
Dimensions
Electrical drawing
Elevation drawing
Floor plan
One-line diagram
Plan view
Power-riser diagram
Scale
Schedule
Schematic diagram
Sectional view
Shop drawing
Site plan
Written specifications

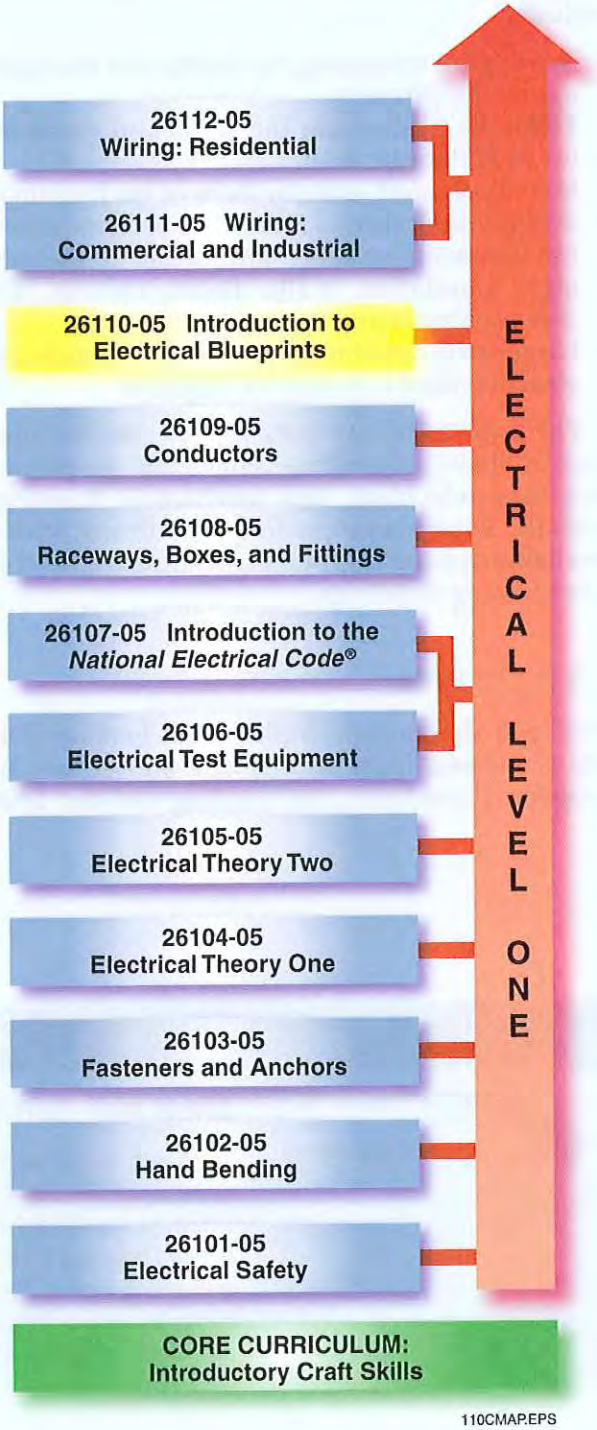
Required Trainee Materials

1. Paper and pencil
2. Copy of the latest edition of the *National Electrical Code®*
3. Appropriate personal protective equipment

Prerequisites

Before you begin this module, it is recommended that you successfully complete *Core Curriculum* and *Electrical Level One,* Modules 26101-05 through 26109-05.

This course map shows all of the modules in *Electrical Level One.* The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map. The local Training Program Sponsor may adjust the training order.



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1.0.0 ◆ INTRODUCTION TO BLUEPRINT READING

In all large construction projects and in many of the smaller ones, an architect is commissioned to prepare complete working drawings and specifications for the project. These drawings usually include:

- A **site plan** indicating the location of the building on the property.
- **Floor plans** showing the walls and partitions for each floor or level.
- Elevations of all exterior faces of the building.
- Several vertical cross sections to indicate clearly the various floor levels and details of the footings, foundation, walls, floors, ceilings, and roof construction.
- Large-scale **detail drawings** showing such construction details as may be required.

For projects of any consequence, the architect usually hires consulting engineers to prepare structural, electrical, and mechanical drawings, with the latter encompassing pipe-fitting, instrumentation, plumbing, heating, ventilating, and air conditioning drawings.

1.1.0 Site Plan

This type of plan of the building site looks as if the site is viewed from an airplane and shows the property boundaries, the existing contour lines, the new contour lines (after grading), the location of the building on the property, new and existing roadways, all utility lines, and other pertinent details. The drawing **scale** is also shown. Descriptive notes may also be found on the site (plot) plan listing names of adjacent property owners, the land surveyor, and the date of the survey. A legend or symbol list is also included so that anyone who must work with the site plan can readily read the information. See *Figure 1*.

1.2.0 Floor Plans

The **plan view** of any object is a drawing showing the outline and all details as seen when looking directly down on the object. It shows only two **dimensions,** length and width. The floor plan of a building is drawn as if a horizontal cut were made through the building—at about window height—and then the top portion removed to reveal the bottom part. See *Figure 2*.

If a plan view of a home's basement is needed, the part of the house above the middle of the basement windows is imagined to be cut away. By looking down on the uncovered portion, every detail and partition can be seen. Likewise, imagine the part above the middle of the first floor windows being cut away. A drawing that looks straight down at the remaining part would be called the first floor plan or lower level. A cut through the second floor windows would be called the second floor plan or upper level. See *Figure 3*.

INSIDE TRACK

Then and Now

Years ago, blueprints were created by placing a hand drawing against light-sensitive paper and then exposing it to ultraviolet light. The light would turn the paper blue except where lines were drawn on the original. The light-sensitive paper was then developed, and the resulting print had white lines against a blue background. Modern blueprints are usually blue or black lines against a white background and are generated using computer-aided design programs. Newer programs offer three-dimensional modeling and other enhanced features.

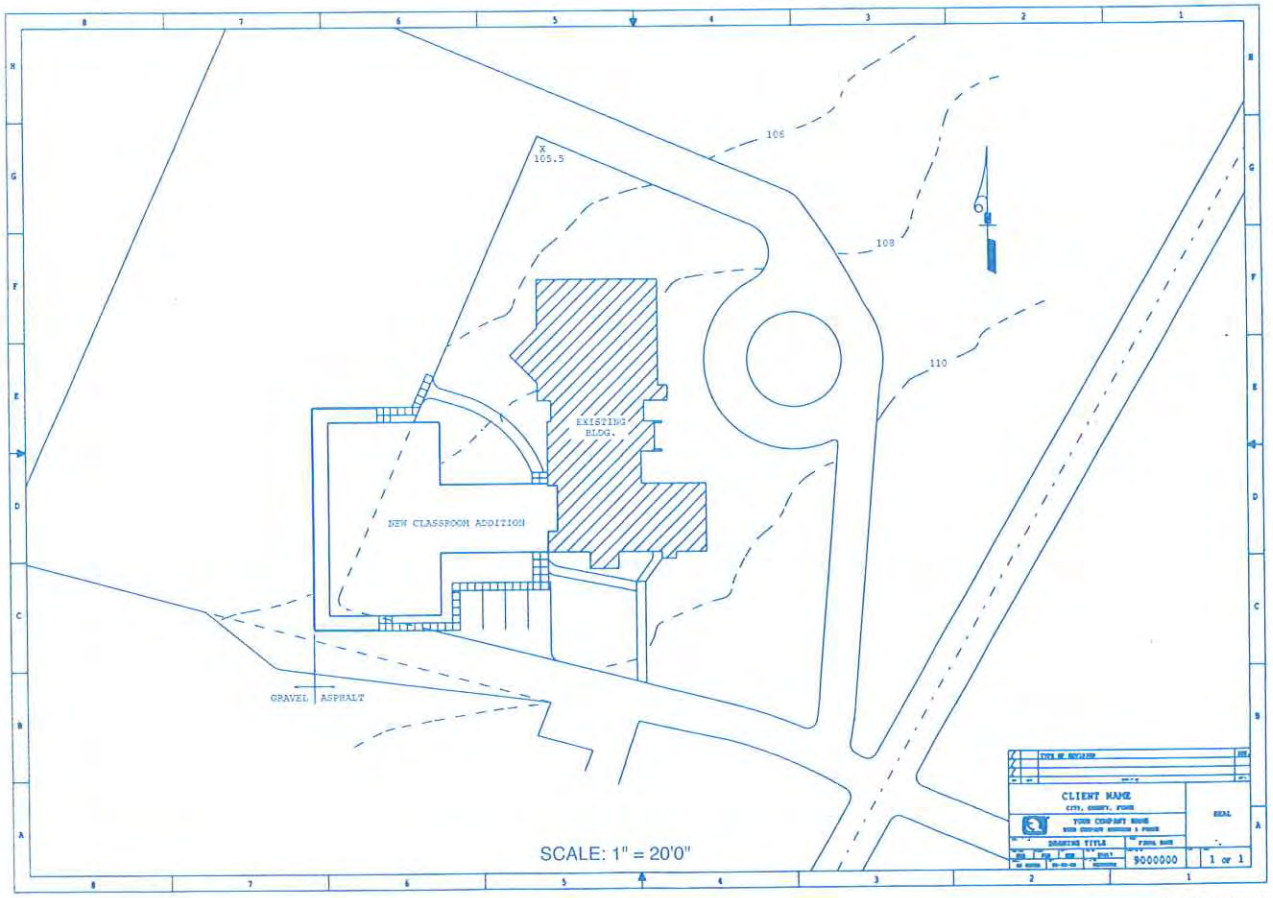

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Figure 1 ◆ Typical site plan.

INSIDE TRACK

Using a Drawing Set

Always treat a drawing set with care. It is best to keep two sets, one for the office and one for field use. After you use a sheet from a set of drawings, be sure to refold the sheet with the title block facing up.

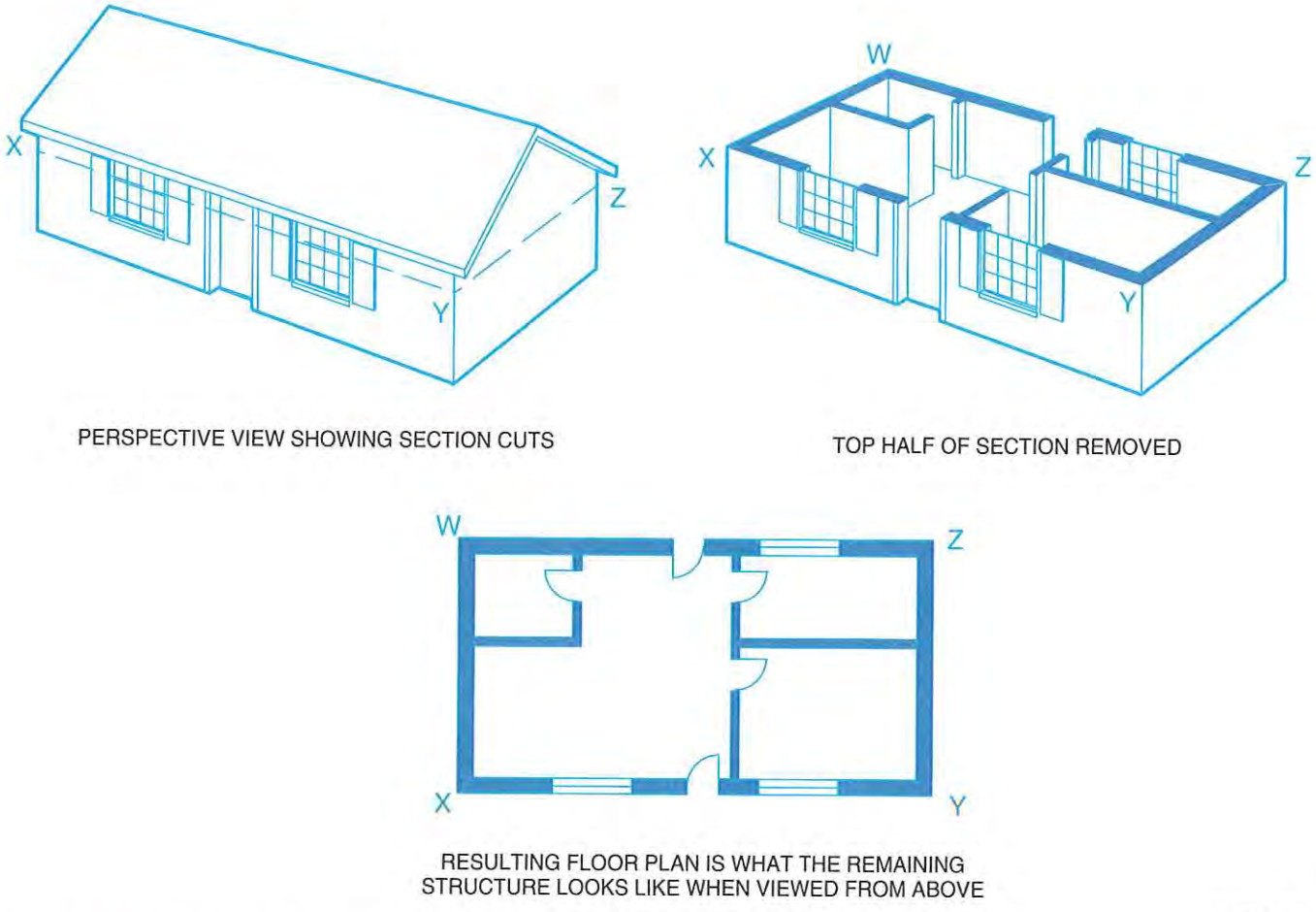

Figure 2 ◆ Principles of floor plan layout.

1.3.0 Elevations

The elevation is an outline of an object that shows heights and may show the length or width of a particular side, but not depth. *Figures 4* and *5* show **elevation drawings** for a building.

NOTE

These elevation drawings show the heights of windows, doors, and porches, the pitch of roofs, etc., because all of these measurements cannot be shown conveniently on floor plans.

1.4.0 Sections

A section or **sectional view** (*Figure 6*) is a cutaway view that allows the viewer to see the inside of a structure. The point on the plan or elevation showing where the imaginary cut has been made is indicated by the section line, which is usually a dashed line. The section line shows the location of the section on the plan or elevation. It is necessary to know which of the cutaway parts is represented in the sectional drawing. To show this, arrow points are placed at the ends of the section lines.

In **architectural drawings**, it is often necessary to show more than one section on the same drawing. The different section lines must be distinguished by letters, numbers, or other designations placed at the ends of the lines. These section letters are generally large so as to stand out on the drawings. To further avoid confusion, the same letter is usually placed at each end of the section line. The section is named according to these letters (e.g., Section A-A, Section B-B, and so forth).

A longitudinal section is taken lengthwise while a cross section is usually taken straight across the width of an object. Sometimes, however, a section is not taken along one straight line. It is often taken along a zigzag line to show important parts of the object.

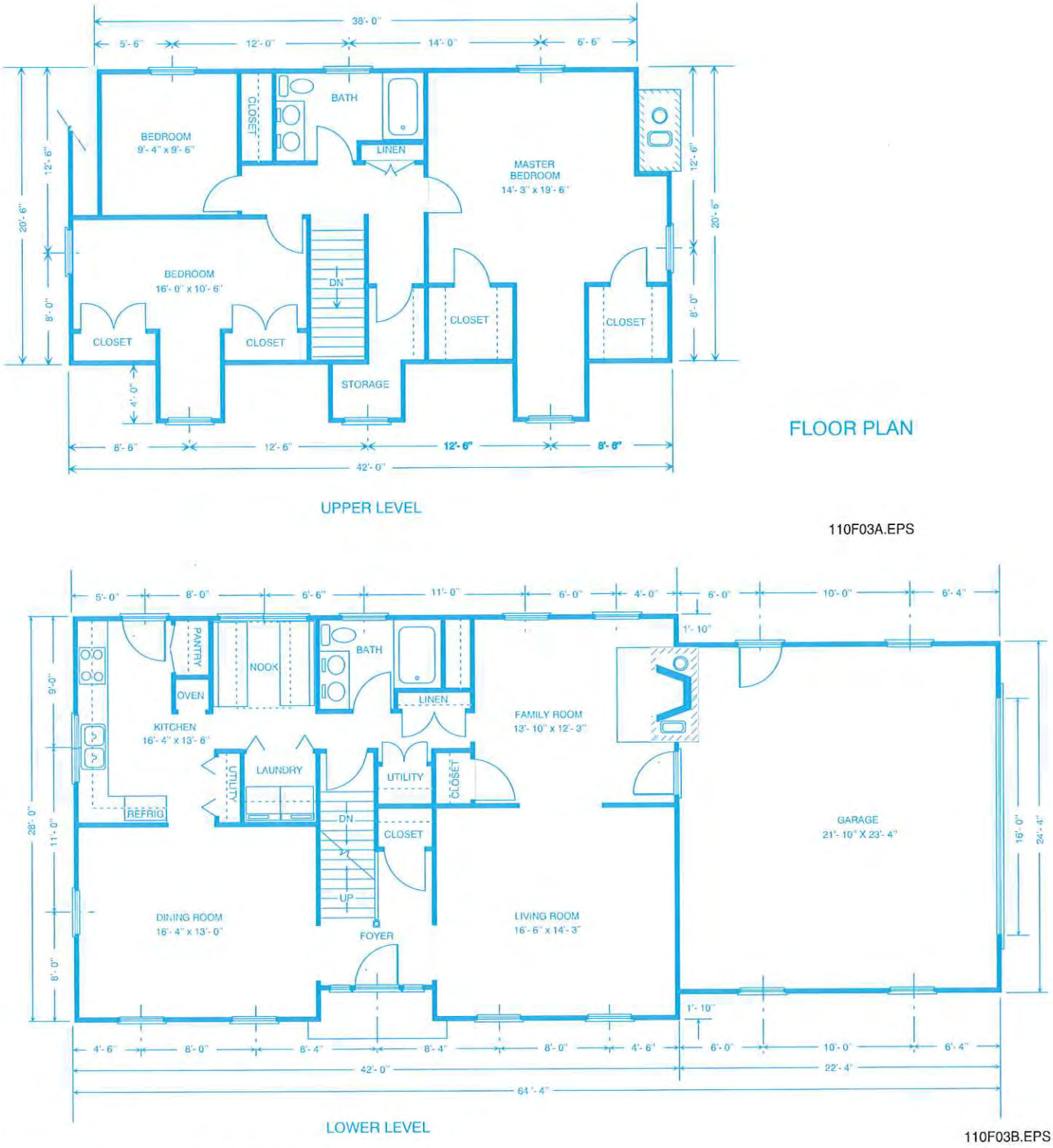

Figure 3 ◆ Floor plans of a building.

FRONT ELEVATION

REAR ELEVATION

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Figure 4 ◆ Front and rear elevations.

A sectional view, as applied to architectural drawings, is a drawing showing the building, or portion of a building, as though it were cut through on some imaginary line. This line may be either vertical (straight up and down) or horizontal. Wall sections are nearly always made vertically so that the cut edge is exposed from top to bottom. In some ways, the wall section is one of the most important of all the drawings to construction workers, because it answers the questions as to how a structure should be built. The floor plans of a building show how each floor is arranged, but the wall sections tell how each part is constructed and usually indicate the material to be used. The electrician needs to know this information when determining wiring methods that comply with the *NEC*®.

1.5.0 Electrical Drawings

Electrical drawings show in a clear, concise manner exactly what is required of the electricians. The amount of data shown on such drawings should be sufficient, but not overdone. This means that a complete set of electrical drawings could consist of only one 8½" × 11" sheet, or it could consist of several dozen 24" × 36" (or larger) sheets, depending on the size and complexity of a given project. A **shop drawing,** for example, may contain details of only one piece of equipment, while a set of working drawings for an industrial installation may contain dozens of drawing sheets detailing the electrical system for lighting and power, along with equipment, motor controls, wiring diagrams, **schematic diagrams,** equipment **schedules,** and a host of other pertinent data.

LEFT ELEVATION

RIGHT ELEVATION

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Figure 5 ◆ Left and right elevations.

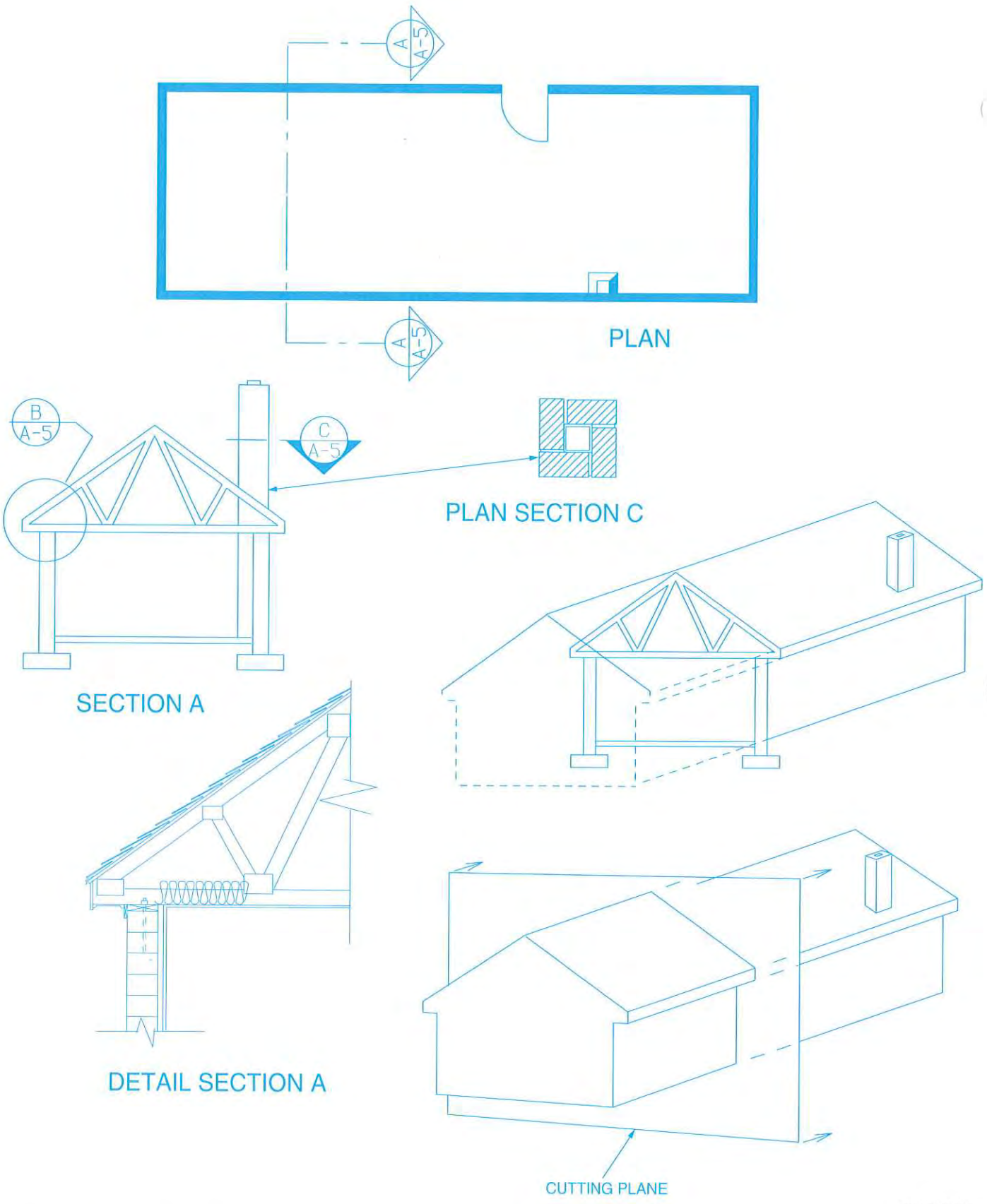
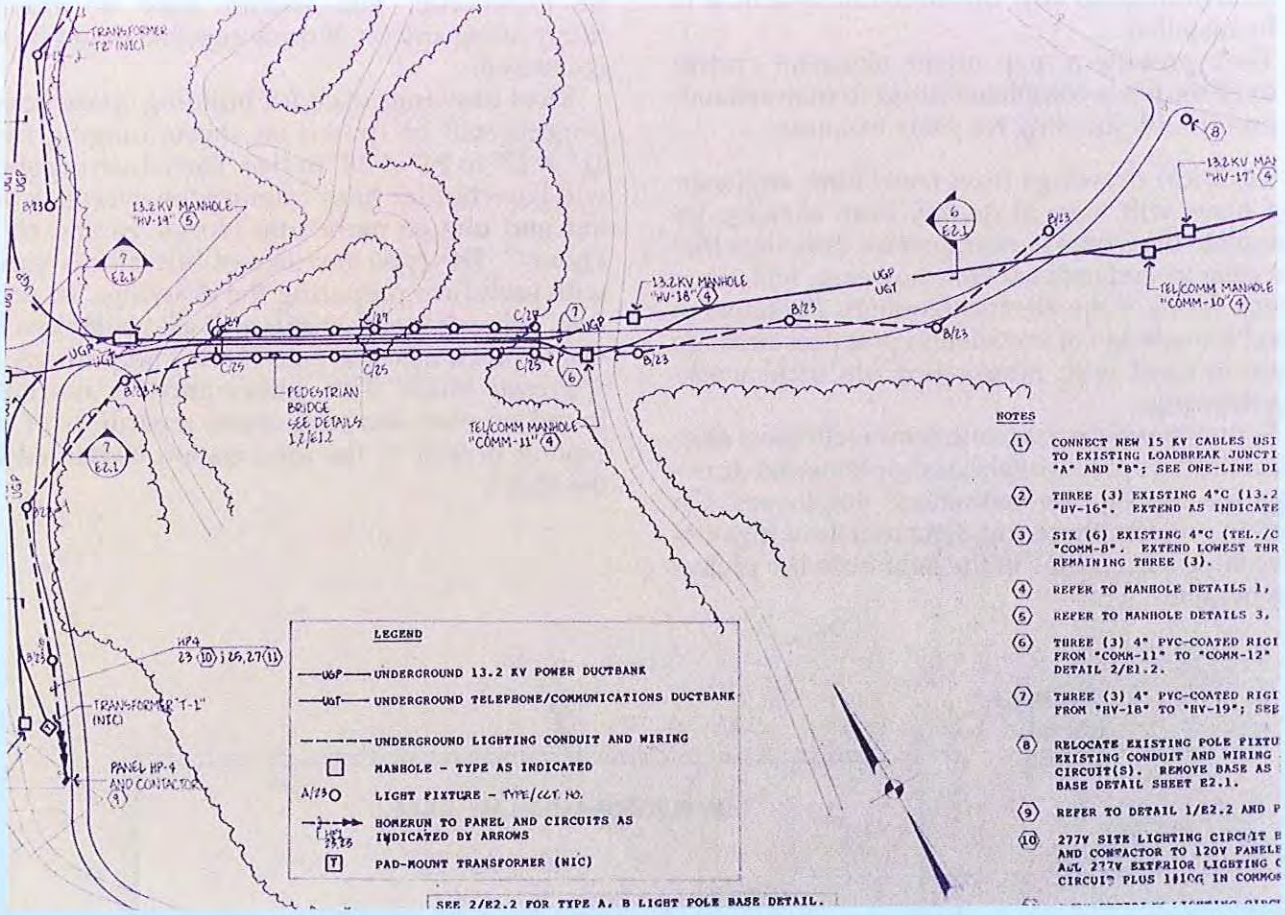


Figure 6 ◆ Sectional drawing.

Orient Yourself

INSIDE TRACK

When reading a drawing, find the north arrow to orient yourself to the structure. Knowing where north is enables you to accurately describe the locations of walls and other parts of the building.



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Using All of the Drawings

THINK ABOUT IT

Look back over the information on floor plans, elevations, and sections. What kinds of information would an electrician get from each of these drawings? What could a sectional drawing show that a floor plan could not?

In general, the electrical working drawings for a given project serve three distinct functions:

- They provide electrical contractors with an exact description of the project so that materials and labor may be estimated to project a total cost of the project for bidding purposes.
- They provide workers on the project with instructions as to how the electrical system is to be installed.
- They provide a map of the electrical system once the job is completed to aid in maintenance and troubleshooting for years to come.

Electrical drawings from consulting engineering firms will vary in quality from sketchy, incomplete drawings to neat, precise drawings that are easy to understand. Few, however, will cover every detail of the electrical system. Therefore, a good knowledge of installation practices must go hand-in-hand with interpreting electrical working drawings.

Sometimes electrical contractors will have electrical drafters prepare special supplemental drawings for use by the contractors' employees. On certain projects, these supplemental drawings can save supervision time in the field once the project has begun.

2.0.0 ◆ BLUEPRINT LAYOUT

Although a strong effort has been made to standardize drawing practices in the building construction industry, **blueprints** prepared by different architectural or engineering firms will rarely be identical. Similarities, however, will exist between most sets of blueprints, and with a little experience, you should have no trouble interpreting any set of drawings that might be encountered.

Most drawings used for building construction projects will be drawn on sheets ranging from 11" × 17" to 24" × 36" in size. Each drawing sheet will have border lines framing the overall drawing and one or more title blocks, as shown in *Figure 7*. The type and size of title blocks varies with each firm preparing the drawings. In addition, some drawing sheets will also contain a revision block near the title block, and perhaps an approval block. This information is normally found on each drawing sheet, regardless of the type of project or the information contained on the sheet.

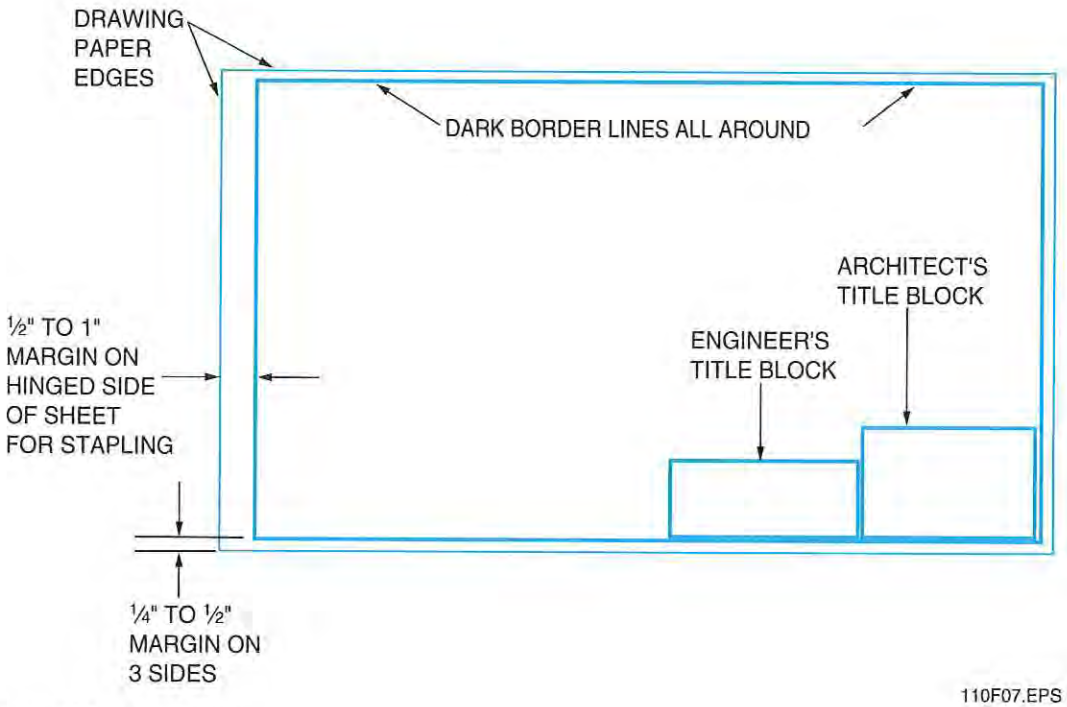

Figure 7 ◆ Typical blueprint layout.

2.1.0 Title Block

The architect's title block for a blueprint is usually boxed in the lower right-hand corner of the drawing sheet; the size of the block varies with the size of the drawing and with the information required. See *Figure 8*.

In general, the title block of an electrical drawing should contain the following information:

- Name of the project
- Address of the project
- Name of the owner or client
- Name of the architectural firm
- Date of completion
- Scale(s)
- Initials of the drafter, checker, and designer, with dates under each
- Job number
- Sheet number
- General description of the drawing

INSIDE TRACK

Interpreting Electrical Drawings

A good example of when an electrician must interpret the drawings is when wiring a log cabin. The drawings will show the receptacle and switch locations in branch circuits as usual, but the electrician must figure out how to route wires and install boxes where there is no hollow wall and sometimes no ceiling space.

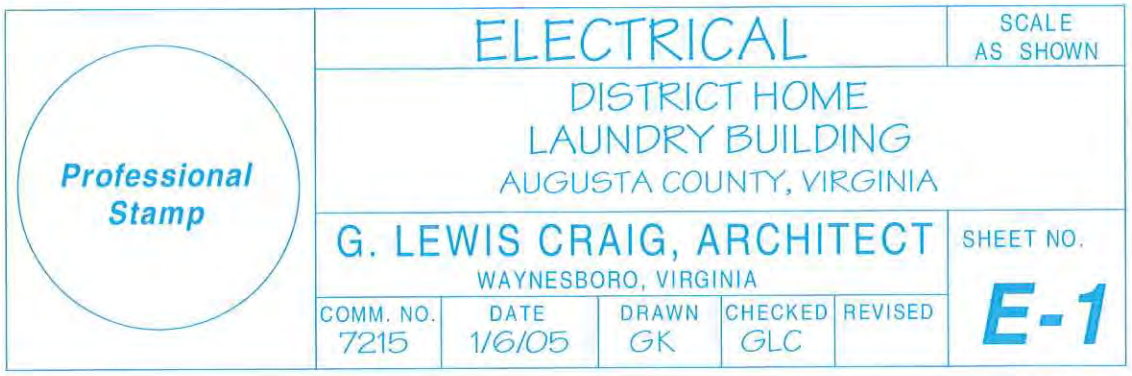

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Figure 8 ◆ Typical architect's title block.

INSIDE TRACK

Check the Title Block

Always refer to the title block for scale and be aware that it often changes from drawing to drawing within the same set. Also check for the current revision, and when you replace a drawing with a new revision, be sure to remove and file the older version.

Applying Your Skills

INSIDE TRACK

Once you learn how to interpret blueprints, you can apply that knowledge to any type of construction, from simple residential applications to large industrial complexes.

Every architectural firm has its own standard for drawing titles, and they are often preprinted directly on the tracing paper or else printed on a sticker, which is placed on the drawing.

Often, the consulting engineering firm will also be listed, which means that an additional title block will be applied to the drawing, usually next to the architect's title block. *Figure 9* shows completed architectural and engineering title blocks as they appear on an actual drawing.

2.2.0 Approval Block

The approval block, in most cases, will appear on the drawing sheet as shown in *Figure 10*. The various types of approval blocks (drawn, checked, etc.) will be initialed by the appropriate personnel. This type of approval block is usually part of the title block and appears on each drawing sheet.

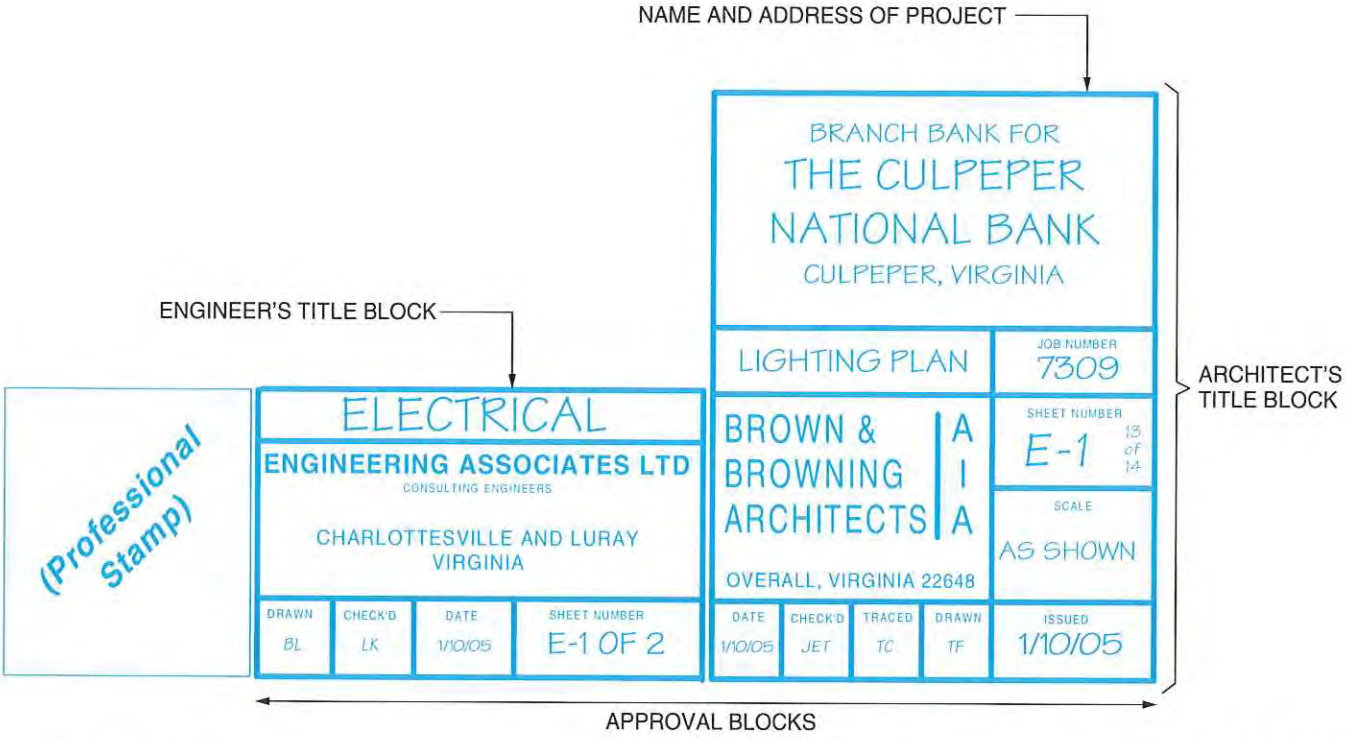

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Figure 9 ◆ Title blocks.

COMM. NO.	DATE	DRAWN	CHECKED	REVISED
7215	1/6/05	GK	GLC	

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Figure 10 ◆ Typical approval block.

On some projects, authorized signatures are required before certain systems may be installed, or even before the project begins. An approval block such as the one shown in *Figure 11* indicates that all required personnel have checked the drawings for accuracy, and that the set meets with everyone's approval. Such an approval block usually appears on the front sheet of the blueprint set and may include:

- *Professional stamp* – Registered seal of approval by the architect or consulting engineer.
- *Design supervisor* – Signature of the person who is overseeing the design.
- *Drawn (by)* – Signature or initials of the person who drafted the drawing and the date it was completed.
- *Checked (by)* – Signature or initials of the person who reviewed the drawing and the date of approval.
- *Approved* – Signature or initials of the architect/engineer and the date of the approval.
- *Owner's approval* – Signature of the project owner or the owner's representative along with the date signed.

2.3.0 Revision Block

Sometimes electrical drawings will have to be partially redrawn or modified during the construction of a project. It is extremely important that such modifications are noted and dated on the drawings to ensure that the workers have an up-to-date set of drawings to work from. In some situations, sufficient space is left near the title block for dates and descriptions of revisions, as shown in *Figure 12.* In other cases, a revision block is provided (again, near the title block), as shown in *Figure 13.*

NOTE

Architects, engineers, designers, and drafters have their own methods of showing revisions, so expect to find deviations from those shown here.

CAUTION

When a set of electrical working drawings has been revised, always make certain that the most up-to-date set is used for all future layout work. Either destroy the old, obsolete set of drawings or else clearly mark on the affected sheets, *Obsolete Drawing—Do Not Use.* Also, when working with a set of working drawings and written specifications for the first time, thoroughly check each page to see if any revisions or modifications have been made to the originals. Doing so can save much time and expense to all concerned with the project.

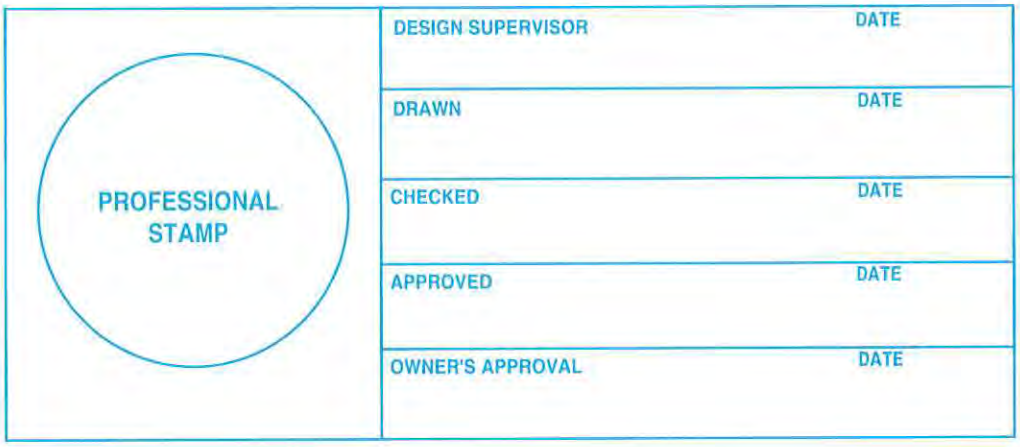

Figure 11 ◆ Alternate approval block.

REVISIONS
1/8/05 - REVISED LIGHTING FIXTURE
NO. 3 IN. LIGHTING FIXTURE SCHEDULE

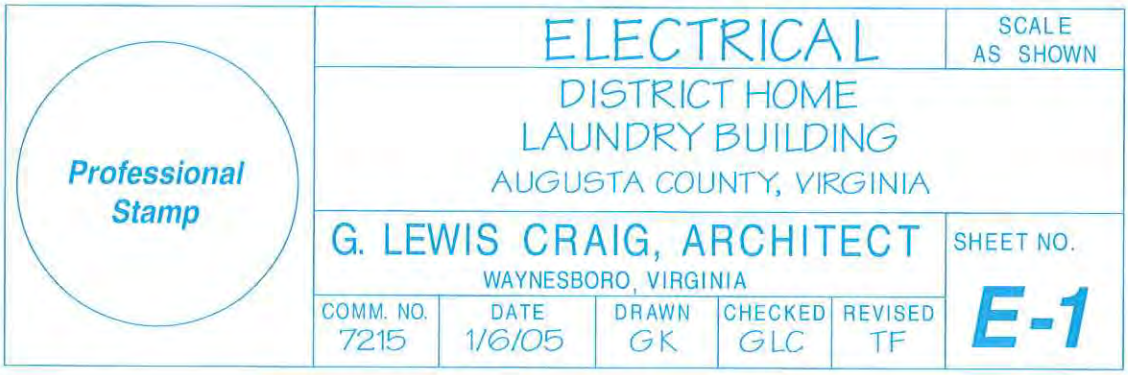

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Figure 12 ◆ One method of showing revisions on working drawings.

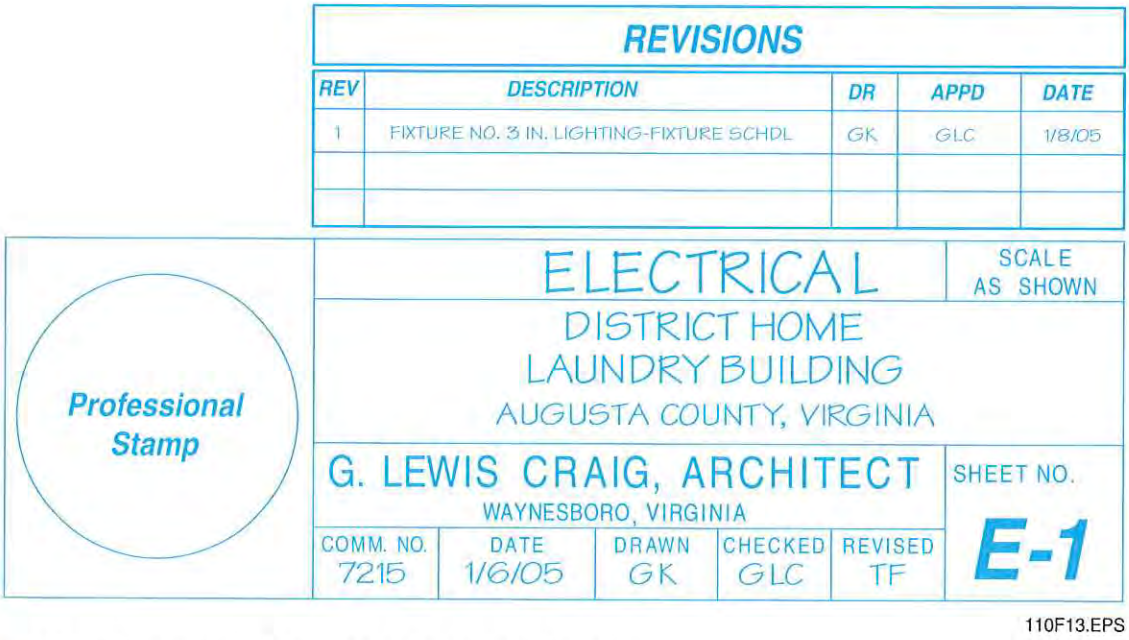

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Figure 13 ◆ Alternative method of showing revisions on working drawings.

3.0.0 ◆ DRAFTING LINES

You will encounter many types of drafting lines. To specify the meaning of each type of line, contrasting lines can be made by varying the width of the lines or breaking the lines in a uniform way.

Figure 14 shows common lines used on architectural drawings. However, these lines can vary. Architects and engineers have strived for a common standard for the past century, but unfortunately, their goal has yet to be reached. Therefore, you will find variations in lines and symbols from drawing to drawing, so always consult the legend or symbol list when referring to any drawing. Also, carefully inspect each drawing to ensure that line types are used consistently.

The drafting lines shown in *Figure 14* are used as follows:

- *Light full line* – This line is used for section lines, building background (outlines), and similar uses where the object to be drawn is secondary to the system being shown (e.g., HVAC or electrical).
- *Medium full line* – This type of line is frequently used for hand lettering on drawings. It is

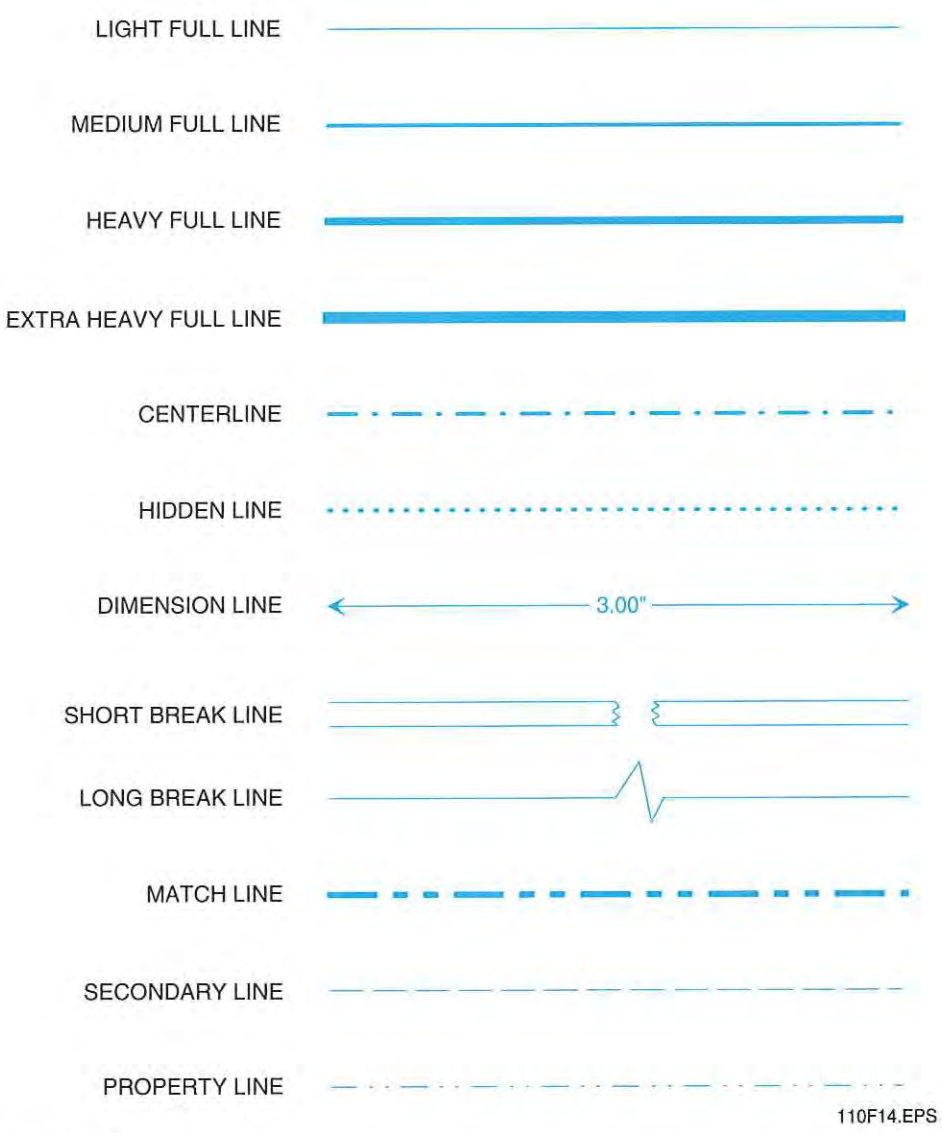


Figure 14 ◆ Typical drafting lines.

further used for some drawing symbols, circuit lines, etc.

- *Heavy full line* – This line is used for borders around title blocks, schedules, and for hand lettering drawing titles. Some types of symbols are frequently drawn with a heavy full line.
- *Extra heavy full line* – This line is used for border lines on architectural/engineering drawings.
- *Centerline* – A centerline is a broken line made up of alternately spaced long and short dashes. It indicates the centers of objects such as holes, pillars, or fixtures. Sometimes, the centerline indicates the dimensions of a finished floor.
- *Hidden line* – A hidden line consists of a series of short dashes that are closely and evenly spaced. It shows the edges of objects that are not visible in a particular view. The object

INSIDE TRACK

Check the Legend

Be sure to check the legend on every drawing set. Symbols and abbreviations often vary widely from drawing set to drawing set.

outlined by hidden lines in one drawing is often fully pictured in another drawing.

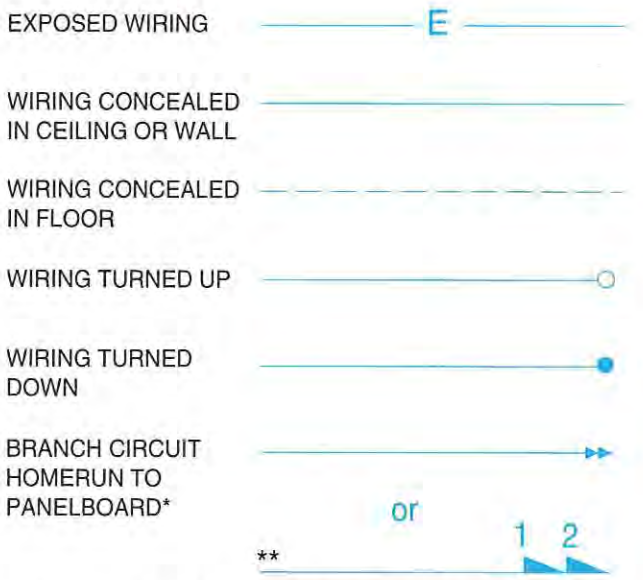
- *Dimension line* – These are thin lines used to show the extent and direction of dimensions. The dimension is usually placed in a break inside the dimension lines. Normal practice is to place the dimension lines outside the object's outline. However, it may sometimes be necessary to draw the dimensions inside the outline.
- *Short break line* – This line is usually drawn freehand and is used for short breaks.
- *Long break line* – This line, which is drawn partly with a straightedge and partly with freehand zigzags, is used for long breaks.
- *Match line* – This line is used to show the position of the cutting plane. Therefore, it is also called the cutting plane line. A match or cutting plane line is a heavy line with long dashes alternating with two short dashes. It is used on drawings of large structures to show where one drawing stops and the next drawing starts.
- *Secondary line* – This line is frequently used to outline pieces of equipment or to indicate reference points of a drawing that are secondary to the drawing's purpose.
- *Property line* – This is a light line made up of one long and two short dashes that are alternately spaced. It indicates land boundaries on the site plan.

Other uses of the lines just mentioned include the following:

- *Extension lines*–Extension lines are lightweight lines that start about ⅛ inch away from the edge of an object and extend out. A common use of extension lines is to create a boundary for dimension lines. Dimension lines meet extension lines with arrowheads, slashes, or dots. Extension lines that point from a note or other reference to a particular feature on a drawing are called leaders. They usually end in either an arrowhead or a dot and may include an explanatory note at the end.
- *Section lines*–These are often referred to as *crosshatch lines.* Drawn at a 45° angle, these lines show where an object has been cut away to reveal the inside.
- *Phantom lines*–Phantom lines are solid, light lines that show where an object will be installed. A future door opening or a future piece of equipment can be shown with phantom lines.

3.1.0 Electrical Drafting Lines

Besides the architectural lines shown in *Figure 14*, consulting electrical engineers, designers, and drafters use additional lines to represent circuits and their related components. Again, these lines may vary from drawing to drawing, so check the symbol list or legend for the exact meaning of lines on the drawing with which you are working. *Figure 15* shows lines used on some electrical drawings.



* Number of arrowheads indicates number of circuits. A number at each arrowhead may be used to identify circuit numbers.

** Half arrowheads are sometimes used for homeruns to avoid confusing them with drawing callouts.

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Figure 15 ◆ Electrical drafting lines.

4.0.0 ◆ ELECTRICAL SYMBOLS

The electrician must be able to correctly read and understand electrical working drawings. This includes a thorough knowledge of electrical symbols and their applications.

An electrical symbol is a figure or mark that stands for a component used in the electrical system. *Figure 16* shows a list of electrical symbols that are currently recommended by the American National Standards Institute (ANSI). It is evident from this list of symbols that many have the same basic form, but, because of some slight difference, their meaning changes. For example, the receptacle symbols in *Figure 17* each have the same basic form (a circle), but the addition of a line or an abbreviation gives each an individual meaning. A good procedure to follow in learning symbols is to first learn the basic form and then apply the variations for obtaining different meanings.

It would be much simpler if all architects, engineers, electrical designers, and drafters used the

SWITCH OUTLETS

- Single-Pole Switch — S
- Double-Pole Switch — S_2
- Three-Way Switch — S_3
- Four-Way Switch — S_4
- Key-Operated Switch — S_K
- Switch w/Pilot — S_P
- Low-Voltage Switch — S_L
- Switch & Single Receptacle — S
- Switch & Duplex Receptacle — S
- Door Switch — S_D
- Momentary Contact Switch — S_{MC}

RECEPTACLE OUTLETS

- Single Receptacle
- Duplex Receptacle
- Triplex Receptacle
- Split-Wired Duplex Recep.
- Single Special Purpose Recep.
- Duplex Special Purpose Recep.
- Range Receptacle — R
- Special Purpose Connection or Provision for Connection. Subscript letters indicate Function (DW - Dishwasher; CD - Clothes Dryer, etc.) — DW
- Clock Receptacle w/Hanger — C
- Fan Receptacle w/Hanger — F
- Single Floor Receptacle

Note: A numeral or letter within the symbol or as a subscript keyed to the list of symbols indicates type of receptacle or usage.

LIGHTING OUTLETS

Ceiling / Wall

- Surface Fixture
- Surface Fixt. w/Pull Switch — PS
- Recessed Fixture — R
- Surface or Pendant Fluorescent Fixture
- Recessed Fluor. Fixture — R
- Surface or Pendant Continuous Row Fluor. Fixtures
- Recessed Continuous Row Fluorescent Fixtures — R
- Surface Exit Light — X
- Recessed Exit Light — XR
- Blanked Outlet — B
- Junction Box — J

CIRCUITING

- Wiring Concealed in Ceiling or Wall
- Wiring Concealed in Floor
- Wiring Exposed
- Branch Circuit Homerun to Panelboard. Number of arrows indicates number of circuits in run. Note: Any circuit without further identification is 2-wire. A greater number of wires is indicated by cross lines as shown below. Wire size is sometimes shown with numerals placed above or below cross lines.
  - 3-Wire
  - 4-Wire

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Figure 16 ◆ ANSI electrical symbols.

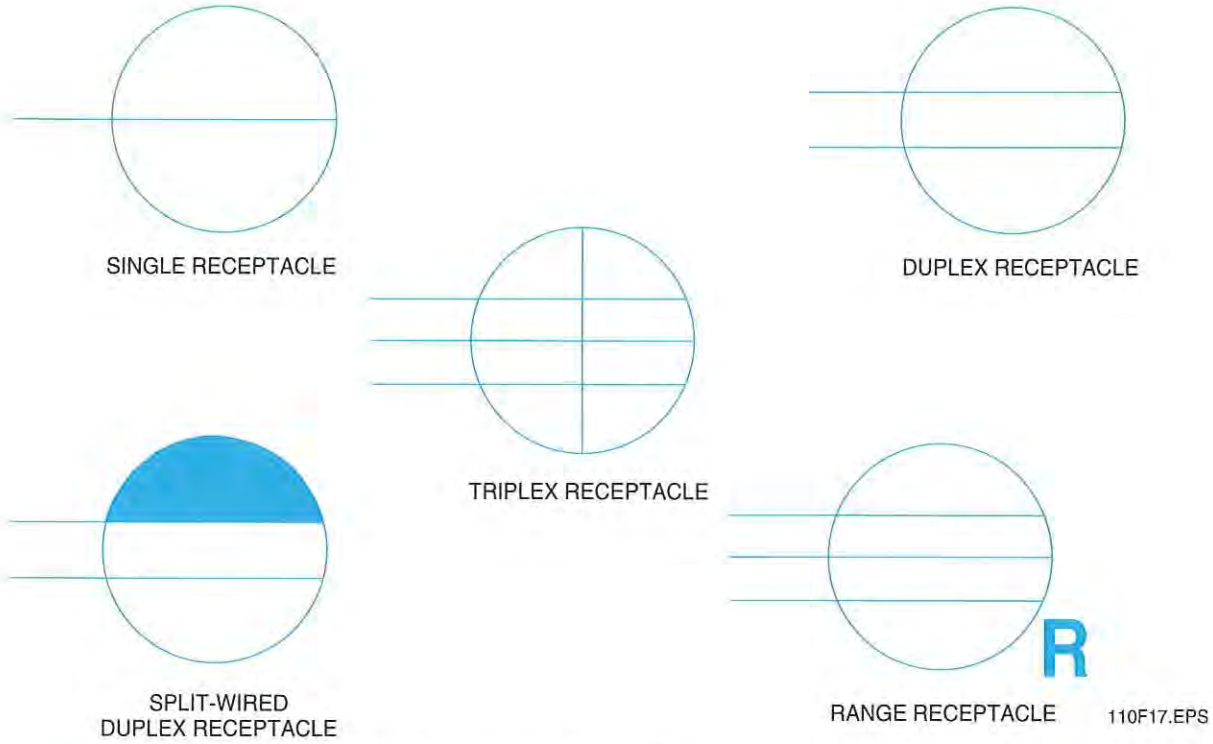


Figure 17 Various receptacle symbols used on electrical drawings.

same symbols; however, this is not the case. Although standardization is getting closer to a reality, existing symbols are still modified, and new symbols are created for almost every new project.

The electrical symbols described in the following paragraphs represent those found on actual electrical working drawings throughout the United States and Canada. Many are similar to those recommended by ANSI and the Consulting Engineers Council/US; others are not. Understanding how these symbols were devised will help you to interpret unknown electrical symbols in the future.

Some of the symbols used on electrical drawings are abbreviations, such as WP for weatherproof and AFF for above finished floor. Others are simplified pictographs, such as (A) in *Figure 18* for a double floodlight fixture or (B) for an infrared electric heater with two quartz lamps.

In some cases, the symbols are combinations of abbreviations and pictographs, such as (C) in *Figure 18* for a fusible safety switch, (D) for a nonfusible safety switch, and (E) for a double-throw safety switch. In each example, a pictograph of a switch enclosure has been combined with an abbreviation: F (fusible), DT (double-throw), and NF (nonfusible), respectively.

Lighting outlet symbols have been devised that represent incandescent, fluorescent, and high-intensity discharge lighting; a circle usually represents an incandescent fixture, and a rectangle is used to represent a fluorescent fixture. These symbols are designed to indicate the physical shape of a particular fixture, and while the circles representing incandescent lamps are frequently enlarged somewhat, symbols for fluorescent fixtures are usually drawn as close to scale as possible. The type of mounting used for all lighting fixtures is usually indicated in a lighting fixture schedule, which is shown on the drawings or in the written specifications.

The type of lighting fixture is identified by a numeral placed inside a triangle or other symbol, and placed near the fixture to be identified. A complete description of the fixtures identified by the symbols must be given in the lighting fixture schedule and should include the manufacturer, catalog number, number and type of lamps,

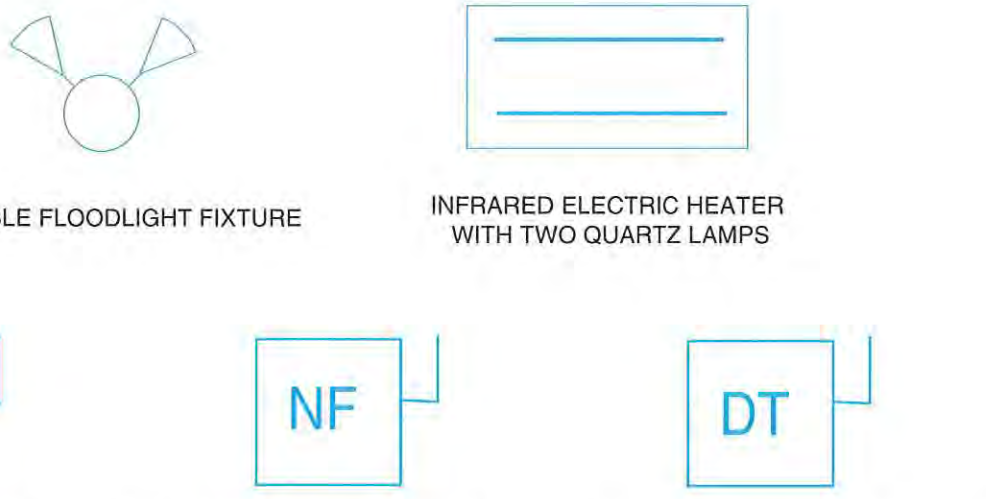


Figure 18 ◆ General types of symbols used on electrical drawings.

voltage, finish, mounting, and any other information needed for proper installation of the fixture.

Switches used to control lighting fixtures are also indicated by symbols (usually the letter S followed by numerals or letters to define the exact type of switch). For example, S_3 indicates a three-way switch; S_4 identifies a four-way switch; and S_P indicates a single-pole switch with a pilot light.

Main distribution centers, panelboards, transformers, safety switches, and other similar electrical components are indicated by electrical symbols on floor plans and by a combination of symbols and semipictorial drawings in riser diagrams.

A detailed description of the service equipment is usually given in the panelboard schedule or in the written specifications. However, on small projects, the service equipment is sometimes indicated only by notes on the drawings.

Circuit and feeder wiring symbols are getting closer to being standardized. Most circuits concealed in the ceiling or wall are indicated by a solid line; a broken line is used for circuits concealed in the floor or ceiling below; and exposed raceways are indicated by short dashes or else the letter *E* placed in the same plane with the circuit line at various intervals. The number of conductors in a conduit or raceway system may be indicated in the panelboard schedule under the appropriate column, or the information may be shown on the floor plan.

Symbols for communication and signal systems, as well as symbols for light and power, are drawn to an appropriate scale and accurately located with respect to the building. This reduces the number of references made to the architectural drawings. Where extreme accuracy is required in locating outlets and equipment, exact dimensions are given on larger-scale drawings and shown on the plans.

Each different category in an electrical system is usually represented by a basic distinguishing symbol. To further identify items of equipment or outlets in the category, a numeral or other identifying mark is placed within the open basic symbol. In addition, all such individual symbols used on the drawings should be included in the symbol list or legend. The electrical symbols shown in *Figure 19* were modified by a consulting engineering firm for use on a small industrial electrical installation. The symbols shown in *Figure 20* are those recommended by the Consulting Engineers Council/US. You should become familiar with these symbols.

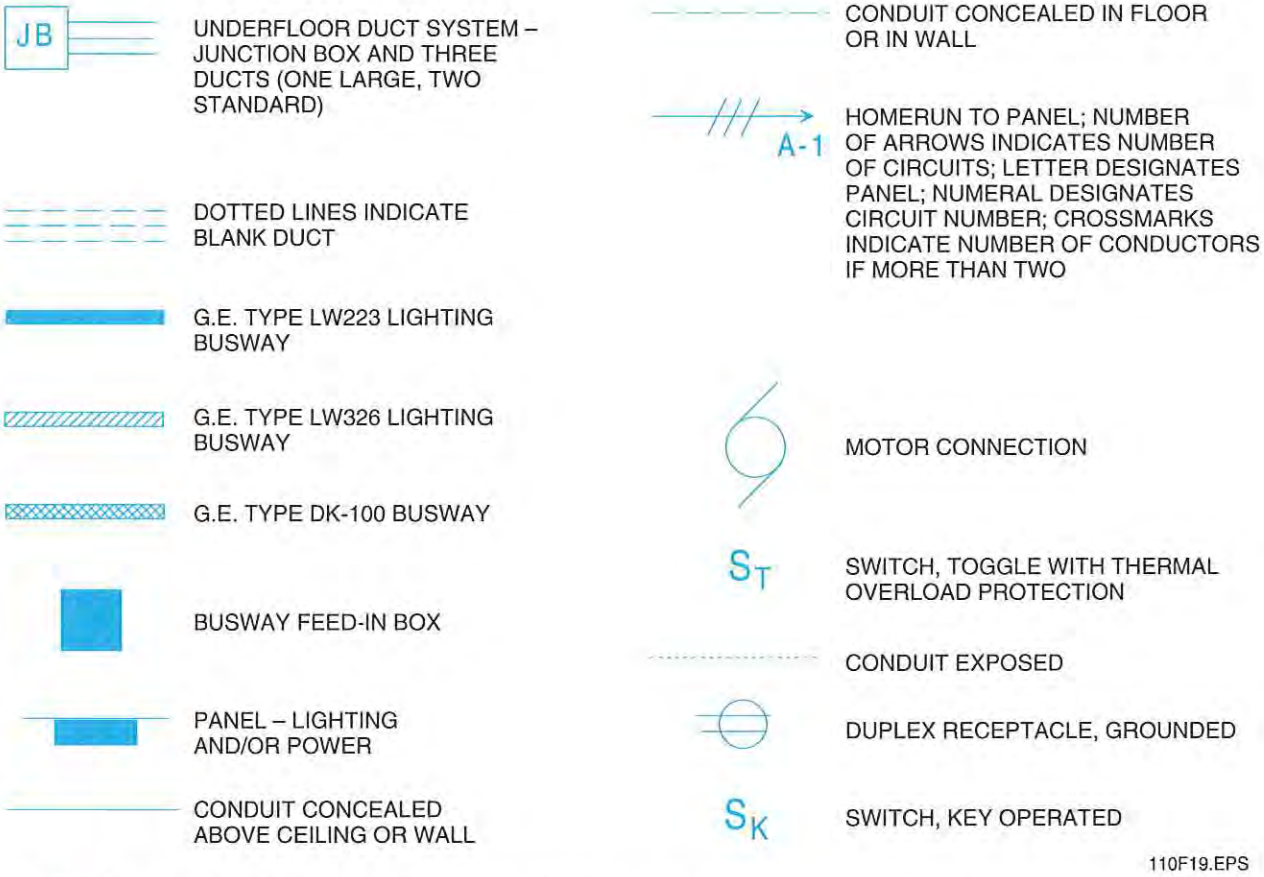


Figure 19 ◆ Electrical symbols used by one consulting engineering firm.

SWITCH OUTLETS

Single Pole Switch	S
Double Pole Switch	S_2
Three-Way Switch	S_3
Four-Way Switch	S_4
Key-Operated Switch	S_K
Switch and Fusestat Holder	S_{FH}
Switch and Pilot Lamp	S_P
Fan Switch	S_F
Switch for Low-Voltage Switching System	S_L
Master Switch for Low-Voltage Switching System	S_{LM}
Switch and Single Receptacle	S
Switch and Duplex Receptacle	S
Door Switch	S_D
Time Switch	S_T
Momentary Contact Switch	S_{MC}
Ceiling Pull Switch	(S)
"Hand-Off-Auto" Control Switch	HOA
Multi-Speed Control Switch	M
Pushbutton	●

RECEPTACLE OUTLETS

Where weatherproof, explosionproof, or other specific types of devices are to be required, use the upper-case subscript letters to specify. For example, weatherproof single or duplex receptacles would have the upper-case WP subscript letters noted alongside the symbol. All outlets must be grounded.

Single Receptacle Outlet	
Duplex Receptacle Outlet	
Triplex Receptacle Outlet	
Quadruplex Receptacle Outlet	
Duplex Receptacle Outlet Split Wired	
Triplex Receptacle Outlet Split Wired	
250-Volt Receptacle/Single Phase Use Subscript Letter to Indicate Function (DW - Dishwasher, RA - Range) or Numerals (with explanation in symbols schedule)	
250-Volt Receptacle/Three Phase	
Clock Receptacle	C
Fan Receptacle	F
Floor Single Receptacle Outlet	
Floor Duplex Receptacle Outlet	
Floor Special-Purpose Outlet	*
Floor Telephone Outlet - Public	
Floor Telephone Outlet - Private	

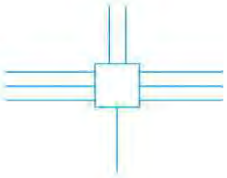
** Use numeral keyed explanation of symbol usage*

Figure 20 ◆ Recommended electrical symbols (1 of 7).

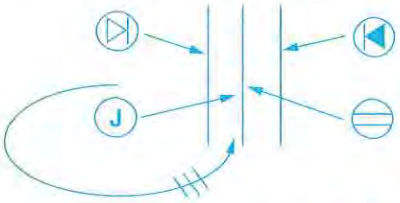
110F20A.EPS

Example of the use of several floor outlet symbols to identify a 2, 3, or more gang outlet:

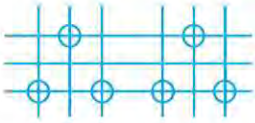
Underfloor duct and junction box for triple, double, or single duct system as indicated by the number of parallel lines



Example of the use of various symbols to identify the location of different types of outlets or connections for underfloor duct or cellular floor systems:



Cellular Floor Heater Duct



CIRCUITING

Wiring Exposed (not in conduit) — E

Wiring Concealed in Ceiling or Wall

Wiring Concealed in Floor

Wiring Existing*

Wiring Turned Up

Wiring Turned Down

Branch Circuit Homerun to Panelboard — 2 1

Number of arrows indicates number of circuits. (A number at each arrow may be used to identify the circuit number.)**

BUS DUCTS AND WIREWAYS

Trolley Duct*** — T T

Busway (Service, Feeder or Plug-in)*** — B B

Cable Trough Ladder or Channel*** — C C

Wireway*** — W W

PANELBOARDS, SWITCHBOARDS AND RELATED EQUIPMENT

Flush Mounted Panelboard and Cabinet***

Surface Mounted Panelboard and Cabinet***

Switchboard, Power Control Center, Unit Substation (Should be drawn to scale)***

Flush Mounted Terminal Cabinet (In small scale drawings the TC may be indicated alongside the symbol)*** — TC

Surface Mounted Terminal Cabinet (In small scale drawings the TC may be indicated alongside the symbol)*** — TC

Pull Box (Identify in relation to Wiring System Section and Size)

Motor or Other Power Controller May be a starter or contactor***

Externally Operated Disconnection Switch***

Combination Controller and Disconnection Means***

*Note: Use heavy-weight line to identify service and feeders. Indicate empty conduit by notation CO.

**Note: Any circuit without further identification indicates two-wire circuit. For a greater number of wires, indicate with cross lines, e.g.:

3 wires 4 wires, etc.

Neutral wire may be shown longer. Unless indicated otherwise, the wire size of the circuit is the minimum size required by the specification. Identify different functions of wiring system (e.g., signaling system) by notation or other means.

***Identify by Notation or Schedule

110F20B.EPS

Figure 20 ◆ Recommended electrical symbols (2 of 7).

POWER EQUIPMENT

Electric Motor (HP as Indicated) — 1/4

Power Transformer

Pothead (Cable Termination)

Circuit Element
e.g. Circuit Breaker — CB

Circuit Breaker

Fusible Element

Single-Throw Knife Switch

Double-Throw Knife Switch

Ground

Battery

Contactor — C

Photoelectric Cell — PE

Voltage Cycles, Phase — EX: 480/60/3

Relay — R

Equipment Connection (as noted)

REMOTE CONTROL STATIONS FOR MOTORS OR OTHER EQUIPMENT

Pushbutton Station — PB

Float Switch - Mechanical — F

Limit Switch - Mechanical — L

Pneumatic Switch - Mechanical — P

Electric Eye - Beam Source

Electric Eye - Relay

Temperature Control Relay
Connection (3 Denotes Quantity) — R 3

Solenoid Control Valve Connection — S

Pressure Switch Connection — P

Aquastat Connection — A

Vacuum Switch Connection — V

Gas Solenoid Valve Connection — G

Flow Switch Connection — F

Timer Connection — T

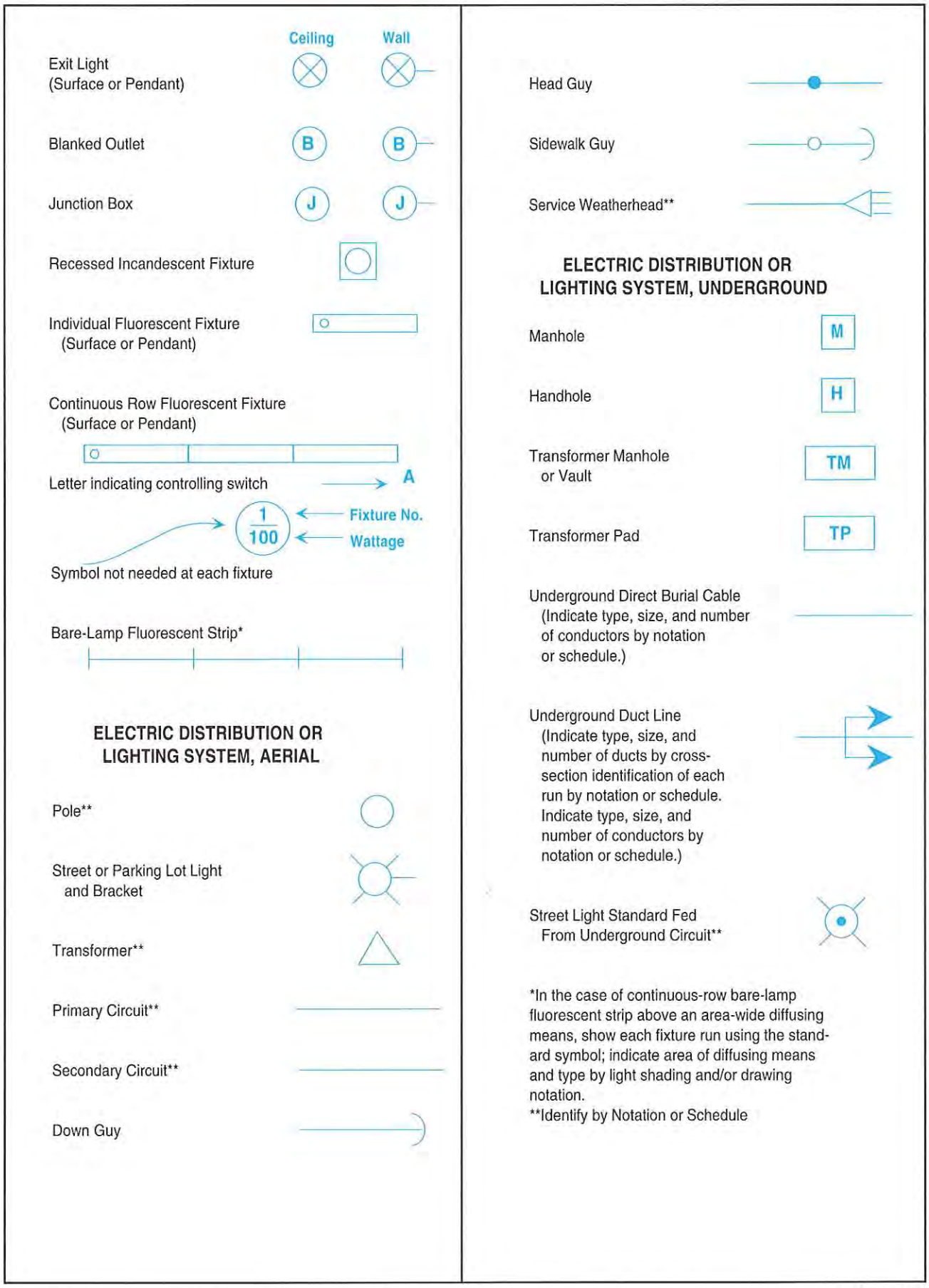
Limit Switch Connection — L

LIGHTING OUTLETS

	Ceiling	Wall
Incandescent Fixture (Surface or Pendant)		
Incandescent Fixture with Pull Chain (Surface or Pendant)	PC	PC

110F20C.EPS

Figure 20 ◆ Recommended electrical symbols (3 of 7).



110F20D.EPS

Figure 20 ◆ Recommended electrical symbols (4 of 7).

SIGNALLING SYSTEM OUTLETS

INSTITUTIONAL, COMMERCIAL, AND INDUSTRIAL OCCUPANCIES

I NURSE CALL SYSTEM DEVICES (Any Type)

Basic Symbol

(Examples of Individual Item Identification Not a Part of Standard)

Nurses' Annunciator (Add a number after it as +①24 to indicate number of lamps)

Call Station, Single Cord, Pilot Light

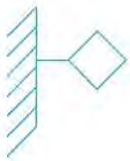
Call Station, Double Cord, Microphone Speaker

Corridor Dome Light 1 Lamp

Transformer

Any Other Item On Same System Use Number As Required

II PAGING SYSTEM DEVICES



Basic Symbol

(Examples of Individual Item Identification Not a Part of Standard)

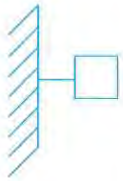
Keyboard

Flush Annunciator

2-Face Annunciator

Any Other Item On Same System Use Numbers As Required

III FIRE ALARM SYSTEM DEVICES (Any Type) Including Smoke and Sprinkler Alarm Devices



Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Control Panel

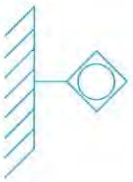
Station

10" Gong

Pre-Signal Chime

Any Other Item On Same System Use Numbers As Required

IV STAFF REGISTER SYSTEM DEVICES (Any Type)



Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Phone Operators' Register

Entrance Register - Flush

Staff Room Register

Transformer

Any Other Item On Same System Use Numbers As Required

V ELECTRIC CLOCK SYSTEM DEVICES (Any Type)

Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

110F20E.EPS

Figure 20 ◆ Recommended electrical symbols (5 of 7).

Master Clock

12" Secondary - Flush

12" Double Dial - Wall Mounted

18" Skeleton Dial

Any Other Item On Same System
Use Numbers As Required

VI PUBLIC TELEPHONE SYSTEM DEVICES

Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Switchboard

Desk Phone

Any Other Item On Same System
Use Numbers As Required

VII PRIVATE TELEPHONE SYSTEM DEVICES (Any Type)

Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Switchboard

Wall Phone

Any Other Item On Same System
Use Numbers As Required

VIII WATCHMAN SYSTEM DEVICES (Any Type)

Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Central Station

Key Station

Any Other Item On Same System
Use Numbers As Required

IX SOUND SYSTEM

Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Amplifier

Microphone

Interior Speaker

Exterior Speaker

Any Other Item On Same System
Use Numbers As Required

X OTHER SIGNAL SYSTEM DEVICES

Basic Symbol

(Examples of Individual Item Identification. Not a Part of Standard)

Buzzer

Bell

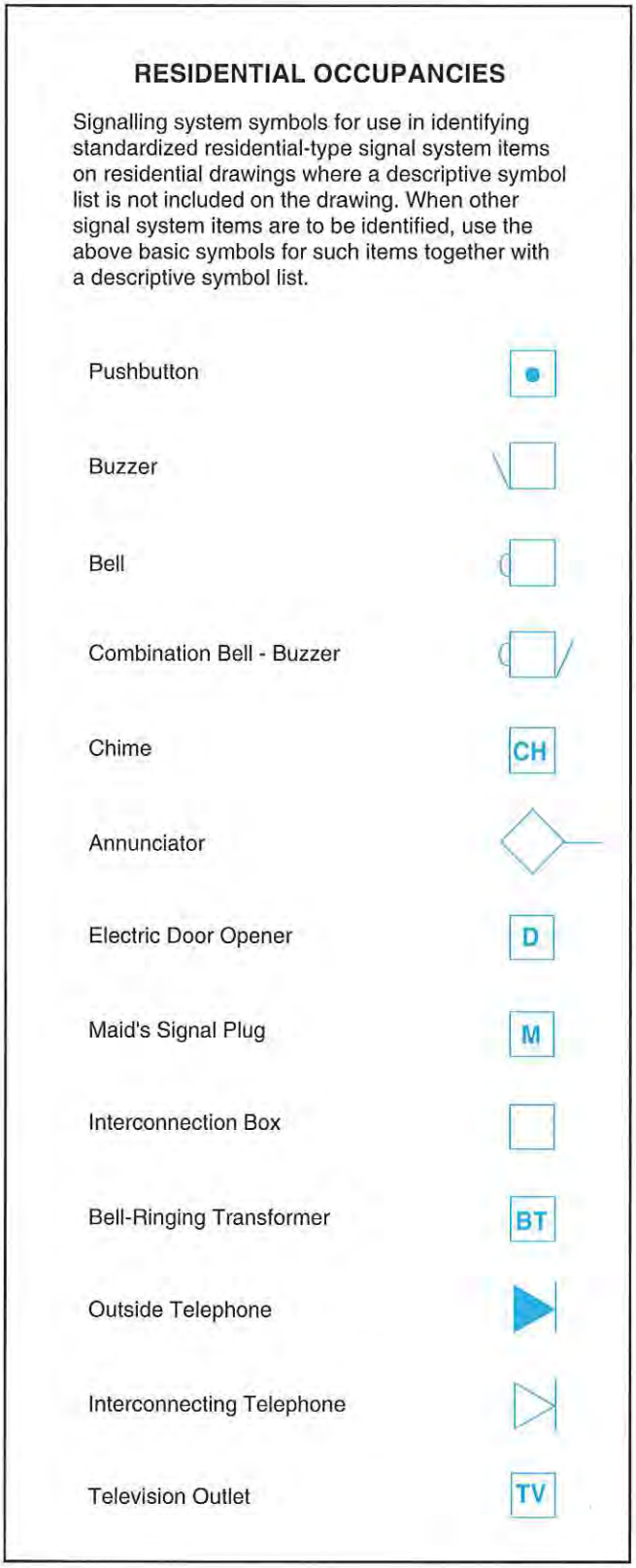
Pushbutton

Annunciator

Any Other Item On Same System
Use Numbers As Required

110F20F.EPS

Figure 20 ◆ Recommended electrical symbols (6 of 7).



110F20G.EPS

Figure 20 ◆ Recommended electrical symbols (7 of 7).

5.0.0 ◆ SCALE DRAWINGS

In most electrical drawings, the components are so large that it would be impossible to draw them actual size. Consequently, drawings are made to some reduced *scale;* that is, all the distances are drawn smaller than the actual dimensions of the object itself, with all dimensions being reduced in the same proportion. For example, if a floor plan of a building is to be drawn to a scale of ¼" = 1'–0", each ¼" on the drawing would equal 1 foot on the building itself; if the scale is ⅛" = 1'–0", each ⅛" on the drawing equals 1 foot on the building, and so forth.

When architectural and engineering drawings are produced, the selected scale is very important. Where dimensions must be held to extreme accuracy, the scale drawings should be made as large as practical with dimension lines added. Where dimensions require only reasonable accuracy, the object may be drawn to a smaller scale (with dimension lines possibly omitted).

In dimensioning drawings, the dimensions written on the drawing are the actual dimensions of the building, not the distances that are measured on the drawing. To further illustrate this point, look at the floor plan in *Figure 21;* it is drawn to a scale of ½" = 1'–0". One of the walls is drawn to an actual length of 3½" on the drawing paper, but since the scale is ½" = 1'–0" and since 3½" contains 7 halves of an inch (7 × ½ = 3½"), the dimension shown on the drawing will therefore be 7'–0" on the actual building.

As shown in the previous example, the most common method of reducing all the dimensions (in feet and inches) in the same proportion is to choose a certain distance and let that distance represent one foot. This distance can then be divided into 12 parts, each of which represents an inch. If half inches are required, these twelfths are further subdivided into halves, etc. Now the scale represents the common foot rule with its subdivisions into inches and fractions, except that the scaled foot is smaller than the distance known as a foot and, likewise, its subdivisions are proportionately smaller.

When a measurement is made on the drawing, it is made with the reduced foot rule or scale; when a measurement is made on the building, it is made with the standard foot rule. The most common reduced foot rules or scales used in electrical drawings are the architect's scale and the engineer's scale. Drawings may sometimes be encountered that use a metric scale, but using this scale is similar to using the architect's or engineer's scales.

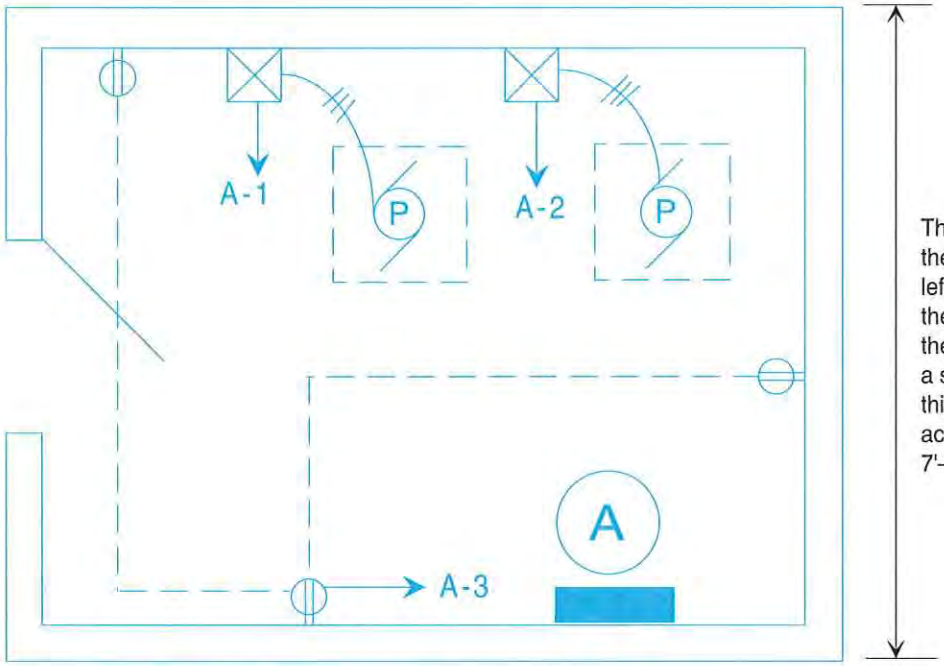


Figure 21 ◆ Typical floor plan showing drawing scale.

THINK ABOUT IT

Using Electrical Symbols

Although there are many electrical symbols, you must be able to read the common ones at a glance. Looking at the simple pump house drawing in *Figure 21*, see how quickly you can explain the symbols and the circuits that they identify.

5.1.0 Architect's Scale

Figure 22 shows two configurations of architect's scales. The one on the top is designed so that 1" = 1'–0", and the one on the bottom has graduations spaced to represent ⅛" = 1'–0".

Note that on the one-inch scale in *Figure 23*, the longer marks to the right of the zero (with a numeral beneath) represent feet. Therefore, the distance between the zero and the numeral 1 equals one foot. The shorter mark between the zero and 1 represents ½ of a foot, or six inches.

Referring again to *Figure 23*, look at the marks to the left of the zero. The numbered marks are spaced three scaled inches apart and have the numerals 0, 3, 6, and 9 for use as reference points. The other lines of the same length also represent scaled inches, but are not marked with numerals. In use, you can count the number of long marks to the left of the zero to find the number of inches, but after some practice, you will be able to tell the exact measurement at a glance. For example, the measurement A represents five inches because it is the fifth inch mark to the left of the zero; it is also one inch mark short of the six-inch line on the scale.

The lines that are shorter than the inch line are the half-inch lines. On smaller scales, the basic unit is not divided into as many divisions. For example, the smallest subdivision on some scales represents two inches.

5.1.1 Types of Architect's Scales

Architect's scales are available in several types, but the most common include the triangular

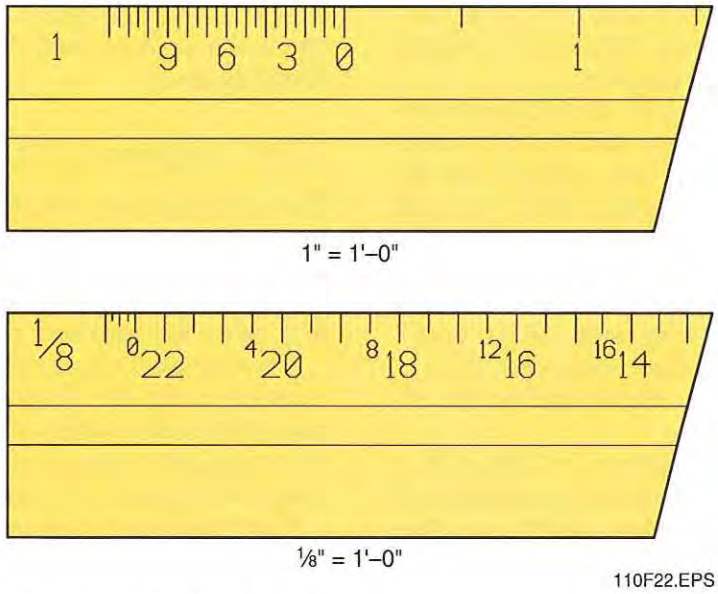


Figure 22 ◆ Two different configurations of architect's scales.

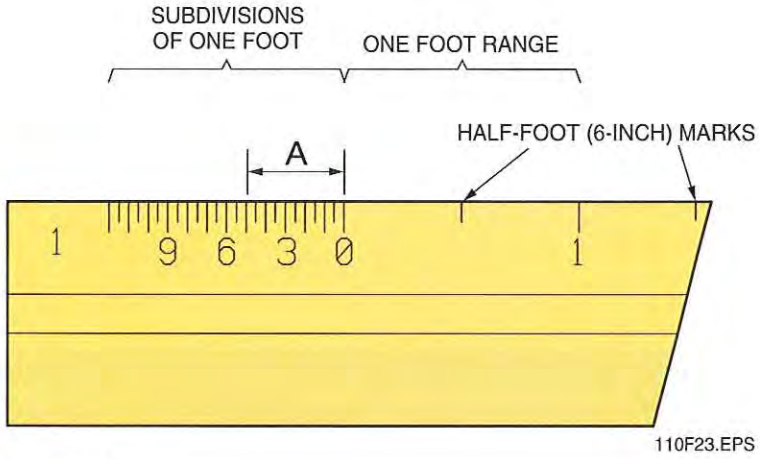


Figure 23 ◆ One-inch architect's scale.

scale (*Figure 24*) and the flat scale. The quality of architect's scales also varies from cheap plastic scales (costing a dollar or two) to high-quality wooden-laminated tools that are calibrated to precise standards.

The triangular scale (*Figure 24*) is frequently found in drafting and estimating departments or engineering and electrical contracting firms, while the flat scales are more convenient to carry on the job site.

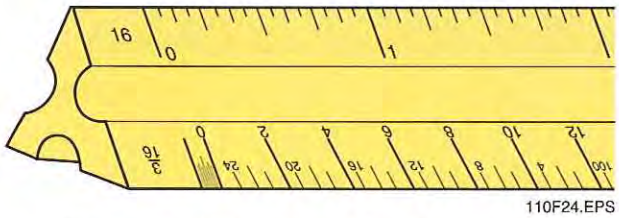


Figure 24 ◆ Typical triangular architect's scale.

Triangular architect's scales have 12 different scales—two on each edge—as follows:

- Common foot rule (12 inches)
- 1/16" = 1'–0"
- 3/32" = 1'–0"
- 3/16" = 1'–0"
- 1/8" = 1'–0"
- 1/4" = 1'–0"
- 3/8" = 1'–0"
- 3/4" = 1'–0"
- 1" = 1'–0"
- 1/2" = 1'–0"
- 1 1/2" = 1'–0"
- 3" = 1'–0"

Two separate scales on one face may seem confusing at first, but after some experience, reading these scales becomes second nature.

In all but one of the scales on the triangular architect's scale, each face has one of the scales placed opposite to the other. For example, on the one-inch face, the one-inch scale is read from left to right, starting from the zero mark. The half-inch scale is read from right to left, again starting from the zero mark.

On the remaining foot-rule scale (1/16" = 1'–0") each 1/16" mark on the scale represents one foot.

Figure 25 shows all the scales found on the triangular architect's scale.

The flat architect's scale shown in *Figure 26* is ideal for workers on most projects. It is easily and conveniently carried in the shirt pocket, and the four scales (1/8", 1/4", 1/2", and 1") are adequate for the majority of projects that will be encountered.

The partial floor plan shown in *Figure 26* is drawn to a scale of 1/8" = 1'–0". The dimension in question is found by placing the 1/8" architect's scale on the drawing and reading the figures. It can be seen that the dimension reads 24'–6".

Every drawing should have the scale to which it is drawn plainly marked on it as part of the drawing title. However, it is not uncommon to have several different drawings on one blueprint sheet—all with different scales. Therefore, always check the scale of each different view found on a drawing sheet.

5.2.0 Engineer's Scale

The civil engineer's scale is used in basically the same manner as the architect's scale, with the principal difference being that the graduations on the engineer's scale are decimal units rather than feet, as on the architect's scale.

The engineer's scale is used by placing it on the drawing with the working edge away from the user. The scale is then aligned in the direction of the required measurement. Then, by looking down at the scale, the dimension is read.

Civil engineer's scales commonly show the following graduations:

- 1" = 10 units
- 1" = 20 units
- 1" = 30 units
- 1" = 40 units
- 1" = 60 units
- 1" = 80 units
- 1" = 100 units

The purpose of this scale is to transfer the relative dimensions of an object to the drawing or vice

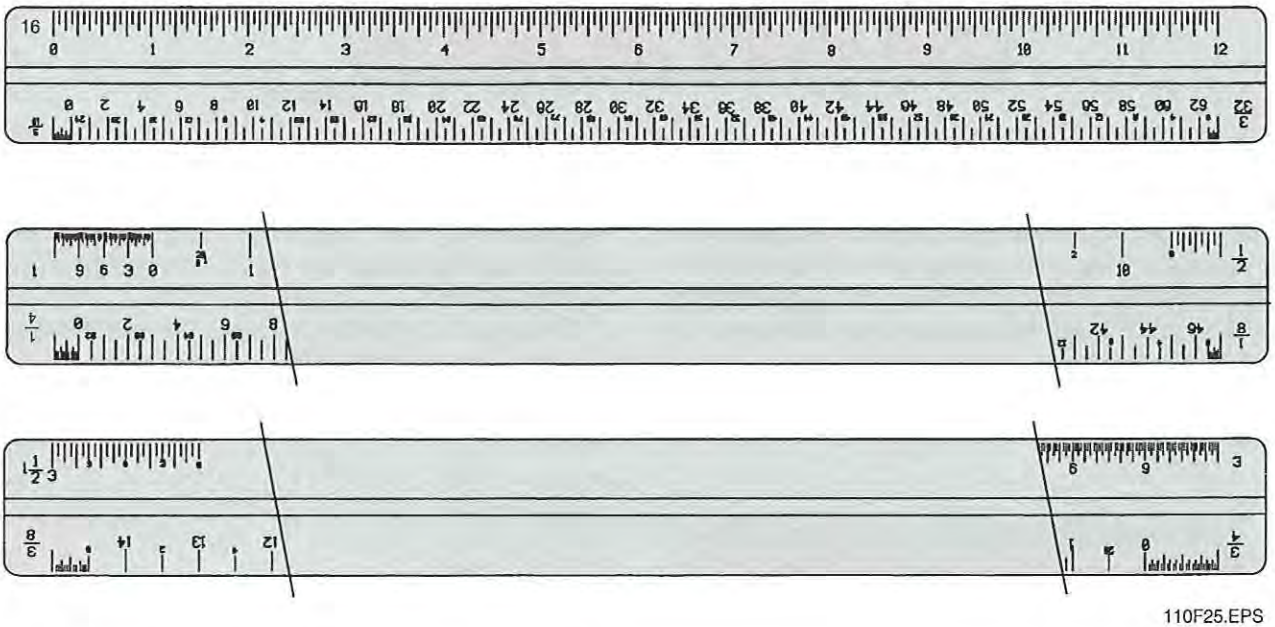


Figure 25 ◆ Various scales on a triangular architect's scale.

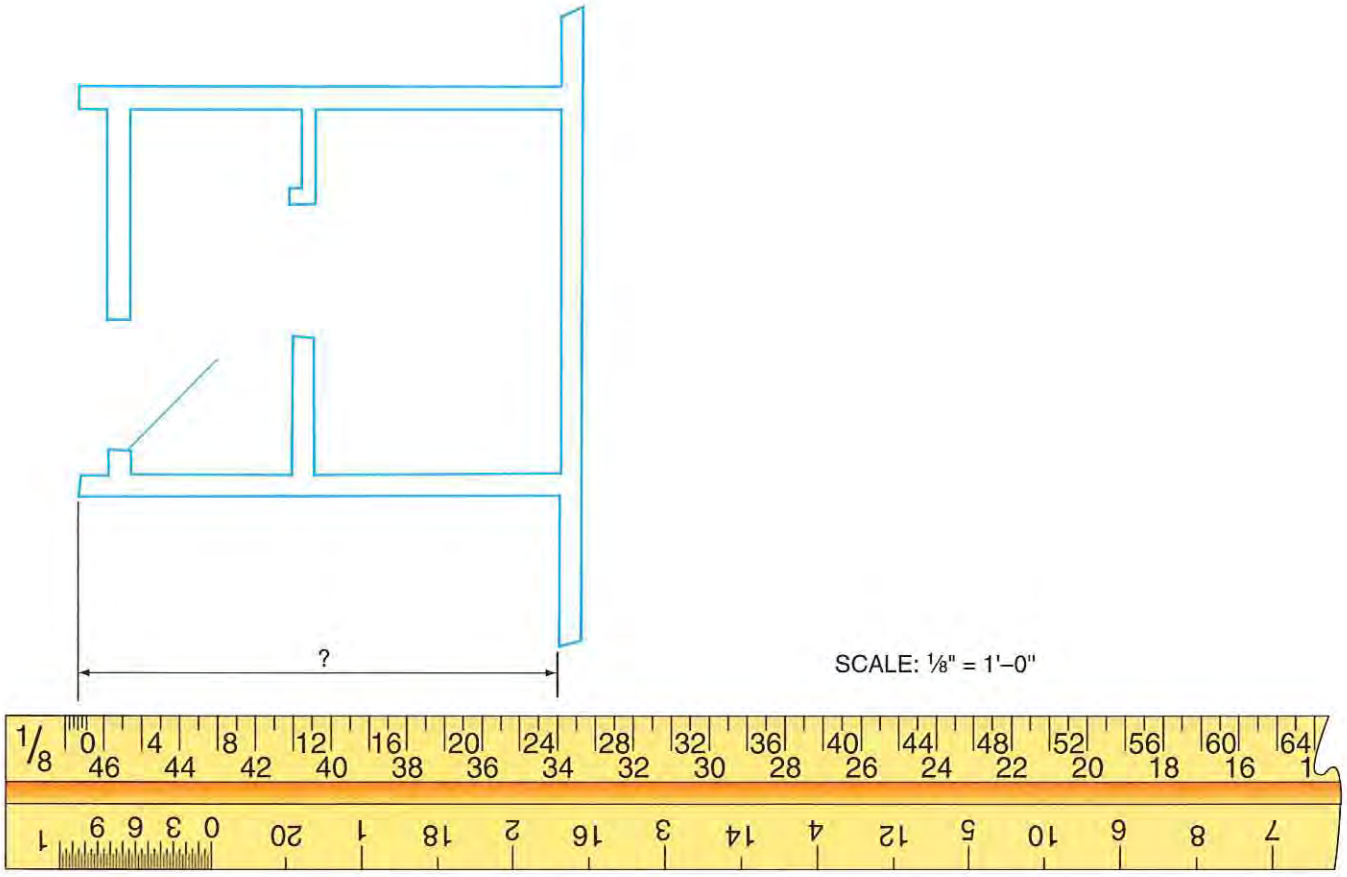


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Figure 26 ◆ Using the ⅛" architect's scale to determine the dimensions on a drawing.

versa. It is used mainly on site plans to determine distances between property lines, manholes, duct runs, direct-burial cable runs, and the like.

Site plans are drawn to scale using the engineer's scale rather than the architect's scale. On small lots, a scale of 1 inch = 10 feet or 1 inch = 20 feet is used. For a 1:10 scale, this means that one inch (the actual measurement on the drawing) is equal to 10 feet on the land itself.

On larger drawings, where a large area must be covered, the scale could be 1 inch = 100 feet or 1 inch = 1,000 feet, or any other integral power of 10. On drawings with the scale in multiples of 10, the engineer's scale marked 10 is used. If the scale is 1 inch = 200 feet, the engineer's scale marked 20 is used, and so on.

Although site plans appear reduced in scale, depending on the size of the object and the size of the drawing sheet to be used, the actual dimensions must be shown on the drawings at all times. When you are reading the drawing plans to scale, think of each dimension in its full size and not in the reduced scale it happens to be on the drawing (*Figure 27*).

5.3.0 Metric Scale

Metric scales are calibrated in units of 10 (*Figure 28*). The two common length measurements used in the metric scale or architectural drawings are the meter and the millimeter, the millimeter being 1/1,000 of a meter. On drawings drawn to scales between 1:1 and 1:100, the millimeter is typically used. On drawings drawn to scales between 1:200 and 1:2,000, the meter is generally used. Many contracting firms that deal in international trade have adopted a dual-dimensioning system expressed in both metric and English symbols. Drawings prepared for government projects may also require metric dimensions. See also *Appendix A*.

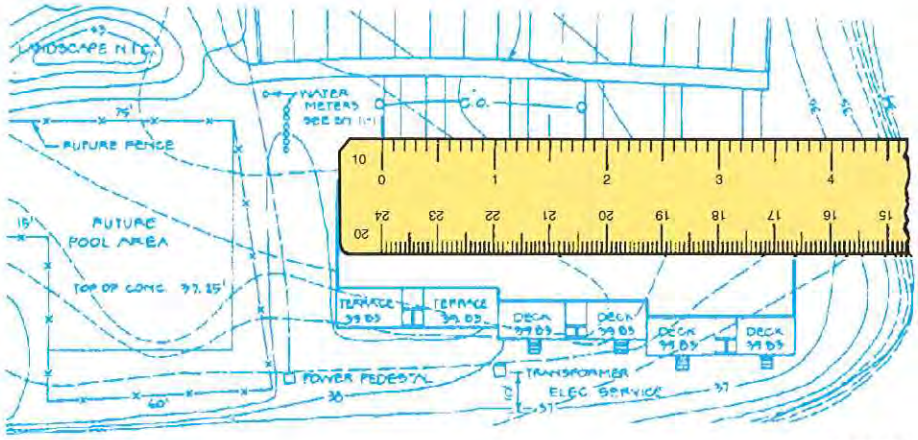

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Figure 27 ◆ Practical use of the engineer's scale.

110F28.EPS

Figure 28 ◆ Typical metric scale.

6.0.0 ◆ ANALYZING ELECTRICAL DRAWINGS

The most practical way to learn how to read electrical construction documents is to analyze an existing set of drawings prepared by consulting or industrial engineers.

Engineers or electrical designers are responsible for the complete layout of electrical systems for most projects. Electrical drafters then transform the engineer's designs into working drawings, using either manual drafting instruments or computer-aided design (CAD) systems. The following is a brief outline of what usually takes place in the preparation of electrical design and working drawings:

- The engineer meets with the architect and owner to discuss the electrical needs of the building or project and to discuss various recommendations made by all parties.
- After that, an outline of the architect's floor plan is laid out.
- The engineer then calculates the required power and lighting outlets for the project; these are later transferred to the working drawings.
- All communications and alarm systems are located on the floor plan, along with lighting and power panelboards.
- Circuit calculations are made to determine wire size and overcurrent protection.
- The main electric service and related components are determined and shown on the drawings.
- Schedules are then placed on the drawings to identify various pieces of equipment.
- Wiring diagrams are made to show the workers how various electrical components are to be connected.
- A legend or electrical symbol list is drafted and shown on the drawings to identify all symbols used to indicate electrical outlets or equipment.
- Various large-scale electrical details are included, if necessary, to show exactly what is required of the electricians.
- Written specifications are then made to give a description of the materials and installation methods.

6.1.0 Development of Site Plans

In general practice, it is usually the owner's responsibility to furnish the architect/engineer with property and topographic surveys, which are made by a certified land surveyor or civil engineer. These surveys show:

- All property lines
- Existing public utilities and their location on or near the property (e.g., electrical lines, sanitary sewer lines, gas lines, water-supply lines, storm sewers, manholes, telephone lines, etc.)

A land surveyor does the property survey from information obtained from a deed description of the property. A property survey shows only the property lines and their lengths, as if the property were perfectly flat.

The topographic survey shows both the property lines and the physical characteristics of the land by using contour lines, notes, and symbols. The physical characteristics may include:

- The direction of the land slope
- Whether the land is flat, hilly, wooded, swampy, high, or low, and other features of its physical nature

All of this information is necessary so that the architect can properly design a building to fit the property. The electrical engineer also needs this information to locate existing electrical utilities and to route the new service to the building, provide outdoor lighting and circuits, etc.

Electrical site work is sometimes shown on the architect's plot plan. However, when site work involves many trades and several utilities (e.g., gas, telephone, electric, television, water, and sewage), it can become confusing if all details are shown on one drawing sheet. In cases like these, it is best to have a separate drawing devoted entirely to the electrical work, as shown in *Figure 29*. This project is an office/warehouse building for Virginia Electric, Inc. The electrical drawings consist of four 24" × 36" drawing sheets, along with a set of written specifications, which will be discussed later in this module.

The electrical site or plot plan shown in *Figure 29* has the conventional architect's and engineer's title blocks in the lower right-hand corner of the drawing. These blocks identify the project and project owners, the architect, and the engineer. They also show how this drawing sheet relates to the entire set of drawings. Note the engineer's professional stamp of approval to the left of the engineer's title block. Similar blocks appear on all four of the electrical drawing sheets.

When examining a set of electrical drawings for the first time, always look at the area around the title block. This is where most revision blocks or revision notes are placed. If revisions have been made to the drawings, make certain that you have a clear understanding of what has taken place before proceeding with the work.

Refer again to the drawing in *Figure 29* and note the North Arrow in the upper left corner. A North Arrow shows the direction of true north to help you orient the drawing to the site. Look directly down from the North Arrow to the bottom of the page and notice the drawing title, *Plot Utilities*. Directly beneath the drawing title you can see that the drawing scale of 1" = 30' is shown. This means that each inch on the drawing represents 30 feet on the actual job site. This scale holds true for all drawings on the page unless otherwise noted.

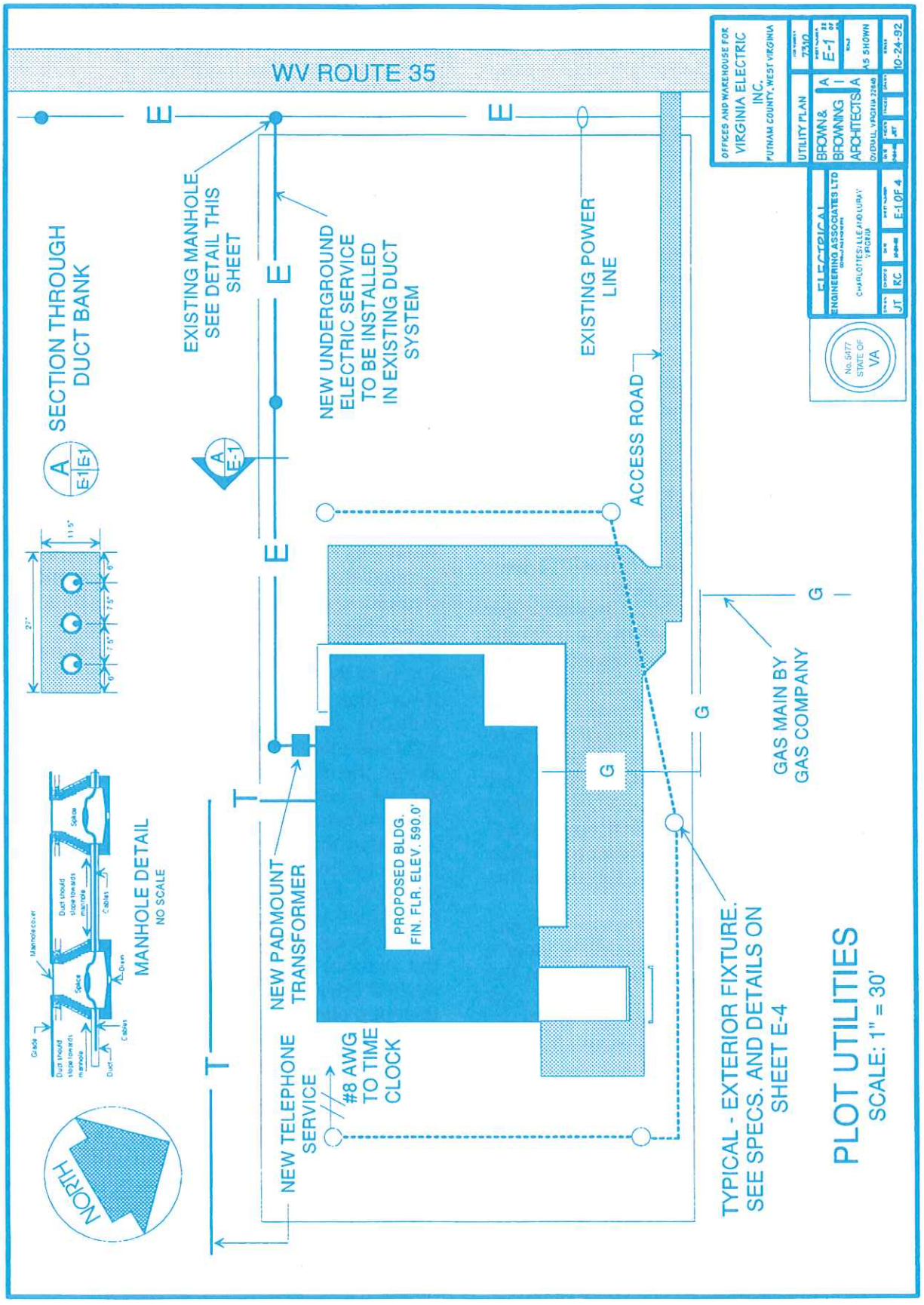
An outline of the proposed building is indicated on the drawing by cross-hatched rectangles along with a callout, *Proposed Bldg. Fin. Flr. Elev. 590.0*. This means that the finished floor level of the building is to be 590 feet above sea level, which in this part of the country will be about two feet above finished grade around the building. This information helps the electrician locate conduit sleeves and stub-ups to the correct height before the finished concrete floor is poured.

The shaded area represents asphalt paving for the access road, drives, and parking lot. Note that the access road leads into a highway, which is designated Route 35. This information further helps workers to orient the drawing to the building site.

Existing manholes are indicated by a solid circle, while an open circle is used to show the position of the five new pole-mounted lighting fixtures that are to be installed around the new building. Existing power lines are shown with a light solid line with the letter E placed at intervals along the line. The new underground electric service is shown in the same way, except the lines are somewhat wider and darker on the drawing. Note that this new high-voltage cable terminates into a padmount transformer near the proposed building. New telephone lines are similar except the letter T is used to identify the telephone lines.

The direct-burial underground cable supplying the exterior lighting fixtures is indicated with dashed lines on the drawing—shown connecting the open circles. A homerun for this circuit is also shown to a time clock.

The manhole detail shown to the right of the North Arrow may seem to serve very little purpose on this drawing since the manholes have already been installed. However, the dimensions and details of their construction will help the electrical contractor or supervisor to better plan the pulling of the high-voltage cable. The same is true of the cross section shown of the duct bank. The electrical contractor knows that three empty ducts are available if it is discovered that one of them is damaged when the work begins.



110F29.EPS

Figure 29 ◆ Typical electrical site plan.

Interpreting Site Plans

THINK ABOUT IT

Study *Figure 29* and explain as many of its features as you can. How much can be understood using common sense? What features require special information?

Although the electrical work will not involve working with gas, the main gas line is shown on the electrical drawing to let the electrical workers know its approximate location while they are installing the direct-burial conductors for the exterior lighting fixtures.

7.0.0 ◆ POWER PLANS

The electrical power plan (*Figure 30*) shows the complete floor plan of the office/warehouse building with all interior partitions drawn to scale. Sometimes, the physical locations of all wiring and outlets are shown on one drawing; that is, outlets for lighting, power, signal and communications, special electrical systems, and related equipment are shown on the same plan. However, on complex installations, the drawing would become cluttered if both lighting and power were shown on the same floor plan. Therefore, most projects will have a separate drawing for power and another for lighting. Riser diagrams and details may be shown on yet another drawing sheet, or if room permits, they may be shown on the lighting or power floor plan sheets.

A closer look at this drawing reveals the title blocks in the lower right corner of the drawing sheet. These blocks list both the architectural and engineering firms, along with information to identify the project and drawing sheet. Also note

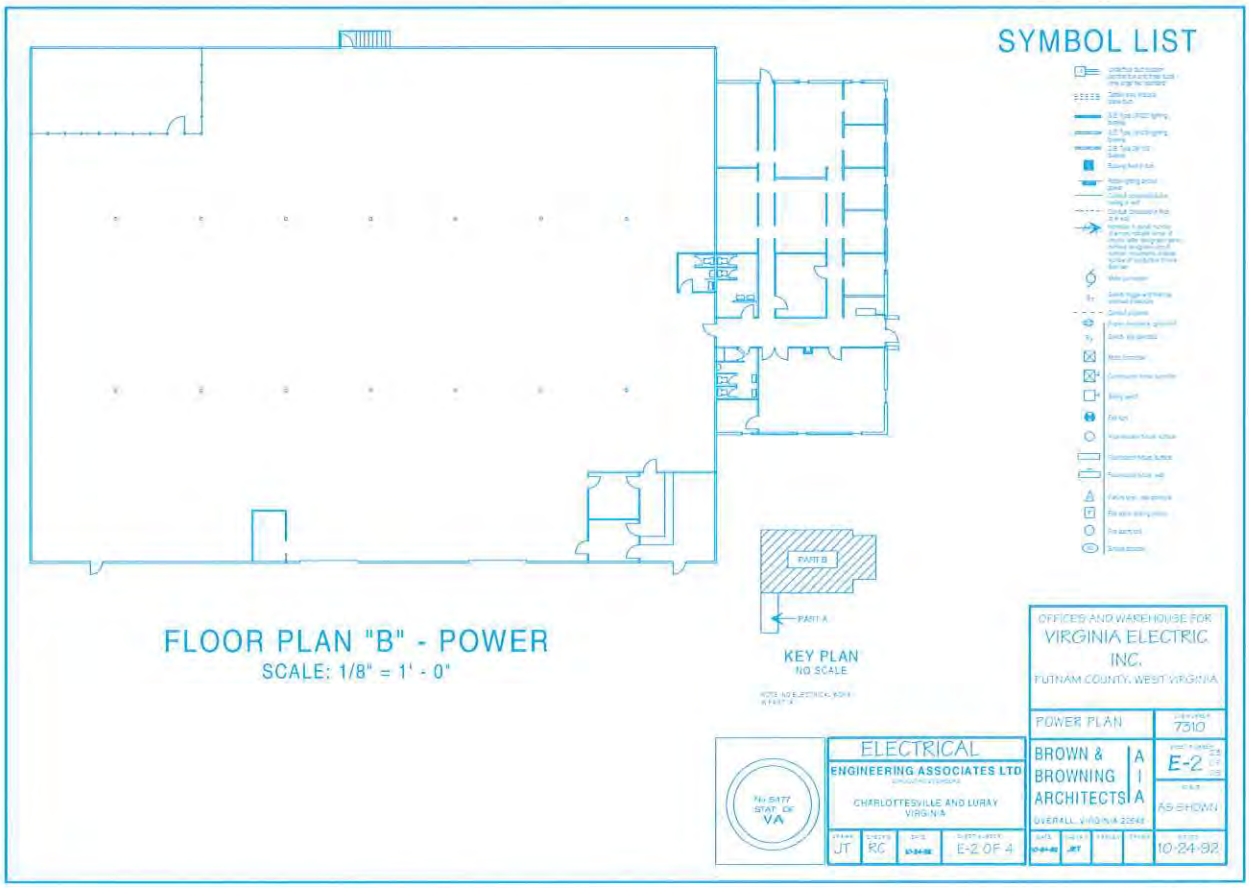


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Figure 30 ◆ Electrical power plan.

that the floor plan is titled *Floor Plan "B"—Power* and is drawn to a scale of ⅛" = 1'–0". There are no revisions shown on this drawing sheet.

7.1.0 Key Plan

A key plan appears on the drawing sheet immediately above the engineer's title block (*Figure 31*). The purpose of this key plan is to identify that part of the project to which this sheet applies. In this case, the project involves two buildings: Building A and Building B. Since the outline of Building B is cross-hatched in the key plan, this is the building to which this drawing applies. Note that this key plan is not drawn to scale—only its approximate shape.

Although Building A is also shown on this key plan, a note below the key plan title states that there is no electrical work required in Building A.

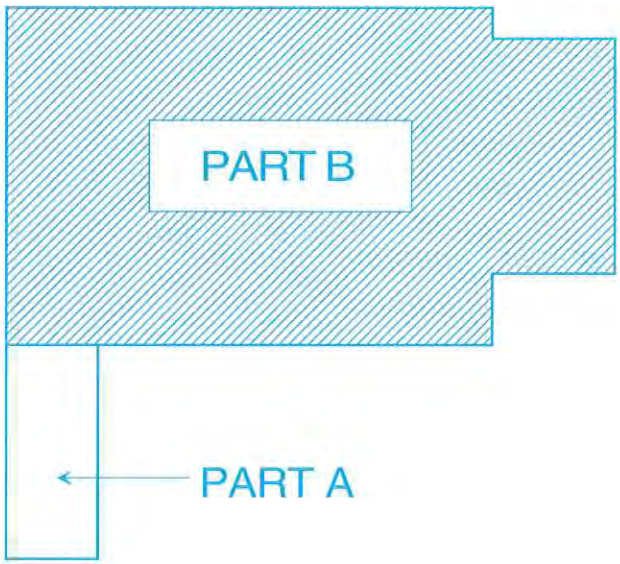
On some larger installations, the overall project may involve several buildings requiring appropriate key plans on each drawing to help the workers orient the drawings to the appropriate building. In some cases, separate drawing sheets may be used for each room or area in an industrial project—again requiring key plans on each drawing sheet to identify applicable drawings for each room.

7.2.0 Symbol List

A symbol list appears on the electrical power plan (immediately above the architect's title block) to identify the various symbols used for both power and lighting on this project. In most cases, the only symbols listed are those that apply to the particular project. In other cases, however, a standard list of symbols is used for all projects with the following note:

These are standard symbols and may not all appear on the project drawings; however, wherever the symbol on the project drawings occurs, the item shall be provided and installed.

Only electrical symbols that are actually used for the office/warehouse drawings are shown in the list on the example electrical power plan. A close-up look at these symbols appears in *Figure 32*.



KEY PLAN
NO SCALE

NOTE: NO ELECTRICAL WORK
IN PART "A"

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Figure 31 ◆ Key plan appearing on electrical power plan.

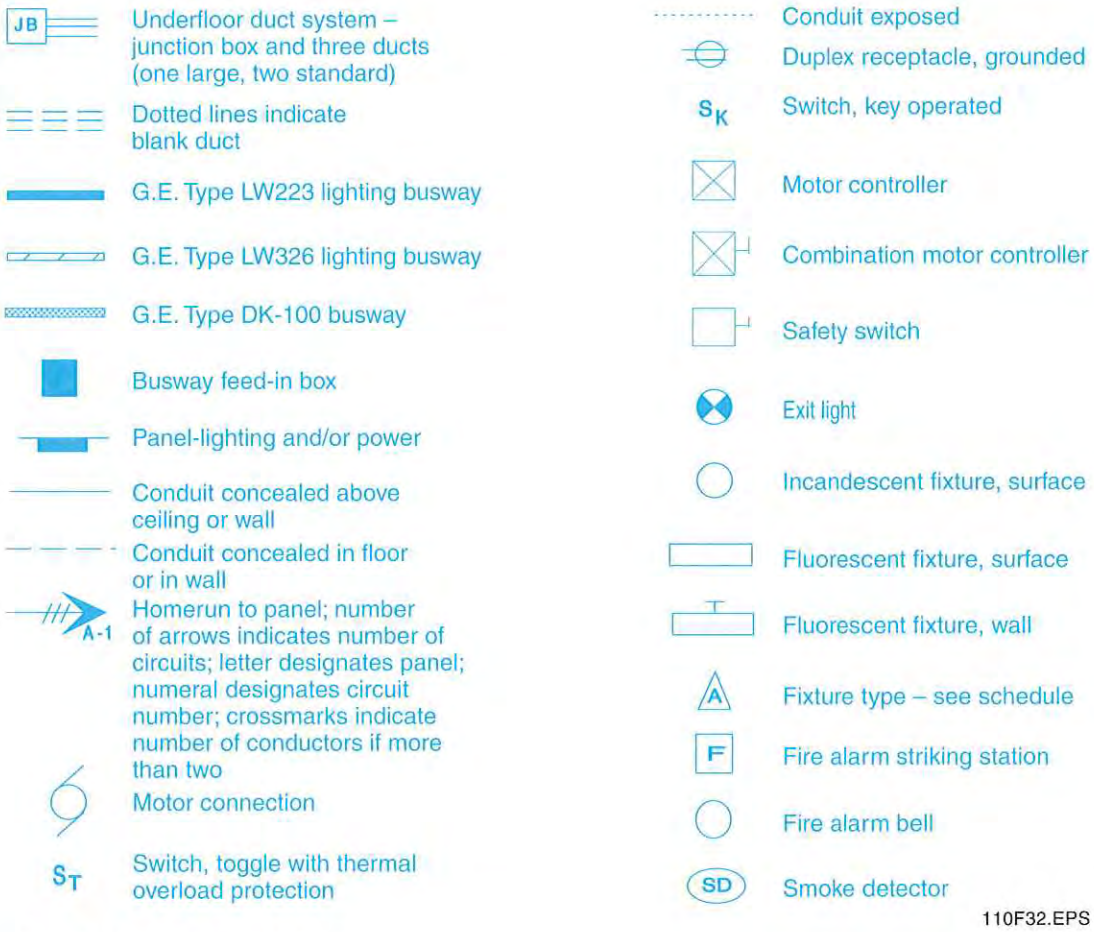


Figure 32 ◆ Sample electrical symbols list.

7.3.0 Floor Plan

A somewhat enlarged view of the electrical floor plan drawing is shown in *Figure 33*. However, due to the size of the drawing in comparison with the size of the pages in this module, it is still difficult to see very much detail. This illustration is meant to show the overall layout of the floor plan and how the symbols and notes are arranged.

INSIDE TRACK

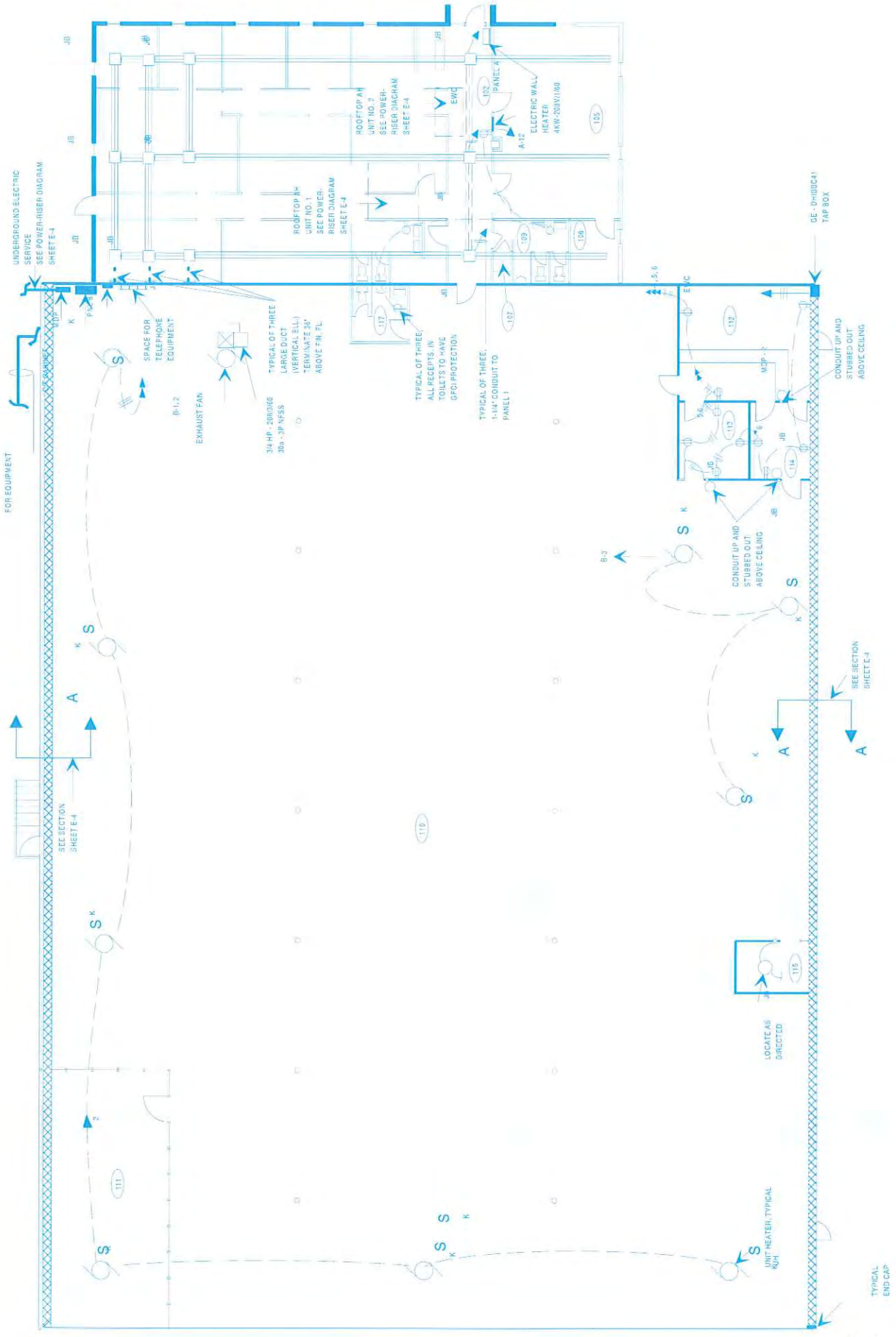
Watch Specified Dimensions

When devices are to be located at heights specified above the finished floor (AFF), be sure to find out the actual height of the flooring to be installed. Some materials, such as ceramic tile, can add significantly to the height of the finished floor.

THINK ABOUT IT

Power Plans

Study *Figure 33*. Where does the power enter, and how is it distributed and controlled? What is meant by each of the symbols and lines? Is every electrical connection marked or are some left to the discretion of the electrician?



110F33.EPS

Figure 33 ◆ Power plan for office/warehouse building.

In general, this plan shows the service equipment (in plan view), receptacles, underfloor duct system, motor connections, motor controllers, electric heat, busways, and similar details. The electric panels and other service equipment are drawn close to scale. The locations of other electrical outlets and similar components are only approximated on the drawings because they have to be exaggerated to show up on the prints. To illustrate, a common duplex receptacle is only about three inches wide. If such a receptacle were to be located on the floor plan of this building (drawn to a scale of ⅛" = 1'–0"), even a small dot on the drawing would be too large to draw the receptacle exactly to scale. Therefore, the receptacle symbol is exaggerated. When such receptacles are scaled on the drawings to determine the proper location, a measurement is usually taken to the center of the symbol to determine the distance between outlets. Junction boxes, switches, and other electrical connections shown on the floor plan will be exaggerated in a similar manner. The partial floor plan drawing in *Figure 34* allows a better view of the drawing details.

7.3.1 Notes and Building Symbols

Referring again to *Figure 33*, you will notice numbers placed inside an oval symbol in each room. These numbered ovals represent the room name or type and correspond to a room schedule in the architectural drawings. For example, room number 112 is designated as the lobby in the room

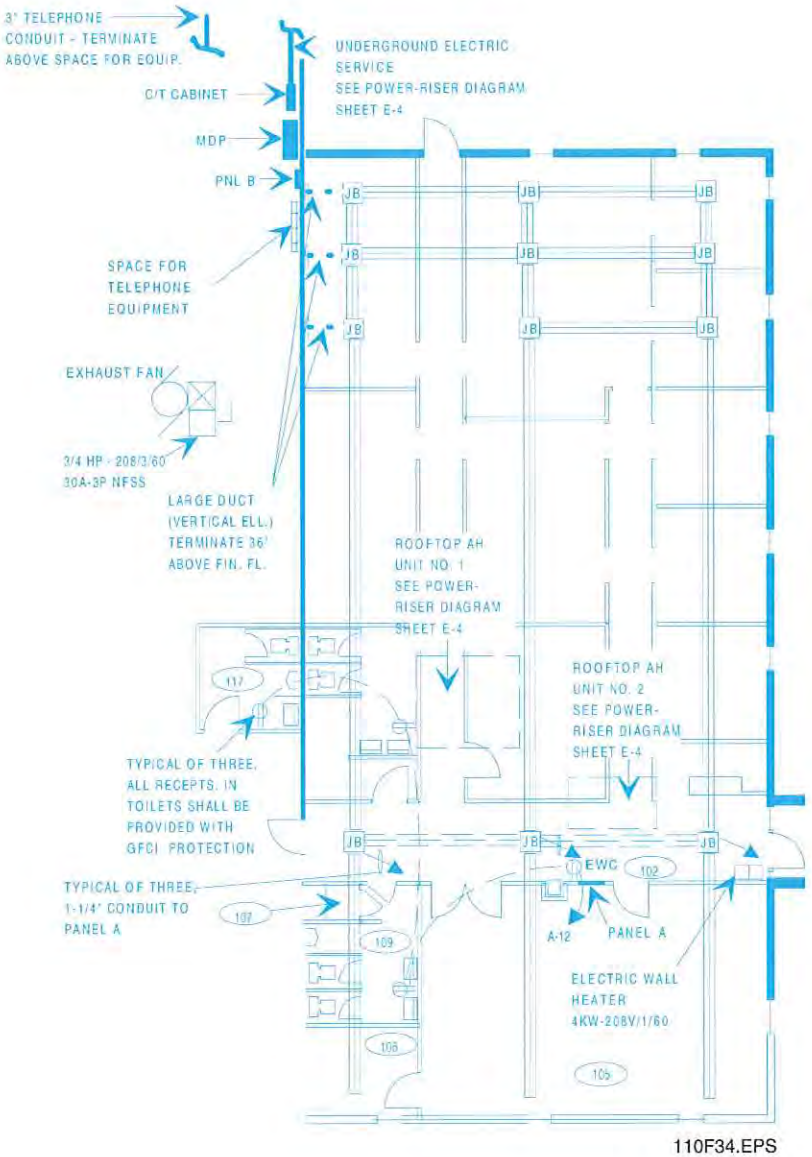


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Figure 34 ◆ Partial floor plan for office/warehouse building.

INSIDE TRACK

Reading Notes

The notes are crucial elements of the drawing set. Receptacles, for example, are hard to position precisely based on a scaled drawing alone, and yet the designer may call for exact locations. For example, the designer may want receptacles exactly 6" above the kitchen counter backsplash and centered on the sink.

schedule (not shown), room number 113 is designated as office No. 1, etc. On some drawings, these room symbols are omitted and the room names are written out on the drawings.

There are also several notes appearing at various places on the floor plan. These notes offer additional information to clarify certain aspects of the drawing. For example, only one electric heater is to be installed by the electrical contractor; this heater is located in the building's vestibule. Rather than have a symbol in the symbol list for this one heater, a note is used to identify it on the drawing. Other notes on this drawing describe how certain parts of the system are to be installed. For example, in the office area (rooms 112, 113, and 114), you will see the following note: *CONDUIT UP AND STUBBED OUT ABOVE CEILING.* This empty conduit is for telephone/communications cables that will be installed later by the telephone company.

7.3.2 Busways

The office/warehouse project utilizes three types of busways: two types of lighting busways and one power busway. Only the power busway is shown on the power plan; the lighting busways will appear on the lighting plan.

Figure 33 shows two runs of busways: one running the length of the building on the south end (top wall on drawing), and one running the length of the north wall. The symbol list in *Figure 32* shows this busway to be designated by two parallel lines with a series of X's inside. The symbol list further describes the busway as General Electric Type DK-100. These busways are fed from the main distribution panel (circuits MDP-1 and MDP-2) through GE No. DHIBBC41 tap boxes.

The *NEC®* defines a busway as a grounded metal enclosure containing factory-mounted, bare or insulated conductors, which are usually copper or aluminum bars, rods, or tubes.

The relationship of the busway and hangers to the building construction should be checked prior to commencing the installation so that any problems due to space conflicts, inadequate or inappropriate supporting structure, openings through walls, etc. are worked out in advance so as not to incur lost time.

For example, the drawings and specifications may call for the busway to be suspended from brackets clamped or welded to steel columns. However, the spacing of the columns may be such that additional supplementary hanger rods suspended from the ceiling or roof structure may be necessary for the adequate support of the busway. To offer more assistance to workers on the office/warehouse project, the engineer may also provide an additional drawing that shows how the busway is to be mounted.

Other details that appear on the floor plan in *Figure 34* include the general arrangement of the underfloor duct system, junction boxes and feeder conduit for the underfloor duct system, and plan views of the service and telephone equipment, along with duplex receptacle outlets. A note on the drawing requires all receptacles in the toilets to be provided with ground fault circuit interrupter (GFCI) protection. The letters EWC next to the receptacle in the vestibule designate this receptacle for use with an electric water cooler.

8.0.0 ◆ LIGHTING FLOOR PLAN

A skeleton view of a lighting floor plan is shown in *Figure 35*. Again, the architect's/engineer's title blocks appear in the lower right corner of the drawing. A key plan, as discussed previously, appears above the engineer's title block. This plan is

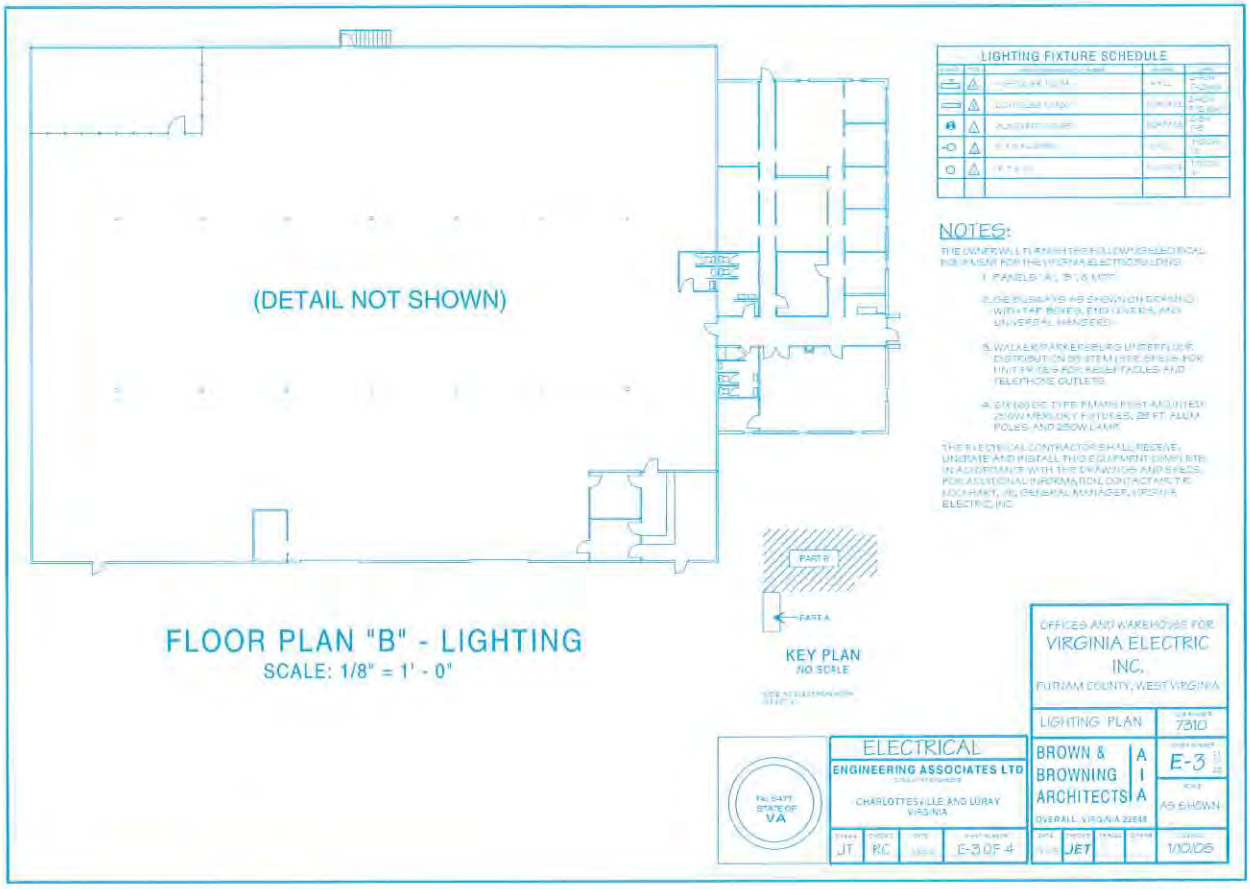

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Figure 35 ◆ Sample lighting plan.

drawn to the same scale as the power plan; that is, ⅛" = 1'–0". A lighting fixture schedule appears in the upper right corner of the drawing and some installation notes appear below the schedule.

The lighting outlet symbols found on the drawing for the office/warehouse building represent both incandescent and fluorescent types; a circle on most electrical drawings usually represents an incandescent fixture, and a rectangle represents a fluorescent one. All of these symbols are designed to indicate the physical shape of a particular fixture and are usually drawn to scale.

The type of mounting used for all lighting fixtures is usually indicated in a lighting fixture schedule, which in this case is shown on the drawings. On some projects, the schedule may be found only in the written specifications.

The type of lighting fixture is identified by a numeral placed inside a triangle near each lighting fixture. If one type of fixture is used exclusively in one room or area, the triangular indicator need only appear once with the word ALL lettered at the bottom of the triangle.

8.1.0 Drawing Schedules

A schedule is a systematic method of presenting notes or lists of equipment on a drawing in tabular form. When properly organized and thoroughly understood, schedules are powerful timesaving devices for both those preparing the drawings and workers on the job.

For example, the lighting fixture schedule shown in *Figure 36* lists the fixture and identifies each fixture type on the drawing by number. The manufacturer and catalog number of each type are given along with the number, size, and type of lamp for each.

At times, all of the same information found in schedules will be duplicated in the written specifications, but combing through page after page of written specifications can be time consuming, and workers do not always have access to the specifications while working, whereas they usually do have access to the working drawings. Therefore, the schedule is an excellent means of providing essential information in a clear and accurate

LIGHTING FIXTURE SCHEDULE

SYMBOL	TYPE	MANUFACTURER AND CATALOG NUMBER	MOUNTING	LAMPS
	A	LIGHTOLIER 10234	WALL	2-40W T-12WWX
	B	LIGHTOLIER 10420	SURFACE	2-40W T-12 WWX
	C	ALKCO RPC-210-6E	SURFACE	2-8W T-5
	D	P 7 S AL 2936	WALL	1-100W 'A'
	E	P 7 S 110	SURFACE	1-100W 'A'

110F36.EPS

Figure 36 ◆ Lighting fixture schedule.

manner, allowing the workers to carry out their assignments in the least amount of time.

Other schedules that are frequently found on electrical working drawings include:

- Connected load schedule
- Panelboard schedule
- Electric heat schedule
- Kitchen equipment schedule
- Schedule of receptacle types

There are also other schedules found on electrical drawings, depending upon the type of project. However, most will deal with lists of equipment such as motors, motor controllers, and similar items.

9.0.0 ◆ ELECTRICAL DETAILS AND DIAGRAMS

Electrical diagrams are drawings that are intended to show electrical components and their related connections. They show the electrical association of the different components, but are seldom, if ever, drawn to scale.

9.1.0 Power-Riser Diagrams

One-line (single-line) **block diagrams** are used extensively to show the arrangement of electric service equipment. The **power-riser diagram** in *Figure 37*, for example, was used on the office/warehouse building under discussion and is typical of such drawings. The drawing shows all pieces of electrical equipment as well as the connecting lines used to indicate service-entrance conductors and feeders. Notes are used to identify the equipment, indicate the size of conduit necessary for each feeder, and show the number, size, and type of conductors in each conduit.

A panelboard schedule (*Figure 38*) is included with the power-riser diagram to indicate the exact components contained in each panelboard. This panelboard schedule is for the main distribution panel. On the actual drawings, schedules would also be shown for the other two panels (PNL A and PNL B).

In general, panelboard schedules usually indicate the panel number, type of cabinet (either flush- or surface-mounted), panel mains (ampere and voltage rating), phase (single- or three-phase), and number of wires. A four-wire panel, for example, indicates that a solid neutral exists in the panel. Branches indicate the type of overcurrent protection; that is, they indicate the number of poles, trip rating, and frame size. The items fed by each overcurrent device are also indicated.

9.2.0 Schematic Diagrams

Complete schematic wiring diagrams are normally used only in complicated electrical systems, such as control circuits. Components are represented by symbols, and every wire is either shown by itself or included in an assembly of several wires, which appear as one line on the drawing. Each wire should be numbered when it enters an assembly and should keep the same number when it comes out again to be connected to some electrical component in the system. *Figure 39* shows a complete schematic wiring diagram for a three-phase, AC magnetic non-reversing motor starter.

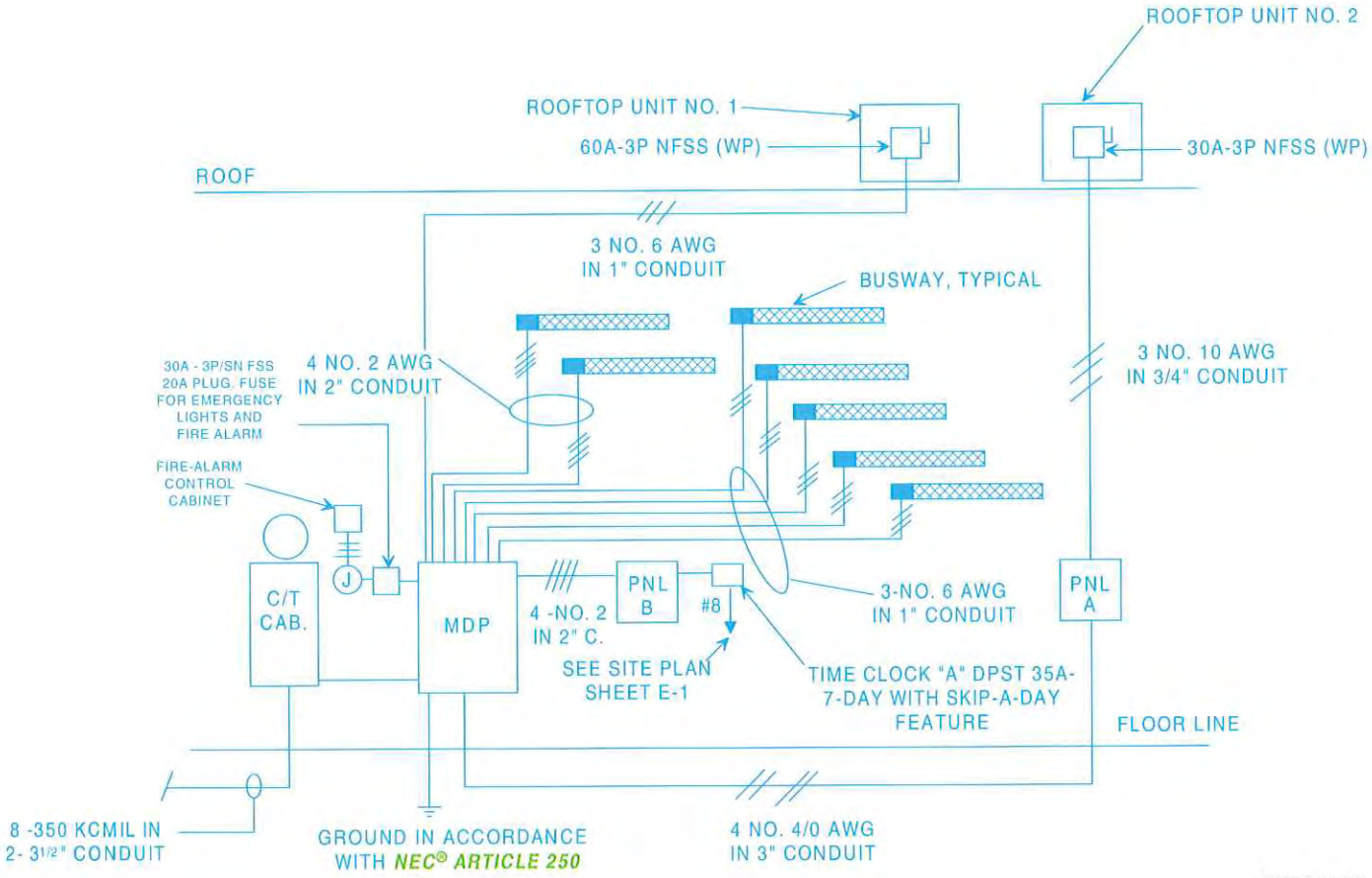

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Figure 37 ◆ Typical power-riser diagram.

PANELBOARD SCHEDULE

PANEL No.	CABINET TYPE	PANEL MAINS			BRANCHES					ITEMS FED OR REMARKS
		AMPS	VOLTS	PHASE	1P	2P	3P	PROT.	FRAME	
MDP	SURFACE	600A	120/208	3ϕ,4-W	-	-	1	225A	25,000	PANEL "A"
					-	-	1	100A	18,000	PANEL "B"
					-	-	1	100A		POWER BUSWAY
					-	-	1	60A		LIGHTING BUSWAY
					-	-	1	70A		ROOFTOP UNIT #1
					-	-	1	70A		SPARE
					-	-	1	600A	42,000	MAIN CIRCUIT BRKR

110F38.EPS

Figure 38 ◆ Typical panelboard schedule.

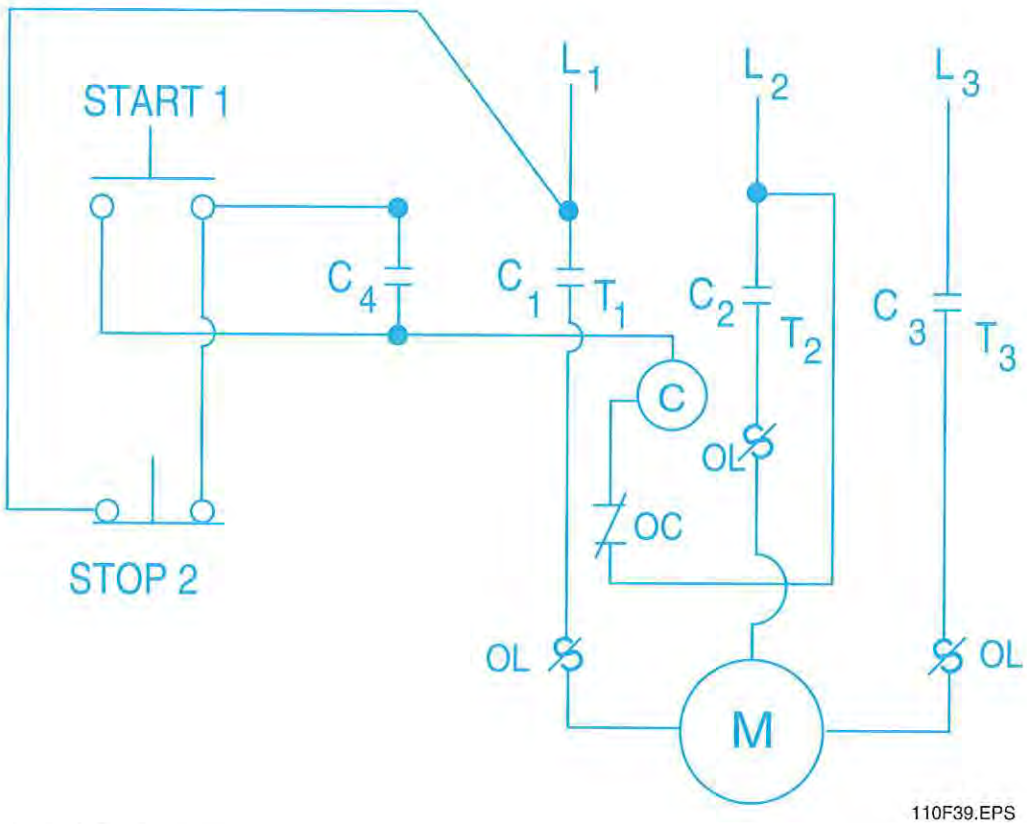

Figure 39 ◆ Wiring diagram.

Note that this diagram shows the various devices in symbol form and indicates the actual connections of all wires between the devices. The three-wire supply lines are indicated by L_1, L_2, and L_3; the motor terminals of motor M are indicated by T_1, T_2, and T_3. Lines L_1, L_2, and L_3 each have a thermal overload protection device (OL) connected in series with normally open line contacts C_1 and C_3, respectively, which are both controlled by the magnetic starter coil, C. The control station, consisting of start pushbutton 1 and stop pushbutton 2, is connected across lines L_1 and L_2. Auxiliary contacts (C_4) are connected in series with the stop pushbutton and in parallel with the start pushbutton. The control circuit also has normally closed overload contacts (OC) connected in series with the magnetic starter coil (C).

Any number of additional pushbutton stations may be added to this control circuit similarly to the way in which three-way and four-way switches are added to control a lighting circuit. When adding pushbutton stations, the stop buttons are always connected in series and the start buttons are always connected in parallel. *Figure 40* shows the same motor starter circuit in *Figure 39*, but this time it is controlled by two sets of start/stop buttons.

Schematic wiring diagrams have only been touched upon in this module; there are many other details that you will need to know to perform your work in a proficient manner. Later modules cover wiring diagrams in more detail.

9.3.0 Drawing Details

A detail drawing is a drawing of a separate item or portion of an electrical system, giving a complete and exact description of its use and all the details needed to show the electrician exactly what is required for its installation. For example, the power plan for the office/warehouse has a sectional cut through the busduct. This is a good example of where an extra, detailed drawing is desirable.

A set of electrical drawings will sometimes require large-scale drawings of certain areas that are not indicated with sufficient clarity on the small-scale drawings. For example, the site plan may show exterior pole-mounted lighting fixtures that are to be installed by the contractor.

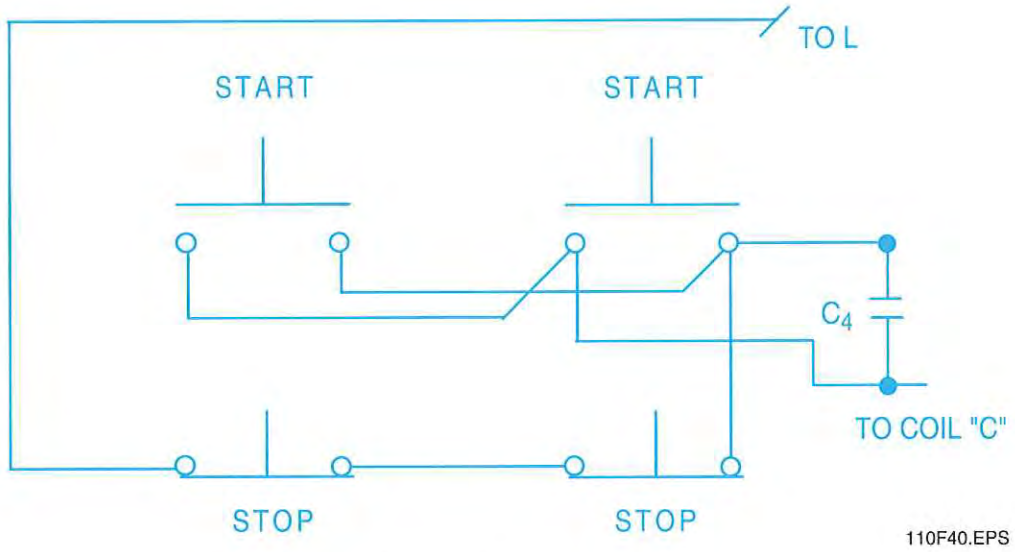

Figure 40 ◆ Circuit being controlled by two sets of start/stop buttons.

INSIDE TRACK

Understanding Contact Symbols

When a drawing shows normally open or normally closed contacts, the word normally refers to the condition of the contacts in their de-energized or shelf state.

INSIDE TRACK

Don't Just Check the Electrical Plan

Always review all of the drawings in a drawing set, not just the electrical plan. Several drawings in the set will have information of relevance to the electrician. For example, you should review:

- Site plans for utility lines and elevation information
- Mechanical drawings for routing, clearances, and HVAC equipment and controls
- Architectural drawings for the type of construction (block, wood, metal stud, etc.), fire ratings, and special details.
- Finish drawings (e.g., reflected ceiling plans) for locations of fixtures, fans, and other devices
- Room finish schedules for ceiling heights and floor and wall finishing details
- Plumbing drawings for pumps, water service, and sprinklers

10.0.0 ◆ WRITTEN SPECIFICATIONS

The **written specifications** for a building or project are the written descriptions of work and duties required of the owner, architect, and consulting engineer. Together with the working drawings, these specifications form the basis of the contract requirements for the construction of the building or project. Those who use the construction drawings and specifications must always be alert to discrepancies between the working drawings and the written specifications. Such discrepancies may occur when:

- Architects or engineers use standard or prototype specifications and attempt to apply them without any modification to specific working drawings.
- Previously prepared standard drawings are changed or amended by reference in the specifications only and the drawings themselves are not changed.
- Items are duplicated in both the drawings and specifications, but an item is subsequently amended in one and overlooked in the other contract document.

In such instances, the person in charge of the project has the responsibility to ascertain whether the drawings or the specifications take precedence. Such questions must be resolved, preferably before the work begins, to avoid added cost to the owner, architect/engineer, or contractor.

10.1.0 How Specifications Are Written

Writing accurate and complete specifications for building construction is a serious responsibility for those who design the buildings because the specifications, combined with the working drawings, govern practically all important decisions made during the construction span of every project. Compiling and writing these specifications is not a simple task, even for those who have had considerable experience in preparing such documents. A set of written specifications for a single project will usually contain thousands of products, parts, and components, and the methods of installing them, all of which must be covered in either the drawings and/or specifications. No one can memorize all of the necessary items required to accurately describe the various areas of construction. One must rely upon reference materials such as manufacturer's data, catalogs, checklists, and, most of all, a high-quality master specification.

10.2.0 Format of Specifications

For convenience in writing, speed in estimating, and ease of reference, the most suitable organization of the specifications is a series of sections dealing successively with the different trades. All the work of each trade should be incorporated into the section devoted to that trade. Those people who use the specifications must be able to find all information needed without spending too much time looking for it.

10.2.1 CSI Format

The Construction Specification Institute (CSI) has developed the Uniform Construction Index, which allows all specifications, product information, and cost data to be arranged into a uniform system. This format is followed on most large construction projects in North America. All construction is divided into 16 divisions, and each division has several sections and subsections. The following outline describes the various divisions normally included in a set of specifications for building construction.

Division 1: General Requirements – This division summarizes the work, alternatives, project meetings, submissions, quality control, temporary facilities and controls, products, and the project closeout. Every responsible person involved with the project should become familiar with this division.

Division 2: Site Work – This division outlines work involving such items as paving, sidewalks, outside utility lines (electrical, plumbing, gas, telephone, etc.), landscaping, grading, and other items pertaining to the outside of the building.

Division 3: Concrete – This division covers work involving footings, concrete formwork, expansion and contraction joints, cast-in-place concrete, specially finished concrete, precast concrete, concrete slabs, and similar items.

Division 4: Masonry – This division covers concrete, mortar, stone, masonry accessories, and similar items.

Division 5: Metals – Metal roofs, structural metal framing, metal joists, metal decking, ornamental metal, and expansion control normally fall under this division.

Division 6: Carpentry – Items falling under this division include rough carpentry, heavy timber construction, trestles, prefabricated structural wood, finish carpentry, wood treatment, architectural woodwork, and the like. Plastic fabrications may also be included in this division.

Division 7: Thermal and Moisture Protection – Waterproofing is the main topic discussed under this division. Other related items such as dampproofing, building insulation, shingles and roofing tiles, preformed roofing and siding, membrane roofing, sheet metal work, wall flashing, roof accessories, and sealants are also included.

Division 8: Doors and Windows – All types of doors and frames are included under this division: metal, plastic, wood, etc. Windows and framing are also included, along with hardware and other window and door accessories.

Division 9: Finishes – Included in this division are the types, quality, and workmanship of lath and plaster, gypsum wallboard, tile, terrazzo, acoustical treatment, ceiling suspension systems, wood flooring, floor treatment, special coatings, painting, and wallcovering.

Division 10: Specialties – Specialty items such as chalkboards and tackboards, compartments and cubicles, louvers and vents that are not connected with the mechanical system, wall and corner guards, access flooring, specialty modules, pest control, fireplaces, flagpoles, identifying devices, lockers, protective covers, postal specialties, partitions, scales, storage shelving, wardrobe specialties, and similar items are covered in this division of the specifications.

Division 11: Equipment – The equipment included in this division could include central vacuum cleaning systems, bank vaults, darkrooms, food service, vending machines, laundry equipment, and many similar items.

Division 12: Furnishing – Items such as cabinets and storage files, fabrics, furniture, rugs and mats, seating, and similar furnishings are included under this division.

Division 13: Special Construction – Such items as air-supported structures, incinerators, and other special items will fall under this division.

Division 14: Conveying Systems – This division covers conveying apparatus such as dumbwaiters, elevators, hoists and cranes, lifts, material-handling systems, turntables, moving stairs and walks, pneumatic tube systems, and power scaffolding.

Division 15: Mechanical – This division includes plumbing, heating, ventilating, and air conditioning and related work. Electric heat is sometimes covered under Division 16, especially if individual baseboard heating units are used in each room or area of the building.

Division 16: Electrical – This division covers all electrical requirements for the building including lighting, power, alarm and communications systems, special electrical systems, and related electrical equipment. This is the division that electricians will use the most.

A sample set of electrical specifications is shown in *Figure 41*.

NOTE

In June 2004, CSI issued a new specification format (see *Appendix B*) but it was not in common use at the time of this revision. Be aware that future specifications will follow this new format.

NOTE

The above specifications refer to color coding. Please refer to ***NEC Sections 200.6 and 210.5(C)*** for specific requirements.

Putting It All Together

Study the specifications in *Figure 41*. How would you need to combine information from the drawings and the written specifications to create a finished installation?

SECTION 16011 - ELECTRICAL OUTLINE OF WORK

PART 1 - GENERAL

The work included in Division 16 electrical includes, but is not necessarily limited to the following items and systems:

- Two new 480/277 volt, 3 phase underground services from Duke Power Company pad mounted transformer.
- Connection to power company transformers.
- Concrete pad for power company transformers.
- Installation of new power company meter box.
- All coordination, labor and materials required to connect new chiller service to existing Duke Power Company pad mounted transformer.
- Motor control center.
- Lighting and receptacle panelboard.
- Feeder circuits, including conduits, conductors, troughs and fittings.
- Branch circuits, including conduits, conductors, outlets, boxes, receptacles, switches and fittings.
- Lighting fixtures including lamps.
- Equipment tests.
- Wiring devices
- Grounding systems.
- Safety switches.
- Power connection to all equipment requiring power.
- Provide new lay-in ceiling in corridor of Building 'B'.
- Remove existing ceiling in part of Guidance Area of Building 'A' and provide new lay-in ceiling throughout the entire Guidance Area.

END OF SECTION

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Figure 41 ■ Sample electrical specifications (1 of 12).

SECTION 16110 - RACEWAYS

PART 1 - GENERAL:

GENERAL

All wiring shall be in rigid metal conduit, 'RMC', except as otherwise noted.

Electric metallic tubing 'EMT' may be used for concealed and exposed work, except as listed below.

(1) Exposed to the weather, or in damp location.
(2) In earth or stone.
(3) In concrete slabs on grade.
(4) Where obviously subject to mechanical injury.
(5) Where specified otherwise.

EMT may be used in lieu of 'RMC' in the following sizes, 1/2 inch through 2-inch for power circuits, 1/2 inch through 4 inch for communications circuits and control wiring as applicable, subject to the use limitations specified above. Intermediate metal conduit 'IMC' may be used for 'RMC'.

Rigid non-metallic conduit (RNC) may be used in in the following applications only. (All stub-ups shall be 'RMC' or 'IMC' elbows.)

Below slab, encased all around in not less than three inches of concrete and not less than 18 inches of ground cover for power service and power feeders, under building. Except, that conduit under building foundation, or conduit run through footings or foundations, shall be rigid steel conduit.

Underground, buried not less than 30" below grade for area lighting circuits.

In concrete slab on grade for branch circuits utilizing 3/4 inch or smaller conduit when encased by at least 2-inches of concrete all around.

Flexible metallic conduit shall not be used as a wiring method, other than when specifically noted to be used, without prior permission of the Architect/Engineer.

Type AC (BX) armored cable is not permitted in this project.

SLEEVES AND PENETRATIONS:

See Section 16115 for required sleeves and method of achieving raceway penetrations.

APPLICABLE SPECIFICATIONS AND STANDARDS:

The materials specified here shall meet the following specifications and standards in their current edition.

16110-1

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Figure 41 Sample electrical specifications (2 of 12).

(1) UL Standards

Electric metallic Tubing
Flexible Metal Conduits-UL-1
Rigid Metal Conduit UL-6
Intermediate Metal Conduit UL-1242

(2) NEMA Standards

Electric plastic conduit-TC-2

(3) ANSI Standards

Specifications for Rigid Steel Conduit, Zinc Coated,
ANSI C80.1.

PART 2 - PRODUCTS:

RACEWAYS:

General: Minimum size conduit shall be 1/2 inch.

Rigid Metal Conduit:

Rigid metal conduit shall be schedule 40, of the best quality steel.

The interior and exterior surfaces of the conduit shall be protected with a metallic zinc coating. Rigid steel conduit shall be galvanized by the Hot-Dip process in accordance with ASTM A 123.

Fittings for 'RMC' shall be threaded UL listed.

Electric Metallic Tubing:

Electrical metallic tubing shall be rigid metal conduit of the thin-wall type in straight lengths, elbows or bends for use as raceways for wire or cables in an electrical system.

Electrical metallic tubing shall utilize hexagonal steel type compression threadless fittings of galvanized steel throughout. All fittings shall be UL listed for concrete-tight and rain-tight construction. All EMT entrance fittings shall be provided with insulated throats.

Flexible Metallic Conduit:

Flexible metallic conduit shall conform to UL standard 'Flexible Steel Conduit'. All steel used in the fabrication of the conduit shall be zinc coated.

Liquid-tight flexible steel conduit shall be provided with a protective jacket of polyvinyl chloride extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals and corrosive fumes.

Flexible conduit connectors shall be UL listed T & B nylon-insulated "Tite-Bite", or equivalent from "Blackhawk.'

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Figure 41 ◆ Sample electrical specifications (3 of 12).

Rigid Non-Metallic Conduit:

Schedule 40 (EPC-40), heavy wall polyvinyl chloride plastic conduit and fittings, UL listed, suitable for 90 degree C. conductors.

Minimum size RNC conduit shall be 3/4-inch.

Intermediate Metal Conduit:

Intermediate metal conduit 'IMC' shall be zinc coated steel, UL listed and labeled.

Fittings shall be the same type as for 'RMC.'

Wireways and Troughs:

Wireways or troughs shall be of the size noted on the drawings or as required by the NEC of code gauge galvanized steel. Sizes 6 inch x 6 inch and smaller wireways and all troughs shall be of the hinged cover type except as otherwise noted on the drawings. Larger sized wireways shall be of the flangeless screw cover lay-in type. All shall be without knockout, and shall be provided with fittings, supports, and apurtenances as required.

PART 3 - EXECUTION:

INSTALLATION OF CONDUIT AND TUBING:

Metallic raceways shall not be stored exposed to the weather.

Conduits shall be concealed within the walls, ceilings, and floors, where possible, and shall be kept at least 6 inches from parallel runs of flues, steam pipes, or hot water pipes. Exposed runs of conduit or tubing, and conduit or tubing run above suspended ceilings, shall have supports spaced not more than 8 feet apart and shall be installed with runs parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings with right-angle turns consisting of cast metal fittings or symmetrical bends. All raceways shall be run in a neat and orderly fashion. Conduits or tubing run in diagonal or disorganized way shall be removed from the premises if so instructed by the A/E. Bends and offsets shall be avoided where possible, but where necessary shall be made with an approved hickey or conduit bending machine. Conduit or tubing which has been crushed or deformed in any way shall not be installed.

Conduit and tubing shall be supported on approved types of galvanized wall brackets, ceiling trapezes, strap hangers, or pipe straps, secured by means of toggle bolts on hollow masonry units, expansion bolts in concrete or brick, machine screws on metal surfaces, and wood screws on wood construction. Nails shall not be used as the means of fastening boxes on conduits. Wooden plugs inserted in masonry or concrete shall not be used as a base to secure conduit supports.

Conduits shall be installed in such manner as to insure against trouble from the collection of trapped condensation, and all runs of conduit shall be arranged so as to be devoid of traps where feasible. The contractor shall exercise the necessary precautions to prevent the lodgment of dirt, plaster, or trash in conduit, tubing, fittings, and boxes during the course of installation by the use of T & B pushpennies, appleton pennies, or equal closures. A run of conduit or tubing which has become clogged shall be entirely freed of these accumulations or shall be replaced.

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Figure 41 ◆ Sample electrical specifications (4 of 12).

Conduit shall be securely fastened to all sheet metal enclosures with double galvanized locknuts and insulated bushings, care being observed to see that full number of threads project through to permit the bushing to be drawn tight against the end of conduit, after which the locknuts shall be made up sufficiently tight to insure positive ground continuity between conduit and box.

Double locknuts shall be used on all feeder and motor circuit conduits and where insulated bushings are used. Insulated bushings of molded bakelite shall be used on all conduit entrances, one inch over in size, into junction boxes, panel boxes and motors starters having sheet metal enclosures. Galvanized steel insulated throat fittings shall be used for EMT work.

Rigid metal conduit 'RMC' installed underground 5 feet or more from the building shall have a minimum cover of three feet. 'RMC' directly installed underground shall be coated with two coats of bitumastic or asphalt paint. Conduit installed underground or in concrete on ground shall be made watertight by wrapping the joints with 'Teflon' tape.

EXPANSION FITTINGS:

Conduit crossing expansion joints in concrete slabs shall be provided with suitable expansion fittings, or other suitable means shall be provided to compensate for the building expansion and contraction.

PULL WIRE:

Nylon pull wire not less than 5/32 inches in diameter shall be installed in all empty conduit longer than 10 feet. Pull wire shall be secured at each end and tagged for identification of the use of the conduit.

END OF SECTION

110F41E.TIF

Figure 41 Sample electrical specifications (5 of 12).

SECTION 16120 - CONDUCTORS

PART 1 - GENERAL

SCOPE:

This Section applies to secondary conductors for systems rated 600 volts and below.

A complete system of conductors shall be installed in the raceway systems as specified here and shown on drawings.

APPLICABLE SPECIFICATIONS AND STANDARDS:

Compliance:

The materials specified here shall meet the following specifications and standards in their current edition.

(1) UL Standards:

Insulation tape
Wire Connectors and Soldering lugs

(2) NEMA Standards:

Thermoplastic - Insulated WC 5 (IPCEA S-61-402)

PART 2 PRODUCTS

CONDUCTORS:

All conductors shall be made of copper.

Conductors, unless otherwise noted, shall be heat and moisture resistant grade, thermoplastic insulated. Conductors No. 8 AWG and larger shall be stranded copper conductors, dual rated, Type THHN-THWN; Conductors No. 10 and smaller shall be solid copper, Type THHN-THWN (dual rated), unless otherwise required below. Branch circuit conductors for all other lighting fixtures shall have a temperature rating of not less than what is required by the UL listing of the fixture with a minimum rating of 90 degrees C.

Conductors for signal and control circuits above 50 volts AC may be THWN-THHN as permitted by NEC, No. 14 AWG. Conductors for signal and control circuits below 50 volts AC may be 300-volt, PVC insulated, No. 14 AWG.

Branch circuit conductors shall be not smaller than No. 12 AWG, except that conductors for branch circuits whose length from panel to center of load exceeds 75 feet for the 280/120 volt system, or 150 feet for 277/480 volt system, shall not be smaller than No. 10 AWG from the panel to the first outlet box in the circuit regardless of what is scheduled on panelboard schedule.

Conductors being connected to transformers and other equipment shall have a temperature rating as required by the transformer or equipment manufacturer.

PART 3 - EXECUTION:

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Figure 41 ◆ Sample electrical specifications (6 of 12).

SPLICES:

Solid Conductor Splices:

Solid conductors namely those sized #10, #12, and #14 AWG copper, and smaller, shall be spliced by twisting securely and by means of hot-dipped solder plus gum rubber tape, plus friction tape, or plastic tape approved as a substitute for friction tape. The contractor shall use Ideal "wire-nuts" for recessed lighting fixture lead splices to branch circuit conductors.

Stranded Conductor Splices:

Namely #8 AWG and larger, shall be spliced by approved mechanical connectors plus gum tape, plus friction or plastic tape. Solderless mechanical connectors, for splices and taps provided with U.L. approval insulating covers, may be used instead of mechanical connectors plus tape.

INSTALLATION OF CONDUCTORS:

Conductors shall be continuous from outlet to outlet, and no splices shall be made except within outlet or junction boxes, troughs and gutters. Junction boxes may be utilized where required. No 'condulet' type fitting shall be used on any service conduits. If other than long radius bends are required, pull boxes sized in accordance with the NEC shall be used.

Home runs may be combined in one conduit, provided all connections are in accordance with National Electrical Code requirements, and the maximum unbalanced current in the neutral does not extend the capacity of the conductor, and the conductors are not required to be derated to below circuit capacity.

Conductors in vertical runs shall be supported as required by NEC 300.19.

COLOR CODING:

Conductors, feeders, and branch circuits shall be color coded by phases as follows:

480/277-volt systems: Phase A-brown; Phase B-orange; Phase C-yellow; Neutral - white with identifiable color stripe, other than green; grounding wire - green.

208/120-volt systems: Phase A-black; Phase B-red; Phase C-blue; neutral-white; Grounding wire-green.

Insulating tape of proper color shall be used to identify the phase conductors No. 6 AWG and larger conductors.

All feeders, sub-feeds to panels, motors, etc., shall be completely phased out as to sequence and rotation. Phase sequence shall be A-B-C from front to rear, top to bottom, left to right when facing equipment.

16120-2

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Figure 41 ◆ Sample electrical specifications (7 of 12).

SECTION 16136 - WIRING DEVICES, BOXES & ENCLOSURES

PART 1 GENERAL

WORK INCLUDED:

Work under this Section includes but is not necessarily limited to the following.

Receptacles, toggle switches, dimmers and photoelectric switching devices.
Outlet Boxes
Cabinets and Enclosures

APPLICABLE SPECIFICATIONS AND STANDARDS:

Equipment specified in this Section shall meet the following specifications and standards.

(1) UL Standards

Attachment Plug and Receptacles
Electric Cabinet and Boxes
Outlet Boxes and Fittings
Snap Switches

(2) NEMA Standards

Boxes, OS1
Wiring Devices, General - Purpose, WD1
Wiring Devices, Specific - Purpose, WD5

PART 2 PRODUCTS

OUTLET BOXES, PULL BOXES, CABINETS AND ENCLOSURES:

Boxes:

Boxes shall have sufficient volume to accomodate the number of conductors entering the box in accordance with the requirements of NFPA 70, Article 314. Boxes that are exposed to the weather or that are in normally wet locations shall be of the cast-metal type having threaded hubs. Boxes shall be of suitable construction for installation in the environment of their location. Unless otherwise specifically stated all boxes shall be metallic boxes.

Zinc-coated or cadium-plated sheet steel boxes, or a class to satisfy the conditions of each outlet, shall be used in concealed work or in exposed work above eight feet from floor.

Fixture outlet boxes on ceiling shall be not less than 4 inch octagonal. Fixture outlet boxes in concrete ceiling shall be of the 4 inch octagonal concrete type, set flush with the finished surface. Fixture outlet boxes on plastered ceilings shall be fitted with open covers set to come flush with the finished surface.

Switch and receptacle outlet boxes in dry walls, plastered walls and pour-in concrete walls shall be not less than 4 inches square cut with appropriate extension to set flush with the finished surface. One-piece gang or gangable boxes not less than 2 inches deep shall be utilized where the

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Figure 41 ◆ Sample electrical specifications (8 of 12).

use of 4-inch square boxes is not feasible.

Unless otherwise noted on the drawings, outlet, junction or pull boxes not larger than 5 inches square and within eight feet from floor level in exposed work shall be of cast steel or alloy with threaded hubs and appropriate covers.

Outlet boxes in unplastered masonry and gypsum drywall walls shall be tile type.

Outlet boxes for use with conduit and tubing systems shall be not less than 1-1/2 inches deep.

A device plate or cover shall be provided for each outlet to suit the outlet.

Pull Boxes:

Pull boxes shall be constructed of code-gauge galvanized sheet metal. Boxes shall be of not less than the minimum size required by the National Electrical Code and shall be furnished with screw fastened covers. When several feeders pass through a common pull box they shall be tagged to indicate clearly their electrical characteristics, circuit numbers and panel designations.

Pull boxes shall be furnished and installed where necessary in the raceway system to facilitate conductor installation. Except as otherwise noted for telephone raceways, conduit runs longer than 150 feet, or with more than 360 degrees compound angle bends, shall have a pull box insalled at a convenient intermediate location. Normally, when feeder routing is shown on drawings, pull boxes are not acceptable. It is the responsibility of the electrical contractor to provide pull boxes as necessary to meet the stated requirements.

Cabinets:

Cabinet boxes shall be constructed of zinc-coated sheet steel and shall conform with the requirements of Underwriters' Laboratories "Standards for Cabinets and Cutout Boxes". Unless otherwise noted, surface mounted cabinet trims shall have a corrosion inhibiting primer and a lacquer finish. Flush mounted cabinets shall be factory primed ready for finish painting by the General Contractor. Cabinets shall be of suitable construction for installation in the environment of their locations.

Systems cabinet, if shown, shall be provided with interior dimensions not less than those indicated on the drawings. Trims shall provide maximum size openings to the box interiors. Cabinets shall be provided with 5/8 inch fire retardant plywood back-boards having an insulating varnish finish.

Device Plates:

A device plate shall be provided for each outlet (including telephone and computer system outlets) to suit the device installed. Screws shall be of metal with countersunk heads, with finish to match the finish of the plate.

Device plates shall be of the one-piece type, of suitable shape for the devices to be covered. The use of sectional device plates will not be permitted. Plates shall be as follows:

. Plates on surface boxes in unfinished areas shall be of galvanized steel with beveled edges.
. All plates on walls with flush switches or receptacles shall be 302 stainless steel, 0.32" nominal thickness.

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Figure 41 ◆ Sample electrical specifications (9 of 12).

Plates on surface boxes in finished areas shall be as for flush outlets.

Switches and Receptacles:

Switches and receptacles shall be as shown on the drawings and in the symbol schedule, and shall meet the latest federal specifications W-S 896 or W-C 596 as verified by UL. Devices shall be the product of one of the following manufacturers complying with referenced NEMA Standards - Arrow-Hart Electric Company, Bryant Electric Company, General Electric Company, Harvey Hubbell, Inc., Slater Electric, Inc., Pass & Seymour, Inc., Sierra Electric, or Leviton. 20-ampere and 15 ampere receptacles shall be heavy duty, hospital grade with nylon body. Switches shall be 20-ampere, specification grade.

Color of switches and receptacles shall be gray.

Receptacles with ground fault interrupting (GFI) Protection.

GFI receptacles shall be NEMA 5-15R configuration, UL listed with"noise-suppressed" circuitry to eliminate false trippings. GFI receptacles shall provide protection to all other receptacles installed "downstream" on the same branch circuit. Provide separate neutral conductor for GFI receptacle circuit.

Wiring Device Schedule

For clarity and to identify the class and type of devices required, refer to the following schedule of devices by Pass & Seymour (P&S). Device color shall be as previous specified.

Switches:	Catalogue Number
Single Pole	20 AC 1
Double Pole	20 AC 2
Three Way	20 AC 3

Receptacles:

NEMA Configuration	P&S Catalogue Number
5-15R	5262
5-20R	5362
5-30R	3802
5-50R	3803
6-20R	5862
6-30R	3801
6-50R	3804
10-30R	3860
10-50R	3890
14-30R	3864
15-20R	3821
15-30R	5740
18-20R	3822
L5-20R	L520-R
L5-30R	L530-R
L6-20R	L620-R

Figure 41 Sample electrical specifications (10 of 12).

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L6-30R	L630-R
L15-20R	L1520-R
L15-30R	L1530-R

MULTI-OUTLET ASSEMBLIES AND SURFACE METAL RACEWAYS:

Surface metal raceways shall be provided as indicated on the drawings, complete with all appropriate fittings as required, to provide a safe and complete installation. All components shall be UL listed. Raceways shall be supported on approximately 18" centers with #8 flat lead fasteners. The entire installation shall meet the requirements of Articles 380 and 386 of the NEC All field cuts of the raceway shall be made square and shall have no rough edges.

PART 3 - EXECUTION:

INSTALLATION OF OUTLETS:

Location of outlets shown on drawings, other than those dimensioned, are only approximate, the Owner shall have the right to make slight changes in the position of outlets if the Contractor is notified before roughing-in is done. The Contractor shall study the general building plans in relation to the spaces surrounding each outlet in order that his work may fit the other work required by these specifications. When necessary, the Contractor shall relocate outlets of junction boxes so that, when fixtures or other fittings are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment. Do not install outlets back to back. Outlets flush mounted in fire or sound wall shall be mounted not closer than 24" apart horizontally when on same face of wall and 12" apart horizontally when mounted on opposite sides of wall. For those outlets in fire or sound rated walls that must be closer than 24" apart, provide Nelson Firestop system 'putty pads' all around outlets to maintain fire rating.

Minimum length of conduit connecting to adjacent flush in sound rated walls outlets sound rated walls shall be 18".

Boxes shall be installed in a rigid and satisfactory manner, either by wood screws on wood, expansion shields on masonry, or machine screws on steel work.

Recessed boxes in dry wall type construction shall be supported from both adjacent studs, or by the use of metal stud brackets as manufactured by E-Z Mount Bracket Co., or equivalent.

PLATES:

Plates for receptacles and switches shall be installed with all four edges in continuous contact with the finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch.

SURFACE METAL RACEWAYS

Surface metal raceways shall be installed where noted on the drawings. Support on approximately 30" centers with #8 flat head screws. In addition, couplings, fittings and boxes shall be supported independent of the raceway.

INSTALLATION OF PULL BOXES

Pull boxes shall be installed overhead or on walls at locations free of interference with equipment,

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Figure 41 ◆ Sample electrical specifications (11 of 12).

ducts, piping and activities being carried out at the premises. Pull boxes with covers larger than 4 square feet shall be provided with two handles.

END OF SECTION

16136-5

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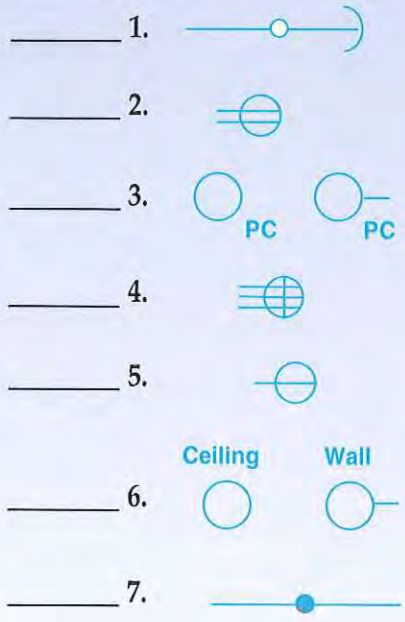
Figure 41 ◆ Sample electrical specifications (12 of 12).

Review Questions

Questions 1 through 7 refer to the seven electrical symbols shown below. In the spaces provided, place the letter corresponding to the correct answer found in the list.



a. Single receptacle outlet

b. Duplex receptacle outlet

c. Triplex receptacle outlet

d. Incandescent fixture (surface or pendant)

e. Incandescent fixture with pull chain (surface or pendant)

f. Head guy

g. Sidewalk guy

110RQ01.EPS

Questions 8 through 10 refer to the sample electrical specifications shown in Figure 41.

8. Which of the following tasks is *not* covered under Division 16?
   a. Lighting fixtures
   b. New lay-in ceiling in the corridor of Building B
   c. Concrete pad for power company transformers
   d. Telephone cable

9. What is the minimum size RNC allowed by the specifications?
   a. ½ inch
   b. ¾ inch
   c. 1 inch
   d. 5/16 inch

10. The color code specified for a 208/120V system is _____.
   a. phase A—black; phase B—red; phase C—blue; neutral—white; grounding wire—green
   b. the same as that for a 480/277V system
   c. phase A—brown; phase B—orange; phase C—yellow; neutral—white; grounding wire—green
   d. any color but green or green with a yellow stripe

Summary

In this module, you learned the symbols and conventions used on architectural and engineering drawings. As an electrician, you need to know how to recognize the basic symbols used on electrical drawings and other drawings used in the building construction industry. You should also know where to find the meaning of symbols that you do not immediately recognize. Schedules, diagrams, and specifications often provide detailed information that is not included on the working drawings.

Reading architectural and engineering drawings takes practice and study. Now that you have the basic skills, take the time to master them.

Notes

Trade Terms Quiz

1. A(n) _____ drawing typically includes the following information: a site plan, floor plans, elevations of all exterior faces of the building, and large-scale detail drawings.
2. A(n) _____ is an exact copy or reproduction of an original drawing.
3. A simple, single-line diagram used to show electrical equipment and related connections is a(n) _____ diagram.
4. A(n) _____ shows the path of an electrical circuit or system of circuits, along with the circuit components.
5. To convey a substantial amount of detailed information to installation electricians, an engineer will use a(n) _____ drawing.
6. Shown in a separate view, a(n) _____ view is an enlarged, detailed view taken from an area of a drawing.
7. A cutaway drawing that shows the inside of an object or building is a(n) _____ drawing.
8. The sizes or measurements that are printed on a drawing are called _____.
9. The relationship between an object's size in a drawing and the object's actual size is the _____.
10. The height of the front, rear, or sides of a building is shown in a(n) _____ drawing.
11. A building's location on the site is shown in a(n) _____ plan.
12. A drawing that has a top-down view of a building is a(n) _____ plan.
13. A drawing that has a top-down view of a single object is a(n) _____ view.
14. A(n) _____ diagram is a single-line block diagram used to indicate the electric service equipment, service conductors and feeders, and subpanels.
15. Owners, architects, and engineers use written _____ to specify material and workmanship requirements.
16. A(n) _____ is a systematic way of presenting equipment lists on a drawing in tabular form.
17. Complicated circuits, such as control circuits, are shown in a(n) _____ diagram.
18. Usually developed by manufacturers, fabricators, or contractors, a(n) _____ drawing shows specific dimensions and other information about a piece of equipment and its installation methods.

Trade Terms

Architectural drawings
Block diagram
Blueprint
Detail drawing
Dimensions
Electrical drawing
Elevation drawing
Floor plan
One-line diagram
Plan view
Power-riser diagram
Scale
Schedule
Schematic diagram
Sectional view
Shop drawing
Site plan
Written specifications

Profile in Success

Wayne Stratton

Associated Builders and Contractors

How did you choose a career in the electrical field?
Three events in my childhood created the desire to learn the electrical trade. At age six, the farmhouse we lived in was totally destroyed by fire. The cause was electrical. As a young teen, a local electrician had incorrectly wired a heating element and electrocuted several pigs. In 1973, my father hired this electrician to install a motor starter on a grain conveyor. He could not figure it out. I wanted to learn how to do this type of work and do it safely.

Tell us about your apprenticeship experience.
My education is from a technical school. I have attended several manufacturers' training sessions. I had to gain the hands-on experience after learning the trade. My observation of the apprenticeship programs is this: you get hands-on experience while you learn.

What positions have you held in the industry?
I worked as a plant industrial electrician responsible for motor control, DC motors, co-generation, and medium voltage distribution. Later, I began working for an electrical contractor who wanted to expand his business into the industrial field. I worked as a PLC technician designing and installing control systems. In 1987, I began teaching apprenticeship classes.

What would you say is the primary factor in achieving success?
The desire to learn all that I can learn, the ability to think outside the box, and the opportunities to gain a variety of experiences. All this helps me continue to learn and share with trainees.

What does your current job involve?
I teach electrical apprenticeship levels one through four at two different locations in Iowa. My other responsibilities involve task training for electrical licensing, fire alarm, and code updates.

Do you have any advice for someone just entering the trade?
Continue to learn. Completing an apprenticeship program or acquiring an electrician's license is not the end of learning. With code changes every 3 years, there is always more to learn. If you don't understand something, ask! Observe and learn from experienced individuals.

Trade Terms Introduced in This Module

Architectural drawings: Working drawings consisting of plans, elevations, details, and other information necessary for the construction of a building. Architectural drawings usually include:

- A site (plot) plan indicating the location of the building on the property
- Floor plans showing the walls and partitions for each floor or level
- Elevations of all exterior faces of the building
- Several vertical cross sections to indicate clearly the various floor levels and details of the footings, foundations, walls, floors, ceilings, and roof construction
- Large-scale detail drawings showing such construction details as may be required

Block diagram: A single-line diagram used to show electrical equipment and related connections. See *power-riser diagram.*

Blueprint: An exact copy or reproduction of an original drawing.

Detail drawing: An enlarged, detailed view taken from an area of a drawing and shown in a separate view.

Dimensions: Sizes or measurements printed on a drawing.

Electrical drawing: A means of conveying a large amount of exact, detailed information in an abbreviated language. Consists of lines, symbols, dimensions, and notations to accurately convey an engineer's designs to electricians who install the electrical system on a job.

Elevation drawing: An architectural drawing showing height, but not depth; usually the front, rear, and sides of a building or object.

Floor plan: A drawing of a building as if a horizontal cut were made through a building at about window level, and the top portion removed. The floor plan is what would appear if the remaining structure were viewed from above.

One-line diagram: A drawing that shows, by means of lines and symbols, the path of an electrical circuit or system of circuits along with the various circuit components. Also called a single-line diagram.

Plan view: A drawing made as though the viewer were looking straight down (from above) on an object.

Power-riser diagram: A single-line block diagram used to indicate the electric service equipment, service conductors and feeders, and subpanels. Notes are used on power-riser diagrams to identify the equipment; indicate the size of conduit; show the number, size, and type of conductors; and list related materials. A panelboard schedule is usually included with power-riser diagrams to indicate the exact components (panel type and size), along with fuses, circuit breakers, etc., contained in each panelboard.

Scale: On a drawing, the size relationship between an object's actual size and the size it is drawn. Scale also refers to the measuring tool used to determine this relationship.

Schedule: A systematic method of presenting equipment lists on a drawing in tabular form.

Schematic diagram: A detailed diagram showing complicated circuits, such as control circuits.

Sectional view: A cutaway drawing that shows the inside of an object or building.

Shop drawing: A drawing that is usually developed by manufacturers, fabricators, or contractors to show specific dimensions and other pertinent information concerning a particular piece of equipment and its installation methods.

Site plan: A drawing showing the location of a building or buildings on the building site. Such drawings frequently show topographical lines, electrical and communication lines, water and sewer lines, sidewalks, driveways, and similar information.

Written specifications: A written description of what is required by the owner, architect, and engineer in the way of materials and workmanship. Together with working drawings, the specifications form the basis of the contract requirements for construction.

Appendix A

Metric Conversion Chart

Inches		mm	Inches		mm	Inches		mm	Inches		mm
fractions	decimals		fractions	decimals		fractions	decimals		fractions	decimals	
–	.0004	.01	25/32	.781	19.844	–	2.165	55.	3-11/16	3.6875	93.663
–	.004	.10	–	.7874	20.	2-3/16	2.1875	55.563	–	3.7008	94.
–	.01	.25	51/64	.797	20.241	–	2.2047	56.	3-23/32	3.719	94.456
1/64	.0156	.397	13/16	.8125	20.638	2-7/32	2.219	56.356	–	3.7401	95.
–	.0197	.50	–	.8268	21.	–	2.244	57.	3-3/4	3.750	95.250
–	.0295	.75	53/64	.828	21.034	2-1/4	2.250	57.150	–	3.7795	96.
1/32	.03125	.794	27/32	.844	21.431	2-9/32	2.281	57.944	3-25/32	3.781	96.044
–	.0394	1.	55/64	.859	21.828	–	2.2835	58.	3-13/16	3.8125	96.838
3/64	.0469	1.191	–	.8661	22.	2-5/16	2.312	58.738	–	3.8189	97.
–	.059	1.5	7/8	.875	22.225	–	2.3228	59.	3-27/32	3.844	97.631
1/16	.062	1.588	57/64	.8906	22.622	2-11/32	2.344	59.531	–	3.8583	98.
5/64	.0781	1.984	–	.9055	23.	–	2.3622	60.	3-7/8	3.875	98.425
–	.0787	2.	29/32	.9062	23.019	2-3/8	2.375	60.325	–	3.8976	99.
3/32	.094	2.381	59/64	.922	23.416	–	2.4016	61.	3-29/32	3.9062	99.219
–	.0984	2.5	15/16	.9375	23.813	2-13/32	2.406	61.119	–	3.9370	100.
7/64	.109	2.778	–	.9449	24.	2-7/16	2.438	61.913	3-15/16	3.9375	100.013
–	.1181	3.	61/64	.953	24.209	–	2.4409	62.	3-31/32	3.969	100.806
1/8	.125	3.175	31/32	.969	24.606	2-15/32	2.469	62.706	–	3.9764	101.
–	.1378	3.5	–	.9843	25.	–	2.4803	63.	4	4.000	101.600
9/64	.141	3.572	63/64	.9844	25.003	2-1/2	2.500	63.500	4-1/16	4.062	103.188
5/32	.156	3.969	1	1.000	25.400	–	2.5197	64.	4-1/8	4.125	104.775
–	.1575	4.	–	1.0236	26.	2-17/32	2.531	64.294	–	4.1338	105.
11/64	.172	4.366	1-1/32	1.0312	26.194	–	2.559	65.	4-3/16	4.1875	106.363
–	.177	4.5	1-1/16	1.062	26.988	2-9/16	2.562	65.088	4-1/4	4.250	107.950
3/16	.1875	4.763	–	1.063	27.	2-19/32	2.594	65.881	4-5/16	4.312	109.538
–	.1969	5.	1-3/32	1.094	27.781	–	2.5984	66.	–	4.3307	110.
13/64	.203	5.159	–	1.1024	28.	2-5/8	2.625	66.675	4-3/8	4.375	111.125
–	.2165	5.5	1-1/8	1.125	28.575	–	2.638	67.	4-7/16	4.438	112.713
7/32	.219	5.556	–	1.1417	29.	2-21/32	2.656	67.469	4-1/2	4.500	114.300
15/64	.234	5.953	1-5/32	1.156	29.369	–	2.6772	68.	–	4.5275	115.
–	.2362	6.	–	1.1811	30.	2-11/16	2.6875	68.263	4-9/16	4.562	115.888
1/4	.250	6.350	1-3/16	1.1875	30.163	–	2.7165	69.	4-5/8	4.625	117.475
–	.2559	6.5	1-7/32	1.219	30.956	2-23/32	2.719	69.056	4-11/16	4.6875	119.063
17/64	.2656	6.747	–	1.2205	31.	2-3/4	2.750	69.850	–	4.7244	120.
–	.2756	7.	1-1/4	1.250	31.750	–	2.7559	70.	4-3/4	4.750	120.650
9/32	.281	7.144	–	1.2598	32.	2-25/32	2.781	70.6439	4-13/16	4.8125	122.238
–	.2953	7.5	1-9/32	1.281	32.544	–	2.7953	71.	4-7/8	4.875	123.825
19/64	.297	7.541	–	1.2992	33.	2-13/16	2.8125	71.4376	–	4.9212	125.
5/16	.312	7.938	1-5/16	1.312	33.338	–	2.8346	72.	4-15/16	4.9375	125.413
–	.315	8.	–	1.3386	34.	2-27/32	2.844	72.2314	5	5.000	127.000
21/64	.328	8.334	1-11/32	1.344	34.131	–	2.8740	73.	–	5.1181	130.
–	.335	8.5	1-3/8	1.375	34.925	2-7/8	2.875	73.025	5-1/4	5.250	133.350
11/32	.344	8.731	–	1.3779	35.	2-29/32	2.9062	73.819	5-1/2	5.500	139.700
–	.3543	9.	1-13/32	1.406	35.719	–	2.9134	74.	–	5.5118	140.
23/64	.359	9.128	–	1.4173	36.	2-15/16	2.9375	74.613	5-3/4	5.750	146.050
–	.374	9.5	1-7/16	1.438	36.513	–	2.9527	75.	–	5.9055	150.
3/8	.375	9.525	–	1.4567	37.	2-31/32	2.969	75.406	6	6.000	152.400
25/64	.391	9.922	1-15/32	1.469	37.306	–	2.9921	76.	6-1/4	6.250	158.750
–	.3937	10.	–	1.4961	38.	3	3.000	76.200	–	6.2992	160.
13/32	.406	10.319	1-1/2	1.500	38.100	3-1/32	3.0312	76.994	6-1/2	6.500	165.100
–	.413	10.5	1-17/32	1.531	38.894	–	3.0315	77.	–	6.6929	170.
27/64	.422	10.716	–	1.5354	39.	3-1/16	3.062	77.788	6-3/4	6.750	171.450
–	.4331	11.	1-9/16	1.562	39.688	–	3.0709	78.	7	7.000	177.800
7/16	.438	11.113	–	1.5748	40.	3-3/32	3.094	78.581	–	7.0866	180.
29/64	.453	11.509	1-19/32	1.594	40.481	–	3.1102	79.	–	7.4803	190.
15/32	.469	11.906	–	1.6142	41.	3-1/8	3.125	79.375	7-1/2	7.500	190.500
–	.4724	12.	1-5/8	1.625	41.275	–	3.1496	80.	–	7.8740	200.
31/64	.484	12.303	–	1.6535	42.	3-5/32	3.156	80.169	8	8.000	203.200
–	.492	12.5	1-21/32	1.6562	42.069	3-3/16	3.1875	80.963	–	8.2677	210.
1/2	.500	12.700	1-11/16	1.6875	42.863	–	3.1890	81.	8-1/2	8.500	215.900
–	.5118	13.	–	1.6929	43.	3-7/32	3.219	81.756	–	8.6614	220.
33/64	.5156	13.097	1-23/32	1.719	43.656	–	3.2283	82.	9	9.000	228.600
17/32	.531	13.494	–	1.7323	44.	3-1/4	3.250	82.550	–	9.0551	230.
35/64	.547	13.891	1-3/4	1.750	44.450	–	3.2677	83.	–	9.4488	240.
–	.5512	14.	–	1.7717	45.	3-9/32	3.281	83.344	9-1/2	9.500	241.300
9/16	.563	14.288	1-25/32	1.781	45.244	–	3.3071	84.	–	9.8425	250.
–	.571	14.5	–	1.8110	46.	3-5/16	3.312	84.1377	10	10.000	254.001
37/64	.578	14.684	1-13/16	1.8125	46.038	3-11/32	3.344	84.9314	–	10.2362	260.
–	.5906	15.	1-27/32	1.844	46.831	–	3.3464	85.	–	10.6299	270.
19/32	.594	15.081	–	1.8504	47.	3-3/8	3.375	85.725	11	11.000	279.401
39/64	.609	15.478	1-7/8	1.875	47.625	–	3.3858	86.	–	11.0236	280.
5/8	.625	15.875	–	1.8898	48.	3-13/32	3.406	86.519	–	11.4173	290.
–	.6299	16.	1-29/32	1.9062	48.419	–	3.4252	87.	–	11.8110	300.
41/64	.6406	16.272	–	1.9291	49.	3-7/16	3.438	87.313	12	12.000	304.801
–	.6496	16.5	1-15/16	1.9375	49.213	–	3.4646	88.	13	13.000	330.201
21/32	.656	16.669	–	1.9685	50.	3-15/32	3.469	88.106	–	13.7795	350.
–	.6693	17.	1-31/32	1.969	50.006	3-1/2	3.500	88.900	14	14.000	355.601
43/64	.672	17.066	2	2.000	50.800	–	3.5039	89.	15	15.000	381.001
11/16	.6875	17.463	–	2.0079	51.	3-17/32	3.531	89.694	–	15.7480	400.
45/64	.703	17.859	2-1/32	2.03125	51.594	–	3.5433	90.	16	16.000	406.401
–	.7087	18.	–	2.0472	52.	3-9/16	3.562	90.4877	17	17.000	431.801
23/32	.719	18.256	2-1/16	2.062	52.388	–	3.5827	91.	–	17.7165	450.
–	.7283	18.5	–	2.0866	53.	3-19/32	3.594	91.281	18	18.000	457.201
47/64	.734	18.653	2-3/32	2.094	53.181	–	3.622	92.	19	19.000	482.601
–	.7480	19.	2-1/8	2.125	53.975	3-5/8	3.625	92.075	–	19.6850	500.
3/4	.750	19.050	–	2.126	54.	3-21/32	3.656	92.869	20	20.000	508.001
49/64	.7656	19.447	2-5/32	2.156	54.769	–	3.6614	93.			

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Appendix B

Breakdown of CSI Divisions

Division Numbers and Titles

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP

Division 00 Procurement and Contracting Requirements

SPECIFICATIONS GROUP

GENERAL REQUIREMENTS SUBGROUP

Division 01 General Requirements

FACILITY CONSTRUCTION SUBGROUP

Division 02 Existing Conditions
Division 03 Concrete
Division 04 Masonry
Division 05 Metals
Division 06 Wood, Plastics, and Composites
Division 07 Thermal and Moisture Protection
Division 08 Openings
Division 09 Finishes
Division 10 Specialties
Division 11 Equipment
Division 12 Furnishings
Division 13 Special Construction
Division 14 Conveying Equipment
Division 15 *Reserved*
Division 16 *Reserved*
Division 17 *Reserved*
Division 18 *Reserved*
Division 19 *Reserved*

FACILITY SERVICES SUBGROUP

Division 20 *Reserved*
Division 21 Fire Suppression
Division 22 Plumbing
Division 23 Heating, Ventilating, and Air Conditioning
Division 24 *Reserved*
Division 25 Integrated Automation
Division 26 Electrical
Division 27 Communications
Division 28 Electronic Safety and Security
Division 29 *Reserved*

SITE AND INFRASTRUCTURE SUBGROUP

Division 30 *Reserved*
Division 31 Earthwork
Division 32 Exterior Improvements
Division 33 Utilities
Division 34 Transportation
Division 35 Waterway and Marine Construction
Division 36 *Reserved*
Division 37 *Reserved*
Division 38 *Reserved*
Division 39 *Reserved*

PROCESS EQUIPMENT SUBGROUP

Division 40 Process Integration
Division 41 Material Processing and Handling Equipment
Division 42 Process Heating, Cooling, and Drying Equipment
Division 43 Process Gas and Liquid Handling, Purification, and Storage Equipment
Division 44 Pollution Control Equipment
Division 45 Industry-Specific Manufacturing Equipment
Division 46 *Reserved*
Division 47 *Reserved*
Division 48 Electrical Power Generation
Division 49 *Reserved*

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Additional Resources

This module is intended to present thorough resources for task training. The following reference works are suggested for further study. These are optional materials for continued education rather than for task training.

American Electrician's Handbook. Terrell Croft and Wilford I. Summers. New York: McGraw-Hill.

National Electrical Code® Handbook, Latest Edition. Quincy, MA: National Fire Protection Association.

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