NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL INSTALLATION PROJECT DRAWING

Graduation Project
EE- 400

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ABSTRACT

The electrical installations are an application of the theories and rules in Electrical Engineering. In life nearly all equipments requires electrical energy for their operation. Therefore, in order to satisfy this requirements electrical installation should be well designed and applied with professionally knowledge. This emphasizes the importance of the electrical engineers.

This project is an important study of the electrical installations made in buildings, it is based on the I.E.E. regulations.

My project is about electrical installation of a hotel, and this project needs well knowledge about electrical installation and also researching the present systems.

The wiring and cabling are the important part in this project to continue the installation correctly. Illumination is also an important part to achieve the correct illumination for each purpose.

This project consists the installation of lighting circuits, the installation of sockets, emergency illumination, fan and motor for central heating system, fire alarm system, TV and telephone systems.

Power circuits and distribution panels and protection and safety and prevention of accidents were also discussed and studied in my project.

The main objective of this thesis is to study and give an outlook about the electrical installations and how it is worked and done under a specific regulation, in order to accomplish a desired objective.

INTRODUCTION

The electrical installations is an important subject to be studied due to that it gives the idea about applied side of electrical engineering and the ability to use the electrical and mathematical theories behind the electrical practical side.

This thesis is aimed to provide a convenient way to study the electrical installations done in a hotel.

The thesis consists of an introduction, ten chapters and conclusion.

The first chapter gives an idea about the historical background of the electrical industry and how it started.

The types and sizes of conductors used in the electrical installations a discussed, as well as, the types of insulators.

Chapter two talks about the illumination and the factors affecting illumination, as well as, giving examples of the types of lamps used in electrical installations, and their principle of operation and faults in the connecting circuits.

The photometer, the instrument used to measure the illumination is also discussed.

In chapter three insulators are described. Different characteristics of different insulators are discussed.

Chapter four is devoted to protection of electrical installations, the principle of operation of circuit breakers.

Chapter five is about transmission and generation of electricity. It describes how the electricity produced and supplied to consumers.

In chapter six, the importance of earthing is described with detail. The application of earthing and the installation of lighting prevention are discussed.

Chapter seven devoted to the cables used in electrical installations. The colors and sizes are given in that chapter.

Chapter eight is about final circuits, this chapter consist installation planning

Circuit ratings, choosing cable sizes and lighting circuits, its about how can you make installation planning and where which type cable will used.

In chapter nine installations which need special design are discussed. Alarm circuits and their main constituents and operation are also presented. The building services and the systems used.

CHAPTER 1: GENERAL

1.1 Historical Review of Wiring Installation

The history of the development of non-legal and statutory rules and regulations for the wiring of buildings is no less interesting than that of wiring systems and accessories. When electrical energy received a utilization impetus from the invention of the incandescent lamp, many set themselves up as electricians or electrical wiremen. Others were gas plumbers who indulged in the installation of electrics as a matter of normal course. This was all very well: the contracting industry had to get started in some way, however ragged. But with so many amateurs troubles were bound to multiply. And they did. It was not long before arc lamps, sparking commutators, and badly insulated conductors contributed to fires. It was the insurance companies, which gave their attention to the fire risk inherent in the electrical installations of the 1880s. Foremost among these was the Phoenix Assurance Co., whose engineer, Mr. Heaphy, was told to investigate the situation and draw up a report on his findings.

The result was the Phoenix Rules of 1882. These Rules were produced just a few months after those of the American Board of Fire Underwriters who are credited with the issue of the first wiring rules in the world.

The Phoenix Rules were, however, the better set and went through many editions before revision was thought necessary. That these Rules contributed to a better standard of wiring, and introduced a high factor of safety in the electrical wiring and equipment of buildings, was indicated by a report in 1892, which showed the high incidence of electrical fires in the USA and the comparative freedom from fires of electrical origin in Britain.

Three months after the issue of the Phoenix Rules for wiring in 1882, the Society of Telegraph Engineers and Electricians (now the Institution of Electrical Engineers) issued the first edition of Rules and Regulations for the Prevention of Fire Risks arising from Electric lighting. These rules were drawn up by a committee of eighteen men, which included some of the famous names of the day: Lord Kelvin, Siemens, and Crompton. The Rules, however, were subjected to some criticism. Compared with the Phoenix Rules they left much to be desired. But the Society was working on the basis of laying down a set of principles rather than, as Heaphy did, drawing up a guide or 'Code of Practice'. A second edition of the Society's Rules was issued in 1888. The third edition was issued in 1897 and entitled General Rules recommended for Wiring for the Supply of Electrical Energy.

The Rules have since been revised at fairly regular intervals as new developments and the results of experience can be written in for the considered attention of all those concerned with the electrical equipment of buildings. Basically the regulations were intended to act as a guide for electricians and others to provide a degree of safety in the use of electricity by inexperienced persons such as householders. The regulations were, and still are, not legal; that is, the law of the land cannot enforce them. Despite this apparent loophole, the regulations are accepted as a guide to the practice of installation work, which will ensure, at the very least, a minimum standard of work. The Institution of Electrical Engineers (IEE) was not alone in the insistence of good standards in electrical installation work. In 1905, the Electrical Trades Union, through the London District Committee, in a letter to the Phoenix Assurance Co., said they view with alarm the large extent to which bad work is now being carried out by electric light contractors .. As the carrying out of bad work is attended by fires and other risks, besides injuring the Trade, they respectfully ask you to. . Uphold a higher standard of work'.

The legislation embodied in the Factory and Workshop Acts of 1901 and 1907 had a considerable influence on wiring practice. In the latter Act it was recognized for the first time that the generation, distribution and use of electricity in industrial premises could be dangerous. To control electricity in factories and other premises a draft set of Regulations was later to be incorporated into statutory requirements.

While the IEE and the statutory regulations were making their positions stronger, the British Standards Institution brought out, and is still issuing, Codes of Practice to provide what are regarded as guides to good practice. The position of the Statutory Regulations in this country is that they form the primary requirements, which must by law be satisfied. The IEE Regulations and Codes of Practice indicate supplementary requirements. However, it is accepted that if an installation is carried out in accordance with the IEE Wiring Regulations, then it generally fulfils the requirements of the Electricity Supply Regulations. This means that a supply authority can insist upon all electrical work to be carried out to the standard of the IEE Regulations, but cannot insist on a standard which is in excess of the IEE requirements.

1.2 Historical Review of Installation Work

As one might expect to find in the early beginnings of any industry, the application, and the methods of application, of electricity for lighting, heating, and motive power was primitive in the extreme. Large-scale application of electrical energy was slow to develop. The first wide use of it was for lighting in houses, shops, and offices. By the 1870s, electric lighting had advanced from being a curiosity to something with a definite practical future. Arc lamps were the first form of lighting, particularly for the illumination of main streets. When the that it severely threatened the use of gas for this purpose. But it was not until cheap and reliable metal-filament lamps were produced that electric lighting found a place in every home in the land. Even then, because of the low power of these early filament lamps, shop windows continued for some time to be lighted externally by arc lamps suspended from the fronts of buildings.

The earliest application of electrical energy as an agent for motive power in industry is still electricity's greatest contribution to industrial expansion. The year 1900 has bean regarded as a time when industrialists awakened to the potential of the new form of power.

Electricity was first used in mining for pumping. In the iron and steel industry, by 1917, electric furnaces of both the arc and induction type were producing over 100,000 tons of ingot and castings. The first all-welded ship was constructed in 1920; and the other ship building processes were operated by electric motor power for punching, shearing, drilling machines and woodworking machinery.

The first electric motor drives in light industries were in the form of one motor-unit per line of shafting. Each motor was started once a day and continued to run throughout the whole working day in one direction at a constant speed. All the various machines driven from the shafting were started, stopped, reversed or changed in direction and speed by mechanical means. The development of integral electric drives, with provisions for starting, stopping and speed changes, led to the extensive use of the motor in small kilowatt ranges to drive an associated single machine, e.g. a lathe. One of the pioneers in the use of motors was the firm of Bruce Peebles, Edinburgh. The firm supplied, in the 1890s, a number of weatherproof, totally enclosed motors for quarries in Dumfries shire, believed to be among the first of their type in Britain. The first electric winder ever built in Britain was supplied in 1905 to a Lanark coal concern. Railway electrification started as long ago as 1883, but it was not until long after the turn of this century that any major development took place.

Electrical installations in the early days were quite primitive and often dangerous. It is on record that in 1881, the installation in Hatfield House was carried out by an aristocratic amateur. That the installation was dangerous did not perturb visitors to the house who'... when the naked wires on the gallery ceiling broke into flame... nonchalantly threw up cushions to put out the fire and then went on with their conversation'...

Many names of the early electric pioneers survive today. Julius Sax began to make electric bells in 1855, and later supplied the telephone with which Queen Victoria spoke between Osborne, in the Isle of Wight, and Southampton in 1878. He founded one of the earliest purely electric manufacturing firms, which exists today and still makes bells and signaling equipment.

The General Electric Company had its origins in the 1880s, as a Company, which was able to supply every single item, which went to form a complete electrical installation. In addition it was guarantied that all the components offered for sale were technically suited to each other, were of adequate quality and were offered at an economic price.

Specializing in lighting, Falk Statesman & Co. Ltd began by marketing improved designs of oil lamps, then gas fittings, and ultimately electric lighting fittings.

Cable makers W. T. Glover & Co. were pioneers in the wire field. Glover was originally a designer of textile machinery, but by 1868 he was also making braided steel wires for the then fashionable crinolines. From this type of wire it was a natural step to the production of insulated conductors for electrical purposes. At the Crystal Palace Exhibition in 1885 he showed a great range of cables; he was also responsible for the wiring of the exhibition.

The well-known J. & P. firm (Johnson & Phillips) began with making telegraphic equipment, extended to generators and arc lamps, and then to power supply.

The coverings for the insulation of wires in the early days included textiles and gutta-percha. Progress in insulation provisions for cables was made when vulcanized rubber was introduced, and it is still used today.

Siemens Brothers made the first application of a lead sheath to rubber-insulated cables. The manner in which we name cables was also a product of Siemens, whose early system was to give a cable a certain length related to a standard resistance of 0.1 ohm. Thus a No.90 cable in their catalogue was a cable of which 90 yards had a resistance of 0.1 ohm. The Standard Wire Gauge also generally knew Cable sizes.

For many years ordinary VRI cables made up about 95 per cent of all installations. They were used first in wood casing, and then in conduit. Wood casing was a very early invention. It was introduced to separate conductors, this separation being considered a necessary safeguard against the two wires touching and so causing fire. Choosing a cable at the turn of the century was quite a task. From one catalogue alone, one could choose from fifty-eight sizes of wire, with no less than fourteen different grades of rubber insulation. The grades were described by such terms as light, high, medium, or best insulation. Nowadays there are two grades of insulation: up to 600 V and 600 V/1,000 V. And the sizes of cables have been reduced to a more practicable seventeen.

During the 1890s the practice of using paper as an insulating material for cables was well established. One of the earliest makers was the company, which later became a member of the present-day BICC Group. The idea of using paper as an insulation material came from

America to Britain where it formed part of the first wiring system for domestic premises. This was twin lead-sheathed cable. Bases for switches and other accessories associated with the system were of cast solder, to which the cable sheathing was wiped, and then all joints sealed with a compound. The compound was necessary because the paper insulation when dry tends to absorb moisture.

In 1911, the famous 'Henley Wiring System' came on the market. It comprised flat-twin cables with a lead-alloy sheath. Special junction boxes, if properly fixed, automatically affected good electrical continuity. The insulation was rubber. It became very popular. Indeed, it proved so easy to install that a lot of unqualified people appeared on the contracting scene as 'electricians'. When it received the approval of the IEE Rules, it became an established wiring system and is still in use today.

The main competitor to rubber as an insulating material appeared in the late 1930s. This material was PVC (polyvinyl chloride), a synthetic material that came from Germany. The material, though inferior to rubber so far as elastic properties were concerned, could withstand the effects of both oil and sunlight. During the Second World War PVC, used both as wire insulation and the protective sheath, became well established.

As experience increased with the use of TRS cables, it was made the basis of modified wiring systems. The first of these was the Calendar farm-wiring system introduced in 1937. This was tough rubber sheathed cable with a semi-embedded braiding treated with a green-colored compound. This system combined the properties of ordinary TRS and HSOS (house-service overhead system) cables.

So far as conductor material was concerned, copper was the most widely used. But aluminum was also applied as a conductor material. Aluminum, which has excellent electrical properties, has been produced on a large commercial scale since about 1890. Overhead lines of aluminum were first installed in 1898. Rubber-insulated aluminum cables of 3/0.036 inch and 3/0.045 inch were made to the order of the British Aluminum Company and used in the early years of this century for the wiring of the staff quarters at Kinlochleven in Argyllshire. Despite the fact that lead and lead-alloy proved to be of great value in the sheathing of cables, aluminum was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminum-sheathed cable could be put on the market.

Perhaps one of the most interesting systems of wiring to come into existence was the MICS (mineral-insulated copper-sheathed cable), which used compressed magnesium oxide as the insulation, and had a copper sheath and copper conductors. The cable was first developed in 1897 and was first produced in France. It has been made in Britain since 1937, first by

Pyrotenax Ltd, and later by other firms. Mineral insulation has also been used with conductors and sheathing of aluminum.

One of the first suggestions for steel used for conduit was made in 1883. It was then called 'small iron tubes'. However, the first conduits were of itemized paper. Steel for conduits did not appear on the wiring scene until about 1895. The revolution in conduit wiring dates from 1897, and is associated with the name 'Simplex' which is common enough today. It is said that the inventor, L. M. Waterhouse, got the idea of close-joint conduit by spending a sleepless night in a hotel bedroom staring at the bottom rail of his iron bedstead. In 1898 he began the production of light gauge close-joint conduits. A year later the screwed-conduit system was introduced.

Non-ferrous conduits were also a feature of the wiring scene. Heavy-gauge copper tubes were used for the wiring of the Rayland's Library in Manchester in 1886. Aluminum conduit, though suggested during the 1920s, did not appear on the market until steel became a valuable material for munitions during the Second World War.

Insulated conduits also were used for many applications in installation work, and are still used to meet some particular installation conditions. The 'Gilflex' system, for instance, makes use of a PVC tube, which can be bent cold, compared with earlier material, which required the use of heat for bending.

Accessories for use with wiring systems were the subjects of many experiments; many interesting designs came onto the market for the electrician to use in his work. When lighting became popular, there arose a need for the individual control of each lamp from its own control point. The 'branch switch' was used for this purpose. The term 'switch' came over to this country from America, from railway terms which indicated a railway 'point', where a train could be 'switched' from one set of tracks to another. The 'switch', so far as the electric circuit was concerned, thus came to mean a device, which could switch an electric current from one circuit to another.

It was Thomas Edison who, in addition to pioneering the incandescent lamp, gave much thought to the provision of branch switches in circuit wiring. The term 'branch' meant a tee off from a main cable to feed small current-using items. The earliest switches were of the 'turn' type, in which the contacts were wiped together in a rotary motion to make the circuit. The first switches were really crude efforts: made of wood and with no positive ON or OFF position. Indeed, it was usual practice to make an inefficient contact to produce an arc to 'dim' the lights! Needless to say, this misuse of the early switches, in conjunction with their wooden construction, led to many fires. But new materials were brought forward for switch construction such as slate, marble, and, later, porcelain. Movements were also made more positive with definite ON and OFF positions. The 'turn' switch eventually gave way to the 'Tumbler' switch in popularity. It came into regular use about 1890. Where the name 'tumbler' originated is not clear; there are many sources, including the similarity of the switch action to the antics of Tumbler Pigeons. Many accessory names, which are household words to the electricians of today, appeared at the turn of the century: Verity's, McGeoch, Tucker, and Crabtree. Further developments to produce the semi-recessed, the flush, the ac only, and the 'silent' switch proceeded apace. The switches of today are indeed of long and worthy pedigrees.

It was one thing to produce a lamp operated from electricity. It was quite another thing to devise a way in which the lamp could be held securely while current was flowing in its circuit. The first lamps were fitted with wire tails for joining to terminal screws. It was Thomas Edison who introduced, in 1880, the screw cap, which still bears his name. It is said he got the idea from the stoppers fitted to kerosene cans of the time. Like many another really good idea, it superseded all its competitive lamp holders and its use extended through America and Europe. In Britain, however, it was not popular. The Edison & Swan Co. about 1886 introduced the bayonet-cap type of lamp-holder. The early type was soon improved to the lamp holders we know today.

Ceiling roses, too, have an interesting history; some of the first types incorporated fuses. The first rose for direct attachment to conduit came out in the early 1900s, introduced by Dorman & Smith Ltd.

Lord Kelvin, a pioneer of electric wiring systems and wiring accessories brought out the first patent for a plug-and-socket. The accessory was used mainly for lamp loads at first, and so carried very small currents. However, domestic appliances were beginning to appear on the market, which meant that sockets had to carry heavier currents. Two popular items were irons and curling-tong heaters. Crompton designed shuttered sockets in 1893. The modern shuttered type of socket appeared as a prototype in 1905, introduced by 'Diamond H'. Many sockets were individually fused, a practice, which was later meet the extended to the provision of a fuse in the plug.

These fuses were, however, only a small piece of wire between two terminals and caused such a lot of trouble that in 1911 the Institution of Electrical Engineers banned their use. One firm, which came into existence with the socket-and-plug, was M.K. Electric Ltd. The initials were for 'Multi-Contact' and associated with a type of socket outlet, which eventually became the standard design for this accessory. It was Scholes, under the name of 'Wylex', who introduced a revolutionary design of plug-and-socket: a hollow circular earth pin and rectangular current-carrying pins. This was really the first attempt to 'polarize', or to differentiate between live, earth and neutral pins.

One of the earliest accessories to have a cartridge fuse incorporated in it was the plug produced by Dorman & Smith Ltd. The fuse actually formed one of the pins, and could be screwed in or out when replacement was necessary. It is a rather long cry from those pioneering days to the present system of standard socket-outlets and plugs.

Early fuses consisted of lead wires; lead being used because of its low melting point. Generally, devices which contained fuses were called 'cutouts', a term still used today for the item in the sequence of supply-control equipment entering a building. Once the idea caught on of providing protection for a circuit in the form of fuses, brains went to work to design fuses and fuse gear. Control gear first appeared encased in wood. But ironclad versions made their due appearance, particularly for industrial use during the nineties. They were usually called 'motor switches', and had their blades and contacts mounted on a slate panel. Among the first companies in the switchgear field were Bill & Co., Sanders & Co., and the MEM Co., whose 'Kantark' fuses are so well known today. In 1928 this Company introduced the 'splitter', which affected a useful economy in many of the smaller installations.

It was not until the 1930s that the distribution of electricity in buildings by means of bus bars came into fashion, though the system had been used as far back as about 1880, particularly for street mains. In 1935 the English Electric Co. introduced a bus bar trunking system designed to meet the needs of the motorcar industry. It provided the overhead distribution of electricity from which system individual machines could be tapped wherever required; this idea caught on and designs were produced and put onto the market by Marryat & Place, GEC, and Ottermill.

The story of electric wiring, its systems, and accessories tells an important aspect in the history of industrial development and in the history of social progress. The inventiveness of the old electrical personalities, Compton, Swan, Edison, Kelvin and many others, is well worth noting; for it is from their brain-children that the present-day electrical contracting industry has evolved to become one of the most important sections of activity in electrical engineering. For those who are interested in details of the evolution and development of electric wiring systems and accessories, good reading can be found in the book by J. Mellanby: The History of Electric Wiring (MacDonald, London).

CHAPTER 2: ILLUMINATION

2.1 Inverse Square Law

The distinction between terms used in illumination often presents difficulties.

The illumination falling on a working plane varies inversely as the square of the distance of' that surface from the light source. For example, when the distance from source A in Figure 2.1 is doubled (moving from D to 2D) the illumination falling on the working plane is quartered.

Note that it is assumed that the working plane is at right angle to the light source.

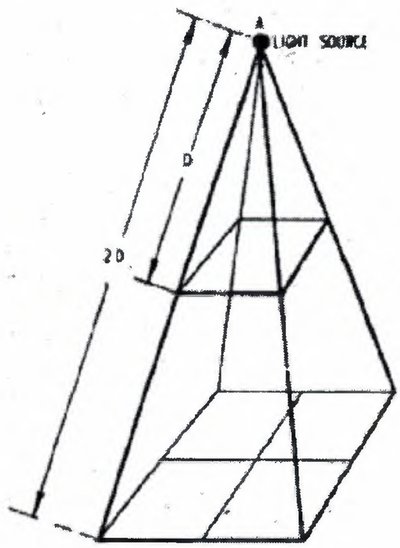

Figure 2.1 Inverse square laws.

The illumination (in lumens per square meter) at a point below a light source on a horizontal work plane (Figure 2.2) is calculated as follows:

Where E = illumination in lumens per square meter, I = luminous intensity in candelas, and d = distance from light source in meters.

For example if we want to calculate the illumination on a working plane at a point A, as

Illumination

In figure 2.2, 2 m vertically below a lamp emitting 720 cd. The surface is at right angles to the light Source.

Since

$$E = \frac{I}{d^2} \qquad (2.1)$$

$$E = \frac{720}{2^2}$$

$$E = 180 \text{ lm/m}^2$$

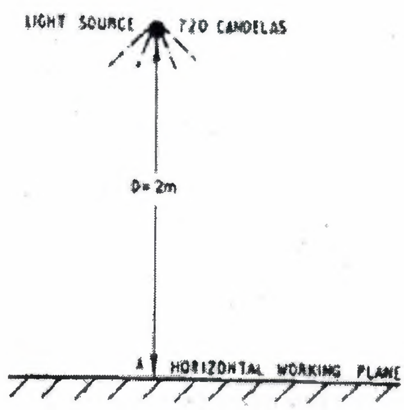

Figure 2.2 Calculating illuminations.

Cosine Law

The illumination at a point on a horizontal working plane which is at an angle to the light source (Figure 2.3) is calculated as follows:

$$E = \frac{I}{d^2}\cos\theta \qquad (2.2)$$

where cos θ = cosine of angle between vertical line AC and diagonal line BC in Fig. 2.3.

Illumination

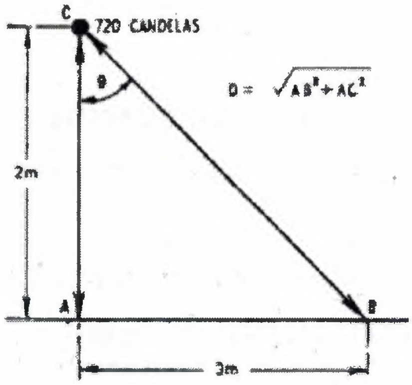

Figure 2.3 Calculating illumination.

2.3 Other Factors in Illumination

2.3.1 Maintenance Factor

This factor (a number without units) takes into consideration losses in light output due to (a) ageing of lamps and (b) dirt collecting on lamps and fittings.

The maintenance factor recommended by the Illuminating Engineering Society is 0.8, for fittings cleaned every six weeks.

2.3.2 Coefficient of Utilization

The level of illumination in a factory or office is affected by:

(a) Light output of lamp (lumens).

(b) The type of reflector used.

(c) Height and spacing of fittings.

(d) The coloring of the walls, ceiling, and floor.

These factors are taken into consideration in the coefficient of utilization (a number without units).

$$\text{Coefficient of utilization} = \frac{\text{light received on working plane}}{\text{light output of lamps}} \qquad (2.3)$$

Illumination

The calculation of total lumens required in an installation

$$\text{Luminous flux (lumens)} = \frac{\text{illumination required } (lm/m^2) \times \text{ area } (m^2)}{\text{maintenance factor} \times \text{coefficient of utilization}} \qquad (2.4)$$

For example: A yard 25w long by 6 m wide is to be illuminated to a level of 20 1m/m^2. Assuming the average lumen output of the lamps is 35 lm/W. the maintenance factor 0.8, and the coefficient of utilization 0.5, calculate the total lamp power required.

Using equation 2.4

$$\Phi\ (lm) = \frac{20 \times (25 \times 6)}{0.8 \times 0.5} = 7500 lm$$

Since each watt used supplies 35 lm:

$$\text{Total Watts required} = \frac{7500\ lm}{35\ lm/W} = 214.3\ W$$

Note. If 80 W fluorescent lamps are used, number required = 214.3/80 = 3 lamps.

2.4 Types of Lamps Used

There many types of lamps used for illumination purposes.

2.4.1 Incandescent Lamps

The principle of operation (Figure 2.4), the Light energy is produced by passing a current through a conductor (usually tungsten) enclosed in an evacuated glass bulb. The operating temperature is over 2000 °C.

Illumination

The efficiency of the lamp is further increased by the following methods:

1. Filling the bulb with an inert gas, usually argon. The gas increased operating temperature (about 2500 °C) giving increased light, as it minimizes the losses from the filament due to evaporation. The life of the lamp is also increased (minimum 1000 hours).

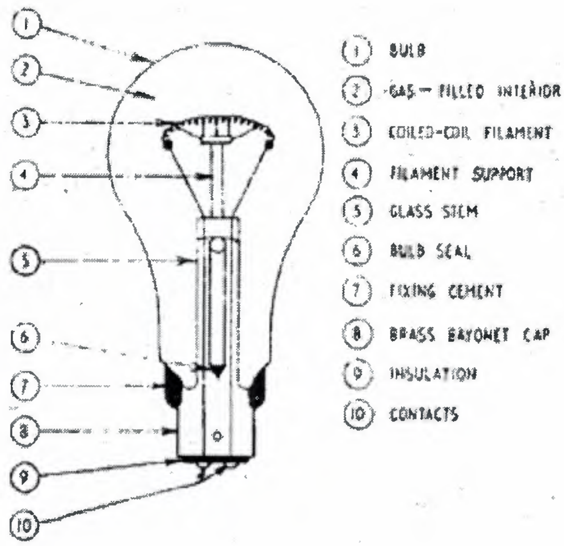

Figure 2.4 Incandescent lamp.

2. Double-coiling the filament (the coiled-coil lamp). This reduces the heat losses due to convection currents in the gas. The filament is operated at the same temperature.

The efficiency of the lamp is approximately 12 lm/W.

The efficiency of a lamp is dependent on:

a) The rating of the lamp (efficiency increases with lamp size).

b) The age of the lamp.

c) The operating voltage Efficiency is decreased when run at values less than rated voltage.

2.4.2 Discharge Lamp

The discharge lamp is shown in figure 2.5. The principle of operation of this lamp is when an electrical pressure is applied across a glass tube containing a certain gas (e.g. neon) an electrical discharge takes place and energy in the form of light is given off. The gas under these conditions is said to be ionized. The electrical connections inside the tube are called electrodes.

Ionization is caused by the movement of electrons in the gas. These electrons 'bombard' the atoms of gas and free other electrons. Light is given off during this Bombardment.

The flow of current through the tube increases with ionization as a' chain reaction' takes place:

1. Increased ionization.
2. Decreased resistance of the discharge path.
3. Increased current.
4. The cycle is repeated.

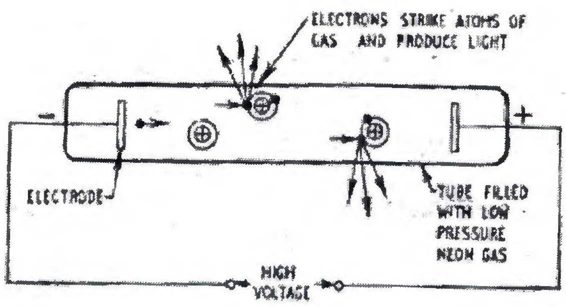

Figure 2.5. Discharge lamp: principle of operation.

This process of ionization is started off by:

(a) A high voltage being applied across the tube; or (b) the use of heated filaments in the lamp.

The filaments are heated at the moment of starting and are coated with a special oxide, which emits electrons. This type of lamp is termed a hot cathode lamp. A current-limiting device (e.g. a choke) must be fitted in the lamp circuit or the tube will disintegrate.

2.4.3 Low-Pressure Mercury Vapour Lamp

The L.P.M.V. (or fluorescent) lamp is the most common type of discharge lamp.

Illumination

The lamp circuit consists of the following (Figure 2.6):

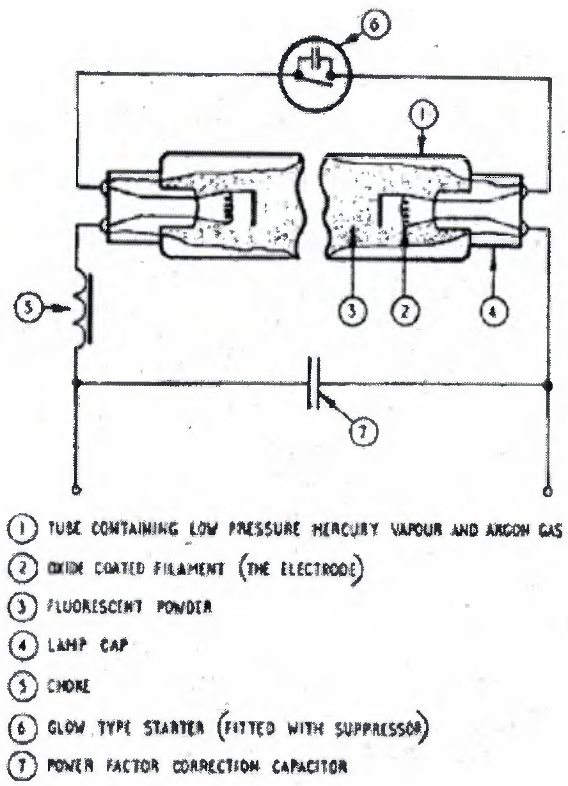

Figure 2.6 Low-pressure mercury vapour (fluorescent) lamp.

1. A glass tube containing low-pressure mercury vapour and argon gas. The argon gas is used to assist in starting.
2. Two oxide-coated filaments (the electrodes). The filaments are heated on starting to assist in ionization (this lamp is called a hot cathode lamp). Two small plates are fitted to the filaments to increase the effective cross-sectional area of the electrode.

3. The fluorescent coat. The tube is coated internally with a fluorescent powder as a large part of the light given off by the low-pressure mercury vapour (ultra-violet rays) is not visible to the human eye. The powder converts these invisible rays into visible light rays, with an efficiency of 35-45 lm/W over a life of 3000 hours.

4. Lamp caps. The connecting caps on the lamps are either bayonet caps or bi-pin.

Ancillary Equipment. This comprises (1) the choke and (2) the starter.

The choke has two functions:

(a) It supplies a high initial voltage on starting, caused by the breaking of an inductive circuit.

(b) It limits the current in the lamp when the lamp is running.

There are two types of starters, the glow starter and the thermal starter. The glow starter is the most common type, and consists of two contacts sealed inside a helium-filled glass tube. When the lamp is switched on, a discharge takes place between the starter contacts, one of which is a bimetallic strip. This discharge heats the bi-metallic strip and causes the contacts to come together. A current now flows through the lamp filaments, heating them and starting the process of ionization in the lamp. The starter contacts open as the temperature decreases in the starter and a high starting voltage is applied across the lamp. The voltage across the tube under running conditions is insufficient to operate the starter and the starter contacts remain open.

The thermal starter has two distinct sections (i) the filament and (ii) a bimetallic contact. The contacts are closed when the lamp is started but the heat of the filament opens them after several seconds and they remain open during the operation of the lamp.

The capacitor (usually about 8 μF) is fitted to correct the power-factor by neutralizing the inductive effect of the choke.

Principle of Operation. When a voltage is supplied across the circuit the following occurs.

1. The filaments glow and emit electrons, which assist in ionizing the gas.
2. The starter switch opens and breaks the inductive circuit of the choke, thus applying a high starting voltage across the lamp.
3. The main discharge commences in the mercury vapour and the starter contacts remain open. The argon gas in the lamp assists in establishing this initial discharge.
4. The choke limits the current flowing when the lamp is operating.

This lamp is termed a hot cathode lamp as heated filaments are used to start the discharge.

Faults in Circuits. The flickering Lamp, check

(a) Ends of lamp. If blackened at filaments renew lamp.

(b) Starter. It is advisable to carry a spare starter to plug in before replacing tube.

(c) Supply voltage. Check that supply voltage is sufficient as voltage is critical.

(d) Draughts. A low ambient (surrounding) temperature may cause flickering, particularly in a draughty corridor.

Slow Flashing of Lamp. This generally occurs when the lamp requires it renewal.

No Flicker but Filament Glows. Check (a) starter for welded contacts or (b) radio suppressor capacitor (fitted across starter contacts) for short circuit.

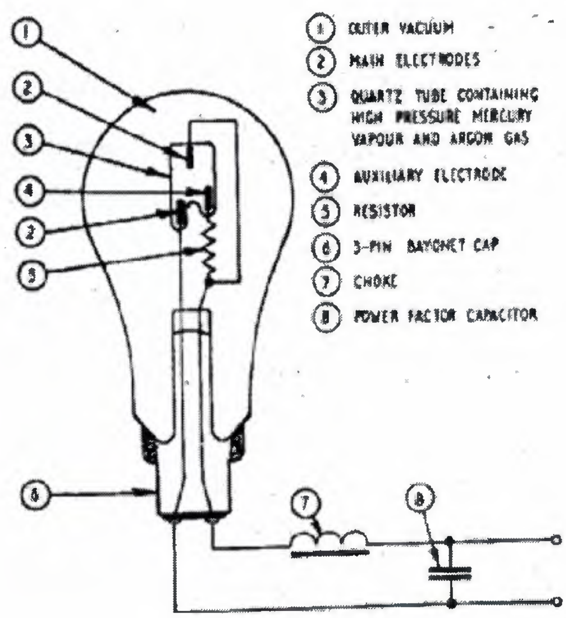

Figure 2.7 High-pressure mercury vapour lamp.

High-Pressure Mercury Vapour Lamp

The H.P.M.V. lamp (Figure 2.7) consists of two tubes:

1. The inner tube, containing (i) high-pressure mercury vapour and argon gas (used to help starting); (ii) two main electrodes in the form of a spiral; and (iii) an auxiliary

electrode connected through a 50,0000 resistor to one side of the supply.

The inner tube is made of boro-silicate glass or quartz to withstand the high operating temperature (600 °C).

...ation

2. The outer tube. This is simply an evacuated case used to minimize heat losses. It also acts as a shield against harmful ultra-violet rays.

Ancillary Equipment. The choke is used to limit the current in the circuit.

Principle of Operation. This is as follows:

1. The initial discharge takes place between one electrode and the auxiliary electrode and then between the two main electrodes. This initial discharge takes place in the argon gas.
2. As the mercury vapour becomes ionized the column of gas shorts the auxiliary electrode and the main discharge takes place.

The H.P.M.V. lamp is a cold cathode lamp. It attains full brilliance after about five minutes. The color is greenish-blue.

The low-wattage (80-125 W) H.P.M.V. lamp looks similar to a pearl incandescent lamp but has a 3-pin B.C. lamp holder to prevent wrong connections.

The applications of the H.P.M.V. lamp is generally used for factory lighting and street lighting as it has a very high luminous efficiency (about 40 lm/W).

2.4.5 Sodium Discharge Lamp

The sodium discharge lamp is made up of the following:

1. A U-shaped 2-ply glass tube (the inner ply consisting of a heat-resisting low-silica glass) containing globules of solid sodium and low-pressure neon gas. Oxide-coated electrodes are fitted at both ends of the tube.
2. An outer vacuum jacket, used to minimize heat losses as the lamp runs at a low temperature (300 °C). Both tubes are supported by a porcelain base, which has a two-contact bayonet cap.

The ancillary Equipment. This is as follows:

1. High-reactance transformer. This transformer is used to give a high voltage (480V) on

starting and acts as a choke, limiting the current, when the lamp is running.

2. Capacitor. The power factor of the circuit is low due to the transformer. The capacitor is used to correct it from 0.3 to 0.9.

The principle of operation is given below:

(a) When a voltage of 240 V is applied across the circuit the transformer supplies 480 V across the lamp electrodes.

(b) This high voltage causes the neon gas to glow red.

(c) The heat from the neon gas vaporizes the metallic sodium and assists in ionizing the sodium vapour.

(d) The increasing current in the circuit, due to the ionization of the Sodium vapour, causes a voltage drop in the transformer.

(e) The lamp runs at normal voltage and the current through the lamp is limited by the choking action of the transformer.

The uses of the sodium discharge lamp are limited by its yellow color but it is used for road lighting as it is highly efficient (70 lm/W).

Note that the U-shaped lamp tube should be handled with care, owing to the danger of fire if the sodium comes into contact with moisture.

2.4.4 Neon Discharge Lamp

The neon lamp (Figure 2.8) is made up of a tube (generally

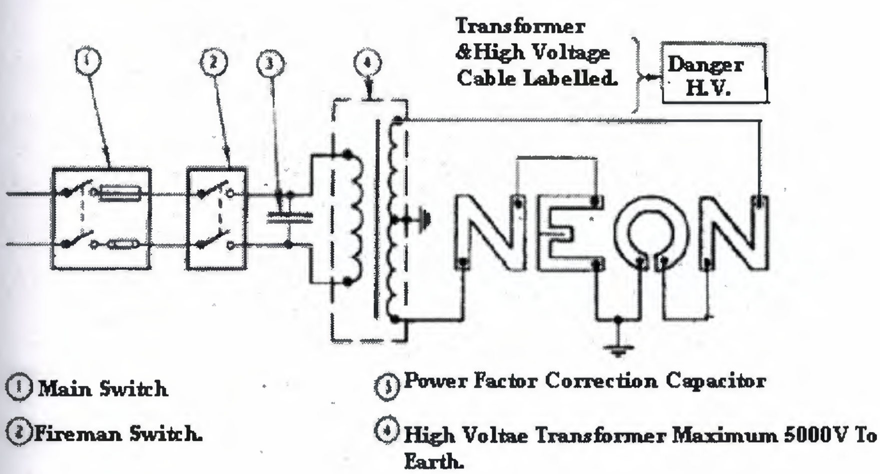

Figure 2.8 Neon discharge lamp.

General Points on Discharge Lamps.

1. All cables must be capable of carrying the circuit current and, in the last of high-

voltage lamps, should be of the correct voltage rating. Cables in high-voltage circuit should be labeled and marked DANGER.

2. Chokes and ancillary equipment should be placed as near as possible to the lamp.

3. Switches must be capable of breaking an inductive load (e.g., a circuit containing a choke or transformer).

4. All live parts must be effectively screened (earthed metal or a strong insulating material) and, in the case of high-voltage installations, must be labeled: **DANGER HIGH VOLTAGE.**

No discharge lamp circuit should use an open-circuit voltage exceeding 5000 V to earth.

2.5 The Photometer

The photometer is used to measure illumination (in lumens per square meter) falling on a surface.

The photometer cell (figure 2.9) consists of three layers of metal:

1. A transparent film of gold.
2. A selenium film.
3. A steel plate.

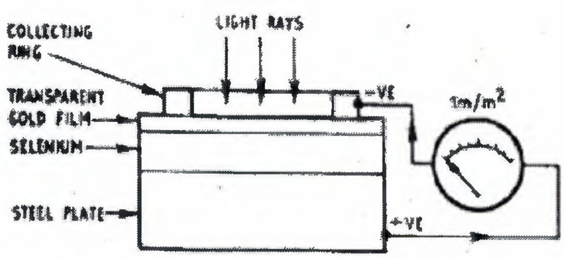

Figure 2.9 Photometer cell.

A connecting ring makes contact with the transparent film; the other connection is taken from the steel plate. Both connections are taken to a very sensitive moving-coil instrument which has a scale sub-divided into lumens per square meter.

Principle of Operation. When light rays strike the surface between the transparent film and the selenium film, electrons are freed and a current flows through the moving-coil instrument.

Stroboscopic Effect. This is the effect, which the flickering of a discharge lamp has on moving machinery. The flickering takes place every 1/100 second on the zero part of the supply cycle. The stroboscopic effect can give the illusion that the moving machinery is stationary.

This may be overcome by (a) using a special retention powder in the lamp, which retains the light over the zero pan of the cycle or (b) by splitting the lamps between different phases.

ILLUMINATION CALCULATION

Illumination calculation is performed in order to find the number of armatures necessary for rooms.

The dimensions of living room kitchen and bedroom have measured separately. [Length(a) width(b) height (h)]

Illumination calculation is done one by one for each part.

THE CALCULATION OF INTERNAL ILLUMINATION

The formulates symbols:

Φ_{dir} = the flow of the direct light

Φ_s = the flow coming to working table.

Φ_{end} = the light flow coming by reflexion

E_s = the avarage level of light of working table

S = m^2 of working table

Φ_t = the sum of light flow (lumen)

The calculation of illumination by the light flow method. The calculation of internal illumination by efficiency method. This method is mostly used in internal illumination installations. As it is known the Φ light that cames to plane has the components Φdır and Φend. (Φ_{dir} shows the flow of the direct light, Φ_s shows the flow coming to working table, Φ_{end} shows the light flow coming by reflexion)

$$\phi_s = \phi_{dir} + \phi_{end}$$

Φ_{dir} can be calculated easily but **Φ_{end}** is difficult to calculate. So that efficiency method is used in internal illumination installations. Now in order to understand this method let's think [illegible] an ideal room that it's walls and ceiling reflects the light totally, (δ=%100) and absorbs the light completely.(α = %100) and no object absorbing the light in it. The **Φ₀** comes out of the light sources falls on the plane S and it is absorbed their whatever the dimensions of the room, number of the lambs, settlement of the lambs, illumination system. The average illumination degree of the plane for an ideal room is

$$E_0 = \frac{\phi_S}{S}$$

E_0 shows the avarage level of light of working table, Φo represents the total light flow from sources in lumen and S represents the area of the plane in m². In reality some of the light flow is absorbed by walls, ceiling, and illumination devices. So that the average illumination degree of the plane is:

$$E_0 = \frac{\phi_0 \eta}{S} = \frac{\phi_S}{S}$$

η factor is called the efficiency of illumination and it is a number less then 1.

$\eta = \frac{\Phi_a}{\Phi_s}$ **Φ_a** represents flow of light to plane and

Φ_s represents total flow of light that is given by light sources.

Efficiency of device illumination (**η**) is multiplication of the efficiency of devices and efficiency of the room.

$\eta_{ayg} = \frac{\Phi_{ayg}}{\Phi_s}$ **η ayg** represents the efficiency of device

$\eta_{oda} = \frac{\Phi_a}{\Phi_{ayg}}$ **η oda** represents the efficiency of room

$$\eta = \eta_{ayg} - \eta_{oda}$$

Efficiency of device is related with the illumination device. Efficiency of the room is related with geometric dimensions of room, reflection factors and colours of walls and ceiling, light distribution curves of illumination devices, height of them to plane and their places. Table 10.1 shows belowed in same situations that are used mostly;

Illumination system	direct illiminiation (nayg=%70)		semi-direct illiminiation (nayg=%80)		Mixed illiminiation (nayg=%80)		semi indirect illiminiation (nayg=%80)		İndirect illiminiation (nayg=%70)	
	n(%)		n(%)		n(%)		n(%)		n(%)	
Room index (a/h)	A	B	A	B	A	B	A	B	A	B
0,5	13	9	9	5	12	7	11	6	9	5
0,7	19	13	13	7	16	10	15	8	12	6
1,0	25	19	17	10	21	13	19	12	15	8
1,5	35	30	24	15	27	17	25	16	20	11
2,0	40	36	29	19	32	21	29	19	23	14
2,5	44	40	33	23	35	24	32	22	26	16
3,0	47	43	36	26	38	26	35	24	28	18
4,0	51	47	41	30	43	30	39	28	32	20
5,0	54	50	45	34	46	33	42	30	34	22
7,0	57	53	51	39	51	37	46	34	36	24
10,0	59	55	57	40	55	40	51	37	38	26

In this Table;

a: lenght of one side of a square room

h: height of light sources to the plane in direct and semi-direct illumination system. Height of ceiling to the plane in direct; mixed and semi-direct illumination system.

A: Situation where is ceiling is white (ρ_T= %75) and walls are quite white (ρ_D = %50)

B: Situation where is ceiling is quite white (ρ_T = %50) and wall are dark (ρ_D = %30)

If the room is a rectangle (a,b) , efficiency is ;

$$\eta = \eta_a + \frac{1}{3}(\eta_a - \eta_b)$$

While preparing the table 10.1 , only two efficiency about illumination devices (η ayg = %70 and η ayg = %80) is taken.

If another illumination device that has the efficiency η^1 ayg is used (η^1 is an aygıt different from %70, %80 efficensy level) , the efficiency that is found from table is multiplied with a of η' ayg / η aygAfter finding the efficiency η , light flow that goes to plane (Φ_o) is found with the help of flow of light by illumination sources (Φ_s). Then the average illumination level is:

$$E_0 S = \phi_s = \eta_s \eta \phi_0$$

The average illumination level of plane is given and total light flow that light sources give Φ_s is looked for ;

$$\phi_{0\eta} = E_0 S$$

Below the dimensions of living room are given and number of armatures are found by performing necessory calculation.

ILLIMINIATION UNITS

NAME	SYMBOL	UNIT	EXPLANATION
Light flow		Lümen (lm)	İt is the amount of the total light source gives in all directions. İn other words it is the port of the electrical energy converted into the light energy. That isgiven to light source.
Light intensity	I	kandela (cd)	İt is the amount of light flow in any direction. (the light flow may be constant but the light indensity may be different in various directions)
Illumination intensity	E	lux (lux)	İt is the total light flow that comes to 1 m^2 area
Flashing	L	cd/cm2	İt is th elight indensity that comes from light sources or unit surfaces that the light sources lighten.

ILUMINATION EQUATION

EQUATION	SYMBOL	EXPLANATION
[illegible]	**n**	Number of light bulbs
	Φ_T	Total light flow necessary (lm)
	Φ_L	Light flow given by a light bulb.
k= a.b/ h(a+b)	**k**	Room index (according to dimensions)
	a	Length (m)
	b	width (m)
	h	Height of the light source to the working sueface (m)
	H	Height of the light source to the floor(m)

	h1	Height of the working surfaces to the flor (m)
Φ_T = E.A.d / η	**E**	Necessary illiminiations level (lux) chosen from the table
	A	Surface area that will be lighted (m2)
	d	Pallution installmentfactors 1,25 - 1,75
	η	Efficensy factors of the installment it is chosen from the table according to wall, ceiling, flor reflexion factors, tipe of armature chosen, room index

TYPICAL FLOWS OF SOME LAMPS

[illegible] OF LAMP	POWER OF LAMP (W)	AVERAGE FLOWS (lm)
[illegible] (GENERAL USİNG –WİRED)	60	610
	100	1230
[illegible]RESCANT	18/20	1100
	36/40	2850
	65/80	5600
[illegible]omic)	9	400
	11	600
	15	900
	20	1200
	23	1500
[illegible]MPACT FLOURESAN	16	1050
	28	2050
	38	3050
[illegible]URY (MBF)	50	1800
	125	6300
	400	12250
	1000	38000
[illegible]RY (MBIF)	250	17000
	1000	81000
[illegible]SURİZED SODİUM (SON PLUS)	100	10000
	400	54000
[illegible]SURİZED SODİUM (SON DELUXE)	150	12250

	400	38000
	300	5950
	500	11000
	750	16500
	1000	22000
TUNGTEN HALOJEN	1500	33000

Light Sources

Light power	ışık akısı (lümen)
15	120-135
25	215-240
40	340-480
60	620-805
75	855-960
100	1250-1380
150	2100-2280
200	2950-3220

Hanger Height

ceiling height	Area wideness	Cord Height
2.0	2.0 4.0 8.0 and upper	ceiling ceiling ceiling
2.5	2.5 5.0 10.0 and upper	ceiling (0.15) ceiling (0.15) ceiling (0.15)
3.0	3.0 6.0 12.0 and upper	0.4 (0.5) 0.25 (0.4) ceiling (0.3)

Bright voice

Stair, Corridor, Shower and WC	10-20
Class, Library and Teacher room	40-80, 80-100, 100-120
Physical and Chemistry Lab.	100-120

CHAPTER 3: INSULATORS

An insulator is defined as a material, which offers an extremely high resistance to the passage of an electric current. Were it not for this property of some materials we would not be able to apply electrical energy to so many uses today. Some materials are better insulators than others. The resistivity of all insulating materials decreases with an increase in temperature. Because of this, a limit in the rise in temperature is imposed in the applications of insulating materials, otherwise the insulation would break down to cause a short circuit or leakage current to earth. The materials used for insulation purposes in electrical work are extremely varied and are of a most diverse nature. Because no single insulating material can be used extensively, different materials are combined to give the required properties of mechanical strength, adaptability, and reliability. Solids, liquids, and gases are to be found used as insulation.

Insulating materials arc grouped into classes:

Class A - Cotton, silk, paper, and similar organic materials; impregnated or immersed in oil.

Class B - Mica, asbestos, and similar inorganic materials, generally found in a built-up form combined with cement binding cement. Also polyester enamel covering and glass-cloth and micanite.

Class C - Mica, porcelain glass quartz: and similar materials.

Class E - Polyvinyl acetal resin. Class H - Silicon-glass.

The following are some brief descriptions of some of the insulating materials more commonly used in electrical work.

3.1 Rubber

Used mainly for cable insulation. Cannot be used for high temperatures as it hardens. Generally used with sulphur (vulcanized rubber) and china clay. Has high insulation-resistance value.

3.2 Polyvinyl chloride (PVC)

This is a plastics material, which will tend to flow when used in high temperatures. Has a lower insulation-resistance value than rubber. Used for cable insulation and sheathing against mechanical damage.

3.3 Paper

Must be used in an impregnated form (resin or oil). Used for cable insulation. Impregnated with paraffin wax, paper is used for making capacitors. Different types are available: Kraft, cotton, tissue, and pressboard.

3.4. Glass

Used for insulators (overhead lines). In glass fiber form it is used for cable insulation where high temperatures are present, or where areas are designated 'hazardous'. Requires a suitable impregnation (with silicone varnish) to fill the spaces between the glass fibers.

3.5. Mica

This material is used between the segments of commutators of de machines, and under slip rings of ac machines. Used where high temperatures are involved such as the heating elements of electric irons. It is a mineral, which is present in most granite-rock formations; generally produced in sheet and block form. Micanite is the name given to the large sheets built up from small mica splitting and can be found backed with paper, cotton fabric, silk or glass-cloth or varnishes. Forms include tubes and washers.

3.6. Ceramics

Ceramic is used for overhead-line insulators and switchgear and transformer bushings as lead-ins for cables and conductors. Also found as switch-bases, and insulating beads for high-temperature insulation applications.

3.7. Bakelite

A very common synthetic material found in many aspects of electrical work (e.g. lamp holders, junction boxes), and used as a construction material for enclosing switches to be used with insulated wiring systems.

3.8. Insulating oil

This is a mineral oil used in transformers and in oil-filled circuit breakers where the arc drawn out when the contacts separate, is quenched by the oil. It is used to impregnate wood, paper, and pressboard. This oil breaks down when moisture is present.

3.9. Epoxide resin

This material is used extensively for 'potting' or encapsulating electronic items. In larger castings it is found as insulating bushings for switchgear and transformers.

Textiles

This group of insulating materials includes both natural (silk, cotton, and jute) and synthetic (nylon, Terylene). They are often found in tape form, for winding-wire coil insulation.

Gases

Air is the most important gas used for insulating purposes. Under certain conditions (humidity and dampness) it will break down. Nitrogen and hydrogen are used in electrical transformers and machines as both insulates and coolants.

Liquids

Mineral oil is the most common insulating material in liquid form. Others include carbon tetrachloride, silicone fluids and varnishes. Semi-liquid materials include waxes, bitumens and some synthetic resins. Carbon tetrachloride is found as an arc-quencher in high-voltage cartridge type fuses on overhead lines. Silicone fluids are used in transformers and as dashpot damping liquids. Varnishes are used for thin insulation covering for winding wires in electromagnets. Waxes are generally used for impregnating capacitors and fibres where the operating temperatures are not high. Bitumens are used for filling cable-boxes; some are used in a paint form. Resins of a synthetic nature form the basis of the materials known as 'plastics' (polyethylene, polyvinyl chloride, melamine and polystyrene). Natural resins are used in varnishes, and as bonding media for mica and paper sheets hot-pressed to make boards.

CHAPTER 4: PROTECTION

The meaning of the word protection, as used in electrical industry, is not different to that in every day used. People protect them selves against personal or financial loss by means of insurance and from injury or discomfort by the use of the correct protective clothing the further protect there property by the installation of security measure such as locks and for alarm systems.

In the same way electrical system need to be protected against mechanical damage the effect of the environment, and electrical over current to be installed in such a fashion that's person and or live stock are protected from the dangerous that such an electrical installation may create.

4.1. REASONS FOR PROTECTIONS

4.1.1. Mechanical Damage

Mechanical damage is the term used to describe the physical harm sustains by various parts of electrical sets. Generally by impact hitting cable whit a hammer by obrasing. Cables sheath being rubbed against wall corner or by collision (e.g. sharp object falling to cut a cable prevent damage of cable sheath conduits, ducts tranking and casing)

4.1.2. Fire Risk:

Electrical fire cawed by;

a) A fault defect all missing in the firing

b) Faults or defects in appliances

c) Mal-operation or abuse the electrical circuit (e.g. overloading)

4.1.3. Corrosion:

Wherever metal is used there is often the attendant problem of corrosion and it's prevented. There is two necessary corrosion for corrosion.

a) The prevention of contact between two dissimilar metals ex copper & aluminium.

b) Prohibition of soldering fluxes which remains acidic or corrosive at the compilation of a soldering operation ex cable joint together.

The protection metal sheaths of cables and metal conductions fittings where they come into contact with lime, cement or plaster and certain hard woods ex: corrosion of the metal boxes.

Protection of cables wiring systems and equipment's against the corrosive action of water, and dumbness if not they are suitable designed to with these conditions.

Over current

Over current, excess current the result of either and overload or a short circuit. The overloading occurs when an extra load is taken from the supply. This load being connected in parallel with the existing load in a circuit decreases. The overload resistance of the circuit and current increases which causes heating the cables and deteriorate the cable insulation. And the short-circuit. Short circuit is a direct contact between live conductors

- Neutral condactor. (Fuse)
- Earthed metal work (Operators)

Protectors of overcurrent

- Fuses
- Circuit Breakers

Fuse

A device for opening a circuit by means of a conductor designed to melt when an excesive current flows along it .

There are three types of fuses.

- Rewireable
- Cartridge
- HBC (High Breaking Copacity)

Rewireable Fuse:

Rewireable fuse consists of a fuse, holder, a fuse element and a fuse carrier. The holder and carrier are being made porselain or bakelite. These fuses have designed with color codes, which are marked on the fuse holder as follows;

Table.1 Fuse current rating and color codes

Current Rating	Color Codes
5A	White
15A	Blue
20A	Yellow
30A	Red
45A	Green
60A	Purple

But this type of fuse has disadvantages.Putting wrong fuse element can be damaged and and so fire risk, can open circuit at starting-current surges.

Note: Today's they have not used anymore.

Cartridge Fuse

A cartridge fuse consists of a porcelain tube with metal and caps to which the element is attached. The tube is filled silica. They have the advantage ever the rewirable fuse of not deteriorating, of accuracy in breaking at rated values and of not arcing when interrupting faults. They are however, expensive to replace.

High –Breaking Capacity (HBC)

It is a sophisticated variation of the cartridge fuse and is normally found protecting motor circuits and industrial installations. Porcelain body filled with silica with a silver element and cartridge end caps. It is very fast acting and can discriminate between a starting surge and an overload.

Circuit-breakers

The circuit breakers can be regarded as a switch, which can be opened automatically by means of a 'tripping' device. It is, however, more than this

Whereas a switch is capable of making and breaking a current not greatly in excess of its rated normal current, the circuit-breaker can make and break a circuit, particularly in abnormal conditions such as the occasion of a short-circuit in an installation. It thus disconnects automatically a faulty circuit.

A circuit breaker is selected for a particular duty, taking into consideration the following. (a) the normal current it will have to carry and (b) the amount of current which the supply will the circuit fault, which current the circuit-breaker will have to interrupt without to itself.

breaker generally has a mechanism which, when in the closed position, holds the together. The contacts are separated when the release mechanism of the circuit is operated by hand or automatically by magnetic means. The circuit breaker with 'tripping' (the term used to indicate the opening of the device) employs a solenoid, is an air-cooled coil. In the hollow of the coil is located an iron cylinder attached to a mechanism consisting of a series of pivoted links. When the circuit breaker is closed, the current passes through the solenoid. When the circuit rises above a certain value (due to overload or a fault), the cylinder moves within the solenoid to cause the attached linkage to and, in turn, separate the circuit-breaker contacts.

breakers are used in many installations in place of fuses because of a number of advantages. First, in the event of an overload or fault all poles of the circuit are disconnected. The devices are also capable of remote control by push buttons, by voltage release coils, or by earth-leakage trip coils. The over-current setting of the breakers can be adjusted to suit the load conditions of the circuit to be controlled. devices can also be introduced so that the time taken for tripping can be delayed in some instances, a fault can clear itself, and so avoid the need for a circuit breaker disconnect not only the faulty circuit, but also other healthy circuits, which may be with it. The time-lag facility is also useful in motor circuits, to allow the circuit- to stay closed while the motor takes the high initial starting current during the run-up its normal speed. After they have tripped, circuit breakers can be closed immediately loss of time. Circuit-breaker contacts separate either in air or in insulating oil.

circumstances, circuit breakers must be used with 'back-up' protection, which the provision of HBC (high breaking capacity) fuses in the main circuit-breaker this instance, an extremely heavy over current, such as is caused by a short circuit, by the fuses, to leave the circuit breaker to deal with the over currents caused by

use for modern electrical installations is the miniature circuit-breaker (MCB). It as an alternative to the fuse, and has certain advantages: it can be reset or reclosed gives a close degree of small over current protection (the tripping factor is 1.1); it a small sustained over current, but not on a harmless transient over current such as surge. For all applications the MCB tends to give much better overall protection both fire and shock risks than can be obtained with the use of normal HBC or fuses. Miniature circuit breakers are available in distribution-board units for final protection.

disadvantage of the MCB is the initial cost, although it has the long-term There is also tendency for the tripping mechanism to stick or become sluggish in after long periods of inaction It is recommended that the MCB be tripped at intervals to 'ease the springs' and so ensure that it performs its prescribed duty with either to itself or to the circuit it protects.

Values of fuses;

16A, 20A, 25A, 32A, 40A, 50A, 63A.

Earth Leakages:

for Earth Leakages:

ELCB, which stands for Earth Leakage Circuit Breaker, does this type of protection. two types of earth leakage circuit breaker.

Current Operated ELCB (C/O ELCB)

flowing through the live conductor and back through the neutral conductor and there opposite magnetic area in the iron ring, so that the trip coils does not operate If a live fault or a neutral to earth fault happens the incoming and returning current will not be magnetic field will circulate in the iron ring to operate the trip coil. This type of is used in today.

are some of the points, which the inspecting electrician should look for:

cables not secure at plugs.

cables.

without mechanical protection.

unearthed metalwork.

over-fused.

broken earth connections, and especially sign of corrosion.

elements of the radiant fires.

additions to final circuits resulting in overloaded circuit cables.

or unearthed socket-outlets.

with earthing requirements being supplied from two-pin BC adaptors.

10) Bell-wire used to carry mains voltages.
11) Use of portable heating appliances in bathrooms.
12) Broken connectors, such as plugs.
13) Signs of heating at socket-outlet contacts.

The following are the requirements for electrical safety:
1) Ensuring that all conductors are sufficient in csa for the design load current of circuits.
2) All equipment, wiring systems, and accessories must be appropriate to the working conditions.

3) All circuits are protected against over current using devices, which have ratings appropriate to the current-carrying capacity of the conductors
4) All exposed conductive pans are connected together by means of CPCs.
5) All extraneous conductive parts are bonded together by means of main bonding conductors and supplementary bonding conductors are taken to the installation main earth terminal.
6) All control and over current protective devices are installed in the phase conductor.
7) All electrical equipment has the means for their control and isolation.
8) All joints and connections must be mechanically secure and electrically continuous and be accessible at all times.
9) No additions to existing installations should be made unless the existing conductors are sufficient in size to carry the extra loading.
10) All electrical conductors have to be installed with adequate protection against physical damage and be suitably insulated for the circuit voltage at which they are to operate.
11) In situations where a fault current to earth is not sufficient to operate an over current device, an RCD must be installed.
12) All electrical equipment intended for use outside equipotent zone must be fed from socket-outlets incorporating an RCD.
13) The detailed inspection and testing of installation before they are connected to a mains supply, and at regular intervals there after.

CHAPTER 5: GENERATION AND TRANSMISSION

The generation of electric is to convert the mechanical energy into the electrical energy. Mechanical energy means that motor which makes the turbine turn.

Electrical energy must be at definite value. And also frequency must be 50Hz or at other countries 60Hz. The voltage which is generated (the output of the generator) is 11KV. After generation the lines which transfer the generated voltage to the costumers at expected value. These can be done in some rules. If the voltage transfers as it is generated up to costumers. There will be voltage drop and looses. So voltage is stepped up. When the voltage is stepped up current will decrease. That is why the voltage is increased. This is done as it is depending on Ohm's law. Actually these mean low current. Used cables will become thin. This will be economic and it will be easy to install transmission lines. If we cannot do this, we will have to use thicker cable.

To transfer the generated voltage these steps will be done. Generated voltage (11KV) is applied to the step-up transformer to have 66KV. This voltage is carried up to a sub-station. In the sub-station the voltage will be stepped-down again to 11KV. At the end the voltage stepped-down to 415V that is used by costumers. As a result the value of the voltage has to be definite value. These;

- line to line – 380 V
- line to neutral – 220V
- line to earth – 0V
- earth to neutral – 0V

CHAPTER 6: EARTHING

efficient earthing arrangement is an essential part of every electrical installation and serves to guard against the effects of leakage currents, short-circuits, static charges and lightning discharges. The basic reason for earthing is to prevent or minimize the risk of shock to human beings and livestock, and to reduce the risk of fire hazard. The earthing arrangement provides a low-resistance discharge path for currents, which would otherwise prove injurious or fatal to any person touching the metalwork associated with the faulty circuit. The prevention of electric shock risk in installations is a matter, which has been given close attention in these past few years, particularly since the rapid increase in the use of electricity in an ever-widening range of applications.

EARTHING TERMS

Earth:

connection to the general mass of earth by means of an earth electrode.

Earth Electrode:

metal plate, rod or other conductor band or driven in to the ground and used for earthing metalwork.

Earthing Lead:

final conductor by means of which the connection to the earth electrode is made.

Earth Continuity Conductor (ECC):

conductor including any lam connecting to the earth or each other those part of an installation which are required to be earthed. The ECC may be in whole or part the metal conduit or the metal sheath of cables or the special continuity conductor of a cable or flexible cord incorporating such a conductor.

Earthing Systems:

Our electricity system, which is same to UK electricity, is an earthed system, which means the star or neutral point of the secondary side of distribution transformer is connected to the general mass of earth.

In this way, the star point is maintained at or about. 0V. Unfortunately, this also means that persons or livestock in contact with a live part and earth is at risk of electric shock.

Lightning protection

Lightning discharges can generate large amounts of heat and release considerable mechanical forces, both due to the large currents involved. The recommendations for the protection of structures against lightning are contained in BS Code of Practice 6651 (Protection of Structures Against Lightning). The object of such a protective system is to lead away the very high transient values of voltage and current into the earth where they are safely dissipated. Thus a protective system, to be effective, should be solid and permanent. Two main factors are considered in determining whether a structure should be given protection against lightning discharges:

1. Whether it is located in an area where lightning is prevalent and whether, because of its height and/or its exposed position, it is most likely to be struck.
2. Whether it is one to which damage is likely to be serious by virtue of its use, contents, importance, or interest (e.g. explosives factory, church monument, railway station, spire, radio mast, wire fence, etc.).

It is explained in BS Code of Practice 6651 that the 'zone of protection' of a single vertical conductor fixed to a structure is considered to be a cone with an apex at the highest point of the conductor and a base of radius equal to the height. This means that a conductor 30 meters high will protect that part of the structure which comes within a cone extending to 60 meters in diameter at ground level Care is therefore necessary in ensuring that the whole of a structure or building falls within the protective zone; if it does not, two down conductors must be run to provide two protective zones within which the whole structure is contained. All metallic objects and projections, such as metallic vent pipes and guttering, should be bonded to form part of the air-termination network. All down conductors should be cross-bonded.

The use of multiple electrodes is common. Rule 5 of the Phoenix Fire Office Rules states: Earth connections and number. The earth connection should be made either by means of a buried in damp earth, or by means of the tubular earth system, or by connection mains (not nowadays recommended). The number of connections should be in the ground area of the building, and there are few structures where less than two ... Church spires, high towers, factory chimneys having two down conductors two earths which may be interconnected.

component parts of a lightning-protective system should be either castings of leaded copper, naval brass or wrought phosphor bronze, or sheet copper or phosphor steel, suitably protected from corrosion, may be used in special cases where tensile or strength is needed.

ons constitute that part of dice system, which distributes discharges into, or discharges from, the atmosphere. Roof conductors are generally of soft annealed strip and interconnect the various air terminations. Down conductors, between earth air terminations, are also of soft-annealed copper strip. Test points are joints in down bonds, earth leads, which allow resistance tests to be made. The earth are those parts of the system designed to collect discharges from, or distribute the general mass of earth. Down conductors are secured to the face of the by 'holdfasts' made from gunmetal The 'building-in' type is used for new structures; type is used for existing structures.

lightning protection system, the resistance to earth need not be less than 10 ohms. But of important buildings, seven ohms is the maximum resistance. Because the of a lightning conductor is dependent on its connection with moist earth, a poor connection may render the whole system useless The 'Hedges' patent tubular earth a permanent and efficient earth connection, which is inexpensive, simple in and easy to install. These earths, when driven firmly into the soil, do not lose efficiency by changes in the soil due to drainage; they have a constant resistance by of their being kept in contact with moist soil by watering arrangements provided at level. In addition, tubular or rod earths are easier to install than plate earths, because require excavation.

conductors should have as few joints as possible. If these are necessary, other than testing-clamp or the earth-electrode clamping points, flat tape should be tinned, and riveted; rod should be screw-jointed.

protective systems should he examined and tested by a competent engineer after alteration, and extension. A routine inspection and test should be made once a any defects remedied. In the case of a structure containing explosives or other

...le materials, the inspection and test should be made every six months. The tests ...ude the resistance to earth and earth continuity. The methods of testing are similar ...escribed in the IEE Regulations, though tests for earth-resistance of earth electrodes ...efinite distances to be observed.

...nti-static earthing

...hich is a shortened term for 'static electric discharge' has been the subject of ... concern in recent years partly due to the increasing use of highly insulating ... (various plastics and textile fibres).

...arthing practice

...Direct Earthing

...'direct earthing' means connection to an earth electrode, of some recognized type, ...ance on the effectiveness of over current protective devices for protection against ... fire hazards in the event of an earth fault. If direct earthing protects non-current-...metalwork, under fault conditions a potential difference will exist between the ... and the general mass of earth to which the earth electrode is connected. This ... will persist until the protective device comes into operation. The value of this ...difference depends on the line voltage, the substation or supply transformer earth ..., the line resistance, the fault resistance, and finally, the earth resistance at the .... Direct earth connections are made with electrodes in the soil at the consumer's .... A further method of effecting connection to earth is that which makes use of the ...sheaths of underground cables. But such sheaths are more generally used to provide a ...metallic connection for the return of earth-fault current to the neutral of the supply ...ather than as a means of direct connection to earth.

...electrode, the means by which a connection with the general mass of earth is made, ... a number of forms, and can appear either as a single connection or as a network of ...electrodes. Each type of electrode has its own advantages and disadvantages.

...of an earth electrode system takes into consideration its resistance to ensure that ...such a value that sufficient current will pass to earth to operate the protective system. ...also be designed to accommodate thermally the maximum fault current during the ...takes for the protective device to clear the fault. In designing for a specific ohmic resistance, the resistivity of the soil is perhaps the most important factor, although it is a variable one.

The current rating or fault-current capacity of earth electrodes must be adequate for the 'fault-current time-delay' characteristic of the system under the worst possible conditions. Undue heating of the electrode, which would dry out the adjacent soil and increase the earth resistance, must be avoided. Calculated short-time ratings for earth electrodes of various types are available from electrode manufacturers. These ratings are based on the short-time current rating of the associated protective devices and a maximum temperature, which will not cause damage to the earth connections or to the equipment with which they may be in contact.

In general soils have a negative temperature coefficient of resistance. Sustained current loadings result in an initial decrease in electrode resistance and a consequent rise in the earth-fault current for a given applied voltage. However, as the moisture in the soil is driven away from the soil/electrode interface, the resistance rises rapidly and will ultimately approach infinity if the temperature rise is sufficient. This occurs in the region of 100^0C and results in the complete failure of the electrode.

The current density of the electrode is found by:

$$\text{Current density} = \frac{I}{A} = \frac{92x10^3}{\sqrt{t}}$$

Where I = short-circuit fault current; A = area (in cm^2); t = time in seconds (duration of the fault current).

The formula assumes a temperature rise of 120^0C, over an ambient temperature of 25^0C, and the use of high-conductivity copper. The formula does not allow for any dissipation of heat into the ground or into the air.

Under fault conditions, the earth electrode is raised to a potential with respect to the earth surrounding it. This can be calculated from the prospective fault current and the earth resistance of the electrode. It results in the existence of voltages in soil around the electrode, which may harm telephone and pilot cables (whose cores are substantially at earth potential) owing to the voltage to which the sheaths of such cables are raised. The voltage gradient at the surface of the ground may also constitute a danger to life, especially where cattle and livestock are concerned. In rural areas, for instance, it is not uncommon for the earth-path resistance to be such that faults are not cleared within a short period of time and animals which congregate near the areas in which current carrying electrodes are installed are liable to receive fatal shocks. The same trouble occurs on farms where earth electrodes are sometimes used for individual appliances. The maximum voltage gradient over a span of 2 meters to a 25 mm diameter pipe electrode is reduced from 85 per cent of the total electrode potential when the top of the electrode is at ground level to 20 per cent and 5 per cent when the electrode is buried at 30 cm and 100 cm respectively. Thus, in areas where livestock are allowed to roam it is recommended that electrodes be buried with their tops well below the surface of the soil. Corrosion of electrodes due to oxidation and direct chemical attack is sometimes a problem to be considered. Bare copper acquires a protective oxide film under normal atmospheric conditions which does not result in any progressive wasting away of the metal. It does, however, tend to increase the resistance of joints at contact surfaces. It is thus important to ensure that all contact surfaces in copper work, such as at test links, be carefully prepared so that good electrical connections are made. Test links should be bolted up tightly. Electrodes should not be installed in ground, which is contaminated by corrosive chemicals. If copper conductors must be run in an atmosphere containing hydrogen sulphide, or laid in ground liable to contamination by corrosive chemicals, they should be protected by a covering of PVC adhesive tape or a wrapping of some other suitable material, up to the point of connection with the earth electrode. Electrolytic corrosion will occur in addition to the other forms of attack if dissimilar metals are in contact and exposed to the action of moisture. Bolts and rivets used for making connections in copper work should be of either brass or copper. Uninsulated copper should not be run in direct contact with ferrous metals. Contact between bare copper and the lead sheath or armouring of cables should be avoided, especially underground. If it is impossible to avoid the connection of dissimilar metals, these should be protected by painting with a moisture-resisting bituminous paint or compound, or by wrapping with PVC tape, to exclude all moisture.

The following are the types of electrodes used to make contact with the general mass of earth:

a) Plates. These are generally made from copper, zinc, steel, or cast iron, and may be solid or lattice type. Because of their mass, they tend to be costly. With the steel or cast-iron types care must he taken to ensure that the termination of the earthing lead to the plate is water-sealed to prevent cathodic action taking place at the joint, If this happens, the conductor will eventually become detached from the plate and render the electrode practically useless. Plates are usually installed on edge in a hole in the ground about 2-3 meters deep, which is refilled with soil. Because one plate electrode is seldom sufficient to obtain a [illegible] earth connection, the cost of excavation associated with this type of electrode [illegible] considerable. In addition, due to the plates being installed relatively near the surface of ground, the resistance value is liable to fluctuate throughout the year due to the seasonal [illegible] in the water content of the soil. To increase the area of contact between the plate and surrounding ground, a layer of charcoal can be interposed. Coke, which is sometimes used [illegible] alternative to charcoal, often has a high sulphur content, which can lead to serious [illegible] and even complete destruction of the copper. The use of hygroscopic salts such as [illegible] chloride to keep the soil in a moist condition around the electrode can also lead to [illegible].

[illegible] In general rod electrodes have many advantages over other types of electrode in that [illegible] less costly to install. They do not require much space, are convenient to test and do [illegible] large voltage gradients because the earth-fault current is dissipated vertically. [illegible] installed electrodes are not subject to seasonal resistance changes. There are several [illegible] of rod electrodes. The solid copper rod gives excellent conductivity and is highly [illegible] to corrosion. But it tends to be expensive and, being relatively soft, is not ideally [illegible] for driving deep into heavy soils because it is likely to bend if it comes up against a [illegible]. Rods made from galvanized steel are inexpensive and remain rigid when being [illegible]. However, the life of galvanized steel in acidic soils is short. Another disadvantage is [illegible] copper earthing lead connection to the rod must be protected to prevent the ingress of [illegible]. Because the conductivity of steel is much less than that of copper, difficulties may [illegible] particularly under heavy fault current conditions when the temperature of the electrode [illegible] and therefore its inherent resistance. This will tend to dry out the surrounding soil, [illegible] its resistivity value and resulting in a general increase in the earth resistance of the [illegible]. In fact, in very severe fault conditions, the resistance of the rod may rise so rapidly [illegible] an extent that protective equipment may fail to operate.

[illegible] bimetallic rod has a steel core and a copper exterior and offers the best alternative to [illegible] the copper or steel rod. The steel core gives the necessary rigidity while the copper [illegible] offers good conductivity and resistance to corrosion. In the extensible type of steel-[illegible] rod, and rods made from bard-drawn copper, steel driving caps are used to avoid [illegible] the rod end as it is being driven into the soil. The first rod is also provided with a [illegible] steel tip. The extensible rods are fitted with bronze screwed couplings. Rods should [illegible] by means of a power driven hammer fitted with a special head. Although rods [illegible] driven vertically into the ground, an angle not exceeding 60° to the vertical is [illegible] in order to avoid rock or other buried obstruction.

[illegible] Copper strip is used where the soil is shallow and overlies rock. It should be buried [illegible] to a depth of not less than 50 cm and should not be used where there is a [illegible] of the ground being disturbed (e.g. on farmland). The strip electrode is most [illegible] buried in ditches under hedgerows where the bacteriological action arising from [illegible] of vegetation maintains a low soil resistivity.

[illegible] mat. These consist of copper wire buried in trenches up to one meter deep. The mat [illegible] out either linearly or in 'star' form and terminated at the down lead from the [illegible] or other items of equipment to be earthed. The total length of conductor used can [illegible] 100 meters. The cost of trenching alone can be expensive. Often scrap overhead [illegible] was used but because of the increasing amount of aluminium now being used, [illegible] conductor is scarce. The most common areas where this system is still used are [illegible] is present near the surface of the soil, making deep excavation impracticable. As [illegible] electrodes, this method of earthing is subject to seasonal changes in resistance. [illegible] is the danger of voltage gradients being created by earth faults along the lengths of [illegible] conductor, causing a risk to livestock.

[illegible] Points of Earthing:

[illegible] the potential of any part of a system at a definite value with respect to earth.

[illegible] current to flow to earth in the event of a fault so that, the protective gears will [illegible] isolate the faulty circuit.

[illegible] sure that in the event of a fault, apparatus "Normally death (0V)" cannot reach a [illegible] potential whit respect to earth.

[illegible] Shock:

[illegible] passage of current through the body of such magnitude as to have significant [illegible] effects these value of currents are;

[illegible]mA	Barely perceptible, no harmful effects
[illegible]mA	Throw off, painful sensation
[illegible]mA	Muscular contraction, cannot let go
[illegible]mA	Impaired breathing

and above Ventricular fibrillation and earth.

There are two ways in which we can be at risk.

Touching live parts of equipment for systems. That is intended to be live. This is called direct contact.

Touching conductive parts which are not meant to be live, but which have become live due to a fault. This is called indirect contact.

Earth testing

Regulations requires that tests he made on every installation to ensure that the earthing arrangement provided for that installation is effective and offers the users of the installation a satisfactory degree of protection against earth-leakage currents. The following are the essential tests prescribed by the Regulations.

Circuit-protective conductors

Regulation 713-02-01 requires that every circuit-protective conductor (CPC) be tested to verify that it is electrically sound and correctly connected. The IEE Regulations Guidance Notes on inspection and testing give details on the recognized means used to test the CPC. For a final circuit, the CPC forms part of the earth-loop impedance path, its purpose being to connect all exposed conductive parts in the circuit to the main earth terminal. The CPC can take a number of forms. If metallic conduit or trunking is used, the usual figure for ohmic resistance of one-meter length is 5 milliohms/m.

Generally if the total earth-loop impedance (Z_s) for a particular final circuit is within the maximum Z_s limits, the CPC is then regarded as being satisfactory. However, some testing specifications for large installations do require a separate test of each CPC to be carried out. The following descriptions of such tests refer to a.c. installations.

Reduced a.c. test.

In certain circumstances, the testing equipment in the a.c. test described above is not always available and it is often necessary to use hand-testers, which deliver a low value of test current at the frequency of the mains supply. After allowing for the resistance of the test lead, a value of impedance of 0.5 ohm maximum should be obtained where the CPC, or part of it, is made of steel conduit. If the CPC is in whole or in part made of copper, copper-alloy, or aluminum, the maximum value is one ohm.

Direct current.

Where it is not convenient to use a.c. for the test, D.C. may be used instead. Before the D.C. is applied, an inspection must be made to ensure that no inductor is incorporated in the length of the CPC. Subject to the requirements of the total earth-loop impedance, the maximum values of impedance for the CPC should be 0.5 ohm (if of steel) or one ohm (if of copper, copper-alloy or aluminium).

The resistance of an earth-continuity conductor, which contains imperfect joints, varies with the test current. It is therefore recommended that a D.C. resistance test for quality is made, first at low current, secondly with high current, and finally with low current. The low-current test should be made with an instrument delivering not more than 200 mA into one ohm; the high-current test should be made at 10 A or such higher current as is practicable. The open-circuit voltage of the test set should be less than 30 V. Any substantial variations in the readings (say 25 per cent) will indicate faulty joints in the conductor; these should be rectified. If the values obtained are within the variation limit, no further test of the CPC is necessary.

Residual current devices

IEE Regulation 713-12-01 requires that where an RCD provides protection against indirect contact, the unit must have its effectiveness tested by the simulation of a fault condition. This test is independent of the unit's own test facility. The consumer who is advised to ensure that the RCD trips when a test current, provided by an internal resistor, is applied to the trip-coil of the unit designs the latter for use. Thus, on pressing the 'Test' button the unit should trip immediately. If it does not it may indicate that a fault exists and the unit should not be used with its associated socket-outlet, particularly if the outlet is to be used for outdoor equipment.

The RCD has a normal tripping current of 30 mA and an operating time not exceeding 40 ms at a test current of 150 mA.

RCD testers are commercially available, which allow a range of tripping currents to be applied to the unit, from 10 mA upwards. In general the lower the tripping current the longer will be the time of disconnection.

It should be noted that a double pole RCD is required for caravans and caravan sites and for agricultural and horticultural installations where socket-outlets are designed for equipment to be used other than 'that essential to the welfare of livestock'.

5.5. Earth-electrode resistance area

The general mass of earth is used in electrical work to maintain the potential of any part of a system at a definite value with respect to earth (usually taken as zero volts). It also allows a current to flow in the event of a fault to earth, so that protective gear will operate to isolate the faulty circuit. One particular aspect of the earth electrode resistance area is that its resistance is by no means constant. It varies with the amount of moisture in the soil and is therefore subject to seasonal and other changes. As the general mass of earth forms part of the earth-fault loop path, it is essential at times to know its actual value of resistance, and particularly of the area within the vicinity of the earth electrode. The effective resistance area of an earth electrode extends for some distance around the actual electrode; but the surface voltage dies away very rapidly as the distance from the electrode increases . The basic method of measuring the earth-electrode resistance is to pass current into the soil via the electrode and to measure the voltage needed to produce this current. The type of soil largely determines its resistivity. The ability of the soil to conduct currents is essentially electrolytic in nature, and is therefore affected by moisture in the soil and by the chemical composition and concentration of salts dissolved in the contained water. Grain size and distribution, and closeness of packing are also contributory factors, since these control the manner in which moisture is held in the soil. Many of these factors vary locally. The following table shows some typical values of soil resistivity.

Table 2.soil-resistivity values

Type of soil	Approximate value in ohm-cm
Marshy ground	200 to 350
Loam and clay	400 to 15,000
Chalk	6000 to 40,000
Sand	9000 to 800,000
Peat	5000 to 50,000
Sandy gravel	5000 to 50,000
Rock	100,000 upwards

When the site of an earth electrode is to be considered, the following types of soil are recommended, in order of preference:

1. Wet marshy ground, which is not too well drained.

Clay, loamy soil, arable land, clayey soil, and clayey soil mixed with small quantities of sand.

Clay and loam mixed with varying proportions of sand, gravel, and stones.

Damp and wet sand, peat.

Dry sand, gravel, chalk, limestone, whinstone, granite, and any very stony ground should be avoided, as should all locations where virgin rock is very close to the surface.

Chemical treatment of the soil is sometimes used to improve its conductivity Common salt is very suitable for this purpose. Calcium chloride, sodium carbonate, and other substances are also beneficial, but before any chemical treatment is applied it should be verified that no corrosive actions would be set up, particularly on the earth electrode. Either a hand-operated tester or a mains-energized double-wound transformer can be used, the latter requiring an ammeter and a high-resistance voltmeter. The former method gives a direct reading in ohms on the instrument scale; the latter method requires a calculation in the form:

$$\text{Resistance} = \frac{Voltage}{Current}$$

The procedure is the same in each case. An auxiliary electrode is driven into the ground at a distance of about 30 meters away from the electrode under test (the consumer's electrode). A third electrode is driven midway between them. To ensure that the resistance area of the first two electrodes do not overlap, the third electrode is moved 6 meters farther from, and nearer to the electrode under test. The three tests should give similar results, the average value being taken as the mean resistance of the earth electrode.

The disadvantage of using the simple method of earth electrode resistance measurement is that the effects of emfs (owing to electrolytic action in the soil) have to be taken into account when testing. Also, there is the possibility of stray earth currents being leakages from local distribution systems. Because of this it is usual to use a commercial instrument, the Megger earth tester being a typical example.

Earth-fault loop impedance

Regulation 113-11-01 stipulates that where earth-leakage relies on the operation of over current devices, an earth-loop impedance test should be carried out to prove the effectiveness of the installation's earthing arrangement. Although the supply authority makes its own earth-loop impedance tests, the electrical contractor is still required to carry out his own tests. The tests carried out by a supply authority will not absolve the contractor from his legal responsibilities for the safe and effective operation of protection equipment which he may install as part of a wiring installation. This applies both to new installations and extensions to existing installations. Earth-loop impedance tests must be carried out on all extension work of major importance to ensure that the earth-continuity path right back to the consumer's earthing terminal is effective and will enable the protective equipment to operate under fault conditions.

4.7 Phase-earth loop test.

This test closely simulates the condition which would arise should an earth- fault occurs. The instruments used for the test create an artificial fault to earth between the 'me and earth conductors, and the fault current, which is limited by a resistor or some other means, is allowed to flow for a very short period. During this time, there is a voltage drop across the limiting device, the magnitude of which depends on the value of the earth loop. The voltage drop is used to operate an instrument movement, with an associated scale calibrated in ohms. The contribution of the consumer's earthing conductor should be not more than one ohm. This is to ensure that the voltage drop across any two Points on the conductor is kept to a low value and under fault conditions there will be no danger to any person touching it at the time of the [illegible]

The testers, which are commercially available, include both digital readouts and analogue scales, and incorporate indications of the circuit condition (correct polarity and a proven earth connection). The readings are in ohms and represent the earth-loop impedance (Z_s). Once a reading is obtained, reference must be made to IEE Regulations Tables 41B1 to 41D, which give the maximum values of Z_s which refer to: (a) the type of over current device used to protect the circuit and (b) the rating of the device. Reference should also be made to any previous test reading to see whether any increase in Z_s has occurred in the meantime. Any increase may indicate a deteriorating condition in the CPC or earthing lead and should be investigated immediately. The values of Z_s indicated in the Tables are maximum values, which must not be exceeded if the relevant circuits are to be disconnected within the disconnection times stated.

Before a test is made, the instrument should be 'proved' by using a calibration unit, which will ensure that it reads correctly during the test. It is also recommended that the serial number and [illegible] model used for the test should be recorded, so that future tests made by the same tester will produce readings, which are correlated.

CHAPTER 7: CABLES

Types of Cables:

- Single core cable
- Two-core cable
- Three-core cable
- Composite cable
- Power cable
- Wiring cable
- Overhead cable
- Equipment cable
- Appliance Wiring cable
- Twin Twisted cable
- Three-Core Twisted
- Twin Circular cable
- Three Core
- Coaxial cable
- Flat cable

The range of types of cables used in electrical work is very wide: from heavy lead-sheathed armoured paper-insulated cables to the domestic flexible cable used to connect a hair-drier to the supply. Lead, tough-rubber, PVC and other types of sheathed cables used for domestic and industrial wiring are generally placed under the heading of power cables. There are, however, other insulated copper conductors (they are sometimes aluminum), which, though by definitions are termed cables, are sometimes not regarded as such. Into this category fall the ordinary rubber and PVC insulated conductors drawn into some form of conduit or trucking for domestic and factory wiring, and similar conductors employed for the wiring of electrical equipment. In addition, there are the various types of insulated flexible conductors including those used for portable appliances and pendant fittings.

The main group of cables is 'flexible cables', so termed to indicate that they consist of or more cores each containing a group of wires, the diameters of the wires and the construction of the cores being such that they afford flexibility.

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Single-core.

These are natural or tinned copper wires. The insulating materials include butyl -rubber, silicon-rubber, and the more familiar PVC.

The synthetic rubbers are provided with braiding and are self-colored. The IEE Regulations recognize these insulating materials for twin-and multi-core flexible cables rather than for use as single conductors in conduit or trunking wiring systems. But that are available from the cable manufacturers for specific insulation requirements. Sizes vary from 1 to 36 mm squared (PVC) and 50 mm squared (synthetic rubbers).

Two-core.

Two-core or 'twin' cables are flat or circular. The insulation and sheathing materials are those used for single-core cables. The circular cables require cotton filler threads to gain the circular shape. Flat cables have their two cores laid side by side.

Three-core.

These cables are the same in all respects to single-and two-core cables except, of course, they have three cores.

Composite cables.

Composite cables are those, which, in an addition to carrying the currency-carrying circuit conductors, also contain a circuit-protective conductor.

To summarize, the following group of cable types and applications are to be found in electrical work, and the electrician, at one time or another during his career, may be asked to install them.

Wiring cables.

[illegible] wiring; domestic at workshop flexible cables and cords. Mainly copper conductors.

Power cables.

Power cables, generally lead sheathed and armored; control cables for electrical equipment. Both copper and aluminum conductors.

Mining cables.

[illegible] field cables are used for trailing cables to supply equipment; shot-firing cables;

lighting; lift -shaft wiring; signaling, telephone and control cables. Adequate [illegible] and fireproofing are features of cables for this application field.

Ship-wiring cables.

[illegible] cables are generally lead-sheathed and armored, and mineral-insulated, metal-sheathed. [illegible] must comply with Lloyd's Rules and Regulations, and with Admiralty requirements.

Overhead cables.

[illegible] lightly-insulated and insulated conductors of copper, copper-cadmium and aluminum [illegible]. Sometimes with steel core for added strength. For overhead distribution cables are [illegible] and in most cases comply with British Telecom requirements.

Communication cables.

[illegible] group includes television down-leads and radio-relay cables; radio frequency cables; [illegible] cables.

Welding cables.

[illegible] flexible cables and heavy cords with either copper or aluminum conductors.

Electric-sign cables.

[illegible] rubber-insulated cables for high-voltage discharge lamps able to withstand the high [illegible]

Equipment wires.

[illegible] wires for use with instruments, often insulated with special materials such as silicon, [illegible] irradiated polythene.

Appliance-wiring cables.

[illegible] group includes high-temperature cables for electric radiators, cookers, and so on. [illegible] used includes nylon, asbestos, and varnished cambric.

Heating cables.

[illegible] floor-warming, road-heating, soil-warming, ceiling-heating, and similar ons.

Flexible cords.

cord is defined as a flexible cable in which the csa of each conductor does not 4 mm squared. The most common types of flexible cords are used in domestic and strial work. The diameter of each strand or wire varies from 0.21 to 0.31 mm. cord come in many sizes and types; for convenience they are groups as follows:

-twisted: These consist of one single insulated stranded conductors twisted together to -cable. Insulation used is vulcanized rubber and PVC. Color identification in red is often provided. The rubber is protected by a braiding of cotton, glazed-cotton, -barding and artificial silk. The PVC-insulated conductors are not provided with protection.

-core (twisted): Generally as two -twisted cords but with a third conductor colored eating lighting fittings.

-core (circular): Generally as twin-core circular except that the third conductor is green and yellow for earthing purposes.

-care (circular): Generally as twin- core circular. Colors are brown and blue.

twin: These are two stranded conductors laid together in parallel and insulated to form cable with rubber or PVC.

-core (flat): This consists of two stranded conductors insulated with rubber, colored . Lay side-by-side and braided with artificial silk.

-temperature lighting, flexible cord: With the increasing use of filament lamps very high temperatures, the temperature at the terminals of a lamp holder can entigrade or more. In most instances the usual flexible insulators (rubber and PVC) suitable and special flexible cords for lighting are now available. Conductors are nickel-plated copper wires, each conductor being provided with two lapping of The braiding is also varnished with silicone. Cords are made in the twisted form ree-core).

...exible cables: These cables are made with stranded conductors, the diameters being ... 0.5, and 0.6 mm. They are generally used for trailing cables and similar applications ...vy currents up to 630 A are to be carried, for instance, to welding plant.

...xial cables (antenna cable):

...cables is a special cable which is used to transfer high frequancy. This cable is a ... flexible cables. We use this cale for TV. We are using this type of cable between ... sockets and from television to antenna.

...ephone cables:

...cable is special cable. We use telephone circuit in the buildings and also for ... circuits. This cables are very slim. Telephone cables are not same as electric cables. ... a lot of size the telephone cables. Telephone cables are 0.5mm and everytime one ... extra near this cables.

Table 3. Telephone cables sizes

$1x2+0.5\ mm^2$
$2x2+0.5\ mm^2$
$3x2+0.5\ mm^2$
$4x2+0.5\ mm^2$
$6x2+0.5\ mm^2$
$10x2+0.5\ mm^2$
$15x2+0.5\ mm^2$
$20x2+0.5\ mm^2$

Conductor Identification:

The wiring regulations require that all conductors have to be identified by some meaning to ensure their functions i.e. phase conductors of a 3 phase system are colored by brown, black, grey with neutral colored by blue, protective conductors are identified by green or yellow green.

IEE Standards;

Brown	Phase 1
Black	Phase 2
Grey	Phase 3
Blue	Neutral
Green or Yellow/Green	Earth

There are some methods to identify the conductors.

- Coloring of the conductor insulation
- Printed numbers on the conductor
- Colored adhesive cases at the termination of the conductor
- Colored see levels types at the termination of the conductors
- Colored paint for bare conductors
- Colored discs fixed to the termination of conductors' e.g. on a distribution board.

Cable size
0.75 mm^2
1 mm^2
1.5 mm^2
2.5 mm^2
4 mm^2
6 mm^2
10 mm^2
16 mm^2
25 mm^2
35 mm^2
50 mm^2
70 mm^2
95 mm^2
120 mm^2
150 mm^2
185 mm^2
240 mm^2
300 mm^2
400 mm^2
500 mm^2
630 mm^2

CHAPTER 8: DOMESTIC INSTALLATIONS

8.1 General Rules for Domestic Installation

There are two types of installation

i) Surface Installation

ii) Under plaster installation

Installation system at costumers place

OPERATOR ➡ DISTRIBUTION BOARD ➡ FUSES ➡ LINES (CABLES)

In both types of installation, same main principle is accepted these are;

1. Lines from metering unit will be applied to the operator (V/O, C/O) or if operator is distribution board, we put 2-pole isolator into box of metering unit and earth continuity conductor will come from another place, not with line and neutral conductor. If the operator is instead of the operator line neutral earth will be connected together to 2-pole isolator, which is distribution board. These maybe 3 phase or 1 phase operator or isolator.
2. In distribution board for each type of circuit different cable sizes and fuses or miniature circuit breakers are used.

8.2 POWER CIRCUITS

8.2.1 Sockets

There are two types of sockets.

1. Radial Socket Circuit
2. Ring Socket Circuit

Radial Socket Circuit:

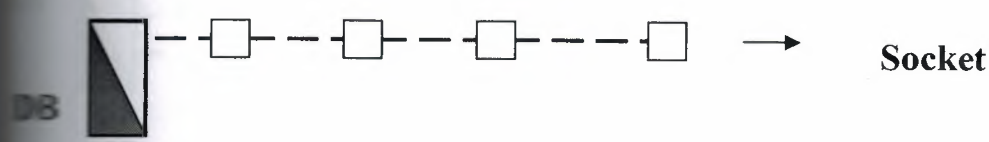
It has some standards.

In kitchen area two sockets can be put in radial socket circuit with 2.5 mm^2 conductor and 20 amps. fuse.

area, which is not in kitchen and less, than 30 m^2, 6 sockets can be put in radial with 2.5 mm^2 conductors and 15 Amp. fuse.

area is greater than 30 m^2, 6 sockets can be put in a radial socket cct. With 4 mm^2 and 20 Amp. fused.

Figure 1. Radial socket circuit



Socket Circuit:

you will start from one point and after you went to each point, you will come first point.

number of socket can be put in a ring socket circuit if the area less than 100 m^2, if greater than 100 m^2 in any building. You have to another ring socket circuits.

any sockets in a ring sockets circuits you can put spur from each sockets.

one stationary appliance can be put in a ring socket circuit either include in the ring as a spur. (Washing machine, dish washer, bathroom heater or heater, and water

these are connected to the ring socket circuit as a spur or with any heater switch. switch has to be fused.

For other power circuits cable sizes and value of fuse.

Figure 2. Ring socket circuit

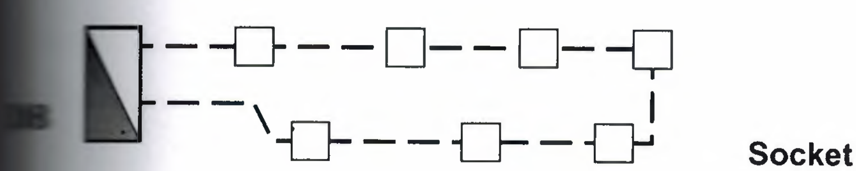


Figure 3. Ring socket circuit with spur sockets

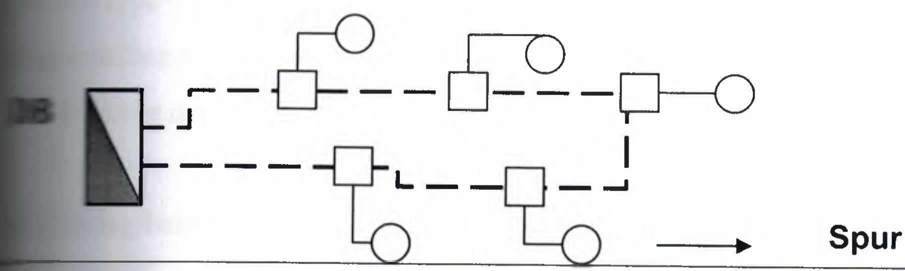


Table 5. Circuits cable thickness and fuses

	L+N	Earth	Fuses
...Control	6 mm^2	2.5 mm^2	30 A
...	2.5 mm^2	1 mm^2	15 A
... Washer	2.5 mm^2	1 mm^2	15 A
...g machine	2.5 mm^2	1 mm^2	15 A
...	2.5 mm^2	1 mm^2	5 A
... Heater	4 mm^2	2.5 mm^2	30 A
...nditioner	2.5-4 mm^2	1-2.5 mm^2	15-30 A

...TING CIRCUITS

...ng circuits generally, 1 mm^2 cable is used with 5 A fuse because the authority says ... lamb circuit you will put 10 lamp (100 W), this will be 1 kW=I=1kW/240=4.16 A. 5 ... must not be passed that's why we use the fife Amp. If we want to put more than10 ... in a circuit we have to change the cable size to 1.5 mm^2 with a 10 A fuse.

TYPES of DOMESTIC INSTALLATION

There are two types of installation; Surface Installation and under plaster installation.

Under Plaster Installation

Steps do this type of installation as follows;

Ceiling installation and stairs.

Inside of home and stairs.

Ceiling Installation;

Plastic pipes and plastic lamb box do this part of installation. Generally, 5/8 plastic pipes are used for cell lighting. While we are doing these also, pipes of stairs installation is fixed. Pipes and lamb boxes are out be cording to the electric installation project.

Following steps to do these.

Ceiling installation and stairs. First the lamp boxes are filled by wet papers. Lamps boxes are fill with concrete there fore we fill the inside of lamp boxes with paper not to have problem.

Lamps boxes will be nailed according to the electrical plan. If there is only single lamp in room. Lamp boxes will be nailed to the center of room. If there is more than one lamp. You have to follow a special ways. For example, in a corridor generally there are two lamps length of corridor will be divided by there and with will be divided two to point the place of lamp.

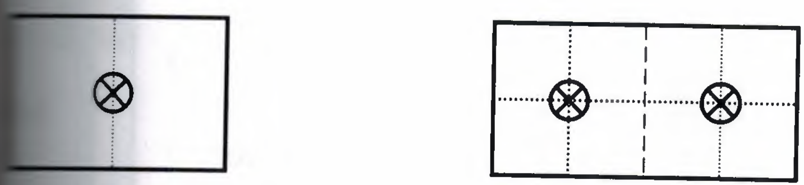
We will take out the pipes from the lamp boxes for switches (to under of the roof). We have to be careful. When we put the pipes inside of the coulomb the pipes, which will be come of must not be above doors or windows and also, it should not be behind doors.

For each circuit, from the lamb boxes, pipes will be taken out up to the distribution board. This done as same as position of switches.

will be put for the heater and for the water tank on the roof to the distribution board.

antenna and telephone lines pipes are fixed to the suitable position (1" or ¾"). In extra pipes are put in stairs for main lines and for the lighting of stairs. They are of the coulomb

Figure 4. Ceiling installation samples



Inside of Home and Stairs.

to the plan, you paint the positions of sockets, switches, etc. with paint (spray Painted places have to be broken. Metal boxes and plastic pipes that are in different each type of circuit.

for lighting, telephone lines, water pump, and earthing.

sockets, antenna, heater circuits.

fore cooker control

thicker is used for main lines,

metal boxes are being put they have to have different heights. These heights are;

dinning rooms, and corridor, sockets/Telephone/Antenna sockets 50cm floor to metal box)

150cm (between floor to metal box)

lamps on wall 200cm (between floor to metal box)

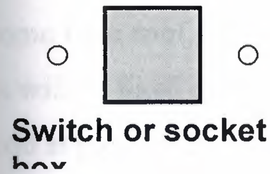


Figure 5. Switch or socket box

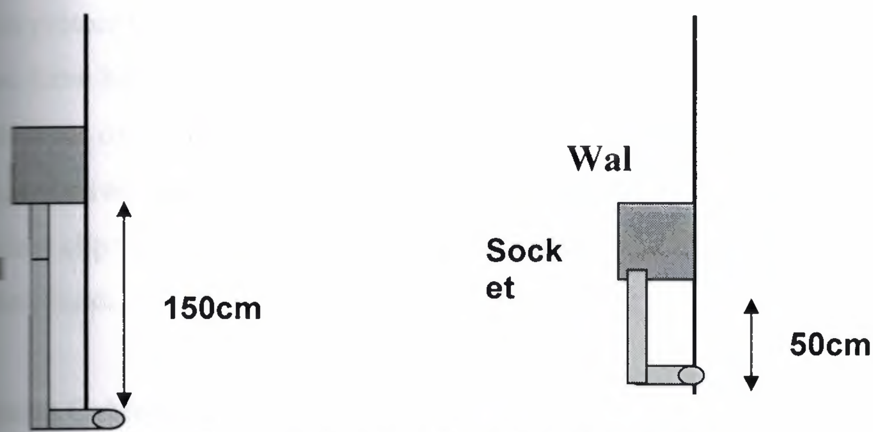


Figure 6. Height of switch and socket boxes

Kitchen;

…have to be careful for position of metal boxes. Because cooker, switches, sockets …ave to be at the same line and you have to measure careful not to put them on the …he cupboards and this height is generally 125cm.

…and Bathrooms;

…not put the metal box of switches inside of toilets or bathrooms, because you may …of electric shock. Lamps must be waterproof. In these wet places, we have to use …components for protection of life. Height of lamp is nearly at 200cm.

…of the metal boxes must not be plastered because, metal box will have corrosion …

…the places of switches, sockets, etc.

ted paces have to be broken, up to 65cm for sockets, switches 150cm, if the pipes of will come from roof, that pipe will come to 150cm painted line.

box will be fixed at painted places, but they have to be flat and good appearance we wire on at piece of flat wood. This wood is nailed to the wall.

bend the pipes from anywhere of pipes, where it is needed and put them in boxes from box.

plasterer to fait and the pipes plasters these boxes which are on floor are also to protect the pipes.

these have been finished, we will pull the cable as connecting to the special stainless What types of cables are suitable for each circuit.

toilets and bathrooms metal place labs will be earthed by special clips which is earthen clips and also switches, sockets and something like these will be connected and alled finish.

sing Cable Sizes

tion of the size of a cable to carry a load current involves the consideration of the type of the protective device, the ambient temperature, and whether other cables ngside the cable (grouping). There are many situations in which cables can find es being overheated. The more obvious are the conditions set up when over currents ed due to overloading and when a short-circuit occurs. Others include the increase in ure when a number of current carrying cables are bunched together, for instance in nd trunking, which is a situation in which each cable contributes its heat to that of which, because of tile enclosed situation, produces an environment, which can ead to the deterioration of the cable insulation (particularly when PVC is involved) a possible source of fire. At about 80 ^{0}C, PVC becomes very son, so that a can 'migrate' or travel through the insulation and eventually make contact with etalwork. This produces a shock-risk situation, with an increase in the leakage ch could prove fatal if the installation earthing arrangement is faulty. Eventually, sulation breaks down completely, a short-circuit occurs and the circuit is now on the ability of the over-current protection device to operate to disconnect the its supply. As is probably realized, the time of operation of the protective device a semi-enclosed fuse will take longer to operate than would a miniature circuit some circumstances, particularly where PVC insulated cables are used, the time semi-enclosed fuse to operate may be long enough for the cables to burn out and fire hazard.

problem, which has occurred in recent years, concerns the use of thermal insulation ...ngs, with cables being installed in conditions where the natural heat produced by even ...al load currents cannot be dissipated easily. The IEE Regulations recognize the fact ... these circumstances, the ratings of cables have to be reduced quite considerably. These ...ions are used in the tables, which give the current-carrying capacities of cables. The ... conditions include 'enclosed (e.g. in conduit, trunking and ducts); 'open and ...irect' (e.g. clipped to a wall, to a cable tray, embedded direct in plaster which is not ...-insulating, and suspended from a catenaries wire); 'defined conditions', which ...cables in free air; and cables 'in enclosed trenches'.

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

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

...ent temperature in which the cable is installed;

...llation condition, e.g. whether grouped or bunched with other current-carrying ...closed or installed open';

... the cable is surrounded by or in contact with thermal insulating material;

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

... of choosing the correct size of conductor for a particular load condition, as ...ded by the IEE Regulations, is based on the rating of the over current protective ... All factors affecting the cable in its installed condition are applied as divisors to the ... the device. In general, the size of every bare conductor or cable conductor shall be ... the drop in voltage from the origin of the installation to any point in that installation ...ceed 4% of the nominal voltage when the conductors are carrying the full load ... It should be noted that conductors of large cross-sectional area have different volt ...ampere per meter for ac circuits than those operating from dc supplies. This is ... the reactance inherent in conductors carrying ac.

...ing process for working out the correct size of cables is as follows:

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

... the correction factor for the ambient temperature, which of course does not

the heat generated in the cable itself, but is more concerned with the maximum
...re of the medium through which the cable runs.
...ne the correction factor for grouping.
...ne the correction factor if the cable is in contact with or is surrounded by thermal
... material. Two factors are given: 0.75 if only one side of the cable is in contact with
...al (e.g. a cable clipped to the side of a joist) and 0.5 if the cable is completely
...ed by the material.
...e rating of the over current device. If this is offering what used to be called 'close'
..., the correction factor is 1. If, however, protection is by means of a semi-enclosed
...actor is 0.725. The rating of the device must at least equal the load current.
...ne the size of the circuit conductor by calculating its current rating.
...at the volt drop does not exceed the maximum permissible allowed.
...ents the current rating of the conductor and I_n the rating of the protective device,

$$I = \frac{I_n}{\left(C_g \times C_a \times C_i \times C_f\right)} amperes$$

C_g is the factor for grouping;
...ctor for ambient temperature;
...factor for thermal insulation (0.5 if cable is surrounded and 0.75 if the insulation is
... with only one side of the cable;
...ctor for the over current device. This factor is 1 for all devices except semi-
...ses, when the factor is 0.725.

CHAPTER 9: SPECIAL INSTALATIONS

Whilst the bulk of electrical installation work carried out in this country does not involve the consideration of special factors in the context of the wiring systems, accessories and the equipment to be used in an installation, there are some types of installation conditions which require special consideration. These conditions create the need for what are called in this book 'special installations', which tend to fall out with the general run of installations and have their special and particular requirements to be satisfied. These special installations are dealt with in the IEE Regulations in a rather general way and the electrician must therefore seek other sources of information as to installation procedures, techniques, and recommended types of equipment. These sources include BS Codes of Practice and manufacturers' instructions, and IEE Regulations.

Damp Situations

In general terms a 'damp situation' is one in which moisture is either permanently present, or intermittently present to such an extent as to be likely to impair the effectiveness of an installation conforming to the requirements for ordinary situations. These situations create a risk from electric shock (particularly from surface leakage over otherwise healthy insulation) and the risks, which attend a gradual deterioration of the metalwork of the installation as the result of corrosion.

The IEE Regulations require that every cable installed in a damp situation, and where it is exposed to rain, dripping water, condensed water, and accumulations of water, shall be of a type designed to withstand these conditions. In addition all metal sheaths and armour of cables, metal conduit, ducts or trunking, and clips and their fixings, shall be of corrosion-resistant material. In particular, they should not be placed in contact with other metals with which they are liable to set up electrolytic action. If steel conduit is involved in such damp situations, it must be of heavy gauge. Conduit threads should be painted over with a protective paint immediately after erection Cables, which are armoured and destined for installation in a damp situation, are required to have further protection in the form of an overall PVC sheath.

Although an installation is not classed as 'damp', there may occasionally arise a situation, which would place it in this category. This is one result of condensation, which, though it may occur intermittently, may well appear in the form of a considerable quantity of moisture. Condensation exists where there is a difference in temperature, for instance, equipment is installed inside a room in which the ambient temperature is high, the being controlled by switchgear outside the room in a lower ambient temperature. If gear and the equipment are connected by trunking or conduit, then condensation is occur. It will also occur where a room has a high ambient temperature during the day the temperature subsequently falls when the room is unoccupied during the night.

whenever dampness, whatever its source, is present, galvanized or sherardised is recommended. In addition, site conditions may be such that fixing accessories rials may also he required to withstand any corrosive action that might occur. If used, drip points should be provided so that water can drip away. Long runs of should be slightly off level to allow any accumulated condensate to run to a drain the lowest level.

blem of condensation occurs frequently in cold-store installations and around on plant. Switchgear and other control equipment should be installed outside the in a position some reasonable distance away from blasts of cold air and clear of ngs where changes in temperature are likely to occur. Cables of the MICS and hed types should be glanded into totally enclosed lighting fittings and run into the bers on wood battens. Cable entries into cold rooms should be sealed with some material. It is important to recognize that working PVC cables in low res will injure the cables. At temperatures below $0^{\circ}C$, PVC has a 'cold-shatter' stic and may crack if hit sharply. There is also a warning note regarding the use of bituminous-compounded beddings or servings.

sion

metal is used there is the attendant problem of corrosion. Two conditions are for corrosion: a susceptible metal and a corrosive environment. Nearly all of the metals in use today corrode under most natural conditions; the bulk of all anti- measures have thus been attempts either to isolate the metal from its environment, ging the environment chemically to render it less corrosive In installation work, the of corrosion tend to be more acute in certain types of installation. Chemical works, cow byres and other ammonia-affected areas, all require special consideration in gn and the work executed to produce the installation. Corrosion, in a normal condition, may affect earth connections.

on of metals in contact with soil or water is an electrochemical reaction; that is, the reaction involves both the chemical change (e.g., from iron to rust) and a flow of current. It is this principle, which is used in the dry cell, where the corrosion of the provides the cell's electrical output. The current flows from the metal into the soil or called the electrolyte) at the anode and then from the electrolyte into the metal at the Corrosion occurs at the point where the current flows from tile metal into tile te. Every metal develops its own particular electrode potential when placed in an or similar medium. If two different metals are coupled together in the same tile difference between their potentials will be sufficient to produce a current of The metal with the more negative potential will suffer corrosion. It follows that the patible the metals are, the less will be the rate of progress of any corrosive action takes place between them, because the amount of potential difference between them is

there is a 'natural' potential of -0.3 to - 0.6 V between a buried mass of metal and its soil. This potential is measured by using a very-high-resistance voltmeter and a called a half-cell, which consists of a copper rod immersed in saturated copper solution contained in a plastic tube which has a porous plug at the bottom for making with the soil as near as possible to the buried mass. Certain areas of the mass surface as anodes (where the current leaves the metal) and these will corrode. The areas, as cathodes (where the current enters the metal) do not corrode. This sub-division in of the surface of the buried mass is due to the fact that the areas assume the roles of and cathodes depending upon variations in the metal itself, its surface treatment, and lyte.

the amount of current that flows from it into the surrounding medium or electrolyte sh the corrosion of a metal. Painting or otherwise coating the metal will increase cal resistance of both anodes and cathodes. But if the coating has flaws or holes in the current concentrates at these points and deep pitting will occur. The corrosion can also be reduced by lowering the electrical potential difference between the anodes thodes either by controlling the purity of the electrolyte or by adding inhibitors to it. only the anodes corrode, current flowing into them from an introduced external as to cause the whole of the buried structure to become a cathode can prevent This is the principle of cathodic protection. The method can be used only where the anode can be accommodated within the electrolyte that surrounds the buried metal, il or water must be present in bulk.

thod is widely employed as a corrosion preventive measure on underground k. Two basic techniques are used to give cathodic protection: (i) the sacrificial anode

(ii) the impressed current system.

first method , a mass of base metal, such as magnesium, is buried in the electrolyte and ...ed electrically to the structure to be protected. The natural difference in potential ... the structure metal, usually steel, and the magnesium causes a current to flow from ...esium (the new anode) through the electrolyte to the steel, which is the new cathode. ...de gradually corrodes and is thus called a 'sacrificial anode'. In practice a closely ...ed magnesium-alloy is used. The main factors which govern the degree of protection, ... current output from the galvanic cell so formed by the protective system, are the ... area, volume and shape of the anodes used, the resistivity of the electrolyte and the ... area of the exposed metal being protected. The sacrificial anode system is common in ...d areas since the low potentials generated by the galvanic system virtually eliminate ...bility of corrosion arising on adjacent metal structures on account of stray current. ...em also needs no external electrical supply and is to a great extent self regulating in ... which latter will vary according to the resistivity of the surrounding medium (e.g., in ... dry weather conditions). The anodes need periodical renewal. In reasonable soil ...ns, the life of an anode may be up to 15 years.

...nd method of protection, the impressed-current system, uses a conventionally ...d direct current from rotating machinery or via a transformer/rectifier unit. The ... side of the supply is connected to the structure to be protected; the positive side is ... 'anode ground-bed' usually formed from high-quality graphite impregnated by resin, ... linseed oil, silicon iron or scrap iron or steel. The buried structure then becomes the ... The anode may, but need not, corrode. Silicon-iron and graphite anode ground-beds ...-inert and have a very long life. Scrap iron or scrap steel beds go into solution quite ... and disintegrate at the rate of about 10 kg/Ampere/year.

...work associated with electrical installations, which may require cathodic protection ... supporting lattice structures, armoured cables with rotted servings, metal pipes ... cables, and general structural steelwork.

... aspect of corrosion may not be too familiar to installation installers. This concerns ...ous exposure of PVC-insulated cables to temperatures above 115°C that may cause ...tion of corrosive products, which can attack conductors and other metalwork. ..., the precautions to prevent the occurrence of corrosion in normal installations

...prevention of contact between two dissimilar metals (e.g. copper and aluminium), ...y where dampness is likely to be present.

protection of cables, wiring Systems and equipment against the corrosive action of oil, and dampness, unless they are designed to withstand these conditions.

protection of metal sheaths of cables and metal-conduit fittings where they come into with lime, plaster, cement and certain hardwoods such as beech and oak.

use of bituminous paints and PVC over sheathing on metallic surfaces liable to in service.

d Distribution Systems

distribution Systems consist essentially of loudspeakers permanently installed in positions in buildings or in open spaces associated with buildings - They are part of the telecommunications Systems of buildings. The currents, which operate stems, are derived from a microphone, gramophone, radio receiver, or other device, or wire broadcasting service. These currents are of a very small order and so require to be to values suitable for the operation of loudspeakers. Sound-distribution systems are schools, theatres and cinemas, churches, meeting halls, factories, offices and stores, hotels and clubs, hospitals, railway stations and sports grounds. Though stems generally operate from mains supplies, some systems, or parts thereof, operate eries or from mains-supplied rectified current, producing low voltages.

nnel call Systems

systems are used in private dwellings, hotels, schools, factories, and other premises is required to attract the attention of individuals to a situation or circumstance. The system is where a caller calls a person to a particular position. In a private house, the is called to the door. A bell push or similar device is fitted at each such position indicator provided to show which push has been operated. A bell or buzzer is used to the sound, which will attract attention to the call. Bell pushes can be of the wall- table or pendant type; the contact points are of a metal, which gives long service becoming pitted or corroded. If the bell push is to be installed outside, protection the ingress of moisture must be provided.

are installed in a central position in the building. In large premises, such as hotels ries, the indicator board is located in a room in which some person is always in e.g., kitchen or reception office. The use of lamps is necessary where the sound must be either objectionable or useless, e.g., in hospitals at night or in noisy Hand-setting indicators should be mounted at a height convenient for access and

-call systems are used in very large hotels where the call points are too many to be conveniently on a single indicator board or panel. Pushes are fitted at each call the circuits are grouped to serve a corridor or floor. Each group gives the indication service room. In these systems, arrangements must be made to have attendants on corridors or floors to deal with the calls. Multiple-call systems use indicators, which be reset by the attendant.

systems are common in schools and factories to indicate the beginning or end of a period (e.g., break, class change, etc.). These systems usually have one or two pushes switches connected in parallel and a number of bells throughout the building, which connected in parallel. The bells can be controlled from a clock system, to eliminate element required with bell pushes.

ar-alarm system is also a call system. The switches in this case are sets of contacts at doors and windows. There are two circuit types; open-circuit and closed circuit. type requires contacts to close to energies the bell circuit. In the closed circuit type, are closed. A circulating current energizes a series relay with normally open When a contact set is opened, this current ceases to flow, de-energizes the relay, and relay contacts to ring an alarm bell. Some alarm systems operate from photoelectric work when an invisible light beam is broken. The large plate-glass windows of shops often have a series length of very thin wire, which, if broken when the is smashed in or a hole cut in it, will bring the relay into operation to ring a bell. In stems today, no bell rings, but a buzzer and light indication circuit is wired from the building and terminated at a nearby police station. Thus the intruder is not warned, have the opportunity of catching the burglar red-handed.

-circuit system is seldom used because it can be interfered with. For instance, a cut will render the complete system inoperative, whereas such a break in the series a circulating-current (closed-circuit) system will immediately set an alarm-bell Supplies are sometimes from the mains, but in this instance a standby-battery supply in the event of a power failure. Alarm bells are often installed in a place to unauthorized persons, and outside the building.

type of call alarm system is the watchman's supervisory service. It is designed to recorded indication of the visits of watchmen or guards to different pans of a the course of the duty round. The system uses a clock movement of the impulse, -time controlled a.c. or 8-day clockwork type installed at each contact station out the building. Each station has a box with a bell push operated by the insertion of a key. Operation of the contacts energizes an electromagnetic ally-operated marker records the time of the visit on a paper marked off in hours. In some systems, an alarm after a predetermined time if the watchman fails to 'clock in' at any contact station.

call systems are used instead of bells. These Systems use color lights, which staff to fulfill a service duty. They are largely used in hospitals and hotels. When the is pressed in any position in the building, a small lamp lights in a duty room to the general area from which the call has come. Alternatively, a lamp outside the call lights and remains so until an attendant extinguishes it by operating a reset push located side the room. Some systems incorporate a single-stroke bell. Call and indicating is also incorporated in lift systems.

Fire-Alarm Circuits

alarm is defined as 'an arrangement of call points, detectors, sounders and other for the transmission and indication of alarm and supervisory signals, for the testing circuits, and where required, for the operation of auxiliary services' Section 37(7) of the Act of 1937 states: where in any factory... more than 20 persons are employed... provision shall be made for giving warning in case of fire, which shall be clearly throughout the building.

alarm system consists of a number of press-buttons or call-points, which operate bells, or hooters, generally known as 'sounders'. Manually operated call-points are effective there are persons present to give an alarm. But if protection from fire is required when premises are unoccupied, as at night and during weekends or during holiday periods, then call-points are necessary. On very large premises, additional circuitry is included in systems to give an indication of the location of the fire, so that firemen can go to the fire and allow staff to leave the building by safe routes which by-pass the fire

closed-circuit type of system is used so that circuit failure or breakage will at once be by an audible alarm. Manual call-points consist of a pair of contacts kept together sheet of glass, which, if broken, in the event of a fire, or maliciously, will cause the to separate and, through a relay, energies a bell or alarm circuit. All call-points are to be colored red. The method of operation (e.g., 'Fire Alarm: in case of fire, break must be clearly indicated either on the point itself or on a label beside it.

call-points are known as 'detectors' and are heat-sensitive, which means that they sitive to a rise in the ambient temperature of a room. They come into operation at a mined temperature (e.g., 80°C).

are two types of heat detector. The more common type is the 'point' detector, which, as me suggests, is relatively small. The other type is the 'line' detector, which has a long ous sensitive detecting element extending over a large area of ceiling. The sensing ts used in heat detectors include:

al strips, rods, wires or coils, which expand when heated.

ble alloys.

ctors whose electrical resistance changes with a rise in the ambient temperature.

w tubes containing a fluid, which expands on heating and applies the resultant re to a diaphragm.

mocouples.

etectors ate of the light-sensitive type: photoelectric cells which operate when a beam illuminating the cells is scattered and absorbed by smoke particles. Heat and smoke s are liable to give false alarms in certain conditions:

t detectors. False alarms may be caused by abnormal increases in temperature due to eating equipment, industrial processes, and sunshine.

ke detectors. Smoke and other fumes, dusts, fibers may cause false alarms, and steam d by normal processes and activities, or by passing road vehicles. Those detectors, se a beam of light to illuminate a photoelectric cell, may also give false alarms if the s accidentally obstructed.

c call-points are sometimes designed to give an alarm and also to bring into an auxiliary fire service, such as a sprinkler system. Other examples of such are the closing of windows and the closing of the covers of tanks, which contain ble liquids.

ans of giving an audible warning of fire is a statutory obligation in certain premises e Offices, Shops, and Railway Premises Act, 1963. Normally for these premises, an c fire alarm system must also be capable of manual operation, but this may not be y if the fire risk is low.

e installation a visual indicator panel (enunciator board) sited in a position agreed ocal Fire Authority, is normally incorporated in the system. All circuits to which are fitted are connected to it. Each circuit is connected to a separate enunciator, so a detector actuates, it indicates on the board the area in which the fire has occurred. ls are also provided with test facilities, by means of which the circuits can be tested ain faults indicated. With some systems, faults are indicated automatically.

devices included bells, sirens, hooters, or whistles; they may be arranged to give ocal or general alarms. In either case, the warning should sound continuously once a has operated, until the Fire Brigade arrives. An external audible warning device is ended for mounting near to the visual indicating panel. The device should indicate uilding is involved, this being particularly necessary for premises, which comprise uildings. In hospitals, department stores and other places where a general internal s not thought desirable, an alarm may be given at a manned central point only and passed by telephone or light signal to other parts of the premises.

ect of an automatic fire-alarm system is to call the fire brigade. The most effective and means of satisfying this requirement is the provision of a signal, which is cally transmitted to the local fire brigade, through a direct-line connection. The line continuously monitored so that an immediate alarm is given as soon as a fault regular testing can be arranged.

ethods use an auto-dialing unit at the protected premises, which connects alarm calls rm of a pre-recorded message, either via the public '911' emergency call service to the ate fire-control room, or direct via the automatic telephone system to a pre-selected e number. This method is cheaper than the direct-line method, but is less reliable. It e reason, connection to the appropriate fire-control point is not achieved at the first it is possible for an alarm call to be lost. Also, this system cannot be continuously d for faults because it is not permanently connected to the point where the alarm calls ved.

endations on wiring and equipment used are set out in BS Code of Practice BS 5839, so includes recommendations on suitable power supplies.

wing bibliography contains information on fire alarm systems:

r Automatic Fire Alarms - Fire Offices' Committee

6 - Heat Sensitive Detectors for Automatic Fire Alarm Systems in Buildings c Fire Detection and Alarm Systems -Fire Protection Association. Fixed Fire hing Equipment in Buildings - Fire Protection Association

Regulations recognize fire-alarm circuits as 'Category 3' circuits, in that fire-alarm or reasons of security, should be segregated from each other as well as completely from any other wiring. Mains-voltage circuits (Category 1) for sounders, battery- and other auxiliary circuits in a fire-alarm system should also be completely from other (Category 2) circuits in the same fire-alarm system. If Category 3 (fire-

...in faults indicated. With some systems, faults are indicated automatically.

... devices included bells, sirens, hooters, or whistles; they may be arranged to give ... local or general alarms. In either case, the warning should sound continuously once a ... has operated, until the Fire Brigade arrives. An external audible warning device is ...ended for mounting near to the visual indicating panel. The device should indicate ... building is involved, this being particularly necessary for premises, which comprise ... buildings. In hospitals, department stores and other places where a general internal ... is not thought desirable, an alarm may be given at a manned central point only and ... passed by telephone or light signal to other parts of the premises.

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...dio and TV

...tion of aerials for the reception of radio and TV broadcasts is usually undertaken by ...ialist. In buildings, which consist of blocks of flats, communal pick-up services are ..., being fed from a communal pre-amplifier. This unit is installed as near as possible ... aerial site so that any interference picked up by the intervening feeder is reduced to a .... The contractor's interest in these Services is mainly confined to the provision of ... or socket-outlet facilities. In a multi-point television installation, Up to twenty ... points may be connected to one cable, which is looped through the socket-outlets.

...ephone Systems

...nciple of Operation (Figure 9.8)

(a) If the resistance of the variable resistor is varied, the current flowing in the circuit will vary (Ohm's Law).

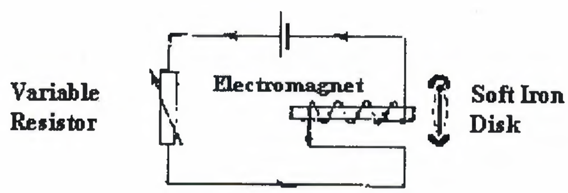


Figure 9.8 Telephone Principle of operation.

(b) These variations in current will cause variations in the strength of the ...ectromagnet.

(c) Variations in the strength of the magnetic field will vary the 'pull' on the soft-... diaphragm (or disc). The disc can be made to vibrate by varying the resistance in ... circuit.

...ple Telephone Circuit. In the simplest telephone circuit (Figure 9.9)

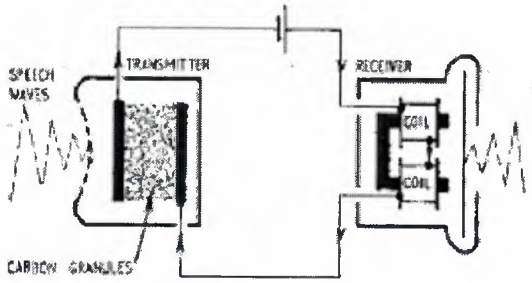


Figure 9.9 Simple telephone circuit

...itter (or microphone) takes the place of the variable resistor. Variations in resistance ...sed by the pressure of sound waves from the voice acting on a layer of carbon ...es, thus varying the current in the circuit. The electromagnet of the receiver changes ...riations in cur-rent back into sound waves by attracting and repelling the soft-iron ...m. Soft iron is used because it does not retain magnetism.

...tion of Transmitter and Receiver. The transmitter (Figure 9.10) consists of a sealed ... containing carbon granules (powdered carbon). The tone-shaped diaphragm presses ...anules, which are placed between two electrodes.

...eceiver (Fig. 9.11) contains the following:

1. A soft-iron diaphragm.
2. Two coils (connected in series) which are wound round a U-shaped permanent ...net.

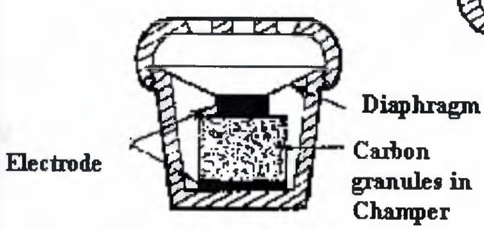


Figure 9.10 The Transmitter.

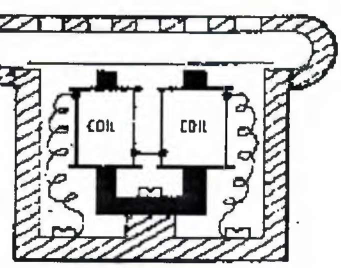


Figure 9.11 The Receiver.

Two-position Telephone Circuit. Figure 9.12 shows the circuit of a simple circuit ... for communicating over short distances.

...sists of a d.c. supply a transmitter and a receiver.

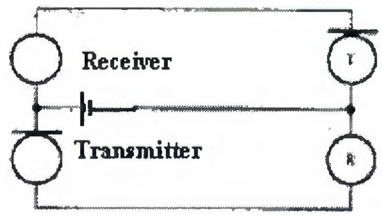


Figure 9.12 Two-position telephone circuit.

The Relay

relay Figure 9.13 consist of coil of insulated wire wound around a soft iron core, when coil is energized the hinged armature is attached

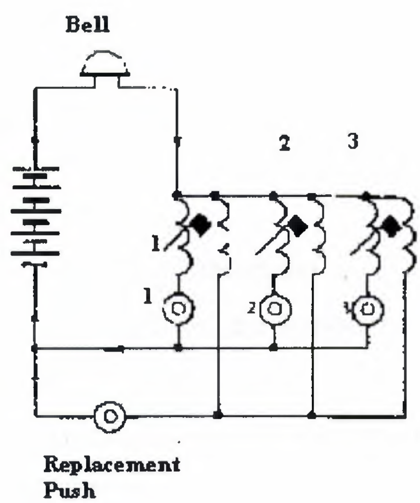
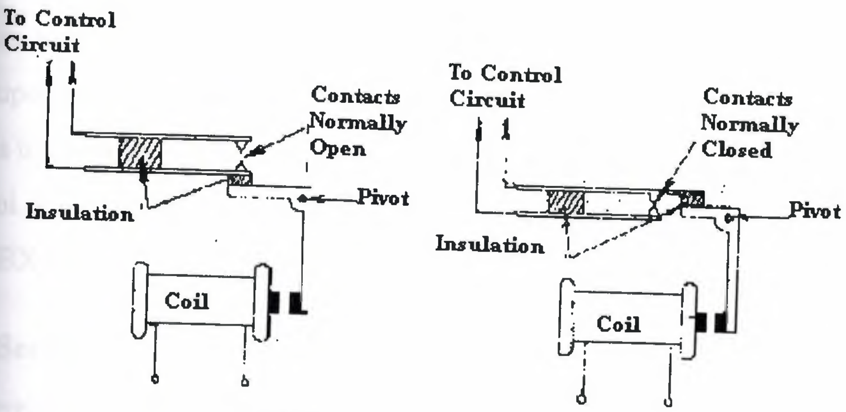


Figure 9.13 Indicator circuit using electrical replacement-type elements.

the electromagnet and presses two contacts together. The relay in Figure 9.14 is a normally open (N.O.) type. The contacts are open until the coil is energized.
The relay in Figure 9.15 is a normally closed (NC.) relay. The contacts remain open while coil is energized. When the coil is de-energized, the contacts close.

Applications. The relay is generally used in industry to control heavy currents from distance so that the power losses (I^2R) in the cables will be minimized. The operating current in a relay is usually a fraction of an ampere.
Examples are: control of circuits in power stations, control panels for industrial machines,

starter circuit, and alarm circuits.



(Left) Figure 9.14. Construction of Relay. (Right) Figure. 9.15. Normally closed (N.C.) relay.

stems are either internal or are connected to the public telephone facilities. All ms, which have public connections, are subject to the supervision and approval of one companies whose engineers normally undertake the final connecting-up. The contractor is generally required to install conduit or trunking to facilitate the wiring lding for telephone outlets. In large buildings a main switchboard is installed to coming calls, which are then switched to the required extension phone. There are s of private installations: PMBX (private manual branch exchange) and PABX tomatic branch exchange).

BX system, each extension phone is wired to the main switchboard and connection y sockets called jacks. There are certain disadvantages associated with this system, ally requires an additional internal phone system.

BX system, all incoming calls are terminated at the manual switchboard and are by the telephone operator. All extension to extension calls are set up automatically out dialing on certain extensions is possible. All extension phones can call the who can identify the extension on a lamp-per-line basis. Direct access to the local

Brigade can be incorporated in the system, a special code being allocated for this purpose. A cordless switchboard (PMBX 4) is a more recent development of the PABX system. It has a switchboard with a translucent screen or lamp signaling. It enables the operator to supervise and connect all calls with full control given by a few levers and keys. When a call is transferred to an extension it disappears from the switchboard and is then under full control of the extension; this is a feature not available with the older approved system known as PABX 3.

Building Services

While the electrical contractor's interest in a contract tends to be centered on the provision of power-fed electrical installation which meets the requirements of the client's specification; there are other services with which he may be involved; these are outlined in general in this chapter. The extent to which these services are part of the overall electrical provision of a client's premises depends on function of the building or buildings.

When new buildings are being considered, the client or owner considers the extent to which additional services (e.g. radio and TV aerials, telephones) are required. There is of course the difficulty and cost incurred if these are installed after the main building is completed. The disturbance to decorations is an expected result of inadequate planning and adds further expense, which can be avoided in the initial stages of the electrical provisions.

Multi-tenanted office blocks require really detailed planning for provision of adequate socket-outlets for mains-operated machines, and for bell and telephone circuits with outlets located in all possible strategic positions which will appear 'right' irrespective of alterations in internal wall positions, changes in the position of desk and other office furniture, or changes in the functions of room. Separate mattering for different tenants may also have to be considered.

Industrial premises have their work areas reasonably stable ones to machinery and

equipment is installed. Even so, the systems of the secondary electrical services have to be considered in the event of possible foreseeable changes.

Domestic premises present the least number of problems where the provision of services is concerned. However, it is common nowadays to cater for doorbells, radio and TV aerials and points, and telephone companies' telephones. Boarding houses and hotels may require staff bell-call systems, and extension phones connected to a small private exchange switchboard. Premises, which comprise a number of buildings, may require outdoor lighting,

ghting provisions, or road lighting.

Clock systems

These clock systems are used where a number of clocks throughout a building are required show the same time, or else used to operate time-recorders for stamping time-cards which state when work has been started or finished.

Most clocks found in small installations are independent units, run by a synchronous motor from mains voltage. Impulse-clock systems are independent of mains and operate from low voltage supplies. The master clock is the name given to the primary unit, which controls all other clocks in the installation. It is pendulum-operated and has an impulse transmitter, which transmits electrical impulses of alternate polarity at one-minute intervals a two-wire circuit to the subsidiary or 'slave clocks'. The slave clocks have movements, accept these impulses and alter their clock hands accordingly.

The mechanism of one type of master clock consists of a pendulum of half-seconds beat driven by an electrically wound spring through a dead-beat escapement. At each one-minute interval, while a small synchronous motor is rewinding the main spring, an impulse is transmitted to the subsidiary clocks. The mains a.c. supply is transformed to 48 V for driving the synchronous motor and gain reduced and rectified to provide 24 Vd.c for the transmitted impulses. Should the mains supply be interrupted for any reason, the main supply sufficient reserve to operate the escapement movement and hands for about 10 hours, but no impulses will be transmitted to the subsidiary clocks. The movement of a subsidiary clock is a one-minute polarized movement with a rotating armature, and incorporates a flywheel to render the hands 'dead-beat'. The usual master-and-slave installation can cater for up to 60 clocks. To add clocks to the system, it is only necessary to connect a clock in parallel with the remainder.

Clock load and the connecting cables should total a certain value of resistance so that the farthest-away clock has sufficient voltage at its terminals. The impulse current is around 220 mA. In series-impulse clock systems, the voltage required for the installation is calculated at total resistance multiplied by the impulse current of

mA. Sixty volts is the required maximum. Should the required operating voltage be above the installation should be sub-divided. As it is occasionally required to remove a clock series system, shorting-blocks' are provided.

CONCLUSION

Every single day, the technology and electronic sector are developing. However an Elecrtic Electronic Engineer has to develop her or himself. Because an Engeneer never be a Perfect Engineer. Engineering knowledge is infinite and increases with the time.

The importance of electrical installations is shown in our daily life, where there are no building or house, in the cities, that are free from electrical installations.

It is something essential in our life, and we cannot manage without it.

Industry, agriculture and transportation, all depend on electricity and electrical installations directly or indirectly.

For an electrical engineer the most important subject is drawing electrical installation projects. Because the engineer is imagining something that is not present and he or she has to think and apply in a very unusual and complex way. We choose a project about electrical installation.

While working in the topic of electrical installation everyone, technicians or engineers should be very careful because small mistakes can cause big damages in application.

This project also showed us it is not enough to just to be an engineer. Also an engineer has to be a good electrical technician to clarify his mine about some critical points while drawing electrical project.

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