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Extracts from Indian Electricity Amendment Rules-1972

The Indian Electricity Rules have been framed to ensure safety, satisfactory operation of equipment and to avoid fire risk. Important extracts from these Rules are given below.

28. **Voltage**. The difference of electric potential measured in volts between any two conductors or between any part of either conductor and the earth as measured by a suitable voltmeter and said to be :

'Low'. Where the voltage does not exceed 250 volts under normal conditions.

'Medium'. Where the voltage does not exceed 650 volts under normal condition.

'High'. Where the voltage does not exceed 22000 volts under normal conditions.

'Extra High'. When the voltage exceed 22 KV.

29. **Construction, installation, protection, operation and maintenance of electric supply lines and apparatus.** All electric supply lines and apparatus shall be of sufficient in mechanical strength and size for the work they may be required to do and shall be constructed, installed and protected in accordance with I.S.I.'s specifications.

30. **Service lines and apparatus on consumer's premises.** (1) The supplier shall ensure that all electric supply lines, wires, fitting, and apparatus belonging to him or under his control which are on a consumer's premises are in a safe condition and in all respects fit for supplying energy, and the supplier shall take due precautions to avoid danger arising on such premises from such supply lines, fittings and apparatus.

(2) Service-lines placed by the supplier on the premises of a consumer which are underground or which are accessible shall be so insulated and protected by the supplier as to be secured under all ordinary conditions against electrical, mechanical, chemical or other injury to the insulation.

(3) The consumer shall, as far as circumstances permit, take precautions for the safe custody of the equipment on his premises belonging to the supplier.

(4) The consumer shall also ensure that the installation under his control is maintained in a safe condition.

31. Cut-out on consumer's premises :— (1) The supplier shall provide a suitable cut-out in each conductor of every service line other than an earthed or earthed neutral conductor or the earthed external conductor of a concentric cable within a consumer's premises, in an accessible position. Such cut-out shall be contained within an adequately enclosed fire-proof receptable.

Where more than one consumer is supplied through a common service-line, each such consumer shall be provided with an independent cut-out at the point of junction to the common service.

(2) The owner of every electric supply line other than the earthed or earthed neutral conductor of any system or the earthed external conductor of a concentric cable, shall protect it by a suitable out-cut.

32. Indentification of earthed and earthed neutral conductors and position of switches and cut-outs therein— Where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor of a multi-wire system or a conductor which is to be connected thereto, the following conditions shall be complied with :

(1) An indication of a permanent nature shall be provided by the owner of the earthed or earthed neutral conductor, or the conductor which is to be connected thereto, to enable such conductor to be distinguished from any live conductor. Such indication shall be provided—

(*a*) where the earthed or earthed neutral conductor is the property of the supplier, at or near the point of commencement of supply ;

(*b*) where a conductor forming part of consumer's system is to be connected to the supplier's earthed or earthed neutral conductor, at the point where such connection is to be made ;

(c) in all other cases, at a point corresponding to the point as of commencement of supply or at such other points may be approved by an Inspector.

(2) No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductors shall be inserted or remain inserted in any earthed or earthed neutral conductor of a two wire system or in any earthed or earthed neutral conductor of a multi-wire system or in any conductor connected thereto with the following exceptions :

(a) A link for testing purposes, or

(b) A switch for use in controlling a generator or transformer.

33. Earthed terminal or consumer's premises :— (1) The supplier shall provide and maintain on the consumer's premises for the consumer's use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under rule 58 :

Provided that in the case of medium, high or extra high voltage installation, the consumer shall, in addition to the aforementioned earthing arrangement, provide his own earthing system with an independent electrode :

Provided further that the supplier may not provide any earthed terminal in the case of installations already connected to his system on or before the date to be specified by the State Government in this behalf if he is satisfied that the consumer's earthing arrangement is efficient.

(2) The consumer shall take all reasonable precautions to prevent mechanical damage to the earthed terminal and its lead belonging to the supplier.

(3) The supplier may recover from the consumer the cost of installation of such earthed terminal on the basis laid down in sub-rule (2) of rule 82.

34. Accessibility of bare conductors :—Where bare conductors are used in a building, the owner of such conductors shall—

(a) ensure that they are inaccessible :

(b) provide in readily accessible position switches for rendering them dead whenever necessary ; and

(c) take such other safety measures as are considered necessary by the Inspector.

35. Caution Notices :—The owner of every medium, high and extra high voltages Installation shall affix. permanently caution notices in Hindi, or English and Local Language of the distriction with a sign of skull and bones on poles, motors. transformers etc.

37. Supply to vehicles, cranes etc. :—Every person owning a vehicle, travelling crane or the like to which energy is supplied from an external source shall ensure that it is efficiently controlled by a suitable switch enabling all voltage to be cut off in one operation and, where such vehicle, travelling crane or the like runs on metal rails, the owner shall ensure that the rails are electrically continuous and earthed.

38. Cables for per portable or transportable apparatus (1) Flexible cables shall not be sued for portable or transportable motors, generators, transformers, rectifiers, electric drills, electric sprays, welding sets or any other portable or transportable apparatus unless they are heavily insulated and adequately protected from mechanical injury.

(2) Where the protection is by means of metallic covering, the covering shall be in metallic connection with the frame of any such apparatus and earth.

42. Ruler. Every circuit and apparatus should be so arranged that there is no danger of their getting charged with a voltage higher than for which they are intended.

43. Provisions applicable to protective equipment :— (1) Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires, in addition to fire extinguishers suitable for dealing with electric fires, shall be conspicuously marked and kept in all generating stations, enclosed sub-stations and enclosed switch stations in convenient situations.

(3) First-aid boxes or cupboards, conspicuously marked and equipped with such contents as the State Government may specify, shall be provided and maintained in every generating station, enclosed sub-station and enclosed switch station so as to be readily accessible during all working hours. All such boxes and cupboards shall, except in the case of unattended sub-stations and switch stations be kept on charge of responsible persons who are trained in first-aid treatment and one of such persons shall be available during working hours.

Instructions for restoration of persons suffering from electric shock :— (1) Instructions, in English, Hindi and the local language of the district, for the restoration of person suffering

from electric shock, shall be affixed by the owner in as conspicuous place in every generating station., enclosed sub-station, enclosed switch station and in every factory as defined in clause (*m*) of section 2 of the Factories Act, 1948 (LXIII of 1948) in which electricity is used and in such other premises where electricity is used as the Inspector may, by notice in writing served on the owner direct.

(2) Copies of the instructions shall be supplied on demand by an officer or officers appointed by the Central or the State Government in this behalf at a price to be fixed by the Central or the State Government.

(3) The owner of every generating station, enclosed sub-station, enclosed switch-station and every factory or other premises to which this rule applies shall ensure that all authorised persons employed by him are acquainted with and are competent to apply the instructions referred to in sub-rule (1).

45. Precautions to be adopted by consumers, owners, electrical contractors, electrical workmen and suppliers :— (1) No electrical installation work, including additions, alterations, repairs and adjustments to existing installations, except such replacement of lamps, fans, fuses, switches, low voltage domestic appliances and fittings as in no way alters its capacity or character, shall be carried out upon the premises of or on behalf of any consumer or owner, for the purpose of supply to such consumer or, owner, except by an electrical contractor licensed in this behalf by the State Government and under the direct supervision of a person holding a certificate of competency issued or recognised by the State Government :

Provided that in the case of works executed for or on behalf of the Central Government and in the case of installations in mines, oil fields and railways, the Central Government and in other cases the State Government may, by notification in the official Gazette, exempt, on such conditions as it may impose, any such work described therein either generally or in the case of any specified class of consumers or owners, from so much of this sub-rule as requires such work to be carried out by an electrical contractor licensed by the State Government in this behalf.

(2) No electrical installation work which has been carried out in contravention of sub-rule (1) shall be connected with the works of any supplier.

(3) The provisions of sub-rule (1) shall come into force in any oil field, mine or railway or any State or part thereof on such date

as the Central or, as the case may be, the State Government may, by notification in the official Gazette appoint.

46. Periodical inspection and testing of consumer's installation.— (1) (*a*) Where an installation is already connected to the supply system of the supplier, every such installation shall be periodically inspected and tested at intervals not exceeding five years either by the Inspector or by the supplier as may be directed by the State Government in this behalf or in the case of installations in mines, oil-fields and railways by the Central Government.

(*b*) Where the supplier is directed by the Central or the State Government, as the case may be, to inspect and test the installation he shall report on the condition of the installation to the consumer concerned in a form approved by the Inspector and shall submit a copy of such report to the Inspector.

(2) (*a*) The fees for such inspection and test shall be determined by the Central or the State Government as the case may be, in the case of each class of consumers and shall be payable by the consumer in advance.

(*b*) In the event of the failure of any consumer to pay the fees on or before the data specified in the fee-notice, supply to the installation of such consumer shall be liable to be disconnected under the direction of the Inspector. Such disconnection, however, shall not be made by the supplier without giving to the consumer seven clear days' notice in writing of his intention so to do.

(3) Notwithstanding the provisions of this rule, the consumer shall at all times be solely responsible for the maintenance of his installation in such condition as to be free from danger.

47. Testing of consumer's installation. (1) Upon receipt of an application for a new or additional supply of energy and before connecting the supply or reconnecting the same after a period of six months, the supplier shall inspect and test the applicant's installation.

The supplier shall maintain a record of test results obtained at each supply point to a consumer, in a form to be approved by the Inspector.

(2) If as a result of such inspection and test, the supplier is satisfies that the installation is likely to constitute danger, he shall serve on the applicant a notice in writing requiring him to make such modifications as are necessary to render the installation safe. The supplier may refuse to connect or reconnect the supply until the required modifications have been completed and he has been notified by the applicant.

48. Precautions against leakage before connection :— (1) The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not, at the time of making the connection, cause a leakage from that installation or apparatus exceeding one-five-thousandth part of the maximum current supplied to the applicant's premises.

(2) If the supplier declines to make a connection under the provisions of sub-rule (I), he shall serve upon the applicant a notice in writing stating his reason for so declining.

49. Leakage on consumer's premises. (1) If the Inspector or the supplier has reason to believe that there is in the system of a consumer leakage which is likely to affect injuriously the use of energy by the supplier or by other persons, or which is likely to cause danger, he may give the consumer reasonable notice in writing that he desires to inspect and test the consumer's installation.

(2) If, on such notice being given—

(*a*) the consumer does not give all reasonable facilities for inspection and testing of his installation, or

(*b*) a leakage exceeding one-five-thousandth part of the maximum current supplied to the consumer's installation is shown to exist, the supplier may and if directed so to do by the Inspector, shall discontinue the supply of the installation but only after sending to the consumer forty-eight hours' notice in writing of disconnection of supply and shall not re-commence the supply until go or the Inspector is satisfied that the cause of the leakage has been removed.

50. Supply to consumers. (1) The supplier shall not commence or continue to give supply of energy to any consumer unless:

(*a*) a suitable linked switch or a circuit-breaker of requisite capacity to carry and break the current is placed as near as possible to, but after the point of commencement of supply as defined under rule 58, so as to be readily accessible and capable of being easily operated to completely isolate the supply to the installation, such equipment being in addition to any equipment installed for controlling individual circuits or apparatus.

Provided that where the point of commencement of supply and the consumer's apparatus are near each other, one linked switch or circuit-breaker near the point of commencement of supply shall be considered sufficient for the purpose of this rule :

(*b*) a suitable linked switch or circuit-breaker of requisite capacity to carry and break the full load current is inserted on the

secondary side of a transformer, in the case of high or extra high voltage installation. Provided, however, that the linked switch on the primary side of the transformer may be such capacity as to carry the full load current and to break only the magnetism current of the transformer :

Provided further that the provision of this clause shall not apply to transformers installed in sub-stations up to and including 100 KVA belonging to the supplier ;

(*c*) every distinct circuit is protected against excess energy by means of a suitable cut-out or a circuit breaker or adequate breaking capacity suitably located and so constructed as to prevent danger from over heating, arcing or scattering of hot metal when it comes into operation and to permit of ready renewal of the fusible metal of the cut-out without danger :

(*d*) the supply of energy to each motor or other apparatus is controlled by a suitable linked switch or a circuit-breaker of requisite capacity placed in such a position as to be adjacent to the motor or other apparatus readily accessible to and easily operated by the person in charge and so connected in circuit that by its means all supply of energy can be cut off from the motor or apparatus, and from any regulating switch, resistance or other device associated therewith ;

(*e*) all insulating material is chosen with special regard to the circumstances of its proposed use, the mechanical strength being sufficient for its purpose, and so far as is practicable, is of such a character or so protected as to maintain adequately its insulating properties under all working conditions in respect of temperature and moisture ; and

(*f*) adequate precautions are taken to ensure that no live parts are so exposed as to cause danger.

(2) Every consumer or other user of energy shall so maintain his installation as to conform at all times to the provisions sub-rule (1), and shall use all reasonable means in his power to ensure that, where energy is supplied by a supplier, no person other than the supplier shall interfere with the service-lines and apparatus placed by the supplier on his premises.

51. Provisions applicable to medium high or extra-high voltage installations. The following provisions shall be observed where energy at medium, high or extra-high voltage is supplied, converted, transformed or used :

(1) (*a*) All conductors (other than those of overhead lines) shall

be completely enclosed in mechanically strong metal casing or metallic covering which is electrically and mechanically continuous and adequately protected against mechanical damage unless the said conductors are accessible only to an authorised person or are installed and protected to the satisfaction of the Inspector so as to prevent danger.

(*b*) All metal work enclosing, supporting or associated with the installation other than that designed to serve as a conductor shall if considered necessary by the Inspector, be connected with earth.

(*c*) Every main switch board shall comply with the following provisions, namely :

(*i*) a clear space of not less than 1 metre in width shall be provided in front of the switchboard ;

(*ii*) if there are any attachments or bare connections at the back of the switchboard, the space (if any) behind the switchboard shall be either less than 20 cms. or more than 75 cms. In width, measured from the farthest outstanding part of any attachment or conductor.

(*iii*) if the space behind the switchboard exceeds 75 cms in width, there shall be a passage-way from either end of the switchboard clear to a height of 1.8 m.

(2) Where an application has been made to a supplier for supply of energy to any installation, he shall not commence, or where the supply has been discontinued, recommence the supply unless he is satisfied that the consumer has complied in all respect with the conditions of supply set out in sub-rule (1) of this rules 50 and 64.

(3) Where a supplier proposes to supply or use energy at medium voltage or to recommence supply after it has been discontinued for a period of six months, he shall, before connecting or reconnecting the supply, give notice in writing of such intention to the Inspector.

(4) If at any time after connecting the supply, the supplier is satisfied that any provision of sub-rule (1) of this rule, or of rules 50 and 64 is not being observed, he shall give notice of the same in writing to the consumer and the Inspector specifying how the provision has not been observed and may discontinue the supply if the Inspector so directs.

48. Appeal to Inspector in regard to defects :— (1) If any applicant for a supply or a commence is dissatisfied with the action of the supplier is declining to commence, to continue or to recommense the supply of energy to his premises on the grounds that the installation is defective or is likely to constitute danger, he may appeal to the Inspector to test the installation and the supplier shall

not, if the inspector or, under his orders, any other officer appointed to assist the Inspector, is satisfied that the installation is free from the defect or danger complained of be entitled to refuse supply to the consumer on the grounds aforesaid, and shall, within twenty-four hours, after the receipt of such intimation from the Inspector, commence, continue or recommence the supply of energy.

(2) Any test for which application has been made under the provision of sub-rule (1) shall be carried out within seven days after the receipt of such application.

(3) This rule shall be endorsed on every notice given under the provisions of rules 37, 48 and 49.

53. Cost of inspection and test of consumer's installation: — (1) The cost of the first inspection and test of a consumer's installation carried out in pursuance of the provisions of rule 47 shall be borne by the supplier and the cost of every subsequent inspection and test shall be borne by the consumer, unless in the appeal under rule 52, the Inspector directs otherwise.

(2) The cost of any inspection and test made by the Inspector, at the request of the consumer or other interested party, shall be borne by the consumer or other interested party unless the Inspector directs otherwise.

(3) The cost of each and every such inspection and test by whomsoever borne shall be calculated in accordance with the scale specified by the Central or the State Government as the case may be in this behalf.

54. Declared voltage of supply to consumer. Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the voltage at the point of commencement of supply as defined under rule 58 to vary from the declared voltage by more than 5 per cent in the case of low or medium voltage or by more than $12\frac{1}{2}$ per cent in the case of high or extra-high voltage.

55. Declared frequency of supply to consumer. Except with the written concent of the consumer or with the previous sanction of the State Government, a supplier shall not permit the frequency of an alternating current supply to vary from the declared frequency by more than 3 per cent.

56. Sealing of meters and cut-outs :— (1) A supplier may affix one or more seals to any cut-out and to any meter, maximum demand indicator or other apparatus placed upon a consumer's

premises in accordance with section 26, and no person other than the supplier shall break any such seal.

(2) The consumer shall use all reasonable means in his power to ensure that no such seal is broken otherwise than by the supplier.

(3) The word 'supplier' shall for the purpose of this rule include a State Government when any meter, maximum demand indicator or other apparatus is placed upon a consumer's premises by such Government.

57. Meters, maximum demand indicators and other apparatus on consumer's premises :— (1) Any meter or maximum demand indicator or other apparatus placed upon a consumer's premises in accordance with section 26 shall be of appropriate capacity and shall be deemed to be correct if its limits of error do not exceed 3 per cent, above or below absolute accuracy at all loads in excess of one-tenth of full load and up to full load.

(2) No meter shall register at no load.

(3) Every supplier shall provide and maintain in proper condition such suitable apparatus as may be prescribed or approved by the Inspector for the examination, testing and regulation of meters used or intended to be used in connection with the supply of energy:

Provided that the supplier may with the approval of the Inspector and shall, if required by the Inspector enter into a joint arrangement with any other supplier for the purpose aforesaid.

(4) Every supplier shall examine, test and regulate all metres, maximum demand indicators and other apparatus for ascertaining the amount of energy supplied before their first installation at the consumer's premises and at such other intervals as may be directed by the State Government in this behalf.

(5) Every supplier shall maintain a register of meters showing the date of a last test, the error recorded at the time of the test the limit of accuracy after adjustment and final test, the date of installation ; withdrawal, reinstallation, etc., for the examination of the Inspector or his authorised representative.

58. Point of commencement of supply :—The point of commencement of supply of energy to a consumer shall be deemed to be the point at the outgoing terminals of the cut-outs inserted by the supplier in each conductor of every service line other than an earthed or earthed neutral conductor or the earthed external conductor of a concentric cable at the consumers premises.

59. Precautions against failure of supply : Notice of failures— (1) The lay-out of the electric supply lines of the supplier

for the supply of the energy throughout his area of supply shall under normal working conditions be sectionalized and so arranged, and provided with cut-outs or circuit-breakers so located, as to restrict within reasonable limits the extent of the portion of the system affected by any failure of supply.

(2) The supplier shall take all reasonable precautions to avoid any accidental interruption of supply, and also to avoid danger to the public or to any employee or authorised person when engaged on any operation during and in connection with the installation, extension, replacement, repair and maintenance of any works.

(3) The supplier shall send to the Inspector notice of failure of supply of such kind as the Inspector may from time to time require to be notified to him, and such notice shall be sent by the earlier practicable post after the failure occurs or after the failure becomes known to the supplier and shall be in such form and contain such particulars as Inspector may from time to time specify.

(4) For the purposes of testing or for any other purposes connected with the efficient working of the undertaking, the supply of energy may be discontinued by the supplier for such period as may be necessary subject (except in cases of emergency), to not less than twenty-four hours' notice being given by the supplier to all classes of consumers specified by the Inspector likely to be affected by such discontinuance ; and in the event of any consumer or consumers from such classes of consumers objected, the supply of energy shall not be discontinued (except in cases of emergency), without the consent of the Inspector and subject to such conditions as he may impose.

60. Text for resistance of insulation :— (1) Where any electric supply line for use at low or medium voltage has been disconnected from a system for the purpose of addition or alteration or repair, such electric supply line shall not be reconnected to the system until the supplier or the owner has applied the test prescribed under rule 48.

(2) The provision of sub-rule (1) shall not apply to overhead lines except overhead insulated cables unless the Inspector otherwise directs in any particular case.

61. Connection with earth :— (1) The following provisions shall apply to the connection with earth of systems at low voltage in cases where the voltage normally exceeds 125 volts and of systems at medium voltage.

(*a*) The neutral conductor of a three-phase four-wire system,

and the middle conductor of a two-phase three-wire system shall be earthed by not less than two separate and distinct connections with earth both at the generating station and at the sub-station. It may also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which may be at consumer's premises.

(*b*) In the case of a system comprising electric supply lines having concentric cables, the external conductor of such cables shall be earthed by two separate and distinct connections with earth.

(*c*) The connection with earth may include a link by means of which the connection may temporarily interrupted for the purpose of testing or for locating a fault.

(*d*) (*i*) In a direct current three-wire system the middle conductor shall be earthed at the generating station only, and the current from the middle conductor to earth shall be continuously recorded by means of a recording ammeter, and if at any time the current exceeds one-thousandth part of the maximum supply current, immediate steps shall be taken to improve the insulation of the system.

(*ii*) Where the middle conductor is earthed by means of a circuit-breaker with a resistance connected in parallel, the resistance shall not exceed 10 ohms and on the opening of the circuit-breaker immediate steps shall be taken to improve the insulation of the system, and the circuit beaker shall be reclosed as soon as possible.

(*e*) In the case of an alternating current system, there shall not be inserted in the connections, with earth any impedance (other than that required solely for the operation of switch-gear or instruments, cut-out or circuit beaker, and the result of any test made to ascertain whether the current (if any) passing through the connection with earth is normal, shall be duly recorded by the supplier.

(*f*) No person shall make connection with earth by the aid of, nor shall be keep it in contact with, any water main not belonging to him except with the consent of the owner thereof and of the Inspector.

(*g*) Alternating current systems which are connected with earth as aforesaid may be electrically interconnected.

Provided that each connection with earth is bonded to the metal

sheathing and metallic armouring (if and) of the electric supply lines concerned.

(2) The frame of every generator, stationary motor, and so far as is practicable, portable motor, and the metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connections with earth.

(3) All metal casings or metallic coverings containing or protecting any electric supply-line or apparatus shall be connected with earth and shall be so joined and connected across all junction boxes and other openings as to make good mechanically electrical connection throughout their whole length :

Provided that where the supply is at low voltage, this sub-rule shall not apply to isolated wall tubes or to brackets, electroliers, switches, fans, regulators covers or other fittings (other than portable hand lamps and portable and transportable apparatus unless provided with earth terminal.

This sub-rule shall come into force immediately in the case of new installation and in case of existing installations the provisions of this sub-rule shall be complied with before the expiry of a period of two years from the commencement of those rules.

(4) All earthing systems shall, before electric supply lines or apparatus are energised, be tested for electrical resistance to ensure efficient earthing.

(5) All earthing systems belonging to the supplier shall, in addition, be tested for resistance on dry day during the dry season not less than once every two years.

(6) A record of every earth test made and the earth thereof shall be kept by the supplier for a period of not less than two years after the day of testing and shall by available to the Inspector when required.

62. Systems of medium voltage :— Where a medium voltage supply system is employed, the voltage between earth and any conductor forming part of the said systems shall not, under normal conditions, exceed low voltage.

63. Approval by Inspector :— (1) Before making an application to the Inspector for permission to commence supply of energy at high or extra-high voltage to any person, the supplier shall ensure that the high or extra high voltage electric supply lines or apparatus

belonging to him are placed in position, properly joined and duly completed and examined. The supply of energy shall not be commenced by the supplier unless and until the Inspector is satisfied that the provisions of rules 65 to 69 both inclusive have been complied with and the approval in writing of the Inspector has been obtained by him :

Provided that the supplier may energise the aforesaid electric supply lines or apparatus for the purpose of tests specified in rule 65.

(2) The owner of any high or extra-high voltage installation shall, before making application to the Inspector for approval of his installation or additions thereto, test every high or extra-high voltage circuit or additions thereto, other than an overhead line, and satisfy himself that they withstand the application of the testing voltage set out in sub-rule (1) of rule 65 and shall duly record the results of such tests and forward them to the Inspector :

Provided that, an Inspector may direct such owner to carry out such tests as he deems necessary or if he thinks fit, accept the manufacturer's certified test in respect of any particular apparatus in place of the tests required by this sub-rule.

(3) The owner of any high or extra-high voltage installation who makes any additions or alternations to his installation shall not connect to the supply his apparatus or electric supply lines comprising the said alterations or additions unless and until such alterations or additions have been approved in writing by the Inspector.

64. Use of energy at high or extra-high voltage. (1) The Inspector shall not authorise a supplier to connect a supply of energy at high or extra-high voltage to any consumer, unless—

(*a*) all conductors and apparatus intended for use at high or extra-high voltage and situated on the premises of the consumer are in accessible except to authorised person and all operations in connection with the said conductors and apparatus are carried out only by an authorised person ;

(*b*) the consumer has provided and agrees to maintain a separate building or a locked weather-proof and fireproof enclosure of agreed design and location, to which the supplier shall at all times have access, for the purpose of housing his high or extra-high voltage apparatus and metering equipment, or where the provision of a separate building or enclosure is impracticable, the consumer has

segregated the aforesaid apparatus of the supplier from any other part of his own apparatus.

Provided that such segregation shall be by the provision fire-proof walls, if the Inspector considers it to be necessary ;

Provided further that in the case of an out-door installation the consumer shall suitably segregate the aforesaid apparatus belonging to the supplier from his own to the satisfaction of the Inspector.

(c) all pole type sub-stations are constructed and maintained in accordance with rule 69.

(2) The following provisions shall be observed where energy at high or extra high voltage is supplied, converted, transformed or used—

(a) All conductors or live parts of any apparatus shall ordinarily be inaccessible.

(b) All windings, at high or extra-high voltage of motors or other apparatus within reach from any position in which a person may require to be, shall be suitably protected so as to prevent danger.

(c) Where transformer or transtormers are used, suitable provision shall be made, either by connecting with earth a point of the circuit at the lower voltage or otherwise, to guard against danger by reason of the said circuit becoming accidentally charged above its normal voltage by leakage from or contact with the circuit at the higher voltage.

(d) (i) Where a sub-station or a switch-station is situated in any building and where fire in the sub-station or switch station might involve risk to the said building and the said sub-station or switch-station contains oil-immersed transformers, switches or static condensers involving the use of more than 2000 gallons (2,270.5 litres of oil in one chamber, provision shall be made for suitable oil soak-pit and where use of more than 2,000 gallons (9,082 liters) of oil in any one oil-tank, receptacle or chamber is involved, provision shall be made for the draining away or removal of any oil which may leak or escape from the tanks, receptacles or chambers containing the same ; special precautions shall be taken to prevent the spread of any fire resulting from the ignition of the oil from any cause and adequate provision shall be made for extinguishing any fire which may occur. Spare oil shall not be stored in any such sub-station or switch-station.

(*ii*) Cable trenches inside sub-stations and switch-stations containing cables shall be filled with sand, pebbles or similar non-inflammable materials or completely covered with non-inflammable slabs.

(*e*) Unless the conditions are such that all the conductors and apparatus for use at high or extra-high voltage may be made dead at the same time for the purpose of cleaning or for other work thereon, the said conductors and apparatus shall be so arranged that they may be made dead in sections, and that work on any section made dead may be carried on by an authorised person without danger.

(*f*) Adequate precautions shall be taken to prevent unauthorised access to any part of the installation designed to be electrically charged at high or extra high voltage.

65. Voltage tests :— (1) High and extra-high voltage electric supply-lines (other than overhead lines) and apparatus of the supplier shall not be connected to a system for the purposes of supply or use of energy unless the insulation of the said electric supply-lines and apparatus has withstood, either—

(*i*) the tests prescribed in that behalf in the appropriate specification of the Indian Standards Institution or in its absence the British Standards Institution then current ; or

(*ii*) in cases where no such tests have been prescribed, the cotinuous application, between conductors and also between conductors and earth during a period of one minute of the testing voltage given in subrule (2).

(2) For the purposes of clause (*ii*) of sub-rule (1)—

(*a*) if the normal working voltage does not exceed 1,000 volts, the testing voltage shall be 2,000 volts ;

(*b*) if the normal working voltage exceeds 1,000 volts, but does not exceed 11,900 volts, the testing voltage shall be double the normal working voltage ;

(*c*) if the normal working voltage exceeds 11,000 volts, the testing voltage shall be normal working voltage plus 10,000 volts :

Provided that an apparatus which is not new shall be tested in such manner as the Inspector may specify.

(3) If the test prescribed in sub rule (1) is made prior to the said electric supply-lines and apparatus being placed in position for the purposes of supply of energy, the said electric supply-lines and

the apparatus after having been placed in position and before being connected to the system shall have withstood a further test for resistance of insulation either by the application of the tests prescribed in sub-rule (1) whenever reasonably practicable, or by the application of a testing voltage of not less than 1,000 volts either alternating current or direct current between conductors and also between conductors and earth during a period of not less than one minute.

(4) Where any electric supply line (other than an overhead line) or apparatus for use at high or extra-high voltage has been disconnected from a system for alteration or repair, such electric supply line or apparatus shall not be recollected to the system until the supplier has applied the test prescribed in sub rule (3) and satisfied himself that the insulation of the electric supply line or apparatus is in sound condition.

(5) The supplier shall duly record the result of every test made under this rule.

(6) Notwithstanding the provisions of sub-rules (1) to (4), (both inclusive) the Inspector may, where he thinks fit, accept the manufacturer's certified tests in place of the tests prescribed in this rule.

66. **Metal sheathed electric supply lines : Precautions against excess leakage** :— (1) The following provisions shall apply to electric supply-lines (other than overhead-lines) of a supplier for use at high or extra-high voltage :

(*a*) The conductors shall be enclosed in metal sheathing which shall be electrically continuous and connected with earth, and the conductivity of the metal sheathing shall be maintained and reasonable precautions taken where necessary to avoid corrosion of the sheathing.

(*b*) In the event of a failure of insulation occurring between one conductor and the metal sheathing at any point along an electric supply line as aforesaid, the impedance of the relevant circuit shall be such that, with the full voltage maintained at the source of supply, the current resulting from such failure shall not be less than twice the value of the current for which a suitable cut-out of adequate rupturing capacity or other suitable overload protective device has been set to operate or the current required to operate a suitable discriminative fault current relay :

Provided that the operation of the aforesaid overload protective

device or of the discriminative fault current relay shall cause the automatic operation of a circuit-breaker of adequate rupturing capacity.

The relevant circuit herein before referred to means the complete circuit from the source of supply to the point of failure of the insulation, including any connection with earth of the system of which the electric supply line as aforesaid forms part and any current-limiting device inserted in such connection with earth ; and the source of supply means the point at which energy is given to the system or circuit of which the electric supply line as aforesaid forms part.

(*c*) Where an electric supply-line as aforesaid has concentric cables add the external conductor is insulated from an outer metal sheathing and connected with earth, the external conductor may be regarded as the metal sheathing for the purposes of this rule, provided that the foregoing provisions as to conductivity are complied with.

(2) Nothing in the provisions of sub-rule (1) shall preclude the employment in generating stations, sub-stations and switch-stations (including outdoor sub-stations and outdoor switch-stations) of conductors for use as high or extra-high voltages which are not enclosed in metal sheathing or preclude the use of electric supply lines laid before the prescribed date to which the provisions of these rules apply.

67. Connection with earth :— (1) The following provisions shall apply to the connection with earth of three-phase systems for use at high or extra-high voltages :

In the case of star-connected systems with earthed neutrals or delta connected systems with earthed artificial neutral point :

(*a*) the neutral point shall be earthed by not less than two separate and distinct connections with earth each having its own electrode at the generating station and at the sub-station and may be earthed at any other point, provided that no interference of any description is caused by such earthing ;

(*b*) in the event of an appreciable harmonic current flowing in the neutral connections so as to cause interference with communication circuits, the generator or transformer neutral shall be earthed through a suitable impedance.

(2) Single-phase high or extra-high voltage systems shall be earthed in a manner approved by the Inspector.

(3) In the case of a system comprising electric supply lines having concentric cables, the external conductor shall be the one to be connected with earth.

(4) Where a supplier proposes to connect with earth an existing system for use at high or extra-high voltage which has not hitherto been so connected with earth, he shall give not less than fourteen days' notice in writing together with particulars to the telegraph authority of the proposed connection with earth.

(5) Where the earthing lead and earth connection are used only in connection with earthing guards erected under high or extra-high voltage overhead lines where they cross a telecommunication line or a railway line, and where such lines are equipped with earth leakage relays of a type and setting approved by the Inspector, the resistance shall not exceed 25 ohms.

(6) In so far as the provisions of rule 61 are consistent with the provisions of this rule, all connections with earth shall also comply with the provisions of that rule.

Rule No. 70. Suitable arrangement for automatic discharge of static condenser shall be made on disconnection of supply.

71. Additional provision for supply to high voltage luminous tube sign installation :— (1) Any person who proposes to use or who is using energy for the purpose of operating a luminous tube sign installation, or who proposes to transform or who is transforming energy to a high voltage for any such purpose shall comply with the following conditions :

(*a*) All live parts of the installation including all apparatus and live conductors in the secondary circuit, but excluding the tubes except in the neighbourhood of their terminals shall be inaccessible to unauthorized persons and such parts shall be effectively screened.

(*b*) Irrespective of the method of obtaining the voltage of the circuit which feeds the luminous discharge tube sign, no part of any conductor of such circuit shall be in metallic connection (except in respect of its connection with earth) with any conductor of the supply system or with the primary winding of the transformer.

(*c*) All live parts of an exterior installation shall be so disposed as to protect them against the effects of the weather, and such installation shall be so arranged and separated from its surroundings as to limit, as far as possible, the spreading of fire.

(*d*) The secondary circuit shall be permanently earthed at the transformer and the core of every transformer shall be earthed.

(*e*) Where the conductor of the primary circuit are not in metallic connection with the supply conductors (*e.g.*, where a motor-generator or a double-wound convertor is used), one phase of such primary circuit shall be permanently earthed at the motor-generator or convertor, or at the transformer.

(*f*) A final sub-circuit which forms the primary circuit of a fixed luminous-discharge-tube sign installation shall be reserved solely for such purpose.

(*g*) A separate primary final sub-circuit shall be provided for each transformer or each group of transformers having an aggregate input not exceeding 1000 volt amperes, of a fixed luminous discharged-tube sign installation.

(*h*) An interior installation shall be provided with suitable adjacent means for disconnecting all phases of the supply except the "neutral" in a three phase four-wire circuit.

(*j*) For installations on the exterior of a building a suitable emergency fire-proof linked switch to operate on all phases except the neutral in a three-phase four-wire circuit shall be provided and fixed in a conspicuous position at not more than 2.75 metre above the ground.

(*k*) A special "caution"notice shall be affixed in a conspicuous place on the door of every high voltage enclosure to the effect that the high voltage supply must be cut off before the enclosure is opened.

(*l*) Where static condensers are used, they shall be installed on the load side of the fuses and the primary (low voltage) side of the transformer.

(*m*) Where static condensers are used on primary side, means shall be provided for automatically discharging the condensers when the supply is cut off :

Provided that static condensers or any circuit interrupting devices on the high or extra-high voltage side shall not be used without the approval in writing of the Inspector.

(2) The owner or user of any luminous tube sign or similar and voltage installation shall not bring the same into use without giving to the Inspector not less than 14 day's notice in writing of his intention so to do.

75. Joints. The ultimate strength of the joint should not be less than 95% of the conductor and electric conductivity equal to the conductor.

76. Maximum stress Factor of safety.

(*a*) For metal supportes—2.0

(*b*) For mechanically processed concrete supports—2.5

(*c*) For hand moulded concrete supports—3.0

(*d*) For wood supports—3.5

77. Clearance above ground of the lowest conductor :— (1) No conductor of an overhead line, including service lines, erected across a street shall at any part thereof be at a height less than—

(*a*) for low and medium voltage lines	...	5.8 metre
(*b*) for high voltage lines	...	6.1 metre

(2) No conductor of an overhead line, including service lines, erected along any street shall at any part thereof be at a height less than—

(*a*) for low and medium voltage lines	...	5.5 metre
(*b*) for high voltage lines	...	5.8 metre

(3)No conductor of an overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than—

(*a*) for low, medium and high voltage lines up to and including 11,000 volts, if bar	...	4.6 metre
(*b*) for low, medium and high voltage lines up to and including 11,000 volts, if insulated	...	4 metre
(*c*) for high voltage lines above 11,000 volts	...	5.2 metre

(4) For extra-high voltage lines the clearance above ground shall not be less than 5.2 metre. plus 0.3 metre for every 33,000 volts or part thereof by which the voltage of the line exceeds 33,000 volts :

Provided that the minimum clearance along or across any street shall not be less than 6.1 metre.

79. Clearance from buildings of low and medium voltage lines and service lines :— (1) Where a low or a medium voltage overhead line passes above or adjacent to or terminates on any building, the following minimum clearances form any accessible point, on the basis of maximum sag, shall be observed :

(*a*) for any flat roof, open balcony, verandah roof and lean to roof—

(*i*) when the line passes above the building a vertical clearance of 2.5 metre from the highest point, and

(*ii*) when the line passes adjacent to the building a horizontal clearance of 1.2 metre from the nearest point, and

(*b*) for pitched roof—

(*i*) when the line passes above the building a vertical clearance of 2.5 metre immediately under the lines and—

(*ii*) when the line passes adjacent to the building a horizontal clearance of 1.2 metre

(2) Any conductor so situated as to have a clearance less than that specified in sub-rule (1) shall be adequately insulated and shall be attached by means of metal clips at suitable intervals to a bare earthed bearer wire having a breaking strength of not less than 350 kg.

(3) The horizontal clearance shall be measured when the line is at a maximum deflection from the vertical due to wind pressure.

80. Clearance from buildings of high and extra-high voltage lines :—(1) Where a high or extra high voltage overhead line passes above or adjacent to any building or part of a building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, of not less than—

(*a*) for high voltage lines up to and including 33,000 volts	...	3.7 metre
(*b*) for extra-high voltage line		3.7 metre plus 0.3 metre for every additional 33,000 volts or part

(2) The horizontal clearance between the nearest conductor and any part of such building shall on the basis of maximum deflection due to wind pressure, be not less than—

(*a*) for high voltage lines up to and including 11,000 volts	...	1.2 metre
(*b*) for high voltage lines above 11,000 volts and up to and including 33,000 volts	...	2 metre
(*c*) for extra-high voltage lines	...	2 metre plus 0.3 metre for every additional 33,000 volts or part thereof.

85. Maximum intervals between supports. All conductors shall be attached to supports at interval not exceeding the safe limits based on the ultimate tensile strength of the conductors and the factor of safety prescribed in rule 76 :

Provided that in case of overhead lines carrying low or medium voltage conductors, when erected in, over, along or across any street, the intervals shall not, without the content in writing of the Inspector, exceed 65 metre.

86. Conditions to apply where telecommunication lines and power lines are carried on same supports. :— (1) Every overhead telecommunication line erected on supports carrying a power lines shall consist of conductors each having a breaking strength of not less than 270 kg.

(2) Every telephone used on a telecommunication line erected on supports carrying a power line shall be suitably guarded against lighting and shall be protected by cut-outs.

(3) where a telecommunication line is erected on supports carrying high or extra-high voltage power line arrangement shall be made to safeguard any person using the telephone against injury resulting from contact, leakage or induction between such power and telecommunication lines.

87. Lines crossing or approaching each other. Where an overhead line crosses or is in proximity to any telecommunication line, the owner of the overhead line shall protect it in a manner laid down in the Code of Practice of the Power and Telecommunication Co-ordination Committee.

(2) When it is intended to erect a telecommunication line which will cross or be in proximity to an overhead line the person, proposing to erect such telecommunication line shall give notice in writing of his intention to the owner of the overhead line and the owner of the overhead line shall, within twnety-one days of receiving such notice provide the protection referred to in sub-rule (1).

(3) Where an overhead line crossed or is in proximity to an overhead line belonging to another person, the owner of the line which was last erected shall so protect it as to guard against the possibility of its coming into contact with the other overhead line.

(4) A person erecting or proposing to erect an overhead line may require the owner of the overhead line to provide the protection referred to in sub-rule (3) within twenty-one days of the receipt of the notice in that behalf.

(5) In all cases referred to in the preceding sub-rule, the expenses of making the guarding arrangement shall be born by person whose line was last erected.

(6) Where two line cross, the crossing shall be made as nearly at right angle as the nature of the case admits.

(7) The guarding arrangement shall ordinarily be carried out by the owner of the support on which is made and he shall be responsible for its efficient maintenance.

(8) All work required to be done by or this rule shall be carried out to the satisfaction of the Inspector.

88. Guarding :— (1) Where guarding is required under these rules the provisions of sub-rules (2) to (4) shall apply.

(2) Every guard-wire shall be connected with earth at each point at which its electrical continuity is broken.

(3) Every guard-wire shall has an actual breaking strength of not less than 635 kg. and if made of iron or steel, shall be galvanized.

(4) Every guard-wire or cross-connected system of guard-wires, shall have sufficient current-carrying capacity to ensure the rendering dead, without risk of fusing of the guard-wire till or wire the contact of any live wire has been removed.

(5) Lines crossing trolley-wires-In the case of a crossing over a trolley wire the guarding shall fulfil the following conditions, namely:

(*a*) where there is only one trolley-wire, two guard-wires shall be erected as in diagram A ;

(*b*) where there are two trolley-wires and the distance between them do not exceed 40 cms. Two guard-wires shall be erected as in diagram B ;

(*c*) where there are two trolley-wires and the distance between them exceeds 40 cms. but does not exceed 48 inches or 1.219 m. three guard-wires shall be erected as in diagram C ;

(*d*) where there are two trolley-wires and the distance between them exceeds 1.20 metre each trolley-wire shall be separately guarded as in diagram D ;

(*e*) the rise of the trolley beam shall be so limited that if the trolley leaves the trolley-wire, it shall not foul the guard-wires ; and

(f) where a telegraph-line is liable to fall or below down upon an arm, stay-wire or span-wire, and so side down upon a trolley-wire, guard hooks shall be provided to prevent such sliding.

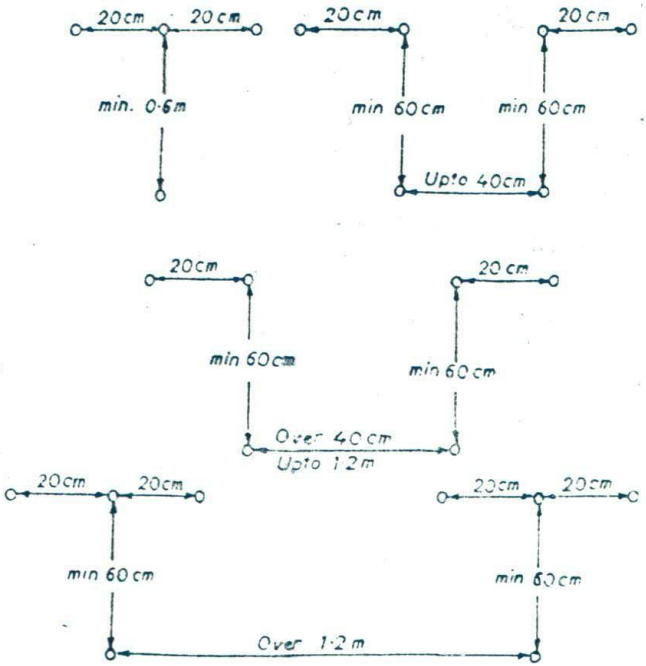


Fig. 19.1

89. Service-lines from overhead lines. No service-line or tapping shall be taken off an over-head line except at point of support.

90. Earthing :— (1) All metal support of overhead line and metallic fittings attached thereto, shall be permanently and efficiently earthed For this purpose a continuous earth wire shall be provided and securely fastened to each pole and connected with ordinarily at f ur point in every mile or 1.6 km. the spacing between the points being as nearly equidistant as possible. Alternatively, each support and metallic fitting attached thereto shall be efficiently earthed.

(2) Each stay-wire shall be similarly earthed unless an insulator has been placed in at a height not less than 3 metre from the ground.

91. Safety and protective devices :— (1) Every overhead line (not being suspended from a dead bearer wire not being covered with insulating material and not being a trolley-wire erected over any part of a streets or other public place or in any factory or mine

or on any consumer's premises) shall be protected with a device approved by the Inspector for rendering the line electrically harmless in case it breaks.

(2) An Inspector may by notice in writing require the owner of any such overhead lines wherever it may be erected to protect it in the manner specified in sub-rule (1).

(3) The owner of very high and extra-high voltage overhead line shall make adequate arrangements to the satisfactions of the Inspector to prevent unauthorised person from ascending any of the supports of such overhead lines without the aid of a ladder or special appliances.

92. Protection against lightning :— (1) The owner of every overhead line which is so exposed as to be injury from lighting shall adopt efficient means for diverting to earth any electrical surges due to lightning.

(2) The earthing lead for any lightning arrestor shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning-arrestor to a separate earth electrode subject to the avoidance of bends wherever practicable.

Service Lines—The licensee shall lay free of charge 100 feet of service line from his nearest distribution main outside the limits of the property, in respect of which the requisition is made. Any length in excess of 100 feet, as defined above and the whole of the service line within the limits of the property in respect of which the application is made shell be paid for by the applicant. The cost mentioned above, however, shall be exclusive of the proportionate cost of first pole and fitting beyond 100 feet aforesaid. The proportionate cost of such poles and fittings shall be in the same ratio as 100 feet is to the length of the line beyond 100 feet from the point or tap-off of the service and the second support of the service line.

The main cut-outs or fuses shell be inserted and sealed by the licensee free of cost to the consumer.

Consumer not to interfere with the supply mains or apparatus—The meter boards, main cut-outs etc. must on, not be handled or removed by any one who is not in the employment of the licensee. The seals which are fixed on the meters and the licensee's apparatus must on, not be broken.

Wiring on consumer's premises— For the protection of the consumer and the public generally, it is necessary that the wiring on the consumers premises should conform to the I.E. Rules and the Rules of the Fire Insurance company in terms of which the building is insured and be carried out by a licensed electrical contractor.

The material used for wiring shall comply with the standard laid down in that behalf by the Indian Standards Institution or equivalent. As soon as the consumer's installation is completed in all respects and tested by the consumer's contractor, the consumer should submit to the licensee, the wiring contractor's completion and test report. A form for this purpose shall be supplied by the licensee. It is important that the conditions named therein are fully complied with as otherwise there will be a delay in obtaining the supply.

As required by Rule 45 of the Indian Electricity Rules, 1956 no electrical installation work (including addition, alteration, repairs and adjustments to existing installations), except such replacement of lamps, fans, fuses, switches, low voltage domestic appliances and fitting as in no way after the capacity and the character of the installation, shall be carried out upon the premises on behalf of any consumer or owner for the purposes of supply of energy to such consumer or owner, except by an electrical contractor, licensed by the Government, in this behalf and under the direct supervision of a person holding a certificate of competency issued or recognised by the Government. Any person holding a certificate of competency issued or recognised by the Government. Any person committing a breach of Rule 45 shall render himself liable to punishment under Rule 139 of the said Rules.

Apparatus on consumer's premises— (*a*) All transformers, switchgear and other electrical equipment belonging to the consumer and connected to the mains of the licensee shall be maintained to the reasonable satisfaction of the license.

(*b*) In the case of high voltage consumers, suitable protective devices approved by the licensee shall be used so as to afford full protection to the licensee's apparatus placed on the consumer's premises.

Procedure for testing installation by the licensee and fee.

(*a*) Upon receipt of the test report, the licensee shall notify to the applicant the time and the day when the licensee's representative proposes to inspect and test the installation. It will then be the duty of the applicant to arrange that a representative of the wiring contractor employed by him is present at the inspection to give the licensee's representative any information that may be required by him concerning the installation.

(*b*) No connection shall be made until the consumer's installation has been inspected and tested by the licensee and found satisfactory. No charge shall be made for the first test by the licensee but subsequent test to faults disclosed at the initial test shall be charged for in accordance with Part III of these conditions. Periodical test of the installation will also be undertaken by the licensee at rates that may be ascertained from his local office.

(*c*) Before taking the insulation test of installation the wiring must be completed in all respects. All fittings, whether incandescent lamps, fans, motor, heating, cooking or other apparatus, must be connected to the conductors and all fuses, must be in place and all switches in the 'on' position before the tests are carried out. Temporary wires or fittings or dead ends should not be included in the installation and no part of the work should be left incomplete.

(*d*) A pressure of 500 volts will be applied between installation and "earth" and the insulation resistance to earth after one minute's electrification shall be such as will not cause a leakage from the installation exceeding one five thousandth part of the maximum current demanded.

(*e*) The test between the poles should give at least half the result of that to "earth".

(*f*) Manufacturer's test certificates in respect of all high voltage apparatus shall be produced if required by the licensee.

Extensions and alterations—Should the consumer, at any time after the supply of energy has been commenced, increase the number or size of lights, fan or motors etc. on his premises or in any way alter the position of his wiring therein, notice thereof must be sent in writing to the licensee whose representative will call and inspect the alteration and if necessary, change the meters and fuses and alter the service line. Failure to give such notice may derange the supply system and render the supply liable to be summarily discontinued. During such time as alteration, additions or repairs are being executed, the supply to the circuit which is being altered, added to or repaired, must be entirely disconnected and it shall remain disconnected until the alternations, additions, or repairs have been tested and passed by the licensee.

Failure of supply :— (*a*) Should at any time the licensee's service fuse or fuses fail, notice thereof should be sent to the licensee's local office or if there are sub-stations, to the nearest sub-station. Only authorised employees bearing the badge of the licensee are permitted to replace these fuses in the licensee's cut-outs. Consumers are not allowed to replace these fuses and they will render themselves liable to a heavy penalty, if the licensee's seals placed to protect his apparatus are broken. The licensee does not allow his employees to carry out any repairs except replacement of fuses in the consumer's installation.

(*b*) The licensee shall not be liable for any claims for loss, damage or compensation whatsoever arising out of failures of supply when such failure is due either directly or indirectly to war, mutiny,

civil commotion, riot, strike, lockout, fire, flood, tempest, lightning, earthquake, or other force, accident or cause beyond his control.

Payment of bills— (*a*) Bills should be paid at the licensee's local office within 15 days from the date of their presentation.

(*b*) Any complaints with regard to the accuracy of the bills shall be made in writing to the licensee and the amounts of such bills shall be paid under protest within the said period of 15 days. The amounts of bills paid under protest will be regarded as advance to the credit of the consumer's account until such time as the bills in dispute have been fully settled.

Accuracy of meters—Should the consumer dispute the accuracy of any meter which is not his own property, he may, upon giving notice and paying of prescribed fee, have the meter tested by the licensee or the Electrical Inspector ..... in accordance with Section 26 of the Act. In the event of the meter being tested by the license and found to be beyond the limits of accuracy as prescribed in the Indian Electricity Rules in force, from time to time, the testing fee shall be returned and the amount of the bill adjusted in accordance, with the result of the test taken with respect to the meter reading of the three months prior to the month in which the dispute has arisen, due regard being given to conditions of occupancy during the months.

Discontinuance of supply :— (*a*) If any consumer adopts any electrical appliance which is likely to affect the supply to other consumers or uses the energy supplied or deals with it in any manner so as unduly of improperly to interfere with the efficient supply of energy to any other person by the licensee, or fails to keep in proper order any meter belonging to him by which the supply is registered. or the licensee may discontinue the supply so long as such an appliance is so adopted energy is so used or dealt with or the meter is not kept in proper order, as the case may be.

System of supply—Supply of energy shall be given by licensee in the following system, namely :

(*i*) Low Voltage—Direct current, two wire; or Alternating Current. 1 Φ 50 Hz,

(*ii*) Medium Voltage—Direct current, three wire, or Alternating Current, three phase. 50 cycles ; and

(*iii*) High Voltage—Alternating Current, three phase, 50 cycles.

Classification of installations—A. C. System— (*a*) Two-wire single phase 230 volts—

(*i*) General supply not exceeding 10 amperes.

(*ii*) Motive power installations upto I BHP in aggregate.

(*b*) Four-wire, three phase, 230 volts between phase wires and neutral — General supply exceeding 10 ampers.

(*c*) Three-wire, three phase, 230 volts between phase — Motive power installations of over I BHP.

D.C. System— (*a*) Two-wire 230 volts.

(*i*) General supply not exceeding 10 amperes.

(*ii*) Motive power installations upto I BHP in aggregate.

(*b*) Three-wire 460 volts between outers—Motive power installations of over I BHP.

General wiring condition :— (*a*) Mains. The consumer's mains shall in all cases be brought back to the licensee's point of supply and sufficient cable shall be provided for connecting up with the licensee's apparatus.

(*b*) **Switches and Fuses.** The consumer shall provide linked quick break main switches and a single pole fuse on each conductor except the neutral conductor which shall be fixed as near as possible to the licensee's meter board.

(*c*) **Balance of Installation.** If the connected load of any installation exceeds 10 ampers at 230 volts, the installation shall be wired on the group system; separate neutral wires being brought back in each case to the licensee's point of supply. An approved type of double pole linked switch shall control each main circuit. The lamp, fans or any other apparatus of which the installation consists shall be so grouped that under normal working conditions the current will be flowing in the neutral wire.

(*d*) **Medium Voltage Supply.** With medium voltage supply, *i.e.*, above 250 volts and upto 650 volts, the licensee's meter and services cut-outs shall be enclosed in a strong teakwood box suitably ventilated and provided with a hasp, staple and lock. All wires between which a difference of potential of over 250 volts exists shall be made inaccessible to unauthorised persons or enclosed in an earthed metallic casing or conduit. A "Caution" Board printed in Hindi and in the local language of the district shall be fixed thereto.

(*e*) **Overhead Mains.** In order to save the expense of a long underground service on private property, a consumer may, with the licensee's approval, erect a pillar on that portion of his property which is nearest to the license's supply mains into which the service shall be laid and from which the consumer shall run overhead mains

to his premises. These overhead mains shall constitute a portion of his installation and shall be laid in compliance with the Indian Electricity Rules in force from time to time. An efficient chocking coil and lightning arrester may be fixed at the commencement of the overhead line at the consumer's cost, should he desire the same, as an additional protection for his installation.

(*f*) **Earthing.** Gas pipes shall on no account be used for earthing purposs.

(*g*) **Domestic heating and cooking.** A special circuit for heating and cooking shall be run from the licensee's point of supply. Wall plugs used on these circuits shall be of the three pin type, the third pin being an earth connection. Two pin plugs or lighting sockets shall not be allowed. All appliances used in the bathroom for heating or washing purposes or in any damp location must be effectively earthed.

(*h*) **Plugs.** All plugs shall be switched on the live wire and not on the neutral.

(*i*) **Wiring.** Single leads shall not be allowed to be run separately in iron conduit.

(*j*) **A.C. Motor installation.** Motor shall be provided with control gear so as to prevent satisfactorily the maximum current demand from the consumer's installation exceeding the limits given in the following schedule at any time under all possible conditions. Failure to comply with these regulations will render the consumer liable to disconnection from the supply on account of interference with the supply to other consumers.

Nature of supply	*Size of installation*	*Limit of maximum current demanded*
Single phase	Upto and including 1 BHP	Six times full load current.
Three phase	Above 1 BHP and up to and including 10 BHP	Three times full load current.
	Above 10 BHP and up to and including 15 BHP	Twice full load current.
	Above 15 BHP	One and a half time full load current.

Motor circuit shall be controlled by a triple pole linked switch projected by a no-volt release and T.P. fuses (or overload releases). It is important that the release should be maintained in thorough working order. Wiring for motors shall be run with all three-phase wires bunched in a single metallic conduit, which shall be efficiently earthed throughout and connected to the frame of the motor from

which two separate earth wires shall be run. The minimum size of the earth wire permitted is No. 14 S.W.G. All motors shall comply in every respect with the Indian Electricity Rules' in force from time to time.

Motor above I BHP shall be wound for three-phase, 400 volts between phases.

(*k*) **Power Factor of Apparatus.** The apparatus shall have a power factor of not less than 85 percent at normal working load.

Intending consumers are advised to consult the Engineer of the licensee before ordering their motors, as in some cases it may be practicable to relax the starting current limit dependent on the location and conditions of working.

93. Unused overhead line :— (1) Where an overhead line ceases to be used as an electric supply line, the owner shall maintain it in a safe mechanical condition in accordance with rule 76 or shall remove it.

(2) Where any overhead line ceases to be used as an electric supply-line, an Inspector may, by a notice in writing served on the owner, required him to maintain it in a safe mechanical condition to remove it within fifteen days of the receipt of the notice.

Annexure A

Table 1. P.V.C. Insulated Wires (Twisted Copper)

Equivalent Copper Conductor Size	Nominal area in mm²	No. and Size of Wire in mm	Unit	P.V.C. Single Core		P.V.C. Twin Core
				Upto 600 volts	1100 volts	Upto 600 V
1/.044/18	1.5	1/1.40	Coil of 91.44 m	175.00	320/-	425/-
3/.036/20	2.0	1/2.80	do	315.00	600/-	750/-
3/.029/22	2.5	1/1.80	do	225.00	415/-	470/-
7/.029/22	4.0	1/1.24	do	480.00	830/-	900/-
7/.036/20	6	1/2.80	do	720.00	1300/-	1550/-
7/.044/18	10	1/3.55	do	1200.00	1900/-	2550/-
7/.052/17	16	7/1.70	do	1400.00	2500/-	2900/-
7/.064/16	25	7/2.24	do	2300.00	3800/-	3800/-
19/.044/18	35	7/2.50	do	3320.00	4650/-	—
19/.052/17	50	7/3.00	do	4500.00	7000/-	—
19/.064/16	70	19/2.24	do	6320.00	9200/-	—
19/.083/14	93	19/2.50	do	12000.00	15500/-	—
37/.072/14	120	37/2.06	do	22000.00	30,000/-	—
37/.064/16	150	37/2.24	do,	13000.00	18000/-	—
37/.128/10			do	45000.00	80000/-	—

Table 2. Approximate Cost of Flexible Cords

Size of Wire in mm.	Unit	250 Volts Grade V.I.R. insulated flexible cord twin twisted.	W/Shop type twin core flexible wire.	Flexible cord unkrinkable domestic type three core
1	2	3	4	5
14/.193	Coil of 100 m.	Rs. 105.00	Rs. 165.00	Rs. 340.00
23/.193	do	Rs. 165.00	Rs. 225.00	Rs. 435.00
40/.193	do	Rs. 215.00	Rs. 365.00	Rs. 725.00
110/.193	do	Rs. 500.00	—	Rs. 1800.00
162/.193	do	Rs. 750.00	—	Rs. 3250.00

Table 3. Approximate Cost of I.C. Switches

I.C. Switches current capacity in Amperes	Unit	D.P.I.C. 250 V.	D.P.I.C. 500 V.	T.P.I.C. 500 V.	T.P.I.C. 500 V. with N.L.
10	Each	Rs. 80.00	—	—	—
15	"	Rs. 100.00	—	Rs. 275.00	Rs. 280.00
30	"	Rs. 230.00	—	Rs. 360.00	Rs. 370.00
60	"	Rs. 260.00	Rs. 600.00	Rs. 875.00	Rs. 890.00
100	"	—	Rs. 950.00	Rs. 1150.00	Rs. 1170.00

Table 4. APPROXIMATE COST OF I.C. DISTRIBUTION FUSE BOARDS

Single phase

S.No.	Description	Unit	Rate	
			IC	MS.
1.	1/2 way I.C.D.B., 250 V. 15 amps/way	Each	Rs. 85.00	Rs. 36.00
2.	3/4 way I.C.D.B., 250 V. 15 amp/way	Each	Rs. 125.00	Rs. 101.00
3.	6 way I.C.D.B., 250 V. 15 amp/way	Each	Rs. 170.00	Rs. 159.00
4.	8 way I.C.D.B., 250 V. 15 amp/way	Each	Rs. 210.00	Rs. 168.00
5.	10 way I.C.D.B., 250 V. 15 amp/way	Each	Rs. 300.00	—
6.	12 way I.C.D.B., 250 V. 15 amp/way	Each	Rs. 450.00	Rs. 216.00
7.	16 way I.C.D.B., 250 V. 15 amp/way	Each	—	Rs. 270.00

Triple pole 4 way

1.	16 amp/way	Each	Rs. 380.00
2.	32 amp/way	Each	Rs. 775.00
3.	60 amp/way	Each	Rs. 1700.00

Triple pole 6 way

1.	16 amp/way	Each	Rs. 430.00
2.	32 amp/way	Each	Rs. 1000.00
3.	60 amp/way	Each	Rs. 2200.00

Table 5. Angle iron Main board, with iron sheet at top and bottom

1.	15 cm × 20 cm	Each	Rs. 26.00
2.	20 cm × 20 cm	"	Rs. 28.00
3.	20 cm × 30 cm	"	Rs. 37.00
4.	25 cm × 30 cm	"	Rs. 40.00
5.	40 cm × 50 cm	"	Rs. 66.00

Table 6. I. C. CUT-OUTS

I. C. Cut-out Current Capacity	Unit	250 Volts S. Pole	500 Volts S. Pole
15 amps	Each	Rs. 15.00	—
30 amps	Each	Rs. 30.00	Rs. 16.00
60 amps	Each	—	Rs. 70.00

Table 7. Approximate cost of "Conduit Fittings"

Items	Unit	RATES in Rupees				
		19 mm. Dia.	25.4 mm. Dia.	31.8 mm. dia.	38.8 mm. Dia.	50.8 mm. Dia.
Bends	Dozen	24.00	30.00	65.00	90.00	150.00
Couplers	"	35.00	60.00	72.00	96.00	120.00

(Contd.)

Items	Unit	RATES in Rupees				
		19 mm. Dia.	25.4 mm. Dia.	31.8 mm. dia.	38.8 mm. Dia.	50.8 mm. Dia.
Tees	"	30.00	36.00	48.00	60.00	72.00
Saddles	Doz.	9.00	10.00	12.00	16.00	22.00
Inspection bends	Dozen	38.00	42.00	90.00	100 00	372.00
Elbows	"	24.00	30.00	40.00	60.00	90.00
Inspection elbows	"	32.00	36.00	50.00	80.00	120.00
Inspection tees	"	35.00	40.00	60.00	80.00	90.00
Circular inspection boxes with cover	"	48.00	60.00	72.00	90.00	120.00
Lock Nut	Gross	34.00	36.00	72.00	84.00	200.00
P.V.C. bushing	100 Nos.	10.00	15.00	25.00	35.00	50.00

"Round Junction Boxes" Rate in Rupees

Items	Unit	RATES in Rupees				
		19 mm. Dia.	25.4 mm. Dia.	31.8 mm. dia.	38.8 mm. Dia.	50.8 mm. Dia.
One-way	Dozen	24.00	26.00	125.00	175.00	280.00
Two-ways	Dozen	30.00	30.00	140.00	190.00	300.00
Three-ways	Dozen	36.00	38.00	180.00	205.00	372.00
Four-ways	Dozen	38.00	42.00	190.00	225.00	410.00

Table 8. Approximate cost of Electrical Accessories

S.No.	Item	Unit	Rate in Rs.
1.	Ceiling rose 2 plate (Bakelite)	Dozen	48.00
2.	Ceiling rose 3 plate (Bakelite)	"	60.00
3.	Ceiling rose 2 plate (porcelain)	"	54.00
4.	5 amps tumbler switch (surface type)	"	36.00
5.	5 amps tumbler switch (surface type) 2 way	"	48.00
6.	5 amps tumbler switch (flush type) (G. E. C. Mutac or Similar Superior make)	"	96.00
7.	15 amps tumbler switch (surface type).	"	180.00
8.	**Plug and Socket**	"	
	(*i*) 5 amps. 3 pin	"	48.00
	(*ii*) 5 amp. 2 pin	"	36.00
	(*iii*) 15 amp. 3 pin	"	120.00
9.	Cut-out single pole 5 amp. bakelite	"	48.00
10.	**Lamp holders.**	Dozen	
	(*a*) Pendant type (brass)	"	72.00
	(*b*) —do— bakelite)	"	36.00

(Contd.)

S.No	Item	Unit	Rate in Rs.
	(c) Batten type (Brass)	"	60.00
	(d) —do— (Bakelite)	"	48.00
	(e) Bracket type (brass)	"	180.00
	(f) —do— (Bakelite)	"	96.00
11.	**Lamp Shades**		
	(a) E. I. 25.40 cm × 8.90 cm.	Each	20.00
	(b) E. I. 25.40 cm × 12.70 cm.	"	35.00
	(c) Opal glass 25.40 cm.	"	110.00
	(d) Glass Coolicon 27.95 cm.	"	250.00
	(e) E. I. Coolicon 27.95 cm.	"	125.00
	(f) Plastic Coolicon 27.95 cm.	"	180.00
	(g) Langham aluminium 25.40 cm.	"	135.00
	(h) Anodized aluminium 25.40 cm.	"	170.00
	(i) —do— Coolicon 27.95 cm.	"	15.00
12.	(a) W.T. Bracket 30 cms. complete with holder and globe	"	30.00
	(b) Brass Bracket with ordinary	"	15.00
	(c) Bakelite Bracket	"	8.00
13.	Call Bell 220/230 V	Dozen	180.00
14.	Bell push	"	60.00
15.	Goliath holder	"	115.00

16.	T.W. Boards.		Single	Double
	(a) 18 cm. × 10 cm.	Dozen	36.00	75.00
	(b) 20 cm. × 15 cm.	"	52.00	110.00
	(c) 20 cm. × 25 cm.	"	60.00	135.00
	(d) 20 cm. × 30 cm.	"	72.00	140.00
	(e) 30 cm. × 25 cm.	"	115.00	150.00
	(f) 25 cm. × 45 cm.	"	118.00	160.00
	(g) 30 cm. × 38 cm.		150.00	190.00
	(h) 30 cm. × 45 cm.	Dozen	175.00	280.00
	(i) 30 cm. × 60 cm.	"	200.00	290.00
	(j) 45 cm. × 60 cm.	"	225.00	310.00
	(k) 60 cm. × 75 cm.	"	300.00	330.00
17.	**T.W. Block**			
	(a) round 7.5 cm. × 2.5 cm. (Single)	Each		3.00

(Contd.)

S.No.	Item	Unit	Rate in Rs.
	(*b*) round 10 cm. × 2.5 cm. (Single)	Each	4.00
	(*c*) round 7.5 cm. × 3.5 cm. (Double)	Each	5.00
	(*d*) round 10 cm. × 2.5 cm. (Double)	Each	6.00
	(*e*) Hexagon 10 cm. × 4 cm.	Each	8.00
18.	P.V.C. Casing & Capping		
	(*a*) 40 mm. × 22 mm.	100 m.	1150.00
	(*b*) 44 mm. × 28 mm.	" m	1300.00
	(*c*) 51 mm. × 35 mm.	" m	2600.00
19.	**T.W. Plugs** 2.5 cm. sq. × 1.9 cm. sq. × 5 cm. long.	100 Nos.	20.00
20.	***T.W. Battens***		
	(*a*) 13 mm. × 13 mm.	100 m	120.00
	(*b*) 19 mm. × 13 mm.	" m	125.00
	(*c*) 25 mm. × 13 mm.	" m	130.00
	(*d*) 31 mm. × 13 mm.	" m	135.00
	(*e*) 38 mm. × 13 mm.	" m	140.00
	(*f*) 51 mm. × 13 mm.	" m	145.00
21.	(*a*) Link clips with pins (4.4 mm.)	Box of 100 Nos.	3.00
	(*b*) Link clips with pins (size 51 cm.)	Box of 100 Nos.	3.50
	(*c*)—do— 6.4 mm.	Box of 100 Nos.	4.00
22.	(*a*) Porcelain cleats 2-way	Gross	24.00
	(*b*)—do— 2-way (Big size)	"	36.00
23.	(*a*) Round cleats (glazed)	"	10.00
	(*b*)—do— (Superior glazed)	"	15.00
24.	2-way 5 amps tumbler switch (Surface type)	Dozen	48.00
25.	2-way tumbler switch 5 amps (Flush type)	"	144.00
26.	5-amps tumbler switch with 2 pins socket and plug. (non-inter-locking).	"	120.00
27.	Pendant-holder Brass (Externally threaded)	"	150.00
28.	Pendant-holder Bakelite (Externally threaded)	"	36.00
29.	**BOXES WITH MASONITE COVER**		C.I. M.S.
	(*a*) 7.60 cm × 7.60 cm × 4 cm.	Each	10.00 6.00
	(*b*) 7.60 cm × 14.2 cm × 4 cm.	"	14.00 8.00
	(*c*) 10 cm × 18 cm × 5 cm.	"	17.50 9.00
	(*d*) 15 cm × 20 cm × 4 cm.	"	28.00 12.00
	(*e*) 20 cm × 20 cm × 10 cm.	"	45.00 18.00
	(*f*) 20 cm × 30 cm × 10 cm.	"	52.00 20.00
	(*g*) 25 cm × 30 cm × 10 cm.	"	60.00 30.00
	(*h*) 30 cm × 45 cm × 10 cm.	"	130.00 42.00

(Contd.)

S.No.	Item	Unit	Rate in
30.	7.6 cm. deep C.I. terminal Box with metal cover (one-way two-ways, three-ways, four-ways)	Doz.	7
	31. Screwed CONDUIT/P.V.C. CONDUIT		P
	(a) H.G. (Heavy Gauge) 19 mm.	1 m.	10.80
	(b) H.G. Conduit 25.4 mm.	"	13.80
	(c) H.G. Conduit 31.8 mm.	"	16.50
	(d) H.G. Conduit 38.8 mm.	"	19.50
	(e) H.G. Conduit 51 mm.	"	33.00
	(f) Flexible conduit 19 mm.	"	10.00
	(g) Flexible conduit 25.4 mm.	"	14.00
	(h) Flexible conduit 31.8 mm.	"	18.00
	(i) Flexible conduit 38 mm.	"	24.00
	(j) Flexible conduit 51 mm.	"	30.00
32.	**SCREWS**	**Pkt. of 100 No.**	**N.F.**
	I. Iron Screws "Nettle Folds" (Flat Head)		
	(a) 1.25 cm × 4 S.W.G.	1 Pkt.	18.00
	(b) 1.80 cm × 4 S.W.G.	"	28.00
	(c) 2.54 cm × 6 S.W.G.	"	33.00
	(d) 3.18 cm × 8 S.W.G.	"	38.00
	(e) 3.80 cm × 8 S.W.G.	"	48.00
	(f) 4.44 cm × 8 S.W.G.	"	50.00
	(g) 5.08 cm × 8 S.W.G.	"	54.00
	(h) 5.08 cm × 10 S.W.G.	"	60.00
	II. Machine Screws (Round Head)	**Pkt. of 100 No.**	
	(a) 1.90 cm × 0.31 cm	1 Pkt.	
	(b) 2.54 cm × 0.31 cm	"	
	(c) 2.54 cm × 0.40 cm	"	
	(d) 2.54 cm × 0.48 cm	"	
	(e) 2.54 cm × 0.63 cm	"	
	(f) 3.18 cm × 0.48 cm	"	
	(g) 3.18 cm × 0.31 cm	"	
	(h) 3.81 cm × 0.40 cm	"	
	(i) 3.81 cm × 0.48 cm	"	
	(j) 5.08 cm × 0.63 cm	"	
	(k) 5.08 cm × 0.31 cm	"	
	(l) 5.08 cm × 0.40 cm	"	
	(m) 5.08 cm × 0.48 cm	"	
	III. Brass Screw (Imported Round Head)		
	(a) 1.25 cm	Gross	
	(b) 1.90 cm	"	
	(c) 2.54 cm	"	
	(d) 3.18 cm	"	
	(e) 3.81 cm	"	
	(f) 5.08 cm	"	

	IV. Iron Hinges (Imported)		
	(a) 1.90 cm	Dozen	18.00
	(b) 3.18 cm	"	22.00
	(c) 3.81 cm	"	24.00
33.	Earth Wire No. 14 G.I.	per kg.	18.00
34.	Earth Wire No. 8 S.W.G.	per kg.	16.00
35.	Nails $\frac{1}{2}$"	per kg.	20.00

Table 9. Approximate Cost of Underground Cable PILC

	Item	*Unit*	*Rate*
1.	H.T., 33 KV U.G. Cable 3 × 70 sq. mm.	metre	Rs1558/-
2.	H.T., 33 KV U.G. Cable 3 × 95 sq. mm.	metre	Rs1728/-
3.	H.T., 33 KV U.G. Cable 3 × 120 sq. mm.	"	Rs1859/-
4.	H.T., 33 KV U.G. Cable 3 × 150 sq. mm.	"	Rs1984/-
5.	H.T., 33 KV U.G. Cable 3 × 185 sq. mm.	"	Rs2268/-
6.	H.T., 33 KV U.G. Cable 3 × 240 sq. mm.	"	Rs2533/-
7.	H.T., 33 KV U.G. Cable 3 × 300 sq. mm.	"	Rs2722/-
8.	H.T., 11/6.6 KV U.G. Cable 3 × 25 sq. mm.	"	Rs. 348/-
9.	H.T., 11/6.6 KV U G. Cable 3 × 70 sq. mm.	metre	Rs. 540/-
10.	H.T., 11/6.6 KV U.G. Cable 3 × 95 sq. mm.	"	Rs. 600/-
11.	H.T., 11/6.6 KV U.G. Cable 3 × 120 sq. mm.	"	Rs. 684/-
12.	H.T., 11/6.6 KV U.G. Cable 3 × 150 sq. mm.	"	Rs. 759/-
13.	H.T., 11/6.6 KV U.G. Cable 3 × 185 sq. mm.	"	Rs. 905/-
14.	H.T., 11/6.6 KV U.G. Cable 3 × 225 sq. mm.	"	Rs. 965/-
15.	H.T., 11/6.6 KV U.G. Cable 3 × 300 sq. mm.	"	Rs. 1217/-
16.	L.T. U.G. Cable 4 × 6 sq. mm.	"	Rs. 51/-
17.	L.T. U.G. Cable 4 × 10 sq. mm.	"	Rs. 60/-
18.	L.T. U.G. Cable 4 × 25 sq. mm.	"	Rs. 88/-
19.	L.T. U.G. Cable 4 × 50 sq. mm.	"	Rs. 135/-
20.	L.T. U.G. Cable $3\frac{1}{2}$ × 70 sq. mm.	"	Rs. 154/-
21.	L.T. U.G. Cable $3\frac{1}{2}$ × 95 sq. mm.	"	Rs. 192/-
22.	L.T. U.G. Cable $3\frac{1}{2}$ × 120 sq. mm.	"	Rs. 237/-
23.	L.T. U.G. Cable $3\frac{1}{2}$ × 150 sq. mm.	"	Rs. 278/-
24.	L.T. U.G. Cable $3\frac{1}{2}$ × 185 sq. mm.	"	Rs. 342/-
25.	L.T. U.G. Cable $3\frac{1}{2}$ × 240 sq. mm.	"	Rs. 444/-
26.	L.T. U.G. Cable $3\frac{1}{2}$ × 300 sq. mm.	"	Rs. 538/-

Table 10. Approximate Cost of Joint Boxes for P.I.I Cables

(*i*) Straight Through

Item	*Unit*	*Rat*
1. H.T. Straight through 11/6.6 KV 3 × 25 sq. mm.	Each	Rs. 1060/
2. H.T. Straight through 11/6.6 KV 3 × 70 sq. mm.	"	Rs. 1460/
3. H.T. Straight through 11/6.6 KV 3 × 120 sq. mm.	"	Rs. 1695/
4. H.T. Straight through 11/6.6 KV 3 × 185 sq. mm.	"	Rs. 2360/
5. H.T. Straight through 11/6.6 KV 3 × 225 sq. mm.	"	Rs. 2765/
6. H.T. Straight through 11/6.6 KV 3 × 300 sq. mm.	"	Rs. 3385/
7. L.T. Straight through 4 × 25 sq. mm.	"	Rs. 475/-
8. L.T. Straight through 4 × 50 sq. mm.	"	Rs. 535/-
9. L.T. Straight through $3\frac{1}{2}$ × 70 sq. mm.	"	Rs. 650/-
10. L.T. Straight through $3\frac{1}{2}$ × 95 sq. mm.	Each	Rs. 660/-
11. L.T. Straight through $3\frac{1}{2}$ × 120 sq. mm.	"	Rs. 1050/
12. L.T. Straight through $3\frac{1}{2}$ × 150 sq. mm.	"	Rs. 1050/
13. L.T. Straight through $3\frac{1}{2}$ × 185 sq. mm.	"	Rs. 1095/
14. L.T. Straight through $3\frac{1}{2}$ × 225 sq. mm.	"	Rs. 1105/
15. L.T. Straight through $3\frac{1}{2}$ × 300 sq. mm.	"	Rs. 1670/-
(*ii*) **Outdoor**		
1. H.T. Outdoor boxes 11/6.6 KV 3 × 25 sq. mm.	Each	Rs. 1525/-
2. H.T. Outdoor boxes 11/6.6 KV 3 × 70 sq. mm.	"	Rs. 1565/-
3. H.T. Outdoor boxes 11/6.6 KV 3 × 120 sq. mm.	"	Rs. 1910/-
4. H.T. Outdoor boxes 11/6.6 KV 3 × 150 sq. mm.	"	Rs. 1910/-
5. H.T. Outdoor boxes 11/6.6 KV 3 × 185 sq. mm.	"	Rs. 1910/-
6. H.T. Outdoor boxes 11/6.6 KV 3 × 225 sq. mm.	"	Rs. 2395/-
7. H.T. Outdoor boxes 11/6.6 KV 3 × 300 sq. mm.	"	Rs. 2395/-
(*iii*) **Indoor**		
1. H.T. Indoor boxes 11/6.6 KV 3 × 25 sq. mm.	Each	Rs. 395/-
2. H.T. Indoor boxes 11/6.6 KV 3 × 70 sq. mm.	"	Rs. 460/-
3. H.T. Indoor boxes 11/6.6 KV 3 × 120 sq. mm.	"	Rs. 535/-
4. H.T. Indoor boxes 11/6.6 KV 3 × 150 sq. mm.	"	Rs. 630/-
5. H.T. Indoor boxes 11/6.6 KV 3 × 185 sq. mm.	"	Rs. 780/-
6. H.T. Indoor boxes 11/6.6 KV 3 × 225 sq. mm.	"	Rs. 780/-
7. H.T. Indoor boxes 11/6.6 KV 3 × 300 sq. mm.	"	Rs. 810/-

Table 11. Approximate Cost of Insulating material

(*i*) Insulating tapes

Item	*Unit*	*Rate*
(*a*) Black adhesive tapes 25 mm, wide 50 metres length	Roll of 50 metres	Rs. 90.00
(*b*) Varnished or empire tape 25 mm. wide 50 meters length	"	Rs. 30.00
(*c*) Cotton tape 25 mm, wide 40 metre length	"	Rs. 15.00
(*ii*) **Insulating Compound**		
(*a*) Plastic Compound for L.T.	kg.	Rs. 12.00
(*b*) Black Bituminous Cable Compound suitable for voltages upto 11 KV.	kg.	Rs. 16.00
(*c*) Rosin oil Cable Compound for voltages upto 33 KV.	kg.	Rs. 50.00
(*d*) Sleeve Compound	kg.	Rs. 10.00

Table 12. Material for overhead lines, service lines and street light

S.No.	*Item*	*Unit*	*Rate*
1.	A.C.S R. Conductor in various sizes	kg.	Rs. 55/-
2.	P.C.C/R.C.C. pole 8.55 metre long	Each	Rs. 1800/-
3.	P.C.C/R.C.C. pole 9.15 metre long	Each	Rs. 2200/-
4.	P.C.C/R.C.C. pole 11.00 metre long	Each	Rs. 3000/-
5.	Wooden pole 8.55 metre long	Each	Rs. 250/-
6.	Wooden pole 9.15 metre long	Each	Rs. 280/-
7.	Wooden pole 11.00 metre long	Each	Rs. 320/-
8.	Danger plate	Each	Rs. 30/-
9.	Anti-climbing device	Each	Rs. 25/-
10.	Arrestors lightning L.T.	Each	Rs. 650/-
11.	Arrestors lightning 11/6.6 KV	Each	Rs. 1850/-
12.	Arrestors lightning 33 KV	Each	Rs. 25500/-
13.	Bobins 15.9 mm.	Doz.	Rs. 10/-
14.	Insulator pin-type with spindle, 500 V	Each	Rs. 12/-
15.	Insulator pin-type with spindle, 1100 V	Each	Rs. 12/-
16.	Insulator pin-type with spindle 6.6 KV/11 KV	Each	Rs. 45/-
17.	Insulator pin-type with spindle 33 KV	Each	Rs. 275/-
18.	Shackle Insulator medium 500 V with straps and bolts	Each	Rs. 12/-
19.	Shackle Insulator large 1,100 V with straps and bolts	Each	Rs. 22/-
20.	H.T. disc type insulator 11 KV	Each	Rs. 225/-
21.	Flat Iron all sizes	Kg.	Rs. 16.25

(Contd.)

S.No.	Item	Unit	Rate
22.	Angle Iron all sizes	Kg.	Rs. 11/-
23.	Stay plate m.s. 6.30 mm. thick, 22.5 cm. × 22.5 cm.	Each	Rs. 75/-
24.	Stay plate m.s. 6.30 thick, 30 cm. × 30 cm.	Each	Rs. 110/-
25.	Galvanised stay or anchor rod 60 cm. long 16 mm. dia.	Each	Rs. 95/-
26.	Galvanised stay or anchor rod 60 cm. long 19 mm. dia.	Each	Rs. 115/-
27.	Stay bow of galvanized iron 15 mm, dia. and 37.5 cm. length	Each	Rs. 30/-
28.	Galvanised thimble	Each	Rs. 4/-
29.	Strain or stay insulator	Each	Rs. 9/-
30.	Stay collar of 3.80 mm. thick flat iron	Each	Rs. 10/-
31.	Earth plate G.I. 60 cm. × 60 cm. × 6.30 mm	Each	Rs. 250/-
32.	Stay wire 7/8 S.W.G.	Kg.	Rs. 18/-
33.	B. brackets 5.08 cm.	Each	Rs. 15/-
34.	Projecting angle iron bracket 0.92 m. × 0.92 m.	Each	Rs. 50/-
35.	Projecting angle iron bracket 1.25 m. × 1.25 m.	Each	Rs. 75/-
36.	Projecting angle iron bracket 1.53 m. × 1.53 m.	Each	Rs. 105/-
37.	2 line cross-arm bracket with suitable clamp.	Each	Rs. 25/-
38.	4 line cross-arm bracket with suitable clamp.	Each	Rs. 55/-
39.	Eye bolts and nuts 20.5 cm. × 1.25 mm.	Each	Rs. 25/-
40.	Eye bolts and nuts 30 cm. × 1.25 mm.	Each	Rs. 30/-
41.	Aerial pole fuse strips 15, amps., 250 V.	Each	Rs. 6/-
42.	Fuse cutout porcelain (bakelite) 5 amps.	Each	Rs. 10/-
43.	Fuse cutout porcelain (bakelite) 15 amp.	Each	Rs. 15/-
44.	Fuse triple pole iron-clad M.E.M. 15 amps., 500 V.	Each	Rs. 30/-
45.	Fuse triple pole iron-clad M.E.M. 30 amps. 500 V.	Each	Rs. 40/-
46.	Fuse triple pole iron-clad M.E.M. 60 amps 500 V	Each	Rs. 55/-
47.	Fuse triple pole iron-clad M.E.M. 100 amps 500 V	Each	Rs. 110/-
48.	D-clamp for shackles of all sizes	Each	Rs. 11/-
49.	H.R.C. fuses 500 volts 100 amps	Each	Rs. 135/-
50.	H.R.C. fuses 500 volts 200 amps	Each	Rs. 210/-
51.	H.R.C. fuses 500 volts 315 amps	Each	Rs. 320/-
52.	H.R.C. Fuses 500 volts 400 amps	Each	Rs. 450/-
53.	H.R.C. Fuse 500 volts 630 amps	Each	Rs. 475/-
54.	Lamp 100 watts 250 volts	Each	Rs. 10/-
55.	Lamp 150 watts 250 volts	Each	Rs. 8/-
56.	Lamp 200 watts 250 volts	Each	Rs. 16/-
57.	Double tube light fitting 0.610 metre length complete in all respect	Each	Rs. 175/-

(Contd.)

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
12.	Binding Wire	kg.	5	16	00	80	00	
13.	Aluminium Thimble	Nos.	4	10	00	40	00	
14.	Stay plate M.S. 6.3 mm. thick and of size 30 cms. × 30 cm. with 19 mm. dia. hole.	Nos.	7	45	00	315	00	
15.	Galvanised Stay or Anchor Rod 19 mm. dia. 60 cm. long	Nos.	7	115	00	805	00	
16.	Galvanised Thimble	Nos.	14	4	00	56	00	
17.	Strain or Stay Insulators	Nos.	7	9	00	63	00	
18.	Earth plate G.I. 60 cm. × 60 cm. × 6.30 mm. thick	Nos.	5	250	00	1250	00	
19.	G.I. pipe 19 mm. dia.	m.	30	12	50	375	00	
20.	Stay Wire 7/8 S.W.G.	kg.	105.0	18	00	1890	00	
21.	Charcoal	kg.	155	6	00	930	00	
22.	Cement	Bags.	45	100	00	4500	00	
23.	Sand	Bags.	300	4	00	1200	00	
24.	Stone Blast	Bags.	90	9	00	810	00	
25.	Bricks	Nos.	1,400	900 (per 1,000) Nos.	00	1260	00	
26.	M.S. Bolts and Nuts having Hexagonal head 50 mm. × 15 mm.	Nos.	40	50	00	200	00	
27.	M.S. Washers 15 mm. hole	Nos.	120	00	20	24	00	

S.No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
	Labour Charges (assuming that the following technicians and mazdoors will complete the job during the nos. of days shown against each)					97155	00	
	Designation *Nos.* *Rate* *Days*							
	(i) Lineman Gd. I 2 70.00 30					26870	00	
	(ii) Mazdoors 15 45.00 30					124025	00	
	(iii) Mason 1 100.00 20							
	(iv) Blacksmith 1 60.00 7							
	Add 10% as Contingencies					12402	50	
	Total					1,36,427	50	Say
	Hence the estimated cost is Rs. 136428.00							Rs. 1,36,428.00

8. We use 2 core 1 mm^2, 1/1.2 cu cable for tapping from 6 mm^2 to the lamp
9. All the 12 lamps are on one side of the street.

Voltage Drop Calculation :

Current in each bulb of 40 W = 40/230 = 0.173 Amps.

The designing current $= 0.173 \times \frac{1.5}{0.8} = 0.326$ Amps.

Distance from pillar to the post No. 1 = 8m.

∴ Length of cable required = (1 + 1 + 8 + 1 + 1.35 + looping) = 15 M

We select 6mm^2, 1/2.80 mm 7.3 m V/Amp./m. single phase, twin core copper cable (Multi-strand Sheathed, Insulated with BUTYL RUBBER).

STREET LIGHTS

The Currents and associated Voltage drop in each section are shown below:

Sl. No.	Section	Distance	Current Amps	Voltage drop Volts	Total
1.	PA	8M	3.912	0.428	
2.	AB	30M	3.587	0.820	
3.	BC	"	3.260	0.713	
4.	CD	"	2.934	0.642	
5.	DE	"	2.608	0.571	
6.	EF	"	2.282	0.429	
7.	FG	"	1.956	0.428	
8.	GH	"	1.630	0.356	
9.	HI	"	1.304	0.285	
10.	IJ	"	0.978	0.213	
11.	JK	"	0.652	0.141	
12.	KL	"	0.326	0.069	5.165

(This drop is within limits)

LABOUR CHARGES

1. For excavation of earth for laying Cable at 1 M below the ground : 10 labourers at Rs. 45/- per day for 3 days — Rs. 1350.00
2. For excavation of earth for erection of 12 Nos. of post. 5 labourers at Rs. 45/- per day for 2 days — Rs. 450.00
3. Bricks for laying 370 m length L.S. — Rs. 275.00
4. Erection of poles, Running the Cable, Fixing the junction boxes, Making the joints, fixing the T.L. fittings etc.
   (a) Supervisor -1 at Rs. 100.00
   (b) Cable jointer - 1 at Rs. 80.00

(c) Electrician-2	at Rs. 80/- each	Rs. 160.00
(d) Helpers - 4	at Rs. 45/- each	Rs. 180.00
	Total Rs. 520.00 Per day for 3 days	Rs. 1560.00
5. Refilling the earth - 2 labourers at Rs. 45.00 per day		Rs. 90.00
6. Mason -1 No - 2 daysat Rs. 80.00 per day		Rs. 160.00
Helper - 2 No - 2 daysat Rs. 45.00 per day		Rs. 180.00
7. Junior Engineer to see that the entire work is completed with in 10 days at Rs. 150.00 per day		Rs. 1500.00
	Total	Rs. 5565.00

ANNEXURE-1

Length of Cable required

From pillar to trench (0.5 + 1.0 = 1.5) = 1.5 m

From trench to 1st Post (Horizontal under the ground = 8.0 m

From under the 1st Post to SB at the 1st post (1 + 1.3 = 2.3) = 2.3 m

From SB to trench (down) (1.3 + 1.0 = 2.3) = 2.3 m

From 1st post to 12th post (11 × 30 = 330) = 330.00 m

Loose = 2.5 m

Total = 346.6 m

Add 10% = 34.6m

Total = 381.2 m

Or say 381/- Mts.

Ionization : The formation of ions by the division of molecules or by the addition or removal of Electrons from atoms, molecules or groups of the latter.

Molecule : The smallest particle of a substance which exists in a free state and exhibits the chemical properties of the substance.

Neutron : An elementary particle having no resultant charge and the mass of which is approx. equal to that of a proton.

Positive Electricity : Electricity which is similar to that produced by rubbing a piece of glass (resin) with silk.

Proton : An elementary particle containing the smallest positive charge of electricity and possessing mass of the same order as the hydrogen atom.

Electrostatics

Capacitance of Capacitor : The charge on one of the capacitor plates divided by the potential difference between them, the influence of any other conductor being negligible

Capacitance of Conductors : The charge of a conductor is divided by its potential, all other conductors assumed to be at zero potential.

Capacitor : A system of two conductors (plates) separated over the extent of their surfaces by an insulation medium which is capable of storing electrical energy as electrical stress.

Eddy currents : The currents induced in the interior of conducting masses by variations of the magnetic flux.

Current Density : A vector of which the integral over given surface is equal to the current flowing through the surface. The mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor.

Electric circuit : An arrangement of bodies or media through which current can flow.

Electric flux : The differential co-efficient of the electric flux density in a dielectric with respect to time.

Conductance : The reciprocal of resistance.

Cathode : The electrode by which the current in a system leaks, that is, by which the electrons enter the medium.

Anode : The electrode by which the current in a system enters, that is by which the electrons leaves the medium,

Alternating Current : A periodic current of which the mean value is zero.

Joule effect : The production of heat due to the passage of electric current through a homonogenous conductor.

Joule's law : The law according to which the power developed in the form of heat in an homogenous conductor is proportional to the product of its resistance and the square of the current which passes through it.

Kirchoff's Law

(*a*) **First Law :** The algebraic sum of the currents meeting at anode of a network is zero.

(*b*) **Second Law :** The algebraic sum of the EMF's in a closed circuit is equal to the algebraic sum of the potential drops due to the resistance.

Non Inductive Circuit : An electric circuit of which the inductance is negligible in the particular condition under consideration.

Ohm's Law : The law which, in the case of direct currents, expresses the proportionality between the current and the potential difference between the ends of a circuit element in which there is no E.M.F. generated.

Parallel Circuit-Shunt Circuits : Electric or magnetic circuit are said to be in parallel (shunt), when the current or flux is divided between them.

Resistance : (in direct current) : The constant difference of potential applied to the ends of a conductor, divided by the current it produces, when the conductor has no E.M.F. acting there.

Resistivity : The resistance of a wire of a given substance multiplied by cross-sectional area of wire and divided by its length.

Series Circuit : Circuit connected so that the same current flows through them.

Skin effect-Kelvin effect : Non-uniform distribution of variable currents in solid conductors resulting in an increase in the current density near the surface.

Voltage-Potential difference : The line integral from one point to another of an electric field, taken along a given path.

Voltage (Potential) drop : The diminution of potential along a conductor or in an apparatus through which a current is passing

Electric Discharge in gases

Corona effect : The particular form of the glow discharge in the case of electric line or apparatus working at high voltage.

Flash over : The passage of a disruptive discharge round an insulating material.

Leakage Path (Electric) : The shortest distance across the surface of a piece of insulating material between two points at different potentials.

Spark : A brilliantly luminous phenomenon of short duration which characterizes a disruptive discharge.

Striking (an arc or a spark)

Variable conditions during which an arc or spark is established.

Megnetism

Absolute Permeability of a substance or of an isotropic medium

The magnetic flux density divided by the magnetic field strength.

Coulomb's low : The law according to which the force exerted between two points of magnetic masses in homogeneous, isotropic medium of a infinite extent and constant permeability is proportional to these poles and inversely proportional to the square of distance between them.

Diamagnetic Substance : A substance which becomes magnetised always reduces by an external magnetic field, the magnetization having the effect of reducing the induction due to field alone.

Ferro-magnetic Substance : A substance which may be magnetized to a considerable extent in an external magnetic field and which retains the whole or part of this magnetization after the effect of the field has ceased.

Para-magnetic Substance : A substance which becomes magnetized, generally reduced in an external magnetic field, the effect of magnetization being to increase the induction due to the field alone.

Magnet-Permanent Magnet : A ferromagnetic body which attains a magnetic field without the aid of external electric currents.

Magnetic Field : A region of space in which there exists a magnetic state associated with forces.

Magnetic Field strength : An exial vector quantity which together with magnetic induction, specifies a magnetic field at any point in space. It can be detected by a small magnetized needle, freely suspended, which sets itself in the direction of field. The free suspension of the magnetized needle assumes, however, that the

medium of fluid or that a small gap is provided of such a shape and in such a direction that free movement is possible. As long as the induction is solenoidal, the magnetic field is irrotational outside the spaces in which the current density is not zero, so that it derives a potential (non-uniform) therefrom. On the other hand, in the interior of currents, its curl in the rationalized system, is equal to the vector current density, including the displacement current.

The direction of the field is represented at every point by the axis of a small elongated solenoid, its intensity and direction being such that if counter-balances all magnetic effects in its interior whilst the field intensity is equal to the linear current density of the solenoid.

Magnetic flux : Flux of the magnetic induction.

Magnetization : An operation by which ferromagnetic body is given the properties of a magnet. A term sometimes used as synonym for intensity of magnetization.

Magnetic Current : Current principally for producing a magnetic field.

Magnetizing Field : A magnetic field used to produce magnetization.

Normal Permeability : Permeability corresponding to normal induction. In practice, when the term permeability is used without any qualification in connection with ferro-magnetic materials, normal permeability is implied.

Residual Magnetism : A property of ferromagnetic bodies by which they retain a certain magnetization (Induction) after the magnetizing force has been removed.

Saturation : The state of a ferromagnetic substance placed in a field, so strong that the intensity of magnetization becomes independent of the field, the substance is then said to be saturated.

In a wider sence, a ferromagnetic substance is said to be more or less saturated according to whether its magnetization is more or less close to saturation.

Electromagnetism Electrodynamic

Electromagnet : A device consisting of a ferromagnetic core and coil which produces appreciable magnetic effect only when an electric current flows through the coil.

Electromagnetic Induction : The production of electromotive force :

(*a*) In a closed circuit, by the variation magnetic flux linking it.

(*b*) In an element of a movable circuit, by the lines of magnetic flux that it cuts.

Electromagnetism : That part of science which deals with the relations between electricity and magnetism.

Excitation : The production of magnetic flux through a magnetic circuit by means of an electric current. The term is sometimes used as a synonym for the magnetomotive force producing the flux through an electromagnet.

Faraday's Law : The fundamental law of electromagnetic induction which states that the E.M.F. induced in a closed circuit is proportional to the rate of change of flux linked by the circuit.

Laplace's Law : The law which gives the force exerted on an element carrying a current placed in a magnetic field.

Lenz's Law : The law which states that the induced E.M.F. tends to produce current in such a direction that it will oppose the cause by which it has been produced.

Magnetic Circuit : A combination of media, mainly comprising ferromagnetic substance, forming a closed circuit and through which a flux of magnetic induction may pass.

Magnetic Core : The part of a magnetic circuit surrounded by a coil.

Magnetomotive force (Along a closed curve). The line integral of a magnetic field strength around the curve.

Mutual Induction : The magnetic flux which the current flowing in one circuit induces in another circuit divided by the current in the first circuit.

Mutual Induction (Between circuits). The induction of an E.M.F. is one circuit by the change in the current flowing through another circuit.

Reluctance : The magnetomotive force applied to a magnetic circuit divided by the flux established in it.

Self Inductance : Co-efficient of self Induction : For a closed circuit the total magnetic flux linked by it divided by the current flowing through it, or the total magnetic energy stored, divided by half the square of the current flowing through it.

Self Induction : The induction of an E.M.F. in the circuit itself by the change in the current flowing through it.

Solenoid : A coil usually of tubular form for producting a magnetic field.

Yoke : The piece of ferromagnetic material not surrounded by windings, used to connect the cores or an electromagnet or a transformer or the pole of a machine.

Units and Systems of Measurement, Absolute Electrical Units

Ampere : (units of Electric Current)

A constant current which flowing in two parallel straight conductors of infinite length of negligible cross section and placed at a distance of one metre apart in a vacuum will produce a force of 2×10^{-7} newton per metre length between the conductors.

Coulomb : The quantity of electricity conveyed in one second by a current of on ampere.

Farad (unit of Capacitance) : The capacitance of an electric capacitor having a difference a Electric potential of one volt between the plates, when it is charged with a quantity of electricity of one coulomb.

Henry (unit of Electric Induction) : The inductance of a closed circuit in which an E.M.F. of one volts is produced when the current in the circuit varies at the uniform rate of one ampere per second.

Ohm (unit of Electrical Resistance)

The electrical resistance between two points of a conductor when a constant potential difference of one volt applied to these points produced a current of one ampere in the conductor, provided no emf is generated in the conductor.

Volt (unit of Potential difference and E.M.F.)

The difference of electric potential which exists between two points of a conductor carrying a constant current of one ampere, when the power dissipated between these points is one watt.

Weber (unit of magnetic flux) : The magnetic flux which linked with a circuit composed of a single turn produced in it an E.M.F. of one volt if it is uniformly reduced to zero in one second.

Barye : The C.G.S. Unit of pressure which is equal to one dyne per square centimetre and which was adopted at the international unit.

Dyne (the C.G.S. Unit of force) : The force which produces on a mass of one gram an acceleration of one centimetre per second.

Electromagnetic C.G.S. Units	
Quantity	*Name*
Magnetic field density	Oersted
Magnetic flux density	Gauss
Magnetic flux	Maxwell
Magnetomotive force	Gilbert

Erg : (the C.G.S. unit of work) : The work done by a force of one dyne when its point of application is moved one centimetre the direction of force

Newton : The force which produces on a mass of one kilogram an acceleration of one metre per second.

Practical Electrical Unit (C.G.S. to Practical units)

Quantity	*Name*	*Conversion Ratio*
Resistance	Ohm	10^{-9}
Voltage	Volt	10^{-8}
Current	Ampere	10
Quantity of electricity	Coulomb	10
Capacitance	Farad	10^{9}
Inductance	Henery	10^{-9}
Magnetic flux	Weber	10^{-8}
Energy	Joule	10^{-7}
Power	Watt	10^{-7}
Reactive Power	Var	10^{-7}
Apparent Power	Volt ampere	10^{-7}

Usual Practical Units : Units which are not actually included in the practical units derived from the C.G.S. system, but which are commonly used. The following units fall under this category :

Ampere Hour : The quantity of electricity which flows if a current of one ampere passes for one hour and is equal to 36000 coulombs.

Ampere turn : The magnetomotive force produced by one ampere flowing through a single turn of a conductor.

Volt-ampere hour : The unit of apparent energy in the practical system, equal to one watt.

Walt-hour : The electrical energy developed during one hour by a power of one watt and is equal to 36000 joules.

Connection of Poly-Phase Circuits

Mesh : Connection in series of the windings of a poly-phase system, effected in such a manner as to form a closed circuit in 3 phase system. This is called the delta connection.

Star : The connection of poly phase apparatus so arranged that one end of the windings, conductor or apparatus corresponding to each phase is connected to a common point the other end being connected to the corresponding conductors at the distribution system. In a 3-phase circuit this is sometimes called a 'Y' connections.

Zig-Zag or Inter-Connected Star

The connection in star of poly-phase windings, each branch of which is made up of winding, that generate phase-displaced voltage.

Inductive reactance : The product of the inductance and the angular frequency.

Effective Resistance : Resistance to alternating current. Ratio of the power dissipated to the square of the R.M.S. value of the current. For sinusoidal current, divided by the current.

Impedance : The terminal voltage of circuit divided by the current flowing through it.

21

The Electrical Panel Boards– Their Design and Drawings

1. Introduction, 2. Types of Panel Boards, 3. Examples of outside dimensions of some electrical accessories, 4. Design of Panel Boards, 5. Specific size of sheet to be used for fitting the accessories, 6. Examples of designing the Panel Board, 7. Types of Switch Boards.

1. Introduction

The switches and receptacles can not be mounted or placed on wall plates or switch boards having hotch-potch appearance. The spacing between switches and other central devices should also be very proper so as to have a neat and tidy appearance. The selection of size of a particular switch board is based on number of switches, sockets and fan regulators to be mounted, depending upon the outside dimensions of switches and other equipments to be installed on that particular switch board.

The purpose behind design and drawing of panel boards is to develop in the students, the ability to utilise outside dimensions for the purpose of selection of the size of switch board and mounting various control accessories which are part of an electrical installation.

2. Types of Panel Boards

There are two types of panel boards in use in house wiring :

(*a*) **Teak wood switch boards for surface wiring :** The switches, sockets and fan regulators are mounted on top of a wooden block, except for the wires.

(*b*) **Teak wood switch board with sunmica cover for concealed wiring.** The major part of the switches and regulators are accomodated below the surface of the wall. The switch board is

embeded in the wall and covered with a sunmica sheet. The switch may be tumbler switch or flush switch, P.V.C. piano type or M.C.B.

Only the part requiring operation will be projected out. Circular/rectangular holes will be drilled in sheet for concealed switches and other electrical accessories etc.

The panel for distribution and control for laboratories and workshops are made of an iron sheet supported on angle irons on which energy meter, iron clad main switch and distribution fuse box and M.C.B etc. are mounted.

3. Example of outside dimensions of some electrical accessories

1. **Tumbler switch.** [Fig. 21.1 (*a*) and (*b*)]

Outside diameter = 50 mm

Distance between terminals = 25 mm

This distance is very important, that the holes on wooden boards are to be drilled at the same distance as that on switch. The wires from beneath the switch board are made to pass through these holes and made to connect the terminals of the switch.

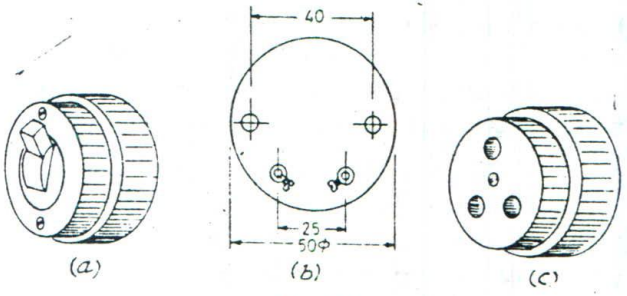


Fig. 21.1

2. **Three pin socket outlet (tumbler) (5 Amps.):** [Fig. 21.1 (*c*)]

Outside diameter = 50 mm

Distance between terminals = 20 mm.

This distance is most important as the distance between terminals of a three pin shoe is also the same. This is a standard dimension according to I.S.I. recommendation which the manufacturer must observe.

Spacing between holes for fixing it with switch board is 40 mm.

3. Flush switch (5 Amps.)

Outside dimensions = 55 mm × 25 mm

Dimensions of the rectangular portion to be fitted in rectangular hole of the sunmica plate = 35 mm × 15 mm.

The switch is fixed to the sunmica sheet with the help of two studs.

The rectangular hole of size 35 mm × 15 mm is made in the sheet for fixing it. The rectangular projection of 35 mm × 15 mm on the back side of switch is made to pass through the rectangular hole on sheet.

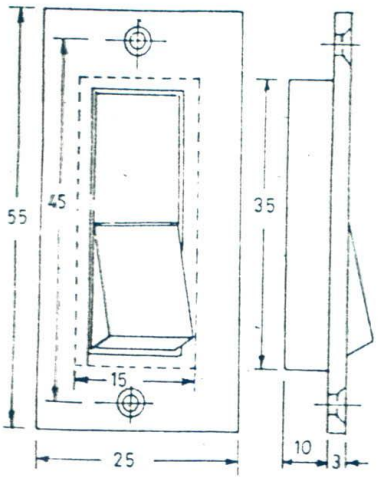


Fig. 21.2

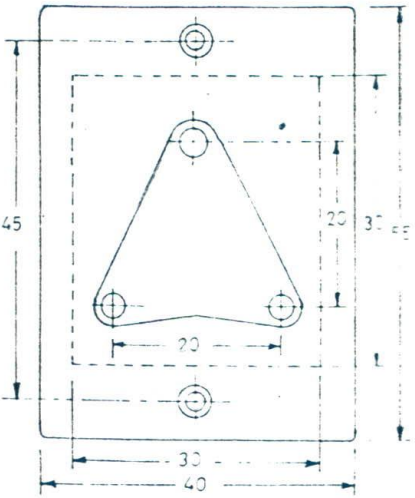


Fig. 21.3

4. Flush socket (5 Amp.). (Fig. 21.3)

Outside dimensions = 55 mm × 40 mm.

Size of the rectangular portion to be fitted in rectangular hole of the sunmica plate = 30 mm × 30 mm

Distance between centres of holes for fixing purposes = 45 mm

5. Fan regulator

The overall outside dimensions of fan regulator vary from company to company. This is important when surface switch board is designed because the holes for connections and far fixing the regulator with switch board will have to be done. But for flush type switch board, only one hole *i.e.* for the speed knob will have to be

drilled in the sheet. The average size of a fan regulator is 125 mm × 100 mm.

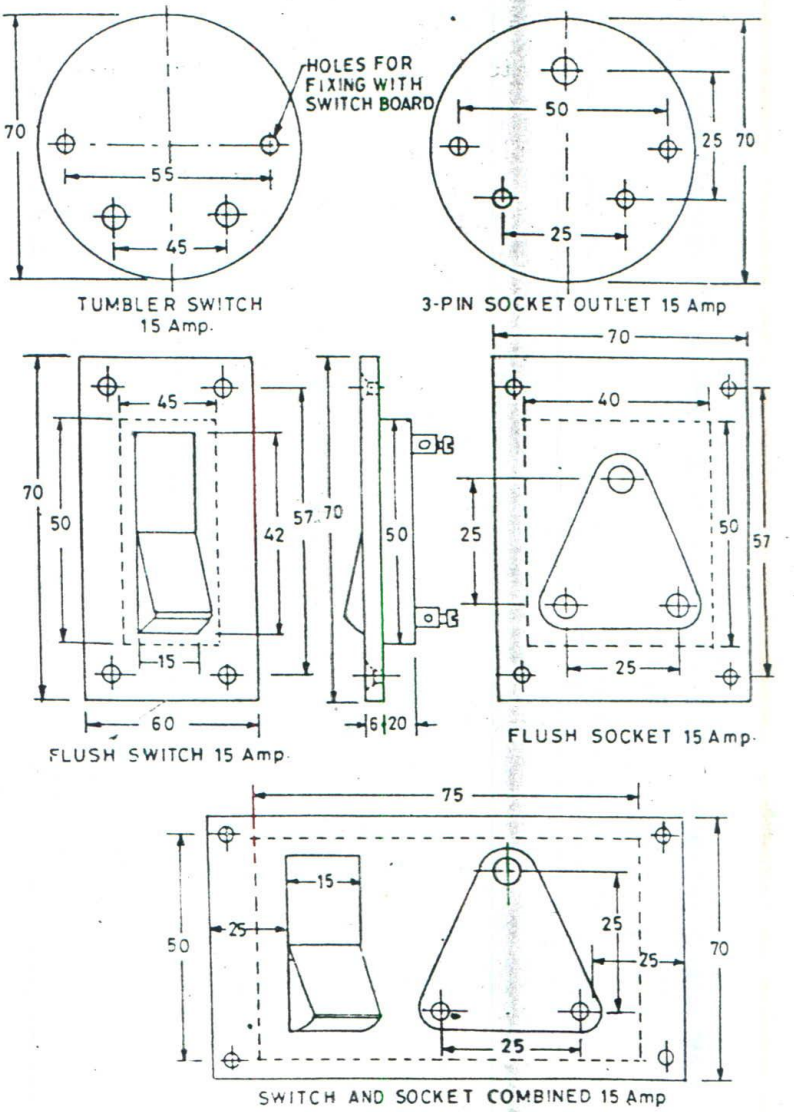


Fig. 21.4

4. DESIGN OF PANEL BOARD

The type of wiring *i.e.* batton system (surface wiring) or conduit wiring (concealed) will determine whether the switch board

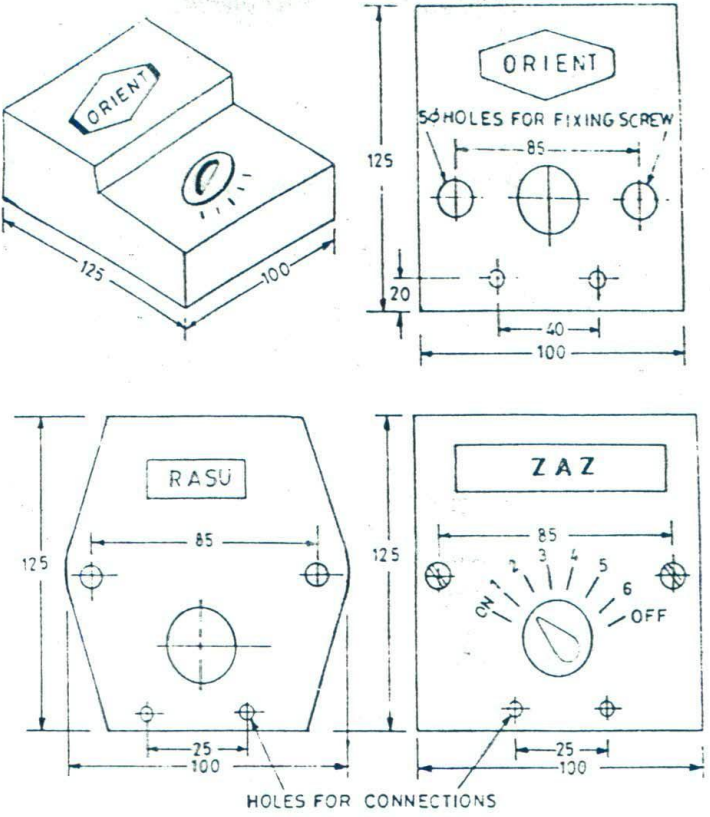


Fig. 21.5

should be mounted on the surface of wall or it should be embedded in wall *i.e.* flush mounted. In the case of batton or casing capping type of wiring, the flush mounted switch board may be used if the house owner so desires.

After considering the outside dimensions of switches, socket outlet, fan regulators and other equipments to be installed on switch board, the following sequence of operation should be observed in selecting and designing the switch board.

(*a*) Total number of switches, sockets, fan regulators and other equipments if any, to be installed on the switch board in such a manner as to give good appearance.

(*b*) Selection of size of switch board should be based on number of switches, sockets and fan regulators to be installed. A few standard sizes of switch boards are available in the

market, but larger switch boards are available only on prior placed demand.

(*c*) The location of each equipment should be based on the utility, *i.e.* the fan regulator should not be placed on bottom side and switches on the upper side or in scattered form. The switches should be preferably installed on the lower side in a row. The fan regulator is normally installed above the row of switches. The space where switches and other equipment is to be installed should be marked on the switch board. No switch or fan regulator should project outside the edges of the board.

(*d*) After marking the location of each equipment on the switch board, the work on switch board can be carried out for drilling the holes and making rectangular grooves etc.

(*e*) The switches and other accessories should be such that their connections are clear and traceable for future repairs.

5. Specific size of sheet to be used for fitting the accessories

Bakelite sheet cover/sunmica sheet cover

The bakelite sheet/sunmica switch board cover is available in large size, it will have to be cut to pieces of required sizes. The normal sizes of switch boards available in market are :

10 cm × 10 cm –	For one switch only.
10 cm × 20 cm –	For one switch and a socket outlet or two switches (flush type) and a socket.
20 cm × 25 cm –	For 2-3 switches socket, and a fan regulator.
20 cm × 30 cm –	For 3 to 4 switches, socket and a fan regulator.
25 cm × 30 cm –	For 4 to 5 swithces, socket outlet and a fan regulator.
30 cm × 30 cm –	For 5 to 6 flush type and 4 to 5 tumbler type switches, a socket outlet and two fan regulators.
30 cm × 45 cm –	For upto 10 switches, a socket and three fan regulators. For flush type and upto 8 tumbler type switches. The sizes above this can be obtained only by special order to carpenter.

The thickness of wooden board for surface wiring should not be less than 6 mm and that of bakelite sheet 2 mm. The size of bakelite should be same as that of the switch board selected.

6. Examples of designing the Panel Boards

Example 1. *Design and draw the bakelite sunmica sheet for concealed wiring, which contains one tumbler switch and a three pin tumbler socket outlet. Give overall size of sheet, and other necessary details. The outside dimensions of the switch and socket are given at page 166 for reference purposes.*

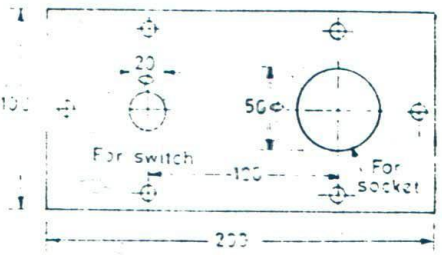


Fig 21.6

Solution. (Refer Fig 21.6). A hole of 20 mm is drilled in the sheet for toggle of the switch to be operated. The other 50 mm diameter hole has been made for the socket outlet. The distance between these two holes has been kept sufficiently large to accomodate the switch and socket easily. Other small holes along outer surface have been made to accomodate countersunk headed wood screws to fix it with the switch board.

Example 2. *Design and draw the bakelite / sunmica sheet for concealed wiring which should contain one flush switch and one flush socket outlet. Give overall size of sheet and rectangular holes to accomodate switch and socket. Other details may also be added.*

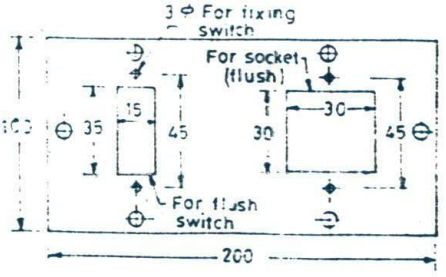


Fig. 21.7

Solution. The left rectangular hole has been made to accomodate the flush switch. The two small holes are meant for the screws so that the flush switch can be fixed to the plate. The right hand rectangular hole is meant for the flush socket outlet. The six small holes along its outer surface are for fixing the switch cover to concealed switch board with the help of C' S' K' headed screws.

Example 3. *Design and draw the surface type switch board which should accomodate, a tumbler switch and a tumbler socket.*

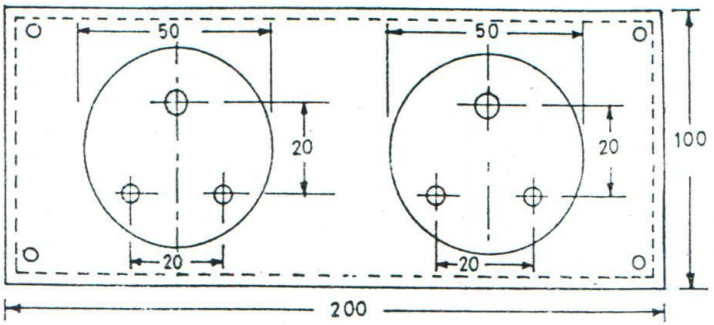


Fig. 21.8

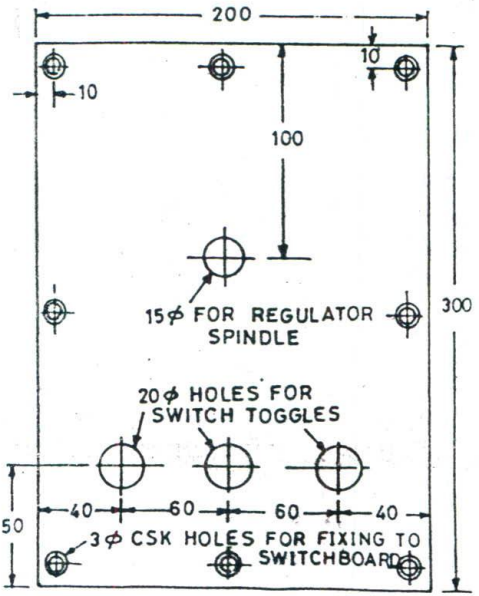


Fig. 21.9

Example 4. *Design and draw a bakelite sheet for the concealed switch board which should contain three tumbler switches and a fan regulator. The necessary outside dimensions of the switches and fan regulator are giver earlier at begining.*

Solution. (Refer Fig. 21.9). Where ever a bakelite/sunmica sheet is to be designed to cover tumbler switches, 20 mm diameter holes shall have to be drilled for a toggle of the switch to project out of the sheet for operating the same. Since, the diameter of each switch is 50 mm, a gap of 60 mm between each two switches is therefore sufficient as shown above. The spindle of the fan regulator will also be projecting outward for the regulator knob. For this purpose, a hole of 15 mm has been drilled. The eight countersunk holes have been drilled for the countersunk screws so that the plate is fixed to the switch board. All overall dimensions have been shown along with other necessary dimensions.

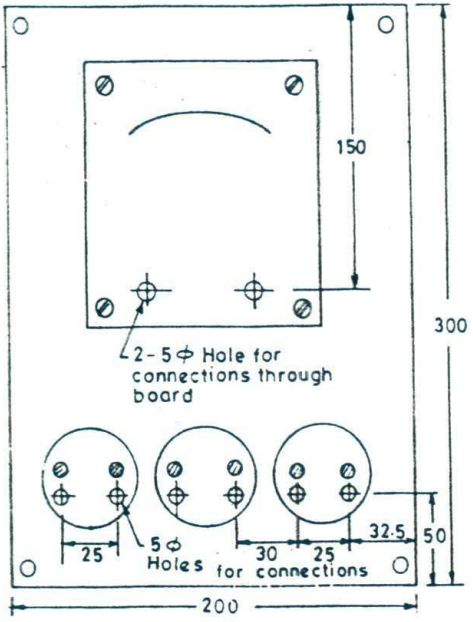


Fig. 21.10

Example 5. *Design and draw a wooden switch board for surface wiring which should contain three tumbler switches and a fan regulator. The outer dimensions of switches and fan regulator are given earlier.*

Solution. (Refer Fig. 21.10). In the wooden boards of this type, only the holes are to be drilled for connections to the switches etc., placed on its outer surface. The three switches have been shown. Two holes of 5 mm diameter each have been shown for connection to the fan regulator through the wooden board. The four counter-sunk holes on four corners of the board are for wood screws for fixing it to four gutties which remain embedded into wall. Two holes have been drilled for connections to the fan regulator. Base of regulator itself will be fixed to the board with two wood screws for which drilled holes may not be required.

Example 6. *Design and draw a bakelite / sunmica sheet for the switch board to be used for concealed conduit wiring which should contain three flush switches, a socket outlet and a fan regulator. The flush switches should remain at a reasonable distance. The necessary outside dimensions of the switches and fan regulator are given earlier.*

Solution. The drawing of Bakelite/sunmica sheet fulfilling the above conditions is given in Fig. 21.11. The rectangular holes

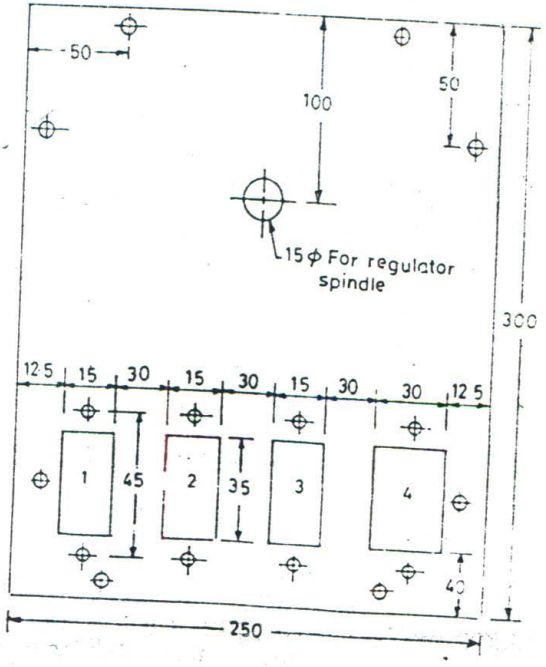


Fig. 21.11

have been made for the rear rectangular portion of the switch to be inserted. The two circular holes around each rectangular holes are for the screws for fixing the switch to the plate. The circular hole has also been drilled for fan regulator spindle. The countersunk hole around the plate are for the wood screws for fixing it with switch board.

Example 7. *Design and draw a bakelite / sunmica sheet for the concealed conduit wiring which should contain six flush switches and a fan regulator.*

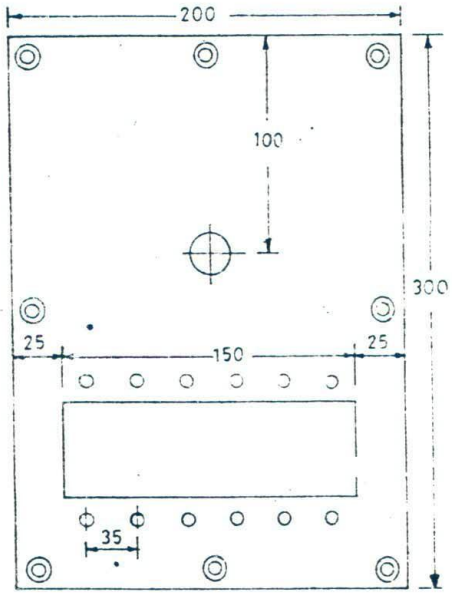
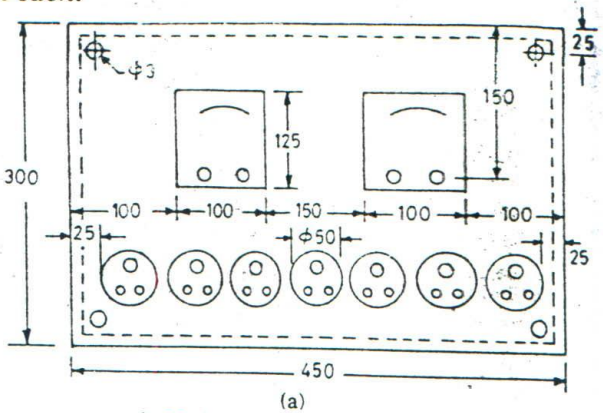


Fig. 21.12

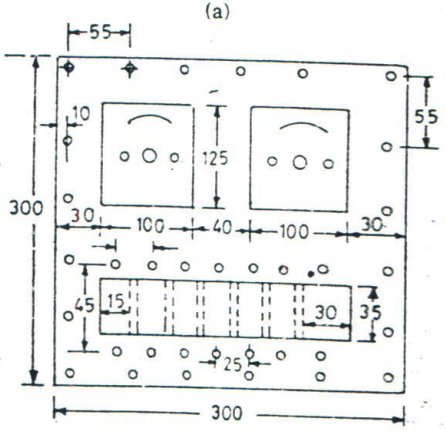
Solution. In this case, a long rectangular groove has been cut to fix all switches in a row on a common groove. This process will require less labour as individual grooves will take more time. The eight countersunk holes along outer surface are for the screws for fixing it with switch board.

Example 8. *Design a surface type wooden switch board and also a bakelite / sunmica sheet for switch panel of flush type underground switch board which contains six switches, one socket outlet and two fan regulators. The switches for the surface switch board are tumbler type whereas for the bakelite sheet are flush mountings. Show the dimensions in both the cases taking dimensions of switches*

from earlier part in this chapter and fan regulator sizes 125 mm × 100 mm each.



(a)



(b)

Fig. 21.13

7. Types of Switch Boards

Surface type wooden switch board. The detailed dimensions of the switch board and the accessories mounted over it is shown in Fig 21.13 (*a*) Since the fan regulators, switches and socket are placed on the front surface, a sufficient gap between each two components should be maintained keeping in view the area covered by switches and regulators, the size of switch board should be 30 cm × 45 cm. The switch board should be placed horizontal.

Bakelite/sunmica sheet for flush switch board. Fig. 21.13 (*b*). The switches and socket should be placed on a common rectangular hole prepared by cutting the sheet. The flush switches cover less space than the tumbler switch. The size of switch board should not be as large as surface type switch board. The sheet size should be 30 cm × 30 cm . The other dimensions have been shown on the sheet itself.

22

Miscellaneous Electrical Components

Slip Rings ; Brush Holders ; Main Parts of Brush Holders and their functions; Types of Brushes ; Brush Rockers and Brackets ; Types of Brush Rockers ; Armatures ; Main Parts of Armature ; Field Poles and Interpoles ; Commutators ; Parts of a Commutator ; Field Magnet frame ; Current Transformer .

SLIP RINGS

The slip rings are employed for wound type rotor of an induction motor. These are the rings by which current is taken to and from the rotating parts (wound type rotor) of a machine. The windings lying in rotor slots are connected to slip rings at one end of rotor shaft. The brushes which rub on the outer surface of the slip rings are made to carry the current from and to the rotor winding. The Brushes are held in brush holders mounted on insulated steel spindles, securely held with end cover of machine. These brushes

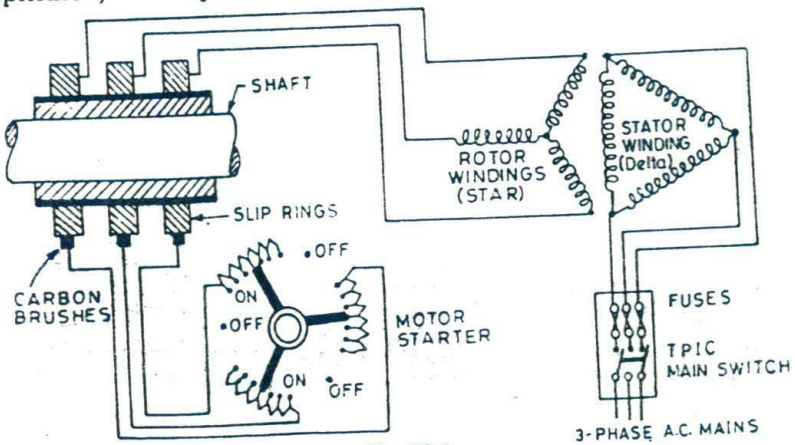


Fig. 22.1

are further connected to 3 phase star delta connected rheostat for speed control and starting purposes. The slip rings are made of brass, bronze or gun metal in single, two or three parts assembled and circular shape obtained. But this is only in case of large slip rings. Small rings are made in single pieces. The slip ring induction motors are very extensively used on account of its higher initial cost and greater maintenance cost. These are used only when speed control is required.

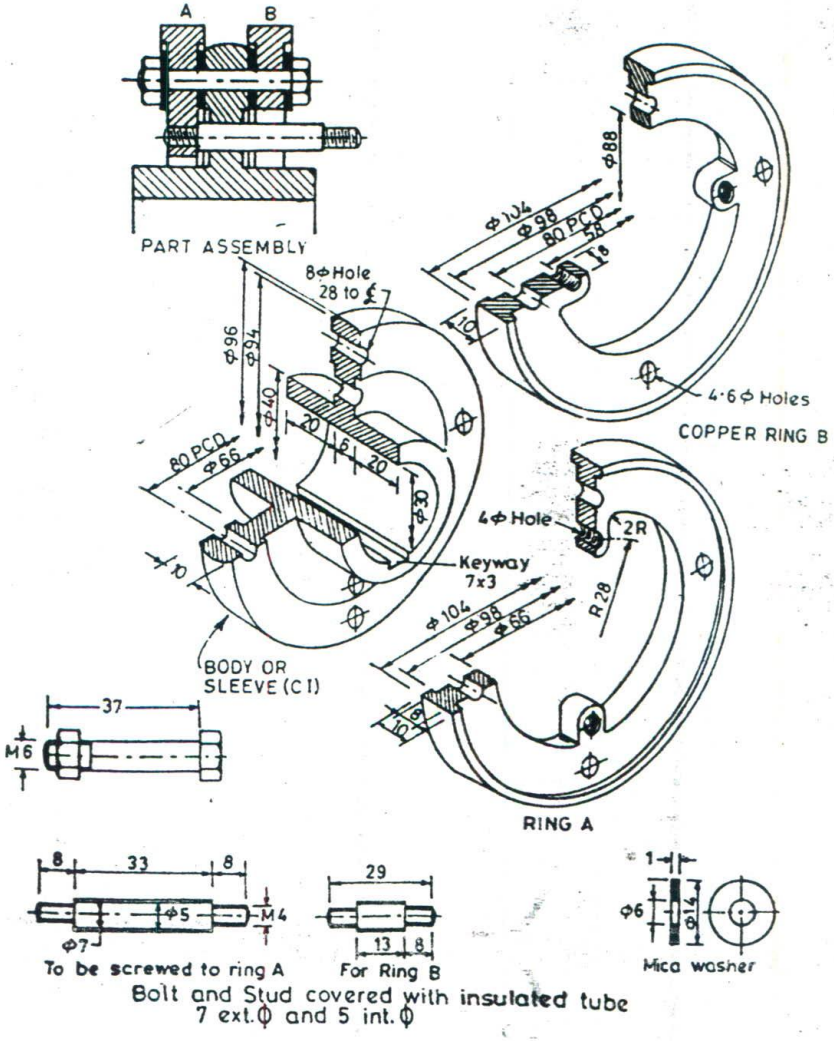


Fig. 22.2. Detail and part assembly of slip rings.

The diagram shown above is a wound type rotor connected in star/delta. The diagram from supply to slip ring is shown in a starter for three phase to explain method of starting a slip ring induction motor. The resistance is inserted in each phase. At the time of starting, the current taken by the motor is limited for safety purposes and as the motor gradually takes up speed, the resistance is cut-off. The moment, the motor catches its full speed, starting resistance is reduced and finally cut-off. The rotor windings are short circuited automatically.

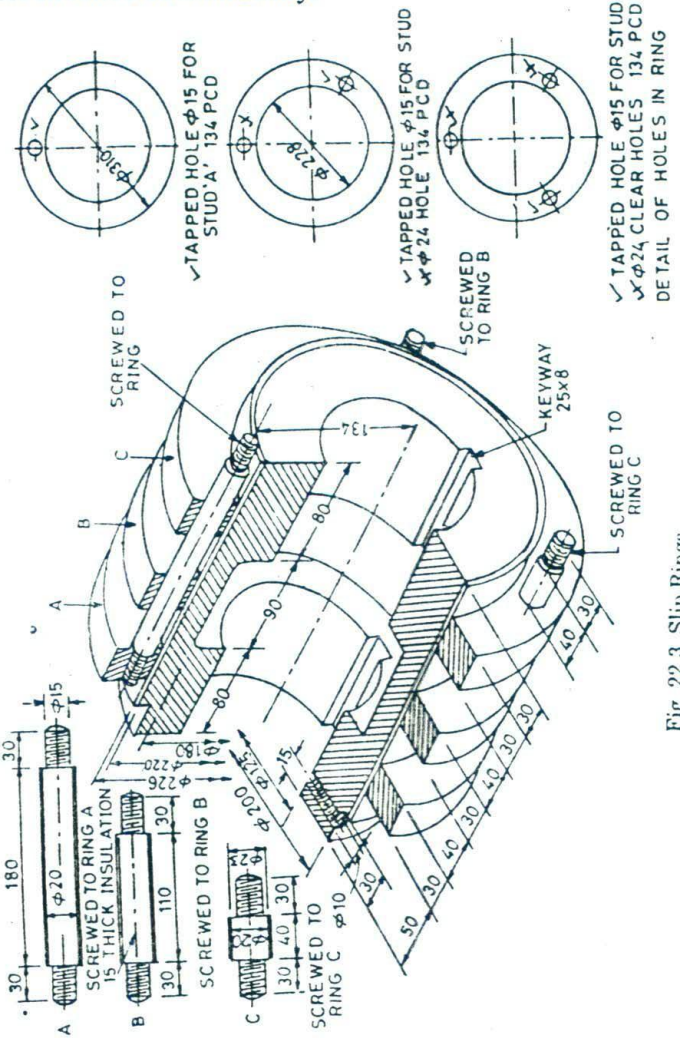


Fig. 22.3 Slip Rings.

An example of two phase slip ring showing detail and part assembly is given in Fig. 22.2. The sleeve has a central hole for shaft. There are various holes along the outward projection of sleeve for fixing slip rings with sleeve with nuts and bolts. The two inward holes are made to pass current carrying studs. The two slip rings in isometric projection are similar to each other. The part assembly of the parts is also shown.

BRUSH HOLDERS

The function of brush holder is to hold the brush against the commutator surface in D.C. machines. The brush holders are held at a place along the end cover of the machine. The brushes are made to deliver the current to the commutator in case of motors and collect in case of generators or dynamos. Each brush is held in the box, which has some device for exerting constant pressure on the brush by way of spring action resulting in rigid contact between carbon brush and commutator surface. There are two types of brush holders in use *i.e.* hammer or lever type. In the case of hammer type, the carbon brush is firmly held at one end of lever and in the later case, the brush is free to slide in the box. However, the brush is forced towards the commutator by spring power. The brushes are firmly held to avoid any vibrations.

Main Parts of Brush Holders and their functions

In the drawing in Fig. 22.4, following are the main parts and their function has been explained in brief:

1. Brush Holding Box (C.I.). The part is casted in one single piece made to receive carbon brush which is free to slide in its rectangular hole. The brush is forced towards commutator by spring power. Two brackets projecting outward are made to support the pressure arm and spring etc. with the help of a pin running between two projecting brackets. There are two projections made in the rear for clamping devices (Fig. 22.4*b*) so that the whole system alongwith its attachments is supported for fixing it to brush holder bracket. The clamping device is fixed in the rear projection and jammed with a screw to the box, a hole for which is shown in the clamping device. The screw will enable the clamping device to be held at any place upward and downward.

2. Pressure Arm (C.I.). The pressure arm is shown on opposite page in two views *i.e.* elevation and end view. In addition to this, an isometric view of pressure arm is shown here so that internal details are clearly understandable. The function is self

explanatory *i.e.* to exert constant pressure on the brush towards commutator. It is supported on the pin between two projecting brackets on the brush holding box. One end of this part comes over the brush. It is operated with spring and spring rod is made to be held in the slot of the pressure arm for desired pressure.

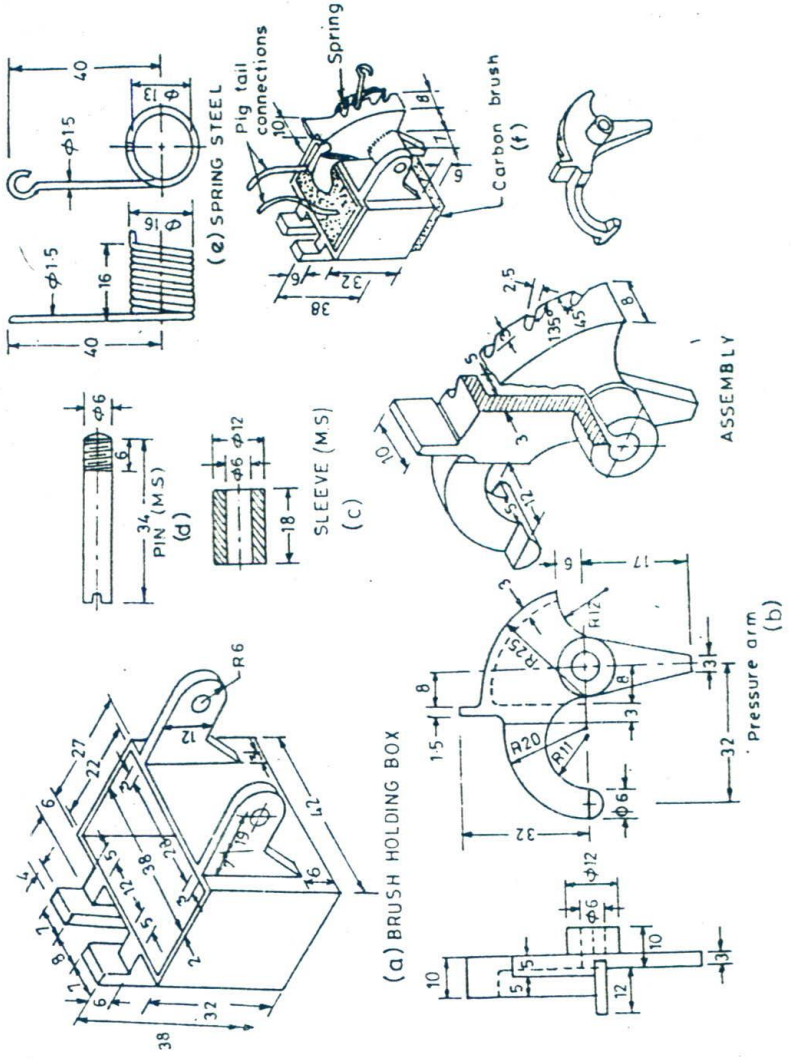


Fig. 22.4. Brush Holder, Details and Assembly.

3. Distance Piece Or Sleeve (M.S.). It comes over the pin between pressure arm and right projecting bracket of the brush

holding box. Its function is to keep the pressure arm at its proper place. Secondly, it is used to support the spring as the distance piece comes under the spring.

4. Pin (M.S.). One end of the pin is threaded and screwed to the tapped hole of the projecting bracket on the brush holding box. The other end will come in the hole of the other bracket and thus, the pin is held between two projecting brackets of the brush holding box. One end has a saw cut for tightning purposes. It is made to support pressure arm and distance piece over it.

5. Springs. It is mounted over the distance piece. The smaller end is secured beneath the right bracket to stop its circular movement. The other end having straight bar is forced towards carbon brush with spring power and thus exert pressure on pressure arm forcing it to press the brush downwards.

6. Clamping Device (C.I.). The function of this part is to support the brush holder assembly along the surface of the commutator. It is later attached to the rocker arm. The drawing shows isometric view of the assembly. The device is in two pieces, the bigger part is attached to brush holding box in the rear. The rectangular side on one side of vertical is made to fit in the rear vertical slot of the brush holding box and jammed by way of screw for which a threaded hole is shown. The smaller one is secured with the bigger one and attached to it with screw.

7. Carbon Brush. The brushes form the connecting link between armature and the external circuit. To ensure good contact. they are held against the commutator by means of pressure arm. The current is received or supplied through the carbon brush which rests on rotating commutator. The brushes are supported in rectangular holes and rub upon rotating outer surface of commutator. The brush is provided with flexible connections known as **'pigtail connections'** which are connected to the fixed connecting lug or terminal. The pigtail connections are connected to brush at top by a screw or soldered to a clip which can be moulded into the brush.

Types of Brushes

There is large variety of brushes based on voltage and speed of commutator. Some of the brushes commonly used are :

(*a*) **Metal Mixture Brushes.** On account of low resistance owing to mixture of graphite and copper, it can be used for extra high currents.

(*b*) **Hard Carbon Brushes.** A special carbon mixed with some other material is used. The brushes are moulded to the required shape and size and then baked at high temperature suitable for normal current density.

(*c*) **Graphite Brushes.** These brushes have special quality due to its material that they can collect greater current as compared to brushes of the same size in other cases.

The drawing on opposite page represents detail of another type of brush holder in isometric projections. The main drawing is a body which holds the carbon brush on one side and has provisions to be held with where ever it is required to be fitted. The spindle which supports the whole assembly (spindle not shown) comes in the main hole and clamped by a screw shown above it. In its middle, there is a tapped hole in which a screw is serewed to serve as a pivot for the pressure arm. The circular side has an inclined projection in which a hole is drilled for connecting screw. The bottom of the connecting screw is circular and has a hole so that spring could be attached. The other threaded rod is made to pass through the hole in the inclined projection. The spring is made to pull the bottom of the pressure arm towards it and as such, the other end will exert pressure on the carbon brush downwards. Whenever pressure on carbon brush is to be increased or decreased. The circular nut is operated upon, which will result tension in the spring reduced or increased and ultimately pressure on carbon brush can be increased or decreased. A separate isometric view of carbon brush is given and pigtail connections are shown.

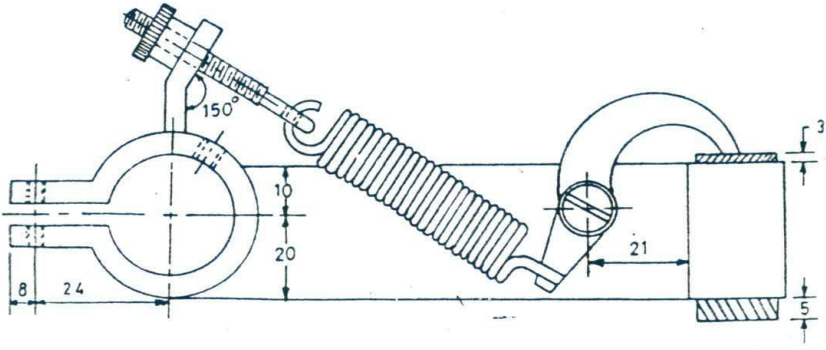


Fig. 22.5

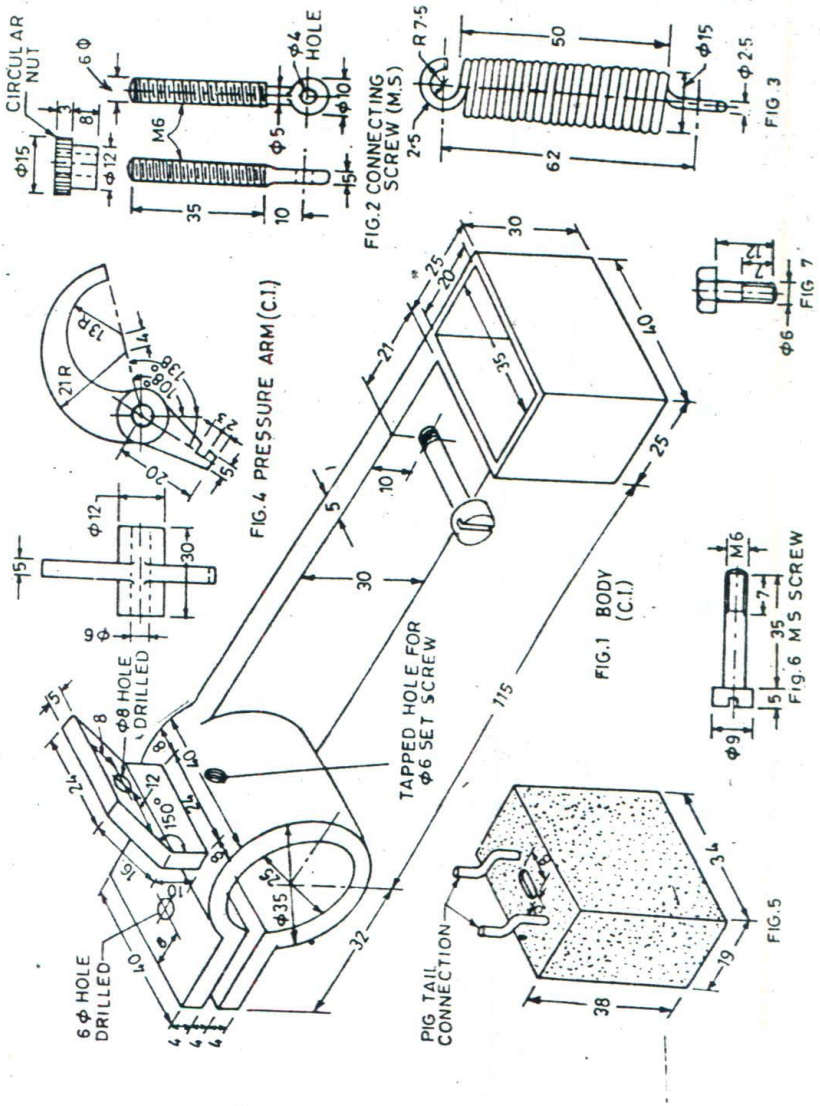

CIRCULAR NUT
Φ15
Φ12
6 Φ
8
M6
Φ5
Φ4 HOLE
Φ10
35
10
5
FIG.2 CONNECTING SCREW (M.S)
R 7·5
2·5
50
Φ15
Φ 2·5
62
FIG. 3
FIG.4 PRESSURE ARM (C.1)
13R
21R
138°
108°
20
5
Φ12
30
9 Φ
8 Φ HOLE DRILLED
24
12
150°
6 Φ HOLE DRILLED
40
Φ35
32
TAPPED HOLE FOR Φ6 SET SCREW
30
10
21
25
20
35
40
25
115
FIG.1 BODY (C.1)
PIG TAIL CONNECTION
38
34
19
FIG.5
Φ9
M6
7
35
Fig. 6 M5 SCREW
Φ6
FIG. 7

Fig.22.6

BRUSH ROCKERS AND BRACKETS

The brush rockers, brackets etc. are all meant to assist a stable position of carbon brushes, through which current enters or leaves the armatures of dynamos or motor. The brushes are firmly held over the commutator and provided with pigtail connections in the form of copper wire embedded in the material of the carbon brush during manufacturing.

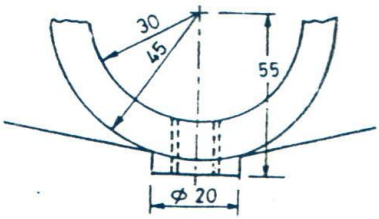


Fig. 22.7

The brush holder or brush box in which the brush exists is mounted on brush spindles or brush bracket (for very large machines) is further bolted or clamped to the brush rocker. Hence, the brush rockers are used to hold brush boxes through the spindles. The brush rocker is fitted over the internal circular extension near to the bearing on end shield of the machine. This is applicable for small machines. In the case of large machines, it is fitted directly with the field magnet frame. The sleeve or spindle which carries one

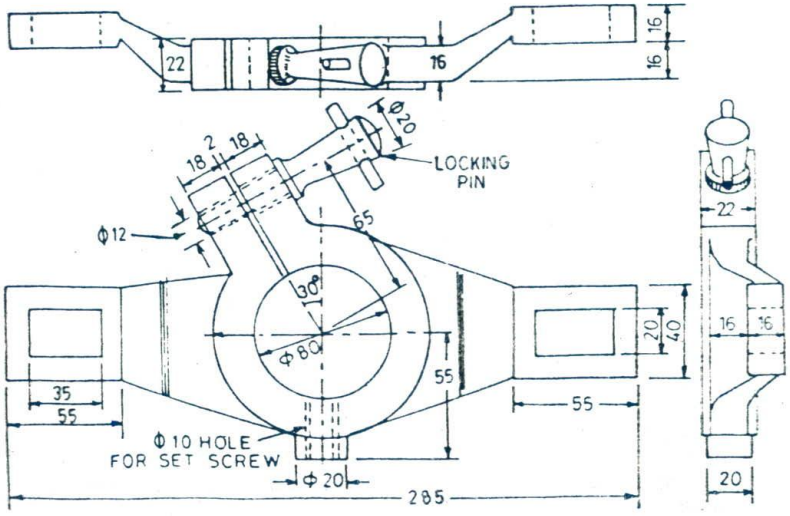


Fig. 22.8

or more brush holders is attached to brush rockers insulated from it with insulation sleeve and washers of ebonite or mica on both sides of rocker arm. The cable holder is held between two nuts on opposite side of spindle. The spindle is covered by a mica sleeve. Each rocker has different arms radially projecting outward which are equal in number to that of sleeve or spindle carrying brush boxes.

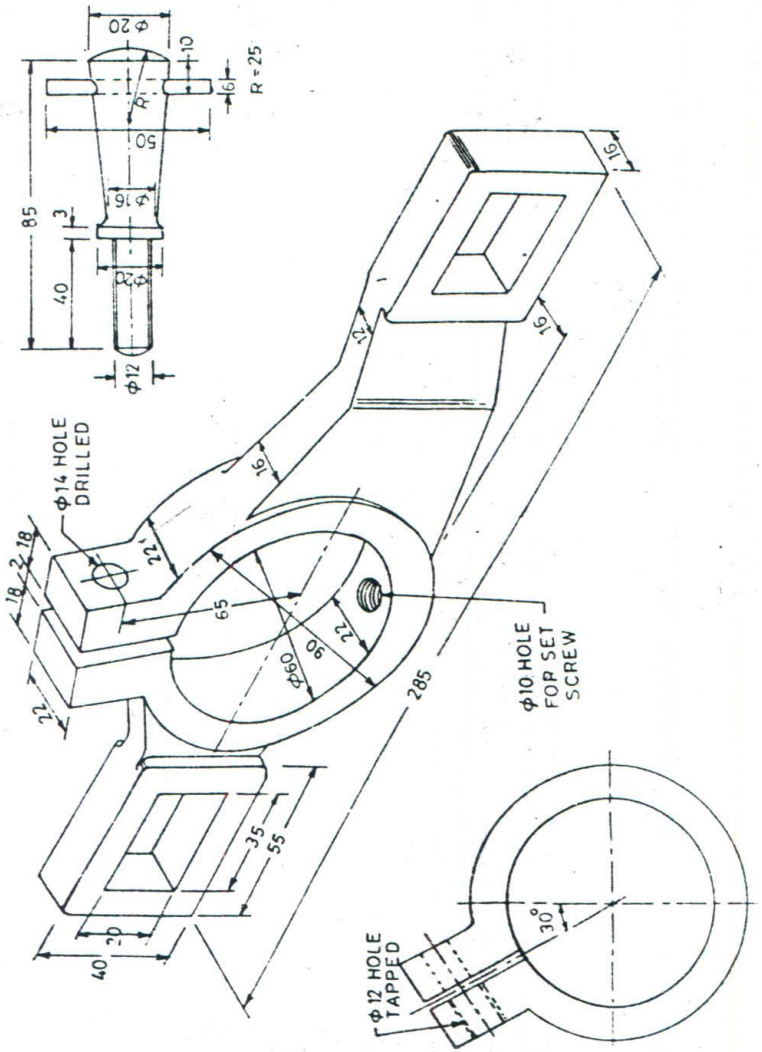


Fig. 22.9

Types of Brush Rockers

1. Brush rocker for two Brushes. The drawing here shows a cast iron brush rocker for supporting two brush spindles and attachments. The rocker is in single casting with a large hole in the centre for fixing it with end cover inner projection.

Elevation, side and plan of brush rocker is shown in Fig. 22.8.

2. Brush rocker for Four Brushes. The rocker is made of cast iron in two pieces, each having four radially projecting arms. Two small projections with tapped holes are provided on both sides around the central hub for clamping the pieces with the help of locking screw. The end of each arm is like a box meant to receive the spindle of the brush holder attachments. The outer boxes are strengthened by ribs. Fig 22.8 shows detail of assembly of two pieces.

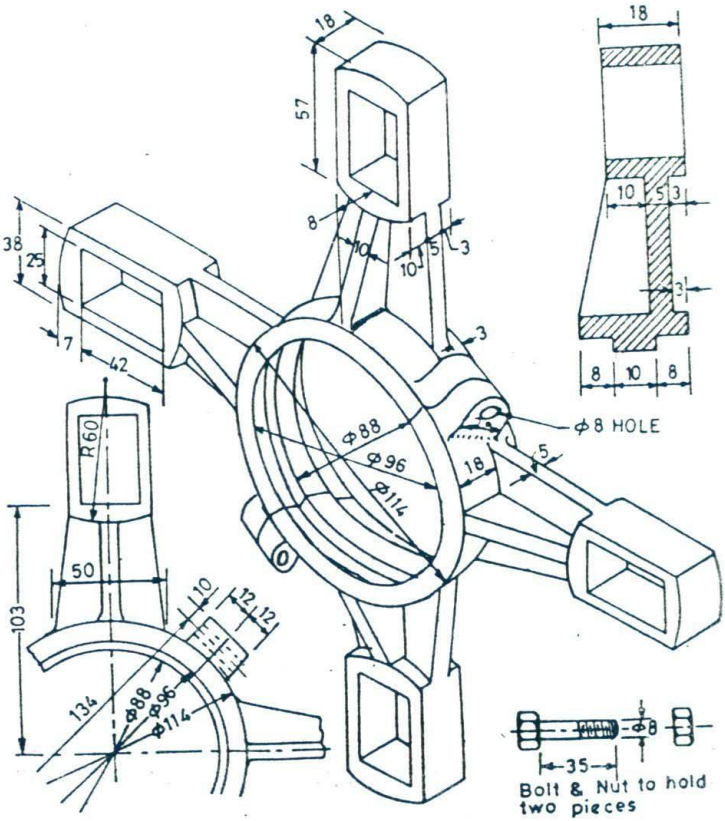


Fig. 22.10 Bolt and Nut to hold two pieces of rocker.

3. Brush Holding Bracket. When more than one brushes are to be placed against the commutator surface, the bracket as shown below is mainly applied. The number of such brackets to be used is the same as that of the number of poles of a machine. This bracket is clamped to the brush rocker ring with the help of the slot, shown near the top. The brush is placed in the brush holder and the brush holder is fastened by means of bolts to the bracket at the bottom.

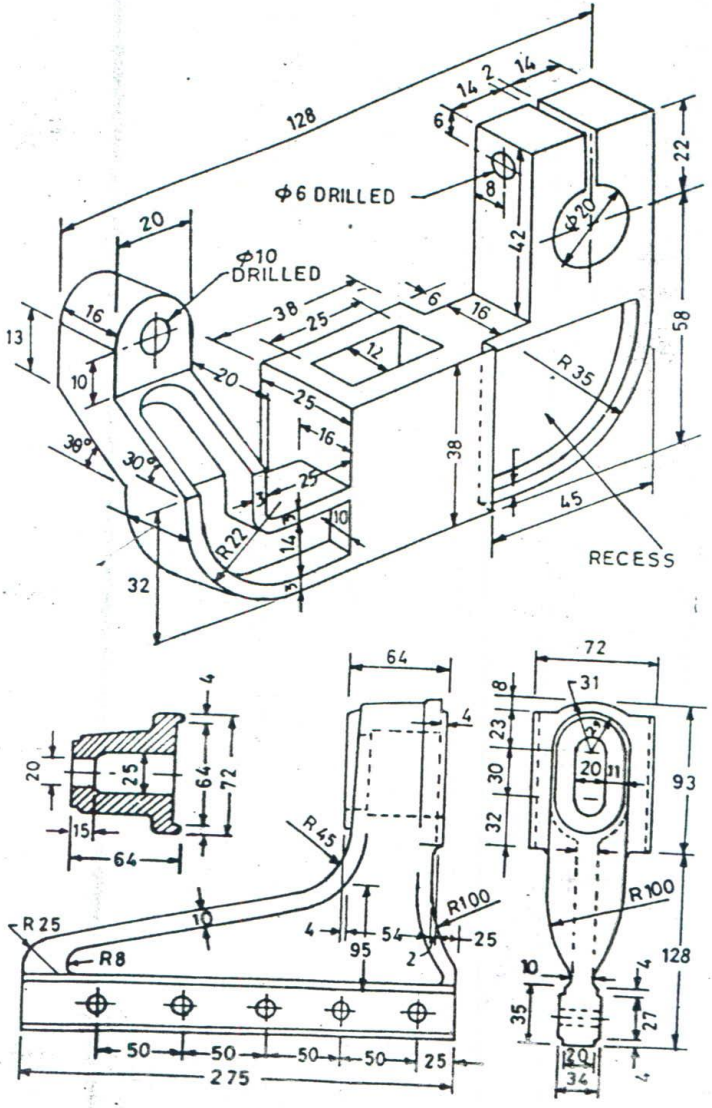


Fig. 22.11. Brush Holding Brackets.

A similar bracket for holding brush spindle is also shown.

ARMATURES

Armature is the main part of a D.C. Machine which revolves in the magnetic field. With the change of flux, an e.m.f. is induced in the conductors laid in the slots of the armature. The current is collected from these conductors by connecting them with the commutator segments and brushes are made to collect the current for external use. This is in the case of dynamos only.

The armatures are made of core plates or stampings held on the shaft between two end rings. The shaft forms the basis of the whole structure which receives the core plate on it and it is the iron part revolving between the poles of the field magnet frame. The stampings or laminations are directly mounted over the shaft and keyed to it, but in large motors, they may be assembled and mounted over the armature SPIDER or frame, which is meant to reduce weight and cost of the armature and hence a substitute to very large size stampings. The thickness of lamination varies from 0-5 to 1 mm depending upon frequency of magnetic reversal. The stampings are insulated from each other by a thin insulated paper layer pasted over it or varnish is applied on both sides of each stamping for insulating purposes so that the total length of iron (excluding insulation) is about 90 per cent of the total core length. The length of core plates when assembled on shaft or spider is known as core length. The laminated core is used to reduce the eddy current losses.

Main Parts of Armature

Following are the main parts of an armature :

1. Laminations or Stampings. The armature core is made of silicon steel stampings. The stampings are insulated from each other by a thin insulated paper layer or spray varnish applied to both sides of each stamping at the time of manufacture. The use of

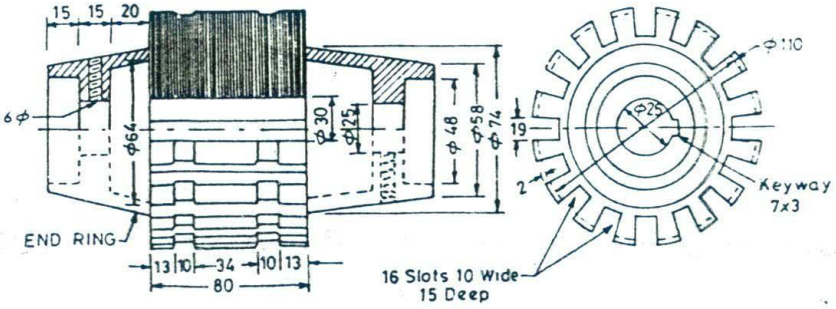


Fig. 22.12

high quality steel is made to keep hysteres is loss low, which is due to cyclic changes of magnetisation caused by rotation of the core in the magnetic field. Secondly, it reduces eddy currents in the core which are caused by the rotaticn of core in magnetic field. The stampings are formed in variety of forms. When stampings are assembled, slots are formed along the armature core, so that armature conductors are laid. The laminations are held in such a way that they are perpendicular to the path of eddy currents and parallel to flux, the path of eddy currents thus is cut into several units.

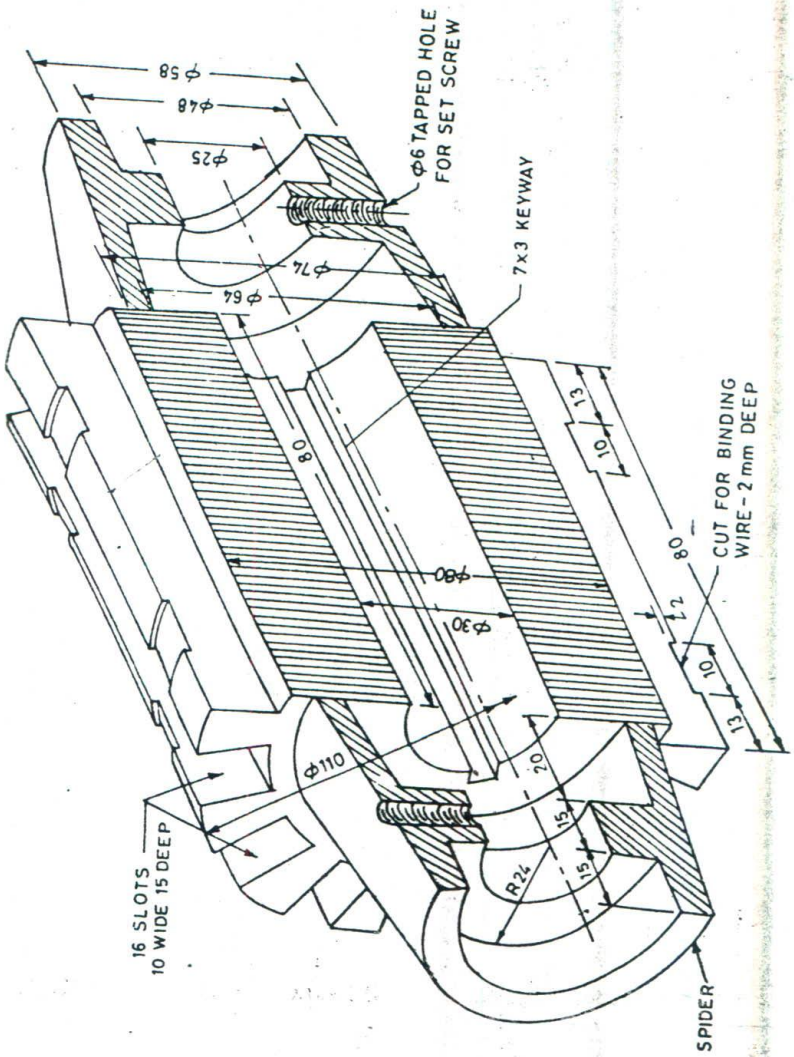


Fig. 22.13. Open and parallel sides slots ARMATURE.

There are many types of laminations with difference in slots only *i.e.* 'H' type for small toy dynamos and for very small motors. Tripolor armatures are used for small motors of low voltage and consist of three big slots and three teeth on its circumference. Some common types of armature stampings are given here.

(*a*) **Parallel sided slots:** This is a very common type of armature. The winding wires are laid in the slots and with separate binding wire, the windings are bound along its circumference, so that they are not affected by centrifugal force caused by high speed of armature. The stampings are mounted over spider and held firmly with spider arms. The outer rectangular shape of spider arms serve the purpose of key to fit in key of stampings.

(*b*) **Semi-enclosed Stampings:** The winding lying in these slots are free from any centrifugal force as the slots are semi-enclosed from top. Hard wooden wedges are driven into the top of each slots above the windings. It is advantageous due to the above reasons but is difficult to wind being the only disadvantage.

(c) **Semi Circular Semi Enclosed Slots:**

The stampings are very similar to that of parallel sided slots. The only difference is that the slots are semi-circular at the bottom and semi-enclosed at top and have parallel surfaces on sides.

Fig. 22.13 and 22.15 are of small armatures shown in isometric views in section. The stampings are to be directly pressed over the shafts and keyed to it. The stampings are clamped between two end rings from both sides. The end rings are also used for supporting windings projecting out of the slots. The end rings are held in place by set screws partly going into shaft. To avoid the effect of

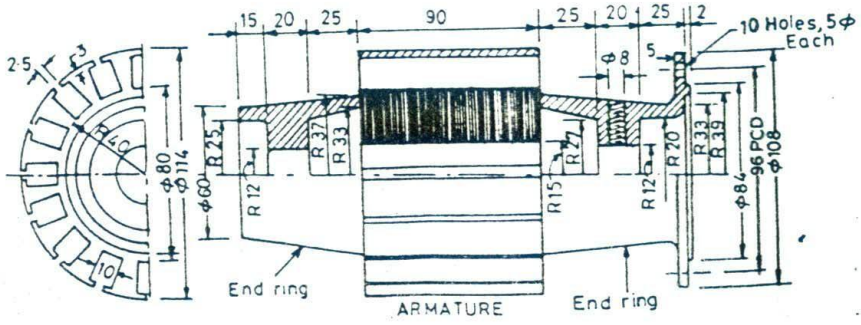


Fig. 22.14 Elevation Upper Half in Section and Side View of ARMATURE

centrifugal force due to high speed of armature, there are two slots along its circumference for binding wires. The slots which are only 2 mm deep are formed by using small sized stampings for that length of slot. The slots in the previous drawing are parallel sided. The effect of centrifugal force on windings is not possible in this case when slots are semi-enclosed as on opposite page. The key is formed in the laminatins and keyway will exist on the shaft. The right ring

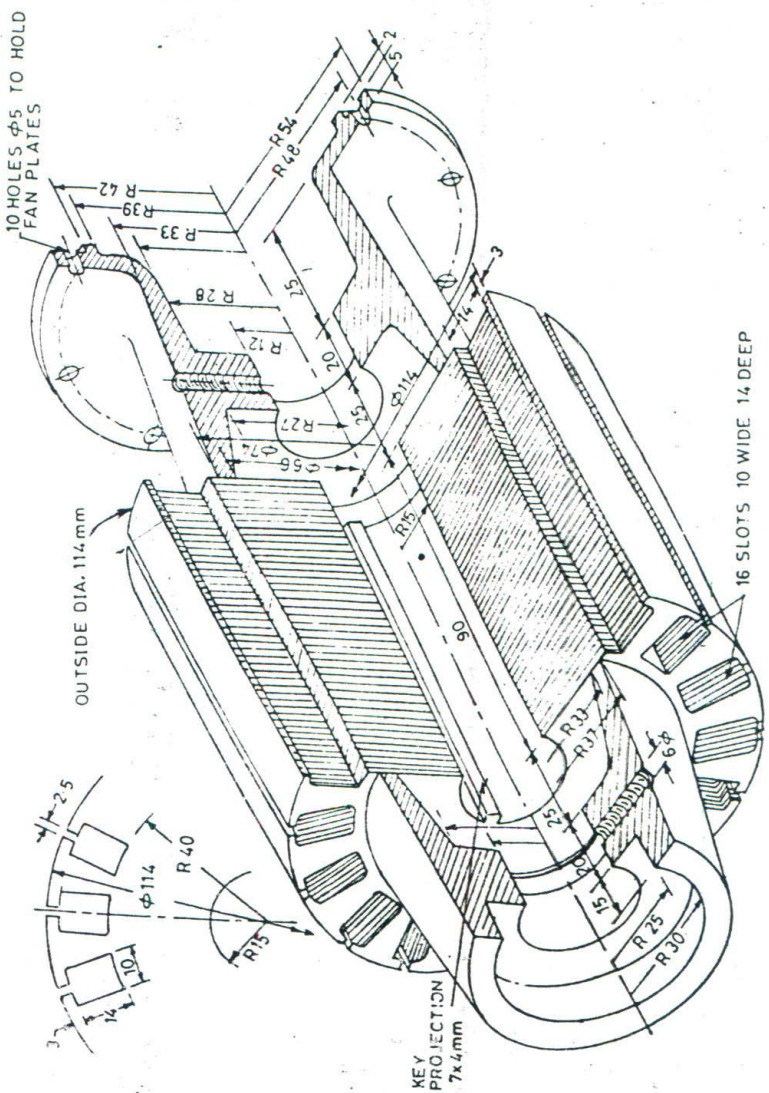


Fig.22.15

is made larger and extended outward which form a flange to receive fan plates which are to be screwed to collar along existing holes. The commutator is mounted on the shaft near the smaller ring. A separate view is given to detail out the slots and teeth.

FIELD POLES AND INTERPOLES

The field magnets in D.C. machine are meant for producing magnetic flux. The pole cores complete the magnetic circuit between the armature and yoke. The field poles are sometimes casted with 'Yoke' or casted separately and bolted to the frame. The poles are either solid castings or built up of laminations assembled together and riveted between end plates. Generally, laminated poles, are preferred due to the reasons that when the armature teeth pass along the poles, the flux density varies and the effect is more on

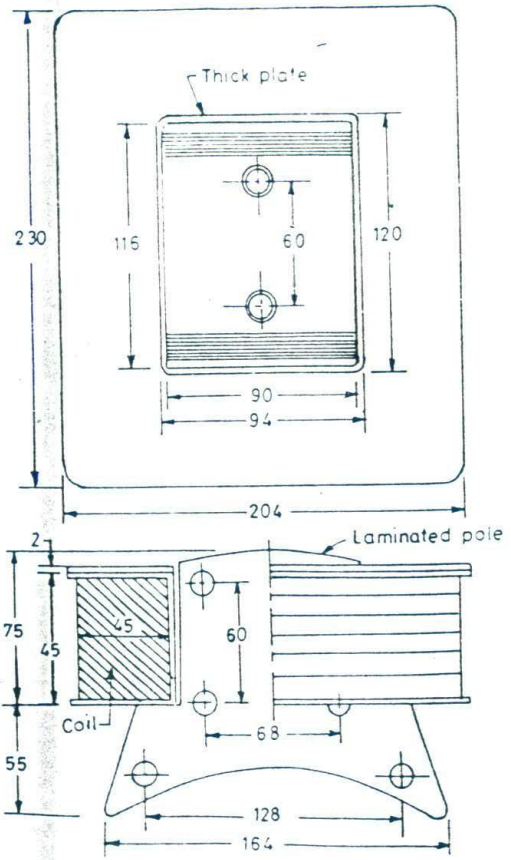


Fig. 22.16

poles. The eddy current losses and heat produced may be more if laminated poles are not used.

Field poles and Windings. The laminations are made of soft steel punchings of suitable size and shape to form the finished core. The core plates are held together between thick plates by countersunk headed rivets. Two tapped holes are made at the top of the pole as shown here so that the stud passing through the field magnet frame from outside can firmly hold the pole along inner surface of the frame. Field winding duly formed is placed over the pole and held between projecting surface of pole and inner surface of frame. The poles are always in pairs and fitted opposite each other. The outer surface of pole is machined to obtain firm contact between pole and frame. The inner curved surface of pole is machined to the

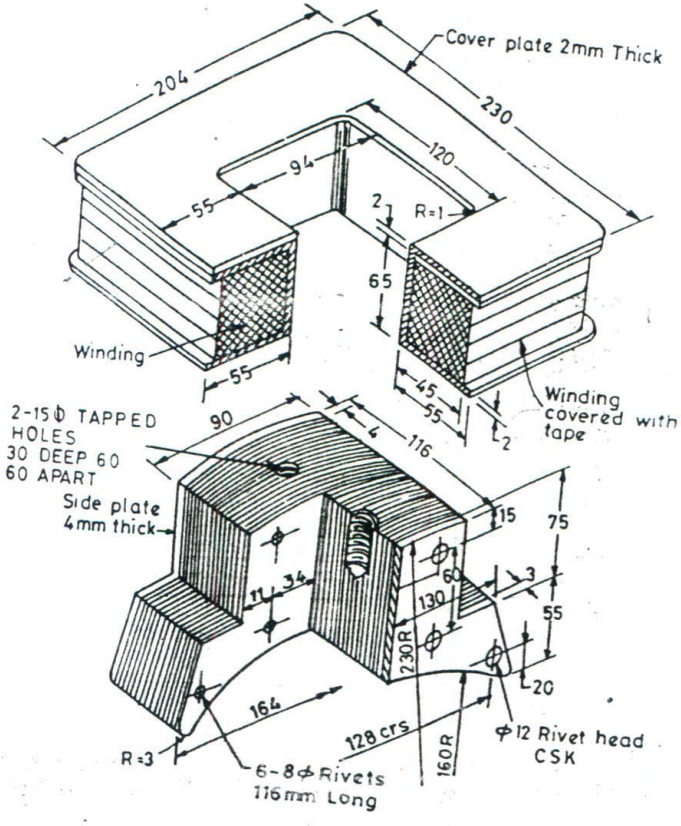


Fig. 22.17. Laminated Pole and Coil.

diameter little more than the diameter of armature to create an air gap.

Field Pole and Winding or Coil: The field pole shown below in section is wound in a 'U' shaped former made of card board or fibre. The coil is covered from top with cover plate and from outer-side with insulating tape half overlaped. The coil is then impregnated in insulating point and dried properly. The assembled views in elevation and plan are shown in Fig. 22.16. The pole consists of silicon steel laminations assembled and held together with the help of six countersunk headed rivets. The two tapped holes at the top are for the studs which hold the pole along the inner surface of Yoke of body. The coil is supported on two shoulders of pole.

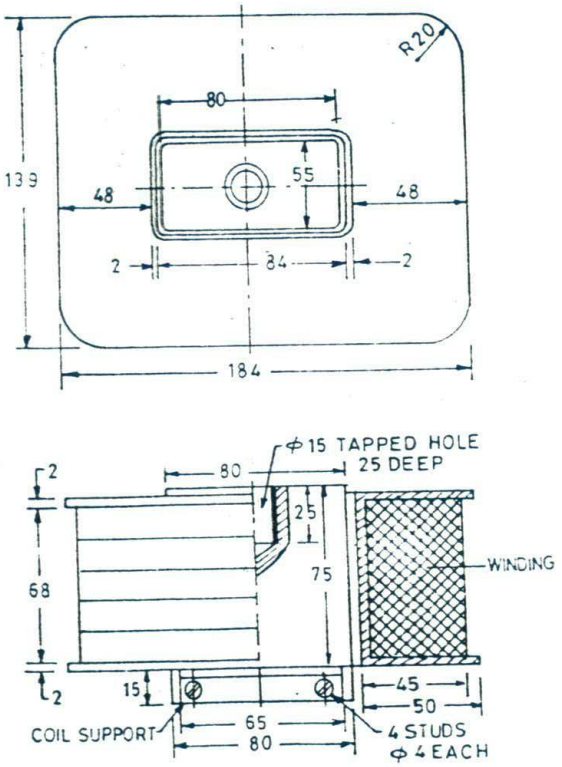


Fig. 22.18

INTER POLE and COIL: This is also known as commutating pole. Commutating poles are fitted to the field magnet frame in the no load neutral axis between main poles of a motor or a generator *i. e.* poles and inter poles will be alternately in the frame. These are used in large machines which have to carry heavy loads. These are used for providing a field in the inter pole air gap for neutralizing

the armature reactance field and for inducing an e.m.f. in the coils undergoing commutation in opposition to the reactance voltage. The inter poles are either made of cast steel or wrought iron stampings held together between thick plates and firmly held by countersunk headed rivets, (This type of inter pole is not shown here). It has smaller cross-section as compared to main poles.

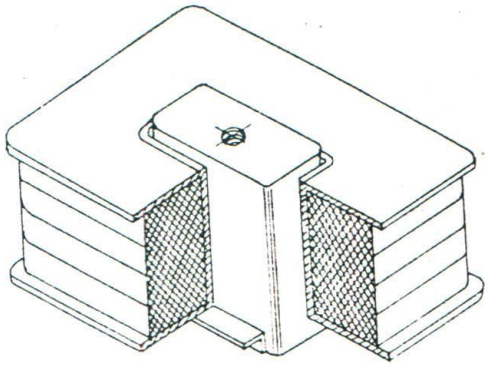


Fig.22.19

The drawing in Fig.22.19 and 22.20 shows a cast steel inter pole of rectangular cross-section. The coil is separately shown in isometric view. The inter pole has a tapped hole at the top to fasten it with field magnet frame with stud. The coil is held over two angle irons to be attached to the interpole with small nuts and bolts.

The laminated pole is shown alongside in isometric projection. There is a rectangular hole in the pole for a rectangular soft iron piece. There are two holes at the top (not tapped). The two studs are made to pass through the field magnet frame and then through the pole top holes. The studs are made to fit in the tapped holes of the rectangular bar (not shown in figure).

Pole Shoe. When the pole is casted alongwith the Yoke, it is attached to the inner surface with the help of studs. The pole shoe is made of wrought iron laminations screwed to the face of the casted pole, with countersunk headed studs.

Another example of an interpole and coil appears on opposite page and its assembly with field magnet frame is shown below. The difference between the previous interpole and this type in that it is

laminated and design and size of winding or coil is different. The laminations made of silicon steel are assembled together with countersunk headed rivets between two thick end plates of the same size as stampings. The steel bar of rectangular cross-section as shown in Fig. 22.21(*b*) is to be inserted in the rectangular hole in the interpole.

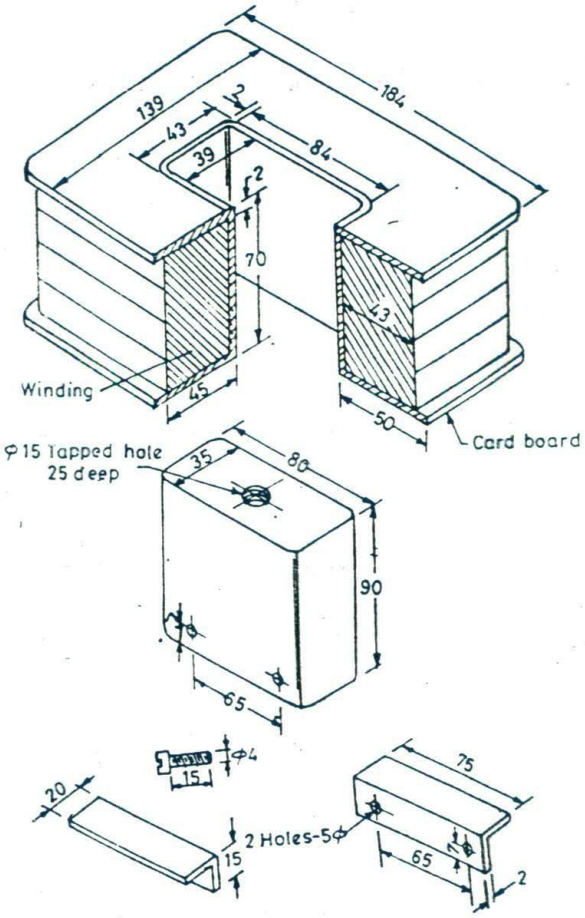


Fig. 22.20 Interpole and Coil

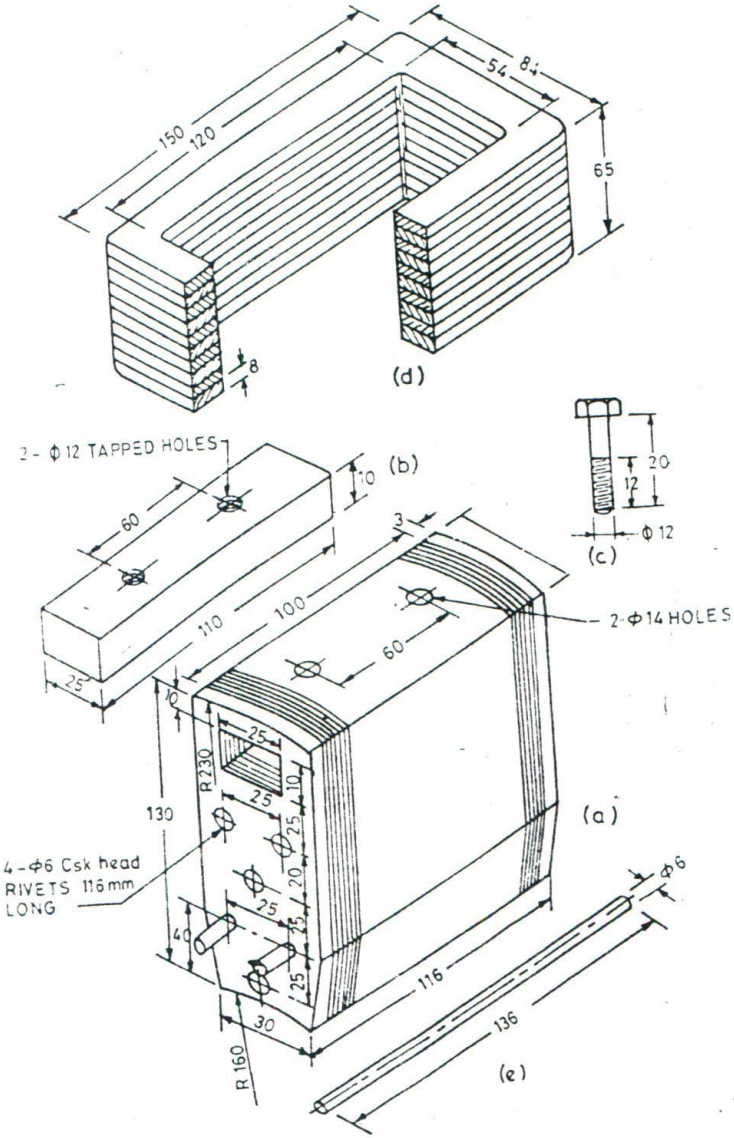


Fig. 22.21. Interpole and Coil.

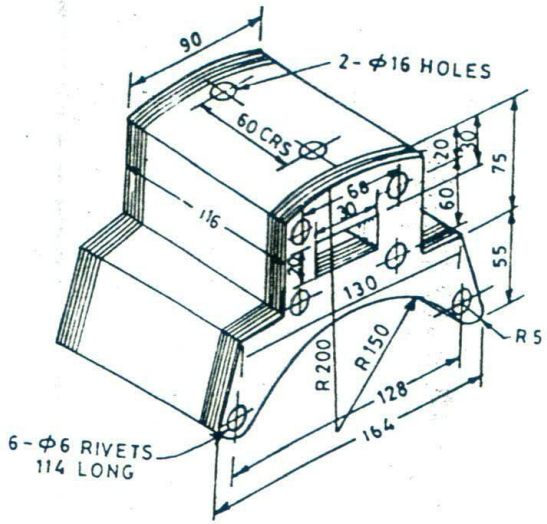


Fig. 22.22. Laminated Pole.

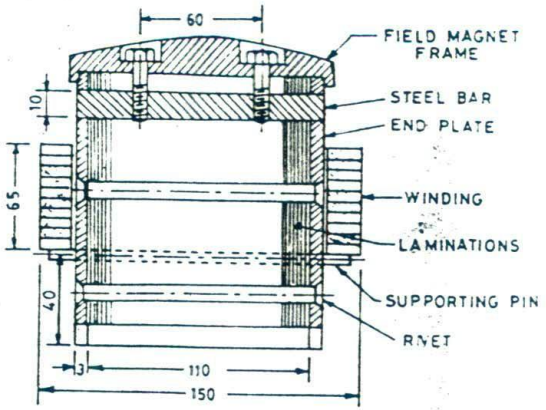


Fig. 22.23. Sectional view showing assembly of field magnet frame and interpole.

COMMUTATORS

The commutator is an electrical device which conducts current to or from the external circuit through stationery carbon brushes in contact with its outer surface. In other words, it is an extension of armature conductors with little more thickness to withstand wear and tear due to carbon brush friction when it rotates. The commutator segments are very carefully insulated from each other with insulating and heat resisting materials. High quality mica is most

suitable material for this purpose. When segments are assembled and built up, commutator will form cylindrical shape. The segment when assembled together and mounted on sleeve or ring, will form cylindrical shape due to the fact that the thickness of each segment on outer side is more than its thickness on inner side. The commutators are mounted over the shaft as near to armature as possible. The commutator is held over the shaft with the help of a key to avoid relative motion between rotating parts. The outside diameter of the commutator is approximately three fourth the diameter of armature.

Parts of a Commutator

The commutators essentially consist of the following parts :

Segment or commutator bar. The segments are made of copper. Each segment has 'V' shaped notch on both sides so as to be held between two cone shaped end rings from both sides. The segments are held together in cylindrical form and mounted on a sleave such that 'V' notches of all the segments will form circular shape and held by conical projecting end of sleeve and end ring. Each commutator bar or segment is insulated from its surroundings *i.e.* sleeve, end ring etc., by providing mica layer 2 to 4 mm thick. The thickness of segments varies at top and bottom so that when certain number of such segments are arranged

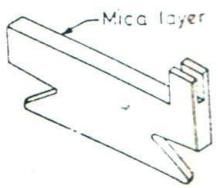


Fig. 22.24

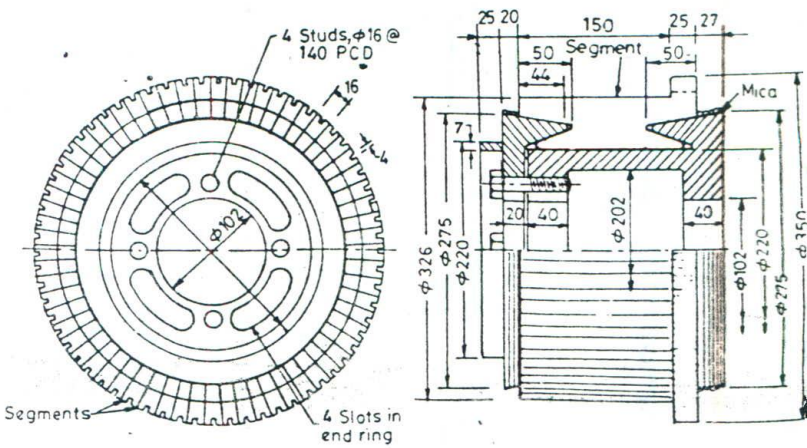


Fig. 22.25

together, it should form a cylindrical shape. The length of commutator outer surface depends upon size and number of brushes and current in the armature. If the number of segments is increased, it will result in better commutation, but thickness of segment connot be ignored for mechanical considerations. The projecting end of each segment has a saw cut to receive the conductor end from the armature and soldered into saw cut. Where projecting ends do not exist, the saw cut is made on one side of each segment. Sometimes,

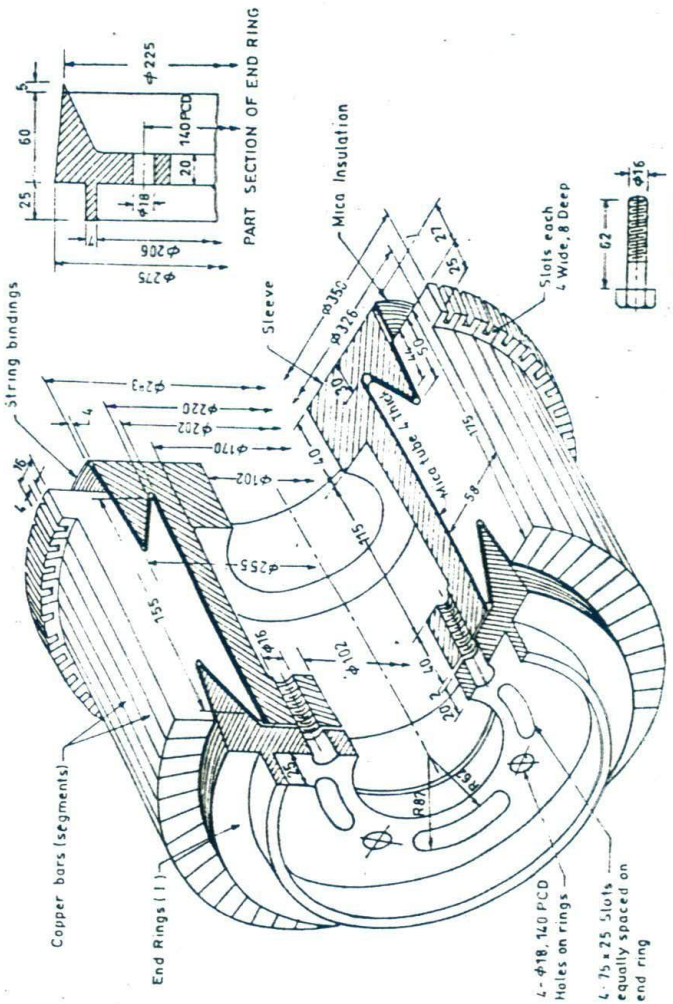


Fig. 22.26. Commutator

separate risers are permanently held in the saw cut and conductors are held and soldered in the risers. The angle of conical cut of segment is normally 33°.

The drawing in Fig. 22.26 represents an isometric view of commutator assembly in section. The segments are held together in cylindrical form and mounted over cast iron sleeve. One end of sleeve is of the form of an end ring. The conical projection of sleeve is covered with mica ring before segments are placed in position. Similarly outer circular surface of the sleeve is covered with mica sleeve. When segment cylinder is placed in position, an additional end ring is provided to hold the segment cylinder from opposite side with the help of studs. The end of each segment is projected outward for placing armature conductor ends in its cuts. The mica layer projecting outward beyond the segments is tied with a cord to avoid centrifugal force on mica.

CURRENT TRANSFORMER

An elevation and isometric view of assembly of transformer with winding in section is given here and detail of parts of the same are given in Fig. 22.28. It consists of five parts assembled together.

Laminated Core Fig. 22.28(*a*). The laminations are made of silicon steel insulated from each other by a thin insulating paper or paint. The thickness of each lamination is .35 mm to 0.5 mm which are made up of two sectors assembled together *i.e.* limb or bottom as one 'U' shaped piece and top straight yoke as other piece. Both the pieces are assembled together making complete rectangular lamination assembly. The laminations covered on front and back (except top) by mica insulation layers.

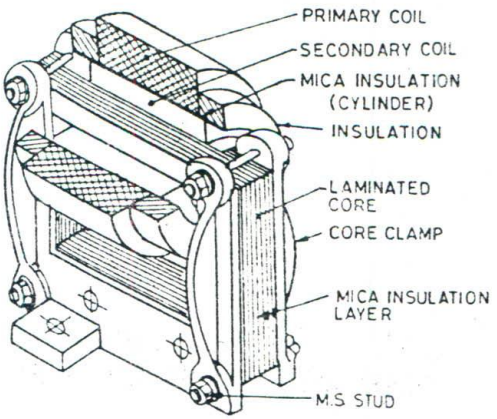


Fig. 22.27. Current transformer in isometric projection.

Winding Coil Fig. 22.28(*b*). The secondary winding is wound over a central mica cylindrical sleeve. Again, another mica sleeve is placed over the secondary coil between primary and secondary coils. The mica sleeve is extended outward on both sides. The primary winding is covered with insulating tape from outsides.

Core Clamp Fig. 22.28(*c*). Two core clamps, one on each side of the core are used to clamp the core between them. Four studs at four corners are used for this purpose. For providing additional strength to the clamp, each clamp is provided with two curved surfaces or projections. A flat horizontal base is also formed on both clamps to provide a base to the assembled transformer.

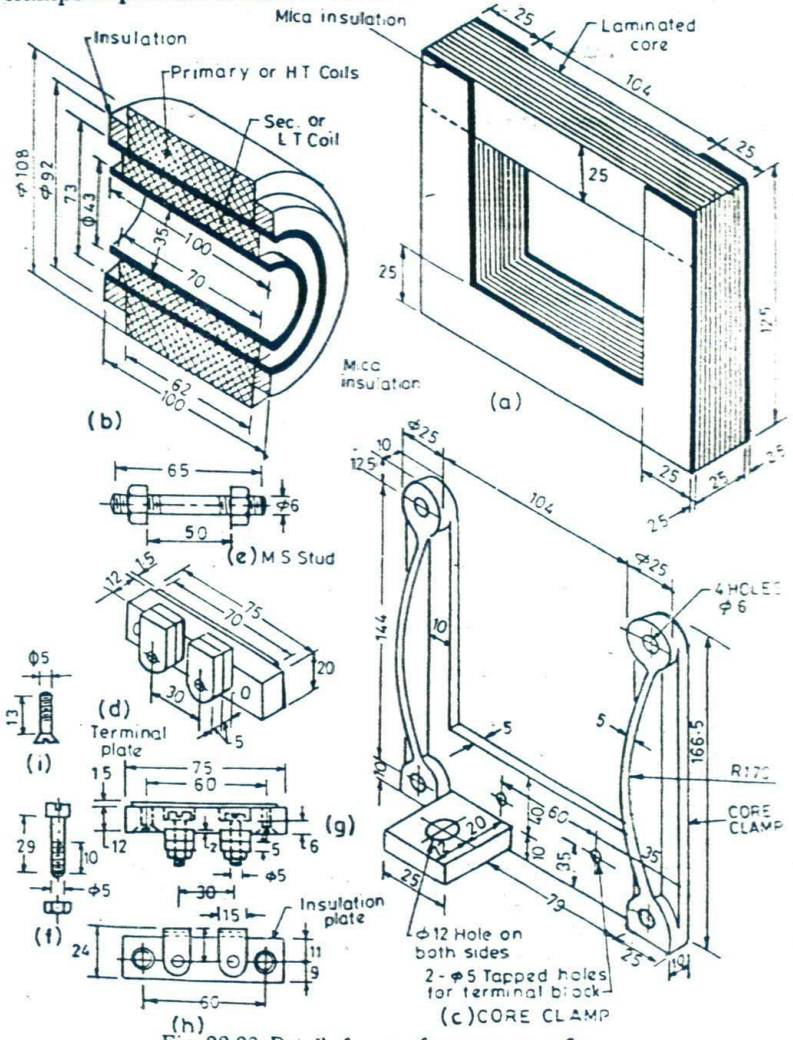


Fig. 22.28. Detail of parts of current transformer.

Terminal Block Fig. 22.28(*d*). It consists of an insulation plate (bakelite) having two countersunk holes one on each side. There are two pairs of connecting block or conductor holders attached to it with studs. Each block has a hole to receive conductor for connections for input and output supply. The studs shown in Fig. 22.28 are used to clamp the core clamps.

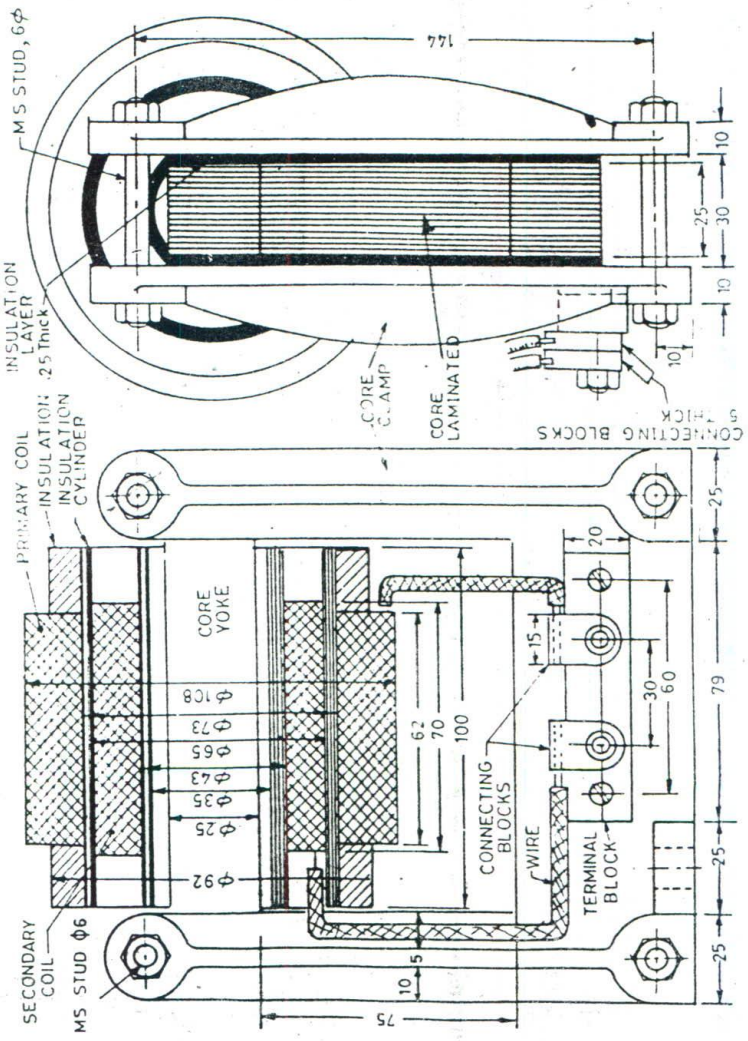


Fig. 22.29 Assembly of current transformer with coil in section.

FIELD MAGNET FRAME

The casting or frame which holds the field magnet poles and interpoles is called **Field Magnet Frame.** The frame is required to complete the path of flux which posses from North Pole through the air gap and armature to the South Pole and back to N-Pole *via* the yoke. The frame provides mechanical protection against the dust and moisture to the armature. It holds field magnet frame and provides suitable support for the bearing in which the armature runs. It may be made of one or two pieces depending upon size of machine. The frames are made of magnetic material such as fabricated rolled steel etc.

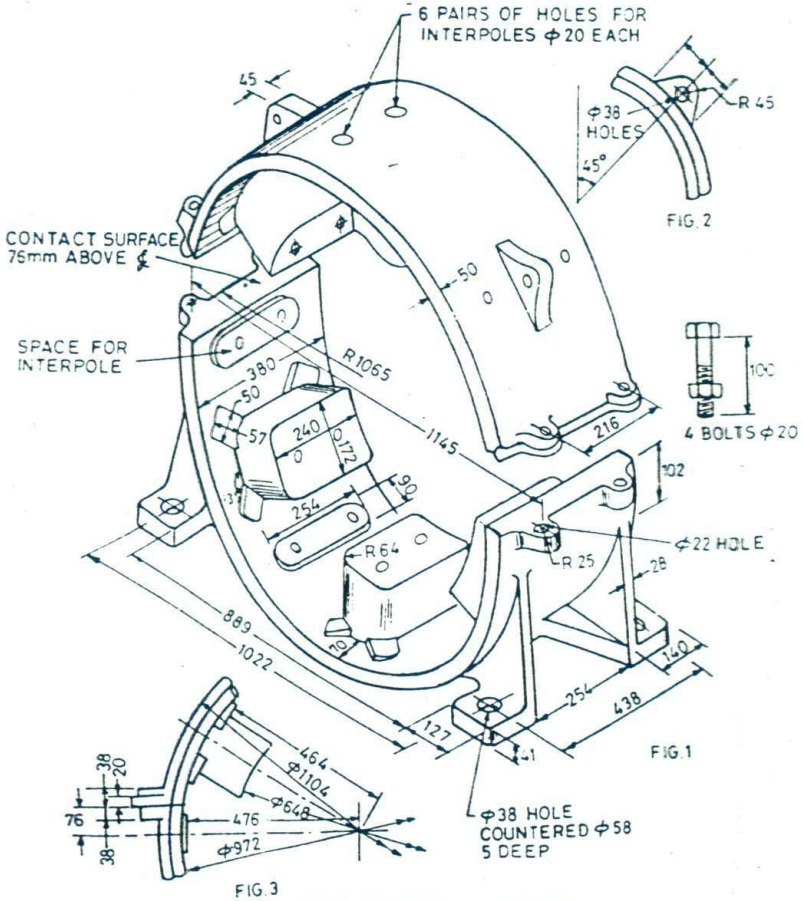


Fig. 22.30. Field Magnet Frame.

23

Bell Circuits and Indicators

Types of Bells and their description ; Bell Transformer ; Simple Alarm Circuits Without Relay ; Types of Diagrams ; The use of Relay in Alarming Circuits ; Bell Circuits using two Supplies ; Exercises ; T.D.R. Circuits ; The Use of Indicators in Various Circuits ; Examples on Indicator Wiring.

Types of Bells and their description

To meet the different requirements electric bells of various types are manufactured. Some of those most commonly used are given below :

1. Vibrating bell.
2. Single stroke bell.
3. Continuous ringing bell.
4. Combination of vibrating and single stroke bell.
5. Bracket bell.

The types of bells which are most commonly used described below :

1. Vibrating bell (Fig. 23.1) It is most commonly used house bell. It consists of two electromagnets, metal projection provided with adjusting screw, pivot armature, hammer, gong, frame and a contact post etc. When the push button is pressed, the current is passed through the electromagnets to the adjusting screw, down through the armature means of contact spring and then to the source of supply. When this condition occurs, the current energies the magnets which attract the armature, causing the hammer to strike the bell, but before it reaches the end of the stroke, the contact breaker breaks the circuit. As soon as the circuit is de-energised, the hammer of armature moves back to the original position, thus again closing the circuit. This process is repeated again and again produc-

ing vibration of the hammer as long as the push button remains pressed.

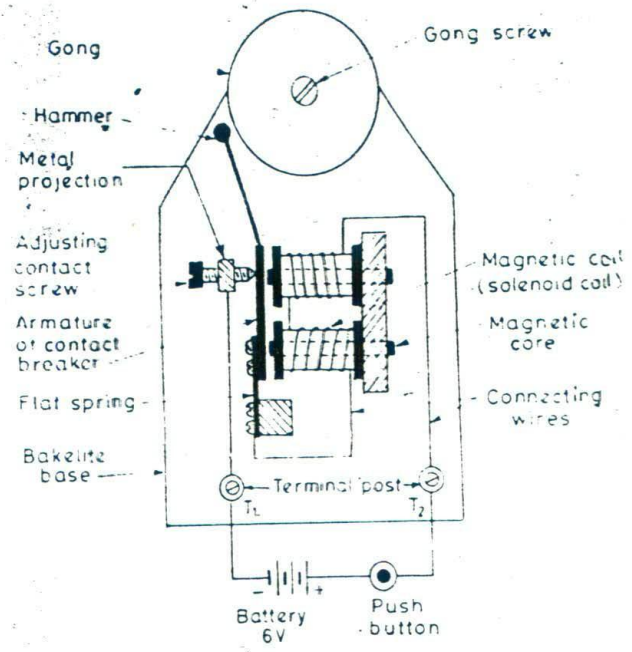


Fig. 23.1

2. Single stroke bell. It is a bell in which the hammer strikes the gong only once, each time the circuit is closed or push button is pressed. It consists of following major parts :

Two electromagnets (solenoid coils)

Pivoted armature

Hammer

Gong and

Iron Frame

In the single stroke bell, the current flows through the solenoid coils not through the armature. When the push button is pressed for operating the bell, the current is sent through the electromagnets (produced in the solenoid coils) which are connected directly across the terminals and energies them. It causes the armature to be

attracted towards the iron cores of solenoid coils. The hammer when attracted by electromagnets, strikes the gong. The armature remains in the attracted position till the push button remains pressed. As soon as the push button is released, the electromagnets are de-energised causing the hammer to return to its original position with the help of spring power. The action is repeated as and when the push button is pressed.

This bell may not be used as a means for providing an acknowledged call or alarm but may be used for the purpose of giving a signal or code of signals such as are required in various types of telegraph and railway signalling apparatus.

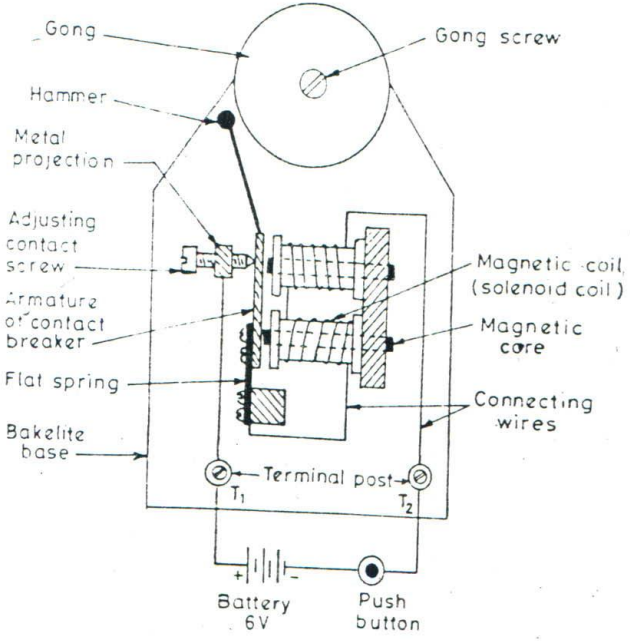


Fig. 23.2

3. Continuous ringing Bell. When the push button for operating the bell is pressed, it continues to ring, until its local battery is fully discharged or until it is silenced purposely by pulling down of a cord or chain attached to it. Sometimes, a switch like object is attached near the bell to silence it. This type of bell is used for giving alarms in special circumstances.

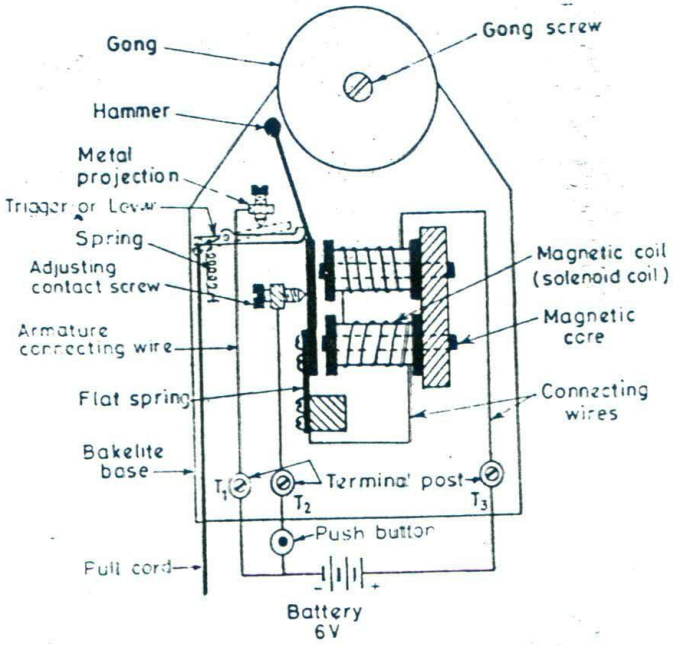


Fig. 23.3

The (Fig. 23.3) above shows detail of parts in the continuous ringing bell alongwith its electrical circuit. The bell consists of parts which are in an ordinary vibrating bell. A few more parts are provided which help to make it continuous ringing. The circuit is completed through solenoid coil, flat spring, armature and adjusting contact screw. The armature is also connected to battery through trigger, contact screw and terminal. When push button is pressed, the electromagnet is magnetised which attracts the soft iron armature towards it. During the process, the end of trigger is lifted up by spring action which comes in contact with the contact screw which is further connected to battery. The current which first flows through the solenoid coils as in normal cases is now cut-off owing to the break in the contact. A new path is thus made upon such that the current flows from pivot to the contact breaker *via* the trigger to the supply mains. Thus the bell continues to ring until the cord operating the trigger is pulled down, so that the later engages with the projection on the contact breaker.

Bell Transformer

The bells for office and domestic purposes are designed for 230 volts AC without using any step-down transformers.

Some electric bells are designed to operate on 6, 9 or 12 volts which can be either obtained from battery or by step down transformer.

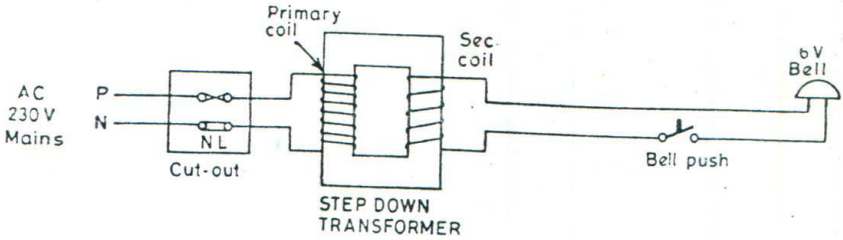


Fig. 23.4

The circuit is easy to understand and operate. If low voltage bell is to be used for domestic purpose supply conductors are extended up to cut-out and from there, the leads are connected to primary winding of the bell transformer. The leads for bell or other equipment are taken from secondary which provides reduced voltage.

Simple Alarm Circuits Without Relay. The alarm circuits connection are used to convey information by means of light or bell signals. The basic principle of wiring connection of bells is same as

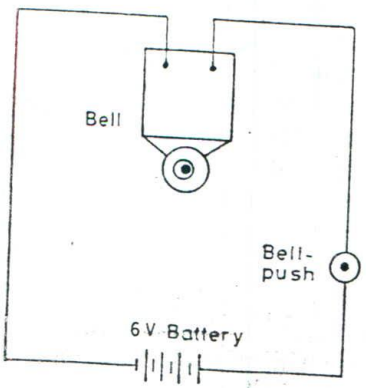


Fig. 23.5

the lighting circuits. In general practice, the neutral is given direct to bells where as phase is supplied through push button. The alarm of signalling system usually installed in small houses may be divided into two general classifications. The first is the audible or a visual type of signalling system which attracts the attention by means of sound, given off by an electric bell or buzzer, or by a visual signal such as the glow of a coloured electric lamp. The second is voice transmission signalling system represented by telephone, by means of which one person may converse with another at any distance.

The simple wiring diagram of electric bell, apart from wiring necessary to conduct the electric current on its path consists of three important parts :

1. Usable load (in this case, a bell).
2. Means of control (in this case, a push button).
3. A source of supply (in this case a battery – or 230 V a.c. supply)

The connections to the bell are made such that the positive path of current of the battery travels through push button to the bell. The negative pole of the battery is connected to other terminal of the bell, completing the path of current through the bell. The bell push, also known as push button is in series with battery and bell. No current will flow through the circuit until the push button is pressed.

Types of Diagrams. There are two ways of drawing alarm circuits. (*a*) The schematic diagram or circuit diagram which is an explanatory diagram for easy understanding of details of operation of an electric circuit. (*b*) The wiring diagram showing connections actually applied and the layout of the wiring.

1. *Draw a wiring diagram, single line representation and schematic diagram of one bell controlled by two push buttons located at two different places. The bell should ring by pressing any of the two buttons. Looping system of wiring should be adopted.*

This circuit is useful when there are two officers to be attended by one peon. The bell should ring by pressing any of the two push buttons located in two different offices. However, the peon cannot know, which of the two officers has called him. In these circumstances, the peon can be made to understand only if different modes of sound are adopted by the officers.

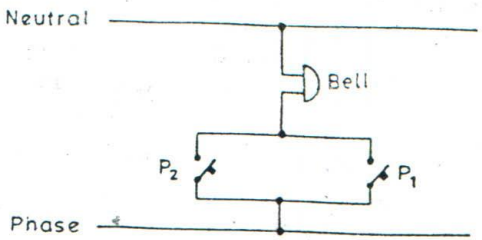


Fig. 23.6. Schematic diagram of the bell operated by two push buttons.

The phase wire first enters push buttons No.1 and from there it is looped-in to push button No.2. The terminals from a push button No.1 and push button No.2 is connected to the bell. The bell should ring when either of the two push buttons is pressed.

2. *Draw a wiring diagram, single line diagram and schematic diagram of two electric bells controlled by their respective push buttons located at two different places, such that the bell should ring when its respective push button is pressed. Looping system of wiring should be adopted.*

This is a very common circuit used in offices. The circuit is useful when there are two officers having their individual bell pushes and bells to call the peon or to pass on some information through bell signal system. The basic idea of this circuit is to create two signal systems from one supply.

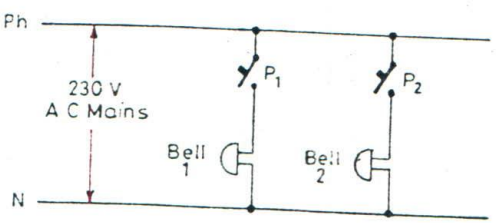
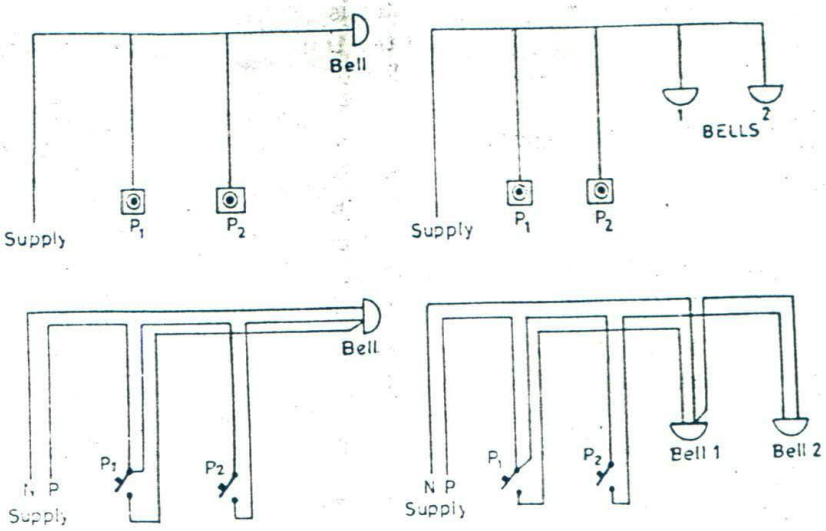


Fig 23.7. Schematic diagram of two bells controlled by their respective push buttons.

The phase wire is taken to one push button P_1, from P_1 it is looped-in to P_2. The second terminal of P_1 is connected to its own bell and similarly second terminal of P_2 is connected to its own bell-2. The bell-1 should ring when P_1 is pressed and Bell-2 should when P_3 is pressed. The two push buttons and bells may be located at different places. Each bell thus has its individual control.



(One bell controlled by two push buttons) (Two bells operated by their respective push buttons)

Fig. 23.8. Single Line and Wiring Diagrams.

3. *Draw a wiring diagram, single line representation and a schematic diagram to control three bells connected in series with three push buttons located at different places. All three bells should ring simultaneously when any of the three push buttons is pressed. Adopt joint box system of wiring.*

The circuit may be very useful when some information is to be conveyed through bell signals simultaneously at three different places from either of the three different locations.

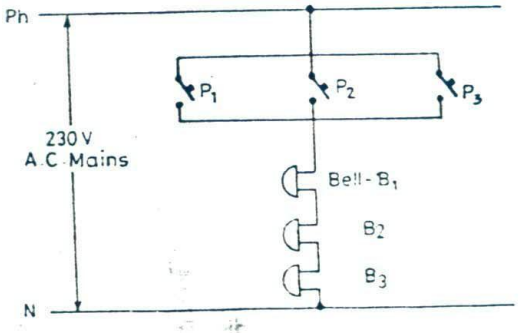


Fig. 23.9

For instance, one push button is provided in officer's office, the other in assistant's office and the third one in the time keeper's office. The bells are similarly located one each in three different sections of the office or industry. When ever some information is to be conveyed through bell signals *i.e.* observance of recess timings, interval etc. it will be conveyed from time keeper office. Some special information for instance for calling three section incharges etc. may be conveyed from officer's office. Some other similar information may have to be conveyed by assistant by pressing a push button from his office. The circuit can also be used for similar other purposes.

4. *Draw a bell circuit in three different ways to control two bells (located at different places) operated by their respective push buttons. These should be a provision to temporarily put out of circuit one of the bells by adding a switch. Adopt looping system of wiring.*

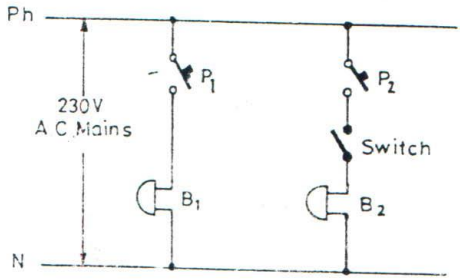


Fig. 23.10

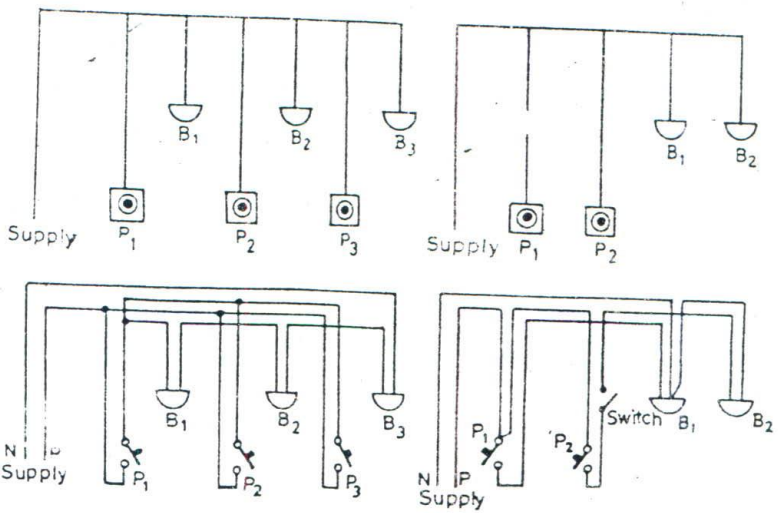


Fig.23.11 Wiring Diagram

Three bells in series to ring together when any of the three push buttons is pressed (Joint box system of wiring). Two bells each controlled independently by two push buttons with provision to temporarily dislocate one bell when required.

Two push buttons are located in the officer's office to call his assistant and peon by call signals. When push button P_1 is pressed, the Bell B_1 in the assistant's office rings to provide a call to him by the officer. The push button P_2 is pressed for calling the peon by ringing of the bell B_2. When peon is to attend some other side, he will dislocate the bell by a switch before going, so that the bell does not ring unecessarily in his absence. When he comes back, he again puts the switch to ON position to attend to that office again.

5. *Draw a bell indicating circuit in which an officer can call any one of his five subordinates sitting at different places by pressing a common push button after adjusting a selector switch installed by the side of the push button. The bell of the subordinate room should ring only for the period for which the push button remains pressed.*

A four terminal selector switch is used, one each for an individual bell. A push button is provided before the selector switch *i.e.* the phase will first enter into push button and then connected to incoming terminal of the selector switch.

The bells are installed in different rooms of the building to provide signals. For example, the person wants to ring bell B_2 he will first set the moving contact of the selector switch to No. 2 terminal and then press the push button, the bell B_2 will ring. Similarly any particular bell can be operated by setting the moving contact on its respective contact and pushing the push buttons.

Several bells say 10 or even more can be controlled from one push button by using selector switch having out going terminal equal to the number of bells installed.

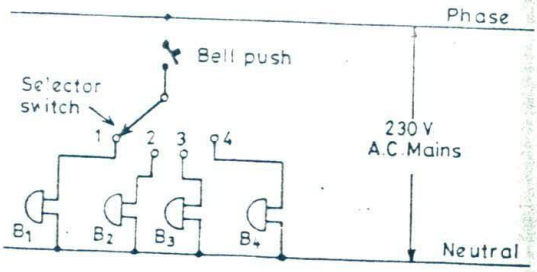
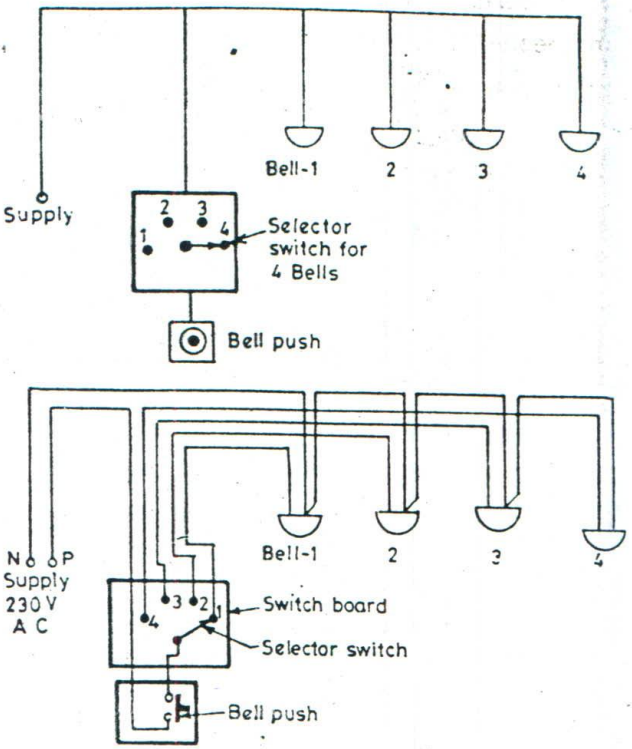


Fig. 23.12

A plan of an office comprising four rooms and a verandah is shown in Fig. 4.14 The installation of wiring of bells and selector switch is also shown in single line representation.



Any of the various bells located at different places can be operated by setting the selector switch to that particular number and pressing the bell push installed near to the selector switch.

Fig. 23.13. Single line and wiring diagram of selector switch circuit.

The selector switch is installed in the manager's office from where he can call his attendant, typist, cashier or head clerk to his office by operating selector switch and pressing a single push button.

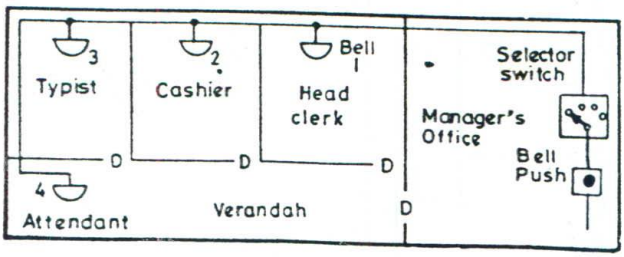


Fig. 23.14

6. ***Prepare a wiring diagram, schematic diagram and a single line representation of bell circuit, where it could be possible to operate***

two bells out of three simultaneously by pressing any of the two push buttons (the third bell is common to both the push buttons). The three bells and two push buttons are all located at different places of the building. The connections should be made such that nowhere there are more than four wires in the circuit.

The bell circuit is not very commonly used in normal cases. It may be used where the person calling the attendant is to make sure that the circuit is working.

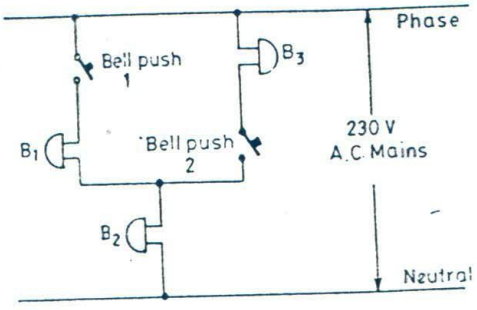
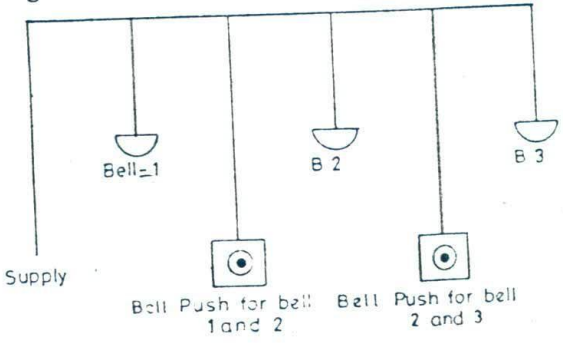
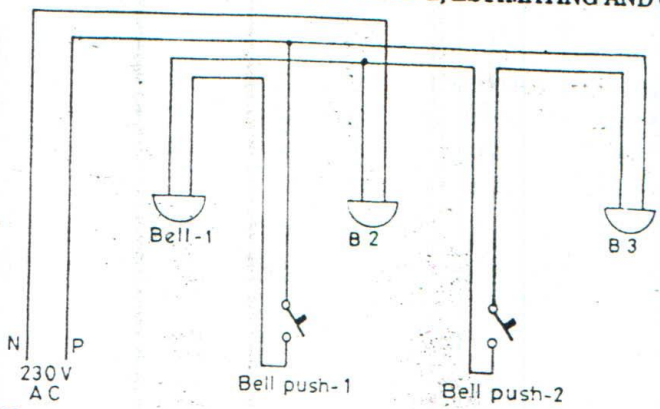


Fig. 23.15

Bell push B_1 are located in one office and Bell push P_2 and Bell B_3 are located in the second office. Bell B_2 is located outside the office in attendant's room. When Bell push P_1 from one office is pressed, bells B_1 and B_2 placed in series will ring. Bell B_1 will make sure of the continuation of circuit. Similarly if Bell push P_2 is pressed, Bell B_3 and B_2 will ring.

The circuit may be used in several ways, where information about calling an individual is to be confirmed through bell signals.





Bell No.1 and 2 or bell No. 3 and 2 will ring in series when any of the two push buttons is pressed. Therefore bell No.2 is common to both the push buttons.

Fig. 23.16 Single Line and Wiring Diagram

7. *The bus is running fully loaded with passengers. The driver of the bus pushes a push button in front of him for a bell to ring in the rear of the bus as signal to the conductor to enquire whether some passengers are to be dropped at the next stop. The conductor presses a push button, for a bell to ring near the driver as a response to his enquiry if the bus is to be stopped. The driver faced no difficulty to enquire about how to act. Draw the schematic diagram, wiring diagram and also add a single line diagram of the response call system.*

8. *Design a bell response circuit in which when an officer sitting in his room presses a push button it gives a ring in the subordinate's room till the bell push remains pressed. To give back a response after the ringing, if a bell push is pressed by the subordinate it glows a lamp in the officer's room giving the indication that the call has been heard.*

Draw the schematic diagram of the circuit and the wiring diagram in looping-in system with multiline representation.

(For solution add signal lamp in place of B_2)

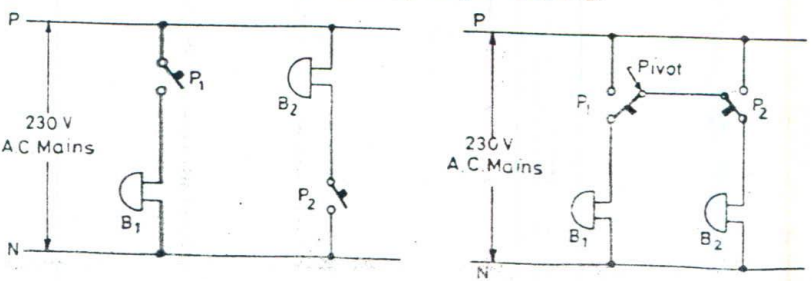


Fig. 23.17. Response call with two electric supplies.

9. *An officer calls his assistant through the call bell which rings in the room of the assistant. The assistant responds to the officer's call from his own room by pressing a push button, a bell rings in the officer's room that the assistant has received the call. The supply of current to the circuit is from two sides. The push buttons having make and a break contacts (NO and NC means normally open and normally closed) NO and NC are used on both sides. Draw the wiring diagram, schematic diagram and single line representation of the circuit.*

Solution. The phase and positive wires of each supply are given to one terminal of each push button. The second terminals are connected to their respective bells. The third terminal of bush button P_1 and P_2 are connected to each other. Push button P_1 and bell B_1

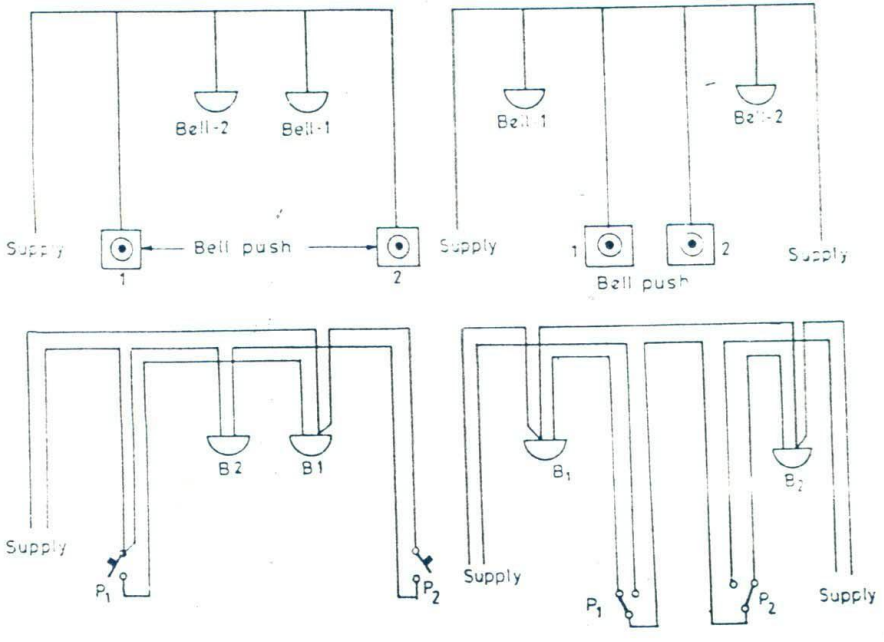


Fig. 23.18. Single line and wiring diagram.

are located in officer's office and push button P_2 and Bell B_2 are located in accountant's office. When push button is pressed the bell B_2 should ring. Similarly, by pressing P_2, the current will flow from P_2 to P_1 and rings the bell B_1.

It is important to note that the moving contact of push button will remain in contact as shown. It will again takes its original position as and when push button is pressed and released.

10. *A man is standing in the front verandah of a bungallow from where he pressed a push button for calling the doctor. The doctor is not in the house and subsequently the assistant of the doctor or some other family member pressed a push button from inside the house for a bell (in verandah) for attention of the person waiting outside and immediately pressed another push button which indicated on the verandah signal panel by lighting a red bulb where the word 'OUT' is written. This is sufficient indication for the person waiting outside to understand that the doctor is not in the house. There are three different coloured bulbs installed on the verandah signal panel–Red, Green and Blue, where the words 'OUT', COME IN and WAIT are written respectively. The bell is also installed in verandah to draw attention of the person waiting outside before giving the signal.*

Draw the diagrams in three different ways to provide following indications on verandah panel as OUT, COME IN and WAIT, by pressing different push buttons from inside the house. An indicating lamp on panel inside the house should be provided to have check on the response signal that call is going through.

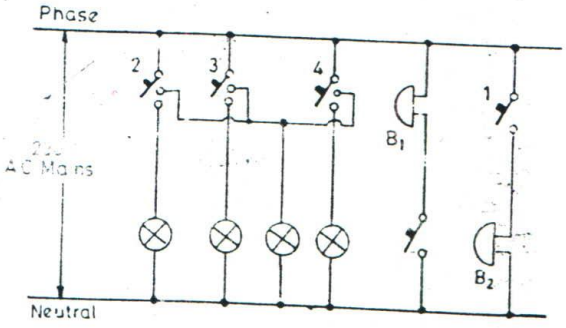


Fig. 23.19

Solution. The single line diagram and wiring diagram on opposite page fulfill the above conditions. A call signal panel in installed in the verandah of the bungallow, on which three signal lamps, one push button and a bell are located.

The response panel is installed at a convenient place inside the bungallow on which four push buttons, a bell and an indicating lamp are installed.

The circuit is very similar to an ordinary lighting circuit where several lamps/fans are controlled from one switch board. Here in this case there are push buttons in place of switches.

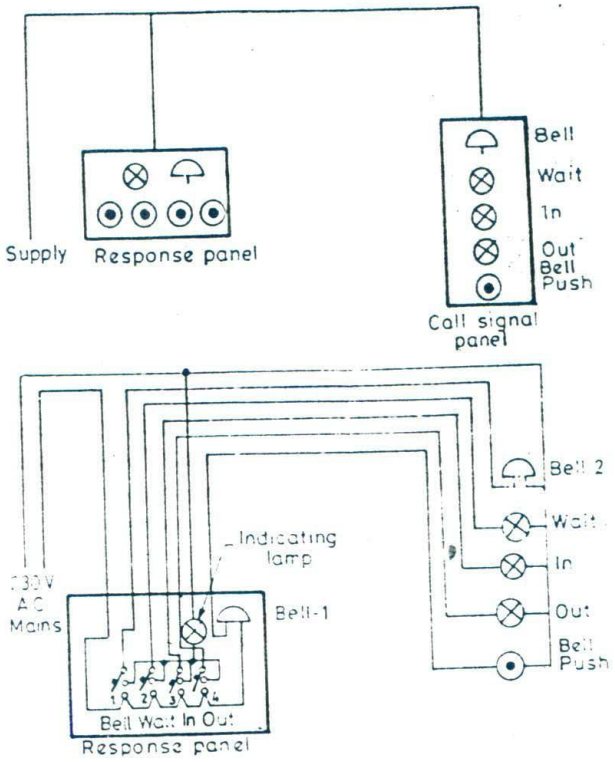


Fig. 23.20. Single Line Representation and Wiring Diagram.

11. *A workshop manager has a provision to call three different persons from a far located section of the workshop or any portion of the building where call signal panel is installed. The caller's panel with push buttons etc. is installed in manager's office from where, any person can be called by pressing either of the three push buttons. The three different coloured lights are provided on the panel from where a particular person is to be called. Each colour of light may be pre-determined to call the particular person. For instance the manager pushes a bell push for extra attention of the person called and then pushes a push button for green light to call engineer. Similarly, red light for foreman and blue light for supervisor can be pre-determined. The person called also has a provision to push a button from his office for a buzzer installed in the office of manager as a response signal that the call has been received.*

An indicating panel with three coloured lights in the same order is also installed in manager's office for a check to ensure that the circuit is functioning.

Prepare a wiring diagram, schematic diagram and single line representation of the circuit to meet the above requirements.

Solution. The panel board consisting of four push buttons, an indicating lamp and a buzzer is installed near to his seat. He can call any person by pressing the pre-determined push button. The person called for has also a provision to respond to his call through an indicating lamp and buzzer by pressing a push button from his own office (push-5). The different coloured lights for calling different persons is pre-determined.

An indicating panel is also installed in the manager's room at a suitable place for providing a check on the call that the call is going. The number and colour of the lights on indicating panel are similar as those on 'caller's signal panel. The layout of offices showing and schematic diagram wiring and installation is shown in Fig. 23.21.

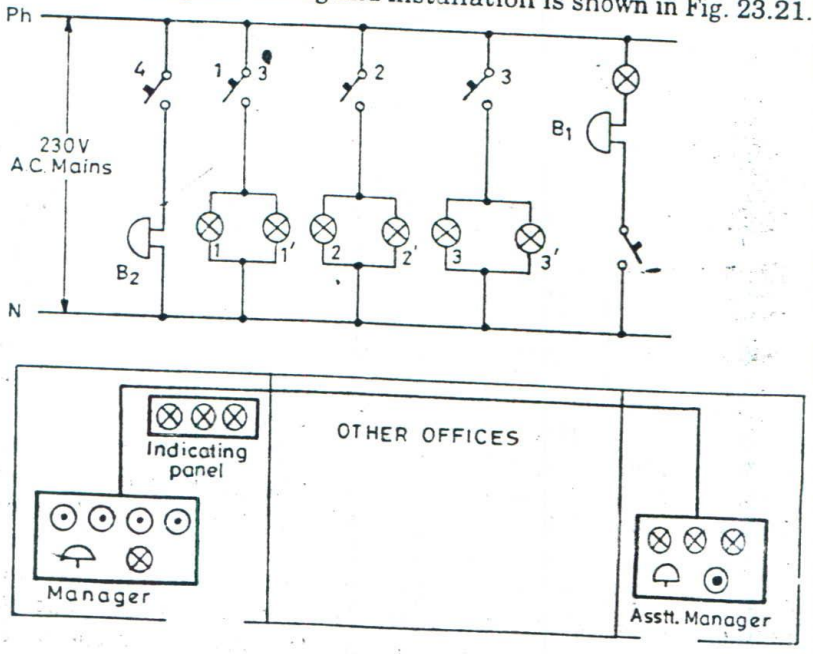


Fig. 23.21. Installation plan of wiring of above circuit.

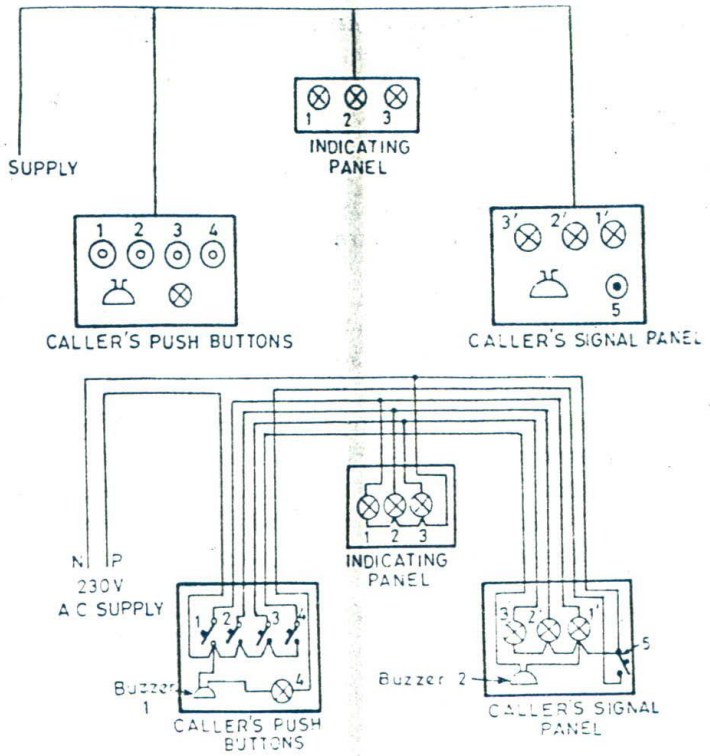
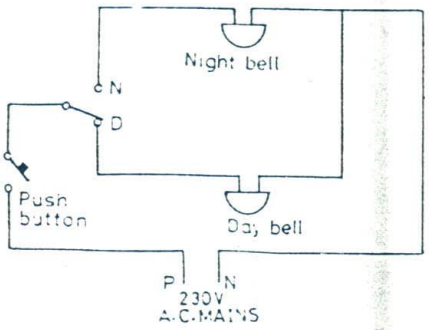


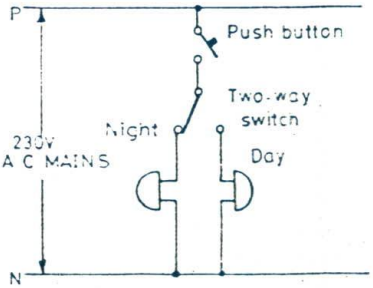
Fig. 23.22. Single Line Representation and Wiring Diagram.

12. *Prepare a schematic diagram, wiring diagram and single line diagram that may fulfil the following conditions :*

A man wants to see a doctor in his bungallow during day time, he pushes a push button located in verandah and the bell rings in the drawing room of bungallow. The doctor attends to the person in response to his bell signal. But during night time, the doctor may



General drawing showing the day and night call bell system



Schemaic Diagram

Fig.23.23

wish to receive the night call in his bed room, although the visitor has to press the same push button.

Solution. A two way switch will be used in between bells and push button, the function of which is to change the path of current to either of two directions *i.e.* bed room or drawing room. A two way switch has two outgoing terminals and one incoming terminal. The connection is given to incoming terminal, but outgoing terminals are connected one each to bells.

When moving contact of the switch is on left side (as in Fig. 23.22), the DAY BELL will ring as and when push button is pressed. When moving contact of switch is on right side, the continuous ringing bell, installed in bed room will ring. If the bell is connected to electromagnetic relay, it will ring continuously till it is silenced by pulling a chain (attached to lever of the bell to de-energise its magnetisation effect) attached to the bell. The bell can only be silenced when the person gets up to pull the chain.

Note. The electromagnetic relay is not installed in the circuit.

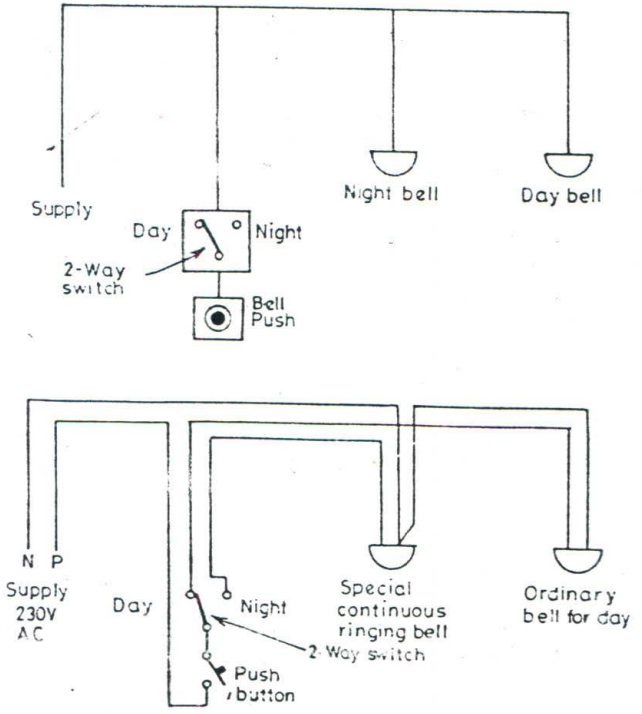
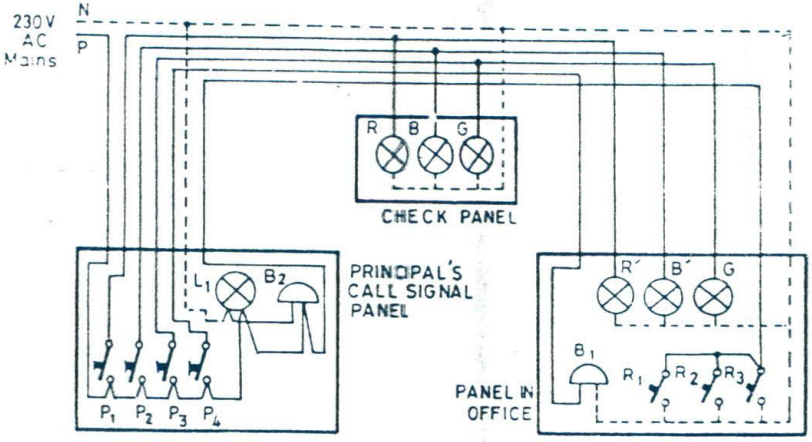


Fig.23.24. Single line representation and wiring diagram of Day and Night call bell system.

13. *Draw in three different ways, a circuit for the office of a principal of a college for giving light and bell signal to call his office staff. The principal has three push buttons, a signal lamp and a buzzer on the panel near to his table. There is another panel in the main office with three indicating lamps and a bell. Each of the three persons to be called has his own bell push for the bell to ring in the principal's office in response to his call. There is another indicator lamp panel with three lights in the principal's office to check that the call is going through. When he presses a push button P_1 to call the head clerk, an indicating lamp on the indicator lamp panel in his office will glow apart from the same coloured lamp in the office panel as an indication for the head clerk. But before this, the principal will press a push button for the bell located in office panel for attention of the persons. The head clerk presses his push button for the bell in principal's office in response to his call.*



Wiring Diagram

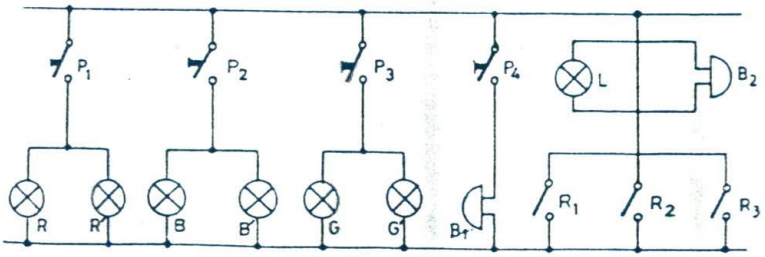


Fig. 23.25

P = Push Button

R = Red Lamp

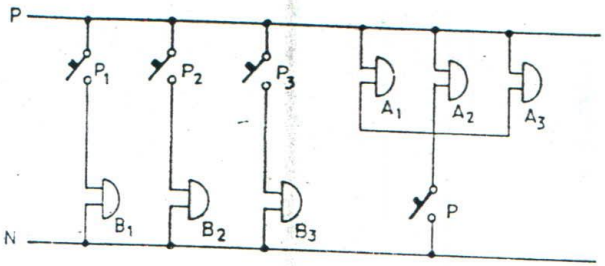
B = Blue Lamp

G = Green Lamp

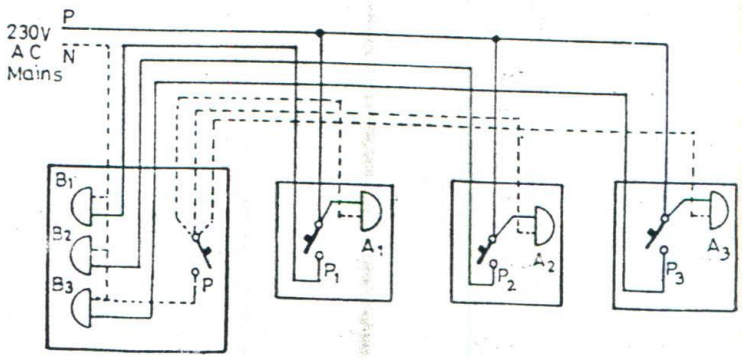
R = Return or Response Push

B_1 = Bell No. 1.

14. *Draw a response circuit for the security personnel of a hotel in which it is possible to give a general call by means of three bells to be given by the security officer to three attendants deputed on three floors of a hotel. The individual push button for attendants enables them to give a response signal to the security officer by means of three bells located in the office of security officer to ensure that they have received the call. Draw schematic and wiring and single line diagram:*



B_1 B_2, B_3 and P are loaded in the office of security officer
A_1, and P_1 for attendent of first floor.
A_2 and P_2 for attendent of second floor.
A_3 and P_3 for attendant of third floor.
Fig. 23.26 (*a*)



Wiring Diagram
Fig. 23.26 (*b*)

THE USE OF RELAY IN ALARAMING CIRCUITS

When the distance between the bell and push button is considerably more for the control of the bell, the length of wire might also

be equally more. The resistance of the circuit or voltage drop is so great that the battery or bell transformer cannot supply a current sufficiently large to operate the bell at a considerably more distance. In these circumstances, it may be advisable that the bell is operated by an independent battery connected through a relay because it may not be convenient to increase the existing battery or bell transformer voltage. It is very convenient and economical to use bell transformer in place of the battery for domestic bells. The bells are designed for 230 V a.c. supply which are more preferred as compared to low voltage bells.

The simple electromagnetic relay is an electrically operated switch which can be closed by a comparatively weak current. Regarding the operation of the bell, the relay is the major part of an electric bell with the armature having trembling action being attracted to the iron core of the relay. Another major aim of bell circuit with relay is that the bell should continue to ring even when the pressure on the push button is released. This can be achieved by using relay operated by various types of push buttons.

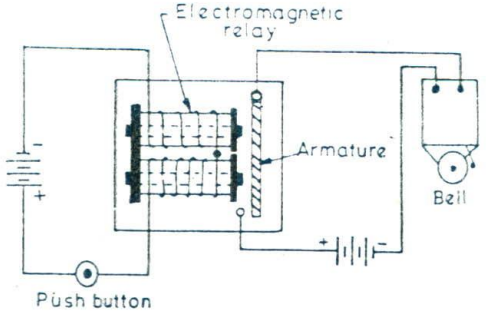


Fig. 23.27. A bell along with an electromagnetic relay.

A simple electromagnetic relay consists of a coil wound over an iron core forming an electromagnet. When current is made to pass through the coil winding, the iron piece is magnetised and attract the soft iron piece known as 'armature' which is further pivoted on one side and provided with make and break contact points on the other side. The armature when attracted by electromagnet closes the local circuit.

The relay in normal cases is open circuit relay, which operates as and when the bell push is pressed. (Open circuit of relay means, the armature is not in attracted position and ultimately not touching

the terminals which otherwise it is made to be in contact). As in the case of relay circuit mentioned above, the relay will operate causing the bell to ring as and when the bell push is pressed. When the push button is released, the bell will cease ringing.

The relay is usually provided with four terminals, two of which are connected to relay winding which are further connected to bell transformer or battery. The other two are connected to the circuit to be controlled. The bell push for making or breaking the circuit is provided on opposite side to the bell. The two terminals of second battery or bell transformer are connected to the terminals which make contact only when relay is energised and armature is attracted.

In ordinary bell circuits, the bell rings as long as its push button remains pressed. But we have to develop the circuit in which the bell should continue to ring even when the pressure on the push button is released. The bell should be got silenced by pressing another push button. This type of circuits are only possible if an electromagnetic relay and special types of push buttons are added in the circuit. The diagram below provides answer to the above mentioned requirements.

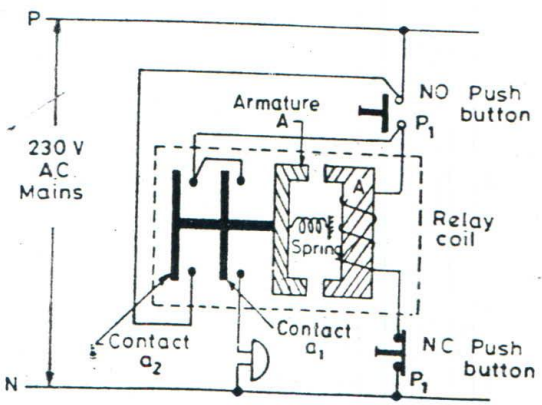


Fig. 23.28. Relay circuit operation.

Two types of push buttons are used in such circuits such as :

N.O. (Normally Open). It remains open or in disconnected form. It closes the circuit when it is pressed but comes to the disconnected position as and when the pressure on the knob is released.

N.C. (Normally Closed). It remains closed or in connected form. It opens or disconnects the existing circuit when it is pressed. It comes to the original or connected form as and when the pressure on its knob is released.

In the circuit shown above, if N.O. push button 'P' is pressed, the electromagnetic relay gets energised and pulls the movable soft iron piece (known as armature) towards it against the pressure of the spring. The contacts C_1 and C_2 being interlocked with armature, are pulled completing the circuit through C_3. When the push button 'P' is pressed, the supply to coil of relay commences and continues through C_2. The bell will thus continue to get supply and keep ringing. If the supply to the relay fails or the circuit is broken intentionally by pressing N.C. push button P_1 the coil will be energised and the armature will be thrown back by the spring pressure resulting in opening the contacts C_1 and C_2. When the supply returns, the bell will not ring unless the push button P_1 is pressed again.

The principle of starting of electric motors is also same. Once the motor is started by pressing the 'Start' push button, the motor starts running. If the supply fails, or another 'Stop' push button is pressed, the motor stops running. It is important to note that the motor cannot start again even if supply returns at the same moment. The motor can be started again only by pressing 'Start' push button.. The relay coil and contacts C_1 and C_2 are housed together as shown by a dotted line and the complete assembly is called relay.

Another simple relay circuit is shown in Fig. 23.29. The relay consists of coil wound on an iron core forming an electromagnet which attracts the armature pivoted at a point near to it as and when the relay is connected to supply. The lower surface of armature comes in contact with terminal 'C' to complete the circuit through armature as and when the push button is pressed.

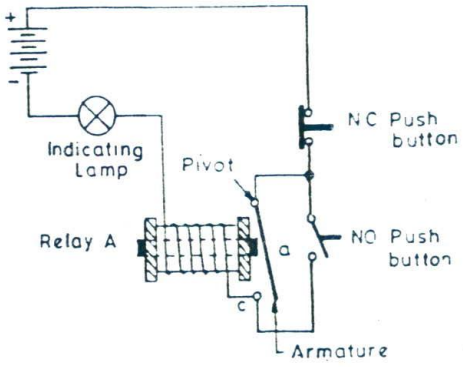


Fig. 23.29. A simple Relay circuit.

When NO (Normally Open) push button is pressed, the circuit will be completed through NC (Normally Closed) push button and terminal 'C' energising the relay coil and

magnetising the iron core. The electromagnetic action of the circuit will attract the armature towards it. The lower end of armature will touch terminal 'C' giving way to a new path of current through the armature and contact 'C' keeping the coil energised even if NO push button is released. This action of the bell created by pushing the NO push button will result in lighting the indicator lamp till the circuit is broken by pushing NC push button. To conclude, it is very clear that the indicating lamp will glow by pressing NO push button. It will continue to glow even if NO push button is released, but will go off when circuit is broken by pressing the NC push button.

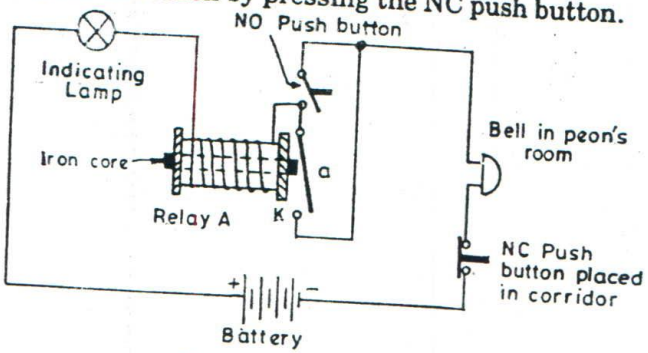


Fig. 23.30. Relay circuit.

Another example of relay circuit is given in Fig. 23.30. When NO push button is pressed momentarily, the armature will be attracted towards the electromagnetic relay coil which makes the contact with terminal 'K'. A new path of current is formed through terminal K and armature keeping the coil energised. The bell will continue ringing and indicating lamp continue lighting till NC push button is pressed releasing the armature and breaking the circuit. The armature will take its original position (as it is spring controlled) to allow the process to be repeated again. It is a very useful circuit. The NO push button, relay and indicating lamp can be installed in principal's office. The bell and NC push button are located in peon's room. The indicating lamp will show that the call is going through.

This bell circuit is similar to the previous circuit except that two magnetic coils and two iron cores are used in this relay to attract the armature. Only one bettery or bell transformer is used. There is only one supply, this circuit is therefore not applicable where bell is located at remote places.

When NO push button is pressed, the iron core is magnetised and attract the armature making the bell to ring. The circuit can be broken by NC push button to silence the bell.

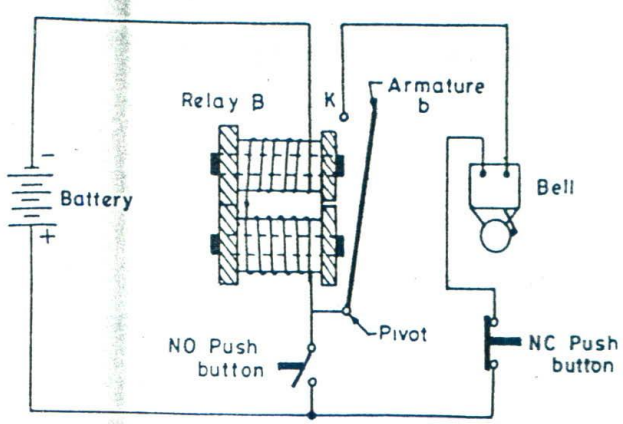


Fig. 23.31. A Relay circuit connected with a bell.

Bell circuits using two supplies

Most of the modern automatic equipment is based upon automatic control using relays and relay circuits. Two supplies have been created to control bell at 230 V a.c. and relay and push buttons at 6 V or 12 volts d.c. It is possible to convey the signal from one circuit to another circuit without the two being necessarily connected electrically. As already stated, we can use the bell rated at 230 volts a.c. and for push button and relay we may use only 6 V or 12 V supply for the sake of human safety.

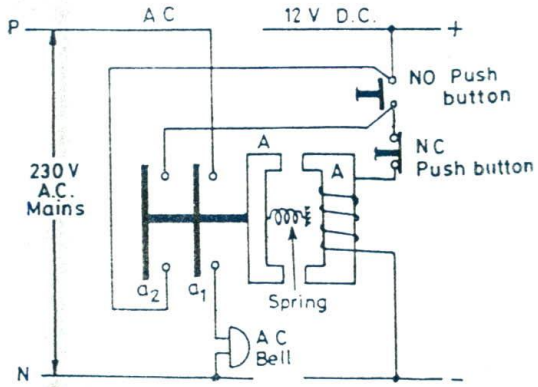


Fig. 23.32. A relay circuit using two supplies *i.e.* AC and DC.

In Fig. 23.32, the two supplies have been used to operate the bell and relay. The coil and push buttons have been connected to 12 volts d.c. supply whereas bell is connected to 230 volts a.c. supply.

When push button is pressed, the electromagnetic relay coil is energised which attracts both the spring controlled and interlocked contactors towards it. The bell starts ringing on 230 volts a.c. supply. The supply to coil commences through contactor A_2 even when NO push button is released and continues to ring. The bell can be silenced only if contactors are pushed back. This can be done only if the coil is de-magnetised by pushing NC push button. The process can be repeated by pressing NO push button for continuous ringing of bell.

Taking references from above Figures, a schematic diagram is reproduced here to understand all the following circuits.

In the schematic diagram shown in Fig 23.33, the relay coil is marked 'A' whereas a_1 and a_2 are the NO contactors of the relay. Practically, the relay and contactors are closed together but here these have been shown at different places because the circuit is to be explained in a proper manner in the schematic diagram. It is not necessary to show the actual position of the components. When NO push button P_1 is pressed, the relay coil gets direct d.c. supply and gets energised. The energised coils gets contactor a_1 and a_2 attracted towards their terminals. The bell starts ringing as its the contactor a_2 is in contact. The coil will continue to get supply through a_1 even if NO push button is released.

If the NC push button is pressed, the contactors a_1 and a_2 will come in original disconnected form thereby disconnecting the a.c. supply to bell. All the following circuits using relay work on the same principle.

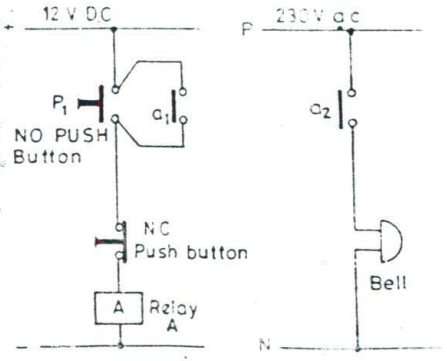


Fig.23.33. Schematic Diagram of relay circuits.

Example 1. *Draw the schematic diagram, wiring diagram and single line diagram for a bell to be operated from a 230 volts supply by means of two push buttons located at two different places. The push buttons and relay are required to be operated at 6 volts d.c.*

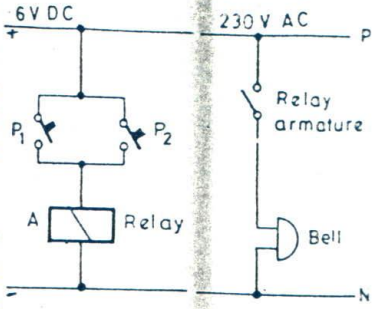
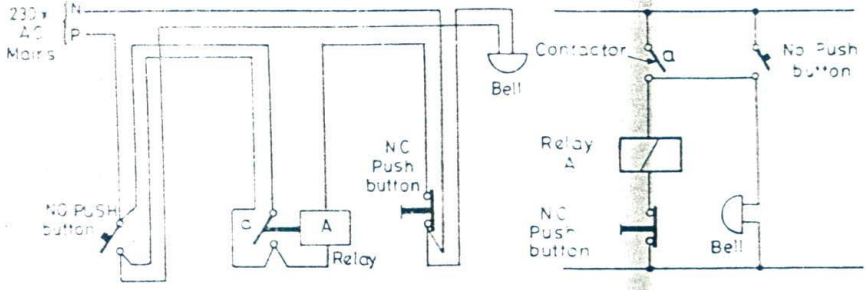


Fig. 23.34

Solution. The relay and two push buttons have been controlled by d.c. supply and bell works on 230 volts a.c. supply.

When either P_1 or P_2 is pressed, the current flows to the relay coil thereby magnetising its iron core. The relay armature or contactor will be attracted. The attracted armature will allow the a.c. current pass through to the bell. It is simple circuit with two supplies. The bell will ring as long as the push button remains pressed.

Example 2. (*a*) *Draw the single line representation, wiring diagram and schematic diagram for an electric bell to be controlled by a push button and a relay. The bell should continue ringing after the 'NO' push button has been momentarily pressed. The bell should stop ringing after pressing the 'NC' push button.*



Wiring Diagram Schematic Diagram

Fig.23.35

Another alternative wiring diagram is given in Fig. 23.36

Example 2 (*b*) *Draw the schematic diagram and the wiring diagram for a relay operated bell circuit. The bell is rated at 230 V a.c. whereas the relay works on 24 volt d.c. upon pressing a push button, the relay should be energised and the bell should get 230 volts a.c. supply through the contact of the relay. (Ans. as in Fig. 23.36).*

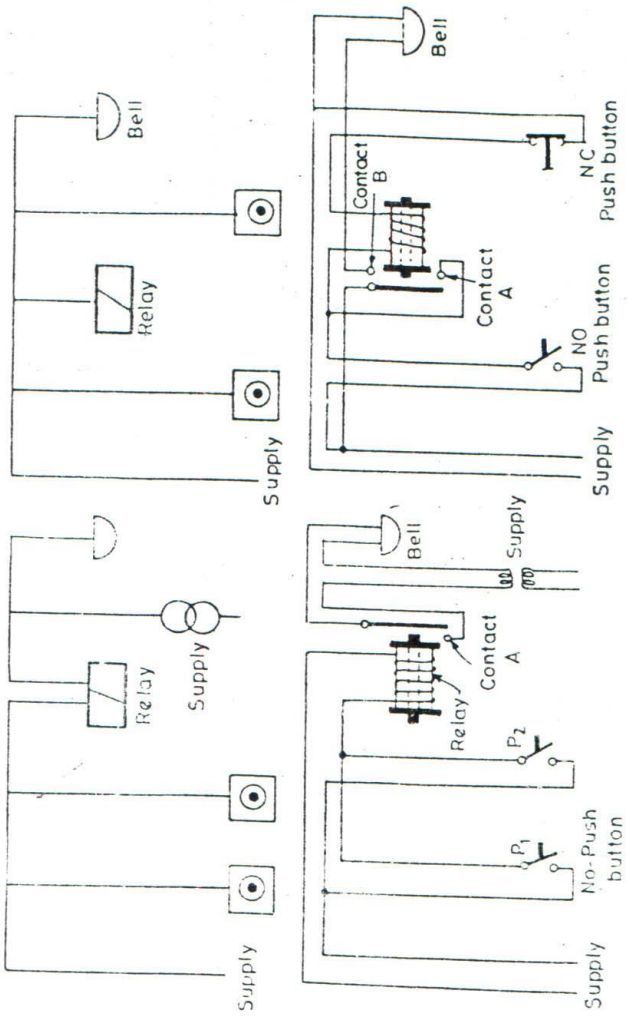


Fig 23.36. Single Line Representation and Wiring Diagram of controlling a bell through a push button and relay.

Example 2. (c) *Draw a schematic diagram, wiring diagram and a single line diagram in which it is possible to ring a bell from three different push buttons located at three different places. The bell should ring by pressing either of the three push buttons but the bell should continue to ring till it is put off by pressing a separate push button. Adopt looping system of wiring.*

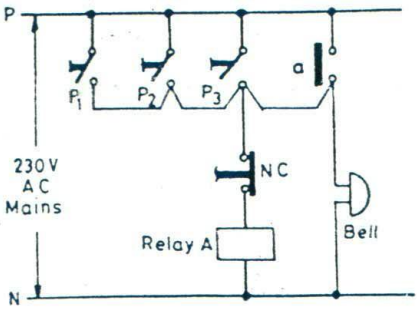


Fig. 23.37 (*a*) A bell to be controlled from three different places.

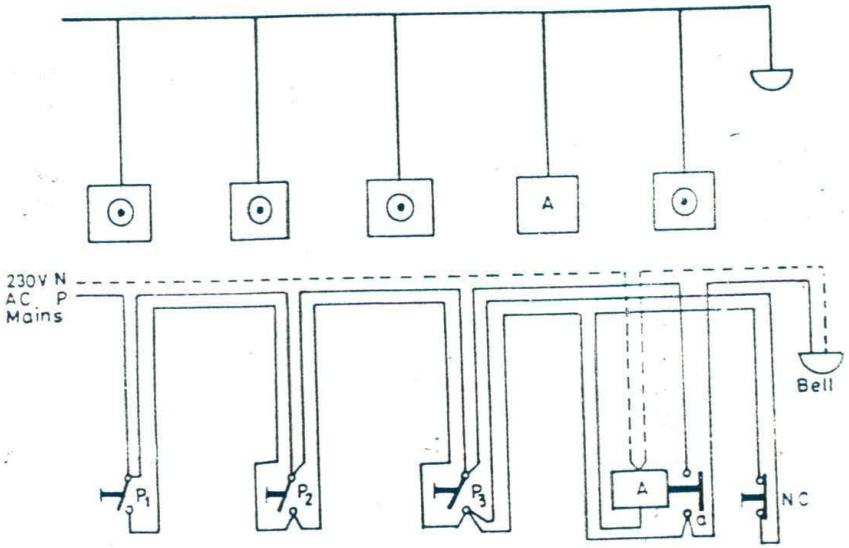


Fig. 23.37 (*b*) Wiring diagram of a bell controlled from three different places.

Example 3. *Design a relay operated relay circuit to be used by an officer. The officer by pressing a push button can make a bell to ring in his P.A's room and the lamp to light in his own room simultaneously. Both the lamp and the bell work on 230 volts a.c. The lamp and the bell get supply through one contact of the relay. The relay coil is rated for 12 volts d.c. Thus by pressing the push button the officer can call his P.A. and also can see through the lamp whether the call is going or not. Draw the schematic diagram for the control circuit and the wiring diagram.*

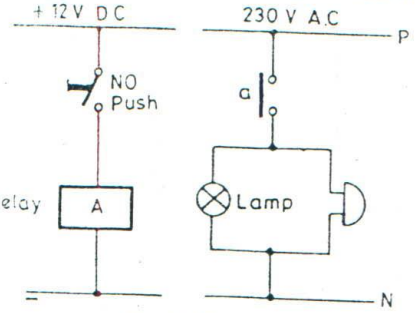


Fig. 23.38 (*a*)

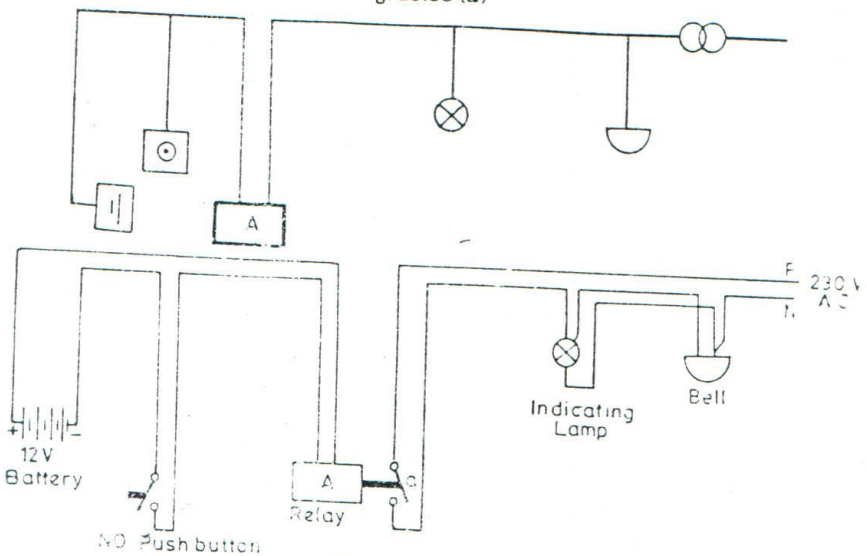
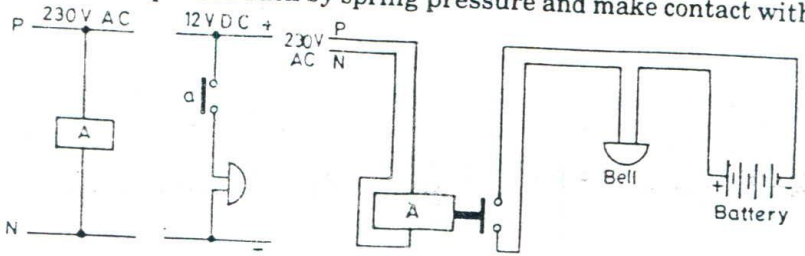


Fig. 23.38 (*b*)

Example 4. *Design an alarm circuit to meet the following requirements :*

In the event of failure of electricity in the shop floor of a factory a bell will ring giving an alarm in the control room. The bell works on 12 V d.c. Draw the schematic diagram and wiring diagram.

Solution. The relay remains energised so long as there is supply. The contactor '*a*' remains attracted. When a.c. fails, the contactor is pushed back by spring pressure and make contact with



another terminal thereby completing the d.c. circuit and ringing the bell. If the circuits are to be isolated in case of need, two switches can be included in the circuits.

Example 5. *Design a relay operated bell circuit in which one common bell is used by two different officers. Two separate push buttons are provided in the two officer's room. When any of the two push buttons is pressed, the bell should ring. The bell should also ring when there is any disconnection in the relay circuit. The relay coil is rated for 12 volts d.c. whereas the bell is rated for 230 V a.c. Draw the schematic diagram and wiring diagram.*

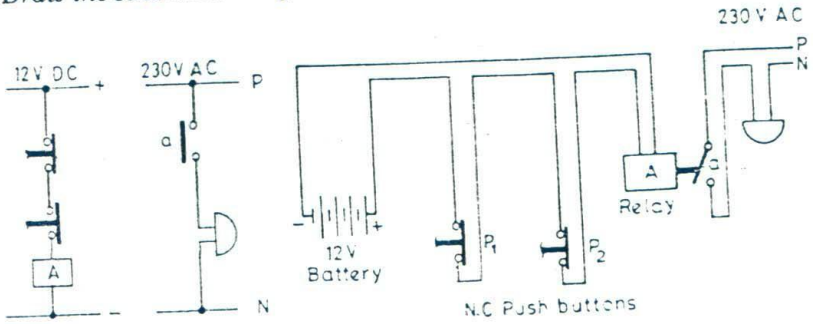


Fig. 23.40

Solution. In this case, NC push buttons have been used for the officers. When any of the two push button is pressed, the relay coil will be de-energised and contactor '*a*' will be closed causing the bell to ring on a.c. supply. The contactor '*a*' will open only when coil is energised. The push buttons have been placed in series. It has the disadvantage that the relay coil A will remain energised causing loss of power. If there is any disconnection in the relay circuit or a loose contact develops in the relay, the bell will ring continuously giving warning for attention.

Example 6. *Draw the schematic diagram, wiring diagram, and single line diagram, for the circuit to be used in a bus. When the conductor presses a push button, for giving signal to the driver to stop the bus, two red lamps, one facing the passengers and another on a panel facing the driver's seat will glow. The conductor should press another push button to switch off both lamps as an indication for the driver to start the bus again. Adopt any system of wiring (looping system or joint box system) but confusion in the diagram due to more number of lines must not exist.*

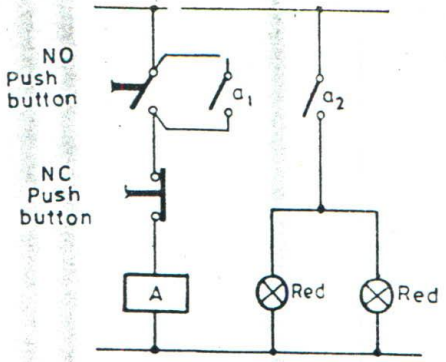


Fig. 23.41

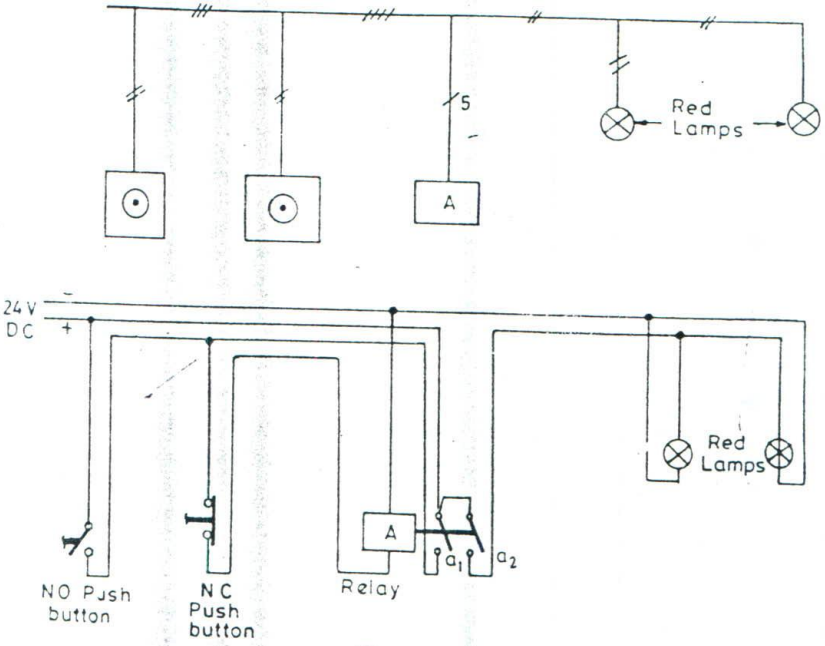


Fig. 23.42

Example 7. *Draw the schematic and wiring diagram of a relay operated signal circuit for an officer's office. The officer can call his H.C. (Head Clerk) by pressing a push button. The bell will ring for as long as the push button remains pressed and simultaneously a signal lamp will continue to glow in H.C.'s office till the H.C. presses another push button in his room to switch off the signal lamp. If he is not in the office, at that time, upon his return, he will find the lamp glowing and thus come to know that he should attend to his officer. The H.C. must push another push button to switch off the signal lamp.*

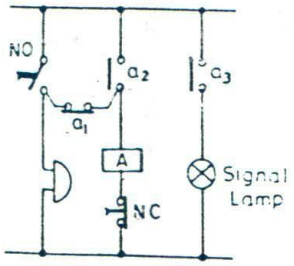


Fig. 23.43

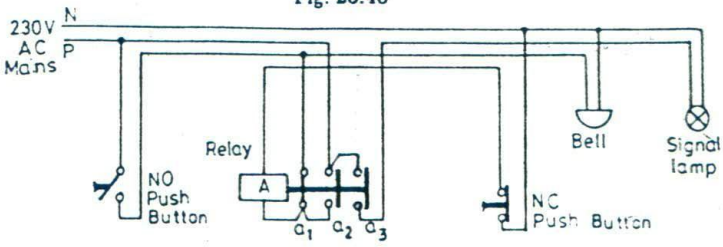


Fig. 23.44

Example 8. *A man wants to see a doctor in his bungallow during day time. He pushes a push button located in verandah and*

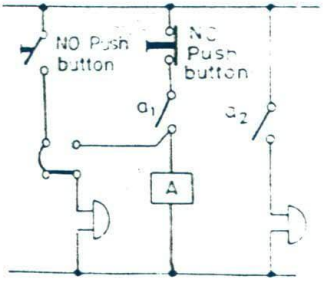


Fig. 23..45

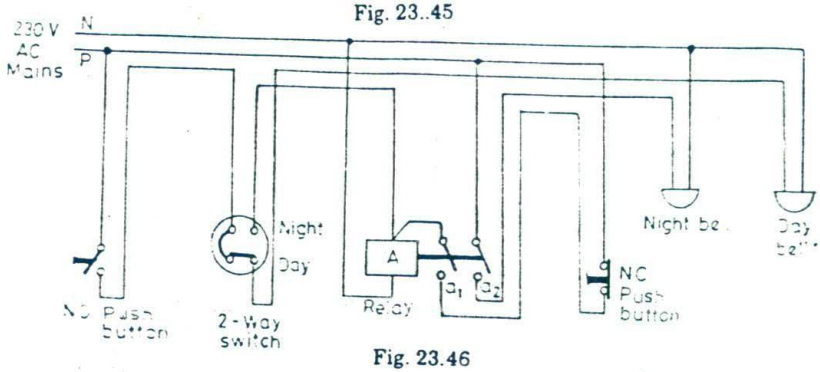


Fig. 23.46

A two way switch is included in the circuit. The two way switch is operated for choice of day or night bell.

the bell rings in the drawing room of the bungallow. But during night time, the doctor may wish to receive the night call in his bed room although the visitor has to push the same push button. Once the push button is pressed, the bell should continue to ring qutomatically till the doctor wakes up and presses another push button to silence the bell. Draw the schematic diagram and wiring diagram.

Example 9. *A bus is provided with two push buttons for the passengers and one red and one green signal lamp in front of the driver's seat. By pressing any of the two push buttons by a passenger who wants to get down, a red signal can be given to the driver to stop the bus but simultaneously a green lamp should go off. The driver stops the bus. When the bus is ready to move, the conductor should be able to switch off the red light and switch on the green light by pressing a re-set push button installed near to his seat. The same procedure can be repeated wherever any passenger wants to get down. Draw the schematic diagram and the multiline wiring.*

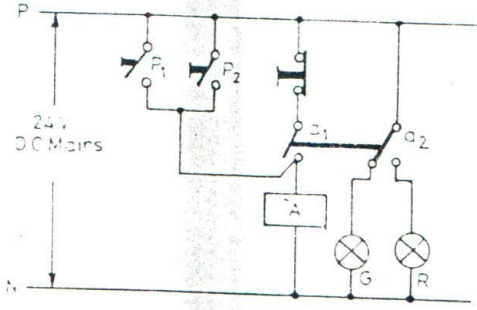


Fig.23.47

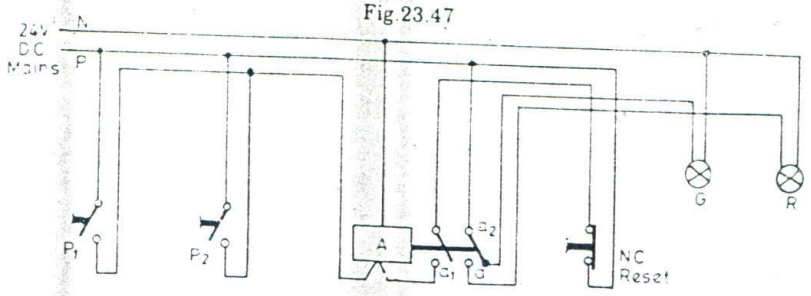


Fig.23.48

Note. Another alternative wiring diagram and single line diagram is given in Fig 23.49.

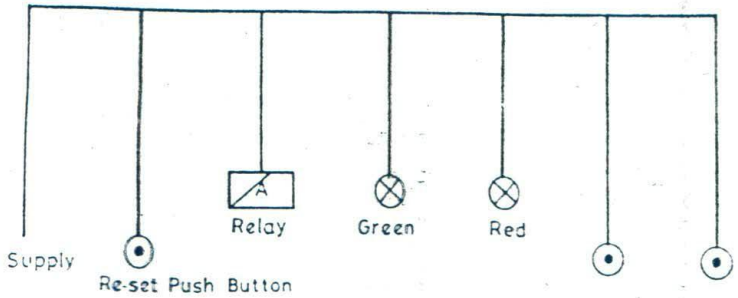


Fig. 23.49 (*a*) Single Line Representation.

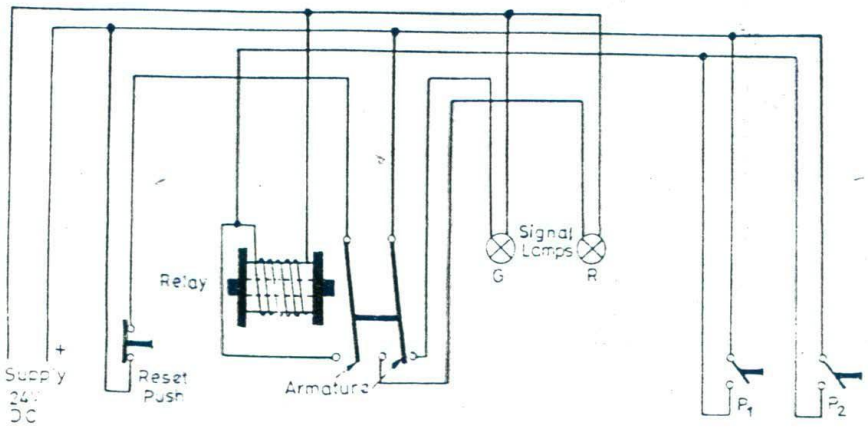


Fig. 23.49 (*b*) Wiring diagram.

Example 10. *Draw a schematic diagram, wiring diagram and a single line diagram which should meet the following requirements :*

The passenger bus consists of a main bus and a trailer (A trailer is an additional compartment coupled to the main bus to carry more

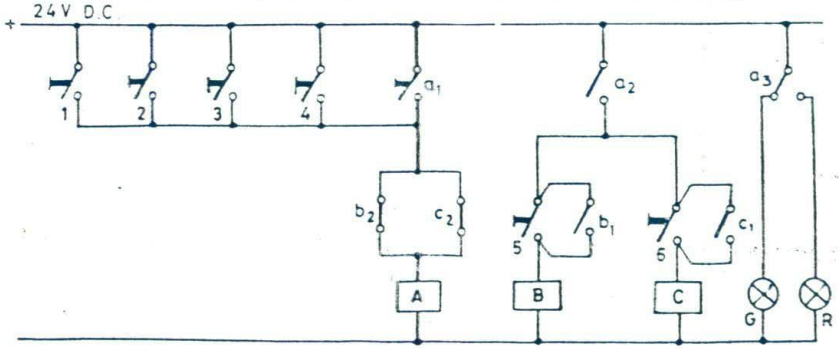


Fig. 23.50

passengers). There is one conductor each in the main bus and in the trailer. The passengers can give to the driver a red signal for stopping the bus by pressing any one of four push buttons. (Two in the main bus and two in trailer). The driver must get a green signal before he may start again. The circuit design must ensure that the green signal comes only when the conductors of the main bus as well as of the trailer have both pressed push buttons provided separately for them. This means that the green signal should not appear on the indication of one conductor only.

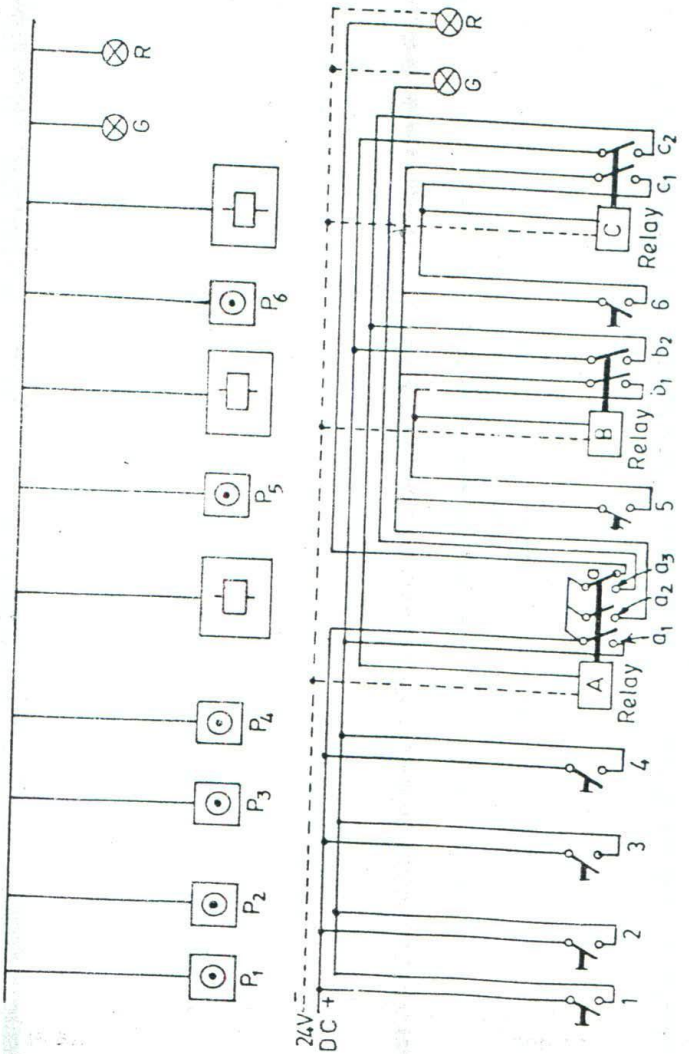


Fig. 23.51. Wiring Diagram.

Four push buttons are meant for the passengers for giving red signal to the driver to stop the bus. Push buttons 1 and 2 are fixed in the main bus and push buttons 3 and 4 are in the trailer. Push button 5 is installed in the bus and 6 in the trailer for use by the conductors.

Example 11. *A light and bell circuit is to be designed for four special rooms of a hospital. The arrangement should be such that when the patient in any of the four rooms wishes to call the nurse, he presses a push button from near his bed. The relay operates and as a result, an indicating lamp outside his room in corridor goes 'on' and another indicating lamp bearing the number of his room on indicating panel in nurse's room also goes 'on'. The only bell (common for all patient rooms) installed in nurse's room also rings for her extra attention. This is an indication for the nurse to know from which room the call has come. If she desires, the bell can be silenced by the nurse by a switch on indicating panel but the signal lamp should be still 'on'. The indicating lamps and bell can be re-set by pressing a push button from patient's room. The second indicating lamp glowing outside the patient's room after his call is an additional indication for the nurse so that she can attend to another patient before returning to her room after attending the first patient.*

Draw the schematic diagram, wiring diagram and a single line representation fulfilling above conditions.

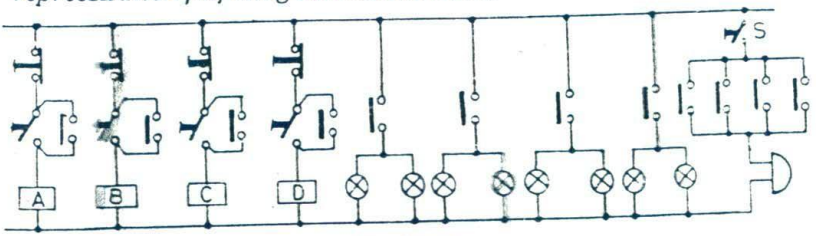


Fig. 23.52

Solution. Mark relay A, B, C and D on the above diagram. Also find and mark the contactors which will be operated by pressing a particular push button to energise that relay. For instance for relay A, a_1 is for relay (near its push button) a_2 for signal lamps (first pair of lamps), a_2 for bell. Similarly mark b_1, b_2 and b_3 for relay B and so on.

Example 12. *The call signal arrangement is to be provided for three special rooms of a hospital. When the patient in any of the three rooms presses a push button from a panel near his bed to call the nurse, the relay operates and one lamp outside his room and a one lamp in nurse's room goes 'on'. This is an indication for the nurse*

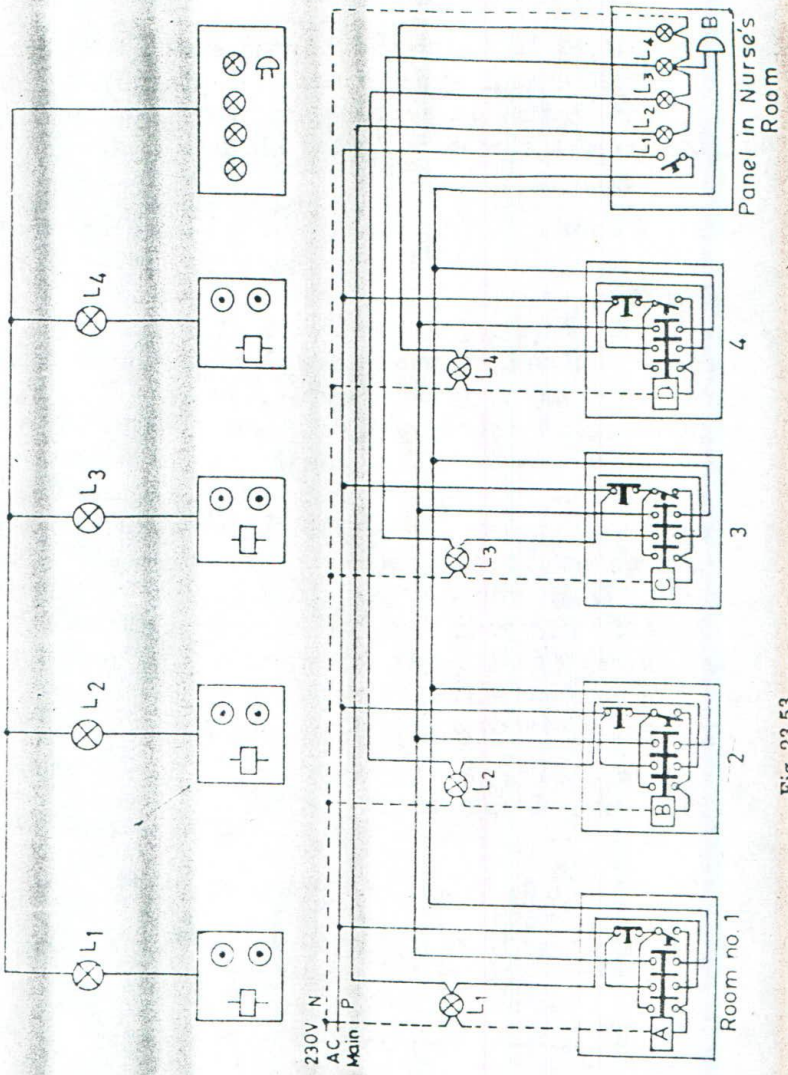


Fig. 23.53

to know some patient has called her and comes out in corridor and immediately know from the indicating lamp glowing outside the patient's room which of the patients has called her. Both the indicating lamps can be switched off by pressing a push button in patient' room.

Draw at least two alternative circuit designs in a schematic diagram and add a multiline and single line diagram.

Solution. The circuit is very similar to the previous circuit except the indication of particular room. Here, only one indicating lamp is installed in nurse's room in place of an indicating lamp and

bell panel. When a push button say P_1 is pressed by the patient, the relay A is energised which attracts contactor a_1 and a_2, the lamp S_1 (placed in series in (a) circuit with relay A) installed in front of room No. I will glow and another lamp S_4 in nurse's room will also glow through contactor a_2. Both the lamps can be switched off by pressing a push button from patient's room.

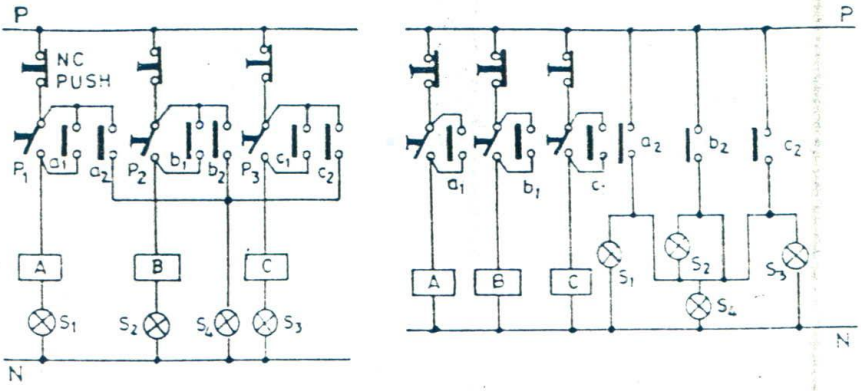


Fig. 23.54

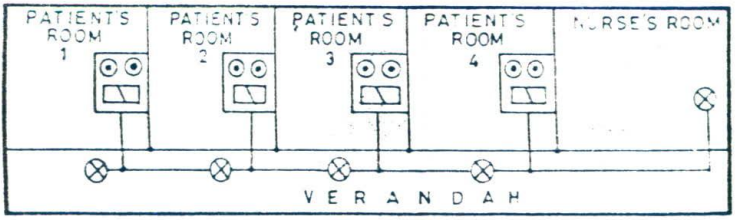


Fig. 23.55

The schematic diagram shown in Fig. 23.54 (a) has been followed here and draw the wiring and schematic diagram as shown below. The relay signal lamps have been shown in series, the relay therefore will have to be designed specially for the purpose.

Draw another diagram showing relay and signal lamp in parallel by taking reference from schematic diagram shown in Fig. 23.54 (b).

Example 13. *A light and bell circuit is to be designed for four special rooms, he presses the push button from near his bed, relay operates and as a result, an indicating lamp outside his room in corridor goes ON and another indicating lamp bearing the number of his room on an indicating panel in nurse's room also goes ON. The only bell (common) for all patient rooms in nurse's room also rings*

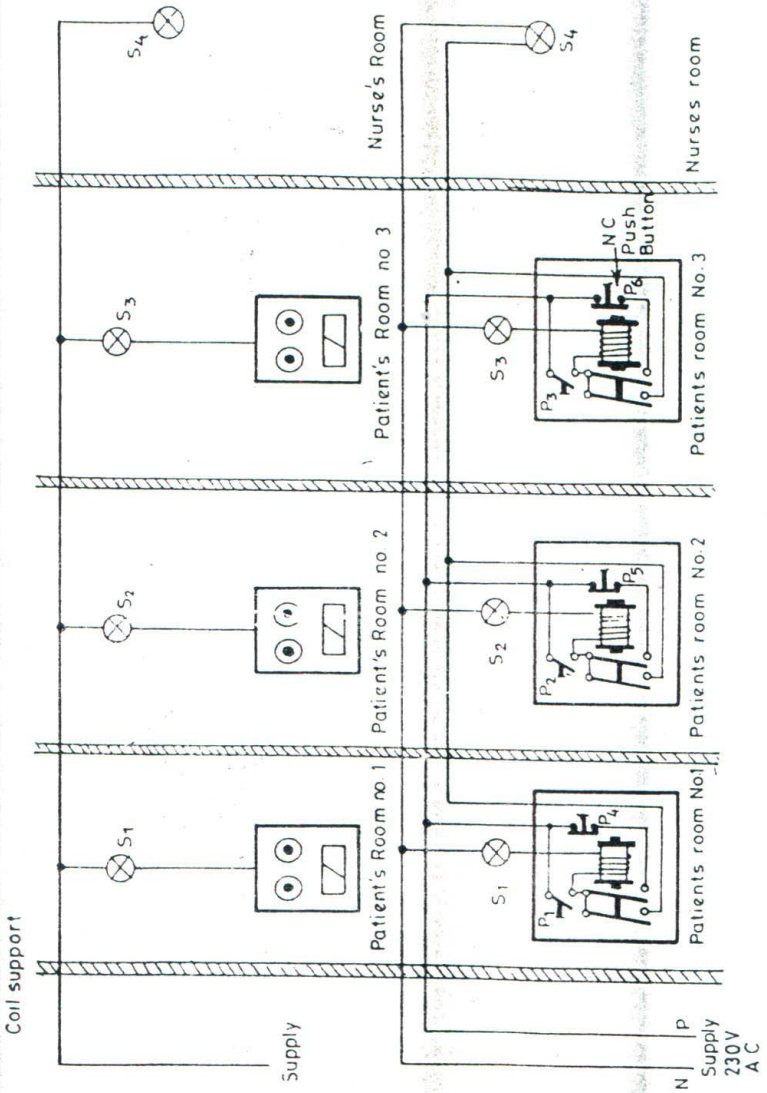


Fig. 23.56 Single line Representation and Wiring Diagram.

for her extra attention. This is an indication for the nurse to know from which room the call has come. If she desires the buzzer can be

silenced by the nurse by a switch on indicating panel but the signal lamp should be still 'on'. The indicating lights and bell can be re-set by pressing a NC push from patient's room.

Draw the wiring diagram, schematic diagram and a single line representation fulfilling the above conditions.

Solution. The problem is interesting and easy to understand. The panels are installed in each room near the patient's bed to call the nurse as and when necessity arises. The indicating panel is installed in nurse's room at a suitable place from where she can immediately see and respond to the call. Four indicating lamps, each representing a different room number and relay are installed on the indicating panel, in addition to this, a buzzer is also provided to invite extra attention of the nurse. The buzzer can be disconnected by a switch if not required momentarily.

When patient in room number 1 presses a push button to call the nurse, she will press button P_1. The armature will then be attracted towards relay and sub-

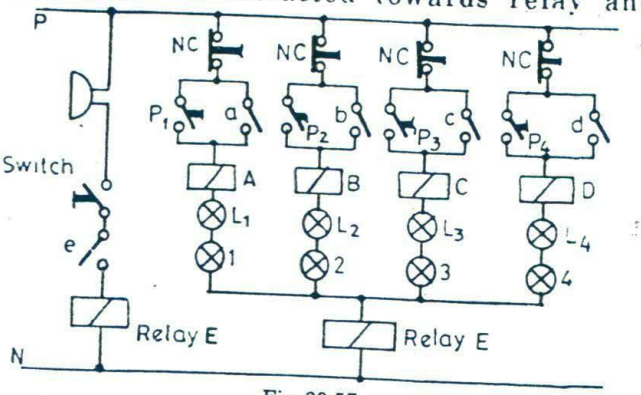


Fig. 23.57

sequently, the lower portion of the armature will make contact with a point and a circuit will be completed through the NC push button, relay, indicating lamp (outside the patient's room), indicating lamp in nurse's room and a relay on indicating panel. The indicating lamp

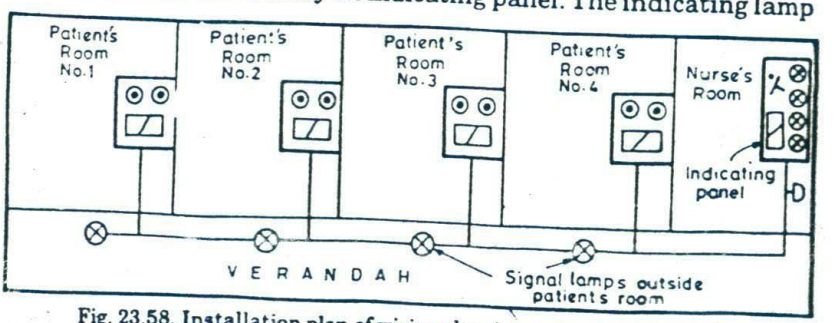


Fig. 23.58. Installation plan of wiring showing various room panels and indicating panel.

L_1 and 1 will glow and keep on glowing, as an indication to the nurse to know which room the call has come from. The indicating lamps will go off, only when NC push button (in patient's room) is pressed to dislocate the existing circuit.

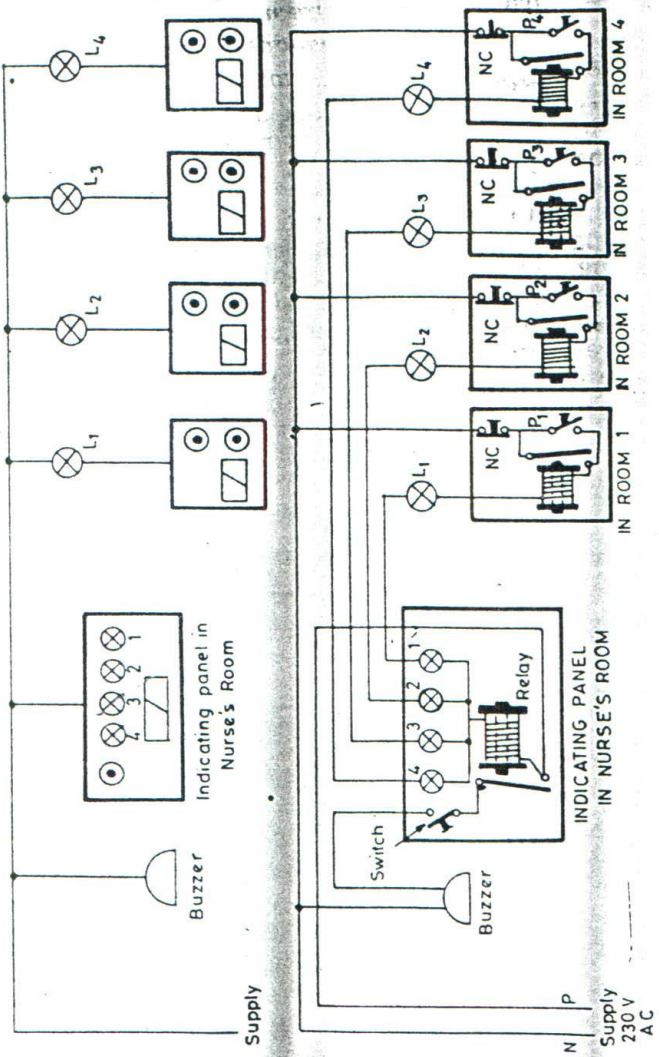


Fig. 23.59. Single Line Representation and Wiring Diagram.

Example 14. *A relay operated signal circuit is to be provided for a three storey hotel building which should meet the following conditions :*

There are five rooms on each of the first and the second floor. One attendant is provided each for the first and second floor. The manager's office is on the ground floor. Each attendant is provided with a panel board having on it five signal lamps (one lamp for each room signal) and a buzzer. In the manager's room on the ground floor, there is a panel board provided with two rows of signal lamps with five lamps each, indicating number of floor and room number. Near the two-rows of lamps, there is also a buzzer. If the push button in any of the rooms provided to call the attendant is pressed the buzzer on the panel of the concerned floor and on the manager's panel will ring for as the push button remains pressed. Two signal lamp *i.e.* one on the concerned attendant's panel board and the other with same room number on the manager's panel will continue to glow even if the push button is released. The lamps (one on attendant's panel and other on manager's panel) can go off simultaneously only when the concerned attendant has gone to attend the guest where he will press a push button marked 'off'. The manager is therefore able to ensure from the panel that the guest's calls are being attended. If a particular lamp on his panel remains 'on' for a long period, the manager can question the attendant for not attending that call. Draw the schematic and wiring diagram which should be clear enough to be incorporated practically.

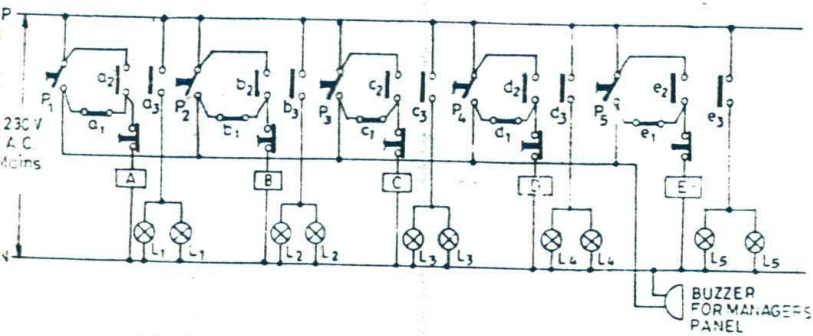


Fig. 23.60. Arrangement for IInd floor Signal Circuit.

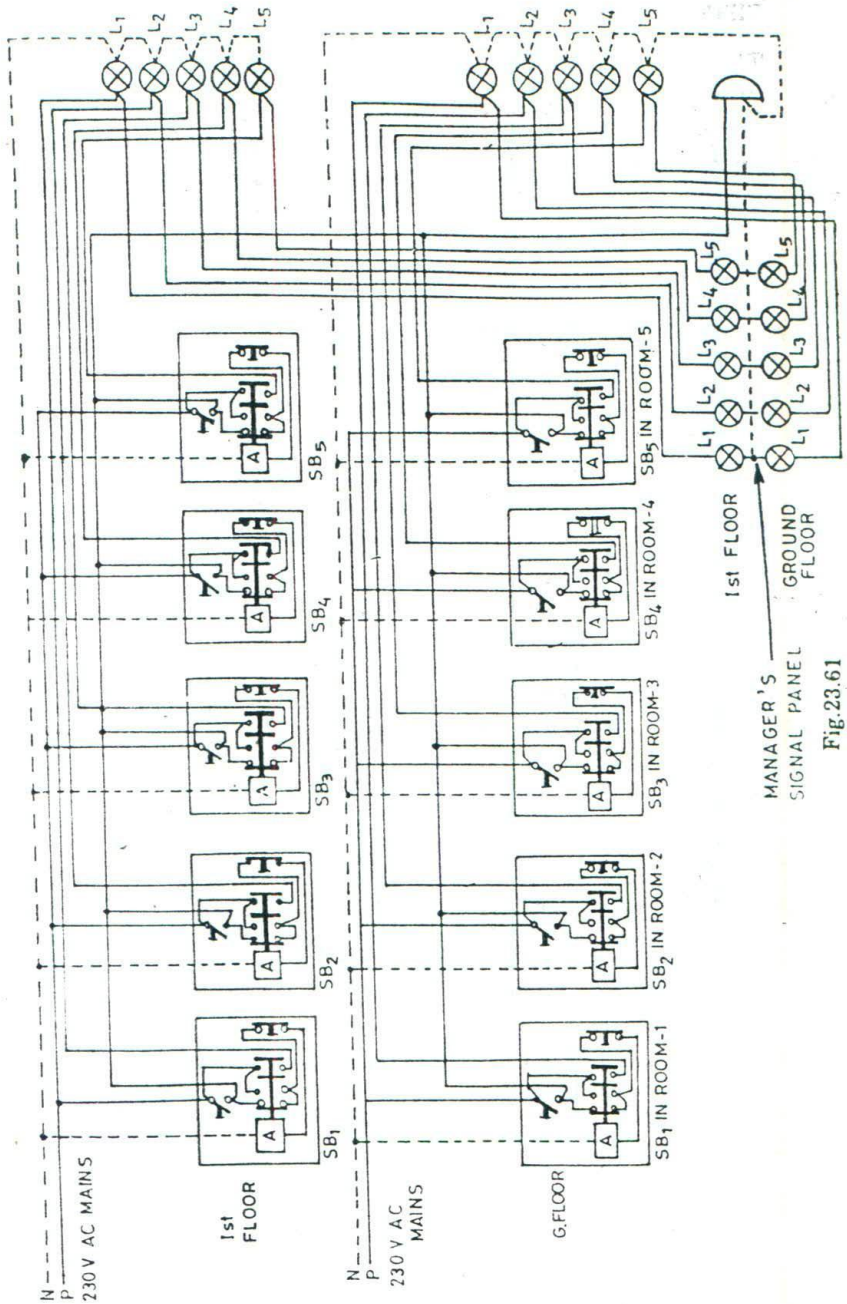


Fig.23.61

Example 15. *A light and bell circuit to be designed for four special rooms of a hospital. The arrangement should be such that when the patient in any of the four rooms wishes to call the nurse, he*

has come. If she desires, the bell can be silenced by her by a switch on indicating panel but the signal lamp should be still 'on'. If the presses a push button from near his bed. The relay operates and as a result an indicating lamp outside his room in corridor goes 'on' and another lamp bearing the number of his room on indicating panel in nurse's room also goes 'on'. The only bell (common for all patient's rooms) installed in nurse's room also rings for her extra attention. This is an indication for the nurse to know from which room the call patient presses a push button to call her, the lamps will glow but the bell will not ring if the switch on indicating panel is 'off'. This is a drawback. The indicating lamps and bell can be switched 'off' by a push button from the patient's room. If the nurse forgets to switch on the bell switch, the bell will not ring when the patient presses their respective push buttons.

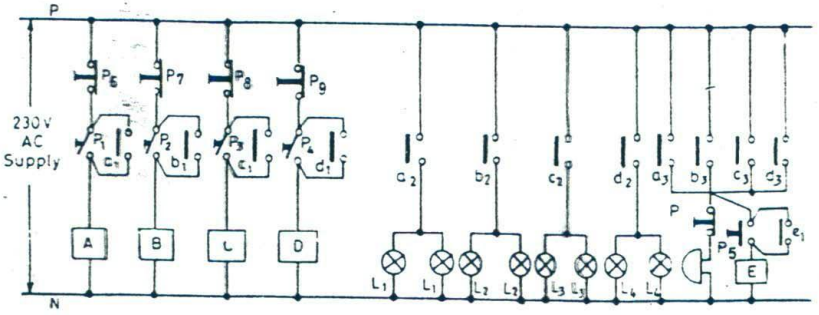


Fig. 23.62

Design a circuit in which the switch is replaced by a push button so that the nurse may press a push button instead of a switch in her room by which, the bell will stop ringing but the lights will continue to remain 'on' until she presses a push button in patient's room. The bell should ring again if any patient presses his push button. Draw the schematic diagram for the above design.

Example 16. *The manager in a big factory is provided with a push button marked CALL in his office to call his three assistant managers for a conference. Each assistant manager is provided with a bell and a signal lamp. When the manager presses a push button marked 'CALL' to call his assistant managers, the bell in the assistant managers offices will ring for as long as push button remains pressed but the signal lamps will continue to glow even after the manager releases the CALL push button. When the assistant managers reach his office, the manager can switch off all the lamps in assistant manager's offices by pressing another push button marked 'OFF' installed near his seat. Draw the schematic diagram and add a wiring diagram.*

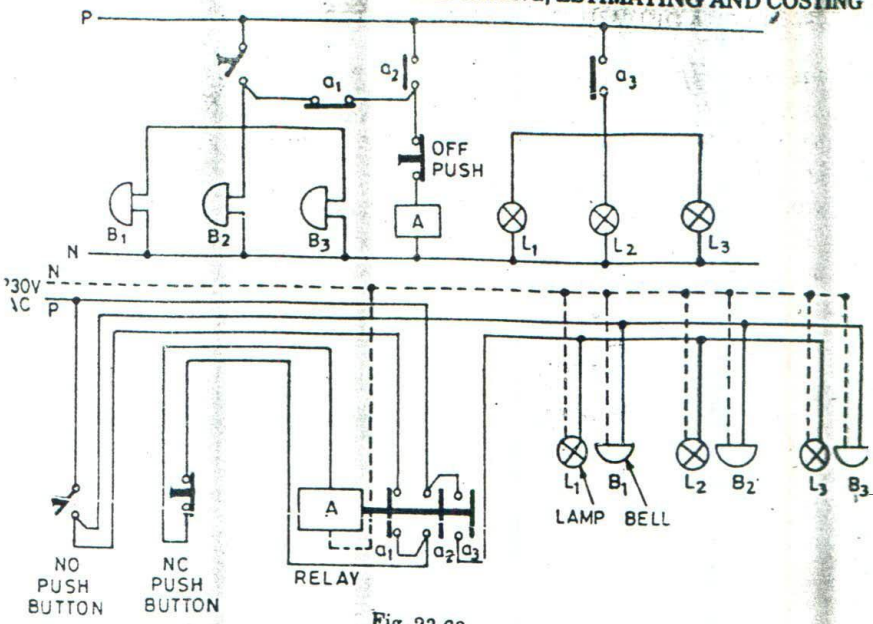
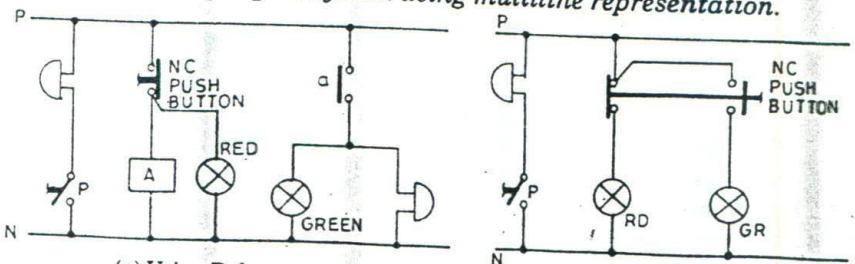


Fig. 23.63

Example 17. *Design a bell circuit in which one push button and two indicating lamps i.e. one green and one red are mounted on the plate outside the residence of Mr. 'X'. In case somebody presses a push button from outside, a bell should ring inside the house. If the doctor is inside the house, he will press a push button from inside. A bell should ring and red lamp goes off and simultaneously a green lamp should glow outside. This should happen only for the period the push button remains pressed, otherwise the red lamp should continue to glow.*

Draw a bell circuit. Draw its schematic diagram and wiring diagram in looping-in system using multiline representation.



(*a*) Using Relay (*b*) Using 1 NO-1 NC Push Button

Fig. 23.64

Solution

1. Circuit using relay. In this case, the relay is used along with a contactor. The relay remains constantly energised and red lamp remains ON as NC push button is used between line and relay.

As long as the relay remains energised, the contactor '*a*' remains open. When NC push button is pressed, the relay is de-energised and red lamp goes off and simultaneously the contactor '*a*' closes the circuit thereby ringing the bell and glowing green lamp. The contactor closes the circuit as long as the NC push button remains pressed. As and when the pressure on the NC push button is relased, the relay is again energised, as a result of which the red lamp will glow and green lamp will go off.

2. Using 1 NO-1 NC push button. This type of push button has two contactors. As it is spring controlled, one contactor is normally open where as the other contactor is normally closed. When push button 1 NO 1 NC is pressed, the red lamp which will normally remain ON will now go off and the greer. lamp will glow for as long as the push button remains pressed. As soon as the push button is relased, again the red lamp will glow and green lamp will go off simultaneously.

EXERCISES

1. The drawing below shows the incomplete schematic diagram and wiring diagram for a bell controlled by two push buttons. The bell will ring if either of the two push buttons is pressed. There are separate supplies for the relay circuit and the bell circuit. Complete the schematic and wiring diagram.

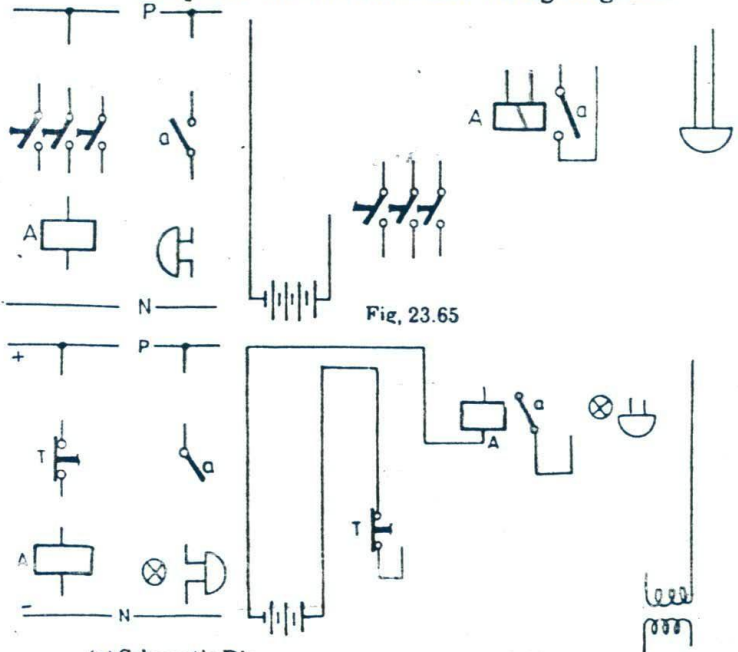


Fig. 23.66

2. The drawing below shows the incomplete schematic and wiring diagram for a relay operated light and bell circuit. Relay A is constantly energised by a D.C. supply. Contact (armature of relay) 'a' is thus in such a position that the light and bell are 'off'. When the NC push button T is pressed, relay 'A' is de-energised and the light and bell must give a signal together. Complete the schematic and wiring diagram. There are separate supplies for the relay circuit and the bell circuit.

3. Draw the schematic and wiring diagram for the following. An electric bell is to be controlled by two push buttons and a relay. The bell should continue ringing after the ON push button has been momentarily pressed. The bell should stop ringing after pressing the OFF push button.

4. The drawing below shows the schematic diagram for a bus driver's indicating lamp control. In the schematic diagram, only the push buttons, contacts, relays and signal lamps have been shown. Complete the schematic diagram and draw the wiring diagram to meet the following requirements.

Push buttons 1 and 2 are to be used by the passengers sitting in the bus. By pressing any of the push buttons meant for the passengers, it is possible to switch off the green light and switch on the red light. On such indication, the driver stops the bus. After a passenger gets down the bus, the conductor can reset the lights *i.e.* switch off the red light and switch on the green light by means of push button T. Also locate the mistake in symbols and rectify it in your diagram. (Follows the fig. of Question No. 5)

5. The figure below shows the schematic representation of a relay circuit drawn incomplete. This circuit is often used in buses. Push button 1, 2 are to be used by the passengers. Push button 't' is with the conductor. The driver will drive the bus on green signal. By pressing one of the push buttons meant for the passengers, the green signal can be switched off and the red signal can be switched

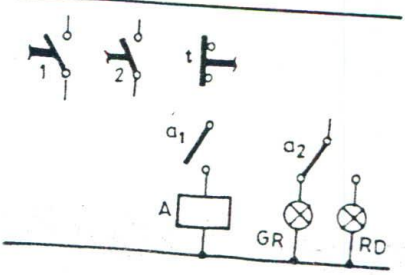


Fig. 23.67

on. By pressing the push button 't' the conductor can reset the lights to give green signal. Complete the schematic diagram for the control circuit.

6. The incomplete diagram below shows a bus driver's indicating lamp control. The push buttons, relay and signal lamps have been shown. Complete the connections of this diagram so that the following conditions are fulfilled.

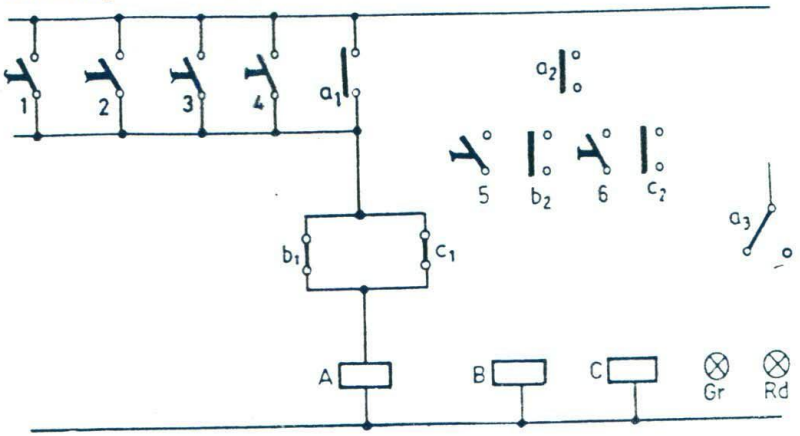


Fig. 23.68

The bus consists of a main bus and a trailer (A trailer is an additional compartment coupled to the main bus to carry more passengers). There is one conductor each in the main bus and in the trailer. The passengers can give to the driver a red signal for stopping the bus by pressing push buttons 1 to 4. The driver must get a green signal before he may start again. The circuit design must ensure that the green signal comes only when the conductor of the main bus has pressed button 5 as well as the conductor of the trailer has pressed button 6 simultaneously.

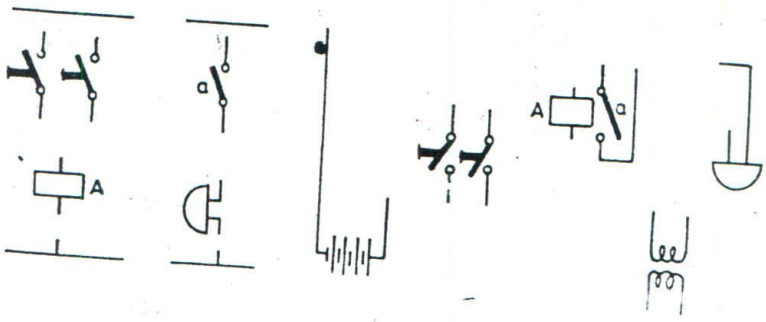
Also find out the mistake in the electrical symbols used here and place correct symbols in the diagram you prepare.

7. Draw the schematic diagram and wiring diagram for a bell circuit such that the bell will continue ringing by pressing a push button but would stop when NC push is pressed.

8. A medical doctor has two bells in his residence, both to be controlled from a single push button located in verandah. During day time a bell in drawing room is used. During night time a bell in bed room is used. The bell in bed room to be used at night is relay operated, such that the bell will continue ringing till the doctor

silences the bell by pressing NC push button from his bed room. Draw the schematic diagram, wiring and single line diagrams.

9. The diagram below shows a bell controlled by three push buttons. The bell should ring by pressing either of the three push buttons. There is a separate supply to the bell and relay. Complete the schematic and wiring diagram.



(a) Schematic Diagram (b) Wiring Diagram

Fig. 23.69.

10. The drawing shows the schematic diagram and wiring diagram of a relay operated bell circuit. The bell will continue ringing after the push button 'K' has been momentarily pressed because the contact 'a' of the relay 'A' will act as a hold on contact. The bell should stop ringing after pressing push button 't' which will de-energise the relay 'A'. Complete the schematic and wiring diagram for the above.

T.D.R. Circuits

T.D.R. Circuit No. 1. Draw the schematic and wiring diagram using time delay relay in which two lamps, one red and one green should continue to glow alternately with a certain interval of time.

When the switch 'S' is closed, the relay A is energised through b and the lamp R glows taking supply through a_1. After a certain interval of time, its contacts a_1 and a_2 operate such that a_1 is disconnected (disconnecting apply to signal lamp R) and a_2 is connected thereby energising relay B. The green lamp starts glowing. After a certain interval of time the contact b operates and makes the supply to relay A and simultaneously, the contacts a_1 and a_2 return to their original position. Thus the green lamp is switched off and the red lamp glows. This cycle of operation repeats as a result, the red and green lamp continue glowing alternately with a

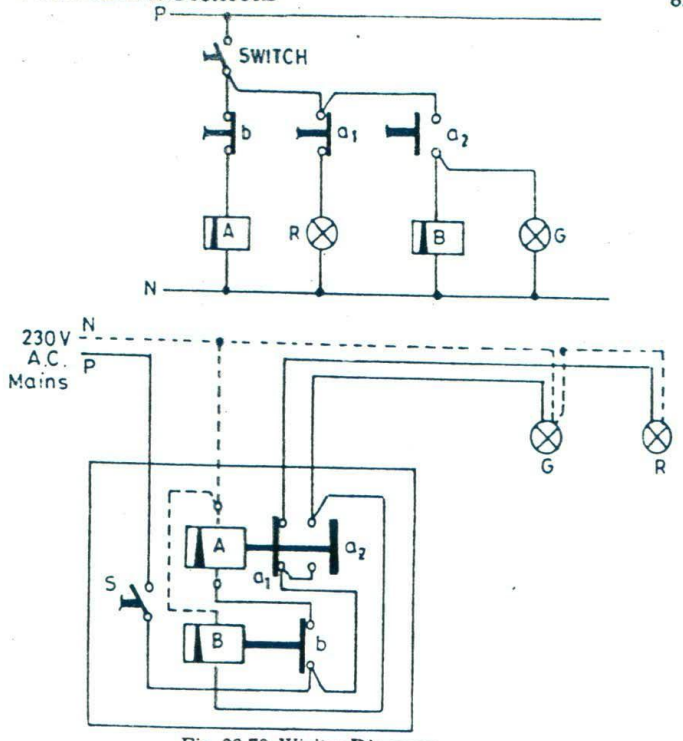


Fig. 23.70. Wiring Diagram.

definite interval of time. The amount of time lag can be increased or decreased with the help of an adjusting screw provided in each T.D.R.

T.D.R. Circuit No. 2. Draw the schematic and wiring diagram of the traffic light for the crossing of two roads. One red lamps and one green light will be installed on each side *i.e.* two red lamps and two green lamps on the two roads at the crossing will glow at a time. When the red lamps on one road are ON to the stop

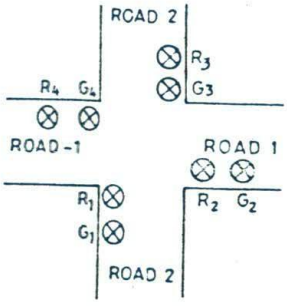


Fig. 23.71

the traffic, the green lamps on the other roads should also be ON to allow the traffic to cross. Draw the circuit using T.D.R.

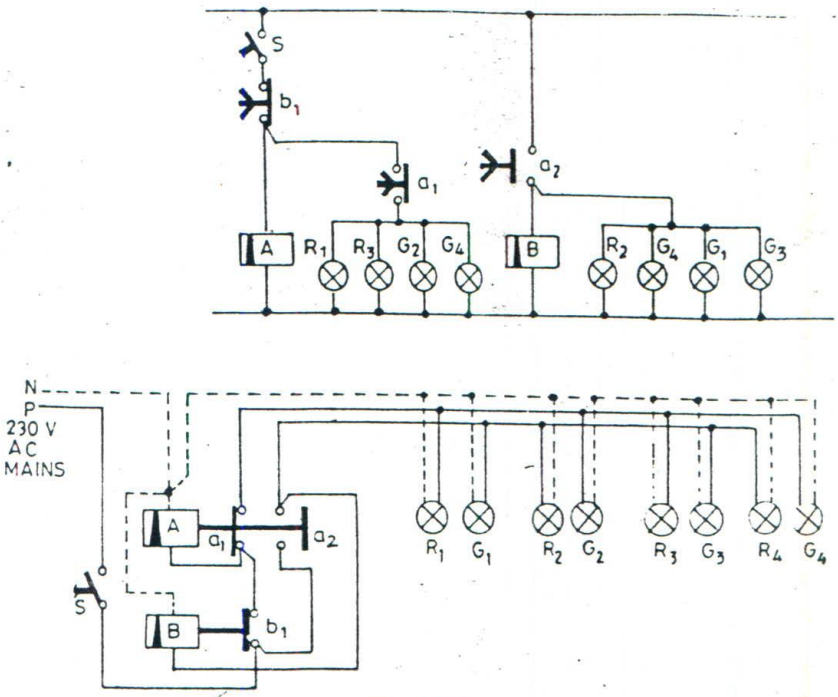


Fig. 23.72

The red and green lights are for giving particular signal to the traffic. When the traffic is allowed to cross along road (1) giving green signal the traffic along road (2) should be made to stop by glowing red signal lamps and *vice versa*. If traffic is allowed to move along road (1) the R_1 and R_3 should be on and G_2 and G_4 should also be ON.

THE USE OF INDICATORS IN VARIOUS CIRCUITS

Indicators are designed primarily for service signals. The indicator systems are installed for the purpose of having all calls terminate at a central location. It is impracticable to have more than two or three bells located at one point, because it results in confusion, even though they may have gongs of different tones. For this reason, a device, known as an indicators is used to indicate by visual means, the signals that are transmitted over electric call bell circuits. The indicators are used mostly in hospitals, hotels, offices, residences and the places where call bell service is required.

There are different types of indicators which are distinguished from one another by the form of the indicating device. The most

commonly types used are :

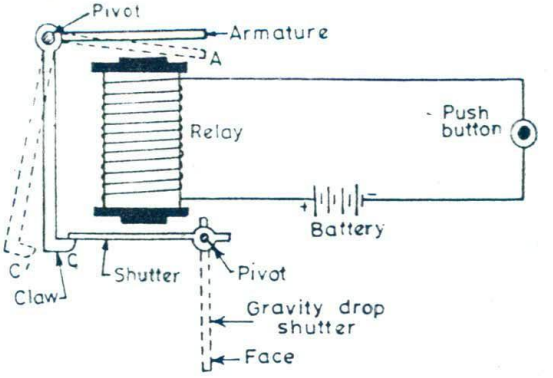
(*a*) Gravity drop (hand operated reset and electric automatic reset types).

(*b*) Needle or arrow drop.

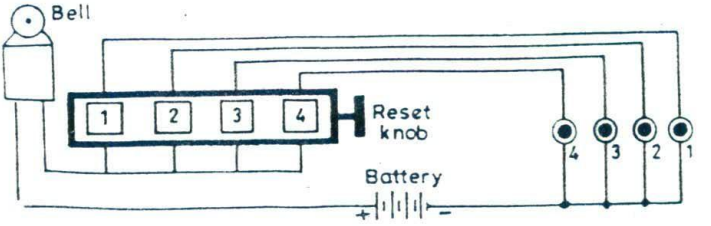
(*c*) Electric drop.

(*d*) Lamp indicators.

(*a*) Gravity drop signal. The Fig. (23.73 *a* and *b*) shows gravity drop indicator. It consists of relay, armature with claw and shutter comprising number on it. By pressing a push button, when the circuit is completed, the relay coil is energised and iron core lying in it is magnetised. It attracts the armature pivoted at one point. When the armature is attracted by the electromagnet, it is pressed downward. Since it is angular in shape and pivoted at one point, the other side of it will move outward forming a dotted shape as shown in the sketch above. The claw C then takes the position of C' thereby releasing the shutter pivoted at P allowing it to drop by gravity to



(a)



(b)

Fig. 23.73

the position marked by dotted line displaying the number marked upon its face. When the armature is attracted shown by dotted lines, the position of claw and shutter will also be as shown by dotted line. The number of electromagnets and other equipment will be equal to the number of drops required in the indicators.

The drawing below shows another type of indicator with gravity drop. Its consists of bell, reset rack push button, electromagnets, shutter, armature and a drop which is used to exhibit the circuit number. The bell is used to make the signal audible. The reset rack is used to hold the drops in the indicating position after being released, and to return them to their original position when desired. When push button No. 1 is pressed, the current flows through the electromagnet to complete the circuit to negative side

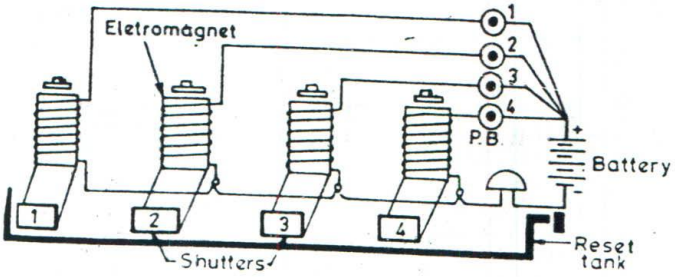


Fig. 23.74

of battery. The electromagnet is thus magnetised and attracts the armature towards it releasing the shutter which falls down on reset rack due to gravity. The number engraved on the face of the shutter come on the front side so that the person can see which number has drawn his attention. To invite more attention, the bell is also placed in series which rings as and when push is pressed. The shutter is shifted to its original position with the help of re-set rack.

The basic principal of almost all indicators is the same. The push buttons and electromagnets may be increased or decreased to any number.

(b) Needle or Arrow drop indicators. The whole mechanism except bell is enclosed in a wooden or backlite case. The bell should be placed as close to the remaining portion of the indicator as possible because, bell will attract the attention by audible sound and needle is to be seen for indication of room number etc. The indicator consists of a hand, or arrow, which is rigidly fastened to the front end of a shaft close to the face of the indicators. A lever is fastened to the rear end of this shaft and is normally held

in position by means of a notched armature. When the electromagnet becomes energised, the armature is attracted causing the lever to be released and to fall upon a supporting pin on the reset rack. As the arm falls, the arrow is rotated upward so that it points towards the number from where the call has come. To return the drop to its original position, the reset handle is forced up, which in turn causes the supporting pin to raise the lever and to turn the arrow downward.

(*c*) **Electric Reset Drop.** The electric reset drop has the advantage over the two types previously mentioned such that the drops may be reset individually or collectively either at the indicator at a distant point or both or it may be arranged for automatic reset. In this case, the last drop operated remains in sight until another call in sent in.

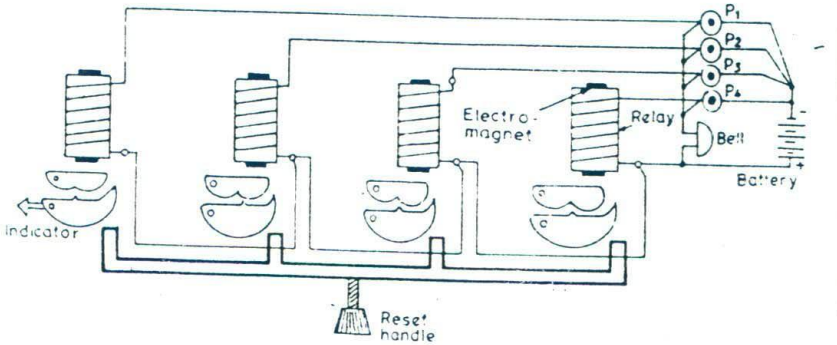


Fig. 23.75. Needle Drop Indicator.

(*d*) **Lamp Indicators.** The lamp indicator makes use of signal lamps instead of drops. When the push button may be pressed, the desired lamp may be illuminated and by pushing a reset push button at the indicator or at any convenient location the lamp may be extinguished.

EXAMPLES ON INDICATOR WIRING

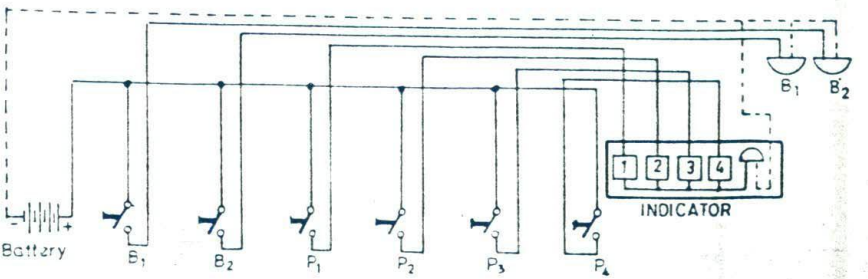


Fig. 23.76

Indicator and Bell system combined. As shown above, there are two push buttons for two electric bells apart from indicator push buttons. The electric bells may be placed somewhere else and the indicator at the room from where calls are to be attended.

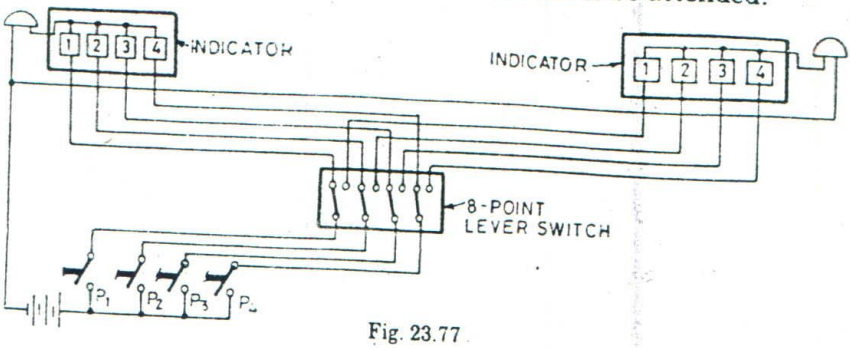


Fig. 23.77

Controlling either of the two indicators with a lever switch. As above, one or the other indicator can be thrown into service. An eight point lever switch is used. Any one of the push buttons when placed on a closed circuit will operate a correspondingly numbered drop in that indicator. If the lever switch is operated, and the same push button is pressed, the other indicator will be affected.

Return call indicator system. As shown above, the indicator and lower set of push buttons *i.e.* P_5, P_6, P_7 and P_8 are installed at a central point. The other four push buttons and four bells constituting four sets of one bell and one push button each are located at different places in the building. The push button at the central point may call its correspondingly numbered station in a

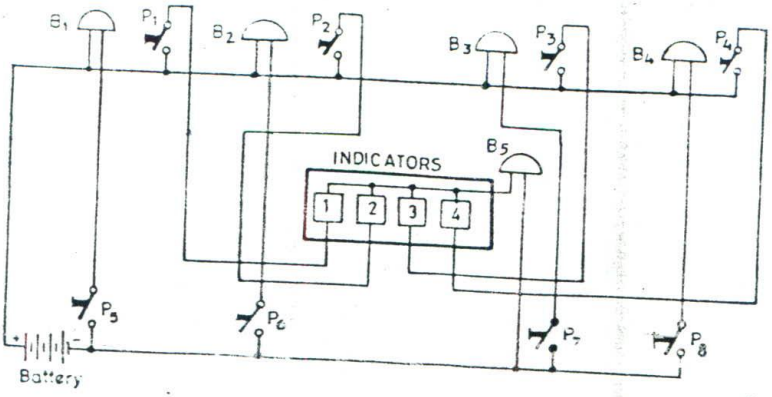


Fig. 23.78

different part of the building by pressing a push button ringing a bell which in turn presses a push button for operation of indiactor and its bell. The correspondingly numbered flag on the indicator will fall giving visual indication for having received the call.

When P_1 is pressed, the flag No. 1 on the indicator will fall and its bell B_5 will ring. In return, the message for having received the call can be conveyed by pressing P_5 for which, the bell B_1 installed near P_1 will ring. It can be used for conveying or receiving the signal. From practical point of view, the circuit is simple, easy to maintain, economical and also very useful.

The diagram (Fig. 23.79) provides answer to the problem given below. A hotel has four rooms on each of its first and second floors. For calling the room service, a bell cum indicating circuit is to be designed. A panel on each floor is to be provided with one bell and four indicating flags. A third panel is also provided on the ground floor where the room service check office is lacated. This third panel has one bell and two flags *i.e.* one flag for each floor to observe that the calls are answered.

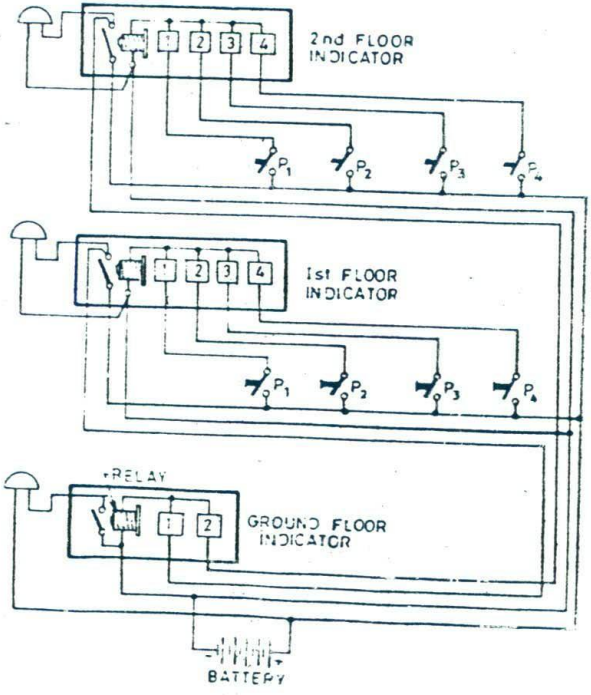


Fig. 23.79

When a call is given from any of the rooms by pressing a push button, the bell placed on the respective floor and the check office should ring simultaneously, at same time room indicating flags on the panel of the respective floor and the floor indicating panel in the check office panel should fall.

Master and Sub-Indicator System. The Fig. 23.80 above shows another type of indicator for room service for three storey building. This may be used for practically the same purpose as that in the last diagram but instead of indicating only floor number on the lower or master indicator it shows all the room numbers of the above floors on the sub-indicators. One sub-indicator of indicator installed on each floor, only the room numbers on their respective floors are registered. For example, when push button 1 is operated,

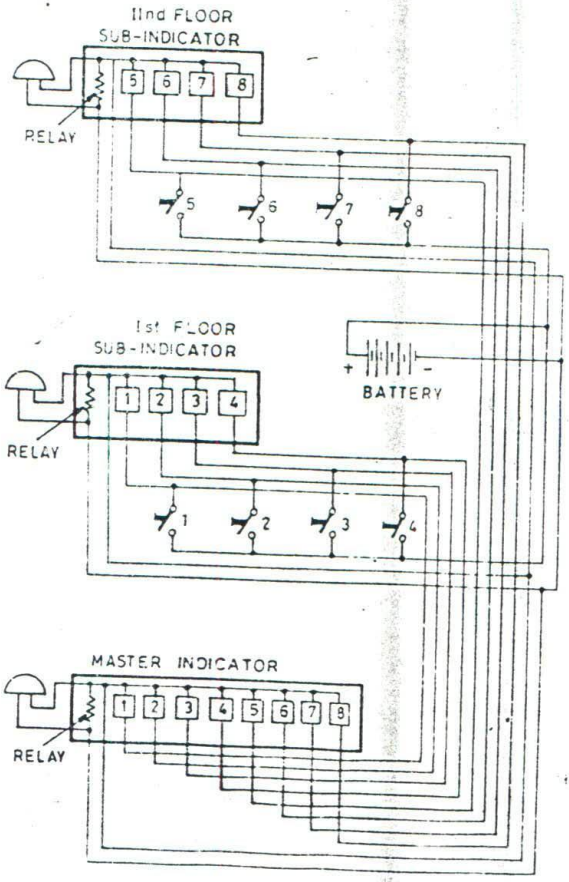


Fig. 23.80

flag 1 on the sub-indicator of the same floor operates and flag 1 on the master indicator at the central location also operates. Only one sources of supply is used to operate the system. Indicators designed for parallel operation have been used to insure proper operation. A tie or common wire is connected between all indicators.

Example. 1. *Draw the wiring diagram, schematic diagram and single line diagram of an indicator circuit which should fulfill the following conditions.*

There are five push buttons provided in five different rooms of a hospital. Indicators with five relays provided with indicating flag are installed in nurse's room. When a push button is pressed, the relay is energised and flag falls giving a visual indication that it has been operated. The nurse called upon then knows from which room the call is given. The indicating flag is reset manually by operating a knob.

Solution. As already stated, the indicators are designed primarily for service signals and they indicate calls from various rooms and points within the same building. The schematic diagram is given below and wiring diagram is also given. When any of the

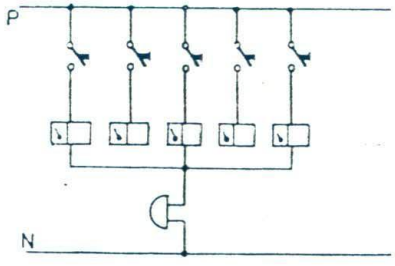


Fig. 23.81

five push button (installed in five different rooms) is pressed, a relay of that number on the indicator operates causing the release of a shutter to drop. The shutter thus dropped will show in the window of the indicator a particular number written on the drop. The bell also rings for extra attention of the person called for. A re-set knob is used to reset the dropped shutter manually after attending to the call, so as to be repeated again by that person as and when be desires.

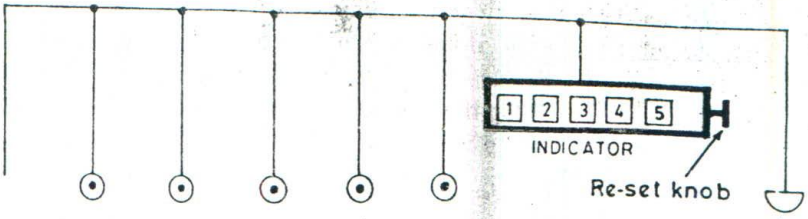


Fig. 23.82 (*a*) Wiring Diagram Indicator Circuits.

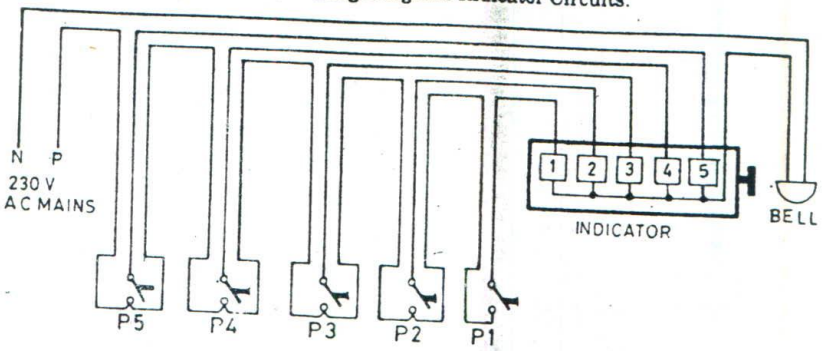


Fig. 23.82 (*b*) Single Line Representation.

Example. 2. *There are five push buttons provided in five different rooms of a hotel. The indicator having relays provided with indicating flags is installed in attendant's room. When any of the push buttons is pressed, the relay is energised and the flag falls giving a visual indication that it has been operated. The person called upon thus knows which room he has to attend. There is another push button near the indicator to reset the indicating flag automatically with the help of relay to allow the call to be repeated again. Draw the wiring diagram and schematic diagram.*

Solution. The circuit is very similar to the previous indicator circuit except the difference that the indicating reset rack is relay operated. The indicating flag is reset back by pressing a push button 'T' automatically.

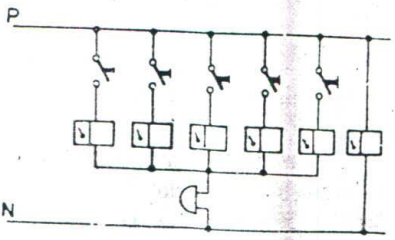


Fig. 23.83

The bell and relays are provided in series. The indicator is installed in attendant's room. As and when a push button is pressed, the relay is energised and indicating flag or shutter falls giving visual indication to the attendant. A shutter or indicating flag is reset back by pressing a push button 'T' automatically with the help of relay.

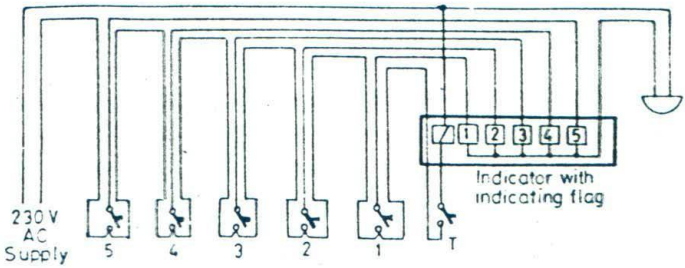


Fig. 23.84

Example. 3. *A hotel has four rooms on each of its first and second floor. For calling room service, a bell cum indicating circuit is to be designed. A panel on each floor is to be provided with one bell and four indicating flags. A third panel is also provided on the*

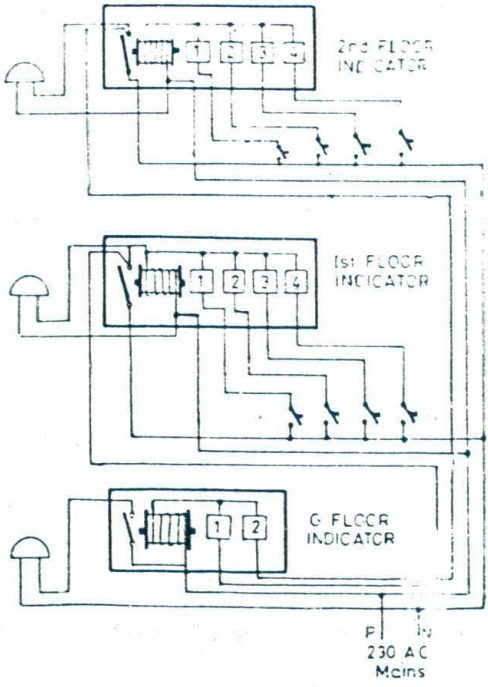


Fig. 23.85

ground floor where the room service check office is located. This third panel has one bell and two flags i.e. one flag for each floor to observe that the calls are answered.

When a call is given from any of the rooms by pressing a push button, the bell placed on the respective floors and at the check office should ring simultaneously, at the same time room indicating flags on the panel of the respective floors and the floor indicating panel in the check office panel should fall.

A push button each on the panel of first and second floors is to be provided which when pressed should reset simultaneously the room indicating flag on the floor panel and the floor indicating flag in the ground floor panel. Draw the schematic and wiring diagram of the circuit.