NEAR EAST UNIVERSTY

Faculty of Engineering

Department of Electrical And Electronic Engineering

ELECTRICAL INSTALLATION OF A RESTOURANT AND HOME SERVICE BUILDING

Graduation Project

EE-400

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ABSTRACT

There are three main sets of regulations to which the electrician must conform in order that an installation shall be safe from excess current, shock, fire, corrosion, mechanical damage, and leakage. These are as follows:

1. **Electricity (Factories** Act) **Special Regulations, 1908 and 1944.** These regulations cover "the generation, transformation, distribution and use of electrical energy" in factories and workshops. An explanatory leaflet, *Memorandum by the Senior Electrical Inspector of Factories on the Electricity Regulations,* is issued by H.M. Stationery Office to explain the workings of these regulations.

2. **The Electricity Supply Regulations** (1937). The purpose of the Electricity Supply Regulations is to secure "the safety of the public and for ensuring a proper and sufficient supply of electrical energy". Under these regulations, the Supply Authority (the Area Board) undertakes to supply the consumer at a stated voltage, phase, and frequency, with permissible variations. The Area Board has the right to withhold connection or disconnect a supply if their regulations are not adhered to.

NOTE. These regulations, or statutes, have the force of law and for an employer, consumer, or electrician to disregard them could lead to legal action being taken against him.

3. **Regulations for the Electrical Equipment of Buildings.** These regulations (commonly called the I.E.E. Regulations) have been devised by the Wiring Committee of the Institution of Electrical Engineers to "ensure safety in the utilization of electricity in and about buildings". The I.E.E. Regulations are of considerable assistance to electricians as they largely cover the requirements of the Electricity Supply Regulations. The I.E.E. Regulations consist of two parts: Part 1 contains "requirements for safety" and Part 2 contains "means of securing compliance with Part 1".

INTRODUCTION

This is a project about electrical installation in this project we made the electrical installation of a restaurant and home service building

This project consist of introduction seven chapter and conclusion.

Chapter- 1 presents types of conductors and cables.

Chapter –2 presents Conduit, Trucking, And Ducting.

Chapter-3 Presents Distribution And Control

Chapter-4 presents Final circuits.

Chapter-5 presents Overcurrent protection.

Chapter-6 presents Protection Against Earth-Leakage Currents

Chapter-7 presents Illumination calculations.

The installation project has two parts. The first part is lighting. The purpose of lighting is to find the best lamps and number of the lamps for every floor. An either purpose is to show the aria light and beautiful.

The second part was making the electric scheme of the building. This project is made standards of KIB-TEK.

1.CONDUCTORS AND CABLES

Definition of Conductors

A conductor is a material, which offers a low resistance to a flow of current. Conductors for everyday use must be *(a)* of low electrical resistance, *(b)* mechanically strong and flexible, and *(c)* relatively cheap. For example, silver is a better conductor than copper but it is too expensive for practical purposes. Other examples of conductors are tin, lead, and iron.

Formation of Conductors

Materials Used. Electrical conductors are usually made of copper, although aluminum is being used to a greater extent, particularly as the price of copper increases. Copper conductors are formed from a block of copper, which is cold-drawn through a set of dies until the desired cross-sectional area is obtained. The copper wire is then dipped into a tank containing molten tin. This is done for two reasons: (a) to protect the copper if the wire is to be insulated with vulcanized rubber, as this contains sulphur which attacks the copper; and *(b)* to make the copper conductor easier to solder. Aluminum wire is also drawn from a solid block but is not tinned.

COMPARISON OF ALUMINIUM AND COPPER AS CONDUCTORS

Aluminum	*Copper*
Smaller weight for similar resistance and	better electrical and thermal
	conductor,
Current-carrying capacity	therefore lower C.S.A. required for
Easier to machine	same voltage drop
Greater current density because larger	Greater mechanical strength
Heat-radiating surface	Corrosion resistant
*Resistively 2-845 μΩ-cm	High scrap value
Temperature coefficient practically simi-	Much easier to joint
lar (0-004Ω/Ω degC)	Lower resistively: 1-78 μΩ-cm

The determining factor in the use of one type of metal for conductors is usually that of cost. The future trend in costs will be for the price of aluminum to drop relative to that of copper, as the underdeveloped countries achieve the industrial capacity necessary to work their bauxite (aluminium ore) deposits.

Stranding of Conductors. Conductors were often stranded to make the completed cable more flexible. A set number of strands are used in cables; 1, 3, 7, 19, 37, 61, 91, and 127. Each layer of strands is spiralled on to the cable in an opposite direction to the previous layer. This system increases the flexibility of the completed cable and also minimizes the danger of 'bird caging', or the opening-up of the strands under a bending or twisting force.

Size of Stranded Conductors. The number of strands and the diameter of the individual strands give the size of a stranded conductor. For example, a 7/0-85 mm cable consists of seven strands of wire, each strand having a diameter *(not* cross-sectional area) of 0-85 mm. Solid (non-stranded) conductors are now being used in new installations.

Bare Conductors. Copper and aluminum conductors are also formed into a variety of sections, for example, rectangular and circular sections, for bare conductor systems. *Applications.* Extra-low voltage electroplating and sub-station work.

The following precautions must be taken with open bus-bar systems (above extra-low voltage). They must be: (a) inaccessible to unauthorized persons, *(b)* free to expand and contract, and *(c)* effectively insulated. Where bare conductors are used in extra-low voltage systems they must be protected against the risk of fire.

Insulators

An insulator is a material, which offers a very high resistance to a flow of current. An insulator should have certain electrical, mechanical, physical, and chemical properties.

Electrical Properties. It must have a high resistance.

Mechanical Properties. It must be capable of withstanding mechanical stresses, for example, compression.

Physical Properties. The perfect insulator would have the following physical properties: (a) non-absorbent; *(b)* capable of withstanding high temperatures.

Chemical Properties. An insulator must be capable of withstanding the corrosive effects of chemicals.

No insulator is perfect and each type is picked for a particular application. For example, porcelain and fireclay are relatively good insulators, but could not be used for covering conductors forming a cable because they are not flexible. P.V.C. is also a good insulator, but cannot be used in conditions where the temperature exceeds 45 °C—for example, insulation for electric fires. Other examples of insulators are mica, wood, and paper.

Definition of Cables

A cable is defined in the I.E.E. Regulations as: "A length of insulated single conductor (solid or stranded), or of two or more such conductors, each provided with its own insulation, which are laid up together. The insulated conductor or conductors may or may not be provided with an overall covering for mechanical protection." A cable consists of two basic parts: *(a)* the conductor; and *(b)* the insulator.

Construction of Cables

A cable usually derives its name from the type of insulation used.

Polyvinyl Chloride (P.V.C.) **Cable.** This is termed a 'thermo-plastic' cable as the insulation is formed from a synthetic resin, which softens when heated. The process of manufacture is as follows:

1. The p.v.c. is extruded on to the conductors by passing them through a die into which soft p.v.c. is forced.
2. The formed cable is then passed through a trough of cold water to harden the plastic insulation.

Multi-core Cable. This is cable, which is made up of two or more insulated conductors. Multi-core cable is sheathed in a protective covering— for example, tough rubber for tough rubber-sheathed cables (t.r.s.) and p.v.c. for plastic cables.

Tough-Rubber-Sheathed (t.r.s.) **Cable.** This is made of specially toughened rubber which is resistant to acids and alkalies. Specially constructed t.r.s., which has been reinforced with tape and an external braiding, is used in farmyards,

Polychloroprene (p.c.p. or neoprene) Cable. An insulation somewhat similar to that of t.r.s. but capable of withstanding most weather conditions and particularly direct sunlight.

Heat-resisting, Oil-resisting and Flame-retardant (h.o.f.r.) Cables. These cables are used in conditions damaging to p.v.c. cables such as high temperature and oil. The resistant qualities are developed by a vulcanising (or curing) process which forms an elastomer capable of withstanding tough conditions and still retaining its flexibility. The following are examples of cables using elastomer material: c.s.p. (chlorosulphonated polythene), butyl rubber, silicon rubber, ethylene propylene rubber (e.p.r.).

Flexible Cables and Flexible Cords

The I.E.E. Regulations define a flexible cable as: "A cable consisting of one or more cores, each containing a group of wires, the diameters of the wires and the construction of the cable being such as to afford flexibility." A flexible cord is defined as: "A flexible cable in which the cross-sectional area of each conductor does not exceed $4mm^2$".

Twisted Twin Flex Cable This is made up of a multi-strand tinned-copper conductor with silicon rubber insulation. *Application:* lighting flex.

Circular Flex. The rubber-insulated cores are formed into a circular section with cotton worming and contained in a cotton braiding. *Applications:* connections to household appliances (irons, kettles, etc.).

Circular Flex, Rubber Sheathed This flex is also packed with jute or cotton to form a circular cross-section but an outer sheath of rubber replaces the cotton braiding. *Applications:* vacuum cleaner and portable drill leads (3-core).

Workshop (or Industrial) Flex This flex is similar in construction to the above, but has the addition of a compounded braiding. *Application:* connections to industrial lighting.

Outdoors Cable

The I.E.E. Regulations- underline the need for adequate mechanical protection when cables are used outdoors and the importance of having sufficient support to avoid mechanical strain. They also supply tables showing the necessary spacing for supports and the minimum allowable radius for bends.

H.S.O.S. (House Service Overhead System) **Cable** H.S.O.S. cable is constructed as follows: *(a)* hard-drawn copper conductor, *(b)* rubber insulation, *(c)* varnished tape, and *(d)* outer coating of compounding braiding. *Application:* house-to-house overhead supplies.

NOTE: p.v.c. Insulated copper and aluminum cables are gradually replacing this cable, except in conditions where creosote is present, as this attacks the p.v.c. Insulation.

Cable Sizes: Use of I.E.E. Tables

The I.E.E. Regulations contain comprehensive information regarding the current-carrying capacity of cables under certain conditions.

These tables supply: (a) cross-sectional area, number, and diameter of conductors; *(b)* type of insulation; *(c)* length of run for IV drop; *(d)* current rating (a.c. and d.c.), single and bunched. The following terms are used in the I.E.E. tables: (a) ambient temperature and *(b)* rating factor. **Ambient Temperature.** This is the temperature of the air surrounding the conductor. The current rating of a cable is decreased as the temperature of the surrounding air increases, and this changed current-carrying capacity can be calculated by using the relevant rating factor. **Rating Factor.** This is a number, without units, which is multiplied with the current to find the new current-carrying capacity as the operating conditions of the cable change. For example, a twin-core 10 mm^2 (7/1-35 mm)

p.v.c. Cable will carry a maximum current of 40 A at an ambient temperature of 25 °C, but if the ambient temperature is increased to 65 °C the maximum current allowed will now be:

40Ax0-44 (rating factor) = 17-6A

The rating factor is also dependent on the type of excess current protection. If cables are bunched together, their current-carrying capacity will decrease: a rating factor is therefore supplied for the bunching, or grouping, of cables.

Permissible Voltage Drop in Cable. Voltage drop is another essential feature in the calculation of cable size, as it is useless installing a cable, which is capable of supplying the required current if the voltage at the consumer's equipment is too low. Low voltage at the consumer's equipment leads to the inefficient operation of lighting, power equipment, and heating appliances. The maximum voltage drop allowed between the consumer's terminals and any point in the installation is 2-5 per cent of the voltage supplied by the Electrkity Board, including motor circuits.

Voltage Drop and the I.E.E. Tables. The I.E.E. tables state the voltage drop across a section of cable when maximum current is flowing through it. If the current is halved, the voltage drop will also be halved. For example, a 4 mm^2 twin-core cable has a current rating of 24 A and a voltage drop of 10 mV per ampere per metre. If the current is halved (to 12 A) the voltage drop will be halved to 5 mV per ampere per metre.

New Voltage Bands. Extra-low voltage (Band I) now covers voltages not exceeding 50 V a.c. or 100 V d.c. (measured between conductors or to earth). The new low voltage range (Band II) is from extra-low voltage to 1000 V a.c. or 1500 V d.c., measured between conductors, or 600 V a.c. and 900 V d.c. between conductors and earth.

Current Density and Cable Size. The current density of a conductor is the amount of current which the conductor can safely carry without undue heating per unit cross-sectional area. For example, if a copper conductor has a current density of 300 A/cm^2 a copper conductor of cross-sectional area 0-5 cm^2 will be capable of carrying one half of 300 A, that is, 150 A.

To calculate the current-carrying capacity of a cable (given cross-sectional area (cm^2) and current density (A/cm^2)):
Current-carrying capacity = current density x cross-sectional area

Example 1.1. Calculate the current-carrying capacity of a O•l cm^2 conductor if the current density of the conductor is 400 A/cm^2.
Current-carrying capacity = 400 A/cm^2 X O•l cm^2 = 40A

Resistance of a Conductor

The resistance which a conductor offers to a flow of current is determined by three factors: (a) the length of the conductor, *(b)* its cross-sectional area, and *(c)* type of material used.

Length. If the length of a conductor is doubled, for example, from 100 m to 200 m, the resistance of that conductor will also double.

Resistance *R* (in ohms) is *directly* proportional to length /

Cross-sectional Area. If the cross-sectional area of a conductor is doubled, for example, from O•l cm^2 to 0-2 cm^2, the resistance of that conductor will be halved.

Resistance *R* (Ω) is *inversely* proportional to cross-sectional area *a*

Resistively (Specific Resistance). This is the factor, which takes into consideration the type of material used. The resistivity of a material is the resistance of a unit cube of that material, measured across opposite faces of the cube. For example, if the resistivity of copper is given as l•7μΩ-cm, then the resistance measured across opposite faces of a centimetre cube of copper will be 1-7μΩ. This may also be written l•? x 10^{-6}Ω-cm or 1•7 microhm-centimetre (μΩ-cm). (1 μΩ is one millionth of an ohm.) The symbol of resistively is *p* (Greek letter rho).

$$R = \frac{\rho l}{a}$$

where *R* is resistance (Ω), *p* = resistively, /= length, and *a* = cross-sectional area.

NOTE. Since resistively is usually given in ohm-centimeters or microhm-centimetres, the length of the conductor must be changed to centimeters. The cross-sectional area is always given in square centimeters.

Effect of Heat on a Conductor

When a current is passed through a conductor the temperature of that conductor rises; an extreme example is the element of an electric fire. The effect of this heat on the resistance of the conductor depends on the composition of the conductor. The resistance of pure metals, such as copper and aluminum, increases as temperature increases. The resistance of certain alloys—for example, constant in and managing—remains relatively constant with increases in temperature. But the resistance of carbon and electrolytes (liquid used in batteries) decreases with increases in temperature.

Temperature Coefficient. The temperature coefficient of a material is the increase in the resistance of a 1-Ω resistor of that material when it is subjected to a rise in temperature of 1 degC. For example, if copper has a temperature coefficient of 0-004 ohm per ohm per degree Celsius (0-004 Ω/Ω degC) a copper resistor of 1 Ω will increase in resistance to 1 Ω + 0-004 Ω if heated through 1 degC. The symbol for temperature coefficient is *a* (Greek letter alpha). Pure metals, such as copper and aluminium, have a *positive* temperature coefficient, that is, their resistance increases as temperature increases. Carbon and electrolytes have a *negative* temperature coefficient, that is, their resistance decreases as temperature increases.

Calculating Resistance Increase. There are two formulae for calculating the increase in resistance of a conductor due to temperature change: *(a)* temperature increases from O°C; (6) temperature increases between two intermediate temperatures.

(a) Temperature increases from O°C.

$$R_f = R_0\,(1+\alpha t)$$

where R_0 = resistance at 0 °C, R_f = final resistance, a = temperature coefficient, and t = rise in temperature.

Where $R_{\cdot}$ = 1st resistance, R_a — 2nd resistance, a = temperature coefficient, *ti* = 1st temperature, and t_z = 2nd temperature.

Terminating and Jointing P.V.C. Cables

Stripping P.V.C. Cables. A single-core p.v.c. cable should be stripped by holding the cutting knife at an angle to the cable, and cutting away from the hand holding the cable. Multi-core cable is stripped by running the cutting knife along the centre of the cable and then nicking the end of the cable to give two finger grips. This allows the sheathing to be pulled down the cable with the thumb and

forefinger'of each hand. The sheath is then folded on top of the cable and cut by drawing the knife between the sheathing
and the cable.

There are two basic methods of joining electrical conductors: (a) mechanical joints; and *(b)* soldered joints.

Mechanical Jointing. This is done by using connector blocks. These consist of one-way or multi-way brass terminal blocks enshrouded with porcelain or plastic insulation. The connector must be capable of containing all the strands of the conductor.

Another method, usually used with larger cables, is mechanical crimping. This is done by placing a sleeve over the conductors to be jointed and crimping (squeezing) the connection with a manual or hydraulically operated crimping jack.

Soldered Joints. Materials required: pliers, sharp knife, soldering bit, flux, blowlamp (or butane gas cylinder), solder, p.v.c. tape and black insulating tape.

Soldering Bit. Every joint which is made by twisting strands together must be soldered. Where a lot of single-core jointing is being carried out, it is often convenient to use a heavy bit which has a slot filed in it to take cables. The soldering bit should be heated until a green flame appears and must always be kept clean. Always' tin' the bit with flux and solder before using. *Flux.* The purpose of the flux is to remove the oxide film from the surface of the conductor and prevent it from re-forming.

NOTE. Corrosive fluxes, such as 'killed spirits', must not be used when soldering electrical connections.

Blowlamp. This should be operated as follows:

1. The lamp should not be more than two-thirds full.

2. Leave the valve open when starting.

3. Start lamp with small rag dipped in methylated spirits.

4. When the lamp is hot, the valve should be closed and the pump operated.

5. The pump forces the paraffin through the heated vaporizing tube and out of the nozzle where it is ignited under pressure.

6. The blowlamp should be played against an asbestos sheet until the Flame is fully established.

Bottled gas (propane and butane) is displacing the blowlamp as the former is cleaner and quicker.

Solder. Two basic types of solder are used in electrical •work: fine solder (tin man's solder), which is 60 parts tin and 40 parts lead, and plumber's metal, which is 30 parts tin and 70 parts lead. Fine solder melts more easily, as tin has a lower melting point than lead, and so it is commonly used for electrical joints. Plumber's metal is used for 'plumbing' joints in armored cables, as it remains in a plastic state, allowing it to be shaped, longer than fine solder.

Methods of Soldering. There are three different methods used for soldering conductors: (a) soldering bit, *(b)* 'stick' method, and (c) (metal) pot and ladle method.

Soldering Bit. The conductors to be jointed are first smeared with a resinous flux. The tinned bit is then applied under the joint until the heat penetrates it. The stick of solder is then applied to the joint until the solder flows freely through it.

' Stick' Method. In this method, the joint is first heated with a blowlamp, flux being applied. The solder is then applied by pressing the stick of solder against the heated joint until it penetrates the joint. Care should be taken to protect the insulation against the blowlamp flame. *Pot and Ladle Method.* Jointers when jointing heavy conductors commonly use this method. A solder pot is heated until the solder is running freely. The solder should not be overheated as this will burn the tin and dross will form on the surface of the solder. When the solder has reached working temperature it is taken from the pot with a ladle. The solder is then poured over the prepared joint and is caught by another ladle placed under the joint. This action is repeated until the solder penetrates The joint. **Soldering Aluminum.** The following special points should be noted

When soldering aluminum:

1. All surfaces must be scrupulously clean.
2. When making a joint between stranded conductors 'step' the strands to increase the surface area.
3. The surface must be heated *before* the flux is applied, as the flux will Only take when the temperature is high enough.
4. Apply aluminum solder until the complete surface is bright.
5. Joints in aluminum should be protected from contact with the atmosphere. Painting, taping, or compounding can do this. **Soldering a Socket (or Lug).** The method used is as follows

1. Strip insulation backs about 5 cm.
2. Tin the socket.
3. Smear both the socket and the bared conductor with flux.
4. Fit the socket to the conductor. The socket should be a hammer fit. If the socket is too large, the conductor can be enlarged with a tinned-wire binding or, better still, by pressing a strand of cable into the centre of the conductor.
5. Play the blowlamp in the top of the socket until the heat has penetrated the conductor, and then apply a stick of solder to the lip of the socket. The completed connection should have a rim of solder showing round the lip of the socket; applying plumber's metal as the joint is cooling can do this.
6. When the termination is cooled, cut back damaged insulation and apply p.v.c. Or cambric tape.
7. Tape is used to replace insulation, which has been removed prior to jointing. It should be stretched before being applied, p.v.c. Tape is also used for this purpose. Black tape should only be used as a protective outer covering on a joint.

NOTE. Do not attempt to cool a soldered joint by pouring water over it, as this can lead to an ineffective soldered connection, often termed a ' dry joint'. Never use a file to smooth or clean up a soldered connection; wiping it with a dry rag before it sets should smooth the solder.

Through Joint. This type of joint is made by using mechanical connectors, compression ferrules or grip-type (weak backed) soldered sleeves.

The completed joint is wrapped with p.v.c. tape. The joint illustrated in would be further protected by the use of a cold pouring resin compound used to fill the protection box.

Straight-through Joint using Weak-backed Ferrule A weak-backed ferrule is a tubular piece of tinned-copper opened along the top and weakened at the bottom by indenting, allowing it to be opened or closed easily. The joint is made as follows:

1. Strip insulation back from the end of both conductors.
2. Clean and tin ferrule.
3. Place ferrule on cable. Butt cables together before tightening ferrule.
4. Wind small pieces of rag at each end of ferrule to contain molten metal.
5. Solder connection.
6. Remove damaged insulation and tape.

Tee (or Breeches) Joint . This type of joint is commonly used to tee-off a service from an armoured cable. The weak-backed ferrule is often used but alternative methods are the mechanical connector or the compression ferrule.

Types of Armoured Cable

This cable is used where there is a likelihood of mechanical damage to conductors or insulation, for example, underground cable runs. There are two main types of armoured cable: *(a)* lead-covered paper-insulated steel wire, or steel tape, armoured cables (shortened to P.I.L.C.S.W.A. and P.I.L.C.S.T.A., respectively) and *(b)* p.v.c. armoured cable. **P.I.L.C.S.W.A. Cable** This consists of the following parts.

1. An inner 'heart' of jute used to keep the cable circular.

2. Copper, or aluminum, conductors insulated with mineral oil-impregnated paper.

3. A lead sheath, which contains the insulation and is also used as an earth continuity conductor.

4. Jute bedding tape impregnated with bitumen, used to protect the lead against the armoring.

5. Galvanized steel wire (one layer) or steel tape (two layers).

6. Bitumen-impregnated jute serving.

Termination of P.I.L.C.S.W.A. Cable. When terminating at the sealing chamber the following procedure should be followed.

1. Place binder 1 m from end of cable.
2. Remove serving to this point (using blowlamp to loosen, if necessary).
3. Bend steel wire armoring back until it is clear of lead sheath.
4. Remove approximately 12cm of lead sheath and clean remainder.
5. Place brass gland on cable, leaving approximately 10 cm of lead sheath showing. Wedge gland with wood to keep central on cable.
6. Plumb joint, using plumber's metal. Tallow is used as flux.
7. Clean galvanized wire with paraffin rag and shape wire over plumb.
8. Clamp wires to gland and bolt gland to sealing chamber.
9. Cut back paper insulation on conductors and make through joint to V.R.I, conductors, using weak-back ferrules.
10. Assemble sealing chamber and pour in hot bitumen to seal oil-impregnated paper insulation against moisture.

P.V.C. Armoured Cable This is made up of p.v.c. Insulated cores packed with p.v.c. To give a circular cross-section. An outer p.v.c. Sheath covers the galvanized steel wire.

Jointing p.v.c. Armoured Cable, p.v.c. armoured cable may be terminated and jointed at the type of cast-iron boxes used for P.I.L.C.S.W.A. armoured cable, although plastic boxes are often used. But the following points require consideration:

1. p.v.c. insulation must be protected against heat (for example with cloth or tape).

2. p.v.c. tapes should be used for insulating the conductors.

3. Particular care must be taken with the cleaning and clamping of the galvanized wire armouring, as it is often the sole earth continuity conductor.

4. *Compound Temperature.* The temperature of hot pouring compound should be such that it does not melt the p.v.c. insulation of the conductors. Dipping a piece of scrap p.v.c can check this. into the compound before pouring.

NOTE. Tables 5 M, 6 M and 25 M of the I,E.E. Regulations give current ratings for p.v.c. armoured cables (copper and aluminium conductors).

Mineral-insulated Metal-sheathed (M.I.M.S.) **Cable** This type of cable is often referred to as M.I.C.C. (copper or aluminium covered) cable. M.I.M.S. cable consists of three parts:

1. *Copper or Aluminium Conductors.* Each core consists of a single copper conductor. Common core numbers are: 1, 2, 3, 4, and 7•

2. *Insulation.* The insulation between the cores is magnesium oxide (magnesia); a material capable of withstanding high temperatures but which is absorbent to moisture.

3. *Outer Sheath.* This is a seamless copper or aluminium tube. Drawing a section through a series of dies forms the cable, so that the relative distance between the cores and the sheath is constant during the manufacture and use of the cable.

NOTE. Tables 13 M to 17 B of the I.E.E. Regulations give current ratings.

ADVANTAGES AND DISADVANTAGES OF M.I.M.S. CABLE

Advantages	*Disadvantages*
Heat resistant. Withstands temperatures of up to 250 °C	Expensive
Sheath provides excellent earth continuity conductor	Terminations take time and must be done by skilled man
Mechanically strong but must be protected against sharp edges	Greater voltage drop per foot run at specified current rating
High current density	
Does not deteriorate with age	

M.I.M.S. cable is often sheathed with p.v.c. to protect it against hazardous conditions (e.g. corrosive chemicals).

Terminating M.I.M.S. Terminations are made at special glands. The procedure for termination is as follows:

1. Slip gland nut, compression ring (sometimes termed 'olive'), and gland body on to cable.

2. Strip sheath using stripping tool.

3. Screw on sealing pot (forced thread).

4. Slip disc and sleeve assembly on cores

5. Press compound into sealing pot (making sure that all copper particles have been removed).

6. Crimp sealing pot with crimping tool. Clean off surplus compound.

NOTE. All terminations should be tested on completion (between poles and poles to earth).

Outline of Regulations relating to Conductors and Cables

1. Correct voltage rating must be used in all cables. NOTE. A 250V grade cable is allowed in 415V 3-phase systems where the neutral is earthed.
2. The voltage drop in a consumer's installation must not exceed *2-5* per cent of supply voltage.
3. Every conductor must be identified by: color, sleeves, numbers (paper insulation), or discs.
4. Single-core armored cable must not be used for a.c

5. The current ratings given in the I.E.E. Regulations must not be exceeded or overheating will result.

6. All cable terminations must be *(a)* mechanically and electrically sound, *(b)* accessible for inspection (unless buried), *(c)* free of mechanical strain, and *(d)* capable of containing *all* the strands of the conductor. Do *not* nick or cut strands as this decreases the current-carrying capacity of the cable and may lead to overheating at the termination.

7. Joints between two different metals (for example, copper and aluminum) should be protected against corrosion. If it is a clamp connection, the copper should be tinned in order to prevent electrolytic action

8. Insulation removed from a conductor during the making of a joint should be replaced by a suitable tape.

9. Joints in M.I.M.S. must be protected against moisture.

10. Fluxes containing acids must *not* be used for electrical jointing.

11. Terminations in a sheathed-cable system (for example, p.v.c. or t.r.s.) must only be made at enclosed positions. The enclosure containing the termination must be made of an incombustible material (for example, hardwood block or plastic patters).

12. Flameproof fittings must be used when cables are terminated under conditions where inflammable materials or gases are present (for example, paint spray shop).

13. t.r.s. must not be installed in direct sunlight without a protective covering.

14. Maximum operating temperature for cables: rubber, *55* °C and p.v.c., 65 °C; impregnated paper, 75 °C.

15. Flexible cable and flexible cord (exceeding 30 V a.c.): Flexible cable of the circular type should only be used for connections to movable equipment. Twisted flex should only be used for fixed lighting fittings, *not* for portable appliances. All flexes must be protected from mechanical damage.

16. Cables installed under floors or above ceilings should be positioned so that they are not damaged by contact with the floor or ceiling or any fixings (e.g. nails or screws). Where cables are run through a wooden joist they should be at least 50 mm from the top or the bottom of the joist, or inserted in securely fixed mechanical protection (e.g. steel conduit).

17. All non-sheathed cable should be mechanically protected e.g. inserted in conduit, trucking or ducting.

18. M.I.M.S. and armored p.v.c.-insulated cable should be protected with an extruded p.v.c. Sheath where they are exposed to the weather or fitted in wet, damp or humid conditions (e.g. concrete ducts).

2.CONDUIT, TRUCKING, AND DUCTING

There are two main types of conduit: (a) *light gauge* and *(b) heavy gauge.*

Light Gauge Conduit

Light gauge conduit is produced from strip steel which is formed into a tube. This type of conduit has an open seam and is only used for small installations at, or below, 250V. The light construction of the tube makes it unsuitable for bending, although it can be set.

Fittings. Two types of fitting are supplied for use with this type of conduit: lug grip and pin grip.

Lug Grip. Paint is cleaned off the end of the conduit, to ensure electrical continuity, and the fitting is connected to the conduit by tightening two brass screws.

Pin Grip. Continuity is obtained in this type by tightening a hardened-steel screw into the cleaned conduit at each fitting. Pin grip sockets are not acceptable under section B.98 of the I.E.E. Regulations.

Application. Slip conduit is only used in small installations where there is no danger of moisture affecting the cable. It is also used in p.v.c. sheathed systems to provide mechanical protection for switch drops. Slip conduit is a cheap form of protection but tends to be unsightly and is open to misuse in installation.

Heavy Gauge Conduit

There are two types of heavy gauge conduit: heavy gauge welded conduit and solid drawn conduit.

Heavy Gauge Welded Conduit is formed from strips of heavy gauge sheet steel and is welded at the seam. This is the most common type of conduit and is supplied in sizes from 16mm to 32mm (outer diameter). **Solid Drawn Conduit** is produced by drawing a heated bar over a ram, forming a heavy-gauge seamless tube. This type of conduit is more expensive than welded steel conduit and is only used for flameproof installations (for example, garages).

Finish. Metallic conduit has two types of finish: enamel paint (black or grey) and galvanized (zinc coated for wet or humid conditions).

Other Types of Conduit

Flexible Metallic Conduit. This type of conduit is formed from a pressed-steel spiral and is used to terminate conduit at electrical machinery or in situations where there is likely to be movement or vibration.

NOTE. A separate earth continuity conductor must be run when this type of conduit is used.

Non-metallic Conduit. This type of conduit is'made of p.v.c. and is supplied in lengths. It has the appearance of conduit when fixed, and can be threaded with conduit stocks and dies, p.v.c. boxes are used at junctions and terminations. Non-metallic conduit systems have the following advantages: absence of condensed moisture in the tube, non-corrosive (rust-free), and non-inflammable. For capacities of steel and p.v.c. conduits see I.E.E. tables B.5M and B.6M respectively.

Installing Conduit

The standard of an electrician's workmanship can often be judged by the finish on a conduit installation. Good conduit work can only be achieved by a systematic approach, constant practice, and a regard for detail. The following points are made to assist the electrician in this field.

Planning the Layout. The following points should be considered before starting the actual layout.

(a) The pipe runs of other trades should be studied (for example: gas and water).

(b) Make sure that the consumer has all his requirements clearly marked on the architect's drawing, this saves time (and temper!).

(c) Make allowances for future extensions.

(d) Conduit runs (with number and sizes of cables) should be marked on the drawing.

Marking Out. When marking out, follow the procedure given below.

1. Position of switches, outlets, etc., should be clearly marked, particular care being taken with the positioning and layout of the main board.
2. Individual conduit runs can now be 'struck*. This is done with a chalk-line as follows. String is chalked and held tightly against the surface of the run. The string is then 'twanged' in the centre, leaving a chalk line on the surface. A chalked plumb line should be used to strike vertical runs. The first job after the marking out is the making of 'ways': cutting and channelling brick and concrete.

NOTE. It is essential that all holes are made up with an incombustible material before the installation is completed; particularly those made between floors, walls, and partitions. This is necessary in order to prevent the spread of fire.

Sub-division of Work. The sub-division of work in the construction of the conduit installations will depend on the size of the installation and the number of 'pairs' *(i.e.,* electrician and mate) employed. On a large installation, where several' pairs' are employed, the job may be sub-divided as follows: one 'pair' on main panel, sub-main cables and local distribution fuse boards (D.F.B.s); all other 'pairs' working from local D.F.B.s to final sub-circuits.

Preparing the Conduit. Conduit comes in lengths (usually about 3-5 m) and is threaded at both ends.

Cutting. Lengths should be cut to size with a hack saw having a fine tooth blade. The blade must be held at right angles to the conduit during cutting. Conduit should always be cut in a pipe vice.

Threading. The thread is cut by using stocks and dies. The stock contains a handle and a holder for the dies. The dies are held in position by a guide. Both the dies and the guide are anchored with two knurled nuts. The dies are made of cast steel and, being brittle, are easily chipped. The thread on the dies is tapered to ease the threading of conduit.

The procedure for threading is as follows.

1. Cut the conduit square.

2. Taper the end of the conduit with a flat file.

3. Lubricate the part to be threaded, using mineral oil or tallow.

4. Press the dies on to the conduit and start the thread: the dies should be 'self-feeding' after the thread has been started.
5. The dies should be reversed half a turn at regular intervals to prevent choking of the thread with swarf.

6. When the thread is complete, the end of the conduit should be smoothed with either a reamer or a rat-tail file. Failure to do this may lead to a serious 'burring' of the cables during drawing-in.

7. The threaded end should now be wiped with a clean rag to remove any excess lubricant or metal filings.

Bending Conduit. Conduit can be bent with either a bending block or a bending machine.

Bending Block This is usually made from a wood block 10 cm x 5cmx 1•2m, preferbly ash. Holes are drilled to about 12cm from each end and tapered to prevent the conduit from 'kinking'.

The method for bending is as follows.

1. Mark the distance on the conduit.

2. Insert the conduit into the bending block with the seam facing the ground.

3. Hold the bending block at an angle so that the conduit starts off at an angle of about 45 ° to the horizontal.

4. Make a series of small bends, feeding the conduit through the hole after each bend. The conduit will flatten if too much is attempted at any one point.

5. Repeat action until bend is completed. **Bending Machine** Conduit *is* bent in the bending machine by placing it between a steel former and a movable steel roller. When the roller is pulled down, it presses the conduits round the former, producing an even bend.

Sets. A set is produced by bending the conduit at two different points, in opposing directions. The angle ofset'is usually about 45°. Both sides of a set should be parallel.

Termination of Conduit. Metallic conduit must always be terminated at an incombustible outlet, preferably a metal box. Conduit runs and Terminations must be electrically and mechanically continuous throughout the installation. The resistance from the main board to the furthest point on the conduit installation must not exceed 0-5 Ω. Consumers rely on metallic conduit to provide an effective earth path for leakage currents: it is essential that all joints in the conduit system are thoroughly tightened when the conduit is installed.

The size and placing of boxes must always be chosen to allow the easy drawing-in of cables. Table B.5M of the I.E.E. Regulations states the maximum allowable number of cables in different sizes of conduit. It is assumed that there is a maximum of two right-angle bends between draw-in points. *Space Factor.* The number of cables run in a conduit is determined by the space factor. The space factor can be calculated by dividing the total (outer) cross-sectional area of the cables by the internal cross-sectional area of the conduit. Multiply the answer by 100 to find the percentage. The space factor for conduit is 40 per cent.

Conduit Terminations at Metal Boxes

Conduit Terminations in Concrete, Conduit is often fixed in conditions where it is to be covered with a cement screed. Conduits are terminated at loop-in boxes—that is, boxes with openings, or knockouts at the bottom. These boxes must be sealed to prevent the ingress of liquid concrete while the floor is being poured. The conduit termination consists of a coupler screwed on to the conduit and fixed to the loop-in box by means of a male brass bush, p.v.c. conduit is terminated at p.v.c. Junction boxes with a special adhesive. It is essential that the loop-in boxes are correctly positioned as they cannot be re-fixed after the concrete sets without considerable inconvenience.

Conduit Terminations on Joisting. Particular care must be taken when installing conduit on joists. Channels cut in the joists must only be of sufficient size to take the conduit and should, if possible, be cut away from the center of the joists, to avoid weakening them.The conduit run is broken at a circular through-box with a bottom outlet. A bottom outlet box is used to terminate the conduit at the fitting. The short length of conduit fitted between the boxes is terminated at each box with a coupler and male brassBush. Terminations at ceiling level can be built flush with the ceiling by fitting an extension ring. Care must be taken to ensure that conduit boxes are not fitted 'proud'—that is, projecting below ceiling level.

NOTE. All junction boxes in a conduit installation must be accessible. This is done, in the case of wooden floors, by making a 'trap'. A 'trap' consists of a short length of floorboard, with the feather removed, fixed between the joists with wood screws. The position of 'traps' should be
clearly marked.

Running Coupler The running coupler is used to join two pieces of conduit together in conditions where neither part can be rotated. It is constructed by making a long thread on one piece of conduit and screwing a locknut and coupler on to this thread; a normal thread is made on the other section of conduit. The conduits are then butted together and the coupler screwed on to the shorter thread. The termination is locked with the lock-nut. It is essential that the ends of the conduit are properly butted (a) to ensure electrical and mechanical continuity, and *(b)* to allow a free passage for the drawing-in of cables.

Fixing Conduit

The I.E.E. Regulations state that conduit must be securely fixed. There are six basic methods of fixing conduit

1. **Crampets.** Crampets, or pipe hooks, are only used to secure conduit in conditions where the conduit is to be covered (for example, in concrete or plaster).

2. **Clips.** The most common type is the saddle: this is simply a clip with two fixing holes.

3. **Spacer Bar Saddles.** This consists of two parts: a saddle and 3 mm thick base plate. The base plate has a slot in the centre which is handy when conduit is being lined up. The saddle is fixed to the base plate by means of brass screws. These saddles are used to hold the conduit away from damp plaster, concrete, etc.

4. **Distance Saddles.** These saddles, sometimes termed hospital saddles, are used to keep dust from collecting between the conduit and the wall. The distance saddle holds the conduit 1 cm from the wall. The use of distance saddles also obviates the need for setting conduits at surface boxes.

5. **Multiple Saddles.** Multiple saddles are used to fasten multiple conduit runs. The multiple saddle consists of either a flat bar drilled to support several saddles or one large saddle capable of clamping several conduits at once.

6. Girder Clips. The basic part of the girder clip is the J-bolt. The J-bolt supports the girder clip without any need for drilling the conduit.

NOTE. Girders and building supports should not be drilled as this may decrease their bearing capacity.

Drawing Cables into a Conduit System.

The conduit installation must be completed before cables are drawn in. **Points on Drawing-in**

Cables. When drawing-in large runs, start at the centre of the run and draw in to both sides separately.

When drawing-in long lengths of cable, or a bunch of very small cables, a reel stand should be used. The simplest reel stand consists of a short piece of conduit fixed in a pipe vice.

French chalk may be used to ease the drawing-in of cables at difficult points but tallow must *not* be used for this purpose.

Use of the Draw Tape. The draw tape consists of a long strip of glass fibre or spring-steel which has a ball-point at one end and a closed loop at the other end. It should only be used for pulling in the actual draw-in wire (for example, p.v.c. cable). It should *not* be used for drawing cables as it is very brittle and soon becomes distorted or broken if misused

Advantages of Metallic Conduit

1. Provides protection against mechanical damage.

2. Provides earth return path.

3. Durability. Conduit, if properly installed, lasts for years without maintenance.

4. Can be easily extended.

5. Low fire risk.

Disadvantages of Metallic Conduit

1. Liable to corrosion (chemicals and condensation).

2. More expensive than t.r.s. and p.v.c. sheathed systems.

3. Difficult to conceal.

Points from the I.E.E. Regulations

1. The conduit installation must be completed before cables are drawn-in and boxes of ample capacity should be provided for this purpose. All such boxes must be accessible. A space factor of 40 per cent is allowed in conduit systems, this space factor is based on a maximum of two 90° bends per draw-in length.

2. The radius of a bend in conduit should not be greater than 2\ times the outside diameter of the conduit,

3. The ends of conduit must be filed or reamed to prevent damage to the cable.

4. Conduit installed in damp and humid situations must have a water-resistant finish (for example, galvanized).

5. Conduit must be securely fixed and protected from mechanical damage.

6. Extra-low-voltage and low-voltage cables must not be run in the same conduit.

7. Metal conduit should be kept separate from gas and water services. Conduit which is likely to come into contact with other services should be bonded to those services.

8. All metal conduit must be effectively earthed and all joints must be mechanically and electrically continuous.

9. Drainage points should be provided at the lowest point in a conduit installation and in conditions where condensed moisture is likely to collect. Drainage points are not made in a gas-tight system.

10. Cables installed in an explosive atmosphere must be enclosed in solid drawn conduit, unless they are metal sheathed.

11. Metal conduits not requiring earthing: *(a)* short isolated lengths used for mechanical protection; *(b)* short unexposed isolated lengths used for the mechanical protection of cleated wiring.

12. *Bunching of Cables.* Outgoing and return cables must be run in the same conduit.

13. Substantial boxes must be supplied at every junction where a cable connection is required in metallic and non-metallic conduit systems. All unused conduit entries must be blanked off and removeable covers secured.

Trunking

Trunking is used in conditions where a considerable number of cables are required in an installation, or where cables are too large for drawing into Conduit. It is manufactured from plastic or sheet steel and is supplied with a large range of terminations and connections

Segregation of Systems. Trucking is available which contains two separate compartments. This type of trucking must be used where extra-low-voltage (30V a.c.) cables are drawn in with low-voltage (250V) or medium-voltage (650V) cables.

Metal Bus-bar Systems. These systems consist of trucking in which the conductors (copper or aluminum sections) are supplied fitted inside the trucking. There are two basic types: bus-bar trucking and tap-on or overhead bus-bar trucking.

Bus bar Trucking. In this trucking the conductors (copper or aluminum sections) are supplied fitted inside the trucking. This trucking is used on rising mains (for example, supplying the mains to each floor of multi-floor flats) and is generally mounted vertically.

Tap-on Trucking This type of trucking is commonly used in industrial installations, where a considerable degree of flexibility is required. Tap-on trucking is somewhat similar in construction to bus bar trucking but the conductors are constructed so that tap-on boxes may be plugged in at regular intervals throughout the length of the trucking. The tap-on box contains a set of contacts for plugging into the bus bars and fuses for protecting the outgoing circuit.

Installation of Bus-bar Trucking

1. This type of trucking must not be installed in conditions where inflammable vapors are present.

2. Fire barriers (for example, asbestos packing) must be installed *inside* the trucking when it passes through floors, walls and partitions. Floors, walls, and partitions must be made up with an incombustible material after the trucking has been installed.

3. Allowance should be made for expansion in long sections; for example, by fitting copper braiding between sections.

4. *Identification.* All bus-bar trunking should be marked DANGER and the voltage stated. Lids must be securely fitted.

Ducting

Ducting is used to provide mechanical protection for cable run in the ground or under concrete. There are three main types of ducting: concrete, steel underfloor, and fibre underfloor.

1. Concrete Ducts cast in situ. These ducts are formed in the ground by erecting shuttering in a channel and pouring the concrete mix round the shuttering. This ducting is only suitable for cables possessing mechanical protection (for example, armoured cable). Concrete ducts are covered with heavy steel plates.

NOTE. Armoured cables may be laid directly in the ground but are only accessible when installed in ducting.

2. Steel Underfloor Ducting This is simply a form of enclosed heavy gauge steel trunking which is supplied with removable outlets. Steel ducting is placed in position before concrete floors are formed and is usually run in double (or triple) sections: one run for medium and low voltage cable and the other for extra-low voltage telephone or communication cables. The ducting is terminated at heavy steel boxes and can be tapped into with conduit fittings. These intersector boxes have separate compartments for E.L.V. and L.V. cables.

3. Fibre Underfloor Ducting. Fibre underfloor ducting ("Key" fibre duct) consists of two parts: a semi-circular 'open bottom" section which is laid on an asbestos sheet and sealed with bitumen. Intersector boxes are supplied, as with the steel underfloor ducting. Fibre ducting is also laid before the floors are formed. This system of underfloor ducting is free from corrosion, is not liable to condensation and allows for easy terminations for fittings at any point throughout its length. Entries can be drilled from above or below; accessories are fitted into the ducting by means of special brass bushes. A separate earth continuity conductor is fitted in the ducting for earthing intersection boxes and outlets. The great advantage of the fibre underfloor duct system is that it provides a network of outlets in conditions where the sub-division and partition of floor space is not being undertaken until the building is complete and floors set. **Space Factor.** The space factor for trunking is 45 per cent but is only 35 per cent for ducting, since ducting is not surrounded by a free flow of air.

Outline of I.E.E. Regulations for Trunking and Ducting

1. Ducts and trunking must be securely fixed and adequately protected against corrosion and mechanical damage.

2. All joint outlets in a duct system must be mechanically sound and free of abrasive surfaces.

3. Entries to ducts and trunking must be protected against the inflow of water. All covers must be securely fixed on the completion of wiring.

4. A maximum space factor of 45 per cent is required in trunking and channels.

5. Where ducts or trunking pass through floors, ceilings or partitions the hold should be plugged with cement or a fire-resisting substance to the thickness of the building material. Internal flame-resisting barriers must also be fitted inside the trunking or ducting in these conditions to prevent the spread of fire.

6. Armoured or M.I.M.S. cable used in concrete ducts must have an overall extruded covering of p.v.c.

7. A continuous partition must be used in conditions where low voltage and mains voltage are run in the same channel or trunking.

Catenary System of Wiring

A catenary wire is a multi-strand steel wire used to support conductors suspended between buildings. There are three basic., types of catenary system: *(a)* catenary used for short lengths of cable, *(b)* catenary for long runs, and (c) proprietary suspension systems using a special cable which incorporates a flexible steel wire.

Catenary Wiring for Short Runs. Under these conditions a stranded steel wire is connected between two buildings (for example, house and garage) and the sheathed conductors are taped on to it. The entry into the buildings is usually taken via a piece of conduit in the shape of a swan neck. The conduit must be bushed. A ' drip loop' is made in the cable where it enters the conduit: this ensures that the conductors do not carry moisture into the conduit. Short lengths of catenary wire do not require to be earthed.

Catenary for Long Runs. This system consists of a series of leather or plastic hangers fastened round the cables and fixed to the catenary wire with a steel wire loop. The catenaries wire is supported by a steel hook at one end and a wire strainer (turnbuckle or union screw) at the other.

Construction of Catenary System

(a) Fix catenary supports.

(b) Erect catenary wire between supports, tightening the wire with a line vice. A line vice is a ratchet arrangement which is used to tighten the line until such time as the ends are anchored.

(c) Measure length of catenary wire and mark similar length on conductor.

(d) Fix the cable hangers to the conductors. The spacing of the cable hangers will depend on the size and type of cable used (see Table B.7M, I.E.E. Regulations).

(e) Hook cable hangers on to catenary at one end and draw cable across the catenary.

(*l*) Leave a ' drip loop' at both ends.

NOTE. **Long lengths of catenary wire must be earthed.**

Proprietary Suspension Systems. These systems use a composite cable of circular cross-section which contains a flexible steel core and a set of conductors covered with impregnated jute or metal braiding. Terminations are made at special boxes which contain an anchoring device for the catenary wire and, where necessary, a set of fuses. Light fittings can also be taken from the termination box; auxiliary supports can be made at these boxes to support heavy fittings. A great virtue of this system, which is often used for indoor factory and warehouse lighting, is that it can be completed at the floor level before being suspended.

Applications of Catenary System. Catenary wiring provides a cheap method of spanning large distances and is often used in shipyards, steelworks, and goods yards.

1. Catenary systems and overhead wiring must be at least 5•8 m above the ground at road crossings.

2. There is no limit to the length of span for cables sheathed with p.v.c..or having a flamc-retardant and oil-resisting or h.o.f.r. sheath, when supported by a catenary wire.

3. All metalwork of wiring systems, including catenary wires, must be connected to an earth continuity conductor.

4. The manufacturer's instructions on the spacing of hangers must be followed when installing catenary systems in which the catenary wire forms part of the cable.

Humidity and High Temperature

The following factors are of particular importance in installations where cables and conductors are used in conditions of humidity (high moisture content in atmosphere) or where equipment is exposed to direct sunlight or high temperatures.

(a) The temperature rating of conductors and cables must be carefully adhered to in the calculation of conductor cross-sectional area.

(ft) It is essential that care is taken in the jointing of dissimilar metals to guard against the effects of electrolysis

(c) Ordinary p.v.c. cables will quickly deteriorate when exposed to direct sunlight. It is essential that special cables are used. Non-metal sheathed cables used in these situations should preferably have a special black p.v.c. sheath or oil-resistant and flame-retardant or h.o.f.r. sheath.

(d) Metallic conduit must be of the galvanised type and spacer saddles should be used to permit the free flow of moisture on surfaces.

(e) The extensive use of air conditioning in hot countries tends to increase the temperature range which equipment must be able to withstand.

(/) There should be adequate breather holes in metallic trunking and conduit installations to minimise condensation and allow moisture to escape.

(&) P•v-c• conduit or trunking should be used where rust is likely to affect the installation. A separate earth-continuity conductor must be run in the p.v.c. conduit or trunking.

3. DISTRIBUTION AND CONTROL

There are three main sets of regulations to which the electrician must conform in order that an installation shall be safe from excess current, shock, fire, corrosion, mechanical damage, and leakage. These are as follows:

1. **Electricity (Factories** Act) **Special Regulations, 1908 and 1944.** These regulations cover "the generation, transformation, distribution and use of electrical energy" in factories and workshops. An explanatory leaflet, *Memorandum by the Senior Electrical Inspector of Factories on the Electricity Regulations,* is issued by H.M. Stationery Office to explain the workings of these regulations.

2. **The Electricity Supply Regulations** (1937). The purpose of the Electricity Supply Regulations is to secure "the safety of the public and for ensuring a proper and sufficient supply of electrical energy". Under these regulations, the Supply Authority (the Area Board) undertakes to supply the consumer at a stated voltage, phase, and frequency, with permissible variations. The Area Board has the right to withhold connection or disconnect a supply if their regulations are not adhered to.

NOTE. These regulations, or statutes, have the force of law and for an employer, consumer, or electrician to disregard them could lead to legal action being taken against him.

3. **Regulations for the Electrical Equipment of Buildings.** These regulations (commonly called the I.E.E. Regulations) have been devised by the Wiring Committee of the Institution of Electrical Engineers to "ensure safety in the utilization of electricity in and about buildings". The I.E.E. Regulations are of considerable assistance to electricians as they largely cover the requirements of the Electricity Supply Regulations. The I.E.E. Regulations consist of two parts: Part 1 contains "requirements for safety" and Part 2 contains "means of securing compliance with Part 1".

It should be noted that the I.E.E. Regulations are not legally binding but are generally accepted as an efficient standard by Electricity Boards, contractors, and industrial and domestic consumers. However, Electricity Boards may have their own particular rules which must be obeyed. Particular industries have their own regulations—for example, coal mines and cinemas. These special regulations have the force of law.

Generally, if an installation complies with the I.E.E. Regulations it complies both with the Factory Acts and with the Electricity Supply Regulations since the I.E.E. Regulations are based on the requirements of these statutory regulations.

Supply System

The Grid is made up of a series of power stations throughout the country which feed current into a system of conductors at a very high voltage. Overhead conductors, supported by steel towers (pylons), are used to carry the current over long distances.

There are three main types of power station: (1) coal-fired, (2) nuclear, (3) hydro-electric.

The most common type is the coal-fired station. Heat, obtained from the burning of low-grade coal, is used to produce high-pressure steam. This high-pressure steam is used to drive a turbine which is mechanically connected to a 3-phase a.c. generator (alternator) generating at 11,000V. The voltage is stepped up, by means of a transformer, to 132,000V (or 275,000V and 400,000V on the super grid). High voltages are used in order to transmit high power with a cable of small cross-sectional area and also to increase the efficiency of transmission by decreasing copper losses *(PR* losses).

Fig. 4.1 shows, in the form of a block diagram, the usual method of subdividing the supply after it leaves the power station.

1. The 132kV (lOOOV=l kV) 3-phase supply is terminated at an open-air sub-station, containing switchgear and transformers, and stepped down tollkVor6•6kV.

2. These voltages (llkV or 6-6 kV) are used to transmit supplies over shorter distances for bulk supplies to large factories possessing their own sub-stations.

3. These voltages are also used to supply pole transformers for agricultural consumers and isolated installations.

4. The Supply Authority's sub-stations step down the 3-phase 6-6 kV or 11 kV to 415 V 3-phase 4-wire (3-phase and neutral).

5. Consumers requiring 240V single phase *(i.e.,* phase or live wire and neutral wire), for example, a housing estate, are fed from a 4-core armoured cable (3-phase and a neutral conductor). Each house is tapped from a different phase (Fig. 4.1) to balance the three phases (red, white, and blue). The underground cable is connected in a series of rings, thus decreasing the voltage drop and cross-sectional area required. This interconnection also ensures a continuity of supply.

Control of Supply at Consumer's Premises

It is essential that the consumer's supply should be effectively controlled and also that all switchgear should be accessible.

NOTE. "All conductors and apparatus must be of sufficient size and power for the work they are called upon to do, and so constructed, installed and protected as to prevent danger."

This quotation from the Electricity Supply Regulations also appears in substance in the Factories Act and the I.E.E. Regulations. The main switchgear in an installation must contain:

(a) Means of isolating the supply.

(b) Protection against excess current.

(c) Means of cutting-off the current if a serious earth fault occurs.

A main switch containing a fuse (or 3 fuses if 3-phase) fulfils these conditions as the switch isolates the supply and the fuse protects the circuit against excess current due to overload or serious earth fault.

Sequence of Control Equipment.

The earth leakage circuit breaker is used where it is difficult to get a good earth path (low-impedance earth return). The earth electrode of the E.L.C.B. must be placed outside the resistance area of any parallel path to ear.th.

Industrial Installations

1. All cables must be rated at, or above, the current which they will normally be expected to carry (Tables 1M to 31M in the I.E.E. Regulations supply this information) without undue heating or voltage drop (normally 2-5 per cent of nominal voltage).

2. All conductors, cables and equipment used in the installation must be of the correct Voltage rating, for example, 250V grade switchgear should not be used on 415V 3-phase installations: 500V switchgear is necessary.

3. The fuse in a circuit must be capable of protecting the smallest conductor in that circuit. For example, a twin flexible cord of 3 A rating should not be used in a circuit fused above 5 A because serious over-heating could occur in the flexible cord under fault conditions.

4. All conductors and equipment must be properly labelled; this saves time and also minimizes the danger of opening the wrong circuit when isolating or fault-finding.

Earth wire

5. All equipment must be protected against: high temperatures, moisture, corrosion, and mechanical damage.

6. The main distribution point should be situated, if possible, at the centre of the installation in order to keep cable runs short.

7. Sufficient capacity should be installed at the outset (in main switches, bus-bar chambers, and cables) to allow for future expansion.

The supply is fed into the premises by means of an underground cable (3-phase and neutral), through a sealing chamber into the Supply Authority's main fuse. Tails are taken from the fuses and neutral block into the meter panel. An armoured cable supplies the consumer's main switch, which, in this case, is a 500 A triple-pole and neutral linked switch (all poles are switched simultaneously). The conductors are then brought out to the bus-bar chamber. Tappings are taken from the bus-bars as follows:

No. 1 switch is a triple pole and neutral linked switch (all poles are switched simultaneously) for the lights. This switch feeds an 18-way distribution fuse board comprising three sets of six ISA fuses and a neutral block.

No. 2 switch is similar to No. 1 but supplies the heating load, which is balanced over 3 phases.

No. 3 switch controls the power circuits.

Sub-division of Loads

This is considered under lighting, heating, and power circuits.

Lighting Circuits The lighting load will be taken from the distribution board to the final sub-circuits. A final sub-circuit is defined in the I.E.E. Regulations as "an outgoing circuit connected to a distribution board and intended to supply electrical energy direct to current-using apparatus". The conductors between the bus-bar chamber and the distribution fuse board are termed the sub-main. The conductors from the lighting distribution fuse board may also feed local switches supplying small distribution fuse boards (for example, 5 A fuses) for offices, stores, etc.

The lighting final sub-circuits comprise a switch-panel and the lights controlled by these switches.

NOTE. All fuses and switches must be placed in the phase conductor and metal lampholders (used in industrial fittings of 200 W and over) must be earthed and the phase conductor should be terminated at the centre pin of Giant Edison Screw (G.E.S.) lampholders.

Heating Circuits.

The heating load is split up over 3 phases to give a balanced load. The heaters, for example, fan heaters, would be controlled by a 3-phase isolator or a 3-phase switch fuse. For example, if 240 V tubular heaters (200 W per metre) are used the heating circuits are subdivided into three sections with a separate phase for each section. *Power Circuit*

The main distribution fuse board may also be used to supply smaller distribution fuse boards for smaller lathes, drills, etc. *The 2-metre Rule.* In conditions where two separate phases (for example, the red and blue phases) are brought into the same room:

(a) The controlling switch must be clearly marked '415 volts'. (&) Switches and socket outlets supplied from different phases must be placed at least 2 metres apart. This is particularly important where portable appliances are used This is termed the '2-metre rule'. It avoids the danger of a voltage of 415V appearing between appliances or switches which can be touched simultaneously.

Domestic Installations

Domestic installations are usually supplied from a 16 mm^2 twin armoured cable. shows the line drawing of a typical layout:

1. The Supply Authority's sealing chamber for the termination of the armoured cable.

2. The Supply Authority's fuse and neutral block.

3. The Supply Authority's energy meter (kWh meter).

4. Consumer's control unit.

NOTE. The Supply Authority's fuses need not be duplicated if the permission of the Authority is obtained.

Domestic Consumer's Control Unit

This type of unit is usually made up of the following:

(a) Main switch (60 A) which isolates *both* the phase and the neutral conductors.

(b) One 30 A fuse for the cooker circuit.

(c) One 30 A fuse for the 13 A ring circuit (capable of taking two 7/0-85 in cables).

(d) One or two 5 A fuses for lighting circuits.

Loading of Final Sub-circuits. The assumed current demand from points is as follows (Table B, I.E.E. Regulations): 15 A socket outlet 15 A 5 A socket outlet 5 A

2 A socket outlet at least J A Lighting outlet minimum 100 W

1. Only one phase of a supply should preferably be brought in to a multi-gang switch box. Where more than one phase is used there must be a rigid screen or barrier separating the phases, and a clearly visible notice warning of the maximum voltage present. This notice must be placed outside the switch.

2. All final sub-circuits must be electrically separate (i.e. there must be no 'bunching' of neutral conductors). All neutral conductors must be connected at the distribution board in the same order as the line conductors.

Domestic Ring Circuit

The domestic ring circuit is defined in the I.E.E. Regulations as " a final sub-circuit in which the current-carrying and earth-continuity conductors are connected in the form of a loop, both ends of which are connected to a single way in a distribution fuse board or its equivalent. A spur of a ring circuit shall be a branch cabk having conductors of a cross-sectional area not smaller than that of the conductors forming the ring".

The main I.E.E. Regulations relating to the ring are as follows.

1. Cable size: minimum twin 2-5 mm^2 and earth p.v.c. or t.r.s.

2. Maximum number of socket outlets allowed: unlimited number in floor area under 100 m^2, but spurs may not number more than half the socket outlets on the ring circuit, including stationary appliances.

3. Fused 13 A plugs to be used at socket outlets supplying portable appliances.

4. Fixed appliances must be protected by a local fuse, for example, a fused spur box.

5. A 30 A fuse should be used to protect the ring circuit.

6. All socket outlets in any one room must be connected to the same phase.

7. Apparatus permanently connected to the ring circuit without a fused plug or socket outlet must be protected by a local fuse or circuit-breaker with a rating not exceeding 15 A. The apparatus must have an adjacent controlling switch.

The purpose of the ring circuit is:

(a) To minimize trailing flexes.

(6) To take advantage of the fact that all outlets in a domestic installation

Lighting circuits, (a) One-way switching: one switch serving four lights. The conductors are looped between the lamps, *(b)* The two-way switching circuit. Used for stairs and corridors, *(c)* The two-way switch used with an intermediate switch for long corridors in hospitals, schools, etc. *(d)* Another type of intermediate switching. The internal connections in the switch determine the circuit used. *(e)* Dim-bright switching. The lamps are connected in series for dim operation and

in parallel for bright.

are not operated simultaneously. This is known as the diversity in an installation.

Diversity Factor. The diversity factor in an installation can be calculated as follows:

The diversity factor varies for different types of installations, for example, the diversity factor suggested in the I.E.E. Regulations for the lighting circuits of a block of residential flats is 50 per cent. This means that the cables supplying the lighting load *(not* the final sub-circuits) need only be rated for 50 per cent of the full-load current. This decrease in the cross-sectional area of the cable is allowed because the likelihood of all the lights being on at the same time is remote, although any one final sub-circuit may be fully loaded.

Domestic Lighting. Domestic lighting circuits are usually wired in 1 mm^2 twin t.r.s. or p.v.c. (twin 1-5 mm^2 may also be used). The protecting fuse is generally *5* A (20 mm tinned copper wire or cartridge fuse with white body). Conductors in a lighting final sub-circuit (or any final sub-circuit) should never be interconnected with other final sub-circuits. For example, a final sub-circuit neutral should never be used to feed more than one final sub-circuit. Each neutral conductor should be connected to its individual terminal at the neutral block: 'bunching' is not permitted. An earthing terminal must be provided at every lighting point. The earth continuity conductor of the final sub-circuit must be connected to this terminal. Non-metallic switches must also be supplied with an earthing to which the final sub-circuit earth continuity conductor must be connected. The earthing terminal is not required where earthed metal boxes are used which have a fixing for the metal switch plate giving reliable electrical contact between the plate and the metal box.

Fittings. Light switches are usually of the 5 A (a.c.) quick-make-slow-break (Q.M.S.B.) type, flush mounting. Switches used in fluorescent lamp circuits must be capable of carrying twice the normal circuit current in order to withstand the inductive effect of the choke.

NOTE. An incombustible material, for example, a hard wood block, must be placed at the back of surface-mounted accessories where these are fitted to soft wood or other combustible material.

Ceiling Roses. There are two main types of ceiling rose: *(a)* the three-plate pattern and *(b)* the two-plate pattern.

The three-plate ceiling rose is used to economize in wire and minimize the number of joint boxes used in the installation.

NOTE. Ceiling roses must not be used on circuits operating above 250 V and no more than one flexible cord is permitted from any one ceiling rose. The earthing terminal of every ceiling rose must be connected to the earth continuity conductor of the final sub-circuit.

Water Heaters. Domestic water heaters are generally rated at 3 kW and are usually supplied from the ring circuit. Asbestos-covered cable should be used to terminate the conductors at the immersion heater since p.v.c. and t.r.s. cables are normally expected to be used where the surrounding temperature (the ambient temperature) does not exceed 30 °C. The temperature range of water heaters is between 43 °C and 82 °C.

The thermostat, in common with all other switching devices, must always be fitted in the phase conductor.

Bathroom

All lampholders must be of the Home Office (skirted) type and lamps should be totally enclosed. Only circular flexible cable should be used where necessary and the switch must be of the pull-cord type. No portable appliances should be fitted or used in the bath-room and fixed appliances, for example, wall fires, must be placed out of reach of persons in the bath.

Garages.

Socket outlets in garages must be placed at a safe distance from floor level. All portable appliances, particularly handlamps, must be earthed and handlamps should be fitted with an earthed shield. **Cooker Control Unit.** This generally consists of a double-pole switch feeding the cooker and an independent 13 A socket outlet. It is essential that the earth continuity conductor supplying the unit should be effectively connected.

The cooker control unit is generally supplied from a separate way in the consumer's control unit and wired with 10 mm^2 twin and earth p.v.c. or t.r.s. cable. It is fused at 30 A which is sufficient to protect a maximum of 9 kW (3-plate cooker). The current demand from a stationary cooking appliance is calculated as follows: 10 A + 30 per cent of the total remaining full load current. Every stationary cooking appliance in domestic premises must have an adjacent control switch fitted within 2 m of the appliance.

NOTE. No diversity factor is allowed with a final sub-circuit supplying a cooker as it is possible that all elements will be in use when the cooker is being fully utilized.

Layout of a Domestic Circuit.

The lighting circuits would be connected from two junction boxes in the attic (one box for each circuit). The cable supplying the cooker would also be run in the attic and the ring circuit would be run below the floor. Socket outlets are placed 30cm above the floor level and light switches 1-5 m above floor level.

4. FINAL CIRCUITS

A final circuit is defined as 'A circuit connected directly to current-using equipment, or to a socket-outlet or socket-outlets or other outlet points for the connection of such equipment.' In addition, the regulations require that where an installation comprises more than one final circuit, each circuit shall be connected to a separate way in a distribution board. They also require that the wiring of each final circuit shall be electrically separate from that of every other final circuit. To facilitate disconnection of each final circuit for testing, the neutral conductors shall be connected at the distribution board in the same order as that in which the live conductors are connected to the fuses or circuit-breakers.

Final circuits make up the greater part of electrical installations and can vary from a pair of 1 mm^2 cables feeding one lamp, to a heavy three-core PILC cable feeding a large motor from a circuit-breaker located at a factory switchboard. The main important regulation which applies to final circuits is No. 27 of the Electricity Supply Regulations: 'All conductors and apparatus must be of sufficient size and power for the work they are called on to do, and so constructed, installed and protected as to prevent danger.'

There are five general groups of final circuits:

1. Rated at not more than 16A.

2. Rated over 16A.

3. Rated over 16A but confined to feeding 13A socket-outlets with fused plugs.

4. Circuits feeding fluorescent and other discharge lamps.

5. Circuits feeding motors.

An industrial installation may have all five types; a domestic installation may have only 1, 2 and 3. Whatever the type of installation and the uses to which electrical energy is put, it is essential that some significant element of planning be introduced at any early stage in the design of an installation.

Before indicating the factors which are involved in the choice of final circuit types, a few brief notes on planning aspects will be relevant.

Installation planning

(a) *Domestic installations* seem to be the simplest to plan, but there are a number of points which are worth considering. And though these might seem obvious at first sight, a close survey of existing installations will reveal rather too many lapses in efficient planning, even for a dwelling house. For example, a room which can be entered from two points should be wired for two-way switching; a two-landing staircase should be wired for intermediate switching; and a large house should have two or more lighting circuits. A note in an olderedition of the IEE Regulations is still relevant: 'In the interests of good planning it is undesirable that the whole of the fixed lighting of an installation should be supplied from one final subcircuit.' The reason for this is not far to seek. If an installation has two lighting circuits and one circuit fails, the house is not plunged into darkness. It is often a good point to consider a slight 'overlap' of lighting circuits: to wire one lighting point from one circuit within the wiring area of the other circuit. If this is done, there should be a note to this effect displayed at the distribution board.The lighting in houses should be regarded as an important aspect of interior decoration, as well as supplying lighting on a purely functional basis. In living rooms and bedrooms, wall-mounted fittings can be used, controlled by multi-point switches at the entrance doors. Thought should be given to the provision of 13A socket-outlets for supplying table and standard lamps. The use of local lighting over working surfaces in kitchens is an aspect of good planning. External lighting should not be overlooked, either to light up the front and back doors or to light the way to outhouses such as detached garages, coal stores and greenhouses In very large houses, driveway lighting may have to be considered.

To facilitate the interchange of fittings and appliances throughout the house, it is recommended that 13A three-pin socket-outlets to BS 1363 should be used exclusively. Where it might be inconvenient to withdraw plugs from the associated socket-outlets when appliances are out of use, switched socket-outlets should be used. Because the past few years have seen a rapid increase in the use of electrical appliances, it is essential that an ample number of socket-outlets be provided, and situated wherever there might arise the need for an electrical outlet. The table shows the provision of socket-outlets, both the desirable number and the minimum provision that can be considered as acceptable:

Part of dwelling	*Desirable provision*	*Minimum provision*
Working area of a kitchen	4	4
Dining area	2	1
Living area	5	3
First (or only) double bedroom	3	2
Other double bedrooms	2	2
Single bedrooms	2	2
Hall or landing	1	1
Store/workshop/garage	1	—
	20	15
Single study-bedrooms	2	2
Single bed-sitting rooms in family dwellings	3	3
Single bed-sitting rooms in self-contained bed-sitting room dwellings	5	5

It can thus be seen that the average house should have an adequate number of socket-outlets. In the living room, there should be a two-gang socket-outlet on each side of the fireplace. Additional socket-outlets should be located less than 2 m from the opposite corners of the room, where they are least likely to be hidden by furniture. In bedrooms, at least a single socket-outlet should be provided at each side of a bed; two-gang units can be used to good advantage (e.g. to supply a bedside lamp and an electric blanket). Additionally, there should be socket-outlets for dressing-table lamps, a heating appliance or a portable television set. The kitchen probably places the greatest demand on the electrical service. Outlets are required for such varied appliances as washing machines, refrigerators, waste-disposal units, food mixers, can-openers, flat irons, coffee percolators and toasters. As far as possible, the outlets should be located above working surfaces and two-gang units are recommended.

In the dining room, small plate-warmers may be required. In halls and on landings the outlet is generally used for a vacuum cleaner or floor polisher, and perhaps a hall heater. No provision is made for the use of portable appliances in a room containing a fixed bath or shower. However, an electric shaver unit to BS 3052 may be installed out of reach of a person in the bath or shower. Additionally, a bathroom heater (of the enclosed-element type) or towel rail should be permanently connected through a fixed control switch out of reach of the bath or shower position.

(b) Commercial installations are often difficult to design because frequently the buildings are built as basic shells with the final requirements for lighting and other circuits not known until the office tenants sign their leases. The lighting in such buildings is 'general, special, and building services'. The general lighting is supplied by a flexible wiring system which will allow for a specific area in a new building to be sectioned or partitioned off into smaller areas for offices, stores and the like. Special lighting may include external lighting, wall points, etc. The service lighting is that associated with lifts, corridors, stairs, landings and is usually the responsibility of the landlord. Where a tenant's specific lighting requirements are not known when the building is being erected, the lighting outlets are laid out on a 'grid' system, in which the outlet points are sited at regular intervals usually related to the module of the building (that is, the basic size, multiples of which are used in the construction of the building). Generally, about 3 m are allowed between outlets. Outlets may be left on the ceiling for ceiling switches. They may also be fitted on structural columns or on the ceiling along the line of future corridors from which extensions to switch positions can be made on future partitions. The provision of adequate socket-outlets is a particular problem, for should the electrical load increase (e.g. an office may go over to all-electric typewriters or install a computer or data-processing system), it is often difficult to extend or alter an inflexible installation. Thus, the electrical services provisions

should allow for the possibility of installing new outlets or revising the positions of existing outlets without difficulty or serious disturbance to the building and its occupants. Where a tenant's requirements for socket-outlets are not known, it is usual practice to install one socket-outlet on the external wall in each building bay and make provision for spur connections to two further outlets to be installed on internal partitions as may be required. Only a limited number of bays, not more than three, should be connected to each ring circuit.

(c) Industrial premises require lighting installations which cater for the intensity of lighting required for the process to be carried out. In addition, local lighting at reduced voltages is often a requirement on machines or for portable inspection lamps. The lighting installation within the factory area should be wired with a system which will allow for extensive alteration and significant addition with ease of maintenance and rewiring when necessary.

(d) Special types of premises include hospitals, theatres, cinemas, hotels, schools and buildings of historic interest. Some of these, such as hospitals, have specific codes of practice laid down by the Ministry of Health. In places of entertainment, secondary lighting installations are required.

Circuits rated under 16A

A final circuit rated at not more than 16A may feed an unlimited number of points provided that the total 'current demand' does not exceed 16A. They include 15, 13, 5 and 2A socket-outlets, lighting outlets, stationary appliances and certain loads which may be neglected because their current demand is negligible (e.g. clocks, bell-transformers, electric shaver supply units), provided that their rating is not greater than 5VA. No diversity is allowed on final circuits. The current rating of the cable must not be exceeded. An important point to note is that if a cable size must be increased to avoid excessive voltage drop in the circuit, the rating of the fuse or circuit-breaker protecting the circuit must not be increased correspondingly. Thesame condition would apply if the ambient temperature of a cable were to be taken into consideration. The reason for this is that the larger cables are not being chosen for the current that they can carry under favourable circuit conditions, but to provide for the special conditions in which they are being installed. The lighting circuits of domestic installations are rated at 5A. Industrial lighting circuits are usually rated at 15/16A because of the higher wattage of the lamps used

Circuits rated over 16A

With two exceptions, circuits rated at over 16A should not serve more than one point. The exceptions are circuits which feed 13A socket-outlets and cooker circuits. Final circuits for cooking appliances are assessed for current demand as follows:

The first 10A of the total rated current of the

connected cooking appliances, plus 30% of the remainder of the total rated current of

the connected cooking appliances, plus 5A, if the cooker control unit has a socket-outlet.

Thus, a cooker with a total load of llkW at 240V (46A) would in fact be supplied by cables rated to carry about 26A, depending on the distance the cooker is away from the distribution board. If a large cooker, which exceeds 30A, is to be installed in domestic premises, and where fuses offer the protection, a supply service of more than the normal 60A rating may be required. In this instance, the supply authority should be consulted. Water-heater circuits are terminated in a 20A double-pole isolating switch, fitted with an earthing terminal and a neon pilot lamp.

Circuits rated for 13A socket-outlets

Final circuits which supply 13A socket-outlets with fused plugs and 13A fused (switched or unswitched) connection units are provided by two types of circuit: ring and radial. Ring circuits serve a maximum floor area of 100 m^2 derived from a 30A protective device. Radial circuits serving a maximum area of 50 m^2 are also protected by a 30A device, while if the area served is no more than20 m^2 a 20A device provides the protection. The following is a summary of the requirements relating to 13A socket-outlet circuits: Each socket-outlet of a two-gang or multiple socket-outlet is to be counted as one socket-outlet. Stationary appliances, permanently connected to a radial or ring circuit, must be protected by a fuse not exceeding 13A rating and controlled by a switch or a circuit-breaker. It is important to realise that the conductor sizes recommended for ring circuits are minima. They must be increased if necessary where circuits are installed in groups, or in conditions of high ambient temperature, taking into consideration the class of excess-current protection provided.

The method of properly connecting circuit conductors of a ring circuit involves correct polarity and security of the terminals.

Except where a ring circuit is run throughout in metallic conduit, ducts or trunking, the CPC shall be run in the form of a ring, having both ends connected to earth at the distribution board (or its equivalent).

The total number of spurs shall not exceed the total number of socket-outlets and stationary appliances connected directly to the ring.

Fused spurs from ring circuits must be connected through fused spur boxes, and the rating of the fuse must not exceed the current rating of the cable forming the spur, and in any event must not exceed 13A.

One socket-outlet or one two-gang socket-outlet unit, or one stationary appliance fed from a connection unit, can be connected to each non-fused spur.

Circuits feeding discharge lamps

One of the main requirements is a consideration of the 'rating' of a discharge lamp outlet, for it has a rather different interpretation from that used for other lighting points. The reason for this is that, owing to the losses in the lamp control gear plus the low power factor (about 0.9), it is necessary to multiply the rated lamp watts by 1.8 and divide by the lamp rated voltage to obtain the actual current flowing in the circuit. It should be noted that certain switches may not be suitable for controlling the highly inductive circuits associated with discharge lighting. If a switch is not specifically designed to break an inductive load (quick-make, slow-break), it should have a current rating of not less than twice the total steady current which it is required to carry.

Circuits feeding motors

Final circuits which supply motors require careful consideration. In particular, cables which carry the starting, accelerating and load currents of a motor must be rated at least to the full-load current rating of the motor. If, however, the motor is subjected to frequent starting and stopping, the csa of the cables should be increased to cater for the consequent increase in conductor temperature. More than one motor may be connected to a 16A final circuit, provided that the aggregate full-load rating of the motors does not exceed 16A. If a motor takes more than 16A full-load current, it should be fed from its own final circuit.

Final-circuit protection

Protection of final circuits is by means of fuses, circuit-breakers or miniature circuit-breakers located at switchboards and distribution boards. The protection is for over-currents caused by short-circuits between conductors, between conductors and earth, or overloads. The protective gear should be capable of interrupting any short-circuit current that may occur without danger of fire risk and damage to the associated equipment. In large installations, where there are main circuits, sub-mains and final circuits, it is often necessary to introduce a discriminative factor in the provision of protective gear. Where circuit-breakers are used, discrimination is provided by setting sub-circuit-breakers to operate at a lower over-current value and a shorter time-lag than the main circuit-breaker. Thus, if a fault occurs on a final circuit,

the associated gear will come into operation, while the main breaker remains closed. However, if the fault persists, or the sub-circuit-breaker fails to operate within its specified time (e.g. 2 seconds), the main breaker will trip out (e.g. 0.5 second later).

Fuses are often used for back-up protection of circuit-breakers. Generally, where cartridge fuses are used the fuse will operate before the circuit-breaker, particularly in the event of a short-circuit current. Where small over-currents occur (e.g. overload) the circuit-breaker is likely to operate before the fuse blows.

Where full use is made of cartridge fuses, their ratings, type and make should be consistent for each circuit protected. The rating of sub-circuit and main fuses should be chosen so that in the event of faults the sub-circuit fuses blow first. Generally, discrimination between the fuses can be obtained if the rating of the sub-circuit fuses does not exceed 50 per cent of the rating of an associated main fuse. If this margin is too large, reference should be made to the data provided by the fuse makers. Discrimination is very difficult to obtain with any degree of accuracy where cartridge fuses and semi-enclosed rewirable fuses are used together because of the many factors which are involved in the operation of the latter type of fuse. These include the type of element, its size, the ambient temperature, its age and its material.

Choosing cable sizes

The selection of the size of a cable to carry a load current involves the consideration of the rating and type of the protective device, the ambient temperature and whether other cables are run alongside the cable (grouping). There are many situations in which cables can find themselves being overheated. The more obvious are the conditions set up when overcurrents are carried due to overloading and when a short-circuit occurs. Others include the increase in temperature when a number of current-carrying cables are bunched together, for instance in conduit and trunking, which is a situation in which each cable contributes its heat to that of others and which, because of the enclosed situation, produces an environment which can quickly lead to the deterioration of the cable insulation (particularly when PVC is involved) and lead to a possible source of fire. At about 80 °C, PVC becomes very soft, so that a conductor can 'migrate' or travel through the insulation and eventually make contact with earthed metalwork. This produces a shock-risk situation, with an increase in the leakage current which could prove fatal if the installation earthing arrangement is faulty. Eventually, when the insulation breaks down completely, a short-circuit occurs and the circuit is now dependent on the ability of the over-current protection device to operate to disconnect the circuit from its supply. As is probably realised, the time of operation of the protective device is crucial: a semi-enclosed fuse will take longer to operate than would a miniature circuit-breaker. In some circumstances, particularly where PVC insulated cables are used, the time taken by a semi-enclosed fuse to operate may be long enough for the cables to burn out and create a fire hazard.

Another problem which has occurred in recent years concerns the use of thermal insulation in buildings, with cables being installed in conditions where the natural heat produced by even their normal load currents cannot be dissipated easily. The IEE Regulations recognise the fact that, in these circumstances, the ratings of cables have to be reduced quite considerably. The regulations list 20 standard methods of installation each of which is identified by 'Methods'. These classifications are used in the tables which give the current-carrying capacities of cables. The installation conditions include 'enclosed' (e.g. in conduit, trunking and ducts); 'open and clipped direct' (e.g. clipped to a wall, to a cable tray, embedded direct in plaster which is not thermally-insulating, and suspended from a catenary wire); 'defined conditions', which include cables in free air; and cables 'in enclosed trenches'.

From this, it can be seen and appreciated that the selection of a cable to feed a circuit is now required to be undertaken with a number of factors to be considered carefully. Situations which were formerly taken for granted must now be investigated so that the cable is installed in the best conditions which will allow the cable to carry itsload current with the safety of the user of the installation in mind.

The IEE Regulations require that the choice of a cable for a particular circuit must have due regard for a number of factors, and not just the circuit current. These factors include:

(a) the ambient temperature in which the cable is installed;

(b) the installation condition, e.g. whether grouped or bunched with other current-carrying cables, enclosed or installed 'open';

(c) whether the cable is surrounded by or in contact with thermal insulating material;

(d) whether the circuit is protected by semi-enclosed (rewirable) fuses to BS 3036.

The method of choosing the correct size of conductor for a particular load condition, as recommended by the IEE Regulations, is based on the rating of the overcurrent protective device. All factors affecting the cable in its installed condition are applied as divisors to the rating of the device, as the following examples show. The requirement of Regulation 525-01-02 must also be considered. In general, the size of every bare conductor or cable conductor shall be such that the drop in voltage from the origin of the installation to any point in that installation does not exceed 4% of the nominal voltage when the conductors are carrying the full load current. Values of volt drop per ampere per metre are given in the current rating tables in Appendix 4 of the Regulations. In this context, it should be noted that conductors of large cross-sectional area have different volt drops per ampere per metre for ac circuits than those operating from dc supplies. This is because of the reactance inherent in conductors carrying ac.

The following process for working out the correct size of cables is as follows:

1. First find the load current of the circuit (I_B).

2. Determine the correction factor for the ambient temperature which of course does not include the heat generated in the cable itself, but is more concerned with the maximum temperature of the medium through which the cable runs.

3. Determine the correction factor for grouping. Here we refer to Table 4B1 of the Regulations

4. Determine the correction factor if the cable is in contact with or is surrounded by thermal insulation material. Two factors are given: 0.75 if only one side of the cable is in contact with the material (e.g. a cable clipped to the side of a joist) and 0.5 if the cable is completely surrounded by the material.

5. Select the rating of the overcurrent device. If this is offering what used to be called 'close' protection, the correction factor is 1. If, however, protection is by means of a semi-enclosed fuse, the factor is 0.725. The rating of the device must at least equal the load current.

6. Determine the size of the circuit conductor by calculating its current rating. The actual size is obtained from the current-rating tables in Tables 9D1A to 4L4A in 7. Check that the volt drop does not exceed the maximum permissible allowed by Regulation 525-01-02.

If 7_Z represents the current rating of the conductor and $/_n$ the rating of the protective device, then

$$I_z = \frac{I_n}{C_g \times C_a \times C_i \times C_f} \text{ amperes}$$

where C_g is the factor for grouping;

C_a is the factor for ambient temperature;

Q is the factor for thermal insulation (0.5 if cable is surrounded and 0.75 if the insulation is in contact with only one side of the cable;

Cf is the factor for the over current device. This factor is 1 for all devices except semi-enclosed fuses, when the factor is 0.725.

The following examples indicate how the installation and circuit conditions affect the final choice of cable size. It should be noted, in passing, that the current-rating tables in Appendix 4 assume that what was previously considered as 'close' protection is offered as circuit protection.

5. OVERCURRENT PROTECTION

IEE Regulation 13-7 states that: 'Where necessary to prevent danger, every installation and every circuit thereof shall be protected against over-current by devices which (i) will operate automatically at values of current which are suitably related to the safe current rating of the circuit, and (ii) are of adequate breaking capacity, and (iii) are suitably located ... and permit ready restoration of the supply without danger'.

Overloading occurs when extra power is taken from the supply system. The increased loading results with the addition of low resistance being connected in parallel with the existing load in a circuit. The decrease in the overall resistance of the circuit produces a proportional rise in the amount of current flowing in the circuit conductors. The increased current will have an immediate effect on the cables: they will begin to heat up. If the overload is sustained the result could be an accelerated deterioration of the cable insulation and its eventual breakdown to cause an electrical fault and perhaps fire.

A heavy sudden overload is not so serious since the overload current flows for a short time (e.g. motor starting), and the rise in cable temperature is neither rapid nor steep. However, this current must flow for a very brief period. Certain types of cable (e.g. paper-insulated and mineral-insulated) can withstand cyclic overloading. In certain circumstances, a sudden heavy overload may in fact approach the characteristic of a short-circuit.

A short-circuit is a direct contact or connection between a phase conductor and (a) a neutral or return conductor, or *(b)* earthed metalwork, the contact usually being the result of an accident. The result of a short-circuit is to present a conducting path of extremely low resistance which will allow the passage of a current of hundreds or thousands of amperes. If the faulty circuit has no over-current protection, the cables will heat up rapidlyand melt; equipment would also suffer severe damage and fire is often the result.

The form which protection against overcurrent takes is either a fuse or a circuit-breaker. Each has characteristics, which offer the protected circuit a degree of protection according to circuit conditions.

The fuse

The fuse was the earliest means used to protect against overcurrents in conductors. Basically, the fuse consists of a short length of suitable material, often in the form of a wire which has a very small cross-sectional area. When a current flows which is greater than the current rating of the wire, the wire will get hot. This happens because its resistance per unit length is greater than its associated circuit conductors (so giving greater power loss and heat) and because this increased heat is concentrated in the smaller volume of the material. The size of the wire is designed to carry indefinitely the normal circuit current.

The following terms are used in connection with fuses:

Current rating. This is the maximum current which the fuse will carry for an indefinite period without undue deterioration of the fuse-element.

Fusing current. This is the minimum current that will cause the fuse-element to heat up and melt or 'blow'.

Fusing factor. This is the ratio of the fusing current to the current rating:

current rating

$$\text{Fusing factor} = \frac{\text{fusing current}}{\text{current rating}}$$

Fuse-element. That part of a fuse which is designed to melt and thus open a circuit.

Fuse-link. That part of a fuse which comprises a fuse-element and a cartridge or other container, if any, and is either capable of being attached to fuse contacts or is fitted with fuse contacts as an integral part of it.

Fuse. A device for opening a circuit by means of a conductor designed to melt when an excessive current flows along it. The fuse comprises all the parts of the complete device.

There are three general types of fuse: (a) rewir-able; *(b)* cartridge; (c) HRC (high-rupturing capacity), which is a development of the cartridge fuse.

The rewirable fuse is a simple device. It consists of a short length of wire, generally of tinned copper. The current at which the wire will melt depends on the length of the wire and its csa. If it is very short, the heat generated (I^2R watts) will be conducted away from the wire by the contacts or securing screws. Also, if the wire is open to the atmosphere, it will cool much more quickly than if it were surrounded by a thermal and electrical insulator such as an asbestos sleeve. In view of these and other factors, the rewirable fuse is a device with a number of variables which affect its performance; any one, or all, of these can differ between similar fuses. Though the rewirable fuse is cheap, involving only the replacement of the fuse-element, it has a number of disadvantages and limitations:

1. The fuse element is always at a fairly high temperature when in use. This leads to oxidation of the element material, which is a form of corrosion, and results in a reduction in the cross-sectional area of the element, so that it fuses at a current lower than its indicated rating. Fuses which carry their rated current for long periods generally require replacement at two-yearly periods, otherwise nuisance blowing will be experienced on the circuit.

2. It is very easy for an inexperienced person to replace a blown fuse-element with a wire of incorrect size or type.

3. When a fault occurs on a circuit, the time taken for the fuse to blow may be as long as several seconds, during which time considerable electrical and physical damage may result to the circuit conductors and the equipment being protected.

4. The calibration of a rewirable fuse can never be accurate, which fact renders this type of fuse unsuitable for circuits which require discriminative protection.

5. Lack of discrimination means that it is possible in certain circuit conditions for a ISA-rated fuse-element to melt before a 10A-rated element. Also, the type is not capable of discriminating between a transient high current (e.g. motor starting current) and a continuous fault current.

6. Owing to the fact that intense heat must be generated in the fuse-element before it can perform its protective action, there is an associated fire risk. Also in this context, should the fault current be particularly high, though the wire breaks, an arc may still be maintained by the circuit voltage and flow through the air and metallic vapour. The rewirable fuse has thus a low rupturing capacity, which is the product of maximum current which the fuse will interrupt and the supply voltage. The capacity is measured in kVA. Generally, a limit of 5000kVA is placed on rewirable fuses.

Semi-enclosed or rewirable fuses are not highly regarded as suitable means of protection against overcurrents. They can carry up to twice their current rating with no guarantee that they will 'blow'. They also present something of a fire hazard in installations.

The cartridge fuse was developed to overcome the disadvantages of the rewirable type of fuse, particularly because, with the increasing use of electricity, the energy flowing in circuits was growing larger. The main trouble with the rewirable fuse was oxidation and premature failure even when carrying normal load currents, causing interruptions in supply and loss of production in factories. Thus, the fully enclosed or cartridge fuse came into existence. Non-deterioration of the fuseelement was, and still is, one of the most valuable features of this type of fuse. The advantage, also, of the cartridge fuse is that its rating is accurately known. However, it is also more expensive to replace than the rewirable type and it is unsuitable for really high values of fault current.

It finds common application for domestic and small industrial loads. As house-service cutout fuselinks (BS 88), they are used by supply authorities for service fuses. Ferrule-cap fuselinks (BS 1361) are used in domestic 250V consumer control units, switchfuses and distribution boards. The domestic cartridge fuselinks (BS 1362) were designed for use specifically in 13A fused rectangular-pin plugs. Domestic cartridge fuselinks (BS 646) are for use specifically in 15A round-pin plugs where the load taken from a ISA socket-outlet is small (e.g. radio, TV or table lamp) in relation to the 15A fuse which protects the circuit at the distribution board. In addition, there are other cartridge fuses for particular applications (e.g. in fluorescent fittings). All these cartridge fuses are so designed that they cannot be interchanged except within their own group.

Essentially, the cartridge fuse is a ceramic barrel containing the fuse-element. The barrel is filled with a non-fusible sand which helps to quench the resultant arc produced when the element melts.

The HRC fuse was introduced in the 1930s. The modern type consists of a barrel of high-grade ceramic able to withstand the shock conditions, which occur when a heavy fault current is interrupted. The end caps and fixing tags are suitably plated to give a good electrical contact. The fixing tags are also planished to ensure satisfactory alignment between contact-making surfaces. Except for very low ratings, the fuse-element is of pure silver wire or tape with a waist at its center designed to give the required operational characteristic. The filler within the barrel is powdered silica, carefully dried before use. When used, the filler is compacted in the barrels by mechanical vibration to ensure complete filling. An indicator is sometimes provided to show when the fuse has blown. This consists of a glass bead held in position in a recess in the external barrel wall by a fine resistance wire, connected in parallel with the fuse-element. The barrels are accurately ground and the caps area force-fit. Correct grades of solder are used for the element and tag fixings. The larger types of multi-element fuses have the elements welded in addition to soldering The short-time characteristics of the HRC fuse enable it to take care of short-circuit conditions in the protection of motor circuits. Tests have shown that HRC fuses have a short-circuit fusing time as low as 0.0013 second. On large ratings they will open circuit in less than 0.02 second. HRC fuses are discriminating, which means that they are able to distinguish between a high starting current taken by a motor (which lasts only a matter of seconds) and a high fault or overload current (which lasts longer). HRC fuses are often used in motor circuits for 'back-up' protection for the machines. Motors are normally protected against damage by overload by thermal magnetic devices in the motor starter; the fuses are required only to give protection against short-circuit currents and severe overloads outside the capacity of the starter protective devices. For instance, modern squirrel-cage induction motors can take up to ten times normal full-load current when stalled. The rating of a fuselink for a motor circuit should be that of the smallest current that will withstand the starting current while providing at the same time the necessary margin of safety.

When a capacitor is switched into a circuit, a heavy inrush of current results. To ensure that This is a plug of eutectic (tin-lead) alloy in intimate contact with the silver element (wire or strip). When the element heats up to the softening point of the alloy — about 300 °C — the silver combines with the tin-lead without altering the melting temperature so that a portion of the element now melts at fuses do not blow unnecessarily in these circumstances, it is necessary to fit higher rated fuses. In general, if the fuses fitted are rated at 125 — 150 per cent of the capacitor rating, nuisance blowing of the fuses will be avoided. Transformer and fluorescent lighting circuits may also need higher rated fuse links to deal with the inrush currents associated with this class of gear. Fuselinks with a rating of about 50 per cent greater than the normal current of the apparatus to be protected are usually found to be satisfactory. The IEE Regulations detail many specific requirements regarding fuses and their applications. 'Protection against Overcurrent', cover the main points to be considered. There is a general recommendation for fuses to be of the cartridge type. The main reason for this is the high fusing factors of semi-enclosed fuses, which can be as high as 1.9, which means that a fuse with a rating of 10A will require a current of 19A before the fuse-element heats up and melts. On the other hand, many cartridge fuses have fusing factors less than 1.5, which means that they can offer better protection for circuit conductors. The HRC fuses can offer fusing factors as low as 1.25, which means that these' fuses will operate with an overcurrent of 25 per cent. This is obviously important when the circuit conductors to be protected are insulated with such thermoplastic materials as PVC, which cannot withstand temperatures much over their limit of 70 °C.

The circuit-breaker

The circuit-breaker is a mechanical device for making and breaking a circuit, both under normal and abnormal conditions, such as those of a short-circuit, the circuit being broken automatically. The circuit-breaker differs from the switch. Whereas the switch is capable of making and breaking a current not greatly in excess of its normal rated current, the circuit-breaker is capable of disconnecting automatically a faulty circuit, even in short-circuit conditions. A circuit-breaker is selected for a particular duty, taking the following into consideration: *(a)* the normai current it will have to carry and *(b)* the amount of current which the supply system will feed into the circuit fault, which current the circuit-breaker will have to interrupt without damage to itself.

Because the circuit-breaker is a protective device, its basic function is *(a)* to permit the installation or appliance it protects to be used up to its full rated capacity, and *(b)* to detect, and to protect equipment against dangerous conditions. Circuit-breakers are also able to provide a closer and more accurate degree of excess-current protection than that normally provided by either semi-enclosed or cartridge fuses. Circuit-breakers also perform duties as local circuit-control switches and as fault-making isolation switches. These latter types are switches capable of making and breaking rated current, and also of being closed against existing short-circuit fault.

The circuit-breaker has a mechanism which, when it is in the closed position, holds the contacts together. The contacts are separated when the release mechanism of the circuit-breaker is operated by hand or automatically by magnetic or thermal means.

The circuit-breaker with magnetic tripping (the term used to indicate the opening of the circuit-breaker contacts) employs a solenoid which is a coil with an iron slug. The normal circuit current which flows through the coil is not sufficiently strong to produce a significant magnetic flux. As soon as the circuit current increases to a predetermined level, the magnetic field strength increases to cause the iron slug to move within the solenoid and collapse the attached tripping linkage to open the contacts.

Thermal tripping uses a heat-sensitive bimetal element. When the element is heated to a predetermined temperature, the resultant deflection is arranged to trip the circuit-breaker. The time taken to heat the element to this temperature provides the necessary time-delay characteristic. The bimetal element may be arranged to carry the circuit current and so be directly self-heated. Indirect heating of the element may also be used. Because of the time lag associated with heating, tripping by this means is not so rapid as with magnetic tripping. In the circuit condition when a small sustained overload occurs, the thermal trip will come into operation after a few seconds or even minutes. However, when a heavier overload occurs, the magnetic trip coil operates quickly to disconnect the faulty circuit. Circuit-breakers are used instead of fuses in many installations because of a number of definite advantages. First, in the event of an overload or fault, all poles of the circuit are positively disconnected. The devices are also capable of remote control by push-buttons. The over-current setting of the circuit-breakers can be adjusted to suit the load conditions of the circuit to be controlled. Time-lag devices can also be introduced so that the time taken for tripping can be delayed because, in some instances, a fault can clear itself, and so is avoided the need for a circuit-breaker to disconnect not only the faulty circuit, but other healthy circuits which may be associated with it. The time-lag facility is also useful in motor circuits, to allow the circuit-breaker to stay closed while the motor takes the high initial starting current during the run-up to attain its normal speed. After they have tripped, circuit-breakers can be closed immediately without loss of time. Circuit-breaker contacts separate either in air or under insulating oil. The miniature circuit-breaker (MCB) has found an increasing application in domestic and small industrial installations. It is used as an alternative to the fuse and has certain advantages: it can be reset or reclosed easily while the fault is present in the circuit; it gives a close degree of excess-current protection (the tripping factor is 1.1); it will trip on a small sustained overcurrent, but not on a harmless transient overcurrent such as a switching surge (e.g. on fluorescent lamp circuits). For most applications, the MCB tends to give much better overall protection against both fire and shock risks than can be obtained with the use of normal HRC or rewirable fuses. MCBs are available in distribution units for final circuit protection.

The following are the advantages generally claimed for circuit breakers:

1. Non-destructive determination of tripping characteristics.

2. Shorter tripping times under moderate over-currents than with fuses.

3. Opening of all poles in every fault condition.

4. Single-phasing is prevented.

5. Re-closing can be effected at once after the fault has been cleared.

6. Switching ON and OFF without danger, even under fault conditions.

7. Factory-coordinated overload and short-circuit tripping characteristics.

8. Same tripping characteristics in all phases.

9. No stock of fuses required.

10. Immediate indication of faulty circuit.

11. Can be used as a circuit-control switch.

On the other hand, the fuse has a number of disadvantages, although cheapness is one of its merits:

1. It must be withdrawn by hand to isolate the circuit.

2. It must be replaced or repaired before the supply can be restored to the interrupted circuit.

3. If it is replaced while the fault is present in the circuit, serious personal danger could result.

4. It does not usually indicate the faulty circuit • (the HRC fuse usually does), and must be withdrawn for inspection.

5. It ages in service and can cause nuisance interruption of the circuit.

6. It is liable to a makeshift repair.

7. It varies in size according to rating.

In particular, it is stressed that the tripping time of a circuit-breaker should not be altered, otherwise the degree of protection offered by the device could present a danger to wiring.

The circuit-breaker is also used for earth-leakage protection.

> Both the Wiring Regulations and the 'Guidance Note', 'Protection against Overcurrent', lay justified stress on the need to understand the performance characteristics of the various types of overcurrent protective devices used to offer final circuits the correct protection they require.

6. PROTECTION AGAINST EARTH-LEAKAGE CURRENTS

Electric shock

IEE Regulation 130-04-01 (in Part 1) states: 'Where metal work of electrical equipment, other than current-carrying conductors, may become charged with electricity in such a manner as to cause danger: (i) the metalwork shall be connected with earth in such a manner as will cause discharge of electrical energy without danger, or (ii) other equally effective precautions shall be taken to prevent danger.' The basic reason for earthing is to prevent or minimise the risk of shock to human beings and livestock. The reason for having properly earthed metalwork in an installation is to provide a low-resistance discharge path for earth-leakage currents which would otherwise prove injurious or fatal to any person touching the metal-work associated with a faulty circuit. The prevention of electric shock in all installations is a matter which has been subjected to close attention in these past few years, particularly since the rapid increase in the use of electricity for an ever-widening range of applications.

An electric shock is dangerous only when the current through the body exceeds a certain minimum value. The degree of danger is dependent not only on the current but also on the time for which it flows. A low current for a long time can easily prove just as dangerous as a high current for a relatively brief period. The applied voltage is in itself only important in producing this minimum current through the resistance of the body. In human beings, the resistance between hand and hand, or between hand and foot, can easily be as low as 500 ohms. If the body is immersed in a conducting liquid (e.g. in a bath) the resistance may be as low as 200 ohms. In the case of a person with a body resistance of 500 ohms, with a 240V supply, the resulting current would be 480mA, or 1.2A in the more extreme case. However, much smaller currents are lethal. It has been estimated that about 3mA is sufficient for a shock to be felt by a tingling sensation. Between 10 and 15mA, a tightening of the muscles is experienced and there is difficulty in releasing any object gripped. Acute discomfort is felt at this current level. Between 25 and 30mA the dangerous level is reached, with the extension of muscular tightening, particularly to the thoracic muscles. Over 50mA results in fibrillation of the heart which is generally lethal if immediate specialist attention is not given. Fibrillation of the heart is due to irregular contraction of the heart muscles.The object of earthing, as understood by the IEE Regulations is, so far as is possible, to reduce the amount of current available for passage through the human body in the event of the occurrence of an earth-leakage current in an installation.

Earthing systems

Chapter 41 of the Regulations deals with the requirements which all earthing arrangements must satisfy if an electrical installation is to be deemed safe. The main basic requirements are:

1. The complete insulation of all parts of an electrical system. This involves the use of wiring systems and apparatus of 'all-insulated' construction, which means that the insulation which encloses the apparatus is durable and substantially continuous.

2. The use of appliances with double insulation conforming to the British Standard Specifications mentioned in Appendix 1 of the Regulations.

3. The earthing of all exposed metal parts (there are some exemptions).

4. The isolation of metalwork in such a manner that it is not liable to come into contact with any live parts or with earthed metalwork.

In addition, the IEE Regulations, as do the statutory regulations, recognise the use of extra-low voltages (less than 50V ac or 12V dc with respect to earth) as an effective measure to prevent dangerous voltages occurring on the exposed metal-work of electrical equipment. There are certain disadvantages with this method because to satisfy modern power requirements, impracticably high currents are involved. Applications of this method are restricted, for example, to control circuits, small portable tools and lighting circuits.
Wiring systems and equipment are either classed as all-insulated or double-insulated. All-insulated equipment is recognised by most of the regulations and

specifications as an alternative to earthing. The principles of design of all-insulated equipment are simple and they are difficult to abuse Double-insulation has yet to be completely recognised under the Factories Act.

The complete isolation of metallic parts associated either directly or indirectly with an installation is often difficult to achieve and is confined as a precautionary method to the following items:

1. Short isolated lengths of conduit or channelling used to protect cables, which have no metallic sheath, from mechanical damage or conduit used to protect high-voltage cables used in a discharge-lighting installation.

2. The metal clips used for fixing cables.

3. The metal caps of lamps.

4. The small metal parts which are isolated by insulating material. In this category are screws or metal nameplates.

5. Metal chains for the suspension of lighting fittings.

6. Metal lighting fittings which use filament lamps and are installed above a non-conducting floor and so mounted, or so screened in nonconducting material that they cannot readily be touched by a person standing on or within reach of earthed metal.

By far the greatest amount of work involved in the provision of protection against earth-leakage currents is the earthing of all relevant metalwork, either directly or indirectly associated with an installation and which, in a fault condition, may experience a rise in voltage above earth potential sufficient to cause a lethal amount of current to flow through a person touching the metalwork.

It should be understood that earthing cannot in itself prevent exposed metalwork from becoming electrically charged in the event of earth leakage or earth fault, but is intended to prevent the metal-work remaining 'live' at a dangerous voltage by allowing the earth-fault current to cut off the supply to the faulty circuit. If an earth fault occurs at some point in a circuit, the fault current will

flow through what is called the earth-loop. This path comprises, starting at the point of the fault, the circuit-protective conductor, the consumer's earthing terminal, the earth conductor, the earth electrode or other metallic return path (e.g. cable sheath/armouring), the continuous earth wire of an overhead conductor (or the neutral conductor in the case of the protective multiple earthing system) or, where no metallic return path is available, the general mass of earth, and the path through the earthed neutral point of the transformer and the transformer secondary winding, and the live conductor.

Neglecting any resistance at the point of the fault, the earth-fault current will be equal to the phase-to-neutral voltage of the supply divided by the impedance of the earth-fault loop path (in ohms). If the impedance of the loop were 10 ohms, then on a 250V supply, a current of 25A would flow, the maximum possible leakage current. This current would, of course, be carried indefinitely by a 30A final circuit fuse of, say, a ring-main. As a result of the fuse remaining inoperative, because of its rating in relation to the value of current flowing, any metalwork bonded to the consumer's earthing terminal would now be permanently connected to the live circuit, and it could be live at anything up to full mains voltage.

A direct short-circuit to earth,, resulting in many tens or hundreds of amperes, would blow a fuse. On the other hand, the fuse would not operate on a leakage through defective insulation of a current of, say, 100mA, which could be dangerous, if not fatal.It is thus seen that there are a number of aspects of earthing which require careful consideration before the earthing provision for an installation is deemed adequate. The factors to be considered are as follows:

The main earthing terminal. This is required to be provided by Regulation 542-01-01. This terminal, to be of a size and type suitable for the connection of a number of conductors to it, must be located adjacent to the consumer's supply terminals. The conductors which are connected to this terminal include:

1. All circuit-protective conductors of the installation's circuits.

2. The circuit-protective conductor from extraneous metalwork (structural steelwork, etc.).

3. The earthing conductor.

4. The neutral conductor of the supply if the protective multiple earthing system (TNCS or PME) is used.

5. The conductor used as a continuous earth wire (CEW) in rural overhead supply systems.

6. The bonding conductor from a cable sheath/ armouring.

Circuit protective conductors. The CPC is the conductor which connects all exposed conductive parts of an installation, and equipment, to the main earthing terminal. These parts include metallic wiring systems, metal-clad switchgear, motor frames, metallic sheathing and armouring of cables and metallic enclosures of electrical equipment. Metallic conduit, however, itself may be a CPC, as would the copper sheath of MI cables.

The CPC can appear in a number of forms and must be of copper if the csa is less than 10 mm^2. The actual csa is calculated from the formula: $S =](I^2t)/k$ where S is the csa in mm^2, / is the fault current, t is the operating time of the disconnecting device in seconds, and k is a constant which depends on the type of CPC (the values for k are contained in Regulation Tables 54B—54G).

Regulations Section 543 to 14 indicates the following types of protective conductor which are generally recognised. All these types of conductor are regarded as being normally dormant (that is, they do not carry current until an earth fault occurs).

1. Conductor contained in a sheathed cable, known as a composite cable. In this cable, the sheath is normally of PVC and the con ductors are the circuit conductors and the CPC (e.g. 2.5 mm^2 twin with CPC). The conductor is either single-strand or multi-stranded, depending on the size of the circuit conductors. And it is uninsulated. If the sheath is of metal, the conductor is always single-stranded. Inspection of different types of such cables will reveal that the cross-sectional area of CPCs in metal-sheathed cables is less than their counterparts in

insulated-sheathed cables; this is because the metal sheath and conductor are in parallel and together constitute a conducting path of very low resistance.

Where these CPCs are made off at, say, a switch position or ceiling rose, they should be insulated with a green-yellow sleeving.

I. Conductor in a flexible cable or flexible cord. The requirement is that the CPC should have a csa equal to that of the largest associated circuit conductor in the cable or cord. The colours of the CPC, which is insulated in this case, are green and yellow.

5. The separate CPC. The requirement in this case is that the CPC should have a csa not less than the appropriate value as shown in Table 54G of the Regulations. The minimum size is 2.5 mm^2, but in practice the size depends on the size of the associated circuit conductors. The reason for this is that if the circuit conductors are rated to carry / amperes, then the CPC should be able to carry a similar current in the event of an earth fault for sufficient time to allow a fuse to blow or to open a circuit-breaker. The resistance of a CPC of a material other than copper should not exceed that of the associated copper conductor. Additional requirements for the separate CPC are that it shall be insulated and coloured green and yellow.

4. Metal-sheath of MICS cable. Where the sheath of MICS cable is used as a CPC, the effective csa of the sheath should be not less than one-half of the largest current-carrying conductor, subject to a minimum of 2.5 mm^2. This requirement is not applicable to MICS cables used in earthed concentric wiring systems (TNC).

5. Conduits, ducting, trunking. Wiring systems which comprise metalwork, such as conduit, trunking and ducting, are used as the CPC of an installation. The requirement here is that the resistance of the CPC should be no more than twice that of the largest current-carrying conductor of the circuit. All joints must be mechanically sound and be electrically continuous. Where there is the possibility of corrosion, precautions should be taken, particularly at joints. In an agricultural installation, in those situations which are accessible to livestock, a metal pipe or conduit is not to be regarded or used as a sole CPC, though it may be used as a supplementary CPC.

6. The conducting paths as follows are not recognised as sufficient to be CPCs in their own right: gas pipes, water pipes, metallic flexible conduit, structural steelwork, and conduits or other pipes in an agricultural installation. A recognised CPC is necessary to complement the earthing requirements in these instances.

The earth conductor. The earthing lead is the final conductor by which the connection to the earth electrode, or other means of earthing, is made. It connects between the consumer's earthing terminal and the earth electrode. The minimum size of earthing conductor acceptable is 6 mm^2, and in any particular installation is related to the size of the largest associated circuit conductor. All earthing leads must be protected where necessary against mechanical damage and against corrosion. The latter requirement is particularly necessary at the point of connection to the earth electrode or other means of earthing. A label, with the words 'Safety Electrical Connection — Do Not Remove', must be permanently attached to the lead. The connection of an earthing lead to an earth electrode or other means of earthing must be readily accessible for inspection. Recommended methods of making this connection include soldered joint, or substantial clamps of non-ferrous metal, which are preferred if isolation of the electrode is needed.

Earth connection. The IEE Regulations recognise the following methods of earthing:

1. A metallic return path provided by the supply company. This can be the cable sheath/ armouring of an underground cable, or the CEW of a rural overhead distribution system.

2. An earth electrode in connection with the general mass of earth. Each earth electrode must be buried in the ground at a position as near as practicable to the consumer's earthing terminal. Neither gas nor water pipes, separately or jointly, should be used as the sole earth electrode of an installation. Electrodes come in a number of types. The pipe is generally a 150 mm diameter cast-iron pipe, about 2 m long and buried in a coke-filled pit. This type requires a certain amount of

excavation and is, of course, subject to corrosion. Copper pipe, if the diameter is sufficient, can also be used, in this instance driven into the ground.

The plate electrode is usually of cast-iron and buried vertically with the plate centre about 1 m below the surface. Copper plates may also be used. Plate electrodes provide a large surface area and are used where the ground is shallow •(where resistivity is low near the surface but •increases rapidly with depth). Again, excavation is required. Care is needed to protect the earth-electrode connection (to the earthing lead) from corrosion, if iron is used as the plate metal.

Copper strip is used where the soil is shallow and overlies rock. Strip should be buried to a depth of not less than 45 cm and should not be used where there is the possibility of digging (e.g. on farmland).

Rod electrodes are very economical and require no excavation for their installation. Because buried length is more important than diameter, the extensible, small-diameter copper rod has many advantages. It can, for instance, be driven into the ground so that the soil contact with the rod is close and definite. Extensible rods are of standard lengths and made from hard-drawn copper. They have a hardened steel tip and a steel driving-cap. Some rods have a steel core running through the centre for strength while they are being driven into rocky soil. Ribbed earth rods have wide vertical ribs to give a high degree of mechanical stiffness so that they are not easily bent or deflected when driven into the ground. The ribbed section also offers increased contact area with the soil.

Where the protective multiple earthing (PME) system is used, the earthing lead is connected to the consumer's earthing terminal and, together with the neutral conductor of the consumer's installation, is so arranged that connection to the neutral conductor on the incoming supply can be carried out by the supply company.

The PME system (TNCS)

The protective multiple earthing system is extremely reliable and is being used increasingly in this country. In the system, all exposed metal work of an installation is connected to the neutral conductor of the supply, by means of the installation's earth-continuity conductors. By doing this, all line-to-earth faults are converted to line-to-neutral faults, the intention being to ensure that sufficient current flows under fault conditions to operate devices (fuses or circuit-breakers) which protect the faulty circuit

There are two main hazards associated with PME. The first is that, owing to the increased earth-fault currents which are encouraged to flow, there is an enhanced fire risk during the time it takes for the protective device to operate. Also, with this method of earthing, it is essential to ensure that the neutral conductor cannot rise to a dangerous potential relative to earth. This is because the interconnection of neutral and protected metalwork would automatically extend the resultant shock risk to all protected metalwork on every installation connected to a particular supply distribution network.

As a result of these hazards, stringent requirements are laid down to cover the use of PME on any particular distribution system. Statutory or Government requirements indicate the full extent of provisions which must be satisfied if PME is to be used. Three points of interest might be mentioned here. First, the neutral conductor must be earthed at a number of points on the system, and the maximum resistance from neutral to earth must not exceed 10 ohms. In addition, an earth electrode at each consumer's installation is recommended. Second, so far as the consumer is concerned, there must be no fusible cutout, single-pole switch, removable link or automatic circuit-breaker in any neutral conductor in the installation. Third, the neutral conductor at any point must be made of the same material and be at least of equal cross-sectional area as the phase conductor at that point.PME can be applied to a consumer's installation only if the supply company's feeder is multiple earthed. This restricts PME to new distribution networks, though conversion from old systems can be made at a certain cost. The supply company has to obtain permission in accordance with the provisions laid down by the Minister of Energy and Secretary of State for Scotland. Post Office approval must also be obtained for every PME installation. British Telecom approval is required since it was once thought that the flow of currents from PME neutrals to the general mass of earth could cause interference with and/or corrosion of BT equipment. In practice, however, no such problems have occurred, though BT still retain their right to approve or otherwise a proposed PME installation.

Should a break occur in a neutral conductor of a PME system, the conductor will be live with respect to earth on both sides of the break, the actual voltage distribution depending on the relative values of the load and the earth electrode resistances of the two sections of the neutral distributor. All earthed metal work on every installation supplied from this particular distribution system would become live. High-resistance joints on the neutral can also have a similar effect, the degree of danger in all cases being governed by the values of the connected load and the various earth electrode resistances. Trouble on a neutral conductor may go undetected for some considerable time, some of the only symptoms being reduced voltages on appliances, lights, etc., and slight to severe shocks from earthed metalwork. Overhead-line distribution systems are, of course, particularly prone so far as broken or discontinuous neutral conductors are concerned.

The aspect of earthed concentric wiring is important in the context of PME. For PME systems, the conventional four-core (three phases and neutral) armoured cable can be replaced by a three-core metallic sheathed and armoured cable where the sheath and armour are used for the earthed neutral. For consumer wiring, the sheath-return concentric cable, in which the sheath acts as both the neutral and earth conductor, is a logical extension of the PME principle and is covered by IEE Section 546-02. The main advantage of heath-return wiring is that a separate CPC is not required. This is because the chances of a complete disconnection of the earth neutral conductor without breaking the included phase conductors are remote.

Sheath return usually means that mineral-insulated cable is used. While most of the MI cable is slightly higher than other types of cable (including any necessary conduit), this is offset considerably by the saving in labour resulting from ease of handling, the small diameter and the reduced amount of chasing work required. Sheath-return wiring can result in savings in installed cost of about 30 per cent compared with a conventional direct-earthed system using plastic-insulated cable in black-enamelled screwed conduit.

For single-phase supplies, single-core MI sheath-return cables are used. Twin-core cables are used for two-way switching. Multi-core cables are used from multi-switch points and rising mains to junction boxes where a number of separate outlets are situated close together. Since the outer sheath of the MI cable is used for both neutral and earth connections, care has to be taken at terminations which are made with pot-type seals and glands into switchgear and terminal boxes at which sockets, ceiling roses, etc. are fitted. Duplicate bonding is used to ensure that the contact remains good at all times. A special seal, with an earth-bonding lead, is used.

Automatic protection

Earth-leakage and earth-fault protection are methods of protection arranged to disconnect the supply automatically from an installation or circuit when the earth-leakage or earth-fault currents exceed predetermined values. Similarly, the protection is offered when the voltage between protected metalwork of the installation and earth rises above a predetermined value. Such a system may be made to operate more rapidly and at lower values of leakage or fault current than one depending on overcurrent protective devices such as fuses, thermal trips, etc. Automatic protection is therefore used where the impedance of the earth-fault loop limits the current flowing in it to a value less than three times the current rating of the fuse or one-and-a-half times the overcurrent setting of the circuit-breaker.

Earth-leakage or earth-fault protection is generally effected by means of a device known as an earth-leakage circuit-breaker (ELCB), now known as a residual current device (RCD). For many years, the fault-voltage earth-leakage circuit-breaker was a popular method of achieving protection against small earth-leakage currents, even though it was generally recognised that the RCD was a more sensitive device for protection. When the 15th edition of the Wiring Regulations appeared in 1981, the device was still recommended. But in 1985 it was replaced by the RCD, which is now the only protective device against small earth-leakage currents recommended to be used. The older type of device may still be found in installations which is why Figure 7.6 is given for information only should these ELCBs be encountered.

Residual current device. This device consists of a transformer having opposed windings which carry the incoming and outgoing current of the load. In a healthy circuit, where the values of current in the windings are equal, the magnetic effects cancel out in the transformer core. A fault causes an out-of-balance circuit condition and creates an effective magnetic flux in the core which links with the turns of a secondary winding and induces an emf in it. The secondary winding is permanently connected to the trip coil of the circuit-breaker. When the circulating current reaches a predetermined value, it is sufficient to pull out the release latch to open the main contacts which are normally held closed against strong pressure springs. In contrast to the fault-voltage ELCB, this type can be used to provide discriminative protection for individual circuits. In practice, the normal order of sensitivity ranges from about one ampere out-of-balance, for a 15A unit, up to about 3A out-of-balance for a 60A unit. These units are also known as 'low-sensitivity units' to distinguish them from the 'high-sensitivity units'. These latter units operate within 1/25 of a heart cycle and can detect a fault current of 30mA to earth, or less. The operating time is in the region of 30 milliseconds. Certain units available do not require an earth connection, relying for their operation on the actual fault current to earth through a person's body. The rapid time of operation, however, ensures that no electrical accident occurs.

One fault found with these high-sensitivity units is what is called nuisance tripping. This occurs because the units can detect very low currents of the order of 25—30mA, which are often found as normal leakage current from cooker boiling plates and immerser elements.

Section 412-06 of the Regulations deals with the use of RCDs as providing supplementary protection against direct contact. The recommended tripping or operating current is 30mA and the device must be able to trip within 40 milliseconds at 150mA. They are required to be installed when electrical equipment is to be used out of doors, that is,

outside the equipotential zone represented by the complete earthing arrangements inside a building. Socket-outlets for this purpose incorporate an RCD and are identified by a warning notice: 'For Equipment Outdoors'.

Additional requirements for protection

(a) Extraneous metalwork

The Wiring Regulations require that extraneous fixed metalwork should be bonded and earthed. This is particularly important where exposed metal-work of all apparatus, which is required by the regulations to be earthed, might come into contact with extraneous fixed metalwork. Two solutions are offered; the bonding of such metalwork, or its segregation. The latter course is often very difficult to achieve and appreciable voltage differences may arise between points of contact. The extraneous fixed metalwork includes baths and exposed metal pipes, radiators, sinks and tanks where there are no metal-to-metal joints of negligible resistance, structural steelwork, and the framework of mobile equipment on which electrical apparatus is mounted, such as cranes and lifts.

(b) Bathrooms

Additional precautions are required to be taken to prevent risk of shock in bathrooms, usually associated with dampness and condensed water vapour. A bathroom is regarded as any room containing a fixed bath or shower. First, all parts of a lamp holder likely to be touched by a person replacing a lamp shall be constructed of, or shrouded in, insulating material and, for BC lamp holders, should be fitted with a protective shield of insulating material. The regulations strongly recommend that lighting fittings should be of a totally-enclosed type. Switches or other means of control should be located so that they cannot be touched by a person using a fixed bath or shower. This means location of the circuit-control device either outside the room itself, or be ceiling-mounted with an insulating cord for its operation. No stationary appliances are allowed in the room, unless the heating elements cannot be touched. There should be no provision for socket-outlets, except to supply an electric shaver from a unit complying with BS 3052.

(c) Bell and similar circuits

Where a bell or similar circuit is energised from a public supply by means of a double-wound transformer, the secondary winding, the core of the transformer and the metal casing, if any, should be connected to earth.

(d) Lightning protection

In certain types of building, it is often the job of the electrical contractor to install an earthing system to protect against the effects of lightning discharges. Very high transient values of voltage and current may be expected when lightning surges are being led away to earth. Thus, it is essential that the overall impedance of the lightning earth path be as low as possible. A common method is the use of multiple electrodes. Rule

5 of the Phoenix Fire Office Rules states: 'Earth connections and number. The earth connection should be made either by means of a copper plate buried in damp earth, or by means of the tubular earth system, or by connection to the water mains (not now generally recommended). The number of connections should be in proportion to the ground area of the building, and there are few structures where less than two are necessary

Church spires, high towers, factory chimneys having two down conductors should have two earths which may be interconnected.'

(e) Portable appliances

To reduce the risk of electric shock when portable appliances are used, the appliance is often supplied with a reduced voltage. A double-wound transformer (Figure 7.7) reduces the mains voltage to a suitable level. The secondary winding has one point earthed so that should a fault to earth occur on the appliance, the shock received will be virtually harmless. Another method of protecting the user of a portable appliance from electric shock is to provide the appliance with automatic protection (Figure 7.7). In the event of an earth-fault, the supply is automatically disconnected from the appliance.

Earthing tests

These tests, as required by the IEE Regulations, are fully described in Chapter 8 of this book. Briefly, the tests are designed to ensure that the earthing arrangements for a particular installation are effective and will considerably reduce the risk resulting in the occurrence of dangerous shock conditions should an earth-leakage current (either through faulty insulation or from a direct live to earth) arise. The recommended tests include:

1. Continuity of ring final circuit conductors, particularly the circuit protective conductor.

2. Continuity of all protective conductors, including main and supplementary equipotential bonding.

3. Earth-electrode resistance.

4. Earth-fault loop impedance.

5. Operation of residual current devices and fault-voltage operated protective devices.

In addition, the visual inspection of the installation earthing arrangements should be carried out to ensure that everything is in order. Section 712 of the IEE Regulations lists the checks, which should be made. In the context of earthing, a check should be made to ensure that the methods of protecting users of the installation against direct contact (including measurement of distances where appropriate) are effective. These include: protection by insulation of live parts; by barriers or enclosures; by obstacles; by placing out of reach; and by non-conducting location.

7. ILLUMINATION CALCULATION

Here I will show the formulas that I wed and the calculation

Z = Number of lamps

$\varnothing_T$ = Total needed lumen

$\varnothing_L$ = The Lamps lumen

k = Section index (According to place dimensions)

a = Length

b = Width

h = Heigth of Lamp to the working place

E = Needed Ligth level (Will be selected from the table)

A=area of the section that will be illuminated .

d=The factor of becoming dirty of the place.

η=The factor of place illumination activity.

FOR THE RESTURANT İLLUMİNATİON

a=10m b=11m h=3m E=200 lux d=1.25

η ceiling=0,8 η wall=0.5 η ground=0.3

$$k = \frac{a \times b}{h \times (a+b)} = \frac{10 \times 11}{3.(10+11)} = 1.594$$

$$\downarrow_T = \frac{E \times A \times d}{\eta} = \frac{200 \times 110 \times 1.25}{0.51} = 53.921 \text{ lümen}$$

$$Z = \frac{\downarrow_T}{\downarrow_L} = \frac{53921}{1800} = 29956$$

$$E = \frac{\downarrow_L \times Z \eta}{d \times A} = \frac{1800 \times 29 \times 0.51}{1.25 \times 110} = 193.614 \text{ lüx}$$

Cost of Electric Installation of This Building

The list below shows the cost of the electrical installation of this building

S.No Type of the work	N.Units	Cost /Units (x1000 TL)	Total (x1000 TL)
3 x 70 + 35 mm^2 Cu PVC SWA	20 m	136.900	2.738.000
60 Amp (c/o-o/l) akım oto.	4 adet	180.500	902.500
(1x8) yollu dağıtım tablosu	3 adet	209.000	627.000
(1x4) yollu dağıtım tablosu	1 adet	152.000	152.000
(1x2) yollu dağıtım tablosu	1 adet	90.000	90.000
askı tipi lamba tesisatı	21 adet	30.200	634.200
tavan globu tesisatı	14 adet	36.100	505.400
duvar globu tesisatı	14 adet	36.100	505.400
gömme spot tesisatı	28 adet	70.300	1.968.400

1x40 floresant tesisatı	4 adet	55.500	222.000
2x40 floresant tesisatı	2 adet	75.700	151.400
4x20 w Petek diff.S.A floresant	3 adet	250.800	752.400
cooker kontrol tesisatı	3 adet	80.400	241.200
su motoru tesisatı	2 adet	110.600	221.200
semaver tesisatı	3 adet	90.200	270.600
1x13 amp priz tesisatı	42 adet	37.000	1.554.000
2x13 amp priz tesisatı	9 adet	44.100	396.900
mutfak aspiratörü tesisatı	2 adet	80.300	160.600
merdiven otom. Tesisatı	1 adet	100.500	100.500
telef.prizi tesisatı	13 adet	40.300	523.900
telef.bağl. kutusu	1 adet	139.100	139.100
tv anten prizi tesisatı	10 adet	49.400	494.000
(2x16+6) mm^2 CU PVC	50m	8.170	408.500
kolon hat.tesisatı			
(2x10+6) mm^2 CU PVC	25m	6.175	154.375
kolon hat.tesisatı			
Bina içi topraklama	8adet	27.750	222.000
Merkezi topraklama	1 adet	1.500.000	1.500.000
TOTAL			15.747.575 (TL)

CONCLUSION

We use electric everywhere so, the electric is very important in our life. In this project the restaurant and one floor two building installation was drawn.

The installation project had two parts. The first part was lighting. The purpose of lighting was to find the best lamps and number of the lamps for every floor. An either purpose was to show the aria light and beautiful.

The second part was making the electric scheme of the building. This project was made standards of KIB-TEK.

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