1939

Vocational training of high school students in electricity

Harry Fredrick Kirkpatrick

Follow this and additional works at: http://scholarsmine.mst.edu/professional_theses

Part of the Electrical and Computer Engineering Commons

Department:

Recommended Citation

Kirkpatrick, Harry Fredrick, "Vocational training of high school students in electricity" (1939). Professional Degree Theses. Paper 125.

This Thesis - Open Access is brought to you for free and open access by the Student Research & Creative Works at Scholars' Mine. It has been accepted for inclusion in Professional Degree Theses by an authorized administrator of Scholars' Mine. For more information, please contact weaverjr@mst.edu.
VOCATIONAL TRAINING OF HIGH SCHOOL STUDENTS IN ELECTRICITY

BY

HARRY FREDRICK KIRKPATRICK JR

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY

OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

ELECTRICAL ENGINEER

Rolla, Mo.

1939

Approved by

P. H. Frame

Professor of Electrical Engineering.
TABLE OF CONTENTS

PART I
OBJECT OF THE TRAINING PROGRAM .................. 3-4

PART II
CLASS OF STUDENTS TRAINED ................. 5

PART III
METHODS USED IN THE TRAINING PROGRAM .... 6-15

PART IV
CONCLUSIONS ........................................ 16-17
ILLUSTRATIONS

1. Photograph No. 1-Section of Booths............ 20
2. Photograph No. 2-Section of Booths............ 21
3. Photograph No. 3-Panelling..................... 22
4. Photograph No. 4-Work Bench................... 23
5. Photograph No. 5-Work Bench................... 24
6. Photograph No. 6-Framework Booth............. 25
7. Photograph No. 7-Metal Mold Installation..... 26
8. Photograph No. 8-Conduit Installation......... 27
9. Photograph No. 9-Armored Cable Installation.. 28
10. Photograph No. 10-Knob and Tube Installation.. 29
11. Photograph No. 11-Wiremold Installation...... 30
12. Photograph No. 12-Xtensionduct Installation.... 31
PART I

At various intervals during the past five years I have had to justify my training program, not only to others but also to myself. After careful study and thought I am convinced that the objectives or purposes of the training program can be classified under four major headings:

1. Intelligent Self Direction.

   The teacher should strive to make the pupil self-reliant; to make him have confidence in his ability to do a job; to give him confidence in his ability to deal with people; and to establish confidence in his ability to take care of himself in an unusual or unfamiliar situation.

2. Social Adjustment.

   The teacher should strive to develop in the pupil a thoughtful attitude in the matter of making things easy and pleasant for others and the ability to work well with others.

3. Work Habits.

   The teacher should strive to develop in the pupil definite habits of work such as an orderly method of procedure in performing any task; the habit of self discipline which requires one to do a thing when it
should be done, whether it is a pleasant task or not; and the habit of careful, thoughtful work without loitering or wasting time.

4. Knowledge and Skills.

The development of knowledge and skills in electricity is the basic objective of the training program. In carrying out this objective there are four points upon which the teacher should place the most emphasis:

1. Give the student a general introduction into Electrical Theory in order that he may better understand circuits and their uses.

2. Build up the student's vocabulary with terms and definitions used in house-wiring.

3. Acquaint the student with the materials and tools used in house-wiring, and help him to develop basic skills in their use.

4. Teach the student how to make and read wiring diagrams.
PART II

In the past five years 86 boys have enrolled in the Vocational Class; 72 completed the course, with 7 taking two years of the work. The greater percentage (about 60%) came from families of very limited means, their parents being either laborers or farmers. The rest were from families of little better circumstances, few being above average means, their parents being either craftsmen (electricians, carpenters, etc.), railroad employees, owners of small business establishments, or ministers.

The intelligent quotient of the group ranged from 60 to 130. 53 Students were below the average, with 8 having intelligent quotients of 60 (one being unable to write); 33 students had average or higher than average intelligent quotients, 12 of which were between 130 and 135. On the whole about one-third of the students were able to comprehend the theoretical or related information.

The rank of these students in their classes coincides with their intelligent quotients, 61 being in the lower half and 25 in the upper half. Thirty-six of the 61 were in the lower fourth, while only 7 of the 25 were in the upper fourth.
PART III

The Smith-Hughes law, under which the vocational training program operates, requires a three-hour period each school day. The law further requires part of the period to be devoted to related subject matter. A good plan is to devote one hour to the related material and two hours to the shop work. A good text is essential for the related study, such as "Elements of Electricity" by Timbie. Plenty of work should be provided for the two hour shop period, because there will be 20 or 25 students in the shop 2 hours a day, 5 days a week, for 36 weeks. The accompanying Work Book was designed to meet these requirements. In arriving at the number of jobs necessary to keep the student busy for the whole year, I prepared more jobs than any one student could complete. Then by taking the average number completed each year, for 2 years, I revised the Work Book so that it now contains only 43 jobs.

Another point to be considered in laying out a Vocational Training Program is the difference in ability of the students. While one student is completing 15 Jobs in 9 weeks, another will finish only 10, perhaps fewer. Therefore the work must be so designed that each student can progress at a speed best suited to his
abilities.

The shop work is divided into three sections: Circuit Wiring, Experimental, and House-wiring. Circuit Wiring (Shop Manual Pages 46-61) consists of various types of circuits using bells and controlling them with push buttons. Under Experimental Jobs (pages 61-78) the connections and uses of various types of switches are made and jobs undertaken to illustrate points of theory discussed in the class. Several jobs are devoted to each type of House-wiring (pages 78-177) in order that the student may become thoroughly acquainted with the materials and their cost, and skilled in the use of the tools and methods of working the various materials. The rules, as specified by the National Electric Code, which govern the various wiring installations are brought out through questions accompanying each job.

The main objective in the organization of the subject Matter of the Work Book, was to make it as simple as possible. If the complete information were not given to the student in simple direct statements he would be asking, "What shall I do next?", or "What do I use here?", and the real purpose of the book would be defeated.

The book is arranged in three sections: Information
Section, pages 1-12; Operation Sheets, pages 13-45; and Work Sheets, pages 46-177.

The Information Section contains material either not found in reference books, or too scattered in these books to be of much use; general information concerning various types of house-wiring and their application, page 9; and instructions as to the use of the book, page 12.

The Operation Sheets are divided into sections containing each type of house-wiring: Conduit, pages 16-23; Armored Cable, page 24; Knob and Tube, pages 32-34; etc.; and detailed descriptions of how to perform each operation necessary in working the material for specific types of wiring. For example, there are given details of how to cut conduit, page 16; how to thread conduit, page 17; how to make all types of bends necessary in conduit installations, pages 17-18; how to install outlets and switches, pages 37-39; etc.

The section containing the Work Sheets, which is divided into three parts, the Circuit Wiring and Experimental Jobs as previously discussed, and House-wiring, are the actual instructions for the various jobs to be performed. The house-wiring sheets are divided into groups of each specific type: Conduit (pages 78-104),
Armored Cable (pages 104-110), Knob and Tube (pages 110-122), Metal Fold (pages 144-165), and Xtensionduct (pages 165-177). Each group has a General Instruction Sheet (as for example see page 78 for General Instructions for Conduit), upon which are stated the instructions that pertain to all installations of that type of wiring; a Unit Operation Checking Sheet (as for Conduit, page 79), upon which the student will check the operations to be performed in installing the job assigned; and a Grading Sheet (as for Conduit, page 79), which gives the points upon which he will be graded. The actual Job Sheet (example—Wiremold Job No. 1, page 146) contains 5 parts: a drawing of the job, which the student is to use as a guide for his installation (page 146), showing the size, name, and in some cases the number of the article to be installed; specifications (page 147), a detailed description of the installation giving the material for all parts, the method of controlling the circuit, the method of connecting the power supply, and general directions; an outline for the Bill of Material (page 147), upon which he puts the quantity, article, and cost; a sheet for the wiring diagram (page 148), which must be completed before the wiring of the job starts; and a list of questions (page
149), which cover information concerning the material, methods of installation, and code rulings covering the use and installation of that type of material.

Four principal points in the organization of a shop are: first, there must be adequate working space; second, a sufficient supply of material; third, an easy and definite method of access to the materials; and fourth, a set routine for the running of the shop.

To supply adequate working space a good solution is the use of booths (Photographs 1 and 2). These together with the panelling above (Photograph No. 3) supply sufficient space for the installation of a great many types of jobs requiring one flat surface. The booths may also simulate 3 walls and the ceiling of a room for use in studying house-wiring installations. In addition to the booths work benches may be provided (Photographs 4 and 5), one containing machinist's vises, pipe vises, and gas furnaces; another having outlets and used as a test bench. A framework (Photograph No. 6), made of 2 x 4's in the form of a room or of several rooms containing doors and windows, is an excellent instrument for teaching knob and tube and armored cable types of house-wiring.

An ideal supply of material would be to have enough
for each student to perform the same job at the same time. If the quantity of material be based upon two or three installations of the same job, in each type of house-wiring, requiring the most material, a sufficient supply will be on hand.

The store room should be conveniently located so that the student will have to spend only a minimum amount of time in going from his job to the point of supply. The supplies should be stored and catalogued so that the store-keeper can quickly and conveniently fill the student's order. The order should be in the form of a requisition and signed by the student, in order that all supplies may be accounted for at all times.

There are many duties in the shop that can be assigned to the student: store-keeper, assistant foreman, safety director, and clean-up detail are examples. A definite assignment of the duties should be made. If the students are given a thorough understanding of the purpose or objective in assigning these duties, that is cooperation and the development of leadership, a smooth working shop can be obtained.

In the preliminary stages of the program the student is under constant and rigid supervision. This is to assure that while performing the circuit wiring and
experimental jobs he obtain a definite understanding of circuits and switches, how they are connected and how they operate. Upon entering the house-wiring phase the supervision is relaxed somewhat, and to a great extent the student is on his own. This method allows him to develop resourcefulness and brings out his ideas.

In order to best explain how the program operates it will be necessary to follow the steps a student takes in starting, doing, and finishing a job.

A student has had the metal mold series (pages 122-144) assigned. The procedure he follows in performing Job No. 1, which will be the same for all 5 jobs, is:

1. He reads the specifications (page 125) of the job and studies the layout (page 124).

2. He lays out the position of all outlets and switches on the ceiling and walls of the booth in which he is to work.

3. He then lists on the Unit Operation Checking Sheet (page 123) the various unit operations, in the order in which they will be performed, and which he will be required to perform in doing the job. This will help to develop an orderly method of procedure in doing a job, and it will aid him to learn the various operations necessary in working the material.
4. He then draws the wiring diagram, on the sheet provided (page 126), showing the method of connecting the switch to control the four outlets. The circuit must be checked by the instructor.

5. The bill of material is next. On the sheet provided (page 125) he places the amount, article, and cost of the article for each part needed. The amounts are added and the total cost of the job determined. The making of a bill of material of this type not only acquaints the student with the cost of the materials used, but also helps him in learning the name of the article and the use of various supply house catalogues.

6. The student is now ready to check the material out of the store room and begin the actual installation. In the process of installation he meets new materials and methods of working them. One of the first will be, how to cut molding. On the Unit Operation Checking Sheet he will find that the method of cutting metal mold is explained in Operation No. 28. Turning to this sheet, page 25, he reads how to perform the task. If he cannot understand the operation from the explanation, the instructor supplements it with an individual demonstration. Most students seem
to grasp the methods quickly and find difficulty only with the harder operations, such as bending and threading conduit, or bending molding.

7. The student then proceeds with the installation, having the work checked at the various checking points until it is completed. The checking points are: (1) Rough check, backing tight with no rough edges (2) Splices, the splice, the soldering job, and the taping and (3) Wiring, to see that the polarity is correct before the switches, lights, and receptacles are installed.

8. Upon completion, the job and the student are graded on a basis of five points (Grading Sheet, page 123):

1. Application-20%: how well has the student applied himself in performing this task?

2. Time-25%: a good electrician must work fast, therefore a standard time is set for each job (page 123), and the time the student requires for the execution of the job is checked against this.

3. Workmanship-25%: how well has the job been executed?

4. Operation-15%: did the job operate properly the first time the switch was thrown or was it necessary to make changes in the wiring?
5. Inspection-15%: does the job meet all code requirements? Were the splices well made, correctly soldered and taped? Did it pass the rough-in inspection the first time?

9. These individual grades are summarized and we have the finished job (Photograph No. 7).

PART IV

The pseudo-type training program, as illustrated by the Shop Work Book, has many advantages over the production type of program. It allows for the repetition of those manipulative processes necessary in developing skill in the working of each type of material; it allows an equal amount of time to be spent on each type of wiring; it allows the instructor to check better the progress of the individual; it promotes an easy assembling of the group for demonstrations and related lectures; it allows the instructor to keep a better check on the activities of the whole group; it prevents the student's entering into competition with the journeymen of the community.

The advantages offered by the production type of training are few but important. It allows the student to practice and learn his skills on the job under actual working conditions; it is not as expensive to operate; it does not require as large a stock to be carried.

There are many more advantages and disadvantages to each type of program, but I believe that the finished student trained under the pseudo-type program will be the better all-around electrician. He will have receiv-
ed a definite, planned training in each form of house- 
wire, and will have repeated the operations necessary 
in working the various materials, until he has become 
skilled in the use of the tools and in handling the 
materials. The student trained under the production 
program may better understand the methods used in in-
stalling one or two types of wiring, but will not be as 
skilled in their installation, because of the lack of 
repetition of the various manipulative processes.

Therefore, it seems quite evident that the pseudo-
type program is better for the student, and will help 
to maintain a better feeling between the school and the 
journeymen or unions.
BIBLIOGRAPHY


INDEX

Background of the students........................................ 5
Class ranking of the students................................. 5
Finished student, The............................................. 16-17
Intelligent quotient of the students....................... 5
Intelligent self-direction...................................... 3
Knowledge and skills............................................ 4
Organization of the shop......................................... 10-11
Organization of the subject matter.......................... 7-10
Program, The....................................................... 6-7
Program at work, The.............................................. 11-15
Pseudo-type training vs the production type of training........................................ 16
Social adjustment.................................................. 3
Work habits.......................................................... 3-4
Photograph No. 1

20
Photograph No. 3
Photograph No. 4
Photograph No. 8
Photograph No. 9
Photograph No. 10

29
SHOP MANUAL
FOR
VOCATIONAL ELECTRICITY

PREPARED BY
HARRY F. KIRKPATRICK
1938
INTRODUCTION

This book has been prepared in order that the individual student may progress, in learning the fundamental principles of house wiring, according to his ability.

Another thought considered was, decreasing the number of individual instructions, thus enabling the instructor to devote more time to those students who need the most aid.

Therefore this book has been written in such a manner that the student may, after once being started, instruct himself. This is done through the medium of the Operation Sheets and Job Specifications. Every operation that the student can possibly do is contained in the Operation Sheets in clear, concise form, labeled and easy to find. The complete Principle of Operation and full instructions for doing the job is found in the Specifications.
TABLE OF CONTENTS

1. Information --------------------------------------------------- 1-12
2. Unit Operations --------------------------------------------- 13-45
3. Bell Circuits ----------------------------------------------- 46-60
4. Experimental Circuits ------------------------------------- 61-77
5. Conduit ----------------------------------------------------- 78-103
6. Armored Cable --------------------------------------------- 104-109
7. Knob and Tube --------------------------------------------- 110-121
8. Metal Mold ----------------------------------------------- 122-143
9. Wiremold -------------------------------------------------- 144-165
10. Xtensionduct --------------------------------------------- 166-177

CONTENTS

PART I

INFORMATION

Par. Page
1. Tools ------------------------------------------------ 2
2. Conductors and Insulators ---------------------------- 3
3. Wires ------------------------------------------------ 4
4. Wire gauge ------------------------------------------- 4
5. Joints ----------------------------------------------- 4
6. The National Code -------------------------------------- 5
7. Solder ----------------------------------------------- 5
8. Fluxes ----------------------------------------------- 5
9. Soldering coppers ------------------------------------- 6
10. The Blow Torch ---------------------------------------- 6
11. Operation of the Blow Torch -------------------------- 6
12. Importance of Bell Wiring ----------------------------- 6
13. Types of Bells --------------------------------------- 6
14. Push Buttons ----------------------------------------- 7
15. Current supply --------------------------------------- 8
16. Bell Circuits ----------------------------------------- 8
17. Use of Voltmeter and Ammeter ------------------------ 8
18. Methods of House Wiring ----------------------------- 9
19. Wires in grounding ----------------------------------- 11
20. How to use book -------------------------------------- 12
21. Bibliography ----------------------------------------- 12
PART I

INFORMATION

1. TOOLS.

a. Pliers - The size of pliers are measured by their overall length. Below are given the four types mainly used and the best size of each.
   1. Side cutting pliers - 7 inch.
   2. Combination pliers - 10 inch.
   3. Diagonal pliers - 6 inch.
   4. Round-nose pliers - 6 inch.

b. Screw drivers - The size is determined by the length of the blade. The best sizes are the three inch and the six inch.

c. Hammers - The size of the hammer is determined by the weight of the head. For general use an electrician will need a 1 lb. ball pein and a 1 lb. claw.

d. Rules - A six-foot Box-wood is recommended. Because of its cheapness and due to the constant danger of damage to a good rule, the box-wood is considered best.

e. Braces - The ratchet brace is the only kind that can be used by the electrician. Due to the frequent use in small spaces this type of brace is practically a necessity. Because of its almost constant use it should be well made and have a chuck capable of taking either square shank or round shank drills.

f. Bits and Drills - The following types of bits and drills are used.
   1. Wood bits.
   2. Steel drills.
   3. Bit extension - 18 inch is the best size. Used to facilitate boring holes for knob and tube work.

g. Saws
   1. The key hole saw is the main type of wood saw used.
   2. The hack saw is used for cutting metal. The saw should have an adjustable frame.

h. Wrenches - The size of the wrench is determined by its overall length.
   1. Pipe - The 10 inch size is best for all around work. Either wood or metal handle can be used.
   2. Crescent - The 8 inch size is preferable.
   3. Open end - A complete set is necessary.
i. Chisels - The size is determined by the width of the blade.  
1. Wood - The best sizes are; $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch.  
2. Cold - The cold chisel can be used on metal, brick, stone, or concrete. The most common sizes are 3/8; $\frac{1}{2}$; and $\frac{3}{4}$ inch.

j. Star drills - Used to cut holes in bricks, stones, or concrete. Sizes vary from $\frac{1}{4}$ to 1".

k. Reamers - Used to remove ragged edges from interior of conduit. The reamer should be tapered.

l. Blow torch - Used for heating metals, soldering coppers, and in direct soldering of splices.  
1. Gasoline - One with a capacity of 1 quart is the best.  
2. Alcohol - A small spirit torch is very handy for soldering small joints in confining places.

m. Soldering iron - The weight of the soldering iron is measured by the weight of the head. A 1 lb. and a 2 lb. iron are the most useful.

n. Files - Both wood and metal files are necessary. 6" and 10" sizes are best.

o. Pipe benders (Hickeys) - Both $\frac{3}{4}$" and $\frac{1}{2}$" are the most frequently used. Separate hickeys are made for Rigid and Thin Wall Conduit.

p. Stock and dies for threading conduit - The stock should be one that will hold $\frac{1}{4}$", $\frac{1}{2}$", and 1" dies.

q. Fish tape - A long band of steel for snaking wire through conduit. Generally a 1/8" x .030 x 100 ft. flat steel wire is used.

2. CONDUCTORS AND INSULATORS.

A conductor is a substance through which electricity will flow. A good conductor is a substance which allows the electricity to easily flow through it. A poor conductor is one which offers opposition to the flow.

An insulator is a substance through which electricity will not flow or is greatly hindered in its flow. A good insulator is one which will either stop the flow of electricity or require a great amount of it to break it down. A poor insulator is one which only hampers the flow and requires very little electricity to break it down.

Table I gives a list of some conductors in the order of the ease with which they will conduct electricity. Table II gives a list of insulators in the order of their property of hindering...
3. WIRES

The wire generally used in electrical work is made of copper. It is in reality a long slender rod. It may be either round or rectangular; the round is more common. It also may be insulated or bare, according to the use which it is to be put. The insulation, in both amount and material, is governed by the use for which it is intended. That is, the insulation on wires designated for use in house wiring would be different from that intended for outdoor use or for motors and generators.

Wire used in house wiring is generally rubber covered, single braid or double braid. The amount of braiding is governed by the size of the wire. The single braid is found on sizes up to and including No. 8. The double braid on No. 6 and larger sizes.

All wires must pass a rigid test set up for them by the Underwriters Laboratories. In addition they carry a colored thread, which is the manufacturer's mark.

There are several special types of wires made which are encased in metallic or non-metallic sheathing to increase their protection against moisture or mechanical injury. Romex, lead-covered cable, and Armored cable are some of these types.

4. WIRE GAUGE

The wire gauge is a device for measuring the diameter of a wire in order to quickly determine its size. It is a round piece of flat metal having notched holes in the edge. These holes are numbered according to the various sizes of wire.

5. JOINTS

Whenever it becomes necessary to join two or more wires together, a joint is made. A good joint is of great importance, because a poorly made one becomes a resistance in the line. This is due to the corrosion that will be built up from arcing caused by the loose joint. In addition, the heat generated by such a joint can become a fire hazard.

A joint may be classes as either a tap or a splice. A tap is a connection between two or more wires, only one of which must be of continuous length. A splice is a connection of two or more wires neither of which is of continuous length.

To be a good joint the splice must first be mechanically
secure. That is, it must be tightly made so that movement will not cause arcing. Second, it must be well coated with solder in order that it will not oxidize or corrode due to the air. Third, it must be well insulated, taped, in order to lessen the danger of fire or personal injury.

6. THE NATIONAL CODE

The National Code is a list of rules or regulations of the National Board of Fire Underwriters for electrical wiring and apparatus. These rules are recommended by the National Fire Protection Association.

The National Electrical Code was originally drawn in 1897 as the result of the united efforts of the various insurance, electrical, architectural and allied interests, through the National Conference on Standard Electrical Rules, composed of delegates from various national associations, unanimously voted to recommend it to their respective associations for approval or adoption.

The National Conference having disbanded, the work of the Underwriters' National Electric Association and of the National Conference was taken over by the National Fire Protection Association which now acts as sponsor for the project under the rules of procedure of the American Standards Association.

These rules are the minimum requirements with which wiring installations must conform throughout the country. Because of the difference in building construction, due to climatic conditions, the various cities, and in some cases states, issue code rulings of their own. These are generally based upon the National Code and take precedence over the National Code.

The National Code is revised every two years. The revision being published in the even-numbered years.

The Underwriters' Laboratories, a subsidiary of the National Association, has been set up in order to assure more perfect materials, fittings, etc., for wiring installations. All of the articles mentioned must pass rigid examinations and receive the stamp of approval of the Laboratories before they can be used on installations.

7. SOLDER

Solder is an alloy of Tin and Lead. The percentage relationship governs the hardness of the solder. For electrical use a 50-50 alloy is the best. Two of the main forms in which solder is made are wire and bar. Because of the ease with which it can be applied to joints, wire solder is best for use in wiring installations.

8. FLUXES

Flux is an agent used to make solder adhere to the joint. In this action it cleans grease and other small particles of dirt from the joint.
A liquid flux is the best, but because of the necessity of carrying it in a tool kit, it is very seldom used. Instead a paste form of flux is used. The paste is applied to the joint and melts, running throughout the joint, due to the heat of the soldering copper or flame of a torch.

9. SOLDERING COPPERS.

A soldering copper or soldering iron has a pure copper head fastened to an iron rod. A round wooden handle is fitted on the end of this rod. The copper head is pointed. Copper is used for the head because it heats quicker and will give up its heat, through the point, better than any other substance. The size is determined by the weight of the head.

10. THE BLOW TORCH.

The blow torch is in reality a portable gasoline stove. It is operated on gasoline and air, giving off a flame of intense heat. It can be used to heat a soldering copper or the joint itself.

11. OPERATION OF THE BLOW TORCH.

A torch under the most efficient condition of operation should emit a bluish-green flame. This flame should have force. If the torch has a yellowish flame, the burner has not been allowed to heat enough. To remedy this, open the valve slightly to emit a longer flame. Then hold or set the torch so that the flame will strike a stone, concrete, or metal and be thrown back upon the burner. If the torch goes out in the process of heating due to a draft, open the valve slightly so that a small flame will be emitted to assist in the heating. If the torch goes out during operation, either the pressure is too great or the tank is empty. If the pressure is too great, close the valve so that only a small flame is burning. Let the torch burn until the pressure is reduced.

12. IMPORTANCE OF BELL WIRING.

Bell wiring is of importance because of its extensive use. Because of the small current carried, under a small voltage, a small size wire (#18) is used. The insulation of this wire is very thin. Therefore, due to this small wire and thin insulation, great care should be taken that it cannot come into contact with wires carrying larger currents and voltages. If it should come into contact with such wires, a normally harmless wire would become dangerous both to life and as a fire hazard.

13. TYPES OF BELL S

There are three standard types of bells manufactured. The
single stroke, the vibrating, and the combination. The single stroke is used in code signalling, such as a fire alarm system. The vibrating is the standard and the most generally used, such as for door bells. The combination is one combining the features of both so that it can be used on both systems at the same time.

The single-stroke bell consists of electromagnet coils, pivoted armature, hammer, and gong. After the bell has been connected in a circuit and the circuit closed, the coils energize and attract the armature causing the hammer to strike the gong once. The armature will remain attracted to the coils as long as the circuit is closed. Opening the circuit will cause the coils to de-energize and release the armature, which has been holding the hammer against the gong.

The vibrating bell is made in the same manner as the single-stroke, with one addition. That is a make and break contact. One contact is fixed, the other is on the pivoted armature. The contacts are closed when the circuit is open. One end of the electromagnet is connected to the fixed half of the make and break contact, the other end is connected to one of the binding posts. The other binding post is connected to the opposite side of the make and break contact, the side on the pivoted armature, through the frame work of the bell. After the bell has been connected in a circuit, and the circuit closed, the coils energize. The circuit through the bell is as follows; from the binding post through the coils to the fixed side of the contacts, through the contacts to the armature, from the armature to the frame, and out through the frame to the other post. The energizing of the coils draws the armature over causing the hammer to strike the gong. At the same time the circuit is broken because the contact on the armature is pulled away from the fixed contact. This break in the circuit causes the coils to de-energize and release the armature. The contacts come together again closing the circuit causing the above operations to be repeated.

A combination bell has three binding posts. Two posts are connected to the ends of the electromagnets. The third is connected to a make and break contact.

A vibrating bell can be changed into a single-stroke by connecting the second binding post direct to the fixed contact.

A high voltage bell can be changed into a low voltage bell by connecting the coils in parallel instead of series. This reduces the resistance of the coils.

14. PUSH BUTTONS

The primary purpose of the push button is to open or close the circuit. They are made in various shapes, sizes, and materials. The most common of course being round and made of wood, bakelite, or brass. There are two main types; the single contact and the double contact.

The single contact or two point button is made of a shell,
button, brass spring, and two binding screws in a fiber insulator. The circuit is always open and is closed by pressure on the button, this presses the brass spring across the ends of the binding screws, shorting between them.

The double contact or three point button is made of a shell, button, contact spring, two contact points, and three binding screws. One binding screw is connected to each contact point, while the other is connected to the contact spring. The contact points are placed so that one is always in contact with the spring, thus keeping one side of the circuit always closed. Pressure on the button causes the spring to break contact with one contact point and make with the other. These types of buttons are used on return call and double-call systems.

15. CURRENT SUPPLY

Because of the low voltage needed either a dry cell or a small transformer can be used to furnish the current.

The dry cell derives its energy from electro-chemical action. That is, the action of the acid or electrolyte upon one plate.

The transformer reduces the normal alternating current supply to the required voltage. This action is through the use of two coils, a primary and a secondary, wound on a steel core.

16. BELL CIRCUITS

Bell circuits are studied in order that a foundation may be laid for the study of more complicated circuits. In the study of your circuit always remember that one side of the bell or bells must be connected to the battery; one side of the button or buttons must be connected to the opposite side of the battery; and the other side of the button must be connected to the other side of the bell it is supposed to ring.

17. USE OF THE VOLTOMETER AND AMMETER.

a. The voltmeter.

The voltmeter is used to measure the voltage or pressure of a circuit. It is to be connected across the circuit, as shown in Fig. 1.

CAUTION: NEVER CONNECT A VOLTOMETER IN SERIES WITH THE CIRCUIT.

b. The ammeter.

The ammeter is used to measure the current flowing through a circuit. Therefore, it is to be connected in series with the circuit, as shown in Fig. 2.

CAUTION: NEVER CONNECT AN AMMETER ACROSS OR IN PARALLEL WITH THE CIRCUIT, BECAUSE OF ITS LOW RESISTANCE IT WOULD BURN OUT.
18. METHODS OF HOUSE WIRING.

There are several methods that can be used in wiring a house. The one chosen depends upon the cost, design, method of construction, and local code rulings.

A. Open work.

There are two types of open work wiring. One is in general use, the other is obsolete.

1. Knob and tube.

This is the most common form of house wiring in use today. Wires are run between walls. When necessary to go through studding a porcelain tube is used. When running over the surface of studding, knobs are used to keep the wire from touching the wood.

2. Cleat wiring.

This type of wiring is obsolete and outlawed in most communities. It not only detracts from the appearance of the room but is also a fire hazard. The wires are run on the surface of the walls and are held only one-half to three-quarters of an inch from the surface, by porcelain cleats. They are exposed to all kinds of danger and objects.

B. Conduit.

This type of wiring is absolutely fireproof and is widely used. The main objection to its use in house wiring is its high cost.

1. Rigid.

Rigid conduit is a heavy iron pipe having a smooth interior and a galvanized or black enamel coating on the exterior. To join the pipe to boxes or other pieces of pipe, threaded fittings are used. Therefore, the pipe must have a thick wall, in order to have sufficient thickness after threads have been cut.

Rigid conduit has the advantage over Steel Tube in that it can stand greater pressures and strains. But in the use of smaller sizes, the speed with which Steel Tube can be installed more than offsets this.

2. Steel Tube.

a. General.

Steel Tube is a Thin Wall Conduit. Because this conduit has clamp-on fittings, making it unnecessary for it to be threaded, the wall does not have to be as thick as that of the rigid type. The exterior of the conduit has a galvanized finish, while the interior has a pebble-grained, enameled finish.

At the present this type of conduit has been approved by the Underwriters' only up to two inches. Greater sizes than this has not been found to stand up under
the hardship of fireproof or concrete construction.

b. Methods of coupling Steel Tube.

1. To boxes.
   A connector is used. One end of the coupling has a threaded end upon which a bushing is screwed. This bushing has a beveled ring inside of it. As the bushing is tightened the beveled ring tightens upon the conduit until it is impossible to remove it without loosening the bushing. The other end is fastened to the box with a lock-nut.

2. To threaded fittings.
   An adapter is used. This has a smooth interior, threaded exterior, hexagon head, and is split. It is screwed into the fitting and the conduit is slipped into it. Tighten with a crescent wrench. The tightening causes the split portion to close, clamping onto the pipe. It makes a very tight fitting.

3. Two lengths of conduit.
   A coupling is used. The coupling has both ends threaded upon which bushings are screwed. Their action is the same as that explained in (1).

c. Construction of the Steel Tube bender.
   The steel tube bender is a rounded, grooved piece of metal several inches in length (7 inches is the general length for a ½-inch bender) and of a curved construction. The depth and width of the groove depends upon the size of the bender. It is so designed that the conduit will fit snugly into it. The bender is curved so that a smooth bend can be obtained. The curve eliminates the possibilities of kinks in the pipe. At one end of the curved groove is a latch to hold the pipe snugly in the groove. On the opposite side of the curved groove is a place to insert a short piece of pipe, to give leverage in bending the pipe.

3. Flexible.
   Flexible conduit or Greenfield is made by winding spirally, steel strips. Thus forming a tube so that the edges of the strips interlock. The tubing is given a galvanized finish both on the exterior and interior. It is made in sizes ranging from ½" to 2", inside diameter, and in lengths from 50 ft. to 250 ft. according to the diameter.
   Flexible conduit is very seldom used for complete wiring jobs. It is generally used for extensions of other wiring systems. For example, rigid conduit or steel tube could not stand up under the vibrations of a motor, so the lead in wires are brought to the motor through flexible conduit. Wires are pulled in after the conduit is installed.

4. Armored Cable.
   Armored Cable is made by winding, spirally, steel strips around rubber covered wire. The edges of the strips
interlock. The exterior is galvanized. This forms a fire-proof, but not moisture proof, flexible conduit with the conductors already installed. Armored Cable is made with either single, twin, or three conductors, and with a wire range of from #14 to #1 (for single), #4 (for twin), or #6 (for three) and is furnished in 100 ft. to 250 ft. lengths. This cable is smaller in diameter than flexible conduit, therefore lending itself more readily to house-wiring. Because of its fire proof construction it is frequently used in the wiring of houses.

When it is necessary to install Bx (Armored Cable) in a damp location, the wires are encased in a solid lead sheath before the spiral steel strips are wrapped on. This type of cable is known as BXL.

C. Metal Raceways.

Metal raceways are steel troughs used to encase wires when it is necessary to make additions to the wiring system. This system is used when surface wiring has to be used or is desired. There are three types of raceways, each designed to match a variety of architectural designs.

1. Wiremold.

Wiremold has a galvanized steel backing and a steel capping. The capping is painted a light tan. The backing slips through grooves in the capping and they are installed together. The wires are pulled in after the molding is installed.

2. Metal Mold.

Metal Mold is a flat steel trough having a grey galvanized or a brown enamel finish. It is made in two parts, the capping and the backing. The backing is installed first; the wires are placed in this trough next; and last the capping is snapped on. This type of molding is designed to take a maximum of four #14 wires.

3. Xtensionduct.

Xtensionduct is a narrow edition of metal mold. Its primary use is in adding more receptacles to those already installed. It is made to hold a maximum of two #14 wires. The backing is installed first, then the wires are laid in, and last the capping is snapped on. It is coated with a brown enamel, but can be painted any color with a quick drying enamel.

10. WIRE USED IN GROUNDING.

The code states that nothing smaller than #10 B. & S. can be used.

It is permissible to use either rubber-covered, cotton-braid or bare wire. In practice a #8 B. & S. bare wire is generally used. The wire is very soft, flexible copper making it
easy to fit into ground clamps or on grounding screws in switch boxes.

20. HOW TO USE BOOK.

This book is divided into several sections or parts. The Information contains general facts concerning tools, materials, and methods used in house wiring. The operation sheets contain specific directions on how to perform every operation necessary in the job. Last are jobs as prepared for the shop.

In the performing of a job; read the general instructions and conform with them. Next fill out the Unit Operation Checking Sheet. This is done by reading the Job Specifications, then considering the steps that will be taken in installing the job, arrange these steps in the order in which they will be done; and last check these steps or operations on the checking sheet in the order they will be performed. Read over this list you have just prepared and see if there are any operations that you do not know how to perform. If there are any, look them up in the Unit Operations. The number of the operation is given on the left hand side of the page with the Unit Operation Checking Sheet. In the Unit Operations you will find detailed directions for performing all types of house wiring operations. The directions for the operation you want to learn will be found listed under the number you obtained from the checking sheet.

21. BIBLIOGRAPHY.

1. Practical and Technical Electricity-Housewiring-Wolber & Rose
2. Interior Wiring - Cook
3. Wiring For Light and Power - Croft
4. Wiring of Finished Buildings - Croft
5. Wiring Simplified - Richter
6. Electric Wiring - Schuhler
7. Hawkins Electrical Guide
8. National Electrical Code Book
9. Trade Catalogues
<table>
<thead>
<tr>
<th>No.</th>
<th>Operation</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Planning and estimating the job</td>
<td>16</td>
</tr>
<tr>
<td>2.</td>
<td>Making a bill of material</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td><strong>RIGID IRON CONDUIT</strong></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Cutting</td>
<td>16</td>
</tr>
<tr>
<td>4.</td>
<td>Reaming and threading</td>
<td>17</td>
</tr>
<tr>
<td>5.</td>
<td>Making a running-thread joint</td>
<td>17</td>
</tr>
<tr>
<td>6.</td>
<td>Bending</td>
<td>17</td>
</tr>
<tr>
<td>7.</td>
<td>Throwing an offset</td>
<td>18</td>
</tr>
<tr>
<td>8.</td>
<td>Making special bends</td>
<td>18</td>
</tr>
<tr>
<td>9.</td>
<td>Installing and connecting to boxes and cabinets</td>
<td>19</td>
</tr>
<tr>
<td>10.</td>
<td>Connecting to fittings</td>
<td>19</td>
</tr>
<tr>
<td>11.</td>
<td>Pulling in conductors</td>
<td>19</td>
</tr>
<tr>
<td>12.</td>
<td>Making splices in outlet boxes and junction boxes</td>
<td>20</td>
</tr>
<tr>
<td>13.</td>
<td>Grounding</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>THIN WALL CONDUIT</strong></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Cutting and reaming</td>
<td>21</td>
</tr>
<tr>
<td>15.</td>
<td>Bending</td>
<td>21</td>
</tr>
<tr>
<td>16.</td>
<td>Throwing an offset</td>
<td>22</td>
</tr>
<tr>
<td>17.</td>
<td>Making special bends</td>
<td>22</td>
</tr>
<tr>
<td>18.</td>
<td>Installing</td>
<td>22</td>
</tr>
<tr>
<td>19.</td>
<td>Connecting to outlet boxes and cabinets</td>
<td>22</td>
</tr>
<tr>
<td>20.</td>
<td>Connecting to fittings</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td><strong>FLEXIBLE STEEL CONDUIT (Greenfield)</strong></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Cutting and reaming</td>
<td>23</td>
</tr>
<tr>
<td>22.</td>
<td>Coupling</td>
<td>23</td>
</tr>
<tr>
<td>23.</td>
<td>Installing and connecting to boxes and fittings</td>
<td>23</td>
</tr>
<tr>
<td>24.</td>
<td>Pulling in conductors</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td><strong>FLEXIBLE ARMORED CONDUIT (Bx)</strong></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Cutting</td>
<td>24</td>
</tr>
<tr>
<td>26.</td>
<td>Stripping armor for splices</td>
<td>24</td>
</tr>
<tr>
<td>27.</td>
<td>Installing and connecting to boxes and fittings</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td><strong>METAL MOLDING</strong></td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>Cutting</td>
<td>25</td>
</tr>
<tr>
<td>29.</td>
<td>Slotting or punching</td>
<td>25</td>
</tr>
<tr>
<td>30.</td>
<td>Coupling</td>
<td>25</td>
</tr>
<tr>
<td>31.</td>
<td>Bending and mitering a turn</td>
<td>25</td>
</tr>
<tr>
<td>32.</td>
<td>Installing and connecting to boxes and fittings</td>
<td>26</td>
</tr>
<tr>
<td>NO.</td>
<td>OPERATION</td>
<td>PAGE</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td><strong>WIREMOLD</strong></td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>Cutting-----------------------------------------</td>
<td>26</td>
</tr>
<tr>
<td>34.</td>
<td>Coupling----------------------------------------</td>
<td>27</td>
</tr>
<tr>
<td>35.</td>
<td>Bending with a wiremold bender-----------------</td>
<td>27</td>
</tr>
<tr>
<td>36.</td>
<td>Installing and connecting to boxes and fittings</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td><strong>XTENSIONDUCT</strong></td>
<td></td>
</tr>
<tr>
<td>37.</td>
<td>Using the cutting and notching gauge-----------</td>
<td>28</td>
</tr>
<tr>
<td>38.</td>
<td>Installing backing-----------------------------</td>
<td>28</td>
</tr>
<tr>
<td>39.</td>
<td>Putting in wires--------------------------------</td>
<td>28</td>
</tr>
<tr>
<td>40.</td>
<td>Putting on capping------------------------------</td>
<td>28</td>
</tr>
<tr>
<td>41.</td>
<td>Coupling----------------------------------------</td>
<td>28</td>
</tr>
<tr>
<td>42.</td>
<td>Mitering a turn-------------------------------</td>
<td>28</td>
</tr>
<tr>
<td>43.</td>
<td>Bending----------------------------------------</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td><strong>CLEAT WORK IN OPEN WIRING</strong></td>
<td></td>
</tr>
<tr>
<td>44.</td>
<td>Installing running boards and guard strips------</td>
<td>29</td>
</tr>
<tr>
<td>45.</td>
<td>Installing cleats------------------------------</td>
<td>29</td>
</tr>
<tr>
<td>46.</td>
<td>Making a turn----------------------------------</td>
<td>29</td>
</tr>
<tr>
<td>47.</td>
<td>Making a dead end-----------------------------</td>
<td>30</td>
</tr>
<tr>
<td>48.</td>
<td>Tapping a circuit------------------------------</td>
<td>30</td>
</tr>
<tr>
<td>49.</td>
<td>Connecting to fittings-------------------------</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td><strong>KNOB AND TUBE IN OPEN WIRING</strong></td>
<td></td>
</tr>
<tr>
<td>50.</td>
<td>Boring joists, studs, etc. for tubes-----------</td>
<td>32</td>
</tr>
<tr>
<td>51.</td>
<td>Installing tubes------------------------------</td>
<td>32</td>
</tr>
<tr>
<td>52.</td>
<td>Stringing conductors---------------------------</td>
<td>32</td>
</tr>
<tr>
<td>53.</td>
<td>Fastening wire with knobs----------------------</td>
<td>33</td>
</tr>
<tr>
<td>54.</td>
<td>Bringing wires into outlet and switch boxes----</td>
<td>33</td>
</tr>
<tr>
<td>55.</td>
<td>Tapping a circuit------------------------------</td>
<td>34</td>
</tr>
<tr>
<td>56.</td>
<td>Grounding a knob and tube system---------------</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td><strong>BELL WIRING</strong></td>
<td></td>
</tr>
<tr>
<td>57.</td>
<td>Planning and making a bill of material---------</td>
<td>34</td>
</tr>
<tr>
<td>58.</td>
<td>Drawing the diagram----------------------------</td>
<td>35</td>
</tr>
<tr>
<td>59.</td>
<td>Installing push buttons------------------------</td>
<td>35</td>
</tr>
<tr>
<td>60.</td>
<td>Installing bells------------------------------</td>
<td>35</td>
</tr>
<tr>
<td>61.</td>
<td>Wiring in a bell circuit-----------------------</td>
<td>35</td>
</tr>
<tr>
<td>62.</td>
<td>Making joints----------------------------------</td>
<td>36</td>
</tr>
<tr>
<td>63.</td>
<td>Connecting dry cells---------------------------</td>
<td>37</td>
</tr>
<tr>
<td>NO.</td>
<td>OPERATION</td>
<td>PAGE</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td><strong>BOXES AND FITTINGS</strong></td>
<td></td>
</tr>
<tr>
<td>64.</td>
<td>Installing switch boxes</td>
<td>37</td>
</tr>
<tr>
<td>65.</td>
<td>Installing fixture outlet boxes</td>
<td>37</td>
</tr>
<tr>
<td>66.</td>
<td>Installing cutouts and panel boxes</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td><strong>SWITCHES AND RECEPTACLES</strong></td>
<td></td>
</tr>
<tr>
<td>67.</td>
<td>Installing flush switch or receptacle</td>
<td>38</td>
</tr>
<tr>
<td>68.</td>
<td>Installing snap switch on spider cover</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td><strong>SPLICING AND SOLDERING</strong></td>
<td></td>
</tr>
<tr>
<td>69.</td>
<td>Splicing</td>
<td>39</td>
</tr>
<tr>
<td>70.</td>
<td>Generating a blow torch</td>
<td>40</td>
</tr>
<tr>
<td>71.</td>
<td>Tinning a soldering iron</td>
<td>40</td>
</tr>
<tr>
<td>72.</td>
<td>Soldering joints</td>
<td>40</td>
</tr>
<tr>
<td>73.</td>
<td>Taping joints</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td><strong>FIXTURE</strong></td>
<td></td>
</tr>
<tr>
<td>74.</td>
<td>Making an underwriters' knot</td>
<td>41</td>
</tr>
<tr>
<td>75.</td>
<td>Making a drop cord</td>
<td>42</td>
</tr>
<tr>
<td>76.</td>
<td>Installing a fixture stud in outlet box</td>
<td>42</td>
</tr>
<tr>
<td>77.</td>
<td>Installing a chain fixture</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td><strong>GENERAL</strong></td>
<td></td>
</tr>
<tr>
<td>78.</td>
<td>Locating outlets</td>
<td>43</td>
</tr>
<tr>
<td>79.</td>
<td>Tracing and testing circuits</td>
<td>43</td>
</tr>
<tr>
<td>80.</td>
<td>Installing the service</td>
<td>44</td>
</tr>
<tr>
<td>81.</td>
<td>Drilling through brick and concrete walls</td>
<td>45</td>
</tr>
</tbody>
</table>
INTERIOR WIRING
UNIT OPERATIONS

1. PLANNING AND ESTIMATING THE JOB.

a. First, go to the place where the job is to be done and look over the layout. If that is impossible, then try to visualize the room or rooms.
b. Second, locate all energy and switch outlets. From the number of these it is possible to estimate the approximate time needed for the job.
c. Third, plan the operations you will perform in doing the job and the order in which they will be done. (For the job books your Unit Operation Checking Sheet will be used as a guide for these steps).

1. Example: Installing a receptacle hot on the line. Use rigid conduit.
   a. Unit operations and their order.
      1. Make a bill of material; 2. Install receptacle box; 3. Install conduit (This operation involves the following things, cutting, threading, reaming, and bending; 4. Pulling in wires; 5. Making splices; 6. Taping; 7. Installing receptacle and plate; 8. Testing.

2. MAKING A BILL OF MATERIAL

In making a bill of material it is very easy to underestimate or leave out some of the material.
a. First, locate all energy and switch outlets.
b. Second, count the number of boxes, sockets, switches, receptacles, plates, covers, and fittings needed.
c. Third, measure between outlets to obtain the length of wire, conduit, or raceways needed. (Be sure to allow enough wire to make splices in the boxes. 6" should be enough).
d. Fourth, from the specifications obtain the information concerning the type and number of fixtures.
e. Fifth, get the prices from the catalogues. Add the price of each article for the total cost of the material for the job. After completing your list sign your name to it and have it checked.

RIGID IRON CONDUIT

3. CUTTING.

a. Marking.
   With a sharp nail, knife, or chalk mark the conduit at the place it is to be cut. Place the conduit in a pipe vice and clamp snugly so that the pipe will not move when you start to cut. If you tighten too tight you may dent the conduit.
b. With a hack saw.
   1. First inspect the saw to see if the blade is loose or the teeth are badly broken. The blade should be strained rather tightly in the frame. 24 teeth to the inch is about right for the blade, as a coarse blade will have its teeth knocked out when sawing pipe. The teeth should point forward.
   2. Saw right through the mark taking pains to have a square cut, sawing with a firm forward cutting movement. If you twist the blade during the stroke you may snap it.

4. REAMING AND THREADING.

a. Reaming.
   After sawing it will be noticed that the inside of the cut will have a sharp edge that is liable to scrape the insulation from the wire when it is drawn through. Take a burring reamer and ream the inside until it is smooth. If the reamer is placed in a brace 8 or 9 turns will generally be enough.

b. Threading.
   See that the size of the die is the same size as the pipe. Put a little lard cutting oil on the pipe and run the die on it until the die engages the pipe. Adjust the guide to the pipe. Turn the stock slowly to the right, pushing hard against the conduit, until the die starts to cut. From time to time put a little oil on the pipe as you cut. Cut until the end of the pipe comes through the dies about three or four threads. Rock the stock back and forth a few times and then unscrew. Take the stock off and rap the pipe smartly a few times with the handle of the stock to knock off any chips that might stick to the pipe and also to knock out any shavings from the inside of the pipe.

5. MAKING A RUNNING-THREAD JOINT.

a. With a right hand pipe die, thread both pieces of conduit to be connected. The thread on one should be of standard length and on the other about one and one-half times the length of the coupling to be used.

b. Run a standard locknut upon the conduit with the longer thread and follow with a standard coupling until the conduit extends through it.

c. Butt the threaded ends of the conduit together. Unscrew the coupling from the long thread and at the same time upon the short thread. Run it upon the short thread until it is tight.

d. After the coupling is in place unscrew the locknut until it strikes the coupling. Tighten the locknut securely with a pair of gas pliers or a pipe wrench.

6. BENDING.

Mark off on the pipe the length of the bend. Move the bending
hickey about \(3\frac{1}{2}\) inches from this mark towards the end of the pipe. Place the foot up tight against the hickey and bend. As the pipe comes up measure it to see if it is likely to be right. If it seems to be a little long slip the hickey further up toward the end. If the bend looks short slip the hickey down and bend. When the bend is nearly straight slip the handle of the bender over the straight end of the bend and pull until the bend is finished.

7. THROWING AN OFFSET.

a. Mark on the pipe the place where the offset is to be and make the bend in the regular manner.
b. Slip the hickey along the pipe to about where the next bend is to be made. Place the hickey handle on the floor and hold it from slipping with the foot. Grasp the pipe tightly with both hands and bend it down until the pipe has the shape needed. Be sure the pipe does not twist in the hands or the pipe will not lay flat.
c. Small offsets on the extreme end of the pipe are generally made with the handle of the hickey on the floor.

8. MAKING SPECIAL BENDS.

a. Bending a goose-neck.
   1. Start the bend in the usual manner but continue the bend until it is parallel with the long end.
   2. Reverse the conduit and make the bend at A, making sure the end of the goose-neck is in line with the long run.

b. Making a saddle bend.
   Make the bend at A first. Finish by making the bends at B and C. The amount of the saddle can be adjusted somewhat by changing the angles of the bends.
9. INSTALLING AND CONNECTING TO OUTLET BOXES AND CABINETS.

a. Knock or drill a hole in the box or cabinet to allow conduit to enter. If enameled the enamel and burrs should be removed to secure good electrical connection. Run a standard locknut over the conduit, well back on the threads.

b. Fasten the box securely to the surface, insert conduit into the box with the locknut on the outside.

c. Run a standard conduit bushing over the end of the conduit inside of the box, and fasten it securely with a pair of slip-joint pliers.

d. Pull the conduit back until the bushing is against the inside of the box. Run a locknut up and tighten securely. Examine to see if the connection is mechanically and electrically secure.

10. CONNECTING TO FITTINGS.

a. Threaded fittings.

There are in common use several makes of conduit fittings which have a tapped hub into which the conduit is screwed. They are made in a variety of types and are used for outlets, junction boxes, and angles. The type of use will depend on the use to which it is to be put. Some of these are made of cast iron and others of malleable iron or pressed steel. Select the proper size and type being careful that the opening will come at the proper place. Screw the conduit into the hub or the hub onto the conduit with a pipe wrench until the conduit is tight, but not so tight as to break or twist the fitting.

b. Connecting to threadless fittings.

Realizing that there is considerable labor involved in threading and connecting to threaded fittings, manufacturers have developed a line of fittings to take their place. These fittings depend on a clamping device instead of threads. They are time savers and are almost a necessity under certain conditions, as they can be used in much the same way as unions are used in steam and gas fittings but without the use of threads.

11. PULLING IN CONDUCTORS.

a. Anneal the end of a fish tape by heating to a red heat with a blow torch and allow to cool in the air.

b. Bend the annealed end into a loop 1 1/2" long.

c. Insert the looped end into one end of the conduit and push forward until it reaches the other end of the run. If difficulty is encountered in running it through, the obstruction can often be passed by jerking the tape backward and forward.

d. If it is found that it is impossible to get the fish tape through in this manner, prepare another fish tape as at first and run it from the opposite end. By twisting one or both tapes when they meet it is usually possible to hook them.
together, after which the tape is withdrawn bringing the first with it.
e. Remove the insulation from about 3 inches of each conductor to be pulled in.
f. Insert these bare ends in the loop of the fish tape and tie the ends around the rest of the wire in the manner of a cable splice. Be careful not to make a lump where the splice is made.
g. Mash the loop, in the fish tape, as flat as possible.
h. Wrap friction tape around the joints beginning with the loop on the fish tape and wrapping spirally backward. Be sure that the friction tape is wrapped tightly and not allowed to form a lump.
i. One man pulls on the other end of the fish tape while another feeds the conductors into the conduit. Great care must be used in the feeding in job to see that the wires do not lap or twist around each other. In heavy pulls rub tallow from a candle on the insulation of the conductors. This will make it much easier.

12. MAKING SPLICES IN OUTLET BOXES AND JUNCTION BOXES.

Pull at least 6 inches of wire into the boxes. Determine which conductors must be spliced. Scrape insulation from at least 3" of the wire. Cross the pairs between the fingers and twist them together, in a Rat-tail splice, for a distance of at least an inch. Several conductors may be twisted together in the same way. After twisting by hand take your pliers and tighten. Cut off the excess part of the splice. After splicing pull the spliced ends as far out of the box as possible and away from each other and the conduit system, until the final circuit tests are made.

13. GROUNDING.

Ground clamps provide a means of effecting a good electrical and mechanical attachment of the ground wire to the pipe to which the system is grounded.

When a conduit system is to be grounded, half-inch conduit is run between the service cabinet and the water pipe to which it is to be grounded. In this conduit pull #8 bare or R.C. copper wire. The end in the service cabinet is connected to a bolt in the bottom of the cabinet. A clamp is placed on the end of the conduit and on the water pipe. The ground wire is brought out of the conduit, tied onto the clamp on the end of the conduit, and run to the other clamp and connected there.

A water pipe is about the best ground obtainable. However, it is necessary to connect on the street side of the meter in grounding. If the distance to a pipe, on the street side of the meter, is considerable, and a cold-water pipe on the house side is available, the ground wire may be attached to the latter, and a copper jumper should then be placed around the meter.
Where gas pipes pass through outlet boxes, as in combination electric and gas fixtures, the gas pipe must be firmly connected to the outlet box.

THIN WALL CONDUIT

14. CUTTING AND REAMING.

a. Cutting.

With a sharp nail, knife, or chalk mark the conduit at the place it is to be cut. Place the conduit in the pipe vice and clamp snugly so that the pipe will not move when you start to cut. If you tighten too tight you may dent the conduit.

Inspect the saw to see if the blade is loose or the teeth badly broken. The blade should be strained rather tightly in the frame. 24 teeth to the inch is about right for the blade, as a coarse blade will have its teeth knocked out when sawing pipe. The teeth should point forward.

Saw right through the mark taking pains to have a square cut, sawing with a firm forward movement. If you twist the blade during the stroke you may snap it.

b. Reaming.

After sawing it will be noticed that the inside of the cut will have a sharp edge that is liable to scrape the insulation from the wire when it is drawn through. There also will be a rough edge on the exterior that will prevent the fittings from slipping on. Take a pair of 10 inch combination pliers or a pair of gas pliers; using the jaws, clamp around this rough external edge. A few twists of the pliers will remove this. Use a burring reamer to remove the sharp edge on the interior.

15. BENDING.

Mark off on the pipe the point at which the bend is necessary (as at A). Mark back from this point 5 3/4 inches (as at B). Place the inner edge of the latch, on the bender, on this mark with the back edge of the bender toward the point of bend. Place the foot on the bender and bend.
16. THROWING AN OFFSET.

Mark on the pipe the place where the offset is to be and make the bend in the regular manner.

Slip the hickey along the pipe to about where the next bend is to be made. Place the hickey handle on the floor and hold it from slipping with the foot. Grasp the pipe tightly with both hands and bend it down until the pipe has the shape needed. Be sure the pipe does not twist in the hands or the pipe will not lay flat.

17. MAKING SPECIAL BENDS.

a. Bending a goose-neck.
   1. Start the bend in the usual manner but continue it until it is parallel with the long end.
   2. Reverse the conduit and make the bend at A, making sure the end of the goose-neck is in line with the long run.

   ![Goose Neck Diagram]

b. Making a saddle bend.
   Make the bend at A first. Finish by making the bends at B and C. The amount of the saddle can be adjusted somewhat by changing the angles of the bends.

18. INSTALLING.

After locating all outlets try to figure out the most direct way of running your pipe. Avoid as many turns or bends as you can. Fasten the conduit to the material being wired over with pipe straps or other approved holding device.

19. CONNECTING TO OUTLET BOXES AND CABINETS.

a. Knock out or drill a hole in the box or cabinet to allow the conduit to enter. The burrs should be removed to secure good electrical connection. Place a connector on the end of the conduit and tighten.

b. Fasten the box securely to the surface, insert the conduit into the box until the connector is flush with the box.

c. Run a locknut over the end of the conduit inside the box and tighten with a screwdriver. (Place the blade of the screwdriver in a slot on the locknut and hit the handle several times with the palm of the hand. This will cause the locknut to tighten).
d. Examine to see if the connection is mechanically and electrically secure.

20. CONNECTING TO FITTINGS.

a. Threaded fittings.

There are in common use several makes of conduit fittings which have a tapped hub into which the conduit is screwed. They are made in a variety of types and are used for outlets, junction boxes, and angles. The type to use will depend on the use to which it is to be put. Some of these are made of cast iron and others of malleable iron or pressed steel. Select the proper size and type being careful that the opening will come at the proper place. Screw an adapter into the hub finger tight. Insert a piece of conduit into the opening and tighten the adapter with a wrench.

FLEXIBLE STEEL CONDUIT (Greenfield)

21. CUTTING AND REAMING.

a. Cutting.

Place the conduit in a vice being careful not to crush it and cut with a fine toothed hacksaw close up to the vice. It is generally best to cut through the middle of one of the spirals, the saw is not so likely to catch and break.

b. Reaming.

Ream or file the burr that is left with a three cornered or rat-tail file. If the end of the spiral bends down it must be bent back out of the way of the wire.

22. COUPLING.

a. Screw two regular Greenfield box connectors together with a standard pipe coupling. Push the ends of the Greenfield in the ends of the connectors as far as they will go and tighten up the set screws.

b. To connect a piece of Greenfield to rigid conduit, screw a connector on a regular coupling and then on the rigid conduit. Push the flexible conduit on the connector and tighten up the set screw.

23. INSTALLING AND CONNECTING TO BOXES AND FITTINGS.

a. Installing.

Flexible conduit is used in wiring old buildings and so must be fished through walls and ceilings. When run parallel to the joists the flexible conduit may lay loose upon the ceiling. When run across the joists bore holes and run the conduit through them. When making turns let them be as large as possible so that the wire will fish through easily.
Fasten the conduit well at the turns so that when the wire is fished through the pull will not kink the conduit or pull it out of the box.

b. Connecting to boxes.

Put a regular connector on the Greenfield then push the connector through the desired knockout in the box. Place the locknut on and tighten securely against the box so that there will be no looseness.

24. PULLING IN CONDUCTORS.

Wires are not installed in Greenfield until all the flexible conduit is in place. In pulling in the wires a type of fish tape other than the flat may have to be used. In this case a round wire will be found best.

FLEXIBLE ARMORED CONDUIT (Bx)

25. CUTTING.

Place the conduit in a vice (or if a vice is not handy grasp it tightly in the hand and hold the arm rigid so that the Bx will be fairly stationary), being careful not to crush it and cut with a fine toothed hacksaw (24 teeth to the inch). Be careful not to cut the insulation on the wires.

In cutting Bx do not cut at right angles with it (as at A), instead cut at an angle of 45° (as at B).

![Hacksaw Diagram]

Do not cut all the way around the conduit, just cut through one layer on the side you start cutting on.

26. STRIPPING ARMOR FOR SPLICES.

After cutting through the sheath (6" will be enough for a splice) grasp the main section in the right hand and the 6" piece in the left hand. Twist the two pieces in the opposite direction, the piece in the right hand clockwise and the piece in the left hand counterclockwise, then pull the 6" piece off.

Next unwind the paper insulation and tear it off below the edge of the sheath. Insert a bushing between the wire and the sheath.

27. INSTALLING AND CONNECTING TO BOXES AND FITTINGS.

a. Armored cable may be used in the wiring of old or new buildings. In old buildings it must be fished through the walls and ceilings, and need not be supported when fished parallel.
to the joists. When run across the joists bore holes and pull the Bx through them. In making turns be careful not to bend the cable too short or it is liable to pull apart and expose the wire. If the cable is broken in a place the whole length must be replaced. When used in new work pipe straps or nails bent over may be used to hold the cable in place.

b. Put a regular Bx connector on the cable and tighten the set screw. Put the connector through the desired knockout in the box and tighten up the locknut against the box.

METAL MOLDING.

28. CUTTING.

a. To cut with a hacksaw place the molding in a vice or in some manner hold it rigid. Use a fine toothed blade and saw squarely through the molding. The cap and the base can be cut at the same time if desired.

b. To cut with a regular molding cutter, place the cap in the cutter so that the mark will be at the edge, and on the side that you wish it, of the cutter. Press down hard on the handle and cut. Proceed in the same manner for the base.

29. SLOTTING OR PUNCHING.

a. When molding is cut it is generally necessary to provide slots for screws on the fittings and also slots for the supporting screws. Hold the molding in the punch and push down hard on the handle. If the punch changes the shape of the molding, straighten with a few taps of a hammer.

b. If a punch is not available place the molding in a vice, and using a fine toothed hacksaw, cut a 1/8" wide by 1/8" long slot in the end of the backing.

30. COUPLING.

a. Screw coupling.

Loosen the screws on the coupling and slip the molding in place. Tighten the screws. Be careful not to strip the threads on the screws or try to remove them entirely as they are made so that they will not come off. The coupling may be put on either before the molding is put up or after.

b. Slotted coupling.

Screw the coupling to the wall. Insert the backing under the raised piece on the coupling. Screw the backing down. Cover over with the capping.

31. BENDING AND MITERING A TURN.

a. Bending.

To bend either use a Metal Molding Bender or bore a hole
through a 2x4, slip the molding through it, and bend. Be very careful to keep the base and cap of the Metal Mold together. It may be bent to any radius not less than 4 inches.

b. Mitering.

The inside bend is made by cutting a 90° notch out of the base, any square corner will give you the desired cut. Hold the molding in the vice and cut with a fine toothed saw, being careful not to cut through the base. The outside bend is made by sawing a straight cut in the base.

32. INSTALLING AND CONNECTING TO BOXES AND FITTINGS.

a. Installing.

The backing of each length of Metal Mold has several holes conveniently located for securing it to the wall or ceiling. The backing is secured to the surface being wired over, by means of screws, toggle bolts, or expansion shields, according to the type of surface.

The wires are then placed in this trough or backing and the capping is pressed on.

Care must be taken in the installation to conform with all code rulings. That is, the raceway must be continuous in order to obtain a good ground; when passing through floors the raceway must be protected, with an iron pipe, from the ceiling to a point 3 inches above the floor; the same holds true when molding passes through partitions whose surroundings are damp.

b. Connecting to boxes and fittings.

Secure the backing of the fitting or box to the surface being wired over. If this is a slotted type coupling, insert the backing of the molding under the raised piece on the backing of the fitting. If it is a screw type coupling, loosen the screw on the backing of the fitting or box and slip the molding in place; tighten the screw. Then secure the backing to the surface. Insert the wires and press the capping of the molding over the backing. Leave the covers of all boxes and fittings off until all connections and splices are made. Then snap, or fasten the covers with screws, according to the type.

33. CUTTING.

Place the Wiremold in a vice or between a couple of nails and saw on the mark with a fine toothed hacksaw (32 teeth). The molding should be held fairly rigid while cutting or you are liable to break the blade of the saw.
34. COUPLING.

Wiremold is furnished with one coupling per length, much the same as rigid conduit. To couple two lengths, slip the coupling out of its groove until the screw hole is visible and drive in the screw. Push the Wiremold to be coupled over the coupling and tap with a hammer until a good fit is obtained.

35. BENDING WITH A WIREMOLD BENDER.

In bending Wiremold both the backing and capping must be bent at the same time.

a. 90° bend
Mark off the distance to the point of bend on the molding. Mark ahead 5½ inches from this point. Place the inner edge of the latch of the bender on this point and bend. In bending apply pressure close to the bender.

b. Offsets.
Mark on the molding the place where the offset is to be and start the bender in the regular manner.
Turn the molding over and place the other point of offset at the latch and bend it down until it has the shape needed. Take short bites (the shorter the bite the better the bend).

36. INSTALLING AND CONNECTING TO BOXES AND FITTINGS.

a. Installing.
In installing Wiremold the backing and capping are installed at the same time. Each length of Wiremold is supplied with a coupling. This coupling has a hole in the center in order to secure it to the surface. After securing it by means of a screw, toggle bolt, or expansion shield, the length of wiremold is slipped over the coupling. The coupling fits in slots between the backing and the surface.
Wiremold may also be secured to the surface by the use of clips or straps. The clips are secured to the surface and the molding pressed into them. The straps are placed over the molding after it has been connected to the boxes and fittings.
After the molding has been installed the wires are pulled through the metal trough, thus completing the job.

b. Connecting to boxes and fittings.
Screw up the backing of all fittings. Slip the Wiremold onto these, being sure that the backing of the molding goes over the backing of the fitting, fasten the molding to the surface. Slip the tongue in the base of the box or fitting under the backing of the molding, and fasten to the surface with a #6 wood screw, expansion shield, or toggle bolt.
Leave the cover piece of all boxes and fittings off until the wire is pulled in and splices are made. Then snap, or fasten the covers on with screws, according to the type.

**XTENSIONDUCT**

37. USING THE CUTTING AND NOTCHING GAUGE.

For neat and accurate work the cutting and notching gauge is used. This will assure close fitting joints and corners.

The gauge is really a mitering box. It has two vertical cutting slots and two 45° slots. The vertical slots are for cutting through the molding, while the 45° slots are for mitering. Place the gauge in a vice so that it will be held rigid. Use a fine toothed hacksaw.

38. INSTALLING BACKING.

Mark the position of the run and measure for length. Cut the length you desire. In the backing are holes spaced about 2 ft. apart. Secure the backing to the surface, through these holes using $\frac{1}{2} \times 6$ F.H. wood screw.

39. PUTTING IN WIRES.

Of all raceways Xtensionduct is the easiest one to put wires in. You just lay the wires in. The backing is just large enough for two wires to fit snugly. Push the wires in, at one end, with the fingers and then press them in all along the backing.

40. PUTTING ON CAPPING.

The capping is snapped on. That is, press it on at one end, then move along its length and press the rest of it on with the hand. It will snap on easily and fit tightly.

41. COUPLING.

A coupling is provided to couple two lengths of backing. This coupling has one hole in it. Screw it on with a $\frac{1}{2} \times 6$ F.H. wood screw. Slip the backing under the slots provided and fasten the backing down. The capping will extend over the coupled pieces.

42. MITERING A TURN.

Place the cutting and notching gauge in a vice. Mark the backing where the miter is to be made. Slip the backing into the gauge and place the mark opposite one 45° slot. Cut with a hacksaw, cutting through the sides but not through the back. Move the mark to the other 45° slot and cut as before. This will leave a V-shaped notch. It can then be bent to make either an external or internal bend.
43. BENDING.

It is possible to bend Xtensionduct by installing the proper latch and adapter to a Metal Mold or Wiremold bender. In bending the base and capping must be assembled.

44. INSTALLING RUNNING BOARDS AND GUARD STRIPS.

a. Wiring over surfaces.

Quite frequently wiring is done over surfaces of brick, stone, or concrete instead of wood. Time will be saved if wooden strips are fastened to the wall and the cleats fastened to this backing, instead of drilling holes and fastening each individual pair of cleats to the wall.

b. Wiring through floors.

In cleat wiring it is sometimes necessary to wire through floors. When wiring through floors the wire must be protected from the ceiling to a point 7 feet above the floor.

One method of doing this is by the use of conduit. A suitable fitting, with bushed holes, is used on either end of the conduit. The conduit is run from the ceiling to a point 7 feet above the floor. Cleats should be used close to the point of entrance and exit of the pipe.

Another method is by use of a wooden box. Bore two holes through the floor, at least 2½ inches apart, with a #10 wood bit. Bush these holes with porcelain tubes long enough to reach through the floor. For 7 feet above the floor build a wooden box around the wires. No part of the box should come any nearer the wires than 1 inch. The wires should be protected, at the point of exit, from the box, by means of porcelain tubes. Use cleats on both sides of the tubes at the point of entrance to the floor and exit from the box.

45. INSTALLING CLEATS.

Examine the cleats to see if they are in good condition and are pairs. Fasten them to the surface with nails or screws. Screws are much better than nails as there is less chance to break the cleats. For ordinary cleats use a #8 screw 2 inches long. For use over plastered surfaces the screw should be at least three inches long.

46. MAKING A TURN.

a. It takes two cleats to make a turn. Space them close together, as shown in the figure. Make a square turn with the outside wire in a neat manner.

b. In making a long straight run, put up the first cleat and then go to the end of the run and put up the last cleat.
Smooth out the wires by sliding the handle of your screwdriver or hammer over them and then pull the wires tight. Put the supporting cleats at the proper intervals along the run.

47. MAKING A DEAD END.

Install a pair of cleats at the end of the run. Pull the wires tight and then make five or six turns about the wire.

48. TAPPING A CIRCUIT.

a. Run the branch circuit up to the place where it is to tap the main circuit. It takes three pairs of cleats to make a tap. Put one pair on the tapping branch about one inch from the main branch. Put the other two on the main branch on each side of where the wires will tap the circuit.

b. Remove the insulation from about 1 inch of the wires. Put a tube on the wire that is to cross the wire of the main line so that it will be under it, that is, the tube is next to the surfaced wired over. Make the joints by twisting the tapping branch wires onto the main wires.
49. CONNECTING TO FITTINGS.

There are only three main types of fittings used in Cleat Wiring. Namely, the cleat receptacle, the rosette, and the snap switch.

a. The cleat receptacle.

The cleat receptacle is generally used as a light outlet. It is made in one piece, either of porcelain or bakelite. It has two exposed terminals and two holes for supporting screws.

To install, fasten the receptacle to the surface being wired over with two #6 wood screws 1 inch long. Remove a small amount of insulation from the wires and wind them around the binding posts in the direction the screw turns to tighten.

b. The rosette.

The rosette is a porcelain fitting used either for a drop cord or extension cord. It is made in two pieces; namely, the cap and the base. The base has two binding screws to connect the line wires to, and two spring clips, connected to the binding screws, to hold the cap on. The capping has two binding screws to connect the drop or extension cord to, and two prongs, connected to the binding screws, to hold the capping and base together. The contact between the base and cap is made through the clips and prongs.

The base is fastened to the surface, with #8 wood screws 2 inches long, by means of a slotted piece called a sub-base. This sub-base keeps the wires from touching the surface. The wires are laid in these slots and brought up through the back of the base and attached to the binding screws. The extension cord is brought into the cap, through a hole in the center, and attached to the binding screws. Tie an Underwriters' knot with this wire, in the cap, so that the weight of the fixture on the other end of the cord will pull against this knot instead of the connection at the screws. Place the prongs on the cap under the clips on the base and twist the cap until the prongs have slipped all of the way under the clips.
c. Snap and toggle switches.

The construction of the switch base is quite similar to the construction of the base of the rosette. That is the wires must be brought in from the back. Therefore, if the switch were attached to the surface without some additional base, the wires would be pressed directly against the surface. The type of base used is the same as that for the rosette, a porcelain sub-base.

Remove the insulation from the ends of the wire, and bring them through the holes provided in the base of the switch. Attach the wires to their respective binding screws, being careful not to leave the ends projecting so that they interfere with the operation of the switch.

Adjust the wires where they enter the base so that they fit into the slots of the sub-base. Secure the two bases to the surface by means of #8 wood screws 2 inches long.

Attach the cap to the switch and operate.

KNOB AND TUBE IN OPEN WIRING

50. BORING JOISTS, STUDS, ETC. FOR TUBES.

In boring holes through joists the holes should be bored at an angle with the floor, rather than parallel to it; this lessens the danger of the tubes becoming dislodged. The holes should be kept in a straight line; this makes the stringing of the wires easier. The holes should be spaced evenly; they must be at least 5 inches apart to meet the Code requirements. The holes should be clean, this to make the installation of the tubes easier.

Bore the holes with a 5/8 inch or #10 wood bit. The job will be much easier to do if an 18 inch bit extension and a ratchet brace are used.

51. INSTALLING TUBES.

After all of the holes have been bored insert the tubes. The tubes should be placed with the head on the higher end of the hole, except where the wire is run from a tube to a knob. Then the head of the tube is placed on the same side of the joist with the knob. In this case the knob and the wire hold the tube in place. If the tube is not placed in this manner it is quite likely to break when the wire is tightened.

52. STRINGING CONDUCTORS.

a. It is best to first lay out the line wires. If possible pull them in the full distance of the circuit. The switch legs, light legs, and wires for receptacles can then be tapped on this.

b. In pulling in the wire pull in the direction of the tube, that is, in the direction which the tube slants or against
its head. It generally will be impossible to pull through more than 3 to 5 joists at a time.

c. Wires cannot be run directly from tubes to outlet boxes. This is because the sagging of the wires makes a fire hazard due to the possibility of their coming into contact with the surface. It is necessary that the wire first be run to a knob and drawn tight; then run into the box.

53. FASTENING WIRE WITH KNOBS.

a. General
   It is not only customary to run wires through joists and studs, but also parallel to them. When wiring over the surface of these pieces it is necessary to support the wires at least every 4½ feet, and to keep them 1 inch from the surface. This is done by means of porcelain knobs.

   Attach the wire at one end of the flat surface to a knob that has been nailed down. At the other end of the run draw the wire fairly tight and attach it to another knob. Tilt this knob so that the head is pointed toward the first one.

   Drive the nail in. The flat surface of the base of the knob will cause the knob to straighten up and draw the wire taut.

   If supports are needed between these two end pieces, additional knobs can be added. It is unnecessary to tilt them in either direction.

b. Solid knobs.
   It is best to use solid knobs at the beginning and end of the run, where the wire terminates at outlet or switch boxes, and also can be used at all other points.

   When solid knobs are used as a support in the middle of a run it is necessary to use a tie wire. That is a wire to hold the main wire against the knob.

   When used at the end of runs it is unnecessary to use the tie. Instead wrap the wire all the way around the knob. Then twist the knob four or five times until there are several end turns at this point. Then drive the knob home.

c. Split knob.
   It is best to use split knobs for supporting a run of wire. Split knobs are also used when tapping a circuit or when changing from a run through joists to a run parallel to them. It is possible but not best to use split knobs at the beginning or end of a run.

54. BRINGING WIRES INTO OUTLET AND SWITCH BOXES.

   It is quite obvious, from the dimensions of outlet and switch boxes, that the 5 inch minimum distance allowed between wires cannot be maintained when bringing wires into them. Therefore, additional insulation must be used. A flexible, non-metallic sheathing, called loom, is used. This loom must be run from the
last support, on the wire, to 1 inch inside the box. It is held in place in the box by means of loom clamps. About 6 inches of wire should be left for the splices. In boxes rat-tail splices are generally used.

55. TAPPING A CIRCUIT.

Split knobs are used when taps are made. Run wires through the joists, using porcelain tubes. Place the heads of the tubes on the side the tap is to be made. Place a split knob, for the tap, on the side where the wires come through the joists, so that the bottom groove holds the main wire and the top groove holds the wire being tapped on. Wrap the tap wire around the main wire four or five times (this affords extra strength to the splice). Then make the splice, solder, and tape it.

The splice on the other wire is made in the same way. In crossing the first wire be sure to place a porcelain tube on the tap wire and tape it to the main wire so that it will not move and rub the insulation off of it. Use another split knob as before and make the splice in the same manner.

The split knob used affords strength to the main wire, the tap wire, and takes the strain off the splice.

56. GROUNDING A KNOB AND TUBE SYSTEM.

In grounding Conduit, Raceways, or Armored Cable, the whole system may be grounded. While in the Knob and Tube system, because there is no metallic connection between outlets other than the wire, only the service cabinet is grounded.

Attach a lug, by means of sweating, on one end of the ground wire. Bolt this lug to the service switch box, be sure to remove all enamel from the point of contact. The other end of the wire should be attached to a water pipe, on the street side of the meter if possible. If this is too far, place a jumper over the meter, and attach to any convenient water pipe. The wire should be #8 bare copper, and run through conduit to a point close to where the ground connection is to be made. There attach a ground clamp to the point of ground and another one to the end of the conduit. Bring the wire out of the conduit and fasten it first to the ground clamp on the conduit; then attach it to the ground clamp on the water pipe. This will afford better support for the wire and will also make a better contact.

BELL WIRING

57. PLANNING AND MAKING A BILL OF MATERIAL.

Making a bill of material for a bell wiring job is much simpler than for a house wiring job. Mainly because of the smaller amount of material needed.
a. Count the number of bells and buttons required.
b. Layout on the booth the location of the bells and buttons. 
Measure for the wire between them (allow for coils at the bells).
c. Estimate the number of screws and tacks needed.

58. DRAWING THE DIAGRAM.

Your diagram will be easy to draw if you always remember that the bell and button must be connected on the opposite sides of the battery. The drawing of the diagram can be shown in three steps.

a. Draw the wire connecting your bell or bells to the battery first. If there is more than one bell connect them together and tap the wire to the battery on to this.
b. Next draw the wire or wires connecting the bells to the buttons that are supposed to ring them. This part requires the most care in tracing the circuit.
c. Last connect the remaining sides of the buttons to the battery. As in the first step, if there is more than one button, connect them all together and tap a wire onto this for the battery.

59. INSTALLING PUSHBUTTONS.

All pushbuttons are mounted on square wooden bases, having three holes for screws. Wires are brought from terminals on the button, through the back, and are connected to clips on the bottom of the base.

The button will be placed at the desired height so that it is parallel with the floor. Use 3-½ x 6 F.H. wood screws to hold the base. If more than one button is used, keep them at the same level or on a line parallel with the floor. The space between buttons is to be large enough so that another one could be placed in it and have one inch room on either side.

60. INSTALLING BELLS.

All bells are mounted on square wooden bases, having 3 holes for screws. Wires are brought from terminals on the bell, through the back, and are connected to clips on the bottom of the base.

The bell will be placed at the desired height so that it is parallel with the floor. Use 3-½ x 6 F.H. wood screws to fasten the base to the wall. If more than one bell is to be used keep them all on the same line parallel with the floor. The bells are to be 8-inches apart when more than two are used. With only two bells they should be placed one foot apart.

61. WIRING IN A BELL CIRCUIT.

There are four operations that will occur in every bell
wiring job; (a) coils must be made at the bells and at the battery; (b) all kinks must be removed from the wire; (c) all turns must be made at right angles and wires run straight horizontally and vertically; (d) the insulation must be removed from the ends of the wire in such a manner that it will not unravel after being installed.

How is all this done? It can best be explained by telling how a complete job is wired in. Let us consider Job No. 1. First assume that the bell, button, and battery have been placed in the positions designated in the diagram.

a. Take a piece of wire that is to be fastened to one pole of the dry cell. Untwist both coverings from about one inch of the end of the wire and tie the two coverings together around the wire. Cut off the excess covering.
b. About an inch from this uncovered portion wind the wire around a pencil four or five turns, to form a neat coil.
c. Fasten the wire to the wall of the booth with a staple, leaving the end just long enough to extend to the terminal of the cell.
d. Loosen the nut on the terminal of the dry cell and wrap the bare end of the wire around the post in the direction the nut will turn to tighten. Make only one wrap and then tighten the nut. Nick the spare end of the wire with a knife at the point where it leaves the nut and break it off by bending it back and forth.
e. If there are any kinks in the wire, straighten them by holding the wire tight and rubbing it with the handle of a screwdriver.
f. Draw the wire tight and staple it to the wall of the booth at the point where it is to make the first turn. It should be tight enough to prevent sagging.
g. Continue the run, making right angle turns, and place a staple at each turn and one near the end of the run.
h. Remove the insulation from the end of the wire (as in a) and clip to the pushbutton.
i. Clip a wire to the other terminal of the pushbutton in the same manner and continue the run to the bell. Staple it to the wall near the bell and make a coil just as you did at the cell. Fasten the wire to one clip on the bell.
j. Make a coil in another piece of wire and fasten to the other clip on the bell and run to the other terminal of the cell. There make a coil and fasten to the other terminal, as you did in (d)

62. MAKING JOINTS.

Only two types of joints are used in bell wiring; the Western Union and the Plain Tap. It is much easier and simpler to make these splices with #18 annunciator wire than with ordinary #14. The wire is soft and pliable, therefore, the splice can be made with the fingers.
The splices are made and formed with the fingers. Then
tightened with pliers.
It is unnecessary to solder a splice for bell wiring.

63. CONNECTING DRY CELLS.

a. In series.
To connect dry cells in series connect the positive poles
to the negative. This will increase the voltage while the
current remains the same.

b. In parallel.
Connect like poles to like poles. That is positive to
positive and negative to negative. This will cause the
current to increase, while the voltage remains the same.

64. INSTALLING SWITCH BOXES

Switch boxes have to be installed in many different types
of walls. The most common being the unfinished frame wall.
The quickest and most common method of installation of a
switch box is by means of the switch box bracket. One side of
the switch box is a bracket or ear; on the other side is a
lath support. This bracket or ear is nailed to one of the
studs. When the laths are nailed on, the other side of the box
is supported by one end of the lath.

65. INSTALLING FIXTURE OUTLET BOXES.

Outlet boxes have to be installed in many different types
of walls and ceilings. The most common type being the unfinished
frame wall or ceiling.

a. The straight bar hanger.
When this type of hanger is used, attach the box and
bend the bar so that it will fit in between the joists.
Place the hanger between the joists so that the surface
of the box will hang about \( \frac{1}{2} \)-inch below their surface.
This will make it flush with the finished plaster. Then
nail the bar in place.

b. The offset bar hanger.
When this type of hanger is used it is only necessary
to attach the box to the bar and nail it on the surface
of the joists. The box will always come flush with the
finished plastered surface.

66. INSTALLING CUTOUTS AND PANEL BOXES.

The service group or board consists of three parts: the meter,
the service switch, and the fuse cabinet.

a. The meter.
   The wireman always installs the meter back and runs the service wires, as explained in Operation 80, to it. The meter is installed and connected by a representative of the power company and not by the wireman.

b. The service switch.
   The service switch or main-line switch is next connected. Two wires are run from it to the meter back and others to the fuse cabinet. A complete explanation of the installation is given in Operation 80.

c. The fuse cabinet.
   In homes it is very seldom that more than two circuits are needed. In some buildings instead of having all of the circuits grouped in one panel, one or more cutouts may be located at various points over the building. The cutout or fuse cabinet is nothing more than a steel box containing the fuses for each circuit, where the number of circuits are small.
   The steel cabinet is either placed flush with the wall or on the surface, according to the situation. It may be fastened to any type of wall. The wires are run to it, through conduit, and connected according to the wiring diagram of the number of circuits in the job.
   On installations larger than the above mentioned and where it is necessary to group the circuits, large steel boxes, known as panel boxes, are used.
   As a general rule these cabinets are recessed into a wall so that the cabinet is flush with the wall surface. These cabinets, besides containing the fuses, sometimes hold switches that control each individual circuit. Where there are more than four circuits it is necessary that the cabinet be "guttered". With these cabinets the wires are run from the meter to the main switch and thence to the various parts of the cabinet, according to the number of circuits required.

SWITCHES AND RECEPTACLES

67. INSTALLING FLUSH SWITCH OR RECEPTACLE.

a. Switches.
   1. Single pole.
      The installation of the single pole switch is very simple. Remove the insulation from about 1/4-inch of the end of the wire. Bend these bare ends in the form of a hook and place around the binding post screw in the direction the screw is turned to tighten. Fold the extra wire back into the switch box and attach the switch to the box with the machine screws furnished with the switch.
Attach plate and the job is done.

2. Three-way switches.

The installation of switches to control lights from two or more points is similar to that for single pole switches in preparing wires, attaching to binding post screws, folding the wire into the switch box, attaching the switch to the box, and attaching plate.

In installing these switches you must be sure to get the line or light wires to the shunt side, or side having the dark terminal, of the switch; and the traveller wires to the other terminals. If these wires are crossed the switch will not work properly. (Under the last named conditions, it is possible to turn the light on only at the point where it was turned off).

3. Do not remove too much of the insulation from the wires that are to go under the binding screws. There is danger of the bare wire touching the switch box and shorting the circuit.

b. Receptacles.

Remove the insulation from about ½-inch of the end of the wires. Bend these bare ends in the form of a hook and place around the binding post screw in the direction the screw is turned to tighten. Be sure to connect the black wire to the dark terminals and the white wire to the white terminals. Fold the extra wire back into the box and attach the receptacle to it with the machine screws furnished. Attach plate and the job is done.

68. INSTALLING SNAP SWITCH ON SPIDER COVER.

When a surface toggle switch or snap switch is used in connection with an octagon outlet box, it is mounted on a "spider cover". The base of the switch is attached to the cover with machine screws or bolts. The wires are brought in through the holes in the base and cover provided for them and attached to the binding screws. The cover is placed on the outlet box and the screws tightened. The switch cover is then placed on.

SPICING AND SOLDERING

69. SPICLING.

Since it is frequently necessary to join two or more wires together, the student should become proficient in the making of several types of splices.

The splices which will prove the most useful are the Western Union Short Tie; the Plain Tap; the Double Wrapped Cross Joint; the Rat-Tail; the Through Fixture Joint; and the Terminating Fixture Joint.
70. GENERATING A BLOW TORCH.

Fill the torch about three-fourths full of gasoline. Pump in enough air so that the gasoline will come out in a good stream when the torch is turned on. Hold the hand over the end of the torch and let the gas run until the little cup is nearly filled. Turn off the gas and light. The idea is to get the neck of the torch good and hot so that the raw liquid gasoline will be turned to a vapor, which when mixed with the air will burn with a hot blue flame. See that there is nothing near that is liable to catch fire while the torch is generating. Protect the blaze from any drafts that might tend to blow the generating flame from the neck of the torch, as this neck must be HOT before the torch will act properly.

When the gasoline has burned out in the cup, turn on and light. The flame should be blue, with little or no yellow in it. If the flame is yellow it will smoke the joint and make it hard to solder.

71. TINNING A SOLDERING IRON

Before the iron can be used it must be put in shape to solder, this is called Tinning the iron. Heat the iron until it will melt solder, then with an old file clean off the scale from the point of the iron only. Do this quickly, and then rub the point on a block of sal-ammoniac, along with a drop of solder, this solder will run and cover the point of the iron, "tinning" it. This whole operation should be done speedily, so as not to allow the iron to cool. If still hot the iron is now ready to use.

72. SOLDERING JOINTS.

a. With an Alcohol Torch.

An alcohol torch is very handy for soldering joints in confining places, and also where there is danger of marring surfaces when using a blow torch or a copper.

There are two types of torches each emitting a small pin flame. One generates its own force for the flame. The other has a rubber tube attached through which the operator blows, thus giving the force.

Apply paste to the joint, light the wick, and generate the force. Apply the flame to the joint, melt the paste, and apply solder to the top. After the solder has melted and flows through all parts of the joint, let it cool and then insulate.

b. With a Blow Torch.

Put some paste on the joint and hold the torch in such a position that the end of the blaze will play on the joint and not burn the insulation of the wire. Hold the flame on the joint until the soldering paste has stopped sputtering,
then move the flame a little to one side and put the solder on the joint and NOT IN THE FLAME. If the joint is not enough the solder will flow smoothly. It is not necessary to put much solder on a joint.

c. **With Copper.**

Rub a little soldering paste on the joint to be soldered. Place the point of the tinned iron about midway on the joint. Place the end of the solder against the iron and melt a small drop. **DO NOT PUT MORE SOLDER ON UNTIL THAT DROP FLOWS FREELY ALONG THE JOINT.** When this occurs a little more solder may be added. Leave the iron on the joint until the solder runs freely and covers the joint.

d. **General.**

These things are necessary for good soldering.
1. A hot iron.
2. A tinned iron.
3. A clean joint.

73. **Taping Joints.**

After the joint has been made and soldered all of the bare copper must be insulated. This is done by wrapping layers of the same type of insulation, that had been removed from the wire, over the joint. The insulation is furnished in tape form, for housewiring rubber and friction tape are used.

To apply this insulation, first put on a layer of rubber tape so that it over-laps half the width of the tape. Apply it so that after the wrapping no metal will show. Next apply at least one layer of friction tape, also letting it over-lap one-half its thickness.

**Fixture**

74. **Making an Underwriters' Knot.**

The making of the Underwriters' knot requires four steps:
1. Separate the ends of the twisted cord far enough to allow for the knot and have enough wire left to make the connections.
2. Hold the wire in the left hand so that the separated ends form a V. Following the figure; loop the end #1 all the way around #2, returning it to its original position.
3. Now loop end #2 around end #1 and bring it up through the loop formed by end #1.
4. Grasp the two ends in the right hand and pull the knot tight.

75. MAKING A DROP CORD.

In making a drop cord, attaching a plug at one end and a brass socket at the other, Underwriters' knots must be tied for both.

a. Attaching the brass socket.
The brass socket has a brass shell and a porcelain interior. They are insulated from each other by means of thin cardboard or insulating paper. The cap of the shell can be removed, making the porcelain piece accessible.
To remove this cap, press with the thumb on the middle part of the shell, next to the key, where the mark "press" is stamped. Lift off the cap.
Run this cap over the cord and tie the Underwriters' knot under it. This knot will remove the weight from the binding screws. Remove the insulation from the wires and attach to the screws on the porcelain piece. Then replace the brass shell.

b. Attaching the plug.
Run the plug over the wire and tie the Underwriters' knot. Pull the knot up tight into the plug. Remove the insulation from the wire and wrap each separate wire around outside, the brass upright to the binding screws. By bringing the wires to the binding screws this way, there is very little danger of shorting out the plug. Connect the wires to the binding screws, and the drop cord is ready.

76. INSTALLING A Fixture STUD IN AN OUTLET BOX.

A fixture stud is a small iron piece having, on one end a tapped hub, on the other end four legs which flare out. These legs afford a means of attaching the stud to the box or surface. The tapped hub is made to receive the fixture pipe.
Attach the stud to a box by means of a machine screw, or to the surface by what means are used to attach to that type of surface.

77. INSTALLING A CHAIN FIXTURE.

The fixture is generally already made up. If of a single chain type, the chain hanging to a hook that screws on the end of the fixture stem. If of a type using more than one chain, it will be hung on canopy hooks or hooks attached to the edge of the canopy. The wires will be run through the chain and connected to the socket or sockets. It is necessary to use flexible conductors when chain fixtures are wired, if solid
conductors are used they are liable to be weakened and broken off by the swaying of the fixture. After installing the fixture stud, screw on the stem. Make the splices between the fixture cord and line wires. Slip the canopy over the fixture stem, slip a brass shell over the part of the stem extending beyond the shell. Then for a single chain, screw the fixture over the end of the stem. If the fixture is of the multiple chain type, a fitting will be provided to go on the end of the stem.

GE
eral

78. LOCATING OUTLETS.

In general the wiring plan will show the number and kind of outlets in a room. If there is more than one ceiling outlet the plans will usually give their location.

a. A single ceiling outlet is always located in the center of the room. To do this one workman will get in one corner of the room and, holding a pencil about one foot in front of his face, sight the opposite corner of the room. Another workman, with a stick held upright, stands in the center of the room. The stick is moved, keeping it upright, until it comes in the line of sight of the first workman. This man then moves to the other corner of the room and again sights. The stick is again moved, so that its line of movement is that between the first corner sighted from to the opposite corner, until it comes in the line of sight of the workman. He then checks from the other position and, if no further movement is required, the outlet is installed.

b. The location of switch boxes are always shown on the plans. The top of the switch box is always 4 feet 6 inches from the floor, unless otherwise specified.

c. The location of the receptacle boxes are always shown on the plans. Unless otherwise specified, they are to be 16 inches above the floor.

79. TRACING AND TESTING CIRCUITS.

a. Tracing.

Where only a few wires are involved in a circuit the best means of assuring identification is the use of varied colored wires. But where there are many wires, or a few of the same color, the best means of tracing is with a buzzer and dry cells connected in series.

For a short run, attach the free terminal of the buzzer or battery to one end of a wire to be tested. Connect a wire to the other free terminal and touch the other end of each wire to be tested with this wire. When the buzzer sounds, you have found your wire. Tag it and test for the next one. However, in long runs a different method must be used.
Attach the batteries to two wires to be tested. Test between two wires at the other end until the buzzer sounds. Temporarily tag these two wires. Disconnect one of the wires from the battery. Connect another to be tested. Again move the buzzer over the other ends of the wire until it sounds. Then mark the first wire to be disconnected #1; the wire used in the first and second test #2; and the other wire #3. If there are more wires continue the test, using wire #3 as a common.

b. Testing.
The job should always be tested for shorts and grounds. All wires are pulled in and marked before the fixtures, switches, and receptacles are installed.

In testing, twist the wires that are to be connected to switches, receptacles, and fixtures together. At the fuse cabinet, touch across the black and white wire of each circuit with a buzzer and battery connected in series. If the buzzer sounds the circuit is O.K. If the buzzer does not sound, there is something wrong somewhere in the wiring of that circuit. If a fuse blows there is a short circuit. This possibly might be caused by some of the untaped wires touching a box.

In a conduit system, an additional test is made by touching the free terminal of the buzzer to the white wire, and the free terminal of the battery to the iron box. The buzzer should not sound. Then touch between the black wire and the iron box. The buzzer should sound.

If these tests check O.K. the circuits are ready to receive the switches, receptacles, fixtures, and fuses.

80. INSTALLING THE SERVICE.

The installation of the service will be made much easier if a wooden backing is used. This is especially true when the installation is made on a concrete or brick wall.

The meter back, which the wireman obtains from the power company, is fastened to the left hand side of the backing, near the top. Below this fasten the service switch box to the backing. Connect the switch box to the meter back with a piece of conduit. If more than one circuit is to be used, a fuse box will be installed. Fasten this to the backing, to the right of the switch box. Connect the fuse box to the switch box, with a short piece of conduit.

Run the required number of wires from the switch up to the meter back. Leave the ends in the meter back extending out, and connect the other ends to the switch. Run your wires from the switch to the fuse box, connecting at each end. Then attach the wires of the various circuits to the fuse block in the box.

Bring the service wires in from the outside through conduit. 3⁄4-inch conduit and #10 rubber-covered single-braid wire are the smallest sizes permitted. On the outside attach an entrance cap to the end of the conduit. The other end of the conduit is
attached to the top of the meter back and the wire left extending out of it.

The entrance cap should be as high as the ceiling of the first floor. The wires are left extending out of the cap. When the power company connects their lines with these wires and install the meter, the service is complete.

81. DRILLING THROUGH BRICK AND CONCRETE WALLS.

Only two tools are necessary for the drilling operations. They are, a star drill and a #2 ball pein hammer.

Begin the hole by tapping, at a good rate, on the head of the drill, turning the drill a very small amount after each tap. As the hole gets deeper swing the hammer harder and continue to turn the drill. This turning of the drill keeps the drill from sticking and makes the hole smooth and round. From time to time clean out the dust in the hole either by blowing or spooning. The former is dangerous because the workman is liable to get the dust in his eyes. The latter is done either by twisting and removing the drill or by a flat piece of metal.
BELL CIRCUITS

GENERAL INSTRUCTIONS

1. Go to the booth in which you are going to work and study the job specifications of the job you are going to do.

2. Layout the position of the bells and buttons on the wall, using chalk.

3. Using the Unit Operation Checking Sheet, list out and check the Unit Operations involved in this job.

4. Make out your Bill of Material, in duplicate, and have it checked by the instructor.

5. Secure from the stock-room all the material you need. At the close of the period lock up in your locker all the material which you have not yet installed. You are responsible for all the material listed on your Bill of Material.

6. Put up your work in a neat, serious-minded fashion, so that you will form workmanlike habits.

7. Keep your booth clean.
## BELL CIRCUITS

### UNIT OPERATION CHECKING SHEET

**INSTRUCTIONS:**

Place in the column at the right the Unit Operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT Operation</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>58. Drawing diagram</td>
<td>2</td>
</tr>
<tr>
<td>57. Planning and making a bill of material</td>
<td>3</td>
</tr>
<tr>
<td>59. Installing push buttons</td>
<td>4</td>
</tr>
<tr>
<td>60. Installing bells</td>
<td>5</td>
</tr>
<tr>
<td>61. Wiring in bell circuits</td>
<td>6</td>
</tr>
<tr>
<td>62. Making joints</td>
<td>7</td>
</tr>
<tr>
<td>63. Connecting dry cells:</td>
<td>8</td>
</tr>
<tr>
<td>a. In series</td>
<td>9</td>
</tr>
<tr>
<td>b. In parallel</td>
<td>10</td>
</tr>
</tbody>
</table>

### METHOD OF GRADING WORK

<table>
<thead>
<tr>
<th>Standard time for each job</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>3</th>
<th>2</th>
<th>6</th>
<th>6</th>
<th>8</th>
<th>6</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time used for each job</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### UNIT GRADES

- Drawing: 20%
- Application: 15%
- Time: 25%
- Workmanship: 25%
- Operation: 15%
- Summarized grade: 100%
This is a simple bell circuit. One bell operated by one button, connected either to a battery or transformer. This type of circuit has many uses, the main one being for a door bell.

**SPECIFICATIONS**

a. 1. Install bell, battery, and button in the position shown on the diagram. They are to be installed in the manner stated in operations 56 and 60.
2. Draw the wiring diagram and have it approved by the instructor.
3. Wire according to your own diagram, using the method of installation as stated in operation 61.
4. Have job checked for neatness of installation and for operation.
5. Keep the place where you are working clean.

b. 1. This is the same as part (a), with the exception of the power supply.
2. Remove the battery from (a). Connect the bell wire of the power supply to the secondary of a transformer. Connect the primary of the transformer to a 2-fuse cutout. The other side of the cutout is to be connected to a 110-volt line.

**BILL OF MATERIAL**

1 Vibrating bell 1 Transformer (110-8 volt)
1 Single-contact push button 1 2-fuse cutout
1 Dry cell 6 ft. #18 Annunciator wire

**QUESTIONS**

The questions for Job No. 1 will be found on page 58.
BELL CIRCUITS
JOB NO. 2

PRINCIPLE OF OPERATION

More than one push button may control a bell, if the buttons are connected in parallel. In this system by pushing any one of the buttons, the bell will ring. However, care must be taken not to connect the buttons in series, inasmuch as it will require closing all buttons at the same time to ring the bell.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
2. Draw the wiring diagram and have it approved by instructor.
3. Wire according to your own diagram, using the method of installation stated in operation 61.
4. Have job checked for operation and neatness of installation.
5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
2. If transformers are used, connect them as stated in part (b) of Job No. 1.

BILL OF MATERIAL

Make out your Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 2 will be found on page 58.
BELL CIRCUITS

JOB NO. 3

〇 〇 〇 BELLS

□ BUTTONS

| BATTERY |

PRINCIPLE OF OPERATION

This is the ordinary parallel system of controlling a number of bells from one location. One source of current supplies the energy for all the bells. The bells are so connected, in parallel, that when the button is pushed all three bells ring.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the positions shown on diagram. Install them as stated in operation 59 and 60.
2. Draw the wiring diagram and have it approved by the instructor.
3. Wire according to your own diagram, using the method of installation stated in operation 61.
4. Have job checked for neatness of installation and for operation.
5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
2. If transformers are used connect them as stated in part (b) of Job No. 1.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 3 will be found on page 58.
**BELL CIRCUITS**

**JOB NO. 4**

![Diagram of bell circuit with 1 bell, 2 buttons, and 1 battery]

**PRINCIPLE OF OPERATION**

In this circuit the bells are to be controlled from different locations. Either push button at the extreme ends operates both end bells simultaneously, and the center button controls only the center bell.

**SPECIFICATIONS**

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
   2. Draw the wiring diagram and have it approved by instructor.
   3. Wire according to your own diagram, using the method of installation stated in operation 61.
   4. Have job checked for operation and neatness of installation.
   5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
   2. If transformers are used connect them as stated in part (b) of Job No. 1.

**BILL OF MATERIAL**

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

**QUESTIONS**

The questions for Job No. 4 will be found on page 58.
BELL CIRCUITS
JOB NO. 5

PRINCIPLE OF OPERATION

This is known as a three-wire return call system. By pressing button 1, bell 1 will ring and by pressing button 2, bell 2 will ring. In other words a person at station 1 may call another person at station 2 and be answered.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
2. Draw the wiring diagram and have it approved by instructor.
3. Wire according to your own diagram, using the method of installation stated in operation 61.
4. Have job checked for operation and neatness of installation.
5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
2. If transformers are used connect them as stated in part (b) of Job No. 1.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 5 will be found on page 58.
This is known as an intercommunicating bell system, and may be used in connection with speaking-tube or interior telephone system. The idea involved is to have a sufficient number of push buttons at each station to enable the remaining stations on the same system to be called independently of one another. This job having only 3 bells works as follows: station #1 has 2 push buttons, so arranged that the bells at stations #2 and #3 may be called by closing the circuit of a button corresponding to their station number. At station #2 the buttons are arranged to control bells #1 and #3, respectively. At station #3 the buttons are connected to bells #1 and #2, respectively.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the positions shown on diagram. Install them as stated in operations 59 and 60.
   2. Draw the wiring diagram and have it approved by instructor.
   3. Wire according to your own diagram, using the method of installation stated in operation 61.
   4. Have job checked for operation and neatness of installation.
   5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
   2. If transformers are used connect them as stated in part (b) of Job. No. 1.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1

QUESTIONS

The questions for Job No. 6 will be found on page 59.
BELL CIRCUITS

JOB NO. 7

1  2  3

4  4  4

1  2  3  4

PRINCIPLE OF OPERATION

This type is an extensive return-call system using single-contact push buttons. Here, a set of the upper bells and buttons may be distributed to various places. The lower set of buttons and the buzzer are installed at a central point. Each of the upper buttons operates the buzzer at the central point, and each of the lower buttons operates a correspondingly numbered bell above.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
   2. Draw the wiring diagram and have it approved by instructor.
   3. Wire according to your own diagram, using the method of installation stated in operation 61.
   4. Have job checked for operation and neatness of installation.
   5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
   2. If transformers are used connect them as stated in part (b) of Job No. 1.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 7 will be found on page 59.
PRINCIPLE OF OPERATION

A return-call and master system may be used as a fire alarm as well as a call system, by installing master buttons in the upper circuit of Job No. 7 and connecting in parallel with a master placed in the lower circuit. Also change the buttons in the lower circuit to double-pole buttons.

When either of the buttons marked 4 are pressed, the buzzer in the lower circuit will ring. When a double-contact button is depressed its correspondingly numbered bell will ring. When the double-buttons are closed in the upper position and any one of the master buttons pressed, all three bells will ring in parallel.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
2. Draw the wiring diagram and have it approved by instructor.
3. Wire according to your own diagram, using the method of installation stated in operation 61.
4. Have job checked for operation and neatness of installation.
5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
2. If transformers are used connect them as stated in part (b) of Job No. 1.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 8 will be found on page 59.
BELL CIRCUITS

JOB NO. 9

PRINCIPLE OF OPERATION

This circuit is used for wiring apartment bells and door-locks. Here, the lower group of push buttons, usually placed in the vestibule or entrance of the building, is arranged so that each rings a bell in a designated apartment. (Button rings correspondingly numbered bells). This is to notify the occupant of the arrival of some one. When they have been identified, by means of a speaking tube, the person in the apartment presses a button, near the speaking tube, which operates the electric door-lock at the entrance of the building. This unlocks the door and allows the person to enter. The door remains unlocked only while the button is pressed down.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
2. Draw the wiring diagram and have it approved by instructor.
3. Wire according to your own diagram, using the method of installation stated in operation 61.
4. Have the job checked for operation and neatness of installation.

b. 1. Transformers may be used instead of batteries if you prefer.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 9 will be found on page 59.
This is an addition to the circuit in Job No. 9. Its essential purpose is to provide a buzzer at the rear entrance of each apartment. The buzzers are rung by correspondingly numbered buttons.

SPECIFICATIONS

a. 1. Install bells, battery, and buttons in the position shown on diagram. Install them as stated in operations 59 and 60.
   2. Draw the wiring diagram and have it approved.
   3. Wire according to your own diagram, using the method of installation stated in operation 61.
   4. Have job checked for operation and neatness of installation.
   5. Keep the place where you are working clean.

b. 1. Transformers may be used instead of batteries if you prefer.
   2. If transformers are used connect them as stated in part (b) of Job No. 1.

BILL OF MATERIAL

Make out your own Bill of Material following the instructions of Operation 57 and Job No. 1.

QUESTIONS

The questions for Job No. 10 will be found on page 60.
QUESTIONS FOR BELL CIRCUITS

Job No. 1.

3. Make a drawing of a dry cell showing its interior construction. Label all parts. Electric Wiring--Schuhler P51
4. When would it be necessary to use more than one bell ringing transformer in a circuit? Electric Wiring--Schuhler P60

Job No. 2.

1. What are the Code requirements for bell wiring? Electric Wiring--Schuhler P45
2. What are push buttons made of? Shop manual P7
3. Describe the bell ringing transformer, its construction, and principle of operation. Electric Wiring--Schuhler P59
4. What is the minimum size wire permitted for connection between the lighting circuit and primary side of the transformer? Electric Wiring--Schuhler P60

Job No. 3.

1. Why is it desirable to keep signal wires more than 2" from light or power wires? Electric Wiring--Schuhler P45
2. How many different types of buttons are available? Shop manual P7
3. What are the essential parts of a bell circuit, and what are their use? Shop manual P8
4. How much energy is consumed by a bell ringing transformer? Electric Wiring--Schuhler P60

Job No. 4.

1. Is it possible for signal wires to occupy the same conduit system? Electric Wiring--Schuhler P45
2. Describe the construction and operation of a single contact button? Shop manual P7-8
3. How is the transformer connected in the circuit? Electric Wiring--Schuhler P60
4. What is the difference between a cell and a battery? "House-wiring" Wolber & Rose P38

Job No. 5.

1. What are the three types of bells manufactured, and for what is each used? Shop manual P6-7.
2. Describe the construction and operation of a double contact button. Shop manual P8
3. What is the relationship between current and voltage when dry cells are connected in series or parallel? Electric Wiring--Schuhler P52
4. What is the difference between series and parallel connections? 
"Housewiring" Wolber & Rose P39

Job No. 6.
1. Describe the construction and operation of the single-stroke bell. Shop manual P7
2. How would two or more transformers be connected to operate together on a bell circuit? Electric Wiring--Schuhler P60
3. What type of wires are used on signaling systems in dry and damp locations? Electric Wiring--Schuhler P54
4. What part of the transformer is governed by the code rulings? "Housewiring" Wolber & Rose P42

Job No. 7.
1. Describe the construction and operation of the vibrating bell? Shop manual P7
2. If push buttons are hooked in series instead of parallel what will be the result? Principle of operation-Job No. 2-P49
3. What size wires are generally used for bell work? Electric Wiring--Schuhler P54

Job No. 8.
1. Describe the construction and operation of the combination bell? Shop manual P7
2. Why is it unnecessary to solder bell splices? Electric Wiring--Schuhler P1
3. How are signaling wires installed in unfinished frame constructed building? Electric Wiring--Schuhler P55
4. Why should wires, bunched together in a vertical run, have a covering? Code Rule 6004b

Job No. 9.
1. How is it possible to adapt a high voltage bell to a low voltage? Shop manual P7
2. What type of current supply may be used for bell systems? Shop manual P8
3. How are signal wires installed in finished frame constructed building? Electric Wiring--Schuhler P55
4. Under what conditions may signal and electric wires be run in the same shaft? Code Rule 6004c
Job No. 10.

1. How can you change a vibrating bell to a single-stroke bell? Shop manual P7
2. Describe the dry cell, its construction and principles of operation. Electric Wiring—Schuhler P50
3. How are signal wires installed in fireproof buildings? Electric Wiring—Schuhler P55
4. Under what condition may signal wires be placed in the same outlet box or junction box with a light or power wires? Rule 6004d
JOB NO. 1

CONTROLLING LIGHTS FROM ONE POINT

1. General Directions.
   
a. Read carefully the entire job sheet and make a list of the steps you will take in doing this job.

b. Make a list of the materials required for this job.


   This job is divided into 4 parts. Each part is to be completed and checked separate from the rest.

   a. Install a circuit containing one 2-fuse cutout; a receptacle; and a single-pole single-throw knife switch on the wall of your booth. Connect to the wall-plug. This circuit should cover no more than a 2 ft. area. Use #14 R.C. wire. Fig. 1.

   b. Repeat (a) but use a single-pole flush toggle switch set in a switch box. Fig. 2.

   c. Repeat (a) using a single-pole snap toggle switch, mounted on a porcelain sub-base. Fig. 3.

   d. Make up a drop cord consisting of a male plug, ordinary key socket, and 2 ft. of cotton twisted lamp cord.

3. Information.

   The switch most often used is the single-pole toggle switch. There is one important thing to remember about its installation and that is, never install it in a damp location, unless all parts are so well insulated that it is impossible to come into contact with the hot wire.

   When a knife switch is used it should be installed so that gravity will not close the blades. Also the blades should never be connected to the line wires. If they should be so connected, there is danger of some metal object falling across the blades and causing a short circuit. When it is impossible to connect the blades to any other wire, except the line wire, the switch must be placed in an iron box.

   The toggle switch and snap switch are really single-pole
knife switches. Their workings should be better understood after operating the knife switch.

Be careful in removing the insulation from the wire in making a drop cord, so as not to cut any of the small wires. If any of the wires are cut this lessens the area of the wire and becomes a fire hazard due to the necessity of a small wire having to carry excess current.

4. Specifications.

a. Secure the necessary tools and material for all four parts.

b. Single pole knife switch.
   1. Screw the fuse cutout, receptacle, and switch to the wall.
   2. Run wires between points as shown in fig. 1. Keep your job clean, run your wire straight, and make all turns at right angles.
   3. Where the wires are put onto the binding post screws, be sure that the wire goes around the screw in the direction of the screw, so that the wire will tighten as the screw is tightened.
   4. Connect to the wall-plug and insert fuses.
   5. Have circuit checked by instructor before throwing switch.
   6. Be careful about blowing fuses. Each fuse must be replaced by the student blowing it.
   7. Is your booth clean?

c. Single pole toggle switch.
   1. Repeat (b) using a single-pole toggle switch.
   2. Screw a switch box to the wall board and place switch in the box.
   3. All wires to the switch must enter the box through a knock out hole.

d. Single pole snap toggle switch.
   1. Repeat (b) using a single pole snap toggle switch.
   2. Place the switch on a porcelain sub-base to keep the wires from touching the surface wired over.

e. Making up a drop cord.
   1. To make up the drop cord, follow the directions as given in Operation 75.
   2. Test by connecting to wall plug.

5. Questions.

1. Under what conditions may the blade of a knife switch be connected to a live wire? Why? Information P61
2. Explain the operation of the single-point control circuit, using a diagram.
3. Why should single-pole switches not be used in damp locations? Information P61.
4. Why should one be careful not to cut any of the small wires when removing the insulation from cotton twisted wire. Information P61

5. Why wind the wires clockwise around the screws of the binding post? Specifications P62

6. Why use the Underwriters' knot under the cap of the socket? Operation 75 P42

7. Why use the Underwriters' knot on the plug? Operation 75-P42

8. Why wind the wires around the brass uprights on the plug? Operation 75 P42

9. Why is a porcelain sub-base used with a snap switch? Specifications P62

10. What is a wire gauge? Shop manual P4
1. General Directions.
   a. Read carefully the entire job sheet and make a list of the steps you will take in doing the job. This is your job plan.
   b. Make a list of the materials required for the job.
   c. Have this list approved by the instructor before starting work on the job.

   This job is divided into three parts. Each part is to be completed and checked before starting on the next part.

   a. Install a circuit containing one two-fuse cutout; two receptacles; and two single-pole double-throw knife switches. Connect to a wall plug. This circuit should cover no more than a 2 ft. area. Fig. 1.

   b. 1. Repeat (a) but use two three-way flush toggle switches set in switch boxes. Fig. 2.
      2. Connect one of the traveler wires to the shunted side of the switch and see what happens when the circuit is operated.

   c. Repeat (a) using two three-way snap toggle switches mounted on porcelain sub-bases. Fig. 3.

3. Information.

   Three way switches are mostly used on stairways and entrances to rooms. The simplest type of three-way switch is the single-pole double-throw knife switch. However it is impractical and dangerous both to life and as a fire hazard to use a knife switch. The knife switch is dangerous because of the bare copper blades, touching brings a shock and should it be touched while in a damp spot the contact might cause death. So a switch had to be developed that had the same action, yet was safe.

   The three way switch has three terminals. Two are independent
of each other and the third is connected to the fourth point through a shunt. Either the line wire or the wire from the lamp is connected to this side. The independent terminals of two switches are connected together by two wires called the traveller wires. When the switch, shown in figure 4, is thrown to the left, the contact is through points AC, and the current passes through traveller wire C. When the switch is thrown to the right, the contact is through points BD, and the current passes through the wire connected to D.

4. Specifications.

a. Secure the necessary tools and material for all three parts.

b. **Three way knife switches.**
   1. Screw the fuse cutout, receptacles, and switches to the wall.
   2. Run wires between points as shown in diagram. Keep your job clean, run wires straight, and make all corners at right angles.
   3. Where wires are put onto binding post screws, be sure that the wire goes around the screw in the direction of the screw.
   5. Have circuit checked before throwing switches.
   6. Be careful about blowing fuses. All blown fuses must be replaced by those blowing them.
   7. Is your booth clean?

c. **Three way flush toggle switches.**
   1. Repeat (b) using three way flush toggle switches.
   2. a. Screw switch boxes to wall boards and place switches in the boxes.
      b. All wires to switches must enter boxes through a knock out hole.
   3. a. Disconnect the wire to one of the shunt terminals and to one of the independent terminals. Connect the wire that had been on the shunt terminal to the independent terminal. Then connect the other wire to the shunt terminal.
      b. Connect to the wall plug, insert fuses in fuse block, and note difference in operation.

d. **Three way snap toggle switches.**
   1. Repeat using two three way snap toggle switches.
   2. Place the switches on porcelain sub-bases to keep the wires from touching the surface wired over.
   3. Connect to wall plug, insert fuses, and operate.
5. Questions.

1. For what purpose or where are three-way switches used? (Name as many places and conditions where this type of circuit is used. You should have at least 5).

2. By means of a diagram explain how the flush toggle switch circuit works.

3. What occurs if one traveller wires is brought to the shunted side of the switch? Specifications—Part-(o3a)—Page 65

4. By means of a diagram explain the circuit operation when knife switches are used.

5. Why is the knife switch dangerous? Information Page 64

6. Why are the wires connected to the independent terminals called traveller wires?

7. What is a shunt? Information Page 64

8. What is the difference between a good conductor and a poor conductor? Shop manual P3

9. What is the difference between a good insulator and a poor insulator? Shop manual P3

10. What is solder? Shop manual P5
JOB NO. 3

CONTROLLING LIGHTS FROM THREE POINTS

1. General Directions.

a. Read carefully the entire job sheet and make a list of the steps you will take in doing this job. This is your job plan.
b. Make a list of the materials required for the job.
c. Have this list approved by the instructor before starting work on the job.


This job is divided into two parts. Each part is separate, the first is to be completed and checked before beginning the second.

a. Install a circuit containing one two-fuse cutout, 2 receptacles, 2 single-pole double-throw knife switches, and one double-pole double throw knife switch on the wall of your booth. Connect to the wall plug. This circuit should cover no more than a 3 ft. area. Use #14 R.C. wire. Fig. 1.

b. Install a circuit containing one 2-fuse cutout, 2 receptacles, two three-way flush toggle switches, and one four-way flush toggle switch on the wall of your booth. Connect to the wall plug. This circuit should cover no more than a 3 ft. area. Use #14 R.C. wire. Fig. 2.

3. Information.

Where the three way switch has only three connection points, the four way switch has four. The four way switch does not have a shunt. All four terminals are independent. Two of the terminals are so connected that the current can cross over from one side of the switch to the other. To control a light from one point a single pole switch is used; to control from two points, two three way switches are used; to control from three points it
is necessary to add a four way switch to the two three way switches; and for each additional point of control a four way switch must be added.

4. Specifications.
   a. Secure the necessary tools and material for both parts.
   b. **Knife switch circuit.**
      1. Screw the fuse cutout, receptacles, and switches to the wall.
      2. Run wires between points as shown in diagram. Keep your job clean, run wires straight, and make all corners at right angles.
      3. Where wires are put onto binding post screws, be sure that the wire goes around the screw in the direction of the screw.
      4. Connect to the wall plug and insert fuses. Leave switches open.
      5. Have circuit checked by instructor.
      6. Be careful about blowing fuses. All blown fuses must be replaced by those blowing them.
      7. Is your booth clean?
   c. **Flush toggle switch circuit.**
      1. Screw switch boxes to wall boards and place switches in the boxes.
      2. All wires to the switches must be brought in to the boxes through a knock out hole.

5. Questions.
   1. Name several places where this type of control may be used.
   2. By means of diagrams, trace the circuits using two three-way flush toggle switches and one four way toggle switch.
   3. Draw a circuit showing the control of lights from four points.
   4. Explain how the cross-over on a four way switch operates.
   6. Why is it practically impossible for an electrician to use liquid flux? What type is used? Shop manual P6
   7. What is a soldering copper? Shop manual P6
   8. Why is copper used for the head? Shop manual P6
   9. How is the size of a soldering copper determined? Shop manual P6
   10. What is a blow torch? Shop manual P6

68
JOB NO. 4

THE RESISTANCE OF WIRE

1. General Directions.

a. Read carefully the entire job sheet and make a list of the steps you will take in doing this job.

b. Make a list of the materials required for the job.

c. Have this list approved by the instructor.


This experiment is divided into three parts. Each part is a separate unit.

a. You will need the following materials: 3-500 ft. rolls of #14 R.C. wire; 1-500 ft. roll of #18 annunciator wire; 1-iron wire resistor; 1-test board (consisting of 12 receptacles, 12 60-watt lamps, 1 double-pole entrance switch); 1 ammeter, 0-10 amperes; 2 voltimeters, 0-30 volts and 0-150 volts; 1 double-pole single throw knife switch; 1 2-fuse cutout. Connect as shown in diagram.

b. The object of this experiment is to show:
   1. The effect of length upon resistance.
   2. The effect of size upon resistance.
   3. The effect of temperature upon resistance.

3. Information.

To calculate resistance use ohms law.

In measuring the diameter of wire the mil is used as a unit. It equals 1/1000 inch. The area in circular mils is determined by finding the square of the diameter (in mils). The table of resistance (page 554-Timbie) gives the circular mil area of the different gauge sizes.

To calculate the change in temperature due to a change in resistance use the following formula:

\[ t_2 = \left( \frac{162 + t_1}{R_1} \right) R_2 - 162 \]

\( t_2 \) will be the final temperature; \( t_1 \) is the initial temperature, use room temperature; \( R_1 \) is the cold resistance of the resistor; \( R_2 \) is the hot or final resistance; the 162 is the constant for commercial iron, it is the reciprocal of the temperature coefficient of resistance.
4. Specifications.

a. Set your apparatus up on the table containing the receptacle.

b. Have your hook-up checked by instructor before throwing the switch.

c. The effect of length.
   1. Connect 500 ft. of #14 wire in series with the test board. Connect the 0-30 volt voltmeter and the ammeter so as to measure the pressure across and the current through the #14 wire. Close the switch just long enough to take the readings. Record in Table I under question 1.
   2. Repeat (1) using a 2-500 ft. rolls of #14 wire connected in series. (NOTE: do not set the rolls on top of each other). Use the 0-150 volt voltmeter. Again record your readings in Table I.
   3. Repeat (1) using 3-500 ft. rolls of #14 wire connected in series. Use the 0-150 volt voltmeter. Again record your readings in Table I.

d. The effect of size.
   1. Connect 500 ft. of #14 wire in series with the test board. Connect the 0-30 volt voltmeter and the 0-10 ampere ammeter so as to measure the pressure across and the current through the #14 wire. Close the switch and take the readings. Record these readings in Table II under question 3.
   2. Connect 500 ft. of #18 annunciator wire in series with the test board. Connect the 0-150 volt voltmeter and the ammeter so as to measure the pressure across and the current through the #18 wire. Close the switch and take the readings. Record your readings in Table II under question 3.

e. The effect of temperature.
   1. Find the resistance of the resistor, which is wound with iron wire, when cold and then when hot.
   2. Screw the switch and 2-fuse cutout to the table. Connect the resistor in series with the switch. Use the 0-150 volt voltmeter to measure the pressure and the 0-10 ampere ammeter to measure current. Close the switch and take readings instantly. Record in Table III under question 7.
   3. Leave the switch closed until the current becomes constant (about one hour). Again take the readings and record in the lower section of Table III under question 7.
   4. From these readings calculate the cold and hot resistance; the hot temperature; and by subtracting the initial temperature from this calculated temperature, find the temperature change.
5 Questions.

1. Table I

<table>
<thead>
<tr>
<th>Kind of wire</th>
<th>Size</th>
<th>Length</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>14</td>
<td>500ft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>14</td>
<td>1000ft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>14</td>
<td>1500ft</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. How does the resistance vary with the length?

3. Table II

<table>
<thead>
<tr>
<th>Kind of wire</th>
<th>Size</th>
<th>Length</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>14</td>
<td>500ft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>18</td>
<td>500ft</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. How does the area of #14 wire compare with that of #18?

5. How does its resistance compare?

6. How does the resistance vary with the change in area?

7. Table III

<table>
<thead>
<tr>
<th>Kind of wire</th>
<th>Size</th>
<th>Length</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>26</td>
<td>150ft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>26</td>
<td>150ft</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. How hot does the resistor get?

9. What is the effect of an increase in temperature on the resistance of a wire?

10. Calculate the change in temperature due to the change in resistance.
JOB NO. 5

MEASURING THE CURRENT, VOLTAGE, AND RESISTANCE IN THE SERIES CIRCUIT

1. General Directions.
   a. Read carefully the entire job sheet and make a list of the steps you will take in doing this job.
   b. Make a list of the materials required for the job.
   c. Have this list approved by the instructor.

2. Materials and General specifications.
   a. This experiment is divided into two separate parts.
   b. The apparatus required: 1-60 watt lamp; 1-100 watt lamp; 1-150 watt lamp; 3 cleat receptacles; 2 voltmeters, 0-30 volt and 0-150 volt; 1 ammeter, 0-5 amperes; 1 double-pole single-throw knife switch; 1 2-fuse cutout.
   c. The object of this experiment is:
      1. To show the differences and similarity between pressure and current for the whole and the parts of a series circuit. Therefore measure:
      2. Pressure and current for each part of the circuit.

3. Information.
   To calculate resistance use ohms law.
   In the series circuit, as has been studied in your text, the current is the same in all parts; the voltage is the sum of the voltages of each separate part; and the resistance is the sum of the resistances of each separate part.

4. Specifications.
   a. Set your apparatus up in a booth.
   b. Screw the receptacles, switch, and cutout to the wall and then wire according to the diagram. Make all corners at right angles.
   c. Total pressure and current.
      After connections have been made and wiring checked, throw the switch and measure the total pressure and current in the
circuit. Record your readings in Table I question 1. Compute the resistance.

d. Separate pressures and currents.
In a similar manner to (c), measure the current through and the pressure across each of the lamps, separately. All the lamps should be burning during the test. Connections are the same as in (c). Record your readings in Table II question 2

5. Questions.

1. Table I.

<table>
<thead>
<tr>
<th>Lamps</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Table II.

<table>
<thead>
<tr>
<th>Lamps</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Why are some lamps brighter than others?
4. How do the pressures across the separate lamps compare with the total?
5. What is the sum of the separate pressures?
6. How does this sum compare with the total measured?
7. How do the resistances of the separate lamps compare with the total?
8. What is the sum of the separate resistances.
9. How does this sum compare with the total resistance?
10. How does the current through the separate lamps compare with the total?
MEASURING THE CURRENT, VOLTAGE, AND RESISTANCE IN A PARALLEL CIRCUIT

1. General Directions.
   a. Read carefully the entire job sheet and make a list of the steps you will take in doing this job.
   b. Make a list of the materials required for this job.
   c. Have this list approved by the instructor.

   a. This experiment is divided into two parts.
   b. The apparatus required: 1-60 watt lamp; 1-100 watt lamp; 1-150 watt lamp; 3 cleat receptacles; 1 voltmeter, 0-150 volt; 1 ammeter, 0-5 amperes; 1 double-pole single-throw knife switch; 1 2-fuse cutout.
   c. The object of this experiment is: to show the difference and similarity between pressure and current for the whole and the parts of a parallel circuit. Therefore measure:
      1. Pressure and current for the whole circuit.
      2. Pressure and current for each part of the circuit.

3. Information.
   To calculate current, voltage, and resistance use your ohms law for the parallel circuit.
   In the parallel circuit, as has been studied in your text the total current is the sum of the currents in each separate part; the total voltage is the same as that of each separate part; and the total resistance is always less than the smallest resistance. The resistance is found by the equation:
   \[
   \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \\
   \]

4. Specifications.
   a. Set your apparatus up in a booth.
   b. Screw the receptacles, switch and cutout to the wall of the
booth and then wire according to the diagram. Make all corners at right angles.

c. Total pressure and current.
   Connect a voltmeter and ammeter so that you can measure the pressure across and the current through a bank of three lamps connected in parallel on a 110-volt line. Record your readings in Table I question 1.

d. Separate pressures and currents.
   Connect the ammeter and voltmeter so as to measure the current through and the pressure across lamp 1. (All lamps should be burning during the test). Repeat for lamps 2 and 3. Record your readings in Table II question 2.

5. Questions.

1. Table I,

<table>
<thead>
<tr>
<th>Lamps</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Table II

<table>
<thead>
<tr>
<th>Lamps</th>
<th>Pressure</th>
<th>Current</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Why do all the lamps burn with full brightness?
4. How do the pressures across the separate lamps compare with the total?
5. How does the current through the separate lamps compare with the total?
6. What is the sum of these currents?
7. How does this compare with the total measured current?
8. How do the resistances of the separate lamps compare with the total?
9. Calculate the total resistance by using the formula given in the Information, part 3.
10. How does this compare with the measured total resistance?
1. General Direction.
   a. Read carefully the entire job sheet and make a list of the steps you will take in doing the job.
   b. Make a list of the materials required for this job.
   c. Have this list approved by the instructor.


   A bank of 12 lamps (60 watt); voltmeter 0-150 volt; ammeter 0-10 amperes; two 500 ft. coils of #14 R.C. wire; 1 double-pole single-throw knife switch; one 2-fuse cutout.

3. Information.

   Line drop is the drop in pressure in the line wires. It represents the voltage used in forcing the current through the line.

   Line loss is the power lost in the line wires. It may be computed by the formula:
   \[
   \text{Line Loss} = \text{Line Drop} \times \text{Current}.
   \]

4. Specifications.

   a. Check out the apparatus and set up on the table. Do not place the coils on top of one another.

   b. Connect the two 500 ft. coils of #14 R.C. wire between the service switch and a bank of 12 lamps. Connect an ammeter in the line. Have circuit checked before closing switch.

   c. Turn on two lamps and take readings of the current, voltage across the switch, and voltage across the lamps. Repeat with other number of lamps indicated in the table, question 2.

5. Questions.

   1. How far are the lamps electrically from the switch?
2. Table I.

<table>
<thead>
<tr>
<th>Lamps</th>
<th>Across Switch</th>
<th>Across Lamps</th>
<th>Line drop</th>
<th>Current</th>
<th>Line Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Calculate the line drop by means of the formula:
   Current thru line x resistance of line.
4. How does this agree with the measured line drop of the table?
5. Make a graph showing line drop and current.
6. How does the line drop vary with an increase in current, as shown on the graph?
7. Calculate the line loss by means of the formula:
   (Current thru line)^2 x resistance of line.
8. How does this agree with the measured line loss of the table?
9. Make a graph showing line loss and current.
10. How does the line loss vary with an increase in current, as shown on the graph.
CONDUIT

GENERAL INSTRUCTIONS

1. Go to the booth in which you are to work and there study the layout and job specifications of the job you are going to do.

2. Carefully locate all energy and switch outlets according to the specifications furnished. Mark centers using chalk.

3. Using the Unit Operation Checking Sheet, list out and check those Unit Operations involved in the job.

4. Study the catalogue of conduit and fittings, especially for those fittings you will use on the job. Also study the chapter on conduit in the books, "Wiring for Light and Power"-Croft, and "House Wiring"-Wolber and Rose.

5. Draw neatly a wiring diagram of the circuit or circuits in such a manner that you will be able to determine the correct size of conduit to use.

6. Make a Bill of Material, in duplicate, and have it checked by the instructor.

7. Secure from the stock-room all the material you will need, except conduit, wire, and lamps, which you will get as you need it. At the close of each session, lock up in your locker all the material which you have not yet installed. You are responsible for all the material listed on your Bill of Material.

8. Put up your job in a neat and serious-minded fashion, so you will form good workmanlike habits.

9. When the job is roughed-in get a rough-in inspection from the instructor.

10. Pull in your conductors according to your wiring diagram and make all necessary splices. Get inspection on splices before and after soldering and taping.

11. Install all switches and other devices and check all your operations before calling instructor for final inspection. Ring out all circuits for shorts, grounds, and proper circuits.

12. Ground all conduit installations.

13. Keep your booth clean.
CONDUIT

UNIT OPERATION CHECKING SHEET

INSTRUCTIONS:

Place in the column at the right the Unit Operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT OPERATION</th>
<th>JOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and estimating the job</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>2. Making a bill of material</td>
<td></td>
</tr>
<tr>
<td>RIGID</td>
<td></td>
</tr>
<tr>
<td>3. Cutting</td>
<td></td>
</tr>
<tr>
<td>4. Reaming and threading</td>
<td></td>
</tr>
<tr>
<td>5. Making a running-thread joint</td>
<td></td>
</tr>
<tr>
<td>6. Bending</td>
<td></td>
</tr>
<tr>
<td>7. Installing and connecting to boxes and cabinets.</td>
<td></td>
</tr>
<tr>
<td>8. Throwing an offset</td>
<td></td>
</tr>
<tr>
<td>THIN WALL</td>
<td></td>
</tr>
<tr>
<td>14. Cutting and reaming</td>
<td></td>
</tr>
<tr>
<td>15. Bending</td>
<td></td>
</tr>
<tr>
<td>16. Throwing an offset</td>
<td></td>
</tr>
<tr>
<td>17. Installing</td>
<td></td>
</tr>
<tr>
<td>18. Connecting to outlet boxes</td>
<td></td>
</tr>
<tr>
<td>19. Connecting to fittings</td>
<td></td>
</tr>
<tr>
<td>20. Soldering joints</td>
<td></td>
</tr>
<tr>
<td>21. Taping joints</td>
<td></td>
</tr>
<tr>
<td>22. Tracing and testing circuits</td>
<td></td>
</tr>
<tr>
<td>23. Splicing</td>
<td></td>
</tr>
</tbody>
</table>

METHOD OF GRADING WORK

Standard time for each job | 4 6 6 8 8 12 |

Time used for each job

UNIT GRADES

Application—---------20%

Time—-------------25%

Workmanship—------25%

Operation---------15%

Inspection--------15%

Summarized grade-----100%
SPECIFICATIONS

In a room install a light which can be controlled by a wall switch. Also install a wall receptacle, not controlled by this switch.

Run #14 B. & S. R.C. copper wire in Steel Tube, or Thin Wall Conduit, exposed on the walls and ceiling. Use fittings and boxes as indicated in the drawing. The installation current shall be furnished by connecting direct to the 4" outlet box in the rear of the booth.

The light fixture shall consist of a plain drop cord, fitted with a porcelain key socket hung 1 ft. from the ceiling. Control the light by a single-pole flush toggle switch mounted in a 2" rectangular galvanized switch box, 4½ ft. from the floor. 3½ ft. from the floor, below the switch, install another switch box with a duplex receptacle.

Offset the conduit whenever it enters boxes that do not allow the conduit to rest against the supporting surface. Strap all conduit securely. The conduit must be grounded.

The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service.

All work must be done according to the rules of the National Electrical Code.

| BILLOFMATERIAL |
|-----------------|-----------------|----------------|
| ALT.            | COST | ALT.         | COST |
| Steel Tube-$\frac{1}{8}"$ |       | #8402-A Drop cord cover |       |
| #14 B&S White wire |       | 4" Blank O.S. cover |       |
| #14 B&S Black wire |       | Porcelain key socket, pendent cap |       |
| #18 B&S Green lamp cord |       | $\frac{1}{8}$-1 hole clamps |       |
| 2" Galvanized switch box |       | $\frac{3}{8}$ F.H. Wood screws |       |
| Duplex receptacle |       | $\frac{1}{4}$ Couplings |       |
| Single-pole flush toggle switch |       | $\frac{1}{8}$ Adapters |       |
| $\frac{1}{2}$" LR Unilet |       | $\frac{1}{8}$ Connectors |       |
| 4-0D-$\frac{1}{8}$" Outlet box |       | 50-50 Wire solder |       |
| Receptacle plate |       | Rubber tape |       |
| Toggle switch plate |       | Friction tape |       |
| Blank metal cover for $\frac{1}{2}$" LR Unilet |       | Ground strap size A |       |
CONDUIT

QUESTIONS FOR JOB NO. 1

1. Why is conduit superior to any other system of wiring?
   "House Wiring" - Wolber & Rose - P244

2. In what way does Rigid Conduit resemble gas or water pipe?
   "House Wiring" - Wolber & Rose - P244

3. What determines the trade sizes of Conduit? "House Wiring" - Wolber & Rose - P245

4. What type of supervision of materials used on wiring jobs is given by the National Board of Fire Underwriters?
   "Interior Wiring" - Cook - P208

5. What is the advantage of the enamel coating on the inside of conduit? "Interior Wiring" - Cook - P211

6. What is the function of outlet boxes in grounding conduit? "Interior Wiring" - Cook - P213

7. Why is it necessary to insert a pull box in a conduit run, when the distance between outlets is great? "Interior Wiring" - Cook - P219

8. Why must all conduit systems be thoroughly grounded?
   "Interior Wiring" - Cook - P223

9. How do you connect Steel Tube to threaded fittings?
   Shop Manual - P10

10. Why is the Steel Tube bender constructed the way it is and what is the purpose of this type of construction? Shop Manual - P10

11. How many quarter-bends are allowed in a conduit system between outlet boxes? "Wiring for Light and Power" - Croft - P320

12. What are the advantages of a conduit system?
    "House Wiring" - Wolber & Rose - P244

13. In what way does rigid conduit differ from gas or water pipe?
    "House Wiring" - Wolber & Rose - P244

14. What two sizes of conduit are most generally used for circuit wiring? "House Wiring" - Wolber & Rose - P245

15. Is it possible to use material not approved by the Underwriters?
    "Interior Wiring" - Cook - P208
SPECIFICATIONS

In the center of the ceiling of a booth install an outlet. Also install on the right hand wall, 3½ ft. from the floor, a convenient outlet which shall be hot on the line. Run #14 B&S R.C. copper wire in Rigid Conduit exposed on the walls and ceiling. Use fittings and boxes as indicated in the drawing. The installation current shall be furnished by connecting direct to the 4" outlet box in the rear of the booth.

The ceiling outlet shall be covered with a standard sign receptacle, H&H #61988. Control this light with a single-pole flush toggle switch, mounted in a 2" rectangular galvanized switch box, 2 ft. directly below the outlet box in the rear of the booth. The outlet on the right hand wall shall be a duplex receptacle mounted in a 2" rectangular galvanized switch box.

Offset the conduit whenever it enters boxes that do not allow it to rest against the supporting surface. Strap all conduit securely. The conduit must be grounded.

The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service.

All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>ART.</th>
<th>ARTICLE</th>
<th>COST</th>
<th>ART.</th>
<th>ARTICLE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

85
CONDUIT
WIRING DIAGRAM
JOB NO. 2
QUESTIONS FOR JOB NO. 2

1. Why is the exterior of conduit galvanized? "Wiring for Light and Power" - Croft P317
2. How are the openings for conduit provided in boxes? What are they called? "Interior Wiring" - Cook - P214
3. What are pull boxes? "Interior Wiring" - Cook - P219
4. Why is galvanized conduit preferred over enameled conduit? "Interior Wiring" - Cook - P223
5. What is Steel Tube? Shop Manual - P9
7. What is the function of a conduit system? "Wiring for Light and Power" - Croft - P266
8. Why are the number of quarter-bends between outlet boxes limited? "Wiring for Light and Power" - Croft - P320
9. What type of construction almost exclusively use the conduit system of wiring? "House Wiring" - Wolber & Rose - P244
10. What is the primary purpose of conduit? "House Wiring" - Wolber & Rose - P244
11. For what are the sizes of conduit other than ½" used? "House Wiring" - Wolber & Rose - P245
12. How is it possible to determine if the material being used is approved by the Underwriters? "Interior Wiring" - Cook - P208
13. What governs the radius of a bend in conduit? "Interior Wiring" Cook - P211-12
14. Why should you remove only those knockout plugs where conduit is to be installed? "House Wiring" - Wolber & Rose - P119-205
15. What determines the size of the conduit? "Interior Wiring" Cook - P219
SPECIFICATIONS

Locate 4 outlets on the ceiling of a booth, so the light will be evenly distributed. Wire this installation so that switch Sl, a single-pole toggle switch, will control lights 1 and 3; and switch S2, a single-pole toggle switch, will control lights 2 and 4. The ceiling outlets are to be plain drop cords. Use type P portable cord and brass key sockets, equipped with 2½" shade holders to match. The shade holder is to be 6 ft. from the floor. Run #14 B&S R.C. copper wire in Steel Tube, or Thin Wall Conduit, exposed on the walls and ceiling. Mount two single-pole flush toggle switches in a 2-gang switch box; this box to be made from 2" rectangular galvanized switch boxes. S1 being the left-hand switch and S2 the other. Furnish the installation current through conduit run from outlet L2 to the 4" outlet box in the rear of the booth. Offset the conduit wherever it enters boxes that do not allow the conduit to rest against the supporting surface. Strap all conduit securely. The conduit must be grounded. The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service. All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>AMT.</th>
<th>ARTICLE</th>
<th>COST</th>
<th>AMT.</th>
<th>ARTICLE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

89
CONDUIT
WIRING DIAGRAM
JOB NO. 3
CONDUIT

QUESTIONS FOR JOB NO. 3

1. To what, and where, is it best to ground conduit?
   "Interior Wiring" - Cook - P223

2. What are the advantages of Steel Tube? Shop Manual - P9

3. In what way does conduit offer fire protection?
   "Wiring for Light and Power" - Croft - P286

4. What is a "bush cap"? Why and where is it used?
   "House Wiring" - Wolber & Rose - P254

5. In the construction of a concrete building, where is the conduit placed?
   "House Wiring" - Wolber & Rose - P244

6. Why is rigid conduit not adaptable to use for water, gas, or steam purposes?
   "House Wiring" - Wolber & Rose - P244

7. What is the smallest size conduit permitted by the code?
   "Interior Wiring" - Cook - P211 - Rule 503d

8. Does the National Electrical Code take preference over local codes?
   "Interior Wiring" - Cook - P209

9. What radius is allowed for the curve of the inner edge in a bend?
   "Interior Wiring" - Cook - P211-12

10. Why are busings used in connection with conduit?
    "Interior Wiring" - Cook - P216

11. Why must the conduit system be continuous between outlets?
    "Interior Wiring" - Cook - P220

12. How is the ground wire connected to the pipes?
    "Interior Wiring" - Cook - P223

13. What tools are done away with when Steel Tube is used?
    Shop Manual - P3

14. How is Steel Tube finished externally? Why?
    Shop Manual - P9

15. Why should a conduit system have a high relative conductivity?
    "Wiring for Light and Power" - Croft - P287
SPECIFICATIONS

This is a three-way switch installation. The lights can be controlled from either 3.

Remove the drop fixtures from your Job #3, save and later re-install. Remove the 2-gang switch box and change it for a single box. Remove all wiring not needed for this job. Install additional exposed Steel tube and another 2" switch box opposite the one on the left hand wall. Mount three-way flush switches in the switch boxes.

Pull in the proper wiring so that either 3-way switch will control the lights. Install the drop cord fixtures used on Job #3, hung with shade holders 6 ft. from the floor.

Ground the conduit, test the wiring for shorts and grounds, and then ask for inspection. Do not connect the installation to the lighting service until inspection has been secured.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
CONDUIT
WIRING DIAGRAM
JOB NO. 4
CONDUIT

QUESTIONS FOR JOB NO. 4

1. What other method is used to obtain the same results as the "bush-cap"? "House Wiring" - Wolber & Rose - P254-55
2. What is an exposed system of wiring? "House Wiring" - Wolber & Rose - P244
3. Why cannot gas, steam, or water pipes be used to encase wires? "House Wiring" - Wolber & Rose - P245
4. How should all interior wiring be installed? "Interior Wiring" - Cook - P208
5. What are the advantages of a properly installed conduit system? "Interior Wiring" - Cook - P209-10
6. What are stock bends? "Interior Wiring" - Cook - P212
7. Where do you use bushings? "Interior Wiring" - Cook - P217
8. Where are the outlet boxes and switch boxes installed in fireproof or concrete construction? "Interior Wiring" - Cook - P220
9. How is Steel Tube finished internally? "Wiring for Light and Power" - Croft - P287
10. What type of wire must be used in conduit? "Wiring for Light and Power" - Croft - P287
11. What would be the result if the wires were allowed to become twisted or kinked during the pulling operation? "House Wiring" - Wolber & Rose - P256
12. Where are exposed systems of wiring used? "House Wiring" - Wolber & Rose - P244
13. What are common types of rigid conduit? "House Wiring" - Wolber & Rose - P245
14. When is it necessary to conform to the rules of the National Electrical Code? "Interior Wiring" - Cook - P208
15. What are the disadvantages of a conduit system? "Interior Wiring" - Cook - P210
   "Wiring for Light and Power" - Croft - P287
SPECIFICATIONS

Locate six outlets on the ceiling evenly spaced. Also locate the two junction boxes. In the middle of the wall and 4 1/2 ft. from the floor install a 2-gang switch box. This box to be made from two 2" rectangular galvanized switch boxes. Connect the switch box and the various boxes on the ceiling with the proper size Steel Tube to carry the necessary conductors, as determined by your wiring diagram. Make saddle bends in the conduit runs where they cross other conduits. Mount two single-pole flush toggle switches in the two-gang switch box and connect them so that the front one controls all lights marked L1 and the other one controls all lights marked L2.

Use 4-OD-3/4 boxes for all junction and outlet boxes. All fixtures shall be standard sign receptacles.

Offset the conduit wherever it enters boxes that do not allow it to rest against the supporting surface. Strap all conduit securely. The conduit must be grounded.

The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>AMT.</th>
<th>COST</th>
<th>AMT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CONDUIT
WIRING DIAGRAM
JOB NO. 5
CONDUIT

QUESTIONS FOR JOB NO. 5

1. Why are stock bends not ordinarily used for \( \frac{3}{4} \)" and \( \frac{5}{8} \)" conduit? "Interior Wiring" - Cook - P212
2. What are locknuts? "Interior Wiring" - Cook - P217-220
   "House Wiring" - Wolber & Rose - P246
3. In exposed work how is conduit fastened to the surface? "Interior Wiring" - Cook - P221
4. How much load should be placed on the branch circuits? Hawkins - P855
5. Why is the steel used in conduit softer than that used for ordinary pipe? "Interior Wiring" - Cook - P211
6. What sizes of Steel Tube have been accepted by the Underwriters? Shop Manual - P9
7. Is it possible to make a splice or tap within the conduit tubing? Why? "Wiring for Light and Power" - Croft - P288
8. How is it possible to keep the wire from twisting or kinking during the pulling operation? "House Wiring" - Wolber & Rose P256
9. What are the advantages of an exposed system? "House Wiring" - Wolber & Rose - P244
10. How is the interior of rigid conduit finished? "House Wiring" - Wolber & Rose - P245
11. What governs the thickness of conduit? "Interior Wiring" - Cook - P210
12. Explain how small sizes of conduit may be bent cold? "Interior Wiring" - Cook - P212
13. Where are locknuts used? "Interior Wiring" - Cook - P217
14. How do you install wires in conduit? "Interior Wiring" - Cook - P222
15. If concealed wiring is to be installed in a finished building, what should be done first? Hawkins - P855
SPECIFICATIONS

Install a service entrance, consisting of a meter back, a service switch, and a 2-circuit fuse box, as explained in Operation Sheet 80. Bring the service wires into the meter back through ½" Steel Tube. Mount a ½" T & B entrance cap on this conduit.

Out of the right side of the circuit fuse box run two circuits in Steel Tube to the outlets as indicated. Each of the circuits is to be fused in the fuse box as a separate branch circuit.

On the right hand facing of the booth mount two single-pole flush toggle switches in a 2-gang switch box. Switch S1 to control all outlets marked L1 and the other S2 to control all outlets marked L2, on the ceiling only. On the right hand wall of the booth as near the front as possible mount 3 single-pole flush toggle switches in a 3-gang switch box. S1 to control outlets L1, S2 to control outlets L2, and S3 to control outlets L3, on the walls only.

All wall outlets to be covered with sign receptacles and all ceiling fixtures to be drop lights made up with type P portable cord and brass pendent key sockets.

Install and connect the meter as shown on the diagram of the meter. Connect the 110-volt line to the wires coming out of the entrance cap.

Offset conduit wherever it enters boxes that do not allow it to rest against the supporting surface. Strap all conduit securely. The conduit must be grounded.

The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service.

All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>ALIT.</th>
<th>COST</th>
<th>ALIT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

101
CONDUIT
WIRING DIAGRAM
JOB NO. 6
CONDUIT

QUESTIONS FOR JOB NO. 6

1. List the various operations in installing a conduit job and show the difference between the use of Rigid Conduit and Steel Tube. Shop Manual - P16 to 23 - "Conduit Fittings" - P8-9
2. Can you successfully use Steel Tube in concrete construction? Shop Manual - P9-10
3. When and why is it necessary to have all the wires of one circuit in the same conduit? "Wiring for Light and Power" - Croft - P293
4. How close should supporting straps be placed in an exposed conduit system? "House Wiring" - Wolber & Rose - P260
5. Where is it best to use the concealed system of conduit wiring? "House Wiring" - Wolber & Rose - P244
6. Of what does the sherardizing process consist? "House Wiring" - Wolber & Rose - P245
7. What type of steel is used in conduit? "Interior Wiring" - Cook - P210
8. What is meant by bending the conduit cold? "Interior Wiring" - Cook - P212
9. Why are locknuts used? "Interior Wiring" - Cook - P217
10. What is a 'fish tape"? "Interior Wiring" - Cook - P222
12. What is the "Loop" system of wiring? "Wiring for Light and Power" - Croft - P312
13. Is it necessary to add any further protection to the wires when conduit is run through floors or walls? Why? "House Wiring" - Wolber & Rose - P260
14. What are the two types of conduit? "House Wiring" - Wolber & Rose - P244
15. What is the standard length of rigid conduit and how is it equipped? "House Wiring" - Wolber & Rose - P245.
ARMORED CABLE

GENERAL INSTRUCTIONS

1. Go to the framework booth where you are to work and there study the layout and job specifications of the job you are going to do.

2. Carefully locate all energy and switch outlets according to the specifications furnished. With chalk, mark the places switch boxes are to be installed and distance above floor. Also mark place for receptacles. Locate exact center of room and mark a line on two rafters that will cut the center mark.

3. Using the Unit Operation Checking Sheet, list out and check those Unit Operations involved in this job.

4. Make a Bill of Material, in duplicate, and have it checked by the instructor.

5. Secure from the stock-room the armored cable, cable boxes, hangers, and fittings. After the cable has been pulled in place, connect to the boxes, and check out switches and other equipment.

6. After checking material from the stock-room, install all boxes and locate entrance switch. Figure how the cable is to be run, and locate position of holes so that the cable will not be bent at an excessive angle. Bore the holes with a #10 bit as near parallel with the floor as possible. Pull in your cable and proceed as in 5.

7. Put up your job in a neat, serious-minded fashion so you will form good, workmanlike habits.

8. When the job is roughed-in get a rough-in inspection from the instructor.

9. Get inspection on your splices before and after soldering and taping.

10. Keep your booth clean.
ARMORED CABLE
UNIT OPERATION CHECKING SHEET

INSTRUCTIONS:
Place in the column at the right the Unit Operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT OPERATION</th>
<th>JOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and estimating the job</td>
<td>1</td>
</tr>
<tr>
<td>2. Making a bill of material</td>
<td>2</td>
</tr>
<tr>
<td>25. Cutting</td>
<td></td>
</tr>
<tr>
<td>26. Stripping armor for splices</td>
<td></td>
</tr>
<tr>
<td>27. Installing and connecting to boxes and fittings</td>
<td></td>
</tr>
<tr>
<td>69. Splicing</td>
<td></td>
</tr>
<tr>
<td>72. Soldering Joints</td>
<td></td>
</tr>
<tr>
<td>73. Taping Joints</td>
<td></td>
</tr>
<tr>
<td>79. Tracing and testing circuits</td>
<td></td>
</tr>
</tbody>
</table>

METHOD OF GRADING WORK

Standard time for each job

Time used for each job

UNIT GRADES

<table>
<thead>
<tr>
<th>Application</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>25%</td>
</tr>
<tr>
<td>Workmanship</td>
<td>25%</td>
</tr>
<tr>
<td>Operation</td>
<td>15%</td>
</tr>
<tr>
<td>Inspection</td>
<td>15%</td>
</tr>
<tr>
<td>Summarized grade</td>
<td>100%</td>
</tr>
</tbody>
</table>

105
ARMORED CABLE

JOB NO. 1

SPECIFICATIONS

Install a light in the center of the ceiling of one of the framework sections, to be controlled by a switch to the right of the door. Also install a duplex receptacle, under the window, that is not on the line.

Use 14-2 Armored Cable (Bx). Run it parallel or through joists and studs. Support along surface where needed with a \( \frac{3}{4} \)" pipe strap. It is unnecessary to bush the holes when Bx passes through joists or studs.

The light will be a plain drop cord, made up with cotton twisted lamp cord, and a brass pull chain socket and pendant cap. Cover the 3\( \frac{3}{8} \)" armored cable box with a black enamel drop cord cover. The drop cord will hang 1 ft. below the cover.

To control the light use a single-pole flush toggle switch mounted in a 2" cable switch box, with bracket and latch holder. The box to be 4\( \frac{1}{2} \) ft. from the floor. Cover the switch box and switch with a toggle switch plate.

Use a standard duplex receptacle, mounted in a 2" cable switch box, with bracket and latch holder, 16" above the floor. Cover with a standard duplex receptacle plate.

The installation current will be brought in in the regular manner for making a service entrance. That is, lock a \( \frac{3}{4} \)" conduit, with a T & B entrance cap, into an iron box. Run the wires through this to an entrance switch mounted in this box. The other side of the entrance switch will be connected to the job.

Solder and tape all joints. Check your job for shorts and grounds before closing entrance switch. Have job inspected. This will save fuses and your money.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANT.</strong></td>
</tr>
<tr>
<td>14-2 Bx</td>
</tr>
<tr>
<td>3( \frac{3}{8} )&quot; Cable box</td>
</tr>
<tr>
<td>2&quot; Cable switch box</td>
</tr>
<tr>
<td>Bx connectors Straight</td>
</tr>
<tr>
<td>Lamp cord</td>
</tr>
<tr>
<td>Drop cord cover</td>
</tr>
<tr>
<td>Brass socket</td>
</tr>
<tr>
<td>Single-pole switch</td>
</tr>
<tr>
<td>Switch plate</td>
</tr>
<tr>
<td>Duplex receptacle</td>
</tr>
</tbody>
</table>

106
ARMOURED CABLE

QUESTIONS FOR JOB NO. 1

1. In what way is armored cable wiring similar to knob and tube work?
2. What are the advantages of Bx installations?
3. How is armored cable constructed?
4. How many and what size wires are encased in Bx?
5. Why are different colored wires used?
6. What is BxL and where is it used?
7. What is the difference between Bx and BxL?
8. What type switch boxes are used with Bx?
9. How is Bx fastened to boxes and to the surface?
10. Why are outlet boxes installed at the beginning of any wiring job?
11. How should the holes for Bx be bored with reference to the floor?
12. Why should they be bored in this manner?
13. What size hole is required for Bx?
14. Why is it preferable to bore all the holes before installing any cable?
15. How do you strip the armor from the end of cable in making splices?
ARMORED CABLE
JOB NO. 2
SPECIFICATIONS

Install a light in the center of the ceiling, of one of the framework sections, to be controlled by two 3-way switches. Also install a duplex receptacle, under the window, that is to be hot on the line.

Use 14-3 Armored Cable (Bx). Run parallel or through joists and studs. Support along surface where needed with a 1/2" pipe strap. It is unnecessary to bush the holes when Bx passes through joists or studs.

The light will be a plain drop cord, made up with #18 B&S green twisted cord, and a porcelain key socket and pendant cap. Cover the 3 1/2" armored cable box with a black enamel drop cord cover. The drop cord will hang 1 ft. below the cover.

The switches for controlling the lights will be 3-way flush toggle switches, mounted in 2" cable switch boxes, with bracket and latch holder, 4 1/2 ft. from the floor. S1 is to be installed at the right of the door, from the entrance side. S2 is to be installed in the center partition.

Use a standard duplex receptacle mounted in a 2" cable switch box, with a bracket and latch holder, 16" above the floor. Cover with a standard bakelite duplex receptacle cover.

The installation current will be brought in in the regular manner for making a service entrance. That is, lock a 2" conduit, with a T&B entrance cap, into an iron box. Run the wires through this to an entrance switch, mounted in the box. The other side of the entrance switch will be connected to the job.

Solder and tape all joints. Check your job for shorts and grounds before closing entrance switch. Have job inspected. This will save fuses and money. All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>AMT.</th>
<th>COST</th>
<th>AMT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

108
ARMORED CABLE

QUESTIONS FOR JOB NO. 2

1. Why are bushings used in the end of a piece of cable?
2. Are splices or taps allowed at any other place than in boxes, when Bx is used? Why? "House Wiring" - Wolber & Rose - P228
3. How do you fasten Bx to the side of joists or studs? "House Wiring" - Wolber & Rose - P229
4. Under what conditions is it necessary to ground Bx?
   "House Wiring" - Wolber & Rose - P229
5. What are the disadvantages of a Bx system? "Interior Wiring" - Cook - P227
6. Can couplings be used with Bx? Why? "Interior Wiring" - Cook - P227
7. Under what conditions may Bx be installed in concrete or permanently damp places? "Interior Wiring" - Cook - P227
8. What types of walls can the regular Bx be installed in?
   "Interior Wiring" - Cook - P227-28
9. Can the wires be withdrawn from Bx? Why? "Wiring for Light and Power" - Croft - P305
10. Why should the radius of the bend, when bending Bx, not be too short? "Wiring for Light and Power" - Croft - P310
11. What are the features of armored cable? Hawkins - P796
12. What type of wires must be used in armored cable? "House Wiring" - Wolber & Rose - P221
13. What is the ruling concerning conductors for the same circuit, when alternating current is used? "House Wiring" - Wolber & Rose - P221
14. How is armored cable connected to other systems of wiring? "House Wiring" - Wolber & Rose - P229-30-31
15. How is Bx installed in finished buildings? "House Wiring" - Wolber & Rose - P231
OPEN WORK

KNOB AND TUBE SYSTEM

GENERAL INSTRUCTIONS

1. Go to the framework booth where you are to work and there study the layout and job specifications of the job you are going to do.

2. Carefully locate all energy and switch outlets according to the specifications furnished. With chalk, mark the places switch boxes are to be installed and distance above floor. Also mark place for receptacles. Locate exact center of room and mark a line on two rafters that will cut center mark.

3. Using Unit Operation Checking Sheet, list out and check those Unit Operations involved in this job.

4. Make a Bill of Material, in duplicate, and have it checked by the instructor.

5. Secure from the stock-room tubes, boxes, and hangers. The wire will be obtained when the tubes and boxes are in place. After wire has been pulled in and all splices made, check out switches and other equipment.

6. After checking material from stock-room install all boxes and locate entrance switch. Figure how wires are to be run and locate holes for tubes so that they will be put in a straight line. Bore holes and install tubes. Pull in wire and proceed as in 5.

7. Put up your job in a neat serious-minded fashion so you will form good, workmanlike habits.

8. When job is rough-in get a rough-in inspection from the instructor.

9. Get inspection on your splices before and after soldering and taping.

10. Keep your booth clean.
INSTRUCTIONS:

Place in the column at the right the Unit Operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT OPERATION</th>
<th>JOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and estimating the job</td>
<td>1</td>
</tr>
<tr>
<td>2. Making a bill of material</td>
<td>2</td>
</tr>
<tr>
<td>50. Boring holes</td>
<td>3</td>
</tr>
<tr>
<td>51. Installing tubes</td>
<td>4</td>
</tr>
<tr>
<td>53. Installing knobs</td>
<td>5</td>
</tr>
<tr>
<td>69. Making joints</td>
<td>1</td>
</tr>
<tr>
<td>73. Taping joints</td>
<td>2</td>
</tr>
<tr>
<td>52. Pulling in wires</td>
<td>3</td>
</tr>
<tr>
<td>54. Bringing wires into outlet and switch boxes.</td>
<td>4</td>
</tr>
<tr>
<td>55. Tapping a circuit</td>
<td>5</td>
</tr>
<tr>
<td>72. Soldering joints</td>
<td>1</td>
</tr>
<tr>
<td>78. Locating outlets</td>
<td>2</td>
</tr>
</tbody>
</table>

METHOD OF GRADING WORK

<table>
<thead>
<tr>
<th>Standard time for each job</th>
<th>8</th>
<th>6</th>
<th>10</th>
<th>14</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time used for each job</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

UNIT GRADES

<table>
<thead>
<tr>
<th>Application</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>25%</td>
</tr>
<tr>
<td>Workmanship</td>
<td>25%</td>
</tr>
<tr>
<td>Operation</td>
<td>15%</td>
</tr>
<tr>
<td>Inspection</td>
<td>15%</td>
</tr>
<tr>
<td>Summarized grade</td>
<td>100%</td>
</tr>
</tbody>
</table>
OPEN WORK

KNOB AND TUBE SYSTEM

JOB NO. 1

SPECIFICATIONS

Install a light in the center of the ceiling, on one of the frame-work sections, to be controlled by a switch to the right of the door. Also install a duplex receptacle, under the window, that is to be hot on the line.

Run #14 B&S R.C. copper wire in porcelain tubes when passing through joists and on porcelain solid or split knobs when running along the surface. From the last knob to the boxes cover the wire with loom.

The light will be a plain drop cord, made up with type P portable cord, with a brass pull chain socket and pendant cap. Cover the loom box with a 3½" black enamel drop cord cover. The drop cord will hang 1 ft. below the cover.

To control the light use a single-pole flush toggle switch mounted in a 2" switch box. The box to be 4½ ft. from the floor. Cover the switch box with a toggle switch plate.

Use a standard duplex receptacle, mounted in a 2" switch box, 16" above the floor. Cover with a standard bakelite duplex receptacle cover.

The installation current will be brought in in the regular manner for making a service entrance. That is, lock a ¼" conduit, with a T&B entrance cap, into a iron box. Run the wires through this to an entrance switch mounted in this box. The other side of the entrance switch will be connected to the job.

Solder and tape all joints. Check your job for shorts and grounds before closing entrance switch. Have job inspected. This will save fuses and your money. All work must be done according to the rules of the National Electrical Code.

NOTE: Do not tear this job down, it will be part of Job #2.

NOTE: The Bill of Material for Job #1 and #2 are the same. See Job #2 for the Bill of Material of this job.
KNOB AND TUBE SYSTEM

QUESTIONS FOR JOB NO. 1

1. What is the cheapest form of concealed wiring?
   "Interior Wiring" -- Cook -- P233
2. What is the use of the head on the tubes?
   "Interior Wiring" -- Cook -- P234
3. Is it possible to run the wires on the same studing? Why?
   "Interior Wiring" -- Cook -- P234
4. In open work in factories where are the wires placed? Why?
   "Interior Wiring" -- Cook -- P235
5. Describe the Tap system and the Loop system, telling which is the best?
   "House Wiring" -- Wolber & Rose -- P204
6. How do you fasten loom where it enters a box?
   "House Wiring" -- Wolber & Rose -- P207
7. (a) What part of the job is installed first?
    (b) How and why is it so installed?
    (c) What purpose do they serve?
   "House Wiring" -- Wolber & Rose -- P212
8. Where is the knob and tube system chiefly used?
   "Interior Wiring" -- Cook -- P233
9. Can this system be used in fire-proof buildings?
   "Interior Wiring" -- Cook -- P233-34
10. What type of knobs are used?
    "Interior Wiring" -- Cook -- P234
In the second room of the framework install a light, switch, and receptacle following the specifications for Job #1. Tap the hot wires of Job #1 to obtain the installation current. Solder and tape all joints. Check this second room for shorts and grounds before closing the entrance switch. This will save fuses and your money. All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
<th>ITEM</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>#14 B&amp;S Black wire</td>
<td></td>
<td>Duplex receptacle plate</td>
<td></td>
</tr>
<tr>
<td>#14 B&amp;S White wire</td>
<td></td>
<td>Toggle switch plate</td>
<td></td>
</tr>
<tr>
<td>Type P portable cord</td>
<td></td>
<td>Flexible tubing (Loom)</td>
<td></td>
</tr>
<tr>
<td>Split knobs</td>
<td></td>
<td>Entrance switch</td>
<td></td>
</tr>
<tr>
<td>Solid knobs</td>
<td></td>
<td>Iron switch box</td>
<td></td>
</tr>
<tr>
<td>Porcelain tubes</td>
<td></td>
<td>2&quot; Conduit</td>
<td></td>
</tr>
<tr>
<td>Single-pole toggle Sw.</td>
<td></td>
<td>3&quot; Locknuts</td>
<td></td>
</tr>
<tr>
<td>Pull chain socket</td>
<td></td>
<td>2&quot; Bushing</td>
<td></td>
</tr>
<tr>
<td>2&quot; Switch boxes</td>
<td></td>
<td>T&amp;B Entrance cap</td>
<td></td>
</tr>
<tr>
<td>Loom box</td>
<td></td>
<td>Solder</td>
<td></td>
</tr>
<tr>
<td>Duplex receptacle</td>
<td></td>
<td>Friction tape</td>
<td></td>
</tr>
<tr>
<td>3/4&quot; Drop cord cover</td>
<td></td>
<td>Rubber tape</td>
<td></td>
</tr>
</tbody>
</table>
QUESTIONS FOR JOB NO. 2

1. What types of tubes are used? "Interior Wiring" -- Cook -- P234
2. What type of boxes are used in connection with the Knob and Tube system? "Interior Wiring" -- Cook -- P234
3. Where, how, and why do you install flexible tubing? "Interior Wiring" -- Cook -- P234
4. Is it necessary to enclose switches and receptacles in boxes? "Interior Wiring" -- Cook -- P234
5. How far apart must the wires be kept? "Interior Wiring" -- Cook -- P234
6. How close should the supporting knobs be placed? "Interior Wiring" -- Cook -- P234
7. Where it is impossible to keep the wires 5 inches apart, what type of protection is afforded? "Interior Wiring" -- Cook -- P235
8. How is flexible tubing constructed? "Interior Wiring" -- Cook -- P235
9. What are the advantages and disadvantages of flexible tubing? "Interior Wiring" -- Cook -- P235
10. What are the advantages of open wiring? "Interior Wiring" -- Cook -- P235
OPEN WORK
KNOB AND TUBE SYSTEM
JOB NO. 3
SPECIFICATIONS

Install a light in the center of the ceiling, of one of the framework sections, to be controlled by two 3-way switches. Also install three receptacles, one under the window, one on the back wall, and the third in the partition.

Run #14 B&S R.C. copper wire in porcelain tubes when passing through joists and on porcelain solid or split knobs when running along the surface. From the last knob to the boxes, cover the wire with loom.

The light will be a plain drop cord, made with #18 B&S green, twisted cord with a porcelain key socket and pendant cap. Cover the loom box with a 3/4″ black enamel drop cord cover. The drop cord will hang 1 ft. below the cover.

The switches for controlling the lights will be 3-way flush toggle switches, mounted in 2″ loom switch boxes, 4½ ft. from the floor. S1 is to be installed at the right of the door, from the entrance side. S2 is to be installed in the center partition.

Use standard duplex receptacles mounted in 2″ loom switch boxes, 16″ above the floor. Install one under the window, one in the center of the back wall, and one in the center of the partition.

The installation current will be brought in in the regular manner for making a service entrance. That is, lock a 1/4″ conduit, with a T&B entrance cap, into an iron box. Run the wires through this to an entrance switch, mounted in this box. The other side of the entrance switch will be connected to the job.

Solder and tape all joints. Check your jobs for shorts and grounds before closing entrance switch. Have job inspected. This will save fuses and your money. All work must be done according to the rules of the National Electrical Code.
QUESTIONS FOR JOB NO. 3

1. What are the disadvantages of open wiring?
   "Interior Wiring" -- Cook -- P235

2. How far above the surface must the knob support the wire?
   "Wiring for Light and Power" -- Croft -- P295

3. Why should tubes be used where conductors pass through timbers?
   "Wiring for Light and Power" -- Croft -- P295

4. What are loom boxes? "House Wiring" -- Wolber & Rose -- P205

5. Where are loom boxes used? "House Wiring" -- Wolber & Rose -- P205

6. What are loom box hangers? "House Wiring" -- Wolber & Rose -- P206

7. How do you install loom boxes between studding?
   "House Wiring" -- Wolber & Rose -- P206

8. What is meant by ganging switch boxes?
   "House Wiring" -- Wolber & Rose -- P209-10

9. How do you gang switch boxes?
   "House Wiring" -- Wolber & Rose -- P210

10. What is a fixture stud, where are they used, and how are they installed?
    "House Wiring" -- Wolber & Rose -- P211
OPEN WORK

KNOB AND TUBE SYSTEM

JOB NO. 4

SPECIFICATIONS

Install entrance switch on the back wall, in the left-hand corner, of booth #1. Connect to external circuit as in Job #1. Run two wires from the switch, the full length of the framework, ending at a receptacle under the window on the opposite end.

Install a light in the center of the ceiling in each of the framework booths. Light in #2 to be controlled by two 3-way switches. Light in #1 to be controlled by a single pole switch.

Run #14 B&S R.C. copper wire in porcelain tubes when passing through joists and on porcelain solid or split knobs when running along the surface. From the last knob to the boxes cover the wire with loom.

The lights will be plain drop cords, made up with #18 B&S green, twisted cord with brass keyless sockets and pendent caps. Cover loom box with a 3½" black enamel drop cord cover. The drop cords will hang 1 ft. below the cover.

Control lights in room #1 with a single-pole flush toggle switch, mounted in a 2" loom switch box, 4½ ft. from the floor. The switch is to be to the right of the door, from the entrance side.

Control the light in room #2 with two 3-way flush toggle switches, mounted in 2" loom switch boxes, 4½ ft. from the floor. S1 to be to the right of the door, on the entrance side. S2 to be in the partition between the rooms, but facing in room #1. The light can be turned on or off when passing from one room to the other. Cover the switch with a toggle switch plate.

Use standard duplex receptacles mounted in 2" loom switch boxes, 16" above the floor. One to be installed in room #2 as stated above, the other to be installed in the middle of the back partition, also in room #2. Cover with a standard bakelite duplex receptacle plate.

Solder and tape all joints. Check your job for shorts and grounds before closing the entrance switch. Have the job inspected. This will save fuses and your money. All work must be done according to the rules of the National Electrical Code.
### QUESTIONS FOR JOB NO. 4

1. What should be the first thing done before beginning a job? "House Wiring" -- Wolber & Rose -- P212
2. How should the holes in the joists be bored with reference to the floor? Why? "House Wiring" -- Wolber & Rose -- P213
3. What size bit is used in boring the holes? "House Wiring" -- Wolber & Rose -- P213
4. What is the minimum distance allowed between holes? Why? "House Wiring" -- Wolber & Rose -- P213
5. How is the tube placed in the hole? Why? "House Wiring" -- Wolber & Rose -- P213-14
6. What is the exception to the case mentioned in question 5? Why? "House Wiring" -- Wolber & Rose -- P214
7. What method is used where the wire passes from a tube to an outlet? Why? "House Wiring" -- Wolber & Rose -- P214
8. Describe the method you would use in installing a wire on a flat surface. "House Wiring" -- Wolber & Rose -- P215
9. Why is loom used? "House Wiring" -- Wolber & Rose -- P216
OPEN WORK

KNOB AND TUBE SYSTEM

JOB NO. 5

SPECIFICATIONS

Install a Trumbrell-Vanderpoel 2-pole 2-circuit entrance switch on the back wall, in the left hand corner, of booth #1. Connect to the external circuit as in job #1. Use circuit #1 for room #1 and circuit #2 for room #2.

Install a light in the center of the ceiling of each room. Also install a light over the door, on the outside, of room #1. Then 2 bracket lights on the rear wall of room #2. The lights in the rooms are to be controlled with 3-way switches; the exterior light to be controlled by a single-pole switch.

Run #14 B&S R.C. copper wire in porcelain tubes where passing through joists and on porcelain solid or split knobs when running along the surface. From the last knob to the boxes cover the wire with loom.

The interior lights to be plain drop cords, made up with type P portable cord and brass key sockets and pendant caps. Cover the loom box, which will be hung in the center of the room by a straight bar hanger, with a 3½" black enamel drop cord cover. The drop cord will hang 1 ft. below the cover.

The exterior light will be a sign receptacle set in a 4" outlet box. The box will be hung above the door on a shallow offset bar hanger.

Control the exterior light with a single-pole flush toggle switch mounted in a 2-gang switch box, 4½ ft. from the floor. The box is to be to the right of the door, from the entrance side.

In room #1, S1 will be a 3-way switch mounted in the 2-gang box containing the single-pole switch for the exterior light. S2 will be a 3-way switch mounted in a 2-gang switch box in the partition facing room #1. It shall be mounted 4½ ft. from the floor.

In room #2, S1 will be a 3-way switch mounted in a 2" switch box, 4½ ft. from the floor, to the right of the door, from the entrance side. S2, a 3-way switch, will be a 2-gang switch box, which is mounted in the partition and contains a switch controlling the light in room #1.

In room #1 install 2 duplex receptacles, in 2" loom switch boxes, 16" from the floor. One to be in the center of the back wall. The other to be under the window.

In room #2, install 2 duplex receptacles, in 2" loom switch boxes, 16" from the floor. One to be in the partition between the two rooms, the other to be under the window. Install the two bracket lights on the rear wall, 5½ ft. from the floor. Separate the two by one panel. Use sign receptacles set in 4" outlet boxes, hung in shallow offset bar hangers. These lights are to be hot on the line.

Solder and tape all joints. Check your job for shorts and grounds before closing entrance switch. Have job inspected. This will
save fuses and your money. All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

QUESTIONS FOR JOB NO. 5

1. What type of splices do you use in outlet boxes? Why
   "House Wiring" -- Wolber & Rose -- P216

2. What is the "polarity" system?
   "House Wiring" -- Wolber & Rose -- P218

3. Why is it difficult to install a concealed knob and tube system in a completed building? "House Wiring" -- Wolber & Rose -- P218

4. Who issues the National Electrical Code?
   "Interior Wiring" -- Cook -- P208

5. Is it necessary to add insulation when wires are crossed or when crossing pipes? "House Wiring" -- Wolber & Rose -- P83-4

6. What method is used when the conductors pass through floors?
   "Wiring for Light and Power" -- Croft -- P296-97

7. What provision should be made in wiring a hallway?
   "Hawkins" -- P846

8. In what parts of the country are the code rules in effect?
   "Interior Wiring" -- Cook -- P208

9. What is the difference between a splice and a tap?
   Hawkins -- P859

10. Are you required to ground a knob and tube system? Why?
    Rules 901 & 903c -- Shop Manual -- Operation 56 -- P34

121
METAL RACEWAYS

METAL MOLD

GENERAL INSTRUCTIONS

1. Go to the booth in which you are going to work and there study the job specifications of the job you are going to do.

2. Lay out the outlets on the walls and ceiling using chalk.

3. Using the Unit Operation Checking Sheet, list out and check those Unit Operations involved in this job.

4. Study the metal mold catalogue and the exhibit board, especially for those fittings you are going to use on this job. Also study the Code rulings for Metal Raceways, and reference books noted in questions.

5. Draw up the wiring diagram.

6. Make out your Bill of Material, in duplicate, and have it checked by the instructor.

7. Secure from the stock-room all the material you will need, except Metal Mold and wire, which you will get as you need it. At the close of each session lock up in your locker all the material which you have not yet installed. You are responsible for all the material listed on your Bill of Material.

8. You will be required to pay for all the fuses you blow, except on inspected jobs. Secure inspection before connecting to lighting service.

9. Solder and tape all joints.

10. Ground all metal mold installations.

11. Put up your work in a neat and serious-minded fashion, so that you will form workmanlike habits.

12. Keep your booth clean.
METAL RACEWAYS

UNIT OPERATIONS CHECKING SHEET

INSTRUCTIONS:
Place in the column at the right the unit operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT OPERATION</th>
<th>JOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and estimating the job</td>
<td>1</td>
</tr>
<tr>
<td>2. Making a bill of material</td>
<td>2</td>
</tr>
<tr>
<td>26. Cutting</td>
<td>3</td>
</tr>
<tr>
<td>31. Bending and mitering a turn</td>
<td>4</td>
</tr>
<tr>
<td>32. Installing and connecting to baseplates</td>
<td>7</td>
</tr>
<tr>
<td>73. Taping joints</td>
<td>8</td>
</tr>
<tr>
<td>79. Testing for shorts and grounds</td>
<td>9</td>
</tr>
<tr>
<td>69. Splicing</td>
<td>6</td>
</tr>
<tr>
<td>30. Coupling</td>
<td>7</td>
</tr>
<tr>
<td>29. Slotting or punching</td>
<td>8</td>
</tr>
<tr>
<td>72. Soldering joints</td>
<td>9</td>
</tr>
<tr>
<td>32. Install wires</td>
<td>5</td>
</tr>
</tbody>
</table>

METHOD OF GRADING WORK

Standard time for each job: 4 6 8 5 10

Time used for each job.

UNIT GRADES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>20%</td>
</tr>
<tr>
<td>Time</td>
<td>25%</td>
</tr>
<tr>
<td>Workmanship</td>
<td>25%</td>
</tr>
<tr>
<td>Operation</td>
<td>15%</td>
</tr>
<tr>
<td>Inspection</td>
<td>15%</td>
</tr>
<tr>
<td>Summarized grade</td>
<td>100%</td>
</tr>
</tbody>
</table>
SPECIFICATIONS

One foot from the front of the ceiling of a booth install 4 lights placed so that the end lights are equally distant from the walls and so that the lights are 1 ft. apart.

Run #14 B&S R.C. wire in #333 Metal Mold, on the surface of the walls and ceilings. Use fittings as shown on the drawing. Furnish the installation current through conduit connected to a #406 combination connector. The lights shall consist of brass keyless socket bodies mounted on a receptacle base. They shall be controlled with a single-pole toggle switch mounted in a #439 1-gang surface switch box 4 1/2 ft. from the floor.

Use bushings in all ends of molding. Strap molding securely. The molding must be grounded.

The wiring installation shall test free of shorts and grounds.

Have the job properly inspected before connecting to lighting service.

All work must be done according to the rules of the National Electrical Code.

---

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>AMT.</th>
<th>COST</th>
<th>AMT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>#333 Metal Mold</td>
<td></td>
<td>#344-X Coupling</td>
<td></td>
</tr>
<tr>
<td>#14 B&amp;S White wire</td>
<td></td>
<td>#345 Strap</td>
<td></td>
</tr>
<tr>
<td>#14 B&amp;S Black wire</td>
<td></td>
<td>#500 Bushing</td>
<td></td>
</tr>
<tr>
<td>Brass keyless socket bodies</td>
<td></td>
<td>#355 Ground clamp</td>
<td></td>
</tr>
<tr>
<td>#406 Combination connector</td>
<td></td>
<td>2 x 5 F.H. Wood screws</td>
<td></td>
</tr>
<tr>
<td>#336 90° Flat elbow</td>
<td></td>
<td>Solder</td>
<td></td>
</tr>
<tr>
<td>#338 Internal elbow</td>
<td></td>
<td>Rubber tape</td>
<td></td>
</tr>
<tr>
<td>#439 1-gang sw. box</td>
<td></td>
<td>Friction tape</td>
<td></td>
</tr>
<tr>
<td>#319 Tee</td>
<td></td>
<td>#400 Receptacle base</td>
<td></td>
</tr>
</tbody>
</table>
METAL MOLD
WIRING DIAGRAM
JOB NO. 1

126
METAL MOLD

QUESTIONS ON JOB NO. 1

1. Of what is metal molding made? "Interior Wiring" -- Cook -- P229
2. What is the reason for galvanizing? "Interior Wiring"--Cook--P229
3. How is the backing and covering put together? "Interior Wiring" -- Cook -- P229
4. How many sizes of metal molding are made? "Interior Wiring" -- Cook -- P230
5. How many and what size wires can it contain? "Interior Wiring" -- Cook -- P230
6. What lengths are furnished? "Interior Wiring" -- Cook -- P230
7. What voltages can metal molding be used on? "Interior Wiring" -- Cook -- P230
8. What is the maximum allowable wattage? "Interior Wiring" -- Cook -- P230
9. What are the advantages of metal molding? "Interior Wiring" -- Cook -- P230 -- Catalogue -- P4
10. Where is it chiefly used? "Interior Wiring" -- Cook -- P230
11. What are some of the special outlet fittings? "House Wiring" -- Wolber & Rose -- P190-91
12. How are they attached to the various lengths of metal molding? "House Wiring" -- Wolber & Rose -- P190-91
13. Why are they attached in this manner? "Interior Wiring" -- Cook -- P230
14. What type of wire may be used? "Interior Wiring" -- Cook -- P230-31
15. How is the size of a plier determined? Shop Manual -- P2
METAL MOLD

JOB NO. 2
SPECIFICATIONS

Install 4 lights in a booth so as to give equal distribution of light throughout the booth.

The lights are to be controlled by two 3-way toggle switches mounted in #439 1-gang switch boxes, 4 1/2 ft. from the floor, on either wall. Use other fittings as shown on the drawing. Furnish the installation current through a combination connector.

The lights shall consist of a plain drop cord, type P portable cord, fitted with porcelain key sockets hung 1 ft. from the ceiling.

Use bushings in all ends of molding. Strap molding securely. The molding must be grounded.

The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting to a lighting service.

All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>AMT.</th>
<th>COST</th>
<th>AMT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

129
METAL MOLD
WIRING DIAGRAM
JOB NO. 2
METAL MOLD

QUESTIONS FOR JOB NO. 2

1. How is metal molding cut? "Interior Wiring" -- Cook -- P231

2. To what extent can you bend metal molding? "Interior Wiring" -- Cook -- P231

3. How do you install metal molding? "Interior Wiring" -- Cook -- P231

4. What protection must be given metal molding when it passes through a floor? "Interior Wiring" -- Cook -- P231

5. What rule governs molding when it passes through a partition? "Interior Wiring" -- Cook -- P231

6. When and where is metal molding used? Catalogue -- P4

7. What are the dimensions of metal molding? Catalogue -- P30

8. Of how many pieces does #333 metal molding consist? Catalogue -- P30

9. What are these pieces and how are they joined? Catalogue -- P30

10. What type of paint can be used on metal molding? Catalogue -- P30

11. What is a terminal block; when and why is it used? Catalogue -- P44

12. What is the natural finish of metal molding? Catalogue -- P30

13. How are conduit and metal molding joined? Catalogue -- P59

14. What type of straps are used for holding metal molding? Catalogue -- P58

15. What are joint caps and for what are they used? Catalogue -- P60-61
SPECIFICATIONS

In a booth install 4 lights so as to give equal distribution of light throughout the booth. Also install a wall light and a plug receptacle on either wall.

Run #14 B&S R.C. wire in #333 Metal Molding on the surface of the walls and ceiling. Use fittings as shown on the drawing. Furnish the installation current through conduit connected to a #406 combination connector.

The ceiling light shall be a plain drop cord made of type P portable cord, hung 1 ft. from the ceiling. They are to be controlled by a single-pole toggle switch mounted in a #439 1-gang surface box 4½ ft. from the floor.

The wall lights are to be brass key socket bodies mounted on a #400 receptacle base and are to act as a pilot light for the #360 plug receptacle.

Use bushings in all ends of molding. Strap molding securely. The molding must be grounded. The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting to the lighting service.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

133
LETAL MOLD
WIRING DIAGRAM
JOB NO. 3
METAL MOLD

QUESTIONS FOR JOB NO. 3

1. What method is used in grounding metal molding?
   Catalogue -- P60-61
2. What type of bushings are used with metal molding?
   Catalogue -- P65
3. Why and where are they used? Catalogue -- P65
5. What is the largest size wire allowed in metal raceways?
   National Code -- Section 504d
6. What are the largest fuses allowed on a circuit in metal raceways?
   National Code -- Section 504d
7. How are holes for screws designed in the backing of raceways?
   National Code -- Section 504f
8. How many raceways may be used for one circuit when AC is used?
   National Code -- Section 504g
9. Why must metal raceways be electrically continuous?
   "Wiring for Light and Power" -- Croft -- P150
10. How can the electrical continuity in metal raceways be assured?
    "Wiring for Light and Power" -- Croft -- P327
11. In what ways are metal raceways similar to conduit?
    "Wiring for Light and Power" -- Croft -- P323
12. Why must metal raceways be continuous from outlet to outlet?
    "Wiring for Light and Power" -- Croft -- P323
13. What is meant by the clause, "They must be continuous both electrically and mechanically"?
    "Wiring for Light and Power" -- Croft -- P324
14. Where must the splices in the system be made?
    "Wiring for Light and Power" -- Croft -- P324
15. What method is used in joining metal raceways to wiring arranged in accordance with the knob and tube, conduit, or open-work method? "Wiring for Light and Power" -- Croft -- P324
METAL MOLD

JOB NO. 4

#338
#336
#358
#348
#406
#338
#336

1
2
3
4

136
SPECIFICATIONS

Install a light in the center of the facing of a booth and another in the center of the ceiling.

Run #14 B&S R.C. copper wire in #333 Metal Molding on the surface of the walls and ceiling. Use fittings as shown on the drawing. Furnish the installation current through conduit connected to a #406 combination connector.

The interior light shall be a plain drop cord, made of type P portable cord, fitted with a brass pull chain socket, hung 1 ft. from the ceiling. It shall be controlled by a single-pole toggle switch.

The exterior light shall be a brass keyless socket body mounted in a #400 receptacle base and controlled by a single-pole toggle switch. The switches shall be mounted in a #440 2-gang surface switch box, 4½ ft. from the floor.

Use bushings in all ends of molding. Strap all molding securely. The molding must be grounded. The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting to a lighting service.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANT.</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

137
METAL MOLD

QUESTIONS FOR JOB NO. 4

1. What method is used whenever conductors leave the metal raceways system to serve as energy consuming devices?
   "Wiring for Light and Power" -- Croft -- P324

2. What is the reason for protecting metal raceways when they pass through floors? "Wiring for Light and Power" -- Croft -- P324

3. To what extent above and below the floor should the protection extend? "Wiring for Light and Power" -- Croft -- P325

4. How is the protecting pipe supported?
   "Wiring for Light and Power" -- Croft -- P325

5. What governs the height which the protecting cover extends above the floor, when metal raceways pass through a floor?
   "Wiring for Light and Power" -- Croft -- P325

6. Why must metal raceways be grounded?
   "Wiring for Light and Power" -- Croft -- P326

7. For what purpose may convenient outlets be used in bed-rooms, living-rooms, dining-rooms, bath-rooms, kitchen, and basement?

8. What is meant by a grounded wire?

9. What do we mean by electrical contact?

10. What are electrical fuses? "House Wiring" -- Wolber & Rose -- P137

11. At what temperature will lead melt?
    "Elements of Physics" -- Smith -- P639

12. At what temperature will copper melt?
    "Elements of Physics" -- Smith -- P639

13. What relation should a fuse wire bear to the rest of the circuit?
    "Electric Wiring" -- Schuhler -- P144

14. What is the purpose of soldering paste?
    "House Wiring" -- Wolber & Rose -- P27

15. Would acid be good to use in soldering joints?
    "Interior Wiring" -- Cook -- P260
METAL MOLD

JOB NO. 5
SPECIFICATIONS

Install in booth #1 a light to be controlled by a switch in that booth. In booth #2 install a light to be controlled by two 3-way switches. The switches to be located in booths #1 & #2 respectively.

Run #14 B&S R.C. copper wire in #333 Metal Molding on the surface of the walls and ceiling. Between booths use a piece of Thin Wall Conduit. Use fittings as shown on the drawings. Furnish the installation current through conduit connected to a #406 combination connector.

The lights in both booths shall be plain drop cord, made of type P portable cord fitted with brass key sockets, hung 1 ft. from the ceiling.

The light in booth #1 will be controlled by a single-pole toggle switch mounted, on the right hand wall, in a #440 2-gang surface switch box. The light in booth #2 will be controlled by two 3-way switches. One to be mounted in the 2-gang switch box in booth #1, the other to be mounted in a 1-gang switch box on the right hand wall of booth #2. The switch boxes are to be mounted 4½ ft. from the floor.

Use bushings in all ends of molding. Strap molding securely. The molding must be grounded. The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting to the lighting service. All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

141
METAL MOLD

QUESTIONS FOR JOB NO. 5

1. Explain in detail how to use a blow torch?
   "Electric Wiring" -- Schuhler -- P36

2. What is a soldering iron? "House Wiring" -- Wolber & Rose -- P27-8

3. Why should joints be carefully soldered?
   "House Wiring" -- Wolber & Rose -- P26

4. What does the solder do to make the joint good?
   "Wiring for Light and Power" -- Croft -- P104

5. Why should joints be taped?
   "House Wiring" -- Wolber & Rose -- P33

6. What kind of tape is required to make the covering of the joint
equivalent to that on the wire?
   "House Wiring" -- Wolber & Rose -- P33

7. Why should servings of tape be wound in opposite directions?
   "House Wiring" -- Wolber & Rose -- P34

8. Why should Conduit, Armored Cable, and Metal Molding systems
be grounded? "Interior Wiring" -- Cook -- P223

9. What is the difference between keyless and pull chain sockets?
   "Interior Wiring" -- Cook -- P280

10. What type of socket should be used on a wall socket in a bath­
room? "Interior Wiring" -- Cook -- P281

11. What precaution must be taken if a lamp is hung from a flexible
cord, to prevent the weight of the lamp from pulling the wires
out of the terminals? "Interior Wiring" -- Cook -- P281

12. To what part of the socket must the grounded conductor be
fastened? National Code -- Section 1402b

13. What is the reason for soldering all splices?
   "House Wiring" -- Wolber & Rose -- P26

14. Under what conditions does the code require porcelain sockets
to be used on drop cords?

15. What is the minimum size ground wire allowed?
   "Wiring for Light and Power" -- Croft -- P144
METAL RACEWAYS

WIREMOLD

GENERAL INSTRUCTIONS

1. Go to the booth in which you are going to work and there study the job specifications of the job you are going to do.

2. Lay out the outlets on the walls and ceiling using chalk.

3. Using the Unit Operation Checking Sheet, list out and check those Unit Operations involved in this job.

4. Study the Wiremold Catalogue and the exhibit board, especially for those fittings you are going to use on this job. Also study the code rulings for Metal Raceways, and the reference books noted in the questions.

5. Draw up the wiring diagram.

6. Make out your bill of material, in duplicate, and have it checked by the instructor.

7. Secure from the stock-room all the material you will need, except Wiremold and wire, which you will get as you need it. At the close of each session lock up in your locker all the material which you have not yet installed. You are responsible for all the material listed on your bill of material.

8. You will be required to pay for the fuses you blow, except on inspected jobs. Secure inspection before connecting to the lighting circuit.

9. Solder and tape all joints.

10. Ground all Wiremold installations.

11. Put up your work in a neat and serious-minded fashion, so that you will form workmanlike habits.

12. Keep your booth clean.
METAL RACEWAYS
WIREMOLD

UNIT OPERATION CHECKING SHEET

INSTRUCTIONS:

Place in the column at the right the Unit Operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT OPERATION</th>
<th>JOBS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and estimating the job</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Making a bill of material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. Bending</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. Cutting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. Installing and connecting to baseplates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>73. Taping joints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79. Testing for shorts and grounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69. Splicing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. Coupling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72. Soldering joints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

METHOD OF GRADING WORK

Standard time for each job 3 3 5 4 6

Time used for each job

UNIT GRADES

Application--------------20%

Time-------------------25%

Workmanship------------25%

Operation---------------15%

Inspection-------------15%

Summarized grade-------100%

145
SPECIFICATIONS

In a booth install a light which can be controlled by a wall switch. Also install a wall receptacle, not controlled by this switch.

Run #14 B&S R.C. copper wire in #500 Wiremold, on the surface of the walls and ceiling. Use fittings and boxes as shown on the drawing. Furnish the installation current through a #5788 open-work coupling.

The light shall consist of plain drop cord made of type P portable cord. It shall be fitted with a brass key socket hung 1 ft. from the ceiling. Control the light with a single-pole switch, #5740, 4¾ ft. from the floor.

Use bushings in all ends of molding. Strap all molding securely. The molding must be grounded. The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td>#500 Wiremold</td>
</tr>
<tr>
<td>#14 B&amp;S White wire</td>
</tr>
<tr>
<td>#14 B&amp;S Black wire</td>
</tr>
<tr>
<td>Type P portable cord</td>
</tr>
<tr>
<td>#5788 Open-work coupl.</td>
</tr>
<tr>
<td>#5711 90° Elbow</td>
</tr>
<tr>
<td>#5717 Internal elbow</td>
</tr>
<tr>
<td>#5740 Single-pole switch and box</td>
</tr>
<tr>
<td>#5743 Duplex receptacle and box</td>
</tr>
<tr>
<td>#5721 Round utility box</td>
</tr>
</tbody>
</table>
WIREMOLD

QUESTIONS FOR JOB NO. 1

1. Why should conductors always be treated as if they were bare? "Wiring for Light and Power" -- Croft -- P1
2. Why should careful attention be paid to the mechanical execution of the work? "Wiring for Light and Power" -- Croft -- P1
3. Why are splices allowed only in outlets in metal raceways? "Wiring for Light and Power" -- Croft -- P282
4. Describe the method of installing switches in a wiremold system. "House Wiring" -- Wolber & Rose -- P180-83
5. Where and why are bushings used in a wiremold system? "House Wiring" -- Wolber & Rose -- P184
6. Where and why are connection covers used in a wiremold system? "House Wiring" -- Wolber & Rose -- P185
7. What are the advantages of rubber insulation for conductors? Hawkins -- P725
8. What are the advantages of Metal Raceways? "Wiring for Light and Power" -- Croft -- P323
9. Why are metal raceways used? "House Wiring" -- Wolber & Rose -- P170
10. Where are metal raceways used? "House Wiring" -- Wolber & Rose -- P170
11. For what service are rubber covered conductors adapted? Hawkins -- P725
12. Is pure rubber used? Hawkins -- P725
13. What kind of wires are suitable for open or exposed wiring? Hawkins -- P766
14. What method is used in joining wiremold and conduit? "House Wiring" -- Wolber & Rose -- P185
15. Under what conditions is it necessary to ground metal raceways systems? "House Wiring" -- Wolber & Rose -- P186 -- National Code -- Section 904a
WIREMOLD
JOB NO. 2

1  2
3  4

150
SPECIFICATIONS

In a booth install 4 lights to be controlled by one single-pole toggle switch.
Run #14 B&S R.C. copper wire in #500 Wiremold on the surface of the walls and ceiling. Use fittings and boxes as shown on the drawings. Connect the #5715 Tee to the outlet box, to furnish the installation current, with a #5781 box connector.

The lights shall consist of plain drop cord, type P portable cord, fitted with porcelain key sockets hung 1 ft. from the ceiling. Control the lights with a single-pole toggle switch set in a #5748 switch box, 4½ ft. from the floor.

The light outlets shall be so spaced on the ceiling that they will furnish equal distribution of light in the room.

Use bushings in all ends of molding. Strap all molding securely. Have the job properly inspected before connecting to the lighting service. It must test free of shorts and grounds. The molding must be grounded, use a #5709 grounding clamp.

All work must be done according to the rules of the National Electrical Code

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
WIREMOLD

QUESTIONS FOR JOB NO. 2

1. How many raceways may be used for one circuit when AC is used? National Code -- Section 504g

2. Why must metal raceways be electrically continuous? "Wiring for Light and Power" -- Croft -- P150

3. What are metal raceways made of? "House Wiring" -- Wolber & Rose -- P171

4. What type of finish do they have? "House Wiring" -- Wolber & Rose -- P171

5. In how many separate pieces are metal raceways made? "House Wiring" -- Wolber & Rose -- P171

6. Why is it necessary to ground wiremold? "House Wiring" -- Wolber & Rose -- P186

7. Describe the method used in grounding wiremold. "House Wiring" -- Wolber & Rose -- P186

8. What is the smallest wire allowable in grounding wiremold? "House Wiring" -- Wolber & Rose -- P186

9. How can the electrical continuity be assured? "Wiring for Light and Power" -- Croft -- P327

10. In what way are metal raceways similar to conduit? "Wiring for Light and Power" -- Croft -- P323

11. How is molding work installed on brick or plaster walls which are liable to dampness? Hawkins -- P776

12. How should molding be placed on a ceiling with respect to appearance? Hawkins -- P776

13. How does the weight of metal raceways compare with that of conduit? "House Wiring" -- Wolber & Rose -- P171

14. What is the color of wiremold and why does it have this finish? "House Wiring" -- Wolber & Rose -- P171

15. What is the standard length of wiremold? "House Wiring" -- Wolber & Rose -- P171
SPECIFICATIONS

In a booth install 4 lights to be controlled by one single-pole toggle switch.
Run #14 B&S R.C. copper wire in #500 Wiremold on the surface of the walls and ceiling. Use fittings and boxes as shown on the drawing. Connect the installation current through conduit as shown.
The lights will be plain drop cord made with type P portable cord, fitted with porcelain key sockets hung 1 ft. from the ceiling. Control the lights with a single-pole toggle switch set in a galvanized conduit switch box, 4½ ft. from the floor.
Use a #5781 male box connector to connect the Wiremold to the switch box.
Use bushings in all ends of molding. Strap all molding securely. The molding must be grounded, use a #5709 grounding clamp.
The light outlets shall be so spaced on the ceiling that they will furnish equal distribution of light in the room.
The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting it to the lighting service. All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>AMT.</th>
<th>COST</th>
<th>AMT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

155
WIREIOLD
WIRING DIAGRAM
JOB NO. 3
1. What is the use of the base coupling each length of wiremold is equipped with? "House Wiring" -- Wolber & Rose -- P171
2. Describe three methods by which wiremold can be fastened to a surface. "House Wiring" -- Wolber & Rose -- P171-72
3. What is the difference between a splice and a tap?
   Hawkins -- P859
4. What precautions should be taken in making joints?
   Hawkins -- P859
5. How should joints be finished after soldering?
   Hawkins -- P860
6. Why must metal raceways be continuous from outlet to outlet?
   "Wiring for Light and Power" -- Croft -- P323
7. Is it possible to make short right angle bends with wiremold?
   "House Wiring" -- Wolber & Rose -- P173
8. Name each type of elbow furnished and describe the use of each.
   "House Wiring" -- Wolber & Rose -- P173-74
9. How many parts are there to an elbow?
   "House Wiring" -- Wolber & Rose -- P174
10. Where must the splices in the system be made?
    "Wiring for Light and Power" -- Croft -- P324
11. What method is used in joining metal raceways to wiring arranged in accordance with the knob and tube, conduit, or open-work methods? "Wiring for Light and Power" -- Croft -- P324
12. What method is used whenever conductors leave the metal raceways system to serve as energy consuming devices?
    "Wiring for Light and Power" -- Croft -- P324
13. Is it possible to bend wiremold?
    "House Wiring" -- Wolber & Rose -- P186
14. How is wiremold bent?
    "House Wiring" -- Wolber & Rose -- P186-87
15. How can wiremold be cut?
    "House Wiring" -- Wolber & Rose -- P186
SPECIFICATIONS

This job is an addition to Job No. 3. On the opposite wall install a #5748 switch box 4½ ft. from the floor. Rewire the circuit so that the lights will be controlled by two 3-way switches situated on either wall.

Do not try to run four #14 wires in #500 Wiremold. Instead use #700 Wiremold.

Be sure that all splices are taped and that the circuit tests free of shorts and grounds.

Have your wiring diagram examined before installing wiring.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

159
WIREMOLD

QUESTIONS FOR JOB NO. 4

1. What type of hacksaw blade should be used in cutting wiremold?
   "House Wiring" -- Wolber & Rose -- P186

2. How are elbows installed?
   "House Wiring" -- Wolber & Rose -- P174

3. Why is the capping not put on until the wires have been drawn into the raceway?
   "House Wiring" -- Wolber & Rose -- P187

4. What are the various uses of the corner box? Describe each.
   "House Wiring" -- Wolber & Rose -- P175

5. Is it possible to make splices in a corner box?
   "House Wiring" -- Wolber & Rose -- P175-76

6. Why should all ends of wiremold be inspected for burrs before installation?
   "House Wiring" -- Wolber & Rose -- P186

7. When is the wire installed in wiremold?
   "House Wiring" -- Wolber & Rose -- P187

8. Why are the covers of various wiremold fittings not fastened on before the wires are pulled in place?
   "House Wiring" -- Wolber & Rose -- P187

9. What are the dimensions of #500 and #700 wiremold?
   Catalogue -- P8

10. What is the reason for protecting metal raceways when they pass through floors?
    "Wiring for Light and Power" -- Croft -- P324-25

11. To what extent above and below the floor should the protection extend?
    "Wiring for Light and Power" -- Croft -- P325

12. How is the protecting pipe supported where metal raceways are run through floors?
    "Wiring for Light and Power" -- Croft -- P325

13. What governs the height which the protecting cover extends above the floor when metal raceways pass through a floor?
    "Wiring for Light and Power" -- Croft -- P325

14. What is a utility box? "House Wiring" -- Wolber & Rose -- P176

15. What are the various uses of the utility box? Describe each.
    "House Wiring" -- Wolber & Rose -- P176
SPECIFICATIONS

In a booth install a light in the ceiling which can be controlled by a wall switch. Also on the back wall install 2 wall lights 6 ft. from the floor and 1½ ft. from the side walls.

Run #14 B&S R.C. copper wires in #500 Wiremold on the surface of the walls and ceiling. Use fittings as shown on the drawing. Furnish the installation current through conduit connected to a #5785 combination connector.

Use a #5738 fixture box in hanging the light. The type of fixture to be used will be designated later. It is to be controlled by a single-pole toggle switch, mounted on the left-hand wall, and set in a #5748 switch box. The switch box is to be mounted 4½ ft. from the floor.

The wall lights are to be brass key socket bodies set in #5725 receptacle bases.

Use bushings in all ends of molding. Strap molding securely. The molding must be grounded. The wiring installation shall test free of shorts and grounds. Have the job properly inspected before connecting to the lighting service.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>ALT.</th>
<th>COST</th>
<th>ALT.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

163
WIREMOLD

QUESTIONS FOR JOB NO. 5

1. What are terminal blocks and what are their uses?
   "House Wiring" -- Wolber & Rose -- P178

2. What is a wiremold rosette and for what purpose may it be used?
   "House Wiring" -- Wolber & Rose -- P178

3. Describe the various types of wiremold receptacles and describe the use of each. "House Wiring" -- Wolber & Rose -- P179

4. What is the single conductor capacity of #500 wiremold?
   Catalogue -- P8

5. Who manufactures wiremold? Catalogue -- P4

6. Where is wiremold manufactured? Catalogue -- P4

7. Who is the sales representative for our district? Catalogue -- P84

8. What is wiremold? Catalogue -- P5


10. How does wiremold serve this purpose? Catalogue -- P5

11. How is it possible to obtain fittings for wiremold installations that are required to meet special problems? Catalogue -- P6

12. Describe the method of installing wiremold. Catalogue -- P7

13. What is the wiremold beam strap? Catalogue -- P10-11

14. Describe the wiremold bender and tell how to use it:
    Catalogue -- P12-13

15. Explain the method of installing rosettes, receptacles, and boxes? Catalogue -- P24-25

165
METAL RACEWAYS

XTENSIONDUCT

GENERAL INSTRUCTIONS

1. Go to the booth in which you are going to work and there study the job specifications of the job you are going to do.

2. Lay out the outlets on the walls using chalk.

3. Using the Unit Operation Checking Sheet, list out and check those Unit Operations involved in the job.

4. Study the Metal Mold Catalogue and exhibit board, especially for those fittings you are going to use on this job. Also study the Code Rulings for Metal Raceways, and reference books noted in the questions.

5. Draw up your wiring diagram.

6. Make out your bill of material, in duplicate, and have it checked by the instructor.

7. Secure from the stock-room all the material you will need, except Xtensionduct and wire, which you will get as you need it. At the close of each session lock up in your locker all the material you have not yet installed. You are responsible for all the material listed on your bill of material.

8. You will be required to pay for the fuses you blow, except on inspected jobs. Secure inspection before connecting to the lighting circuit.

9. Solder and tape all joints.

10. It will be unnecessary to ground these installations, they will be considered as short runs.

11. Put up your work in a neat and serious-minded fashion, so that you will form good workmanlike habits.

12. Keep your booth clean.
METAL RACEWAYS
EXTENSIONDUCT
UNIT OPERATION CHECKING SHEET

INSTRUCTIONS:

Place in the column at the right the Unit Operation involved in the job.

<table>
<thead>
<tr>
<th>UNIT OPERATION</th>
<th>JOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planning and estimating the job</td>
<td>1</td>
</tr>
<tr>
<td>2. Making a bill of material</td>
<td>2</td>
</tr>
<tr>
<td>37. Using cutting &amp; notching gauge</td>
<td>3</td>
</tr>
<tr>
<td>38. Installing backing</td>
<td></td>
</tr>
<tr>
<td>73. Taping</td>
<td></td>
</tr>
<tr>
<td>39. Putting in wires</td>
<td></td>
</tr>
<tr>
<td>40. Putting on capping</td>
<td></td>
</tr>
<tr>
<td>79. Testing for shorts and grounds</td>
<td></td>
</tr>
<tr>
<td>69. Splicing</td>
<td></td>
</tr>
<tr>
<td>41. Coupling</td>
<td></td>
</tr>
<tr>
<td>72. Soldering joints</td>
<td></td>
</tr>
<tr>
<td>42. Mitering a turn</td>
<td></td>
</tr>
<tr>
<td>43. Bending</td>
<td></td>
</tr>
</tbody>
</table>

METHOD OF GRADING WORK

Standard time for each job

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>5</th>
<th>8</th>
</tr>
</thead>
</table>

Time used for each job

UNIT GRADES

<table>
<thead>
<tr>
<th>Application</th>
<th>Time</th>
<th>Workmanship</th>
<th>Operation</th>
<th>Inspection</th>
<th>Summarized grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>25%</td>
<td>25%</td>
<td>15%</td>
<td>15%</td>
<td>100%</td>
</tr>
</tbody>
</table>

167
SPECIFICATIONS

Install an additional receptacle on the baseboard of framework booth #2.

On the outlet install a #141 Box Extension Device using studs provided for that purpose. 4 ft. from the wall containing the #141 receptacle install a #150 duplex receptacle. Use elbow cap #138 in the corner.

Installation current to be brought in through the #141 receptacle. Test the circuit for shorts and grounds. Have circuit inspected. Test outlets with drop cords. All work must be done according to the rules of the National Electrical Code.

WIRING DIAGRAM
### QUESTIONS FOR JOB NO. 1

1. Where is Xtensionduct used? Catalogue -- P4
2. How many, and what size wires does it hold? Catalogue -- P4
3. How many pieces does Xtensionduct consist of? What are they? Catalogue -- P6
4. What type of finish does the capping have? Catalogue -- P6
5. How is the base finished? Catalogue -- P6
6. What is the purpose of the finish given the base? Catalogue -- P6
7. What are the dimensions of Xtensionduct? Catalogue -- P6
8. What is the standard length of Xtensionduct? Catalogue -- P6
9. How is the base installed? Catalogue -- P9
10. What size screw is used in the base? Catalogue -- P9
SPECIFICATIONS

In a booth install 4 duplex receptacles as shown on the diagram. Locate on center top of baseboard, on back, and right hand wall, a #350 duplex receptacle unit. In the center front of the baseboard, on the left-hand wall, locate a #141 Box Extension Device. 4 ft. from the floor, next to the facing on the left hand wall, locate another #350 duplex receptacle unit.

Connect all receptacles with #111 Xtensionduct. Use fittings as shown on diagram, #176 baseboard offset elbows are used instead of bending to make a neater job and to insure a snug fit.

Run #14 B&S R.C. copper wires in the Xtensionduct. Installation current to be brought in through receptacle in the rear of the booth.

Solder and tape all joints. Test circuits for shorts and grounds. Secure inspection of job.

All work must be done according to the rules of the National Electrical Code.

BILL OF MATERIAL

<table>
<thead>
<tr>
<th>ART.</th>
<th>COST</th>
<th>ART.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

171
EXTENSION DUCT
WIRING DIAGRAM
JOB NO. 2
XTENSIONDUCT

QUESTIONS FOR JOB NO. 2

1. When are the wires installed? Catalogue -- P9
2. How are the wires installed? Catalogue -- P9
3. How is the capping placed on the backing? Catalogue -- P9
4. When is the capping installed? Catalogue -- P9
5. Describe how you install Xtensionduct around offsets and corners. Catalogue -- P9
6. What is the cutting and notching gauge? Catalogue -- P9
7. Describe the use of the cutting and notching gauge. Catalogue -- P9
8. When is it possible to bend Xtensionduct? Catalogue -- P9
9. How is it possible to paint Xtensionduct? Catalogue -- P9
10. How many different types of installations can you make with Xtensionduct? Catalogue -- P4 to 13
SPECIFICATIONS

This is a double job. That is, the job on the right hand wall is exactly the same as that on the left hand wall. So install the circuit as shown on the left hand wall, and then repeat on the right hand wall. Be sure to get the parts exactly opposite one another.

Place a #350 duplex receptacle close to the back of the booth, 2 ft. in front, using a #352 utility box as a tee, install a bracket light. The bracket light is to be 4 ft. above the tee. Use a #365 Canopy Base Plate and Cover for the base of the light. Install a 3/8" fixture stud on the base plate, connect fixture pipe, place canopy in position, and install a brass key socket on end of pipe. Next install a #351 single-pole switch on the front edge of the booth level with the bracket light. The switch is to control the light, the receptacle is to be hot on the line.

On the opposite wall install another circuit just like the first one.

Connect the two together by running Xtensionduct along the back wall. In the center of this run place a #350 duplex receptacle unit.

Installation current to be brought in through the duplex receptacle on the back wall.

Run #14 B&S R.C. copper wire in the Xtensionduct. Use fittings as shown on the diagram. Solder and tape all joints. Test for shorts and grounds. Secure inspection of the job.

All work must be done according to the rules of the National Electrical Code.

<table>
<thead>
<tr>
<th>BILL OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT.</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

175
EXTENSION DUCT

WIRING DIAGRAM

JOB NO. 3
XTENSIONDUCT

QUESTIONS FOR JOB NO. 3

1. Do you use bushings with Xtensionduct? How? Catalogue -- P7
2. Why should conductors always be treated as bare?
   "Wiring for Light and Power" -- Croft -- P1
3. How many raceways may be used for one circuit when AC is used?
   National Code -- Section 504g
4. How can the electrical continuity of raceways be assured?
   "Wiring for Light and Power" -- Croft -- P327
5. In what way are metal raceways similar to conduit?
   "Wiring for Light and Power" -- Croft -- P323
6. Where must the splices in the system be made?
   "Wiring for Light and Power" -- Croft -- P324
7. What method is used whenever conductors leave the metal raceway to serve as energy consuming devices?
   "Wiring for Light and Power" -- Croft -- P324
8. What is the object in using the cutting and notching gauge?
   Catalogue -- P9
9. What is Xtensionduct specifically designed for?
   Catalogue -- P4-5
10. How is the box extension adapter installed?
    Catalogue -- P11