13

Measurement of Earth Resistance and Testing of Installations

1. Measurement of earth resistance. 2. Two point method. 3. Three point method. 4. Fall of potential method. 5. Direct measurement of earth resistance. 6. Testing of installation. 7. Insulation resistance of the complete installation to earth. 8. Testing of insulation resistance between conductors. 9. Testing of polarity of the single pole switch. 10. Testing of earth continuity path.

1. Measurement of Earth Resistance. Before the measurement of this resistance is discussed, it is necessary to know its nature. By making an earth connection of the appliance we mean its connection with the mass of earth. As explained earlier, its resistance should be low, so that the fault current through earth is high. The earth resistance comprises of the following :

(*i*) The resistance of the earth wire between the earthed point on the appliance and the earth electrode.

(*ii*) The contact resistance between earthed electrode and the soil immediately around the electrode.

(*iii*) The resistance of the earth to flow of fault current.

The resistance of the earth wire in (*i*) can be easily measured, while it has been investigated that the contact resistance as in (*ii*) is very-very low and may be neglected. We are much concerned about the resistance of earth to flow of fault current.

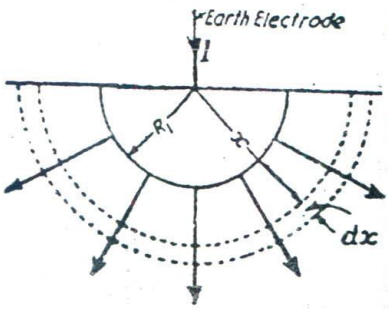


Fig. 13.1

In order to know its nature, consider an electrode shown in Fig. 13.1. Let a fault current I flow to the earthed electrode and assume that the return electrode is long away. The fault current will flow formally

in all directions from the hemisphere of radius R_1. The resistance to flow will consist of a number of hemispherical bowls in series as shown by dotted.

Consider a hemispherical bowl at radius x and let its thickness be dx.

Let ρ be the specific resistance of the soil.

The resistance of the hemispherical bowl

$$= \frac{\rho\, dx}{2\pi x^2} \qquad \ldots(13.1)$$

If the other electrode is at a radius R_2, the earth resistance,

$$R = \int_{R_1}^{R_2} \frac{\rho\, dx}{2\pi x^2} = \left(-\frac{\rho}{2\pi x} \right)_{R_1}^{R_2}$$

$$= -\frac{\rho}{2\pi}\left(\frac{1}{R_2} - \frac{1}{R_1}\right) = \frac{\rho}{2\pi}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad \ldots(13.2)$$

If $R_2 = \infty$ ...(13.3)

Then, $R_\infty = \frac{\rho}{2\pi R_1}$ ...(13.4)

It will be observed that the resistance of the body of the earth extending to infinity is given by the above simple expression. Fig. 13.2 represents a curve for earth resistance for different values of R_2.

From equations (13.2) and (13.4)

$$\frac{R}{R_\infty} = R_1\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

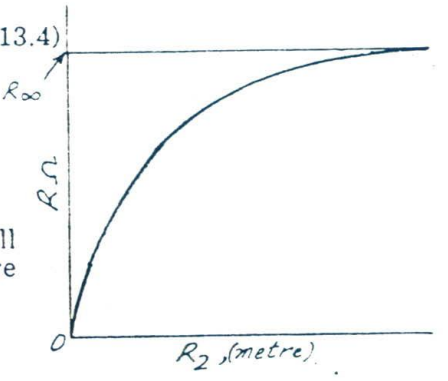
$$= 1 - \frac{R_1}{R_2}$$

From above equation, it will be observed that if R_1 is 1 metre and R_2 is 10 meter,

Then, $\frac{R}{R_\infty} = 1 - 0.1$

$$= 0.9 \qquad \ldots(13.5)$$

i.e. resistance R will be 90 per cent of the infinite resistance. The following table gives the percentage resistance for different values of R_2 :



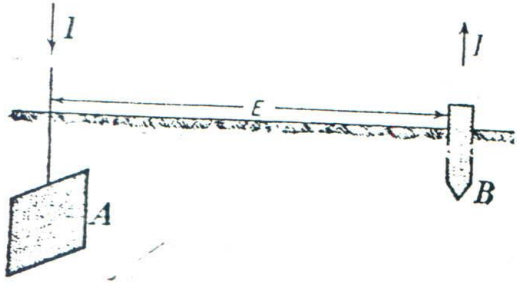
Curve of earth resistance
Fig. 13.2

Value of R_2 in metre	*Percentage resistance*
10	90
20	95
40	97.5
50	98
100	99

In practice it is quite sufficient to measure 98 per cent of the resistance. The following are the practical methods of determining the earth resistance :

(*a*) *Two point method.*
(*b*) *Three point method.*
(*c*) *The fall of potential method.*
(*d*) *Direct measurement with earth testing instruments.*

2. Two Point Method.



Earth resistance—2-point method
Fig. 13.3

This method is useful when an other electrode of known resistance or of negligible resistance is available In Fig. 13.3, A is the earth electrode whose earth resistance is required and *B* is another electrode of known resistance. For measurement a known value of the current I is allowed to flow and the potential *E* between the two electrodes is measured. Then $\frac{E}{I}$ gives the combined, resistance of the two electrodes *A* and *B*.

Thus the resistance of electrode *A*

= Measured Resistance (Resistance of electrode *B* ...(13.6)

If resistance of electrode B is negligible then Eqn. (13.6) can be rewritten as,

Resistance of electrode *A* = Measured Resistance ...(13.7)

The following precautions should be observed for this test :

(1) In order to reduce the polarization effect, only alternating current should be used.

(2) The distance between the two electrodes should be sufficiently large in order that the resistance area of each be reasonably independent.

It may also be noted that the stray direct or alternating currents already flowing in the earth will affect the result.

Generally this method is not used.

3. Three-point Method.

In this method two auxiliary electrodes B and C are used and it is not necessary that their resistance be known. Three electrodes are placed at the corner of a triangle. The resistance between each pair of electrodes is measured. R_1 is the resistance of electrodes A and B, R_2 is that of electrodes B and C, while R_3 that of electrodes A and C.

Then resistance R of electrode A is given as

$$\frac{R_1 + R_3 - R_2}{2} \qquad \ldots(13.8)$$

Again in this method it is necessary that :

(*i*) Alternating current should be used.

(*ii*) The distance between electrode should be sufficiently large so that their resistance areas be quite independent.

(*iii*) The resistance of three electrodes must be of the same order otherwise absurd results may occur.

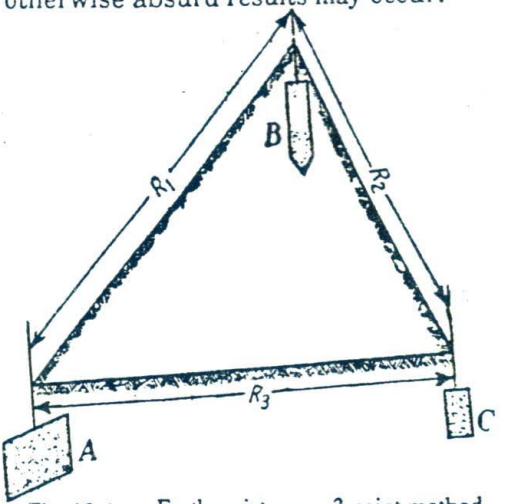
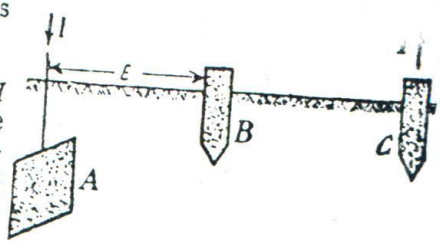


Fig. 13.4 Earth resistance—3-point method

4. Fall of Potential Method.

In this method again the two auxiliary electrodes are used, which are not placed at the corners of a triangle as in a 3-point

method but in a straight line as shown in Fig. 13.5.

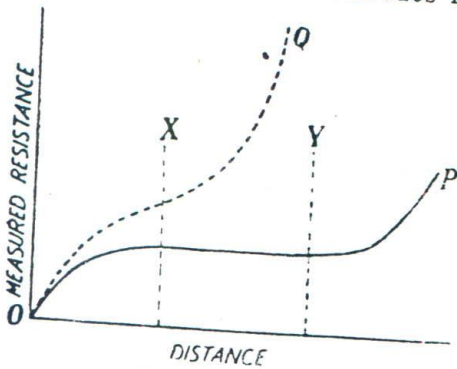


Fall of potential method
Fig. 13.5

An alternating current of I amperes is passed through the electrode A and C and the potential between electrodes A and B is measured. Then the resistance R of electrode A is given as :

$$R = \frac{E}{I} \qquad \ldots(13.9)$$

The resistance of electrodes B and C does not influence the result. The electrodes C must be placed at a sufficient distance from A, so that the resistance area of A and C are quite independent. In order to know whether the electrode C has been so placed or not, the electrode C is placed at any distance and the earth resistance is measured by placing electrode B at different points between A and C and a curve of resistance along Y-axis is obtained as shown in Fig. 13.6. If the curve similar to that of curve Q is obtained, it shows that the areas of electrodes A and C are not independent, and if the areas are independent a curve similar to P will be obtained and the earth resistance can be determined by placing electrode E anywhere between vertical lines X and Y *i.e.*, for horizontal position.



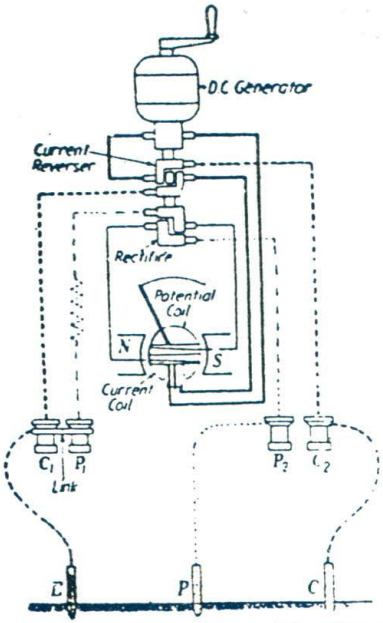
Earth resistance
Fig. 13.6

5. Direct Measurement of Earth Resistance. The Megger Earth Tester works on the fall of potential method explained earlier. It also requires temporary current and potential electrodes. The instrument is so designed that the readings are not affected either by stray alternating or direct current nor by electrolytic back of e.m.f., and it gives resistance directly without calculations.

The Megger Earth Tester is essentially a direct reading ohmmeter and a hand driven generator which supplies the testing current. The ohmmeter consists of two coils (current coil and potential coil) mounted at a fixed angle to each other on a common axle. The current coil carries current proportional to the current

flowing in the test circuit, while the potential coil carries current proportional to the potential across the resistance under test. Thus the potential coil acts as a voltmeter in the fall of potential method while current coil acts as an ammeter in that experiment. Since the deflection of the needle is proportional to the ratio of the current in the two coils, it gives resistance directly.

The hand operated generator produces the direct current, but to eliminate the effect of electrolytic e.m.f. as said earlier, it is necessary to pass alternating current through the coil, so to change the D.C. into an alternating supply, a rotary current reverser is mounted on the same shaft of the generator. The alternating current in the coil will produce an alternating drop in the coil but potential to be applied across the moving coil must be direct because the ohmmeter is a moving coil instrument working on D.C. alone, so for changing the alternating drop into the direct drop, a synchronous rotary rectifier is also attached as shown in Fig. 13.7. Although the instrument is immune to stray currents, yet while taking readings, sometimes it will be observed that the needle vibrates; this happens only at the instant when the stray alternating current has the same frequency as the frequency generated. For such occasions either increase the speed of the generator a little or lower its speed.



Megger Tester Circuit containing direct current shown by full lines. Circuit containing A.C. current shown by dotted lines.
Fig. 13.7

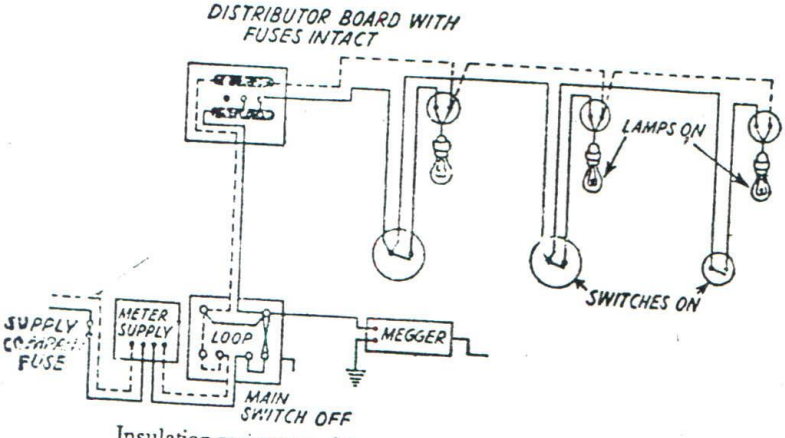
Method of Use. For measurement of earth resistance, two spikes acting as current and potential electrodes are driven into the ground at a distance of 25 m and 12.5 m from earth electrode under test and are connected to terminals C_2 and P_2 respectively. P_1 and C_1 terminals of the meter are shorted and are connected to the earth electrode under test.

The megger is placed on a horizontal firm stand free from the surrounding magnetic field. The range switch is set at the required

position. The handle is then turned at a slightly higher than the rated speed and the reading of the needle deflection is noted. Two or three readings are taken by placing the electrodes (spikes) at other positions keeping the distance same as for the first reading. The average of these readings is the earth resistance.

6. Testing of Installations. According to Indian Electricity Rules No. 47 of 1956, before completing an installation or an addition to an existing installation is put into service, the following tests shall be complied with :

7. Insulation resistance of the complete installation to earth. The aim of this test is to know whether the wires used in the system are quite sound to avoid current leakage. The voltage used for insulation resistance tests must be a D. C. voltage not less than twice that to which the circuit will normally be subjected, but not necessarily exceeding 500 V. A 500 V testing set, the "Megger", may conveniently be used.



Insulation resistance of the complete installation to earth should be taken with all lamps in on position.

Fig. 13.8

Before making an insulation resistance test of the complete installation, all fuse links are provided, all lamps are put in position, all switches are made on. The live wire and the neutral wire are shorted as shown and connected to the line terminal of the megger and earth terminal of megger is connected to either earth continuity conductor or directly to the earth electrode as shown is Fig. 13.8. The measured resistance for *satisfactory wiring must not be less than*

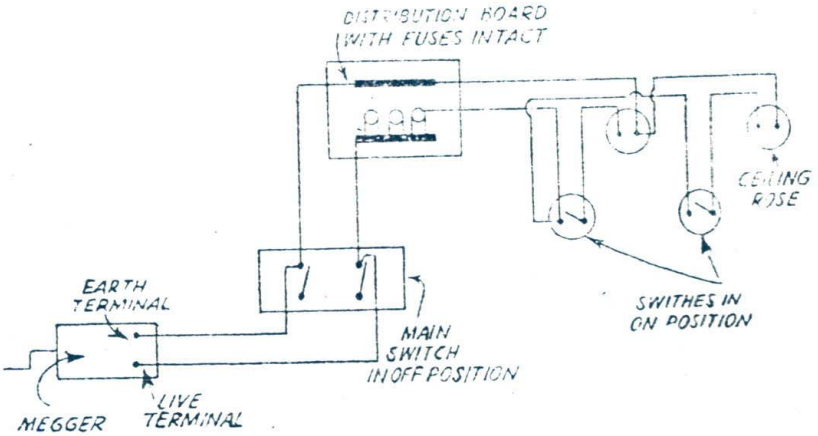
$$\frac{\text{50 megohms}}{\text{number or outlets (points + switches)}}$$

It is desirable that for complete installation, the value of resistance measured should not be more than 1 megohm.

The value of 50 can, however, be further-reduced to $12\frac{1}{2}$ for installations using P.V.C. Insulated cables.

The control rheostats, heating and power appliances, and electric signs, may, if desired, be disconnected from the above test, in which case the insulation resistance between the case or the frame-work and all live parts of each appliance shall not be less than that specified in the appropriate Indian Standard, or where there is no such standard, it should not be less than $\frac{1}{2}$ megohm.

8. Testing of Insulation Resistance between Conductors. For this test use the circuit of Fig. 13.9 which shows that all switches are made on while all the lamps are removed from holders, *i.e.* for such an insulation test, the positive conductor of the circuit is connected to live and the negative conductor is connected to earth terminals respectively as shown in Fig. 13.9.



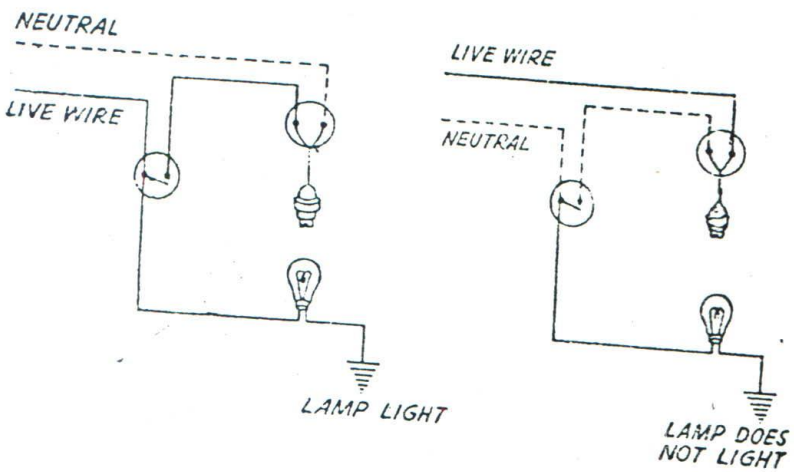
Testing of insulation resistance between conductor
Fig. 13.9

The insulation resistance between the two conductors thus measured with megger should not be less than 50 megohms divided by the number of outlets (points + switch), but need not be more than 1 megohm. If P.V.C. Wires are used the value should be $12\frac{1}{2}$ divided by the number of outlets.

9. Testing of polarity of the single pole switches. As has

already been explained, the switch should always be placed only in the positive side or live wire only to make the lamp holder quite dead when the switch is made off, otherwise if the holder is connected in the live directly, the mechanic is liable to get a shock.

For testing that all the swatches are correctly connected, the lamps removed from the holders and the test is made with a test lamp, the one end of which is earthed, and the other end of the test lamp is connected through a lead to switch ; if the lamp lights, the switch is correctly inserted and if the lamp does not light it means that the switch has not been correctly inserted.



Polarity test
Fig. 13.10

10. Testing of Earth Continuity Path. If the insulation of any of the wires breaks down, the leakage current will start and if the wiring is in metallic conduits they will start giving shock until and unless they are earthed properly. There is a possibility of the conduit joints to be separated or become loose which results in an introduction of high resistance in the earth path. For the earth continuity test, the resistance of the conduit at the extreme end is measured from the earthing electrode with the help of method already explained in article 5. In accordance with I.S. specification 732-1963, the total resistance of the conduit from the earthing point to any other position should not be more than 1 ohm.

TYPICAL QUESTIONS

1. Why is it necessary to measure the earth resistance ? Explain any method for measuring the same.
2. Explain the method of measuring earth resistance with a megger.
3. What are the various tests required to be performed on any installation.
4. How would you test the insulation resistance between conductors and insulation resistance to earth.
5. What is the permissible limit for :
   (*a*) Earth resistance.
   (*b*) Insulation resistance between conductors.
   (*c*) Insulation resistance of installation with earth.

14

Estimating and Conductor Size Calculations For Internal Wiring, H.T. & L. T. Overhead Lines and Underground Cables

1. Estimating. 2. Price Catalogue. 3. Schedule of labour rates. 4. Schedule of rates and estimating data. 5. Determination of conductor size. 6. Current carrying capacity. 7. Voltage drop. 8. Minimum permissible size. 9. Conductor size calculation for internal domestic wiring. 10. Conductor size calculation for underground cable. 11. Conductor size calculation for overhead lines with A.C.S.R.

1. Estimating. Estimating means to determine the quantities of various items required to execute a job and to assess the cost of the execution. The estimator keeping in view the requirements arrived at during initial planning, chalk out a list of items and quantities. The cost is determined by him by consulting the price catalogue and schedule of labour rates. The various steps to form an estimate are :

(*i*) Chalk out a list of items and quantities required.

(*ii*) Consult the rate catalogues for pricing the various items.

(*iii*) Assess the exact number of workmen required to complete the job and after consulting the schedule of labour rates add the labour cost to the estimate under preparation. It should be noted that number of workmen required is dependent upon the time limit fixed to complete the service.

(*iv*) Add supervision charges and executor's profit.

(*v*) In case of Govt. organisation, where the work is to be executed by the contractor, the tenders are floated only after correctly specifying the description of each item, to avoid any misunderstanding while execution.

2. Price Catalogue. It is in the form of a booklet in which rates of various terms are indicated. The price catalogue is required

to be amended as and when there is variation in the market. A specimen of price catalogue is given in Appendix A at the end of this book.

3. Schedule of labour rates. It is also in the form of booklet indicating the labour rates and is given in Appendix B at the end of the book. Sometime lump sum labour *charge as 20% of material cost are added. This is usually done in case of big works costing over one lakh.*

4. Schedule of Rates and Estimating Data. Almost all the Govt. departments have published schedule of rates or estimating data to facilitate the process of estimating. In these schedules or data, the estimated cost including labour charges for per metre run of wiring overhead lines etc. with various sizes of wire, aluminium conductor, pole etc. are given. With the help of such a document, only overhead charges *viz.* supervision, departmental charges etc. are required to be added after working the cost of the any services.

5. Determination of Conductor Size. Before making an estimate it is necessary to find out the size of wire, cable or aluminium conductor. The following essential points are to be considered while calculating the size :

(*a*) Current carrying capacity.

(*b*) Voltage drop.

(*c*) Minimum permissible size.

These have been discussed separately in the following articles.

6. Current Carrying Capacity. As has been discussed earlier that in any circuit the value of the current will be more as compared to sub-circuits. In sub-circuits as the load decreases, the current is also reduced. Thus it is very necessary to divide the services into groups in accordance with the amount of current which will flow through them. Afterwards, size of wire in each group is determined.

7. Voltage drop. As is known to the readers that the voltage drop is there as when the current flows through the wiring and the same should be as low as permissible and economical. The voltage drop can be determined by Ohm's low. As the resistance is inversely proportional to area, so the voltage drop will be less if the area of wire is more.

8. Minimum Permissible Size. Due to mechanical reason, the minimum permissible size of wires U/G cables and conductors should be as follows :

(*a*) *Wire.* The area of aluminium wire should not be less than 1.5 sq. mm and its single strand should not be less than 1.40 mm diameter.

(*b*) *U/G Cable.* The area of conductor for two core cable should not be less than 6 sq. mm and for three and four cores, it should not be less than 25 sq. mm. The area of conductor for three and half cores cable should be 50 sq. mm or more.

A. C. S. R. The size of A.C. S. R. should not be less than 6/.083 inch or 6/1 × .211 mm having total area of cross-section as 20.71 sq. mm.

9. Conductor Size Calculation for Internal Domestic Wiring. The important point to be considered is the current carrying capacity, the voltage drop is usually of very small magnitude and will not have much effect for small domestic wiring. For multistoreyed buildings, factories and industries, the voltage drop is required to be ascertained. If the voltage drop is much, the house-hold appliance and motors will not work.

It should be noted that the maximum voltage drop should not be more than as given below :

(*a*) *Lighting Circuit.* In any circuit :

(*i*) at 200 volt supply, voltage drop should not be more than 5V;

(*ii*) at 210 volts supply voltage drop should not be more than 5.1 volts ;

(*iii*) at 220 volts supply, voltage drop should not be more than 5.4 volts ;

(*iv*) at 230 volts supply, voltage drop should not be more than 5.6 volts ;

(*v*) at 240 volts supply, voltage drop should not be more than 5.8 volts ;

(*vi*) at 250 volts supply, voltage drop should not be more than 6.0 volts.

From the above it will be seen that the permissible voltage drop in a lighting into circuit is 2% of the supply voltage plus one volt.

(*b*) *Industrial loads.* The maximum voltage drop at the extreme end equipment or motor should not be more than 5% of the declared supply voltage.

In tables 14.1, 14.2, and 14.3 various sizes of wires, current rating and voltage drop if loaded fully are given. Considering the

load in amperes and voltage drop, suitable size of wire with required insulation is selected. In a similar fashion flexible cord is selected from table 14.4. It should be noted that the sum of the voltage drop in the wiring and flexible cord should be within permissible limit as given above.

Table 14.1

Current ratings and voltage drop for vulcanised rubber PVC or polythene insulated or tough Rubber PVC lead sheathed single core aluminium wires or cables

Size of Conductor		*2 Cables d.c. or Single-phase a.c.*		*3 or 4 cables of balanced 3-phase*		*4 Cables d.c.*	
Normal area sq. mm.	*Number and diameter of wire in mm.*	*Current rating in amperes*	*Approx. length of run for volt-drop in metres*	*Current rating in amperes*	*Approxi. length of run for 1 volt drop in metres*	*Current rating in amperes*	*Approx. length of run for 1 volt drop in metres*
1.5	1/1.40	10	2.3	9	2.9	9	2.5
2.5	1/1.80	15	2.5	12	3.6	11	3.4
4.0	1/2.24	20	2.9	17	3.9	15	4.1
6.0	1/2.80	27	3.4	24	4.3	21	4.3
10.0	1/3.55	34	4.3	31	5.4	27	5.4
16.0	7/1.70	43	5.4	38	7.0	35	6.8
25.0	7/2.24	59	6.8	54	8.5	48	8.5
35.0	7/2.50	69	7.2	62	9.3	55	9.0
50.0	7/3.0] 19/1.80]	91	7.9	82	10.1	69	10.0

Table 14.2

Current ratings and voltage drop for vulcanised rubber, P. V. C. or polythene insulated or tough rubber, PVC lead sheathed twin, three or four cores aluminium wires or cables.

Size of conductor		*One twin core cable D. C. or single phase A. C.*			*One 3 core or 4-core cable balanced three phase*	
Nominal areas in sq. mm	*Number and diameter of wires in mm.*	*Current rating in Amperes*	*Approx. length of run of 1 volt drop*		*Current rating in Amperes*	*App. length of run for one volt drop in metres*
			D. C. metres	*A. C. metres*		
1.5	1/1.40	10	2.3	2.3	7	3.7
2.5	1/1.80	15	2.5	2.5	11	3.9

(Contd.)

Size of conductor		One twin core cable D. C. or single phase A. C.			One 3 core or 4-core cable balanced three phase	
Nominal areas in sq. mm	Number and diameter of wires in mm.	Current rating in Amperes	Approx. length of run of 1 volt drop		Current rating in Amperes	App. length of run for one volt drop in metres
			D. C. metres	A. C. metres		
4.0	1/2.24	20	2.9	2.9	14	4.8
6.0	1/2.80	27	3.4	3.4	19	5.5
10.0	1/3.55	34	4.2	4.2	24	6.8
6.0	1/1.70	43	5.3	5.3	30	8.7
25.0	7/2.24	59	6.6	6.6	42	10.8
35.0	7/2.50	69	7.1	7.1	48	11.7
50.0	7/3.00] 19/1.80]	91	7.7	7.7	62	13.1
70.0	19/2.24	118	9.0	8.8	82	14.7
95.0	19/2.50	135	9.8	9.5	94	15.7
120.0	37/2.06	162	10.8	10.3	114	16.8

Table 14.3

Wattage loading at unity p.f. on small P.V.C. aluminium conductor two single core wires or one twin core wire.

Size of conductor		Wattage loading on circuit voltage			Current rating	Approx. voltage drop per 100 metres run with current as indicated
Nominal area	Number and diameter	200 V	230 V	250 V		
sq. mm	mm.	Watts	Watts	Watts	Amperes	Volts
1.5	1/1.40	2,000	2,300	2,500	10	4.11
2.5	1/1.80	3,000	3,450	3,750	15	3.73
4.0	1/2.24	4,000	4,600	5,000	20	3.24
6.0	1/2.80	5,400	6,210	6,750	27	2.77
10	1/3.55	6,800	7,820	8,500	34	2.17
16	7/1.70	8,600	9,860	10,750	43	1.74

(Contd.)

Size of conductor		Wattage loading on circuit voltage			Current rating	Approx. voltage drop per 100 metres run with current as indicated
Nominal area	Number and diameter	200 V	230 V	250 V		
sq. mm	mm.	Watts	Watts	Watts	Amperes	Volts
25	7/2.24	10,800	13,570	14,750	59	1.38
35	7/2.50	13,800	15,870	17,250	69	1.29
80	7/3.00 19/1.80	18,200	20,930	22,750	91	1.21

Table 14.4

Current ratings, voltage drop and mechanical strength of flexible cord of copper conductor.

Number and diameter	Approx. overall diameter	Maximum allowable resistance at 20°C for tinned wires	Current rating twin or three or four core cord	Approx. Voltage drop per 10 metre run	Max. permissible weight supported by twin flexible cord
mm.	mm.	ohm/km	Amps	Volts	kg.
14/.193	0.86	45.95	3	4	1.4
16/.200	0.95	37.46	4	3.3	1.5
23/.193	1.17	27.97	6	3.6	2.3
24/.200	1.24	24.97	7	3.7	2.5
32/.200	1.31	18.73	11	4.5	4.5
40/.193	1.45	16.08	13	4.6	4.5
48/.200	1.64	12.49	15	4.0	4.5
70/.193	1.93	9.91	18	3.6	4.5
80/.200	2.08	7.49	20	3.2	4.5
116/.193	3.34	5.85	24	3.0	4.5
128/.200	2.64	4.72	29	3.0	4.5
162/.200	3.05	3.97	31	2.6	4.5

Example 1. *The main circuit wire in a house is required to carry a current of 45 amperes when connected to single phase a.c. supply. Determine the size of the wire if the length of the circuit is 40 metres.*

Solution.

Assuming the declared voltage as 230 V, permissible voltage

$$\text{drop} = \frac{2 \times 230}{100} + 1 = 5.6\text{V}$$

Referring to Table 14.1 if the size of conductor selected is 25.0 sq. mm which can carry 59 amperes, the voltage drop at 59 amperes rating will be

Voltage drop at 59 amps current rating

$$= \frac{40}{6.8}\text{ V}$$

$\therefore$ Voltage drop at 45 amps

$$= \frac{40}{6.8} \times \frac{45}{59.}$$

$$= 4.486\text{ V}$$

which is within permissible limit.

Thus the wire having size as 25 sq. mm (7/2.24) is suitable.

Example 2. *A room is to be wired for single phase a.c. supply directly taken from mains which has declared voltage of 200 volts. The length of the wire from the main switch to light and plug points is 30 metres. If the wire is to carry 5 amps. determine the size of conductor.*

Solution.

$$\text{Permissible voltage drop} = \frac{200 \times 2}{100} + 1 = 5 \text{ volts}$$

Referring to Table 14.1 minimum size of wire 1.5 sq. mm (1/1.40) should be in a position to carry 5 amps safely.

Now it will be seen that there will be a drop of 1 volt after every 2.3 metres for 10 amperes loading.

$\therefore$ Voltage drop at 10 amps

$$= \frac{30}{2.3}$$

Voltage drop at 5 amps

$$= \frac{30}{2.3} \times \frac{5}{10}$$

$$= 6.52\text{ V}$$

Hence this is not suitable.

Now considering the next higher size 2.5 sq. mm (1/1. 80) wire and consulting Table 14.1

Voltage drop at 15 amps $= \frac{30}{2.5}$

$\therefore$ Voltage drop at 15 amps $= \frac{30}{2.5} \times \frac{5}{15} = 4$ V

which is within permissible limit.

This wire having size 2.5 sq. mm (1/1.80)is suitable.

Example 3. *A three-phase 3-wire connection is to be given to a promises in which an electric motor of 50 H.P. is to be installed. 40 metres of wire run from the main switch is required for this purpose. Determine the size of the wire to be used if the available voltage is 400 volts.*

Solution. Assuming p.f. as 0.8,

Current drawn by the motor $= \frac{50 \times 746}{\sqrt{3} \times 400 \times 0.8} = 67.30$ amps.

If 3-core cable is used, then on referring Table 14.2, it will be seen from Table 14.2 that 70 sq. mm (19/2.24) PVC cable will be in z position to carry the motor current safely.

The permissible voltage drop $= \frac{400 \times 5}{100} = 20$ volts

Voltage drop at 82 Amp. $= \frac{40}{14.7}$

Voltage drop at 67.30 $= \frac{40}{14.7} \times \frac{67.30}{82} = 2.21$ V.

As the drop is within permissible limits, **hence 3-core PVC cable size 70 sq. mm (19/2.24) is suitable.**

10. Conductor size calculation for underground cable :—

While determining the size of underground cable, the following factors are to be considered.

(*i*) Current carrying capacity of the cable.

(*ii*) The voltage drop which should not be more then 12.5% and 5% for transmission and distribution system respectively. This drop should be for the complete system *i.e.* in case the transmission or distribution is done by both U/G cable and overhead lines then the maximum permissible drop at the tail end of the feeder should be less than 5%. For internal wiring, if these cables are used then the voltage drop should be as given in article 9.

Current ratings of various types of cables are given in Tables 14.5 to 14.10. In Table 14.11 the resistance of various sizes of insulated cable is given. This will assist the students to determine the voltage drop.

Tables 14.12 and 14.13 indicate the current ratings of A.C. and D.C. motors respectively.

Example 4. *Determine the size of underground cable to be laid for transmitting electrical energy at 11 KV from the substation to the distribution substation at a distance of 500 metres of capacity 300 KVA.*

Solution.

Voltage $= 11$ KV

KVA $= 300$

Current $= \dfrac{300 \times 1,000}{\sqrt{3} \times 11 \times 1,000} = 15.82$ amps.

Allowing 20% overload the current will be

$= 1.20 \times 15.82 = 18.984$ Amps.

From Table 14.7, it will be seen that 3-core P.I.L.C. 25 sq. mm underground cable is suitable for the load. Again referring to table it will be seen that the resistance of this cable is 1.102 ohms per km.

$\therefore$ Resistance of 500 metre length $= \dfrac{1.102 \times 500}{1000}$

$= 0.551$ ohm

Voltage drop $= \sqrt{3} \times I \times R$

$= \sqrt{3} \times 18.984 \times 0.551 = 18.120$ volts

which is within the permissible limits.

Hence P.I.L.C. 3 core, 25 sq. mm and underground cable is suitable.

Example. 5. *A 33 KV substation is to be connected to a 11 KV stepdown substation which is at a distance of 1.5 km by a underground cable. If the size of the transformer in the stepdown substation is 500 KVA, determine the size of the cable.*

Solution.

Voltage = 33 KV

KVA = 500

Current $= \dfrac{500 \times 1,000}{\sqrt{3} \times 33 \times 1,000} = 8.75$ Amps

Allowing 20% overload, the current will be

$= 1.20 \times 8.75 = 10.5$ Amps

Referring to Table 14.10, P.I.L.C., 3-core, 33 KV, 70 sq. mm underground cable is suitable. Again from table 14.11, it will be seen that this cable has a resistance of 0.4068 ohm per km.

∴ Resistance of 1.5 km length of cable = $1.5 \times 0.4068 = 0.6102$ ohm

Hence the voltage drop $= \sqrt{3} \times 0.6102 \times 10.5 = 11.09$ Volts

which is within the permissible limits.

Hence P.I.L.C. 3-core 33 KV, 70 sq. mm. underground cable is suitable.

Example 6. *An underground cable is to be connected to a multistoreyed building with the feeding substation at a distance of 2 km. The connected load is 500 KW at 400 volts at a diversity factor of 0.7 and p.f. as 0.8. Suggest if the building can be directly connected by a L.T. feeder from the substation.*

Solution.

Voltage = 400 V

Connected load = 500 KW.

Actual load = diversity factor × connected load

$= 0.7 \times 500 = 350$ kW

Current, $I = \dfrac{350 \times 1000}{\sqrt{3} \times 400 \times 0.8} = 631.7$

Refer to Table 14.5, it will be seen that P.I.L.C. 1100 V, single core cable of size 625 sq. mm is suitable. Now, from Table 14.11, the resistance of this cable is 0.04645 ohm for a km.

Hence, resistance of 2 km length $= 2 \times 0.04645$.

$= 0.0929$ ohm

Further, voltage drop $= \sqrt{3} \times I \times R$

$= \sqrt{3} \times 631.7 \times 0.0929 = 101.6$ volts

which is much more than the permissible limits.

Hence it is not possible to connect the system with a L.T. underground feeder due the reasons (*i*) high cost and (*ii*) excess of voltage drop. It is advisable to go for 11KV supply and a substation near the building.

Table 14.5

Current Rating as per I. S. S. 692-1965 in amperes for aluminium conductor paper insulated mass impregnated lead covered 1100 V underground cable.

Nominal area in sq. mm.	*Number and size of wires in mm*	*Current Rating for cables laid in ground*			*Current rating for cable laid in ducts*			*Current rating for cable laid in air*		
		Single core unarmoured	*Twin core*	*Three and multi core*	*Single core unarmoured*	*Twin core*	*Three and multi core*	*Single core unarmoured*	*Twin core*	*Three and multi core*
6	1/2.80	50	57	48	42	44	40	56	48	40
10	1/3.55	70	74	62	56	60	51	72	66	56
16	7/1.70	90	96	81	76	80	68	94	88	72
25	7/2.24	115	122	107	98	108	90	124	117	97
35	7/5.50	138	147	128	116	130	105	151	141	119
50	19/1.80	172	180	158	140	159	128	184	177	150
70	19/2.24	208	219	192	170	190	156	227	220	182
95	19/2.50	244	262	224	198	224	184	272	258	224
120	37/2.06	278	302	257	222	254	211	312	298	258
150	37/2.24	316	346	296	249	287	243	358	339	300
185	37/2.50	359	398	336	279	323	278	412	387	348
240	37/3.00	430	485	413	335	397	340	520	492	437
300	61/2.50	466	536	438	358	422	364	570	524	475
400	61/3.00	553	618	513	412	515	425	680	635	545
500	81/2.80	595	—	—	445	—	—	760	—	—
625	91/3.00	670	—	—	490	—	—	895	—	—

Table 14.6

Current rating in amperes as per I. S. S. 692-1965 for aluminium conductor paper insulated mass impregnated lead covered 3.3 KV. and 6.6 KV underground cables

Nominal area in sq. mm.	*Number and Size of wires in mm.*	*Current rating for cables laid in ground*		*Current rating for cables laid in ducts*		*Current rating for cables in air*	
		Single core unarmoured	*3 or more core armoured*	*Single core unarmoured*	*3 or more core armoured*	*Single core unarmoured*	*3 or more core armoured*
25	7/2.24	110	100	96	90	120	101
35	7/2.50	130	120	116	110	150	123
50	19/1.80	160	150	142	134	185	152
70	19/2.24	198	184	170	162	228	190
95	19/2.50	233	218	199	190	279	226
120	37/2.06	263	250	224	216	318	259
150	37/2.24	297	283	252	244	354	299
185	37/2.50	335	320	282	278	419	347
240	37/3.00	400	380	340	335	525	436
300	61/2.50	433	394	359	355	575	474
400	61/3.00	520	490	420	390	725	695
500	61/2.80	558	—	460	—	785	—
625	91/3.00	620	—	500	—	910	—

Table 14.7

Current rating in amperes as per I. S. S. 692-1965 for Aluminium conductor paper insulated mass impregnated lead covered 11 KV. underground cable

25	7/2.24	100	90	96	78	110	86
35	7/2.50	119	109	104	94	136	104
50	19/1.80	147	134	126	116	170	132
70	19/2.24	182	165	151	142	213	162
95	19/2.50	214	194	176	170	255	192
120	37/2.06	244	218	198	192	288	224
150	37/2.24	275	249	222	219	326	258
185	37/2.50	308	284	248	245	372	294
240	37/3.00	365	341	290	285	470	368
300	61/2.50	394	360	310	305	507	400
400	61/3.00	475	440	370	340	640	610
500	91/2.80	575	—	400	—	705	—
625	91/3.00	580	—	435	—	820	—

Table 14.8

Current rating in amperes as per I.S.S. 1554-1961 for Aluminium conductor P.V.C. 1100 volts underground cable.

Nominal area in sq. mm.	*Number and diameter of wires in mm.*	*Current rating for single core*	*Current rating for cable in ground*		*Current rating for cable in Air*	
			2 core	*3 and multicore*	*2 core*	*3 and multicore*
6	1/2.80	37	53	47	43	38
10	1/3.55	51	70	63	59	50
16	7/1.70	68	91	86	76	69
25	7/2.24	90	120	106	99	82
35	7/2.50	112	142	129	123	106
50	19/1.80	139	175	156	152	129
70	19/2.24	172	215	191	189	156
95	19/2.50	207	248	231	227	188
120	37/2.06	242	282	266	262	215
150	37/2.24	278	323	305	301	246
185	37/2.50	316	380	350	320	285
240	37/3.00	381	445	410	365	330
300	61/2.50	440	500	470	410	375
400	61/3.00	500	600	560	490	450
500	91/2.65	540	—	—	—	—

Table 14.9

Current rating in amperes as per I.S.S. 692-1965 for three core screened Aluminium conductors Lead alloy sheathed double steel tape/single wire armoured 22 KV underground cables.

Nominal area of conductor sq. mm.	*Maximum Continuous Current Rating*		
	In Ground amps.	*In Duct amps*	*In Air amps.*
25	90	80	70
35	110	100	90
50	135	120	110
70	170	155	135
95	195	175	155
120	230	210	185
150	260	235	210
185	290	260	230
240	340	305	270
300	385	345	310

Table 14.10

Current rating in amperes as per I.S.S. 692-1965 for three-core screened Aluminium conductors, Lead Alloy Sheathed, Double Steel Tape/Single wire Armoured 33 KV Underground cable

Nominal area of conductor in sq. mm.	*Maximum Continuous Current Rating*		
	In Ground amps.	*In Duct amps*	*In Air amps.*
70	150	130	125
95	170	150	140
120	200	180	165
150	240	220	200
185	265	245	215
240	320	275	255
300	360	320	290

Table 14.11

Resistance of Insulated underground cables

Nominal area in sq. mm.	*Number and nominal diameter of wires in mm*	*Maximum allowable resistance per km. at 20°C for single core cables in ohms*	*Maximum allowable resistance per km. at 20°C for twin and multi-core cables in ohms*
6	1/2.80	4.759	4.851
10	1/3.55	2.960	3.018
16	7/1.70	1.876	1.912
25	7/2.24	1.080	1.102
35	7/2.50	0.8675	0.8843
50	19/1.80	0.6176	0.6299
70	19/2.24	0.3988	0.4068
95	19/2.50	0.3201	0.3263
120	37/2.06	0.2423	0.2470
150	37/2.24	0.2049	0.2088
185	37/2.50	0.1645	0.1677
225	37/2.80	0.1311	0.1337
240	37/3.00	0.1142	0.1165
300	61/2.50	0.09979	0.1070
400	61/3.00	0.06930	0.07069
500	91/2.65	0.05960	—
625	91/3.00	0.04645	—

Table 14.12 Resistance of Solid Copper Wire - Annealed and Hard-Drawn

Gauge No.		Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
SWG	Metric	mm	mm^2	kg/km	ohm/km	ohm/km
—	.025	0.025	.0004909	.004364	36124	36197
50	—	0.025	.0005067	.004505	34026	35063
—	.030	0.030	.0007069	.006284	24392	25136
49	—	.030	.0007297	.006487	23629	24350
—	.036	.036	.0010179	.009049	16939	17473
—	.040	.040	.0012570	.011170	13720	14139
48	—	.041	.0012970	.011530	13291	13696
—	.045	.045	.0015900	.014140	10841	11172
—	.050	.050	.0019640	.017460	8781	9049
47	—	.051	.0020270	.018020	8506	8766
—	.056	.056	.0024630	.021900	7000	7213
—	.060	.060	.0028270	.025140	6098	6284
46	—	.061	.0029190	.025950	5907	6087
—	.071	.071	.0039590	.035200	4355	4487
45	—	.071	.0039730	.035310	4340	4473
—	.080	.080	.0050270	.044690	3430	3535
44	—	.081	.0051890	.046130	3323	3424
—	.090	.090	.0063620	.056560	2710	2793
43	—	.091	.0065670	.058380	2625	2706

Gauge No.		Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	.100	.100	.0078540	.069820	2195	2262
42	—	.102	.008 070	.072070	2127	2192
41	—	.112	.009810	.087210	1757.5	1811.0
—	.112	.112	.009852	.087580	1750.0	1803.0
—	.118	.118	.010940	.097260	1576.0	1623.0
40	—	.122	.011680	.103790	1476.8	1522.0
—	.125	.125	.012270	.109080	1404.9	1449.0
39	—	.132	.013700	.121800	1258.4	1297.0
—	.132	.132	.013700	.121800	1258.4	1297.0
—	.140	.140	.015390	.136850	1120.0	1154.0
—	.150	.150	.017670	.157100	975.7	1005.0
38	—	.152	.018240	.162170	945.2	973.9
—	.160	.160	.020110	.178740	857.5	883.4
—	.170	.170	.023700	.201800	759.6	782.7
37	—	.173	.023430	.208300	735.9	758.2
—	.180	.180	.025450	.227100	677.5	695.5
—	.190	.190	.026350	.252100	608.1	626.6
36	—	.193	.029270	.260200	589.1	607.0
—	.195	.195	.029870	.265500	577.3	595.0
—	.200	.200	.031420	.279300	548.8	565.5
—	.212	.212	.035300	.313800	488.4	503.0
35	—	.213	.035750	.317800	482.2	496.8
—	.224	.224	.039410	.350300	437.5	450.7
34	—	.234	.042890	.381300	402.0	414.3
—	.236	.236	.043740	.388800	394.1	406.2

Gauge No.	Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	.250	.250	.049090	.433400	351.2	362.9
33	—	.254	.05067	.4505	340.30	350.60
—	.258	.254	.05228	.4648	329.80	339.80
—	.265	.258	.05516	.4903	312.60	321.10
32	—	.265	.05910	.5252	291.70	300.80
—	.280	.274	.06158	.5474	280.00	288.50
31	—	.580	.06818	.6063	252.90	260.40
—	.300	.295	.07069	.6284	243.90	251.30
—	—	.300	.07297	.6487	236.30	243.50
—	.307	.305	.07402	.6580	232.90	340.00
30	.315	.307	.07791	.6928	221.30	227.90
—	.335	.315	.08814	.7836	195.61	201.50
29	—	.335	.09372	.8334	183.99	189.50
—	.355	.345	.09898	.8799	174.19	179.40
—	.375	.355	.11045	.9819	156.10	160.80
28	—	.375	.11099	.9865	155.34	160.10
—	.400	.376	.12566	1.1171	137.20	141.40
27	—	.400	.13628	1.2116	126.51	130.40
—	.425	.417	14186	1.2611	121.53	125.20
—	.450	.425	.15904	1.4139	108.41	111.70
26	—	.450	.16417	1.4595	105.02	108.20
—	.462	.457	.16764	1.4903	102.85	106.00

Gauge No.	Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	.475	.462	.17720	1.5753	97.29	100.20
—	.500	.475	.19635	1.7455	87.81	90.40
25	—	.500	.20270	1.8011	85.07	87.43
—	.515	.515	.20830	1.8518	82.75	85.27
—	.530	.530	.22060	1.9611	78.15	80.52
24	—	.559	.2452	2.180	70.300	72.42
—	.560	.560	.2463	2.190	70.000	72.10
—	.600	.600	.2857	2.514	60.980	62.82
23	—	.610	.2919	2.595	59.070	60.85
—	.630	.610	.3117	2.771	53.810	56.98
—	—	.635	.3167	2.816	54.440	56.08
—	.670	.670	.3526	3.135	48.900	50.36
—	.710	.710	.3959	3.520	43.550	44.85
22	—	.711	.3973	3.531	43.400	44.70
—	.730	.730	.4185	3.720	41.190	42.45
—	—	.737	.4261	3.788	40.460	41.68
—	.750	.750	.4418	3.927	39.030	40.19
—	.800	.800	.5027	4.469	34.300	35.33
21	—	.813	.5189	4.613	33.230	34.22
—	.850	.850	.5675	5.045	30.380	31.29
—	.900	.900	.6362	5.656	27.100	27.91
20	—	.914	.6517	5.838	26.260	27.04
	.925	.925	.6720	5.974	25.660	26.42
-	.950	.950	.7088	6.301	24.320	25.05

Gauge No.		Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	1.000	1.000	.7854	6.982	21.950	22.61
19	—	1.020	.8107	7.207	21.270	21.91
—	1.060	1.060	.8825	7.845	19.538	20.12
—	—	1.120	.9810	8.721	17.575	18.10
—	1.120	1.120	.9852	8.758	17.499	18.02
—	1.180	1.180	1.0940	9.726	15.765	16.23
18	—	1.220	1.1680	10.379	14.768	15.21
—	1.25	1.25	1.227	10.910	14.050	14.470
—	—	1.27	1.217	11.262	13.610	14.020
—	1.32	1.32	1.368	12.162	12.598	12.980
—	[illegible]	1.32	1.370	12.180	12.584	12.960
—	1.36	1.36	1.453	12.917	11.870	12.220
—	1.40	1.40	1.539	13.685	11.200	11.530
17	—	1.42	1.589	14.126	10.850	11.180
—	1.50	1.50	1.767	15.710	9.757	10.040
—	1.60	1.60	2.011	17.874	8.575	8.828
16	—	1.63	2.076	18.451	8.307	8.552
—	—	1.68	2.221	19.741	7.764	8.001
—	1.70	1.70	2.270	20.180	7.596	7.820
—	1.80	1.80	2.545	22.620	6.775	6.974
15		1.83	2.627	23.350	6.564	6.756
—	1.85	1.85	2.688	23.900	6.413	6.603

Gauge No.		Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	1.90	1.90	2.835	25.210	6.081	6.253
—	—	2.01	3.170	28.190	5.438	5.597
14	—	2.03	3.243	28.830	5.317	5.471
—	2.06	2.06	3.333	29.630	5.173	5.323
—	—	2.11	3.429	31.030	4.939	5.083
—	2.12	2.12	3.530	31.380	4.884	3.038
—	2.18	2.18	3.732	33.180	4.619	4.754
—	2.24	2.24	3.941	35.030	4.375	4.502
13	—	2.34	4.289	38.130	4.020	4.137
—	2.36	2.36	4.374	38.890	3.941	4.057
—	—	2.36	4.383	38.96	3.9340	4.047
—	—	2.46	4.758	42.80	3.6240	3.731
—	2.50	2.50	4.909	43.64	3.5120	3.614
—	—	2.62	5.376	47.79	3.2070	3.299
12	—	2.64	5.480	48.72	3.1460	3.237
—	2.65	2.65	5.516	49.03	3.1260	3.216
—	2.80	2.80	6.158	54.74	2.8000	2.881
—	—	2.84	6.345	56.40	2.7170	2.797
—	2.90	2.90	6.605	58.73	2.6100	2.685
11	—	2.95	6.818	60.63	2.5290	2.601
—	3.00	3.00	7.069	62.84	2.4390	2.509
—	3.15	3.15	7.791	69.28	2.2120	2.276
10	—	3.25	8.302	73.79	2.0770	2.136
—	—	3.33	8.696	77.30	1.9828	2.038

Gauge No.		Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	3.35	3.45	8.814	78.36	1.9561	2.011
—	3.45	3.45	9.348	83.10	1.8843	1.896
—	—	3.45	9.372	83.34	1.8396	1.891
—	—	3.48	9.510	84.55	1.8129	1.863
—	3.55	3.55	9.898	87.99	1.7419	1.790
—	3.65	3.65	10.460	93.02	1.6478	1.694
9	—	3.66	10.510	93.43	1.6409	1.686
—	—	3.73	10.950	97.35	1.5746	1.6190
—	3.75	3.75	11.050	98.19	1.5610	1.6060
—	—	3.86	11.710	104.07	1.4727	151.40
—	4.00	4.00	12.570	111.71	1.3720	1.4100
—	—	4.02	12.680	112.74	1.3596	1.3970
8	—	4.06	12.970	115.32	1.3291	1.3660
—	—	4.11	13.300	118.22	1.2960	1.3320
—	—	4.22	13.96	124.13	1.2348	1.2690
—	4.25	4.25	14.19	126.15	1.2153	1.2480
7	—	4.47	15.70	130.53	1.0985	1.1290
—	4.50	4.50	15.90	141.39	1.0841	1.1140
—	—	4.52	16.06	142.72	1.0739	1.1030
—	4.75	4.75	17.72	157.53	0.9729	0.9994
6	—	4.88	18.68	166.06	0.9230	.9478
—	—	4.90	18.87	167.79	0.9135	.9379
—	—	4.92	19.03	169.19	0.9060	.9305

Gauge No.		Nominal Dia	Calculated Area	Nominal Weight	Standard Resistance of Plain Annealed Wire at 20°C (68°F)	Standard Resistance of Hard-Drawn wire at 20°C (68°F)
—	5.00	5.00	19.64	174.55	0.6781	.9015
—	5.30	5.30	22.06	196.11	0.7815	.8023
5	—	5.38	22.77	202.40	0.7571	.7770
—	—	5.46	23.42	208.30	0.7361	.7555
—	5.60	5.60	24.63	219.00	0.7000	.7185
—	—	5.68	25.36	225.40	0.6799	.6979
4	—	5.89	27.27	242.40	0.6322	.6489
—	6.00	6.00	28.27	251.40	0.6098	.6257
—	6.30	6.30	31.17	277.10	0.5331	.5675
3	—	6.40	32.18	286.10	0.5388	.5495
—	6.50	6.50	33.18	295.00	0.5196	.5329
2	—	7.01	38.60	343.20	0.4467	.4579
—	7.10	7.10	39.59	352.00	0.4355	.4465
—	7.50	7.50	44.18	392.70	0.3903	.3999
1	—	7.62	45.60	405.40	0.3781	.3375
1/10	—	8.23	53.19	472.90	0.3241	.3320
2/10	—	8.34	61.36	545.50	0.2310	.2877
3/10	—	9.45	70.12	623.40	0.2459	.2516
—	9.50	9.50	70.88	630.10	0.2439	.2489
4/0	—	10.20	81.70	720.70	0.2127	.2175
5/0	—	11.00	94.56	840.70	0.1823	.1863
—	—	11.70	107.20	953.20	0.1608	.1642
6/0	—	11.80	109.10	969.80	0.1580	.1613
7/0	—	12.70	126.70	1126.00	0.1361	.1388

Table 14.13 L.T. Lines Using AAC on RCC Poles

Sl. No.	No. of wires	Height of post Mts.	Size in mm			Span in Mts.
			Phase	Neutral	Street light	
1.	5	8.23	7/1.95	7/1.96	7/1.96	45
2.	5	8.23	7/2.48	7/1.96	7/1.96	45
3.	5	8.23	7/2.78	7/2.48	7/1.96	45
4.	5	8.23	7/3.50	7/2.78	7/1.96	45
5.	4	7.32	7/2.78	7/2.48	—	60
6.	4	7.32	7/2.48	7/1.96	—	65
7.	4	7.32	7/1.96	7/1.96	—	75
8.	4	8.23	7/1.96	7/1.96	—	45
9.	4	8.23	7/2.48	7/1.96	—	45
10.	4	8.23	7/2.78	7/2.48	—	45
11.	5	8.23	7/2.11	7/2.11	7/2.11	45
12.	3	8.23	7/2.11	7/2.11	7/2.11	45
13.	5	8.23	7/2.59	7/2.11	7/2.11	45
14.	5	8.23	7/3.00	7/2.59	7/2.11	45
15.	5	8.23	7/3.66	7/3.00	7/2.11	37.5

Table 14.14

H.T. Lines with ACSR on RCC Post

Sl.No.	*Voltage KV*	*Size of ACSR Phase & Neutral mm.*	*Height of post Mts.*	*Span in Mts.*
1.	22	7/2.59	9.15	120
2.	22	7/3.35	9.15	120
3.	22	7/2.59	8.23	[illegible]
4.	22	7/3.35	8.23	[illegible]
5.	22	7/3.35	9.15	[illegible]
6.	11	7/2.59	9.15	[illegible]
7.	11	7/3.35	9.15	[illegible]
8.	11	7/2.59	9.15	75
9.	11	7/3.35	9.15	65
10.	11	7/2.59	7.32	75

Table 14.15
Regulation Constants For L.T. O.H. Lines at 50 Hz Per 100 KVA

Sl. No.	Size of conductor mm	Phase to phase voltage	Equivalent spacing in Mts.	Resistance at 40°C ohms/Km	Reactance ohm/Km	Regulation constant for p.f. of	
						0.8 lag	1.0
	A.A.C.						
1.	7/1.96	415 V	0.483	1.472	0.3396	89.5	85.5
2.	7/2.44	"	"	0.950	0.3230	55.4	55.0
3.	7/2.79	"	"	0.726	0.3140	44.6	42.0
4.	7/3.40	"	"	0.489	0.3020	33.2	28.4
	A.C.S.R.						
1.	7/2.11	433 V	0.483	1.486	0.353	74.51	79.08
2.	7/2.59	"	"	0.985	0.340	52.77	52.40
3.	7/3.00	"	"	0.734	0.335	41.93	39.05
4.	7/3.35	"	"	0.587	0.332	35.58	31.23
5.	7/3.66	"	"	0.493	0.330	31.52	26.22
	COPPER						
1.	SWG 8	415 V	0.483	1.438	0.356	85.5	89.7
2.	6	"	"	0.995	0.344	62.5	62.3
3.	4	"	"	0.684	0.333	46.6	42.7
4.	2	"	"	0.483	0.321	36.2	30.2

Table 14.16
Regulation constants for H.T. O.H. Lines using various conductors at 50 Hz per 100 KVA per KM
11 K.V. Lines

Sl. No.	Size of conductor mm		Commercial Name	Resistance at 40°C ohms/KM	Reactance ohms/KM	Power Factor		
						0.70	0.80	0.90
	A.C.S.R.							
1.	7/2.11	13 mm^2	Squirrel	1.486	0.3900	0.1090	0.1176	0.1246
2.	7/2.36	16 mm^2	Gopher	1.185	0.3865	0.0914	0.0975	0.1021
3.	7/2.59	20 mm^2	Weasel	0.985	0.3820	0.0796	0.0841	0.0871
4.	7/3.00	25 mm^2	Panther	0.734	0.3760	0.0647	0.0672	0.0682
5.	7/3.35	30 mm^2	Rabbit	0.587	0.3700	0.0558	0.0572	0.0570
6.	7/3.66	40 mm^2	Mink	0.493	0.3650	0.0499	0.0507	0.0499
	COPPER							
7.	7/1.36	10 mm^2		1.174	0.3870	0.0908	0.0968	0.1013
8.	7/1.60	14 mm^2		1.000	0.3830	0.0805	0.0851	0.0882
9.	7/1.70	16 mm^2		0.858	0.3780	0.0720	0.0755	0.0775
10.	19/1.36	30 mm^2		0.743	0.3710	0.0649	0.0675	0.0684
11.	19/1.60	40 mm^2		0.496	0.3580	0.0498	0.0506	0.0498

Table 14.17. 33 K.V. Lines

Sl.No.	Phase to phase voltage	Size of conductor in mm	Equivalent spacing in metre	Resistance at 40°C ohms/Km	Reactance ohms/Km	Regulation percentage for P.F. of 0.8 Lag.	Constant percentag for P.F. of 0.9 lag
1.	33 K.V.	7/2.36	1.371	1.185	0.4130	0.0110	0.0114
2.	„	7/2.59	„	0.985	0.4085	0.0095	0.0098
3.	„	7/3.00	„	0.734	0.4030	0.0076	0.0077
4.	„	7/3.66	„	0.493	0.3980	0.0058	0.0057

Note : Reactance of A.C.S.R. conductors at 1,000 amps/Sq. mm has been taken from alignment charge given in "Electrical Characteristics of O.H. lines, by S. Butterworth.

Table 14.18. Conductor sizes for various lines (Aluminium Conductor Steel Reinforced/All Aluminium Conductor)

Line Voltage	Conductor Size Range (Equivalent Cu. Area)
	Sq. mm
Service Lines	7.5
Lines other than Service Lines	13
Low Voltage Lines	16—130
Lines upto 33 K.V	25—160
Lines upto 66 K.V.	30—160
Lines upto 132 K.V.	80—260
Lines upto 220 K.V.	160—260

Table 14.19
66 KV Lines

Sl. No.	Size of A.C.S.R. conductors in mm (inch) (Al + Steel)	Resistance at 40°C ohms/Km	Reactance in ohms/Km** Equivalent spacing of conductors in metres		Percentage lagging Equivalent in Metres 2.439 (8)		Regulation at Power Factor spacing of conductor Meters (feet) 2.743 (9)	
					Power Factor		Power Factor	
			2.439 (8)	2.743 (9)	0.8 $\times 10^2$	0.9 $\times 10^2$	0.8 $\times 10^2$	0.9 $\times 10^2$
1.	7/3.66 (7/.144)	0.493	0.433	0.439	0.150	0.145	0.151	0.146
2	7/4.09 (7/.161)	0.395	0.428	0.435	0.132	0.125	0.133	0.125
3	6/4 .72+7/1.57	0.296	0.415	0.422	0.112	0.103	0.113	0.104
4	6/.186 + 7/.062 6/5.28 + 7/1.76 (6/.208 + 7/.0693)	0.236	0.408	0.415	0.100	0.090	0.101	0.090
5	37/2.36 (37/.093)	0.240	0.373	0.380	0.096	0.087	0.097	0.088
6	37/2.59 (37/.102)	0.199	0.367	0.374	0.087	0.079	0.088	0.079
7	37/2.79 (37/.110)	0.172	0.362	0.370	0.082	0.072	0.082	0.072
8	37/3.00 (37/.118)	0.149	0.359	0.366	0.077	0.067	0.078	0.067

** Reactance of ACSR conductors at 155 amps per sq. mm (1000 amps. per sq. inch) has been taken from Alignment chart given in "Electrical Characteristics of O.H. Lines, by S. Butterworth.

Table 14.20 . 110 K.V. LINES

Sl. No.	Size of A.C.S.R. conductors in mm (inch) (Al + Steel)	Resistance at 40°C ohms/Km	Reactance in ohms/Km** Equivalent spacing of conductors in metres		Percentage Regulation at lagging Power Factor Equivalent spacing of conductor in Meters (feet)			
			3.963 (13)	4.572 (15)	3.963 (13) Power Factor		4.572 (15) Power Factor	
					0.8 $\times 10^{-2}$	0.9 $\times 10^{-2}$	0.8 $\times 10^{-2}$	0.9 $\times 10^{-2}$
1.	6/4.72 + 7/1.57 (6/.186 + 7.062	0.296	0.444	0.453	0.042	0.038	0.042	0.038
2.	6/5.28+7/1.76 (6/.208+7/.0693	0.236	0.436	0.446	0.037	0.033	0.038	0.034
3.	37/2.36 (37/.093)	0.240	0.403	0.412	0.036	0.032	0.036	0.033
4.	37/2.59 (37/.102)	0.199	0.398	0.408	0.033	0.029	0.034	0.030
5.	37/2.79 (37/.110)	0.172	0.391	0.401	0.031	0.027	0.031	0.027
6.	37/3.00 (37.118)	0.149	0.388	0.397	0.029	0.025	0.030	0.025

** Reactance of ACSR conductors at 155 amps per sq. mm (1000 amps. per sq. inch) has been taken from Alignment chart given in "Electrical Characterisitcs of O.H. Lines, by S. Butterworth.

Table 14.21. CHARACTERS OF 400 KV OH LINE IS : 398/PART V - 1982
A.C.S.R. : Al. 54/3.533 mm + Steel 7/3.533 mm

Nominal Al, Area mm²	Sectional Area mm²	Total Area mm²	Overall dia. mm	Weight Kg/Km	Resistance. at 20°C Ohm/KM	Breaking load KN
520	528.5	597.0	31.77	2004	0.05552	161.20

Table 14.22 .Recommended Clearance of Over Head, LT, & EHT Lines

Sl. No.	Types of overhead line	Minimum clearance of conductor above ground			Vertical clearance above building if the line is passing over it	Horizontal clearance from building
		While crossing the road or a public through fare	Along a road or a public place	At other places		
		Mts.	Mts.	Mts.	Mts.	Mts.
1.	Low tension	5.8	5.5	4.6	2.5	1.25
2.	Upto 11 KV	6.1	5.8	5.2	3.66	1.25
3.	Upto 33 KV	6.1	5.8	5.2	3.66	1.83
4.	Above 33 KV	do	do	5.2 + 0.305 for every additional33 KV or part thereof	3.66 + 0.305 for every additional33 KV or part thereof	1.83 + 0.305 for every additional 33 KV or part thereof

Table 14.23

Sl. No.	Working voltage	Spacing between conductors for		Spacing between conductors and supporting structure
		Vertical formation Mts.	Horizontal formation Mts.	Mts.
1.	Low Tension	0.38	0.46	0.150
2.	6.6. KV or 11 KV	0.76	1.14	0.305
3.	33 KV	1.22	1.53	0.610
4.	66 KV	1.98	3.23	0.760
5.	110 KV	3.13	4.96	1.070
6.	Above 110 KV	3.66	4.87	1.300

Table 14.24. PANEL BOARD WIRING
Plain copper conductor PVC Insulated Unsheathed 650/1100 V Single Core

Area sq. mm	*Conductor construction*	*Conductor dia. mm*	*Max. Resistance ohm/km at 20°C*	*Insulation thickness mm*	*Nominal Cable dia. mm*	*Current rating Amps.*
0.50	16/0.2	0.94	37.10	0.6	2.2	4
0.75	24/0.2	1.20	24.70	0.6	2.5	7
1.00	32/0.2	1.34	18.50	0.6	2.6	11
1.50	48/0.2	1.64	12.70	0.6	2.9	14
2.50	80/0.2	2.08	7.60	0.7	3.5	19
4.00	56/0.3	2.61	4.71	0.8	4.3	26
6.00	85/0.3	3.50	3.073	1.0	5.6	30
10.00	140/0.2	4.60	1.866	1.0	6.7	33
16.00	101/0.45	5.90	1.150	1.2	8.4	41
25.00	168/0.45	7.60	0.6911	1.40	10.50	54
35.00	220/0.45	8.70	0.5277	1.40	11.60	66
50.00	325/0.45	10.60	0.3572	1.60	13.90	85
70.00	440/0.45	12.30	0.2639	1.60	15.50	115
95.00	485/0.50	14.70	0.2040	1.80	18.50	140
120.00	614/0.50	16.70	0.1530	2.00	20.90	160
150.00	943/0.45	18.30	0.123	2.00	22.50	189
185.00	925/0.5	20.00	0.101	2.20	24.60	240
240.00	1221/0.5	23.00	0.0763	2.20	27.60	300

Note : Cables above 4 sq.mm. are not covered by IS : 694.

Table 14.25. Flexible Cables For working Voltage 1100 V

Conductor						Insulation Nominal	Overall Diameters					
									Nominal			
Area	No. & Size of wire	Diameter	Max. Res. at 20°C ohms / km		Current DC or 1 ϕ or 3 ϕ AC	Thickness	SC unsh	SC SH	TFSH	2 Cr Rd	3 Cr Rd	4 Cr Rd
Sq. mm	mm	mm	S.C.	M.C.	Amps	mm	mm	mm	mm	mm	mm	mm
0.50	7/.3	0.94	37.10	39.0	4	0.6	2.30	4.20	4.2 × 6.5	6.50	6.85	7.45
0.75	11/.3	1.20	24.70	26.0	7	0.6	2.55	4.45	4.45 × 7.0	7.00	7.40	8.05
1.00	15/.3	1.34	18.50	19.5	11	0.6	2.70	4.60	—	7.30	7.75	8.45
1.50	22/.3	1.605	12.70	13.3	14	0.6	2.95	4.85	—	7.80	8.25	9.25
2.50	36/.3	2.10	7.60	7.98	19	0.7	3.65	5.75	—	9.40	10.00	10.95
4.00	56/.3	2.61	4.71	4.95	26	0.8	4.35	6.50	—	10.75	11.50	12.65

Table 14.26 .Three and Four Coree Heavy Duty Flexible Cables

Conductor					Insulation Thickness	Core diameter	Thickness of sheath		Overall diameter	
							3 Cr	4 Cr	3 Cr	4 Cr
Nominal Area	No. and size of wires	Diameter	Max. Res. at 20°C	Current rating						
mm²	mm	mm	ohm /km	3 ph. amps	mm	mm	mm	mm	mm	mm
6	85/.3	3.2	3.259	31	0.8	5.30	1.15	1.40	13.80	15.65
10	140/.3	4.6	1.978	42	1.0	6.60	1.40	1.40	17.10	18.80
16	226/.3	6.0	1.226	57	1.0	8.20	1.40	1.40	20.50	22.65
25	354/.3	7.6	1.7825	72	1.2	10.10	2.00	2.00	26.00	28.75

Table 14.27
Heavy Duty Flexible Cables As per IS : 694/1977

Area	Conductor			Insulation		
	No. and Size	Diameter of wire	Max. Res. at 20°C ohm / Km	DC or 1 ph. AC Amps.	Nominal Thickness	Nominal OD
6.0	85/.30	3.2	3.100	46	0.8	5.65
10.0	140/.30	4.6	1.884	64	1.0	7.15
16.0	101/.45	5.9	1.138	85	1.40	8.95
25.0	168/.45	7.6	0.6845	112	1.40	10.65
35.0	220/.45	8.7	0.5227	138	1.40	11.75
50.0	325/.45	10.6	0.3538	172	1.60	14.05
70.0	440/.45	12.3	0.2613	214	1.80	16.15
95.0	485/.50	14.7	0.1920	254	1.90	18.75
120.0	614/.50	16.7	0.1517	300	2.10	21.25
150.0	943/.45	18.3	0.1219	340	2.10	22.50
185.0	925/.50	20.0	0.1007	390	2.50	25.50
240.0	1221/.50	23.0	0.0763	460	2.50	28.50

Table 14.28. Estimated Full Load Currents For Motors

H.P.	*KW*	*Single phase Amp*	*Three phase Amp*	*Recommendd cable size sq. mm*	*Earth leatl copper SWG*
0.5	0.37	3.7	1.0	1.5—Copper	14
0.75	0.55	5.0	1.3	1.5—Copper	"
1.00	0.75	6.5	1.9	1.5—Copper	"
1.50	1.10	11.5	2.6	1.5—Copper	"
2.0	1.50	—	3.7	1.5—Copper	"
3.0	2.20	—	4.8	1.5—Copper	"
5.0	3.70	—	7.8	1.5—Copper	"
7.0	5.50	—	11.2	1.5—Copper	"
10.10	7.50	—	15.5	2.5—Copper	"
12.5	9.30	—	19.0	2.5—Copper	"
15.0	11.00	—	22.0	6 — Aluminium	"
20.0	15.00	—	29.0	10 — Aluminium	12
25.0	18.00	—	35.0	16 — Aluminium	"
30.0	22.00	—	40.0	16 — Aluminium	8
35.0	26.00	—	47.0	25 — Aluminium	"
40.0	30.00	—	53.0	25 — Aluminium	5
50.0	37.00	—	65.0	35 — Aluminium	"
60.0	45.00	—	80.0	50 — Aluminium	"
75.0	55.00	—	94.0	70 — Aluminium	"
100.0	75.00	—	127.0	95 — Aluminium	4
125.0	90.00	—	152.0	125 — Aluminium	"

In place of Aluminium Cable if proper cables are to be used, take one size lower than size recommended f or Aluminium cable. ie. for 75 H.P. 70 sq. mm. Aluminium Cable is recommended. If you desire to use Copper Cable for the 75 H.P. Motor, then use 50 sq. mm. Copper Cable.

Table 14.29

3 Core Flat Connecting Cables For Submersible Pumps Motors

(For a maxm. temp. of 70°C and Nil Humidity)

Conductor	*Insulation*		*Sheath*		*Electrical*	
Nominal Area	*Radial thickness*	*Core diameter*	*Thickness of sheath*	*Overall dimension*	*Maximum Resistance ohms/km*	*Current carrying capacity at an ambient temp. of 40°C*
Sq. mm	*mm*	*mm*	*mm*	*W mm T mm*	*at 20°C*	*amps*
1.6	1.8	3.25	1.15	12.8 × 6.0	11.500	14
2.5	0.9	3.85	1.15	14.6 × 6.4	7.254	18
4.0	1.0	4.65	1.15	17.2 × 7.4	4.583	26
6.0	1.0	5.30	1.15	18.7 × 7.9	3.073	31
10.0	1.0	6.60	1.4	23.7 × 9.9	1.866	42
16.0	1.0	8.20	1.4	28.0 × 11.4	1.178	57
25.0	1.2	10.10	2.0	35.5 × 14.7	0.752	72
35.0	1.2	11.50	2.0	39.5 × 16.2	0.528	90
50.0	1.4	13.60	2.2	45.5 × 18.3	0.367	115
70.0	1.4	15.30	2.2	51.0 × 20.0	0.259	143

Table 14.30

PVC Insulated Winding Wires For Submersible Pump Motors

Size Conductor Diameter / Maxi OD mm	Conductor Resistance Maximum / ohms / km	Approximate Motor HP range *
0.6/1.2	62.817	2—3.5 H.P
0.6/1.4	62.817	
0.7/1.5	46.149	
0.8/1.6	35.333	4—5 HP
0.9/1.6	27.917	
0.9/1.7	27.917	
1.0/1.75	22.610	5—10 H.P
1.0/1.8	22.610	
1.1/1.9	18.687	
1.2/2.2	15.701	
1.3/2.2	13.382	
1.3/2.3	13.382	10—20 H.P
1.4/2.4	11.539	
1.5/2.5	10.050	
1.5/2.8	10.050	
1.6/2.6	8.830	20—30 H.P
1.7/2.7	7.823	
1.7/2.8	7.823	
1.8/2.8	6.978	
1.9/2.9	6.264	20—35 HP
2.0/3.14	5.652	
2.1/3.3	5.126	
2.2/3.4	4.672	
2.26/3.6	4.470	
2.3/3.5	4.274	35—75 HP
2.4/3.7	3.005	
2.5/3.5	3.617	
2.5/3.3	3.617	
2.6/3.9	3.345	
2.7/4.0	3.101	
2.8/3.8	2.884	
2.8/4.1	2.884	
3.0/4.6	2.512	
3.3/5.0	2.076	above 75 HP
3.5/5.2	1.846	
3.8/5.5	1.566	
4.0/5.9	1.4/13	
4.6/6.7	1.069	

Note : * This is only a general guideline. Final selection depends on individual design of motor. FINOLEX also manufactures multistranded winding wires for higher HP submersible motors. Details available on request.

Table 14.31

Recommended Size of Earth Lead and Electrodes

Type of loads and instaliation	Size of the earth lead			Size of the earth electrode		
	Copper S.W.G.	Area in sq. mm.	G.T. Wire S.W.G.	Area in sq. mm.	Copper in Mts.	G.I.
Cunsumers residential premises	8	12.97	8	12.97	0.6 × 0.6 (3.18 mm thick)	0.6 × 0.6 (6.35 mm thick)
Pole earthing of transmission or distribution lines	—do—	—do—	—do—	—do—	—do—	—do—
Industrial Loads :						
upto 10 HP	—do—	—do—	—do —	—do—	—do—	—do—
Between 10 to 15 HP	—do—	—do—	6	18.68	—do—	—do—
Between 15 to 30 HP	6	18.68	2	38.60		—do—
Between 30 to 50 HP	4	27.27		Not used	0.9 × 0.9 (6.35 mm thick)	Not used
Between 50 to 100 HP	2	38.60		Not used	—do—	Not used
	Copper strip	12.7 × 2.54 mm				
Above 100 HP	Copper strip	25.4 × 2.54 mm		Not used	—do—	Not used
Power Houses and Sub-Stations	—do—	—do—		Not used	—do—	Not used

Table 14.32 Working Temperature of Commonly Used Elastomeric and Thrmoplastic Cable Insulating and Sheathing Materials

MATERIAL	*Temp. °C*	
	Max.	*Min.*
Natural Rubber	60	−55
—do—		
(Heat Resisting Grade	75	−55
Synthetic (Styrene Butadine Rubber)	60	−55
—Do—		
(Heat Resisting Grade)	90	−55
Polychloroprene (P. C. P.)	70	−30
NBR/PVC (Nitrite Butadine)		
Rubber) PVC	80	−20
Oil based Rubber	70	−55
PVC (General purpose)	70	−20
PVC (Hard grade)	70	−20
PVC (Low Temp.)	70	−40
Polyethylene (Weather Rsistant)	70	−60

MATERIAL	*Temp. °C*	
	Max.	*Min.*
Polyethylene (high density)	80	−10
Polypropylene	80	−10
PVC (Heat Resisting)	85	−10
Butyl Rubber	85	−55
Hypalon (CSP)		
Chlorosulphenated Polynethylene)	90	−35
Butyl (CSP)	85/90	−35
Ethylene Propylene (EP)	90	−60
Rubber (EPR)	90	−35
Cross Linked Polyethylene (XLPE)	90	−60
Nylon	100	−40
Silicone Rubber	150	−55
F.E.P. (Fluoronated Ethylene Propylene)	200	−50
P.T.F.E,. (Poly terafluoroethylene)	250	−59

Table 14.33. Characteristics of Conductor Materials

	Annealed copper	Hard-drawn copper	Cadmium copper	Aluminium hard-drawn	Steel galvanized
Conductivity, per cent ...	100	97 (average)	79.2 (minimum)	61 ** (minimum)	—
Volume resistivity at 20°C ohm-mm²/m ...	.017241* (standard)	.01771* (average)	.021769 (maximum)	.028264 (maximum)	—
Mass resistivity at 20°C ohm-mm² ...	.15328	.15741	.19472	.076398	—
Resistance at 20°C ohm-mm²/km ...	17.241	17.71	21.769	28.264	—
Density at 20°C gramme/cm² ...	8.89	8.89	8.945	2.703	7.78
Weight kg/mm²/km ...	8.89	8.89	8.945	2.703	7.84
Temperature coefficient of Res. at 20°C/°C ...	.00393	.00381	.0031	.00403	—
Coefficint of linear expan. at 20°C/°C ...	17×10^{-6}	17×10^{-6}	17×10^{-6}	23×10^{-6}	11.5×10^{-6}
Tensile stress kg/mm² ...	25.3	42.2	63.3	16.5	13.6
Modulus of elasticity kg/mm² × 10^3 ...	9 to 10.5	12.66	12.66	6.96	19.7

* For calculations, this value has been extended to .017241379
* Assumed average ultimate tensile strength : 27 Tons/inch²
* For conductors for covered cables, this is the assumed standard value

Table 14.34
Sizes of Fuse Elements Composed of Tinned Copper Wire or Standard Alloy* Wire for Use in Semi-Enclosed Fuses

Current rating of fuse amps	*Tinned Copper Diameter* mm	S.W.G.	*Standard Alloy Diameter* mm	*Wire* S.W.G.
1.8	—	—	0.417	27
3.0	0.152	38	0.610	23
4.3	0.193	36	—	—
5.0	0.213	35	0.813	21
8.5	0.315	30	—	—
10.0	0.345	29	—	—
15.0	0.508	25	—	—
17.0	0.559	24	—	—
20.0	0.610	23	—	—
24.0	0.711	22	—	—
29.0	0.813	21	—	—
32.0	0.914	20	—	—
38.0	1.02	19	—	—
45.0	1.22	18	—	—
55.0	1.43	17	—	—
78.0	1.83	15	—	—
102.0	2.03	14	—	—

Standard Alloy → (63% tin + 37% lead)

Table 14.35

Current Rating for A. C. Motors (Approx.)

B. H. P. of the motor	*Current Rating per phase of Induction motor allowing allowance for efficiency and p.f.*		
	Single phase 230 V	*Three phase 400 Volts*	*Three phase 440 Volts*
0.125	1.0	0.3	0.3
0.25	1.8	0.7	0.6
0.50	3.5	1.2	1.0
0.75	4.8	1.7	1.4
1.00	6.2	2.0	1.7
1.25	7.4	2.5	2.2
1.50	8.7	2.8	2.5
1.75	10.00	3.2	2.8
2.00	11.8	3.5	3.2
2.50	14.00	4.3	4.0
3.00	17.5	5.0	4.5
4.00	20.00	6.5	6.0
5.00	24.00	8.0	7.5
7.50	36.00	12.0	11.0
10.00	47.00	15.0	14.0
12.50	59.00	19.0	18.0
15.00	70.00	22.0	21.0
20.00	91.00	29.0	28.0
30.00	135.00	42.0	39.0
40.00	183.00	56.0	53.0
50.00	227.00	71.0	66.0

Table 14.36

Current Rating (full load current in amperes) for d.c. motors allowing allowance for efficiency.

Supply voltage

H. P.	*200*	*220*	*230*	*240*	*400*	*420*	*440*	*460*
1	5	5	5	4	3	3	2	2
2	10	9	8	8	5	5	4	4
3	14	13	12	12	7	7	6	6
5	23	21	20	19	12	11	10	9
7.5	33	30	29	28	17	16	15	14
10	44	40	38	36	22	21	20	19
15	64	59	56	54	32	31	29	28
20	85	77	74	71	43	41	38	36
30	125	114	109	105	63	60	57	55
40	165	150	143	137	82	78	75	72
50	206	187	179	172	103	98	93	89
75	308	280	268	257	154	147	139	134
100	408	370	354	340	204	194	185	122
125	506	460	440	422	253	241	230	144

Table 14.37

Current Rating, Resistance and Impedance of ACSR Conductor

Trade Name	*Nos. of strands and size of each strand in mm.*	*Nos. of strands, size of each strand in inches*	*Area in sq. mm.*	*Current carrying capacity*		*Resistance per km in ohms*	*Inductance per km in ohms*	*Impedance per km in ohms*
				30°C	*50°C*			
Squirrel	6/1 × 2.11	6/1 × .083	20.71	70	97	1.366	0.320	1.400
Weasel	6/1 × 2.59	6/1 × .102	31.21	100	123	0.9047	0.308	0.955
Ferret	6/1 × 3.00	6/1 × .118	41.87	125	155	0.6760	0.298	0.738
Rabbit	6/1 × 3.33	6/1 × .132	52.21	148	183	0.5404	0.291	0.614
Mink	6/1 × 3.66	6/1 × .144	62.32	167	208	0.4540	0.285	0.536
Beaver	6/1 × 3.99	6/1 × .157	74.07	189	235	0.3820	0.2795	0.484
Otter	6/1 × 4.22	6/1 × .166	82.85	207	252	0.3418	0.2752	0.437
Cat	6/1 × 4.50	6/1 × .177	94.21	229	285	0.3005	0.2725	0.406
Hare	6/1 × 4.72	6/1 × .186	103.6	254	311	0.2722	0.2695	0.383
Leopard	6/1 × 5.28	6/1 × .208	129.7	286	367	0.2157	0.2625	0.340

Table 14.38

Voltage Drop Calculations for L.T. 400 Volts, 3-phase, 4-wire overhead Aluminium Lines

Load KW	*Load in amperes assuming p.f. as 0.8*	*Voltage drop for 100 metre length of L.T. 400 volts, 3 phase, 4 wire distributors with*									
		3 of Squirrel	*3 of weasel of squirel for neutral*	*3 of Ferrot 1 of weasel for neutral*	*3 of Rabbit 1 of weasel for neutral*	*3 of Mink 1 of weasel for neutral*	*3 of beaver 1 of Ferrot for neutral*	*3 of Otter 1 of Ferret for neutral*	*3 of Cat 1 of rabbit for neutral*	*3 Hare 1 of rabbit for netural*	*3 of Leapord 1 of Beaver or Mink far neutral*
1	1.811	0.439	0.30	0.232	0.193	0.168	0.152	0.137	0.127	0.120	0.107
2	3.622	0.878	0.60	0.464	0.386	0.336	0.304	0.274	0.254	0.240	0.214
3	5.433	1.317	0.90	0.696	0.579	0.504	0.456	0.411	0.381	0.360	0.321
4	7.244	1.756	1.20	0.923	0.772	0.672	0.608	0.548	0.508	0.480	0.428
5	9.055	2.195	1.50	1.160	0.965	0.840	0.760	0.685	0.635	0.600	0.535
6	10.866	2.634	1.80	1.392	1.158	1.008	0.912	0.822	0.762	0.720	0.642
7	12.677	3.073	2.10	1.624	1.351	1.176	1.064	0.959	0.889	0.840	0.749
8	14.488	3.512	2.40	1.856	1.544	1.344	1.216	1.096	1.016	0.960	0.856
9	16.299	3.951	2.70	2.088	1.737	1.512	1.368	1.233	1.143	1.080	0.963
10	18.110	4.390	3.00	2.320	1.930	1.680	1.520	1.370	1.270	1.200	1.070

11. Conductor size calculations for overhead lines with A.C.S.R.

While determining the size of conductor for overhead lines, the following factor are to be considered :

(*i*) Current rating of A.C.S.R. The current rating for various A.C.S.Rs. is given in table 14.37.

(*ii*) The voltage drop should not be more than 12.5% and 5% of the declared voltage for transmission and distribution overhead lines respectively.

In Table 14.37, the resistance and impedance of various sizes of A.C.S.Rs. are given. The voltage drop is to be calculated after determining the load in amperes. For readily calculating the voltage drop, the voltage drop of 100 metres of LT, 400 volts 3 phase, 4 wire, distributors with various sizes of A.C.S. Rs. is tabulated in table 14.38.

After going through examples 7 to 9, the reader will find himself equipped with the procedure to determine the size of A.C.S.R conductor overhead lines.

Examples. 7. *A L.T. 3-phase, 4-wire distributor is to be designed for supplying to loads as shown in Fig. 14.1. Determine the size of A.C.S.R. conductors for phases and neutral. Assume p.f. of the loads as 0.8. Assuming the voltage at the substation is 420 V.*

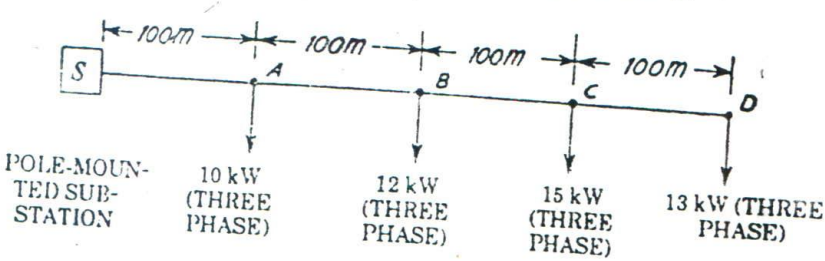


Fig. 14.1

Solution.

Loads in kilowatts and amperes by consulting Table 14.38 in various section will be as in Table 14.39.

Table 14.39

Section	*Load in KW*	*Load in Amperes*
SA	30	90.55
AB	40	72.44
BC	28	50.708
CD	13	23.543

$$\text{Total permissible drop} = \frac{400 \times 5}{100}$$

$$= 20 \text{ volts.}$$

Now again considering the various sections, and calculating the voltage drop after arriving at the suitable size of A.C.S.R. by consulting Table 14.15, the Table 14.40 is drawn.

Table 14.40

Section	*Load in amps.*	*Suggested size of A.C.S.R.*	*Voltage Drop*	*Voltage available at the end of the section*
SA	90.55	3 of Leopard / 1 of Beaver	5.350 V	414.65 V
AB	72.44	(3 of 6/1 × 5.28) / (1 of 6/1 × 3.99) 3 of Cat / 1 of Rabbit *i.e.*	5.08 V	409.57 V
BC	50.708	(3 of 6/1 × 4.50) / (1 of 6/1 × 3.50) 3 of other / 1 of Ferret *i.e.*	3.836 V	405.734 V
CD	23.543	3 of 6/1 × 4.22 / 1 of 6/1 × 3.00 3 of Weasel / 1 of Squirrel *i.e.* 3 of 6.1 × 2.59 / 1 of 6.1 × 2.11	3.90 V	401.834 V

As the voltage drop is within permissible limits, the arrangement shown in Table 14.40 is suitable.

Example 8. *An 11 KV overhead line is to be erected for feeding a substation at a distance of 5 km which has to feed the following connected L.T. load. Determine the size of conductor and transformer*

Load : (i) *Lighting : 210 KW (Single phase)*

(ii) *Fans, air conditioner : 66 KW (Single phase)*

(iii) *Industrial : 200 KW (three phase)*

Solution. The lighting and fans are single phase loads and therefore on each phase the load will be 70 KW and 22 KW for lighting and fans, air conditioner respectively *i.e.* three phase balanced lighting and fans or air conditioner load will be 70 KW and 22 KW respectively. Now draw the Table 14.41.

Table 14.41

Details of load	*Diversity factor*	*Connected load (three phase)*	*Actual load during day*	*Actual load during night*
(*i*) Lighting	0.8 during night 0.2 during day	70 KW	14.00	56.00
(*ii*) Fans and air conditioner	0.5 both during day and night	22 KW	11.00	11.00
(*iii*) Industrial load	0.9 during day. 0.1 during night.	200 KW	188.00	20.00
		Total	213 KW	87 KW

From Table 14.41, it will be seen that day load is more, therefore the transformer should be in a position to take this load. Assuming 0.8 as p.f. for this load.

$$\text{KVA capacity for the transformer} = \frac{213}{0.8} = 266.6 \text{ KVA}$$

Hence 300 KVA capacity transformer is suitable and *will also meet the future increase of load*

In view of the above, the overhead H.T. 11 K.V. line should be designed to cope 300 KVA load to meet even the additional increase at a later time.

Hence,

$$\text{Current,} \quad I = \frac{300 \times 1000}{\sqrt{3} \times 11 \times 1,000}$$

$$= 15.75 \text{ Amps.}$$

Permissible voltage drop

$$= \frac{12.5}{100} \times 11,000$$

$$= 1375 \text{ V}$$

Now referring to the table 14.37, it will be seen that if squirrel conductor (6/1 × 2·11), the resistance of 5 Km. length will be,

$$R = \frac{1.40 \times 5000}{1000} = 7 \text{ ohms}$$

$\therefore$ Voltage drop $= \sqrt{3} \times 16.59 \times 7$

$= 190.9$ V which is within the permissible limits

Hence, the overhead H.T. 11 KV line should be stretched with **squirrel (6/1 × 2.11) of A.C.S.R.**

Example 9. *A 6.6. KV feeder of length 1 km is to be erected to feed on Industrial substation of 500 KVA capacity. Find out the suitable size of A.C.S.R. conductor to be used for the purpose.*

Solution.

Maximum current, $I = \frac{500 \times 1,000}{\sqrt{3} \times 6{\cdot}6 \times 1,000}$

$= 43.75$ Amps.

Permissible voltage drop $= \frac{12.5 \times 6.6 \times 1000}{100}$

$= 825$ volts

Now referring to Table 14.37, it will be squirrel (6/1 × 2.11) A.C.S.R. if used will be in a position to carry this load safely.

Now the resistance of squirrel for 1 km length will be,

$R = 1.4$ ohms

$\therefore$ Voltage drop $= \sqrt{3} \times 43.75 \times 1.4$

$= 106.0$ volts which is within the permissible limits.

Hence, the overhead H.T. 6.6 KV line should be streched with **squirrel (6/1 × 2.1) of A.C.S.R.**

Typical Questions

1. What are the factors to be considered while determining the size of conductors ?
2. What do you understand by 'Estimating' ?
3. Explain the following terms used in estimating and costing :
   (a) Price catalogue
   (b) Schedule of labour Rates
   (c) Schedule of Rates

4. Explain the importance of (*a*) current carrying capacity and (*b*) voltage drop while determining the size of conductor.
5. Explain the method of determining the size of A.C.S.R. to be used in an overhead line.
6. How will you determine the size of conductor of an underground cable ?
7. What is the maximum permissible voltage drop in case of (*a*) internal wiring and (*b*) overhead lines for distribution and transmission ?

15

Internal Wiring Estimates

Before an estimate for a wiring scheme can be had, it is necessary for the electrical engineer to be conversant with the method and technique by which an architect gives to the wiring contractor specifications and drawings of the proposed building. *The architect usually never gives details of wiring circuit but definitely tells whether he wants direct or indirect light at a particular place, also he generally shows the positions of wall or bracket light, pendant light, position of switches, and of power points etc.*

After obtaining the blue prints from the architect the estimator or contractor goes through the plans and collects the specification of the electrical wiring asked for. Then he prepares an estimate which must comprise the estimates for :

(*a*) Accessories required and their cost.

(*b*) Wiring materials (conduit and cables) and their cost etc.

(*c*) Labour.

Under accessories comes an estimate for the number and types of switches, sockets, holders etc. Usually there is no difficulty in obtaining their number which is definitely specified by the architect and the estimator is simply to add.

Under wiring material comes the length of the conduit, or P.V.C. casing-capping or wooden batten required ; the length of the cable or P.V.C wire which will be used and other relevant material required for the completion of the wiring. *This part of the estimate cannot be calculated very accurately and to the point, but from site plans a sufficiently accurate estimate can be made. Before estimating this part of the estimate, it is necessary for him to visit the site personally and he must give a due allowance for cutting and wastage of the material.*

Thus labour is the most difficult part to be assessed There are many factors upon which labour cost depends, such as nature of

construction of building, its distance from the normal working point and the type of wiring to be had. A great experience is required for its stimulation.

Procedure to be followed while Estimating for Internal Electrification

The following general points are to be considered.

1. (*i*) System of Writing. (*ii*) Method of wiring.
2. Particulars of load. (*i*) Total load (*ii*) Total current. (*iii*) Designing current
3. No. of Sub-circuits, based on the above.
4. Distribution points in circuit.
5. Lay out (*i*) Line diagram (*ii*) Flow diagram (*iii*) Photographic view diagram
6. Size of Cable. (*i*) From Central Distribution Board (CDB) (*ii*) In Sub-Circuit
7. Main Switch.
8. Distribution box.
9. Size and Length of conduits.
10. Size and Length of cable required from DB to load points based on voltage drop Calculation.
11. Cost of materials ineluding CST, ST, SC and transport.
12. Labour for wiring.
13. Tool charges if any.
14. Over head charges, contingencies. etc.
15. Special fittings if any.

Points to be adhered to while preparing the estimate

1. Length of conduit required can be calculated by going through the plan of the building.
2. Allow 10% of total length for wastage in any system.
3. To calculate the length of wire, take the length of conduit after allowing wastage.
4. The length of wire can be taken as 2.5 times the length of conduit for looping system and 2 times for junction box system.
5. The length of the looping wire etc. in switch boxes shall not be lesser than 0.5 times of the height of the box itself.
6. The length of wire to be provided from the main board for connection to meter board shall not be more than 7.5 metres and should be one size higher than the actual size selected for wiring.

7. The clearance provided between ceiling and the running installation on the wall normally is taken as 0.25 to 0.5 metres. However this should be judged only by the type of building, beams crossing etc. Appearance should also be given due consideration.
8. All the controlling switches in power wiring shall be mounted on the metal frame of suitable design.
9. All the sub-circuits must have its own continuous earth wire.
10. The wiring of power and light must be seperated from each other, from the commencement of supply itself and shall not be run on the same conduits.
11. There is no necessity of providing separate earth for the lighting loads by the consumer ; supplier's earth shall be sufficient.
12. All the wall plugs must be of three pins and should be earthed.
13. More than one circuit, wires should not be dropped down in one switch box. Separate boxes must be provided for each circuits.
14. Labour can be calculated by calculating man days and multiplying by the charges/day.
15. For material handling (*i.e.*, transporting charges of materials to the site) will usually be judged by route length and available cargo movers.
    Any how it should not be more than 5% (max.) of material cost.
16. Over head charges will generally be assumed as 10% to 15% of the total cost.
17. In large installations, tool charges are to be included. It is usually 3 to 5% of the total cost.
18. Strictly follow I.E. Rules of 1956. ISI specifications, National Electric Code and the requirements of State Electricity Board Inspectors.
19. Wiring of All multi-storied buildings above 15.0 M Height must be inspected by Electrical Inspector and he has to approve (Rule 50 A)
20. Any wiring system has to last for 25 years. Hence high quality materials are to be used, high quality workmanship

must be executed through qualified contractors - hence materials cost and labour charges will be high.

21. For loads above 4 KW, 3 ph. supply must be arranged.
22. The wiring should be done very close to the ceiling.
23. For final sub-circuits, use 1 sq. mm of copper or 1.5 sq. mm. Al.
24. The bottom of ceiling fan should have a min. clearance of 2.75 m.
25. Provide 3 pin plug points at switch boards, with switch controls and solidly earth and third pin.
26. The consumer should provide ONE earth electrode for single phase supply and TWO earth electrodes for 3 phase supply. Earth pipe dimension : 40 mm dia and 2.5 M length.
27. If more than one electrode is provide, all earth electrodes must be linked, for combined low resistance. Water them periodically.
28. Use a minimum of 14 SWG TC (Tinned-Copper) for earth leads.
29. All non-current carrying metallic parts must be provided with 2 separate and distinct earth wires.
30. In bath rooms, all non electrical metal work including bath tubs, water pipes sinks must be bonded to-gether and earthed.
31. Do not exceed per circuit 800 watts or 10 lights or fans.
32. Do not exceed per circuit 2 numbers of plug points for power circuit.
33. Use heavily insulated, flexible cables for domestic appliances.
34. Do not keep pump motors exposed to open atmosphere. Provide weather proof covers.
35. Provide lighting arresters, for High Rise Buildings. IR values must be 1 MΩ.
36. Provide Earth Leakage Circuit breakers, for loads exceeding 5 KW.
37. If Generators are used, connect them in a standard way and ensure that it is NOT paralleled with EB supply.
38. Insist upon safety precautions as per I.E. rules.

Example 1. *Draw the electrical circuit and estimate the quantity of materials and their cost required for the P.V.C. casing-capping wiring system used in a house the plan of which is as shown below. Assume that the height of roof is 3.75 m. and one plug point is to be provided in each room.*

Solution.

No. of Light points = 5

No. of Fan points = 2

No. of Plugs = 2

Let us assume that the wattage of each lamp is 60 W, that of fan point 60W and that of plug 100 W.

$\therefore$ Wattage of Light points $60 \times 5 = 300$ W

Wattage of Fan points $60 \times 2 = 120$ W

Wattage of Plug points $100 \times 2 = 200$ W

Total Wattage = 620 W

$$\text{The line current} = \frac{\text{Total Wattage}}{\text{Supply Voltage}}$$

$$= \frac{620}{230} = 2.7 \text{ A}$$

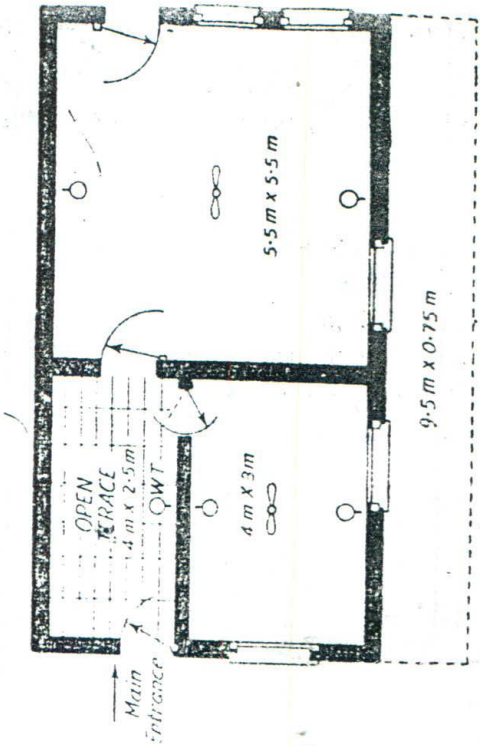
Now according to Tables 14.1 and 14.3 given in Appendix for the above current and wattage, a wire of size 1.5 sq. mm (1/1.40) with maximum current rating and wattage loading of 10 amps and 200 watts will suitable. This wire has 1 volt drop for 2.9 m. length. On the next page the length of positive wire has been worked out as 80 metre. In view of this, the voltage drop will be voltage drop

$$= \frac{2.7}{10} \times \frac{80}{2.9} = 7.449 \text{ V}$$

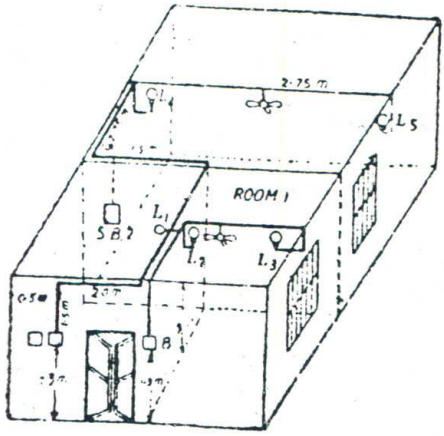
which is within permissible limits. *Hence single core P.V.C. of 1.5 sq mm (1/1.40) will be used for wiring.*

Fig. 15.2 represents the P.V.C. casing capping run in the building since the total connected load is 620 watts. The maximum number of points in a circuit can be 8 or 500 watt. But taking into account diversity factor so only one circuit is sufficient.

Length of P.V.C. Casing Capping required. Let the service meter be fixed to the left of the main entrance at a height of about 1.5 m. from the ground. Since only one circuit is to be carried, so the

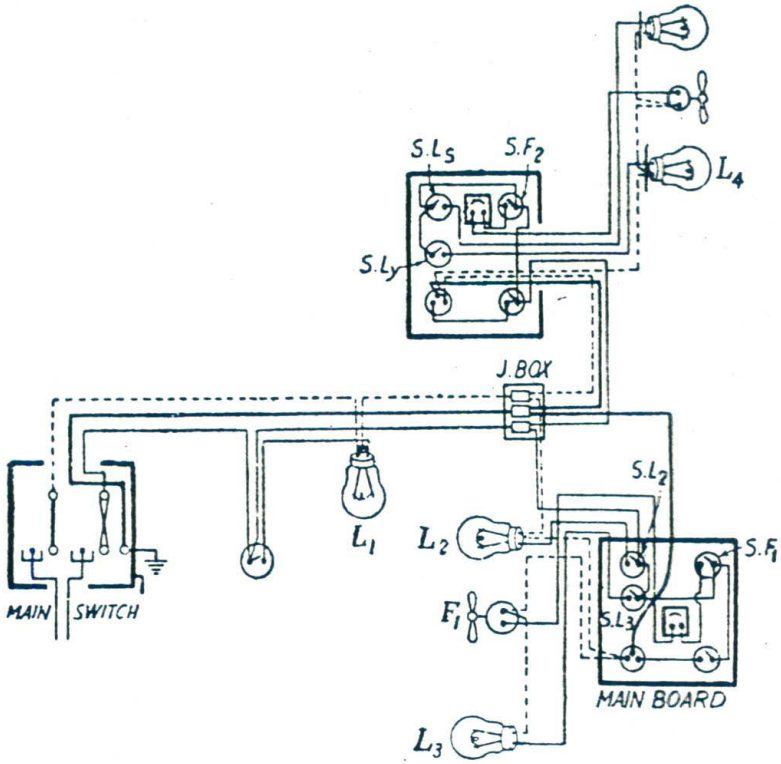


Plan showing the details of electrical fitting
Fig. 15.1



Sketch showing the various details of electrical fittings
Fig. 15.2

consumer's Main Board will consist of only 10 A Iron-clad Main Switch. The casing will be run on the surface of the wall. *The casing is being run at a distance of 3 m. from ground.* The total length of casing is arrived at as follows :



Circuit diagram
Fig. 15.3

Casing between Meter Board and Main Board	= 0.10 m.
The vertical run of casing above M.B.	= 1.50 m.
The horizontal run along the wall above the main entrance	= 2.00 m.
Run along the right-hand terrace wall up to the Junction Box	= 2.00 m.
Casing up to Lamp, L_1	= 1.00 m.

(The lamps are being provided at a distance of about 2.0 m. from the ground level, on the brackets).

Casing up to Switch of L_1, provided at a distance of about 1 m. along the right terrace wall at a height of about 1.3 metres from ground *i.e.*, the lamp L_1 is controlled from a point just at the entrance of the door = 1.70 m.

8.30 m.

Near the junction box the wall is punctured and the branch of circuit is taken into room No. 1, in which the casing will be run on the ceiling.

Vertical run up to ceiling = 0.75 m.

Casing along the ceiling to L_3 (3.00 + 0.75) = 3.75 m.

Casing up to L_2 (0.3 + 1) = 1.30 m.

Casing up to S.B_1 (0.7 + 1.7) = 2.40 m.

Casing along the wall up to lamp L_4 (2 m. + 1.5 + 2.75 +1) = 7.25 m.

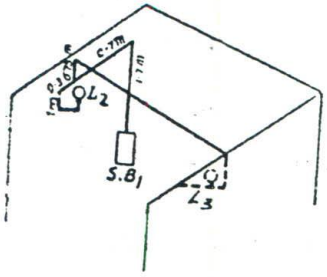
Casing up to lamp L_5 (0.75 + 5.5 + 1.75) = 8.00 m.

Casing along the wall up to S.B_2 which is again just outside the entrance = 1.70 m.

Total length of casing 33.45

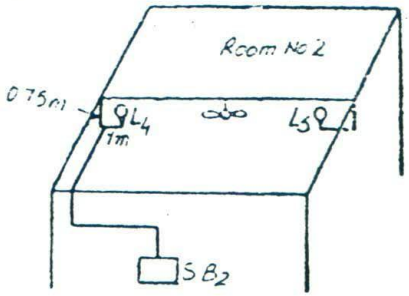
Allowing about 20% as wastage and the length used for jointing etc. = 6.69

40.14 m.



Layout of wiring in room No. 1
Fig. 15.4

Say, 40 m. is the total length of P.V.C. casing capping required.



Layout of wiring in Room No. 2
Fig. 15.5

Length of Negative wire required (of specification 1.5 sq. mm (1/1.40) black in colour)

Meter Board to Switch Board	= 10 m.
Up to lamp L_1	= 5.5 m.
Up to lamp L_2 allowing 1 m. length in junction box and the conduit through the wall (1 + 1)	= 2.0 m.
Up to lamp L_3	= 3.0 m.
	11.5 m.
From lamp L_2 to $S.B_1$ to be used in plug for both go and return (1 + 0.3 + 2(0.7 + 1.7)	= 6.1 m.
From junction box to the point just above the $S.B_2$	= 3.5 m.
From a point to the $S.B_2$ both go and return (1.7 + 1.7)	= 3.4 m.
Up to lamp L_4 (1 + 2.75 +1)	= 4.75 m.
Up to lamp L_5 (1 + 5.5 +1)	= 7.50 m.
Total	36.75 m.
Wastage 10 per cent (say)	3.68 m.
Wire used up for connections, 10% say	3.68 m.
	44.11 m.

Say 44 m.

Length of positive wire required (of specifications 1.5 sq. mm (1/1.40) white in colour)—

Meter Board to Switch Board	= 1.0 m.
From switch board to lamp L_1 through switch (1.5 + 2.0 + 1.7 + 1.7 + 2)	= 8.9 m.
From junction box to $S.B_1$ (1.7 + 0.7 + 1.7)	= 3.4 m.
From $S.B_1$ to L_2 *i.e.* half wire for L_2 (1.7 + 0.7 + 0.3 + 1)	= 3.7 m.
From S_1B_1 to fan (ceiling rose) (1.7 + 0.7 + 0.75 + 1.5)	= 4.65 m.
From $S.B_1$ to lamp L_3 (1.7 + 0.7 + 0.75 + 3 + 1)	= 7.15 m.
From junction box to $S.B_3$ (2 + 1.5 + 1.7)	= 5.20 m.
From $S.B_2$ to L_4 (1.7 + 1 + 2.75 + 1)	= 6.45 m
From $S.B_2$ to Fan (1.7 + 1 + 2.75 + 0.75 + 2.75)	= 8.95 m.
	49.40
From $S.B_2$ to L_5 (1.7 + 1 +2.75 + 0.75 + 5.5 +1)	= 12.70 m.
Total	62.10 m.
Wastage @ 10 per cent	6.21 m.
Wire used up in connections etc. @ 20%	12.42 m.
Total length	80.73 m.

Say 80 m.

Hence total length of wire used as positive and negative

= 80 + 44

= 124

Say 125 m.

Note that in practice the length of wire to be used may not be calculated in full details like this, but as a general rule the total length of wire is approximately 3 times that of length of the casing-capping out of which the positive is approximately double the length of that of the negative.

Earth Wire. The earth wire is required for the plugs in two rooms.

Wire required from main switch board to $S.B_1$ (a connection will be provided for earth-wire in junction box for it to be carried away to $S.B_2$ simply by providing a simple twisted joint	
(1.5 + 2.0 + 2.0 + 1.0 +0.7 + 1.7)	= 8.9 m
From J. Box to $S.B_2$	
(2 + 1.5 + 1.7)	= 5.2 m
	14.1 m
Wastage etc. and length to be used in connection etc. 10%	1.4 m
	15.5 m

Now prepare the schedule of material and cost as shown in Table 15.1.

Example 2. *A P.V.C. wiring is to be provided in a double storey 2 roomed, 4 flat house. Draw the circuit and estimate, the quantity of material required and its cost, on the assumption that two Supply Meters are to be taken. Also indicate difference if a separate Supply Meter for each flat is taken.*

Fig. 15.6 represents the ground plan of the ground floor. The plan for the first floor is just the same with a balcony of 1 m. in the inner courtyard side opposite two rooms, kitchen, bath and latrine. The requirements are represented in the plan.

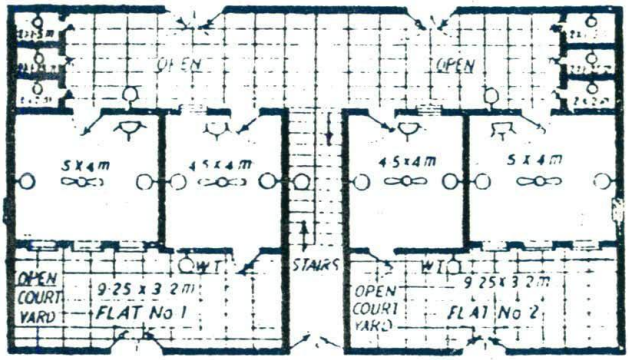


Fig. 15.6

Table 15.1

S. No.	Schedule of material			Cost					Remarks
	Material with specifications	Unit	Qty. reqd.	Rate		Per	Total cost		
				Rs.	P.		Rs.	P.	
1.	P.V.C. Casing Capping 44 mm × 28 mm width	m.	40	1300	00	100 m.	520	00	
2.	P.V.C. Wire 1.5 sq. mm (1/1.40)	m.	125	175	00	100 m.	218	75	
3.	Tumbler Switches 5 A Surface type	No.	9	36	00	Doz.	27	00	
4.	Brackets with holders (Bakelite)	No.	4	96	00	Doz.	32	00	
5.	Watertight brackets with holder	No.	1	30	00	Each	30	00	The fitting L_1 will be water-tight one
6.	Ceiling rose 2 plate (Bakelite)	No.	2	48	00	Doz.	8	00	
7.	Junction Box 3 way	No.	1	36	00	Doz.	6	00	
8.	Plug Socket 3 pin 5 A	No.	2	48	00	Doz.	8	00	
9.	Teak wood Boards (single)								
	(*i*) 30 cm. × 25.4 cm.	No.	2	105	00	Doz.	17	50	
	(*ii*) 20 cm. × 15 cm.	No.	1	52	00	Doz.	4	35	For main switch.
10.	Round Blocks (Single) 8 cm. × 2.5 cm.	No.	9	36	00	Doz.	27	00	5 for lamps, 1 for J. Box, 1 for switch, 2 for ceiling rose.
11.	Wooden Screws								
	3.18 cm × 8 S.W.G for casing	Pkt	1	38	00	1 Pkt of 200 Nos.	38	00	
	1.25 cm × 4 S.W.G for capping	Pkt	1	18	00	1 Pkt of 200 Nos.	18	00	
	1.90 cm × 4 S.W.G for switches etc.	Pkt	1/2	28	00	1 Pkt of 200 Nos.	14	00	
						C.O.	968	60	

(Contd.)

S.No.	Schedule of material: Material with specifications	Unit	Qty. reqd.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
						B.F.	968	60	
	5.08 cm × 10 S.W.G for boards	Pkt	1/4	54	00	1 Pkt of 200 Nos.	13	50	
12.	G.I. Wire No. 14 for earthing	Kg	15.5, m say approx. it will weigh 1 kg	18	00	Kg.	18	00	
13.	Conduit 19 mm. dia.	m	1	10	80	m.	10	80	
14.	Teak wood Plugs or Cutties 2.5 cm. sq. × 1.9 cm. sq. × 5 cm. long	Gross	1	20	00	Gross	20	00	
15.	Double pole iron clad 15 A, 250 V switch	No.	1	100	00	Each	100	00	
16.	I.C. Cutout 15 A	No.	1	15	00	Each	15	00	
						Total	1145	90	
							220	00	
							1365	90	
	Labour at Rs. 20/- per point, taking Main board as 2 points contingencies at 10%						136	59	Hence the estimated cost of internal wiring is Rs. 1503.
	Say 1503/-						1502	49	

Solution. The estimate can be made on the basis that either two meters are provided, one common for ground and first floor, or on the basis of 4 supply meters, one for each flat.

(a) *On the basis of two supply meters.*

No. of points in one flat and their wattage :

Light points 8 with wattage of	60×8	= 480 W
Fan points 2 with wattage of	2×60	= 120 W
Plug points 2 with wattage of	2×100	= 200 W
Total wattage per flat		800 W

Since the maximum wattage allowed in each circuit is 500 W or 8 points, so two circuits will be used in each flat.

Hence Wattage of each circuit $= \frac{800}{2} = 400 W$

If supply voltage $= 230 V$

Current from supply main $= \frac{400}{230} = 1.74 A$

(The power factor is unity, since there is only resistive load). From table 14.1 the safe current which can be carried by 1.5 sq. mm. (1/1.40) is 10 amperes. Due to mechanical reason this is the minimum size permissible for house wiring, so this wire will have an added advantage to meet the increased load due to extension in future. On the next pages the length of the positive wire run for each circuit has been worked out to be 60 metres. Now there is 1 volt drop for every 2.9 metre length of wire for 10 Amps flow of current, thus total voltage drop

$$= \frac{1.74}{10} \times \frac{60}{2.9}$$

$= 3.599$ V which is within permissible limits.

Hence wiring will be done with 1.5 sq. mm (1/1.40) aluminium P.V.C. wire single core conductor.

Connected load of two flats $= 800 \times 2 = 1600$ W

One lamp in the staircase $= 60$ W

Hence total connected load = 1660 W

Load current $= \frac{1660}{230}$

= 7.22 A. approx.

From tables, the wire between supplier meter board and main switch board may be either 2.5 sq. mm (1/1.80 capable of carrying safe current of 15 A or 4.00 sq. mm (1/2.24 capable of carrying 20 A, but the latter is preferred.

Assumption :

Height of proof = 3.5 m

Height of light points from ground = 2.0 m

Height of switches from ground = 1.3 m

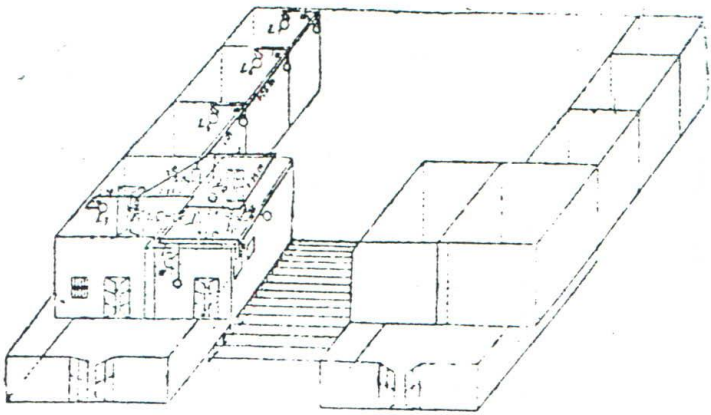
Height at which batten will be run = 3.0 m

Length of Teakwood batten 2.5 cm. wide to be used in each room of the ground floor.

Let the supplier meter be installed in the staircase.

Vertical length along the wall of staircase	=	1.0 m
Batten along the wall up to the point from where the tapping will be taken for watertight bracket	=	2.5 m
Vertical run along the wall for watertight fittings round block	=	1.0 m
Vertical run up to switch for above	=	0.7 m
Horizontal run along the wall up to lamp L_1	=	3.5 m
Vertical run along the wall up to lamp L_1	=	1.00 m
Vertical and horizontal run up to the ceiling above L_1 (0.25 + 0.5)	=	0.75 m
Run along the ceiling	=	2.00 m
Length of batten from F_1 to $S.B_1$ (2.25 + 1.7)	=	3.95 m
	C.O.	16.40 m

	B.F.	= 16.40 m
Batten length up to L_2 and its switch (3 + 1 + 0.7)		= 4.7 m
Batten from lamp L_2 to F_2 (1 + 0.5 + 2.5)		= 4.0 m
Batten from F_2 to L_3 (2.5 + 1)		= 3.5 m
Batten length upto L_5 (2.0 + 0.5 + 2 + 1 + 1)		= 6.5 m
Vertical run from the switch of L_5		= 1.7 m
Batten length up to L_6 (1.25 + 1 + 1)		= 3.25 m
Vertical run from switch of L_6		= 1.75 m
Similarly the length for L_7 and its switch (3.25 + 1.75)		= 5.00 m
		46.80 m
Wastage 15%		7.02 m
		53.82 m
	Say 55 m.	



Plan for wiring for each flat
Fig. 15.7

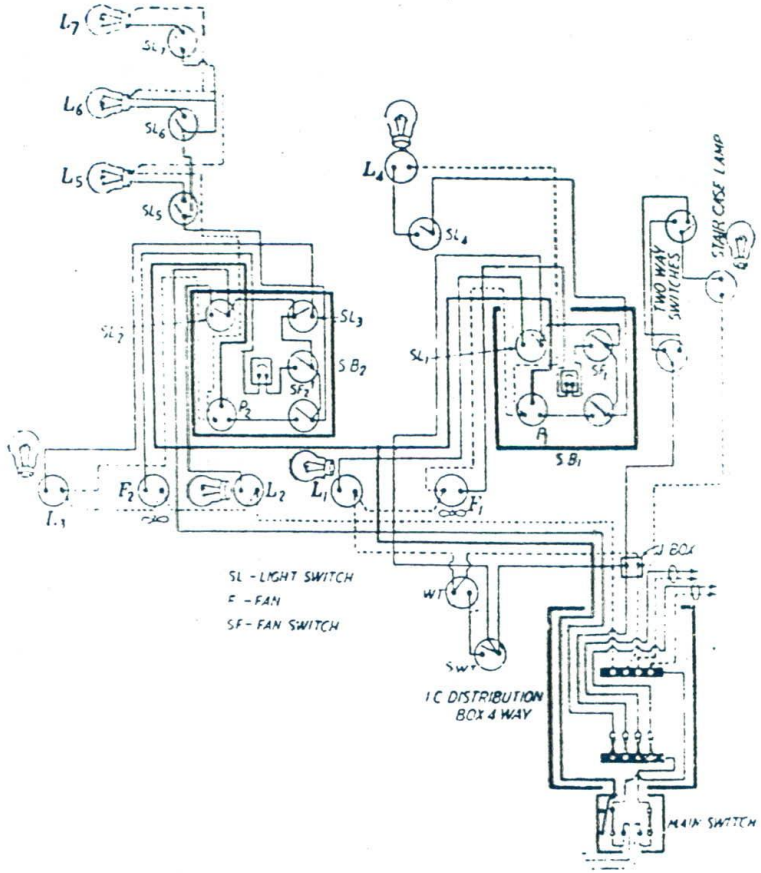
Since the thickness of the wall for the top floor is less and the rooms are of bigger dimensions, and if the scheme for the batten run is kept the same, the length used will be about 10% more, say 60 m.

Length of batten used for the top and ground floor

= 60 + 55 = 115 m.

Length of batten to be used in staircase = 5 m.(say)

Hence **total length of batten used** 120 m.



Circuit Diagram
Fig. 15.8

The length of single core 1.5 sq. mm. (1/1.40) copper conductor single core P.V.C. wire will be approximately 3 times the length of batten used.

∴ Total length of P.V.C. 1.5 sq. mm. (1/1.40) single core = 360 m (approx.)

$$\therefore \text{ Length of the positive wire } = \frac{360 \times 2}{3}$$

$$= 240 \text{ (approx.)}$$

As there will be 4 circuits, therefore length of positive wire for each circuit will be :

Length of positive wire in each circuit

$$= \frac{240}{4}$$

$$= 60 \text{ m. (approx.)}$$

Length of earth continuity conductor. The earth conductor is required for 3 pin plugs only and for that purpose 14 S.W.G. conductor is being used.

Length of conductor in the ground floor [(1 + 2.5 + 1.5 + 2 + 0.25 + 2 + 2.25 + 1.7 for room No.1) + (2.5 + 2.0 + 1.7 for room No. 2 having a joint at point near about L_1)]	= 19.40 m.
Length of wire used in connections and in passing through walls	2.60 m.
Wastage etc.	2.00 m.
	24.00 m.

Length of conductor used in the first floor will be 10% more say 26 m. Hence total length of wire used for 2 floors

$$= 24 + 26 = 50 \text{ m.}$$

Now prepare the schedule of material and cost as shown in Table 15.2.

On the basis of 4 Meters. When 4 meters are to be provided the difference will be only in the distribution. *There will be four distribution boards instead of two. Each distribution board will be having a main I.C. switch 15 A and I.C. distribution board 2-way. The internal wiring will remain necessarily the same, so the readers are advised to prepare an estimate themselves for this on the above lines.*

Table 15.2.

S. No.	Schedule of material: Material with specifications	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Per	Total cost Rs.	Total cost P.	Remarks
1.	Teakwood batten 25 mm × 13 mm	m.	120	120	00	100 m.	144	00	
2.	Single core 1.5 sq. mm. (1/1.40) P.V.C. wire	m.	360	175	00	100 m.	630	00	
3.	Tumbler surface switches, Single way, 5 A.	No.	42	36	00	Doz	126	00	
4.	Tumbler surface switches 2-way, 5 A	No.	2	48	00	Doz	8	00	
5.	Bracket with holders (Brass).	No.	28	180	00	Doz	420	00	
6.	Watertight brackets and switches	No.	4	30	00	Each	120	00	
7.	Batten holder (Brass)	No.	2	60	00	Doz	10	00	For staircase lamp.
8.	Plug Socket 3 pin 5 A	No.	8	48	00	Doz	32	00	
9.	Ceiling rose two plate (Bakelite)	No.	12	48	00	Doz	48	00	Four for junction box and eight for fans.
10.	Teakwood Boards	No.							
	(*i*) 30.5 cm × 25.4 cm	No.	8	105	00	Doz	70	00	One in each room for fixing plugs and switches
	(*ii*) 46 cm × 61 cm.	No.	2	225	00	Doz	37	50	For main switch and I.C. 2-way distribution board
11.	Round Blocks Single 8 cm. × 2.5 c.m.	No.	18	36	00	Doz.	54	00	2 for stair case, 4 for outer lights and 3 for each flat
						C.O.	1699	50	

(Contd.)

S. No.	Schedule of material: Material with specifications	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Per	Total cost Rs.	Total cost P.	Remarks
						B.F.	1699	50	
12.	Wooden Screws								
	3.18 cm × 8 S.W.G. for batten	Pkt	2	38	00	Pkt of	76	00	
	1.90 cm × 4 S.W.G. for switches	Pkt	2	28	00	100 Nos.	56	00	
	5.08 cm × 10 S.W.G. for boards	Pkt	3/4	60	00	Pkt of 200 Nos.	45	00	
						Pkt of 100 Nos.			
13.	Link Clips								
	(*i*) 4.4 cm.	Box of 100	12	3	00	Box	36	00	
	(*ii*) 6.4. cm.	Box of 100	4	3	50	Box	14	00	
14.	Nails, 1.25 cm	Kg.	1	20	00	Kg.	20	00	
15.	G.I. wire No. 14 S.W.G.	Kg.	50 m say 3 kg	18	00	Kg.	54	00	
16.	Teakwood Plugs or gutties 2.5 cm sq. × 1.9 cm. sq. × 5 cm. long	Gross	8	20	00	Gross	160	00	
17.	19 mm. dia P.V.C. Pipe	m.	3	5	80	m	17	40	For passing wire through the walls
18.	Double Pole Iron-clad 15 A, 250 V, Switch	No.	2	100	00	Each	200	00	
19.	I.C. Distribution Fuse Board 4-way, 15 A	No.	2	125	00	Each	250	00	
20.	I.C. Cut-out 15 A.	No.	2	15	00	Each	30	00	One each in first floor
						C.O.	2657	90	

(*Contd.*)

B.F.	2657	90
Labour cost, assuming that one wireman Grade I and one helper in one day can complete 4 points, take 2 points for the distribution board, and one point for plug No. of points = 48 + 2 = 50 *i.e.* 13 days for one wireman and one helper is required to complete the job.		
Electrician and helper will be employed at Rs. 80/- and Rs. 45/- per day respectively.	1625	00
Contingencies at 10% (including cement, sand and finishing).	428	29
(Note that the labour cost on point basis can also be obtained : the approx. cost is at Rs. 20/- per point.)	4711	19

The estimated cost therefore is Rs. 4711/-

Power Wiring Installations

Important points to be considered are :

1. I.E.E. rules Nos. 22, 50, 51 are to be satisfied.
2. Wiring is to be installed either in surface conduits system or recessed conduit system.
3. Earth wire of 8 S.W.G. must run along the pipes.
4. Consumer must be provided two distinct earths in addition to the supplier's earth. All the earths should be linked with each other.
5. Every switch board or control board of the machine or equipment must accompany with a suitable circuit breaker so that, if required, the supply must be terminated without any delay.
6. Controlling board should be placed as near as possible to the equipment.
7. For the selection of cable, the starting current of the equipment of motor is to be given due consideration.
8. The capacity of main switches or circuit breakers shall be of three times that of the normal current.
9. Efficiency, power factor are to be given due consideration. It can be assumed as 80% and 0.7 respectively unless otherwise stated.
10. Proper Bushes (wooden or porcelain) are to be provided in all the metal frame of suitable design.
11. All the controlling switches in power wiring shall be mounted on the metal frame of suitable design.
12. When the outgoing lead is of U.G. Cable, allow a loop of 25 cm or the minimum bending radius above the switch. This is necessary the cable is not subjected to undue strain due to bending.
13. Avoid crossing in U.G. Cables within a shop.
14. In the case of the U.G. Cables, the size, the number of cores in the cable and the direction of flow of power, shall be clearly marked within the point.
15. The layout of the U.G. cable must be clearly marked with suitable indicators of G.I. or Aluminium boards indicating the location of the cable. It shall be of about 30 cm. This is used in open grounds and side of the streets.
16. Length of flexible metallic conduit shall not be greater than 2 mts.
17. Provision must be made for the emergency lights in the switch board room. This will until in illumination of the room whenever the supply fails.

18. Proper safety precautions must be provided as per I.E. rules 41, 42, 43, 44, 45, 46.

Example 3. *In a single-storey building (the plan of which is given in Fig. 15.9) the light and power points are to be provided in conduit wiring as per figure. Draw a wiring circuit for the distribution board, indicate the conduit run on the plan. Estimate the quantity of material required, the cost of material and labour cost. The wiring is to be of concealed conduit type.*

Solution. As the building is to be provided with a light and fan circuit as well as with a power circuit, they will be designed separately. First *designing Light and Fan circuit only :*

No. of light points		=	19
No. of fan points		=	6
No. of plug points		=	4
Wattage for light points	19 × 60	=	1140 W
Wattage for fan points	6 × 60	=	360 W
Wattage for plug points	4 × 100	=	400 W
Total connected load			1900 W

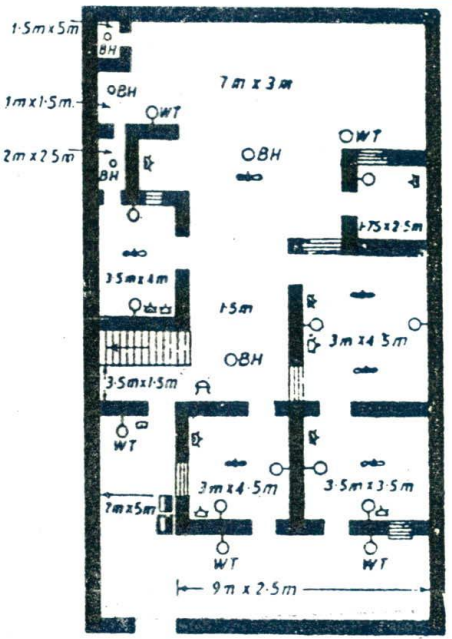


Fig. 15.9

Since the maximum number of lamps in a circuit is to be 8 and the total load in the circuit should be 500 W.

$$\text{The maximum current in each circuit} = \frac{500}{230}$$

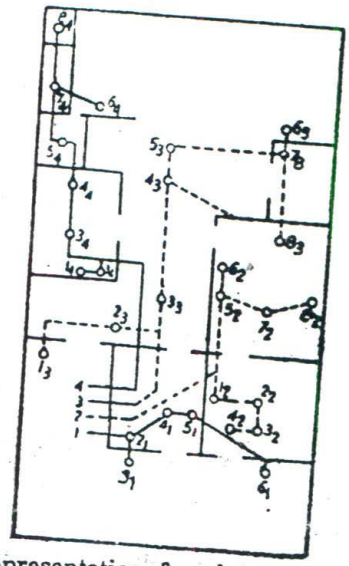
$$= 2.2 \text{ A.}$$

From Table 14.1, the safe current which can be carried by P.V.C. wire, 1.5 sq.mm (1/1.40) is 10 amperes and hence this size is suitable. While red colour is used for live wire and black for the negative.

The connected load requires necessarily 4 circuits. *For having a connected conduit wiring, the conduit is run over the roof before putting up concrete over it along with necessary outlet boxes, junction boxes etc.* Fig. 15.10 represents the conduit run for the four separate circuits. The outlets in circuit 1 are represented as 1_1, 2_1, 3_1 ....., and in circuit 2 they are represented as 1_2, 2_2, 3_3 .....and similarly outlets in circuit no. 3 and 4 are represented. Since 4 to 6 wires at a time are to run in one conduit, so 25.4 mm. conduit may be used.

Assumptions

The height of the light bracket from floor level=2.5 m
The height of switch etc. from floor level = 1.5 m.
The height of ceiling from floor level = 3.5 m.



Representation of conduit run
Fig. 15.10

Length of conduit used in circuit No. 1.-

Note that the lengths assumed are all approximate.

Conduit run along ceiling to outlets

$2_1 = (1\text{ m}), 4_1 = (2\text{ m}), 5_1 = (1.5\text{ m.}), 6_1 = (1.5\text{ m})$ = 6 m

From Main Board to ceiling = 2 m

The socket outlet 1_1 and its control will be on the switch board controlling outlets 2_1, 4_1 and 5_1.

The conduit run up to outlet 5_1 from ceiling	=	1 m
The conduit run up to outlet 3_1 from ceiling	=	1 m
The conduit run up to outlet 6_1 from ceiling	=	1 m
The conduit length from 2_1 to switch	=	1.2 m
The conduit length from 3_1 to its switch	=	1 m
The conduit by 6_1 to its switch	=	1 m
		14.2 m
Wastage etc.		1.6 m
		15.8 m
Total length of conduit used		16 m.

No. of inspection boxes to be provided at each bend, one above the outlet and one below when it has a switch behind just below it = 8

No. of outlet boxes—one two-way and the others single-way = 4

Junction Box = 1

Length of 1.5 sq. mm (1/1.40) P.V.C. wire used for circuit No. 1

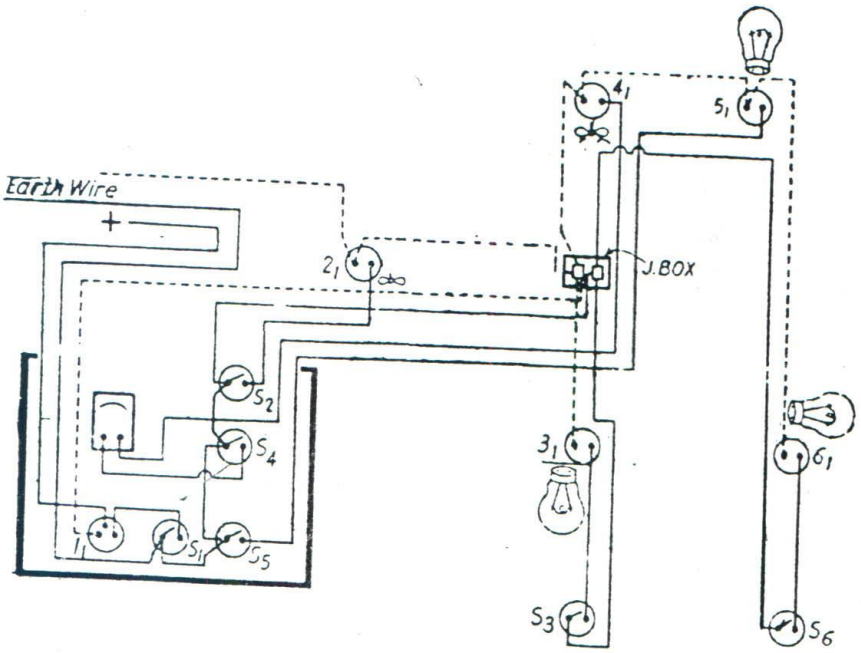
Length of negative wire—

From distribution board to outlet $2_1 = (2 + 1 + 1)$	= 4 m
From 2_1 to Junction Box	= 1 m
From Junction Box to 1_1	= 2 m
From Junction Box to 3_1	= 0.5 m

(as the wall at back will be punctured)

From Junction Box to 4_1	= 2.0 m
From 4_1 to $5_1 = (1.5 + 1)$	= 2.5 m
From 5_1 to $6_1 = (1 + 1.5 + 1)$	= 3.5 m
	=15.5 m

Length used for connection etc.	= 3 m.
	18.0 m.
The positive wire will be approx. double of the the negative wire length	36.0 m.
Total	54.0 m.



Representing line diagram for circuit No. 1.
Fig. 15.11.

Length of conduit used in circuit No. 2—

Conduit run along ceiling to outlets 1_2 = (4m), 2_2 = (1.75 m), 3_2 = (1.75 m), 5_2 = (1.75 + 2.25), 6_2 = (1 m.), 7_2 = (2 m), 8_2 = (2 m) = 16.5 m.

The socket outlets 4_2 and 6_2 and their control will be provided on switch boards in the two respective runs.

Conduit run upto outlet 1_2 along the wall from ceiling = 1.0 m.

Conduit run up to 3_2 along the wall from ceiling = 1.0 m.

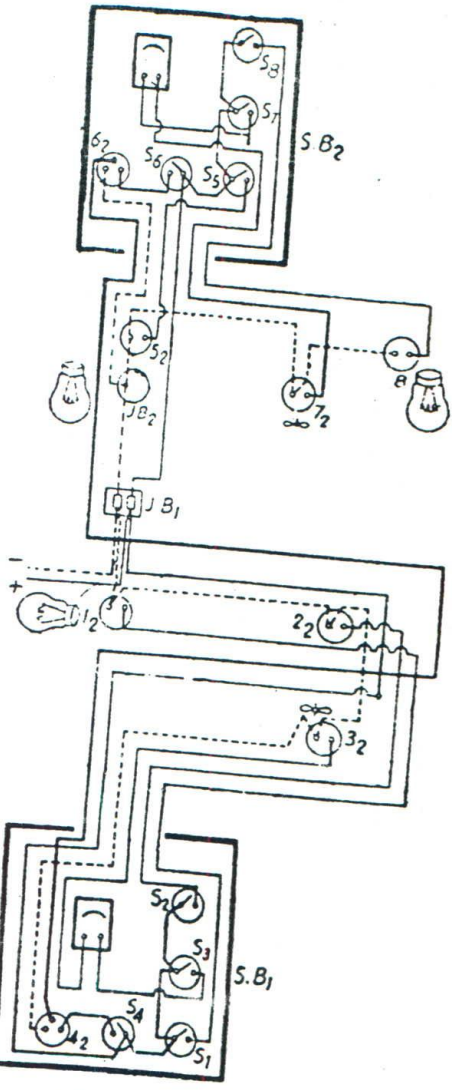
Conduit run up to switch board from outlets 3_2	= 1.2 m
Conduit run up to outlet 5_2 along the wall from ceiling	= 1.0 m
Conduit run up to outlet switch board	= 1.2 m
Conduit run up to outlet 8_2 along the wall from ceiling	= 1.0 m
	22.9 m
Wastage etc.	2.1 m
Total	25.0 m

No. of inspection boxes = 8
No. of outlets = 8
(2 two-way and 6 one-way)
Junction Boxes = 2

Length of 1.5 sq. mm (1/1.40) wire used—

Length of negative wire—

From distribution board to outlet Junction Box (2 + 4 + 1)	= 7.0 m
From $J.B._1$ to 1_2	= 0.5 m
From 1_2 to 2_2 = (1 + 1.75) and from 2_2 to 3_2 (1.75 + 1)	= 5.5 m
From 3_2 to $S.B._1$	= 2.0 m (approx.)
From $J.B._1$ to $J.B_2$ = (1.75 + 2.25 + 1)	= 5.0 m
From $J.B._2$ to 5_2	= 0.5 m
From $J.B_2$ to 7_2 = (2 m) and from 7_2 to 8_2 = (2 m)	= 4.0 m
From 5_2 to 6_2	= 2.0 m (approx.)
Total	26.5 m
Wastage etc. and the wire used in switch board and in outside etc.	6.5 m
	33.0 m
The positive wire will be approx. double the negative length	66.0 m
Total	99.0 m



Circuit diagram for circuit No. 2.
Fig. 15.12

Length of conduit used in circuit No. 3.-

Conduit run along the ceiling to 3_3 = (3.5 m), 3_3 to 1_3 = (2.5 m), 3_2 to 4_2 = (4.5 m), 4_3 to 5_3 = (0.5 m), 5_3 to 7_3 m = (3 m), 7_3 to 6_3 = (1 m) and 7_3 to 8_3 = (2.5 m) = 17.5

From main board to ceiling = 2.0 m

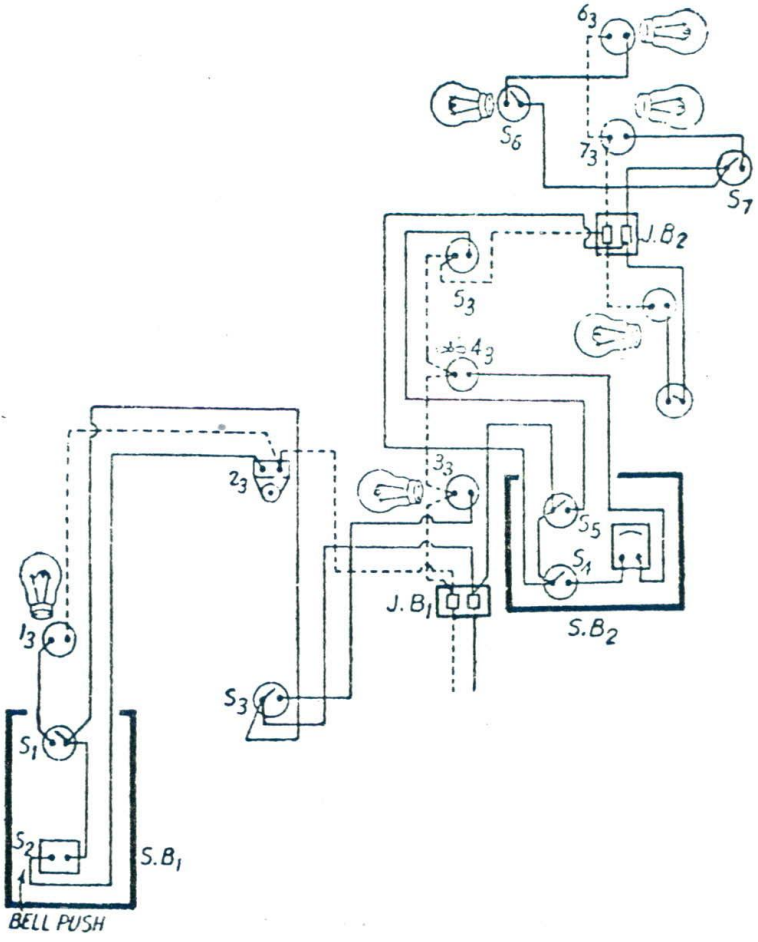
From ceiling to outlets 2_3 = (1m) and l_3 = (1 m) = 2.0 m

From ceiling to outlets 7_3 = (1 m) and 6_3 = (1 m) = 2.0 m

From 4_3 to $S.B._2$ (controlling outlet 4_3 and 5_3) = 3.5 m

From l_3 to $S.B._1$ (controlling outlets l_3 and 2_3) = 1.0 m

28.0 m



Circuit diagram for circuit No. 3
Fig. 15.13

B.F.	= 28.0 m
From 2_3 to the switch controlling 3_3	= 1.0 m
From 6_3 to its switch	= 1.0 m
From 7_3 to its switch	= 1.0 m
From 8_3 to its switch	= 1.0 m
	32.0 m
Wastage etc.	2.0 m
Total	34.0 m

No. of inspection boxes = 11
No. of outlet boxes = 8
(5 two-way, 3 one-way) Junction Boxes = 2

Length of wire 1.5 sq. mm (1/1.40) used in circuit No. 3.

Length of the negative wire

From distribution board to $J.B._1$	= 3.5 m
From $J.B_1$ to outlet 3_3	= 0.5 m
From outlet 3_3 to outlet 2_3	= 3.5 m
From outlet 2_3 to outlet 1_3	= 1.0 m
From outlet 3_3 to outlet 4_3	= 4.5 m
From outlet 4_3 to outlet 5_3	= 0.5 m
From outlet 5_3 to outlet 7_3 = (3 + 1)	= 4.0 m
From outlet 7_3 to 8_3	= 2.5 m
From outlet 7_3 to 6_3 = (1 + 1 + 1)	= 3.0 m
	23.0 m
Wastage and length of wire used in switch boards and outlets etc.	= 4.0 m
	27.0 m
Length of positive wire is approx.	= 54.0 m
Total	81.0 m

Length of conduit used in circuit No. 4

Length of conduit along ceiling to outlet 2_4 = (5 m), from outlet

2_4 to 1_4 = (0.5 m), 2_4 to 3_4 = (2 m), 3_4 to 4_4 = (2 m), 4_4 to 5_4 = (2 m), 5_4 to 7_4 = (1.5 m) and 7_4 to 8_4 = (1.0 m) = 14 m

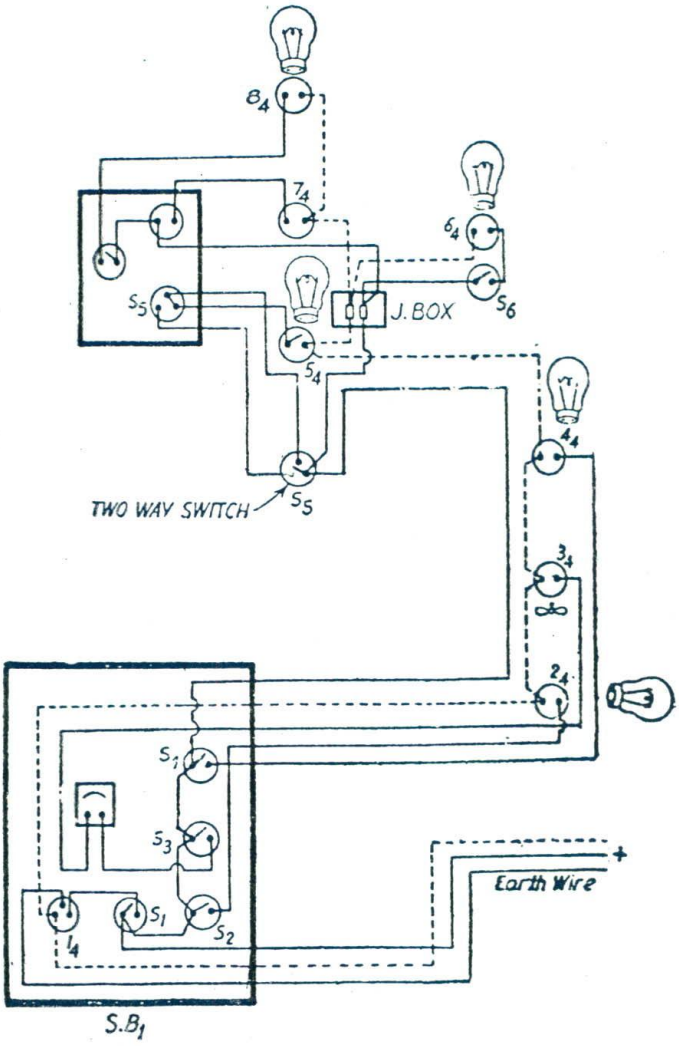
Conduit run from ceiling along the wall up to 2_4 = 1.0 m

Conduit run up to 4_4 along the wall = 2.0 m

Length of conduit along the wall to outlet 4_4 = 1.0 m

Length of conduit along the ceiling to outlet 6_4 = (1 +1) = 2.0 m

20.0 m.



Circuit diagrams for circuit No. 4
Fig. 15.14

B.F. = 20.0 m

The lamp 5_4 will be controlled from two points, one inside the run and the other outside the bath, while the control for the lamps 7_4 and 8_4 will be outside.

Length of conduit along the wall inside the run for control of lamp 5_4	= 2.0 m
Length along the wall for control of outlets 5_4, 7_4 and 8_4 = (0.5 + 2)	= 2.5 m
Length along the wall for control of outlet 6_4	= 1.0 m
	25.5 m
Wastage etc.	2.5 m
Total	28.0 m

Inspection Boxes	= 5
Outlet Boxes	= 8
(3 two-way and 5 single-way) Junction Boxes	= 1
Length of 1.5 sq. mm (1/1.40) wire used—	
Length of the negative wire	
From distribution board to $S.B._4$ = (5 + 1 + 2)	= 8.0 m
From $S.B._1$ to outlet 2_4	= 3.0 m
From outlet 2_4 to outlet 3_4	= 2.0 m
From outlet 3_4 to outlet 4_4	= 2.0 m
From outlet 4_4 to outlet 5_4	= 2.0 m
From outlet 5_4 to Junction situated at a distance of 2.5 m. from floor level in the kitchen	= 0.1 m
From Junction box to outlet 7_4 = (1 + 1.5)	= 2.5 m
From outlet 7_4 to outlet 8_4	= 1.0 m
	21.5 m
Wastage and the length used in connections etc.	= 3.5 m
	25.0 m
Length of the positive wire	= 50.0 m
Total	75.0 m

For estimating the light points, the various working and details have been given in Table 15.3.

Table 15.3

S.No.	Schedule of material Material with specification	Unit	Qty.	Cost Rate Rs. P.	Per	Total cost Rs. P.	Remarks
1.	Length of conduit 25.4 mm. heavy gauge Circuit No. 1 16 Circuit No. 2 25 Circuit No. 3 34 Circuit No. 4 28 103	m.	103	13.80	m.	1421.40	
2.	Length of 1.5 sq.mm. (1/1.40) PVC wire used Circuit No. 1 54 Circuit No. 2 99 Circuit No. 3 81 Circuit No. 4 75 309	m.	309	175.00	coil of 100 m.	540.75	One third of this quantity will be black and the remaining will be white.
3.	Inspection Boxes (2-way) round 7.6 cm. dia. with cover for 25.4 mm. dia. conduit (8+11+8+5)	No.	32	225.00	Doz.	600.00	
					C.O.	2562.15	

(Contd.)

S.No.	Schedule of material	Cost					Remarks
	Material with specification	Unit	Qty.	Rate Rs. P.	Per	Total cost Rs. P	
					B.F.	2562.15	
4.	Outlet Boxes 7.6 mm. dia. one way for 25.4 mm. conduit (3 + 6 + 3 + 5)	No.	17	225.00	Doz.	318.75	
5.	Outlet Boxes 7.6 mm. dia. two way for 25.4 mm. conduit (1 + 2 + 5 + 3)	No.	11	225.00	Doz.	206.25	
6.	Conduit steel U-hooks 25.4 mm. dia. for fixing conduit in the wall recess provided for running the conduit.	Kilo	2	17.00	Kilo	34.00	Approximate quantity
7.	Junction Boxes (7.6 cm × 7.6 cm.) with masonite cover (1 + 2 + 2 + 1)	No.	6	300.00	Doz.	150.00	
8.	Round Teakwood Blocks 10 cm. × 2.5 cm (4 + 8+ 8+ 8)	No.	28	48.00	Doz.	112.00	
9.	M.S. Boxes with masonite cover (*i*) 7.6 cm. × 7.6 cm. (2 + 0 + 4 + 2)	No.	8	6.00	Each	48.00	For single switch
	(*ii*) 7.6 cm × 14.2 cm. (0 + 0 + 1 + 0)	No.	1	8.00	Each	8.00	For 2 switches in one Board
	(*iii*) 10 cm. × 18 cm. (0 + 0 + 1 + 1)	No.	2	9.00	Each	18.00	For 3 switches on one Board
	(*iv*) 20 cm. × 30 cm. (1 + 2 + 0 + 1)	No.	4	20.00	Each	80.00	One for outside and other inside the fitting.
					C.O.	3,537.00	

(*Contd.*)

S.No.	Schedule of material Material with specification		Cost Unit	Qty.	Rate Rs. P.	Per	Total cost Rs. P.	Remarks
10.	Locknuts 25.4 mm.					B.F.	3,537.00	
	For Main Board	8						
	For Inspection Boxes	128						
	For Outlet Boxes (34+44)	78						
	For Junction Boxes	12						
	For I.C. Boxes	30						
		256	No.	256	36.00	Gross	63.00	
11.	Conduit couplings 25.4 mm.		No.	24	60.00	Doz.	120.00	
12.	Wooden Bushings 25.4 mm.							
	For Main board	4						
	For inspection boxes	64						
	For outlet boxes one-way	17						
	For outlet boxes 2-way	22						
	Junction boxes	6	No.	113	15.00	100 No.	16.95	
		113						
13.	Lamp-holder brackets		No.	9	15.05	Each	135.00	
14.	Water-tight brackets complete with holder and globe		No.	4	30.00	Each	120.00	
15.	Batten holders brass		No.	5	60.00	Doz.	25.00	
16.	Ceiling rose 2 plate bakelite		No.	6	48.00	Doz.	24.00	
17.	5 A, 3 pin sockets		No.	4	48.00	Doz.	16.00	
18.	5 A, tumbler switches flush type		No.	26	96.00	Doz.	208.00	
						C.O.	4265.10	

(Contd.)

S.No.	Schedule of material Material with specification	Unit	Qty.	Cost Rate Rs. P.	Per	Cost Total cost Rs. P.	Remarks
					B.F	4,265.10	
19.	5 A, tumbler switches flush type 2-way	No.	4	144.00	Doz.	48.00	
20.	D.P.I.C. switch 15 A	No.	1	100.00	Each	100.00	
21.	Call Bell 230/250 V	No.	1	15.00	Each	15.00	
22.	Bell push	No.	1	60.00	Doz.	5.00	
23.	4-way I. C.D.B., 250 V, 15 A/way	No.	1	125.00	Each	125.00	
24.	I.C. cut-out single pole, 15 A, 250 V	No.	1	15.00	Each	15.00	
25.	Main Board 30 cm × 45 cm	No.	1	42.00	Each	42.00	
26.	G.I. wire 14 S.W.G.	Kg.	6	18.00	Kg.	108.00	
27.	Wooden screws						
	(*i*) 3/4" × 4 for switches	Pkt.	1	28.00	Pkt of 200 No.	28.00	Approximate
	(*ii*) 2" × 8 for Boards and round blocks etc.	Pkt.	2	54.00	Pkt of 100 No.	108.00	Approximate
28.	Machine Screws Round Head 1"	Gross	1	18.00	Gross	18.00	
	Labour charges at Rs. 20 per point considering main board as 2 points					4867.00 660.00	
						5527.10	
	Contingencies at 10% including plastering and finishing etc.					551.70	
	Total					6080.81	
	Say					6081.00	

Power Circuits

No. of power plugs to be provided = 6

Wattage of each point = 500 W

∴ Total connected load for the 6 points = 500 × 6 = 3000 W

The maximum number of power points in a circuit is to be 2 or the wattage can be 1000 W.

$$\text{The maximum current in each circuit} = \frac{1000}{230} = 4.4 \text{ A.}$$

The suitable wire is to be 4 sq. mm (1/2.24) which can carry 20 amperes safely and 25.4 mm. conduit will be used. Fig. 15.15 represents the division of circuits.

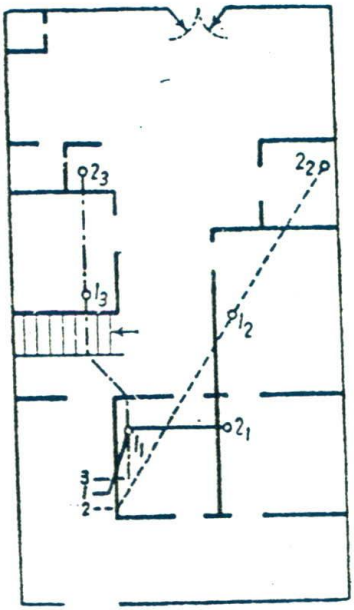
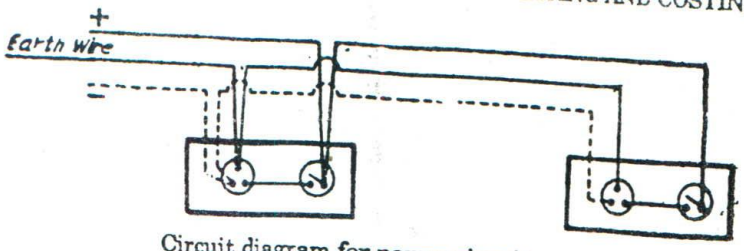


Fig. 15.15

The circuit diagram for each circuit is as shown in Fig. 15.15.

Length of conduit used in circuit 1—

Length from D. B. to l_1 along ceiling (2 + 2) (2 m. length is up to ceiling from D.B.)	=	4.0 m
Length along the wall up to switch board	=	2.0 m
Length from outlet l_1 to outlet 2_1	=	3.1 m
Length along the wall up to switch board	=	2.0 m
		11.1 m



Circuit diagram for power circuit
Fig. 15.16

Length of conduit used in circuit 2—

Length from D.B. to outlet l_2 along roof = (2 + 6)	=	8 m
Length along the wall up to outlet l_2	=	2 m
Length along roof to outlet 2_2	=	4 m
Length along the wall up to the above outlet	=	2 m
		16 m

Length of conduit used in circuit No. 3—

Length along roof from D.B. to outlet l_3 = (2 + 3.5)	=	5.5 m
Length along the wall to outlet l_3	=	2.0 m
Length along the roof from outlet l_3 to 2_3	=	4.5 m
Length along the wall to outlet 2_3	=	2.0 m
		= 14.0 m

Total length of conduit used = 11.1 + 16 + 14	=	41.1 m
Wastage etc.	=	2.9 m
Total		43.0 m

Hence total length of conduit required for power wiring
= 43.0 m

No. of Inspection Boxes = approximately 2 in each outlet run
= 12

Since in power circuits no positive half is run, it is quite reasonable to assume that the total length of wire used is approximately $2\frac{1}{2}$ times the length of conduit instead of it being 3 times. The estimate for power wiring is given in Table 15.4.

Total length of 4 sq. mm (1/2.24) wire used = $43 \times \frac{5}{2} = 107.5$ m

Say, 1 coil of 100 m

Table 15.4

S.No.	Schedule of materials: Material with specification		Units	Qty.	Cost: Rate Rs.	P.	Per	Total cost Rs.	P.	Remarks
1.	Conduit heavy gauge 25.4 mm dia.		m.	43	13	80	m.	593	40	
2.	4 sq. mm (1/2.24) P.V.C. wire		m.	100	480	00	coil of 100 m.	480	00	
3.	Inspection Boxes 7.6 cm. dia. with cover (2-way)		No.	12	225	00	Doz.	225	00	
4.	Conduit steel hooks 25.4 mm.		Kilo	1	17	00	Kilo	17	00	
5.	M.S. box 10 cm. × 18 cm. with masonite cover		No.	6	9	00	Each	54	00	
6.	Conduit coupling 25.4 mm. dia.		No.	1	60	00	Doz	5	00	
7.	Locknuts 25.4 mm.—									
	For Main board	6								
	For Inspection boxes	48								
	For cutting I.C. boxes	24								
		78	No.	78	36	00	Gross	19	50	
8.	Conduit bushings—									
	For Main board	3								
	For Inspection boxes	24								
	For outlet boxes	12								
		39	No.	39	15	00	100 No.	5	85	
9.	3 Pin 15A sockets		No.	6	48	00	Doz.	24	00	
10.	15A, Tumbler switch surface type		No.	6	180	00	Doz.	90	00	
11.	D.P.I.C. switch 250V, 30A		No.	1	230	00	each	23	00	
							C.O	1536	75	

(Contd.)

S.No.	Schedule of materials Material with specification	Cost Units	Qty.	Rate Rs.	P.	Per	Total cost Rs.	P.	Remarks
12.	4-way I.C. Distribution 250 V. 15A/way	No.	1	125	00	B.F. Each	1536 125	75 00	
13.	Main Board 30 cm. × 45 cm.	No.	1	42	00	Each	42	00	
14.	I.C. cut-out single pole 15A. 250 V	No.	1	15	00	Each	15	00	
15.	G.E. wire 14 S.W.G.	Kilo	2	18	00	Kilo	36	00	
16.	Wooden screws—								
	(*i*) 3/4" × 4 for switches etc.	Pkt.	1/4	28	00	Pkt. of 200 Nos.	7	00	
	(*ii*) 2" × 8 for Boards etc.	Pkt.	1/4	54	00	Pkt. of 100 Nos.	13	50	
17.	Machine screws (Brass) round head 1"	Pkt.	1/4	69	00	Pkt. of 200 Nos.	17	25	
							1999	50	
	Labour charges at Rs. 20 per point and 2 points for main board are to be taken.						160	00	
							2159	50	
	Contingencies at 10%						215	95	
	Charges for providing power points						2375	45	
	Charges for providing light and fan points						6068	00	
	Say						8443	00	

Example 4. *A residential double storey building is to be electrified with C.T.S. wiring. Give the approx. Cost for the wiring including labour charges. The details of fittings required are as follows :*

S. No.	Rooms	Size	Tube light	Ordinary light	Fan	Plug pt.
1.	Drawing Room	4.0 m × 2.0 m	1	1	1	2
2.	Bed Room	4.0 m × 3.0 m	1	1	1	1
3.	A Rest Room	2.0 m × 2.0 m	1	—	1	—
4.	Kitchen Room	4.0 m × 2.0 m	1	2	—	1
5.	Bath Room	1.5 m × 1.5 m	—	1	—	1
6.	Toilet Room	1.5 m × 1.5 m	—	1	—	—

Assume necessary data as per I.E. rules and mention them clearly.

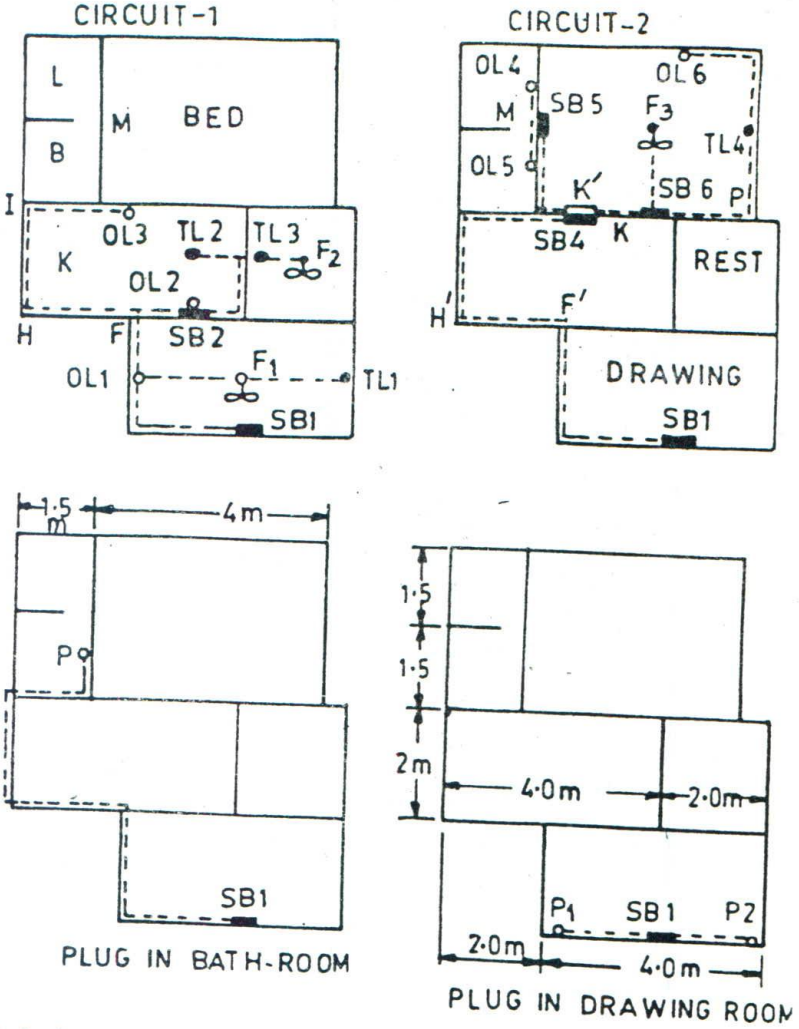
Solution : 1. The plan of the Building is to be supplied by the owner.

2. The location of electrical fittings are marked in consultation with owner (see fig 15.16.1).
3. The height of ceiling, from floor level is 3.3 m.
4. The ground floor and first floor are similar in construction.
5. The C.T.S. wiring, as required by the owner is done at a 3.0 m above the floor level.
6. All switches and plug points are located at a height of 1.35 m above the floor level.
7. The ceiling fans are located as far as possible at the centre of the room.
8. Since it is a concrete ceiling, the charges for provision of hooks for fans are to be met by the owner.
9. The estimate is prepared purely as per requirement of owner.
10. Total load :

Tube Light	4 × 40	:	160
Ordinary light	6 × 60	:	360
Fans	3 × 80	:	240
Plugs	1 × 1000	:	1000
Plugs	4 × 500	:	2000

For the above Load, 4 circuits are formed.

Circuit 1. Loads in Drawing Room, Kitchen and Rest Room, including one plug in Kitchen.
2. Loads in Bed Room, Bath and Toilet rooms including one plug in Bed room.
3. One Plug in Bath room only.
4. 2-plugs in Drawing room. All Switch Boards of the size 0.3m × 0.2m



Jn1 is 1.0 metre away from H
Jn2 is 1.45 metres above SB2
Jn3 is at K
Jn4 is at K'
Jn5 is at M'

All dimensions in metres

Fig. 15.16.1

CABLE LENGTHS REQUIRED

Circuit-1. Drawing Room, Kitchen, and Rest Room including one no. plug in kitchen

SB_1 in Drawing Room has controls for OL_1, TL_1 & F_1.

SB_2 in Kitchen has controls for OL_2, OL_3, TL_2, and plug in SB_2.

SB_3 in Rest Room has controls for TL_3 & F_2.

The ceiling height is 3.1 M from floor level.

Load	*Description*	*Length in Mts.*	*Total Length in Mts.*
Drawing Room			
OL_1	From SB_1 to wiring height	1.45	
	wiring height to Jn_1 (2 + 1)	3.00	
	Jn_1 to CROL1 (down)	0.30	
		4.75	
F_1	From SB_1 to Jn_1 (1.45 + 3.0)	4.45	
	Jn_1 to ceiling (up)	0.30	
	Ceiling to CRF_1	2.00	
		6.75	
TL_1	From SB_1 to CRF_1 (4.45 + 0.30 + 2.00)	6.75	
	CRF_1 to $CRTL_1$ (2 + down 0.3)	2.30	
		9.05	20.55
Kitchen			
SB_2	From SB_1 to Jn_1 (1.45 + 2.0 + 1.0)	4.45	
	Jn_1 to F to F_1 to G (Jn_2) to SB_2 (down)	3.75	
	1.0 + 0.3 + 1.0 + 1.45 = 35	8.20	
OL_2	" SB_2 to OL_2	1.00	
	(The pendant holder for OL_2 is fixed on the Same line of wiring)	9.20	
OL_3	" SB_2 to Jn_2 to F_1 to H to I to $CROL_3$	5.75	
	1.45 + 1.0 + 2.0 + 1.0 + 0.30 = 5.75		
TL_2	" SB_2 to Jn_2 to $CRTL_2$	5.45	
	1.45 + 3.0 + 1.0 = 5.45		
		11.20	20.40
		C.O.	40.95

Rest Room

			B.F.	
To SB_2	From	Jn_2 to J to B_1 to SB_2 3.0 + 1.0 + 0.3 + 1.45 = 5.75	5.75	40.95
TL_3	From	SB_3 to B_1	1.45	
	From	SB_3 to B_1 to Ceiling to F_2 1.45 + 0.30 + 1.0 = 2.75	2.75	9.95
				50.90

Total 50.90 Mts.
Add 10%5.09

55.99 Or say 56.0 Mts.

For Neutral Wire

Drawing Room

OL_1	From	SB_1 to $CROL_1$ 1.45 + 2.0 + 1.0 + 0.3 = 4.75	4.75
F_1	From	Jn_1 to CRF_1 0.30 + 2.00 = 2.30	2.30
TL_1	From	CRF_1 to $CRTL_1$ 2.00 + 0.30	2.30

Kitchen

OL_2	From	Jn_1 to *F* to *G* to G_1 (Jn_2) to OL_2 1.0 + 1.0 + 0.3 + 0.45 = 2.75	2.75
OL_3	From	Jn_2 to F_1 to H to I to OL_3 1.0 + 2.0 + 1.0 + 0.45 = 4.45	4.45
TL_2	From	Jn_2 to J to B ($CRTL_2$) (3.0 + 1.0 = 4.0)	4.00
Plug	From	OL_2 to plug in SB_2 (1.0)	1.00

Rest Room

TL_3	From	$CRTL_2$ to $CRTL_3$	0.30
F_2	From	$CRTL_3$ to ceiling to CRF_2 (0.30 + 1.00 = 1.30)	1.30
		Total length	23:15 m

Add 10% = 23.15 + 2.315 = 25.465 say 26.0 Mts.

∴ For circuit 1, the length of cable required for both Ph. & Neutral ∴ 56.0 + 26.0 = 82.0 Mts.

To find the voltage drop in the line we take the tail end of this circuit i.e. F_2 in rest room. The actual length of the cable from SB is calculated as follows :

Actual wiring length of CRF_3 from SB_1

Phase lead

From SB_1 to Jn_2	
1.45 + 2.0 + 2.0 + 0.3 + 1.0	6.75 Mts.
From Jn_2 to CRF_2	8.50
3.0 + 1.0 + 0.3 + 1.45 + 1.45 + 0.3 + 1.0 = 8.50	
	15.25 Mts.

Neutral

From SB1 to Jn2 to B1 (6.75 + 3 + 1 + 0.3)	11.05 M
From B1 to CRF2 (0.3 + 1.0 = 1.3)	1.30
Total	12.35 M

Hence total length of cable = 15.25 + 12.35 = 27.60
= 27.6 + 2.76 = 30.36 or say 31.0 Mts.

Add 10 %

The maximum current at any time will be $\frac{806}{230} = 3.5$ Amps.

The designing current will be $\frac{3.5 \times 1.5}{0.8} \approx 6.6$ Amps.

Where 0.8 is the Temperature rating factor

∴ SWG 1/18, 1.0 mm^2 copper or SWG 1/18, 1.5 mm^2 Al can be selected for this current.

For 1.5 mm^2 Al. Cable, the drop will be $6.6 \times 19.7/1000 \times 31 = 4.03$ volts.

This is well within limits. Hence we can select,

1.5 mm^2, 1/18 SWG, 1.1 KV grade 1/1.4, 19.7 ohms/KM Aluminium cable

OR

1.0 MM^2, 1/18 SWG, 650/1100 V grade, 1/1.12, 17.7 ohms/KM, Copper cable

OR

1.0 mm^2, 1/18 SWG, 1.1 KV grade, 14.03, 18.84 ohms/KM copper cable can be used.

Circuit-2 : Bed Room, Bath Room and Toilet Room, including one plug in Bed Room

Note : 1. SB_4 in kitchen, SB_5 in Bed room, each have 2 Nos. of 2 Way switches to control lamps in Bath & Toilet Rooms. (OL_4 & OL_5).

2. SB_6 in Bed Room has controls for OL_6, TL_3, F_3 & plug in SB_6.

Phase Lead :

Load	*Description*	*Length in Mts.*
To SB_4	From by the side of SB_1 to wiring height (up) to point A to F to F_1 to H to K (Jn_3) to SB_4 1.45 + 2.0 + 2.0 + 0.3 + 2.0 + 2.0 + 1.45 = 11.20	11.20
Bed Room		
To SB_5	From SB_4 to K, (Jn_3), to K′(Jn_4) to L to M to SB_5 1.45 + 0.3 + 0.5 + 1.5 + 1.45 = 5.20 Here we need 4 times this length, since 2 nos. of 2 way switches : 5.20 × 4 = 20.80	20.80
To SB_6	From Jn_3 (K) to K′ to N to SB_6 (down) 0.3 + 1.5 + 1.45 = 3.25	3.25
TL_4	From SB_6 to N to ceiling to P to $CRTL_4$ 1.45 + 0.3 + 3.0 + 0.3 = 5.05	5.05
OL_6	From SB_6 to $CRTL_4$ to Q to OL_6 5.05 + 2.0 + 1.5 = 8.55	8.55
F_3	From SB_6 to N to ceiling to CRF_3 1.45 + 0.3 + 1.5 = 3.25	3.25
	Total	52.10 m

Add 10% = 52.10 + 5.21 = 57.31 say 58 Mts.

Neutral

To Jn_3	From by the side of SB to wiring height to A to F to F_1 to H to H_1 to L_1 to Jn_5 1.45 + 2.0 + 2.0 + 3.0 + 2.0 + 0.3 + 1.5 + 1.5 = 11.05	11.05
OL_4	From Jn_5 to $CROL_4$	0.75

	From $CROL_4$ to Jn_5 (M) to M to SB_5 0.75 + 0.3 + 1.45 = 2.50		2.50
OL_5	From Jn_5 to OL_5		0.75
	$CROL_5$ to Jn_5 (M_1) to M to SB_5 0.75 + 0.3 + 1.45 = 2.50		2.50
Plug in SB_5	From Jn_5 to M to L to Jn_4 to N Jn_5 to SB_5 0.3 + 1.5 + 0.5 + 1.5 + 1.45= 5.25		5.25
F_3	From Jn_6 to CRF_3	: 0.3 + 1.5= 1.8	1.8
TL_4	From CRF_3 to $CRTL_4$	: 1.5 + 0.3= 1.8	1.8
OL_6	From $CRTL_4$ to OL_6	: 2.0 + 1.5= 3.5	3.5
		Total	29.85 m

Add 10% : 29.85 + 2.98 = 32.83 or say 33.0 Mts.

Total length of cable for circuit 2 is : 58.0 + 33 = 91.0 Mts.

To find the voltage drop we take the tail end of the circuit and assume a maximum current of 6.6 Amp in this circuit.

Tail end length

Phase leas

Phase lead	: From SB_1 to SB_5 to $CROL_5$ 1.45 + 2.0 + 2.0 + 0.3 + 2.0 + 2.0 + 0.3 + 1.5 + 1.45 + 1.45 + 0.3 + 3.0 + 0.3 + 2.0 + 1.5 = 21.55	21.55
Neutral	: From SB_1 to K(Jn_3) to Jn_4 to CRF_3 to $CRTL_4$ to OL_5 1.45 + 2.0 + 2.0 + 0.3 + 2.0 + 2.0 + 0.3 + 1.5 + 0.3 + 1.5 + 1.5 + 0.3 + 2.0 + 1.5 = 18.65	18.65
	Total	40.20 M

Add 10% → 40.20 + 4.02 = 44.22 or say 45.0 Mts.

Taking the designing current as 6.6 Amps, we calculate for 1/18 SWG for 1/18 SWG, 1.5 mm^2 Al., 19.7 Ω/KM cable, the voltage drop will be

$$66 \times \frac{19.7}{1000} \times 45 \approx 5.85 \text{ Volts.}$$

Hence we select 1/18 SWG 1.0 mm², 14/0.3, 18.84 Ω/Km multistrand cable or 1/18 SWG 1.0 mm², 1/1.12, 17.70 Ω/Km cable

Circuit-3 **PLUGS IN DRAWING HALL**

Load	*Description*	*Length in mts.*
Plug P_1	From by the side of SB to wiring height to point A to plug point (down) 1.45 + 2.00 + 1.45 = 4.90 For both phase and Neutral : 4.90 × 2 = 9.80	9.80
Plug P_2	From by side of SB to wiring height to point C to plug point (down) 1.45 + 2.00 + 1.45 = 4.90 for both Ph. and N = 4.90 × 2 = 9.80	9.80
	Total	19.60
	Say	20.00 M

Add 10 % = 20.00 + 2.00 = 2 Mts.

Since each plug is rated for 500W only we select minimum size of copper cable 1.0 Sq. mm SWG 1/18, 14/0.3 multistrand Finolex or 1.0 Sq. mm, SWG 1/18, 1/1.12 single strand cables from other firms like 'SIEMENS' 'POLYCAB' 'INCAB' etc.

Circuit-4 **PLUGS IN BATH ROOM ONLY**

Plug 1500 w	: From by the side of SB to points (Via A, F, F_1, H, H_1, L_1) 1.45 + 2 + 2 + 0.3 + 2 + 0.3 + 2 + 0.3 + 1.5 + 0.75 = 10.30	10.30
	From point S to plug (Down)	1.45
	Total	11.75 m

Total length required for Ph. and N = 11.75 × 2 = 23.50 m
Add 10% = 23.50 + 2.35 = 25.85 or say 26.0 Mts.

Equipment current $I = \frac{1500}{230} = 6.52$ amps. and the designing

Current $= \frac{6.52}{0.8} \times 1.5 = 12.22$ amps

For SWG 3/22 Cu, Resistance = 11.47 Ω/KM

For 26 Mts. Resistance $= \frac{11.47 \times 26}{1000} = 0.298$ ohm

The line drop $= 0.298 \times 11.47 \approx 3.6$ volts.

This is less than the permitted drop

Therefore 1.6 mm², SWG 3/22, 23/0.3 multistrand FINOLEX cable or 1.5 mm², SWG 3/22, 3/0.73 or 1/1.38, 1.1KV, PVC sheathed or Butyl or EP or Silicon Rubber Insulated Cables manufactured by other firms like "Polycab", "Gemscab", "Incab" "Siemens" etc. can be used.

Length of Reaper Required

Circuit 1.

1. Drawing Room

From SB_1 to wiring height : 3 - 1.35 - 0.2	= 1.45 M (up)	
(assumption 5 & 6)	= 2.00	
From wiring height to point A	= 1.00	
From point A to Jn_1	= 0.30	
From Jn_1 to Ceiling (up)	= 0 30	
From Jn_1 to $CROL_1$ (down)	= 2.00	
From Ceiling to CRF_1	= 2.30	
From CRF_1 to $CRTL_1$		
From Jn_1 to G	= 0.30	9.65 M

2. Kitchen

From Jn_2 to SB_2	= 1.45	
Jn_2 to OL_3 [1 + 2 + 0.3 (down)]	= 4.30	
Jn_2 to $CRTL_2$ (3 + 1)	= 4.00	
3. Rest Room		
$CRTL_3$ to SB_3 (down)	= 1.45	11.20
	11.20	20.85 M

Add 10% = 20.85 + 2.85 = 23.70 or Say 24.0 M.

Circuit 2

From by the side of SB_1, to Jn_4 (Via) A, F, F', H, H', L to Jn_4	11.05
Ref. under Neutral of Circuit 2	
From L to K to SB_4 (0.5 + 1.45 = 1.95)	1.95
From L to M	0.75
From Jn_3 to N to SB_6 (1.5 + 1.45 = 2.95)	2.95
From N to Ceiling to P to Q to R (0.3 + 3.0 + 2.0 + 1.5 = 6.8)	6.80
Total	23.50 M

Add 10% = 23.50 + 2.35 = 25.85 or say 26.0 Mts.

Circuit 3

From by the side of SB to Jn_4	11.05
From S to Plug point	1.45
	12.50

Add 10% = 12.50 + 1.25 = 13.75 or say 14.0 Mts.

Circuit 4

From by the side of SB to P_1 (1.45 + 2.00 + 1.45 = 4.90)	4.90
From by the side of SB to P_2 (1.45 + 2.00 + 1.45 = 4.90)	4.90
	9.80

Add 10% = 9.80 + 0.98 = 10.78 or say 11.0 Mts.

ASTRACT - I

Total Length of Cable Required

Circuit 1. 1.0 Sq.mm, 1/18 SWG, 14/0.3, 17.7 ohms/km, 1.1KV grade Multistrand cable	82.0 M
2. —do—	91.0
3. —do—	22.00
Total	195.0
Or Say	200.0 M
4. 1.6 sq. mm, SWG 3/22, 23/0.3, 11.47 ohms/km 1.1 KV grade multistrand cable	26.0 M

ABSTRACT - II

Total Length of Reapers Required :

Circuit 1. 24.0
2. 26.0
3. 14.0
4. 11.0 Total 75.0 Mts.

ABSTRACT - III

LABOUR Charges

Electrician - 1	at Rs. 80/- per day	80.00
Skilled Asst- 2	at Rs. 70/- per day	140.00
Helpers - 2	at Rs. 45/- per day	90.00
		310.00

This job can be completed in 7 days

∴ Total labour charges = 2170.00

DETAILED ESTIMATE

Sl.	Description	Qty.	Rate per	Amount	Remarks
				Rs. P.	
A.	**Main Board Items**				
1.	250V, 30A, I.C. Cut out	1 No.	Rs. 30/- each	30.00	
2.	T.W. Main Switch Board 1.0 × 0.5m	1 No.	Rs. 40/- each	40.00	
3.	250V, 30A, Main Switch	1 No.	Rs. 230/- each	230.00	
4.	250V, 15A, Main Switch	2 No.	Rs. 100/- each	200.00	For Ground &
5.	250V, 15A, 4 Way DB	2 No.	Rs. 380/- each	760.00	First Floors.
6.	Earth link 4 Way	1 No.	Rs. 50/- each	50.00	-do-
7.	2mm², 28/0.3 single core, 1100V grade cable	12 m	Rs. 4.15 per m.	49.80	*for meter board connection*
				1459.80	
B.	**Wiring Materials**				
1.	1.1 KV grade copper PVC 1 mm² (single core)	200 M	Rs. 1200.00 per 100 m	2400.00	As per Abstract I
	1.6 mm² -do-	26 m	Rs. 2.10/- per m	54.60	
2.	Teak Wood Reaper 25mm	76.0 m	Rs. 1.50/- per mtr.	114.00	As per
3.	S.P.T. Switches 250V, 5A (flush)	12 No.	Rs. 96/- per doz.	96.00	Abstract II
4.	Ceiling Roses 250V, 5A, (Bakelite) 2-plate	8 No.	Rs. 48/- per doz	32.00	
5.	Round Blocks 75 mm × 20 mm	24 No.	Rs. 36/- per doz.	72.00	*for fixing ceiling roses TLs etc.*
6.	(i) 3 Pin wall Sockets; 250V, 5A (With switch control)	3 No.	Rs. 9/- each	27.00	
	(ii) .....250V, 15A (With Switch control)	2 No.	Rs. 12.50 each	25.00	
			C.O.	2820.60	

Sl.	Description	Qty.	Rate per	Amount	Remarks
			B.F.	2820.60	
7.	Lamp Holders (Batten-Brass)	6 No.	Rs. 60/- per doz	30.00	
8.	T.W. Switch Box; 0.3m × 0.2m	3 No.	Rs. 6/- each	18.00	
9.	-Do- 0.15m × 0.12m	3 No.	Rs. 35/- each	105.00	
10.	T.W. Jn. Box 0.12m × 0.12 m	6 No.	Rs. 30/- each	180.00	
11.	Link clips 50mm	4 Box.	Rs. 3.50 per Box	14.00	
12.	Nails for link clip.	1 Kg.	Rs. 20/- Kg	20.00	
13.	Screws : 25 mm × 6	24 No.	Rs. 0.33/- each	7.92	Ceiling roses
	30 mm × 8	100 No.	Rs. 38/- per 100 No.	38.00	Reapers
	75 mm × 8	24 No.	Rs. 0.80/- each	19.20	
14.	Rawal Plugs :	200 No.	L.S.	40.00	
15.	Copper No. 14	2 Kg.	Rs. 65/- per Kg	130.00	
16.	Earth pit	1 No.	L.S.	300.00	
			Total	**3712.72**	
			Cost of Main Board items Rs.	1459.80	
			Cost of Wiring Materials Rs.	3712.72	
			Total Rs.	5172.52	
			Sundries 5% Rs.	258.63	
			Sub Total Rs.	5431.15	
			Transport charges 3% Rs.	162.93	
			Total	5594.08	
			Labour charges as per Abstract III Rs.	2170.00	
			Gross Total Rs.	7764.08	
			Contingencies 15% Rs.	1164.08	
			Grand Total Rs.	8928.69	Or say Rs.8929/-

This is for Ground Floor only. The ornamental fittings, T.L. fittings, fans are all extra. There charges are not included in this estimate.

For First Floor, Add the following wiring materials extra.

1.	SWG 3/20, 2.0 mm^2 cable	20.0 Mts.
2.	G.I. pipe 19 mmϕ	5.0 Mts.
3.	G.I. Bend–do–	6 Nos.
4.	G.I. Coupler–do–	4 Nos.
5.	Saddle clamps	24 Nos.
6.	Screws 19 mm × 8	6 Nos.
7.	Earth wire, copper SWG 14	1/2 KG.

The above extra materials are required to take supply from the mains at the entrance of Ground Floor to the entrance of First Floor. The main supply board items at the entrance are already included in the estimate.

The cost of extra materials

1.	SWG 3/20, 2.0 mm^2 PVC cable	20 M	Rs. 3.15	per Mt.	Rs. 63.00
2.	G.I. Pipe 19 mm ϕ	5 M	Rs. 20/-	per Mt.	Rs. 100.00
3.	G.I. Bend 19 mm ϕ	6 No	Rs. 10/-	each.	Rs. 60.00
4.	G.I. Coupler 19 mm ϕ	4 No	Rs. 5/-	each.	Rs. 20.00
5.	Saddle clamp	24 No	Rs. 6/-	per doz.	Rs. 12.00
6.	Wood Screws 20 × 8 mm	60 No	Rs. 30/-	per 100	Rs. 18.00
7.	Earth Wire copper 14 SWG	1/2 Kg	Rs. 65/-	per Kg	Rs. 32.50

Total Rs. 305.50

Add with the wiring material cost of Ground Floor Rs. 3712.72

Total Rs. 4018.22

Sundries 5% Rs. 200.91

Sub total Rs. 4219.13

Transport 3% Rs. 126.37

Labour charges 10% over & above labour charges (Rs. 2170) of ground floor Rs. 2387.00

Gross Total Rs. 6732.70

Contingencies 15% Rs. 1009.91

Grand total Rs. 7742.61

Say Rs. 7743

The total charges

For Ground Floor	Rs. 8929.00
For First Floor	7743.00
Grand total	Rs. 16672.00
Say	Rs. 16675

Spl. Note : The Inspection charges by the Electricity Undertakings from whom the Consumer takes the supply is NOT included. These charges are extra.

Example 5. *A factory of size 36.0 m × 20.0 is to be illuminated, so as to get the illumination of 20 lux at working plane. Estimate the cost for wiring, assuming the necessary data as per I.E. Rules (Incandescent lamps are proposed)*

Electrical Estimate For lighting scheme of a work shop of Floor Area 36.0 × 20.0 m

Given Area of Room : 36.0 × 20.0 = 720.0 sq.m.

Illumination Regd : 20 candles/sq.m.

Assumption made (General) :

1. Depreciation Factor : 0.7
2. Coefficient of utilisation : 0.4
3. Efficiency of lamps : 10.5 lm/watt.
4. Temp. Rating factor : 0.8
5. Designing current of cable = 1.5 × current rating of bulb/Temp. rating factor.
6. Demand factor of lighting load = 0.8

7. No. of points in a lighting circuit not more than 8 or Max. wattage permitted/circuit = 800
8. The height of Meter Board 1.35m from the ground
9. Space height ratio : 1 to 2
10. The voltage drop at tail end is taken as 5.6 volts.

$$\text{Total Illumination required} = \frac{\text{Area} \times \text{level of illumination}}{\text{Coefficient of utilisation} \times \text{Depreciation Factor}}$$

$$= \frac{720 \times 20}{0.4 \times 0.7} = 51428.5 \text{ lumens.}$$

Assuming a moderate efficiency of lamp = 10.5 lumens/watt ....(assumption-3)

Wattage required = 51428.5/10.5 = 5100 watts.

Hence we select 51 No. of 100 W lamps and the following allocation is made.

In each bay	: 18 No.	Total	36 No.
In the passage			9 No.
On the wall having the front entrance			3 No.
On the wall having the back entrance			3 No.
		Total	51 No.

For detailed location of each lamp ref. the sketch shown.

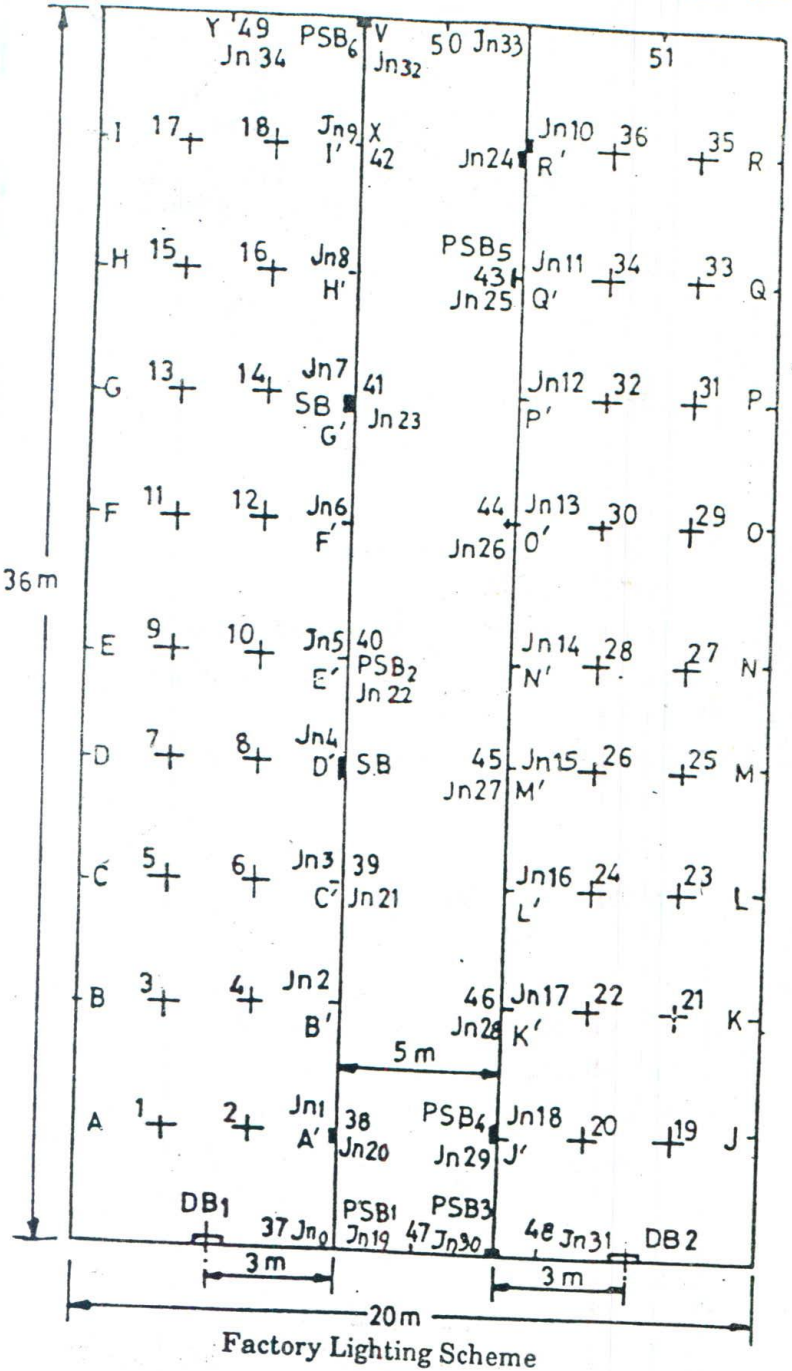
The allotment of phases are as follows :

In the Bays :

R-phase:	Row A, D & G ;	J, M & P.
Y-phase:	Row B, E & H ;	K, N & Q.
B-phase:	Row C, F & I ;	L, O & R.

In the passage :

R-phase :	L–42,	L–43, L–49,	L–50 & L–51
Y-phase :	L–44,	L–45, L–46,	L–47 & L–48
B-phase :	L–37,	L–38, L–39,	L–40 & L–41



Factory Lighting Scheme

Fuse Rating of Distribution Transformers

KVA Rating	11 kV 'D' fuse rating		Fuse on L.T. side			Size of Feeder Cables		
	Ampere Rating	S.W.G. No.	Ampere Rating	S.W.G. No. of Tinned Copper	Full load current on L.T. Side Amp.	No. & dia. in mm	Section area mm^2	permitted load in Amp.
5	2	43	10	33	7.2	7/.914	4.52	23
10	3	41	20/25	28/26	14.5	7/.914	4.52	23
25	5	38	60	21	36	7/1.63	14.52	45
50	7.5	35	120/120	18	72	19/1.63	38.71	82
75	10	33	140/200	2 × 20/2 × 18	108	19/2.11	64.5	118
100	15	30	200/200	2 × 16/2 × 18	145	37/1.83	96.8	151
150	20	28	300	2 × 16	216	37/2.62	193.5	238
200	25	26	320	2 × 15	288	61/2.62	322.6	330
250	30	25			360			
500	50	22			720			

R-Phase :

			Mts.
Row A CR_1 CR_2	From DB_1 to S (wiring height)		2.3 m
	S to Jn_0		3.0 m
	Jn_0 to Beam		0.75 m
	Beam to Jn_1		3.60 m
	Jn_1 to SB_A (down)		2.30 m
	SB_A to Jn_1		2.30 m
	Jn_1 to Top of beam		0.35 m
	Top of beam to CR_1, CR_2		5.00 m
		Total	19.00 m
Neutral :	From DB_1 to Jn		9.65 m
	Jn to CR_1, CR_2 (0.35 + 5.0 = 5.35)		5.35 m
		Total	15.00 m
Row D			
CR_7, CR_8	From Jn_1 to Jn_4	3.6 × 3	10.80 m
	Jn_4 to SB_D		2.30 m
	SB_D to Jn_4		2.30 m
	Jn_4 to CR_7 CR_8		5.35 m
		Total	20.75 m
Neutral :	From Jn_1 to Jn_4 to CR_7 CR_8 (10.8 +5.35 = 16.15)		16.15 m
		Total	36.90 m
Row G :			
CR_{13} CR_{14}	From Jn_4 to Jn_7	3.6 × 3	10.80 m
	Jn_7 to SB_G		2.30 m
	SB_G to Jn_7		2.30 m
	Jn_7 to CR_{13} CR_{14}		5.35 m
		Total	20.75 m
Neutral :	From Jn_4 to Jn_7 to CR_{12} CR_{14} 10.8 5.35 = 16.15		16.15 m
		G. Total	36.90 m

Y-Phase

Row B CR_3 CR_4	Same as Row		A but 3.6 M extra :
	Phase	:	19.60 + 3.60 = 23.20 m
	Neutral	:	15.00 + 3.60 = 18.60 m
Row E CR_9 CR_{10}	Same as Row		D but 3.6 M extra :
	Phase	:	20.75 + 3.60 = 24.35 m
	Neutral	:	16.15 + 3.60 = 19.75 m
Row H CR_{15} CR_{16}	Same as Row		G but 3.6 M extra :
	Phase	:	20.75 + 3.60 = 24.35 m
	Neutral	:	16.15 + 3.60 = 19.75 m

B-Phase

Row C CR_5 CR_6	Same as Row		B, but 3.6 M extra :
	Phase	:	23.20 + 3.60 = 26.80 M
	Neutral	:	18.60 + 3.60 = 22.20 M
Row F CR_{11} CR_{12}	Same as Row		E, but 3.6 M extra :
	Phase	:	24.35 + 3.60 = 27.95 m
	Neutral	:	19.75 + 3.60 = 23.35 m
Row I CR_{17} CR_{18}	Same as Row		H but 3.6 M extra:
	Phase	:	24.35 + 3.60 = 27.95 m
	Neutral	:	19.95 + 3.60 = 23.35 m

PASSAGE : L-37, L-38, L-39, L-40, L-41, L-42

B-Phase Switch controls from L-37 & L-38 are on the same wall of MSB at 3.0 M away from it, towards the passage.

Phase lead	From DB1 to S (wiring height)	2.3 m
	S to Jn_{19} (Horizontal)	3.0 m
	Jn_{19} to PSB, (down)	2.3 m
L-37	PSB_3 to Jn_{19}	2.3 m
L-38	PSB_1 to Jn_{19} to Beam to Jn_{20} at pillar A'	6.65 m
	2.3 + 0.75 + 3.6 = 6.65	

Switch controls for L-39, L-40 and L-41 are in PSB_2 down in the pillar E' facing the passage

PSB_2	From Jn_{19} to Jn_{20} to J_{n21} to Jn_{22} to PSB_2	21.05 m
	0.75 + 3.7 + 7.2 + 7.2 + 2.3 = 21.05	

L-39	From PSB_2 to Jn_{22} to Jn_{21} (2.3 + 3.6).	= 5.9 m
L-40	PSB_2 to Jn_{22}	2.3 m
L-41	PSB_2 to Jn_{22} to Jn_{23} (2.3 + 7.2 = 9.5)	9.5 m
		Total 55.30 m

Neutral :

L-37	From MSB to Jn_{19}	5.30 m
L-38	Jn_{19} to Beam to Jn_{20} (0.75 + 3.6)	4.35 m
L-39	Jn_{20} to L-39 at Jn_{21}	7.20 m
L-40	Jn_{21} to L-40 at Jn_{22}	3.60 m
L-41	Jn_{22} to L-41 at Jn_{23}	7.20 m
		Total 27.65 m

Y-Phase : L-48, L-47, L-36, L-45, L-44

PSB_3	From DB_2 to T (wiring height)	2.3 m
	T to Jn_{31} (Horizontal)	3.0 m
	Jn_{31} to PSB_3 (down)	2.3 m
L-48	From PSB_3 to L-48 at Jn_{31}	2.3 m
L-47	From PSB_3 to L-47 at Jn_{30}	3.25 m
		13.15 m

switch control at pillar J_1 PSB_4 facing the passage controls L-46, L-45 and L-44.

		B.F. 13.15 m
PSB_4	From Jn_{30} to beam	0.75 m
	Beam to pillar J_R (Jn_{29}) to PSB_4 (down)	5.90 m
L-46	From PSB_4 to Jn_{29} to Jn_{28}	3.60 m
L-45	From PSB_4 to Jn_{29} to Jn_{28} to Jn_{27} 2.3 + 3.6 + 7.2 = 13.1	13.1 m
L-44	From PSB_4 to Jn_{27} to Jn_{26} 13.1 + 7.2	20.3 m
		56.0 m

Neutral :

Neutral for L-48, L-47, L-46, L-45 and L-44 are tapped off from Jn_{31}

L-48	From DB_2 to Jn_{31} (L-48) (2.3 + 3.0)	=	5.3 m
L-47	Jn_{31} to Beam to Jn_{30} (L-47) (0.75 + 2.5)	=	3.25 m
L-46	Jn_{31} to Beam to Jn_{29} to Jn_{28} (L-46) (0.75 + 3.6 + 3.6)	=	7.95 m
L-45	Jn_{28} to Jn_{27} (L-45)		7.2 m
L-44	Jn_{27} to Jn_{26} (L-44)		7.2 m
			30.90 m

R-Phase :

	From DB_2 to T (wiring height)		2.30 m
	T to Beam		3.75 m
	Beam to Jn_{25} (Via) J', K', L', M', N', O', P', Q',		28.80 m
	Jn_{25} to PSB_5		2.30 m
L-43	From PSB_5 to Jn_{25} (L-43)		2.30 m
L-42	PSB_5 to Jn_{25} to R' to Jn_{24} (2.3 + 3.6 + 5.0)	=	10.90 m
PSB_6	Jn_{25} to R' to X to U (Jn_{32}) to PSB_6 (down) (3.6 + 3.6 + 0.75 + 2.3 = 10.25)		10.25 m
			60.60 m
L-51	From PSB_6 to Jn_{32} to L-51 (2.3 + 3.75)	=	6.05 m
L-50	PSB_6 to Jn_{32} to X to L-50 (2.3 + 0.75 +2.5 = 5.55)		5.55 m
L-49	PSB_6 to Jn_{32} to X to Y to Jn_{34} (2.3 + 0.75 + 5.0 + 3.75 = 11.80)		11.80 m
			84.00 m

Neutral : For L-43, L-42, L-49, L-50, L-51

L-43	From DB_2 to T to beam to Jn_{25} (2.3 + 3.75 + 28.80 = 34.85)	34.85 m

L-42	Jn_{25} to R' to Jn_{24} (3.6 + 5.0 = 8.6)	8.60 m
L-51	R' to X to L-51 (Via Jn_{32}) (3.6 + 3.75 = 7.35)	7.25 m
L-50	Jn_{32} to X to Jn_{33} (L-50) (0.75 + 2.5 = 3.25)	3.25 m
L-49	Jn_{32} to Jn_{34} (L-49) (2.5 + 3.75 = 6.25)	6.25 m
		60.30

ABSTRACT I

R-Phase	Row	A :	19.6 + 15 = 34.6 Mts.
		D :	20.75 + 16.15 = 36.9 m
		G :	20.75 + 16.15 = 36.9 m
Y-Phase :	Row	B :	23.20 + 18.60 = 41.80 m
		E :	24.35 + 19.75 = 44.10 m
		H :	24.35 + 19.75 = 44.10 m
B-Phase :	Row	C :	26.80 + 22.20 = 49.0 m
		F :	27.95 + 23.35 = 51.3 m
		I :	27.95 + 23.35 = 51.3 m
			390.00 m
	For Both Bays		780.00 M
Passage:	B-Phase		51.70 + 24.05 = 75.75 m
	Y-Phase		56.80 + 30.90 = 87.70 m
	R-Phase		84.00 + 60.30 = 144.30 m
			1087.75 Or Say 1088.0 M

Voltage Drop Calculations :

For voltage drop calculations, we take B phase ie. Row C, Row F and Row I, since this is the tail and row.

Row C : Length of cable from DB_1 to Jn_3 ..... 37.0 M

2.30 + 3.75 + 10.8 = 16.85

For Both Ph. and N. : 33.70 + 10% = 37.0 Mts.

The maximum current in this section = $\frac{600}{230} \times \frac{1.5}{0.8} = 5.0$ A

Selecting SWG 3/22, 1.6 mm², 23/0.3, 11.4Ω/KM.

The voltage drop = $5 \times \frac{11.4}{1.000} \times 37.0 = 2.12$ volts.

Row F : Both ph. & N. are tapped off from Jn_3.

$\therefore$ From Jn_3 to Jn_6 : $10.8 \times 2 = 21.6 + 10\% = 24.0$ M

The maximum current in this section = $\frac{400}{230} \times \frac{1.5}{0.8} = 3.24$ Amp.

Selecting SWG 1/18, 1.0 mm², 14/0.3, 18.84Ω/KM.

The voltage drop = $3.24 \times \frac{18.84}{1000} \times 24.0 = 1.474$ volts.

Row I : The current in this section = $\frac{200}{230} \times \frac{1.5}{0.8} = 1.7$ Amps

Both ph. & N. are tapped off from Jn_6

Selecting SWG 1/18, 1.0 mm², 14/0.3, 18.84 Ω/KM.

$= 1.1 \times \frac{18.84}{1000} \times 24 = 0.768$ volts.

The voltage drop in the section Jn_9 to SB_1 and from SB_1 to CR_{17}

The length of cable = 2.30 + 2.30 + 0.35 + 5.0 = 9.95 m

The Neutral from Jn_9 to CR_{17} = 0.35 + 5.0 = 5.35 m

Total	15.30 m
Add 10%	1.53
Total≈	17.0 Mts

The voltage drop = $\frac{1.7 \times 17.0 \times 18.84}{1000} = 0.544$ volts

Adding this drop with the drop from DB to Jn_9

$= 2.12 + 1.47 + 0.768 + 0.544 = 4.9$ volts.

This is well within limits.

Hence the following sizes of cables are selected.

R-phase From DB to Jn_1 – SWG 3/22, 23/0.3	21.0 M
Y-phase From DB to Jn_2 – SWG 3/22, 23/0.3	29.0 M
B-phase From DB to Jn_3 – SWG 3/22, 23/0.3	37.0 M
Total	87.0 M

For both bays ; $87.0 \times 2 = 174.0$ Mts.

SWG 1/18, 1.0 mm², 14/0.3 = 780 – 174 = 606 Mts

PASSAGES

For B-phase

From DB_1 to wiring height to Jn_{19} to Beam to Jn_{20} (2.30 + 3.00 + 0.75 + 3.6) 9.65 m

For Phase & Neutral 19.30 m

Add 10% 1.93 m

21.23

Or Say 21.0 M

The current in this section will be $= \frac{500}{250} \times \frac{1.5}{0.8} = 4.0$ Amps

For 1/18 SWG, the voltage drop $= \frac{4.0 \times 21.0 \times 18.84}{1000} = 1.582$ volts

The remaining section from Jn_{20} to Jn_{22} (75.75 - 21.0 = 54.75 Mts.) will have a current of 2.45 Amps. and the

Corresponding voltage drop $= \frac{2.45 \times 54.75 \times 18.84}{1000} = 2.528$ volts

∴ Total voltage drop = 1.582 + 2.528 = 4.110 volts, which is less than 5.16 V permitted.

Based on similar calculations, we select 1/18 SWG for Y-phase.

And for R-phase we select 3/20 SWG from DB_2 to Jn_{24} 99.0 M

And for the remaining 45.3 M, 3/22 SWG is selected

For passages :

R-phase SWG 3/20, 28/0.3, 2.0 mm^2 — 99.00 M

Y-phase SWG 3/22, 23/0.3, 1.6 mm^2 — 45.30 M

B-phase SWG 1/18, 14/0.3, 1.0 mm^2 — 87.70 M

SWG 1/18, 14/0.3, 1.0 mm^2 — 75.75 M

ABSTRACT II

SWG 1/18, 14/0.3, 1.0 mm^2

606.0 M for Bays

163.45 M for Passages

769.45 or say 770.0 M

SWG 3/22, 23/0.3 1.6 mm^2

174.0 M for Bays

45.3 M for Passages

219.0 M

Say 220.0 M

SWG 3/20, 28/0.3, 2.0 mm^2 98.0 M for passages.

Say 100 M

SWG 7/22, 44/0.3, 3.0 mm^2 20.0 M

length of C.I. Conduits Required :

R-phase	**Row A** From DB to wiring height-(S)	2.30 m
	S to Jn_0	3.00 m
	Jn_0 to Beam	0.75 m
	Beam to Jn_1	3.60 m
	Jn_1 to SB_A	2.30 m
	Jn_1 to top of beam	0.35 m
	Top of beam to CR_1 CR_2	5.00 m
		17.30 m
	Row D From Jn_1 to Jn_4	10.80 m
	Jn_4 to SB_D	2.30 m
	Jn_4 to CR_7 CR_8	5.35 m
		18.45 m
	Row G From Jn_4 to Jn_7	10.80 m
	Jn_7 to SB_G	2.30 m
	Jn_7 to CR_{13} CR_{14}	5.35 m
		18.45 m

Y-phase :

Row C : Same as Row A but 3.6 M extra : 17.30 + 3.60 = 20.90 m

Row F : Same as Row D but 3.6 M extra : 18.45 + 3.60 = 22.05 m

Row I : Same as Row G but 3.6 M extra : 18.45 + 3.60 = 22.05 m

B-phase

Row C : Same as Row F but 3.6 M extra : 20.90 + 3.60 = 20.90 m

Row F : Same as Row D but 3.6 M extra : 22.05 + 3.60 = 25.65 m

Row I : Same as Row H but 3.6 M extra : 22.05 + 3.60 = 25.65 m

Passages :

B-phase :

From	DB_1 to S (wiring height)	2.30 m
	S to Jn_{19} (Horizontal)	3.00 m
	Jn_{19} to PSB_1 (down)	2.30 m
	Jn_{19} to Beam to Jn_{20} (0.75 + 3.6 = 4.35)	4.35 m

Jn_{20} to Jn_{21} to Jn_{22} to PSB_2 (3.6 + 7.2 + 7.2 + 2.3 = 20.3)	20.30 m
Jn_{22} to Jn_{23}	7.20 m
	39.45 m

Y-phase :

From DB_2 to T (wiring height)	2.30 m
To to Jn_{31}	3.00 m
Jn_{31} to PSB_3	2.30 m
From Jn_{31} to Jn_{30} (2.5 + 0.75 = 3.25)	3.25 m
From Beam to Jn_{29} to Jn_{28} to Jn_{27} to Jn_{26}	21.60 m
	32.45 m

R-phase :

From DB_2 to T (wiring height)	2.30 m
T to Beam	3.75 m
Beam to Jn_{25}	28.80 m
Jn_{25} to PSB_5	2.30 m
Jn_{25} to R′ to Jn_{24} (3.6 + 5.0 = 8.6)	8.60 m
R′ to X to U (Jn_{32}) to PSB_6 (3.6 + 5.0 + 2.3 = 6.65)	6.65 m
Jn_{32} to L-51	3.75 m
X to Jn_{33} to Y to Jn_{34} (2.5 + 2.5 + 3.75 = 8.75)	8.75 m
Total	64.90 M

ABSTRACT - III

Length of C.L Conduits Required

Bays

R—phase 17.30 + 18.45 + 18.45 = **54.20 m**

Y—phase	20.90 + 22.05 + 22.05 =	64.90 m
B—phase	24.50 + 25.65 + 25.65 =	75.70 m
		194.80 m

For Both bays $194.8 \times 2 = 389.60$ or Say 390.0 Mts.

Passage :

R—phase	64.90
Y—phase	32.45
B—phase	39.45
Total	136.80 or Say 137.00

Total Bays	390.00 M
Passages	137.00 M
Total	527.00 M
Add 10%	52.70 M
Grand Total	579.70 or Say 580 Mts.

Since only 3 leads are taken in each pipe, we take 18 SWG, 25.4 mm dia C.I. pipes. From Bay I to Bay II,

38 mm Φ, 18 SWG
20.0 M

ABSTRACT-IV

Labour Charges

Supervisor	1 at Rs. 100/- per day	Rs. 100.00
Fore man	1 at Rs. 80/- per day	Rs. 80.00
Electrician	2 at Rs. 70/- per day	Rs. 140.00
Helper	4 at Rs. 45/- per day	Rs. 180.00
		Rs. 500.00 per day.

This job can be completed with in 15 days.

∴ For Labour charges Rs. 7500/-

Wiring Materials :

Sl	Description of Materials	Qty.	Rate	Amount Rs.	Remarks
1.	**Multi-strand 1.1KV single core cable**				
(*a*)	1.0 mm², 14/0.3, SWG 1/18	770 M	Rs. 200/- per 100 M	1540.00	as per abstract-II
(*b*)	1.6 mm², 23/0.3, SWG 3/22	220 M	Rs. 350/- per 100 M	770.00	—do—
(*c*)	2.0 mm², 28/0.3, SWG 3/20	100 M	Rs. 600/- per 100 M	600.00	—do—
(*d*)	4.5 mm², 65/0.3, SWG 7/20	72 M	Rs. 900/- per 100 M	648.00	From Bay - I to Bay - II
(*e*)	36/0.193, Twin core silk wire	25 M	Rs. 4/-per M	100.00	For lamps suspension at 0.6M per lamp in bays
2.	C.I. conduits 18 SWG 25.4 mm dia.	580 M	Rs. 10/- per M	5800.00	As per Abstract-III

(Cond.)

Sl.	Description of Materials	Qty.	Rate	Amount in Rs.	Remarks
	38 mm dia	20 M	Rs. 15/- per M	300.00	
3.	C.I. Right Angled Inspection Bends 18 SWG, 25.4 mm Φ	30 Nos.	Rs. 8/- each	240.00	
	38 mm Φ	4 Nos.	Rs. 12/- each	48.00	
4.	C.I. Jn. Boxes, 18 SWG, 4 way for 25.4 mm pipes, 100 mm × 100 mm	36 Nos.	Rs. 12/- each	432.00	
5.	Locking Nuts with washers 25.4 mm dia.	144 Nos.	Rs. 0.75 each	108.00	4 Nos. per Jn. Box
6.	Wooden bushings	12 Nos.	Rs. 1.50 each	18.00	
7.	250 V, 5A, 2 plate ceiling rose (Sturdy PVC)	56 Nos.	Rs. 6.00 each	336.00	
8.	250 V, 5A, SPST, Tumber Switch	30 Nos.	Rs. 7/- each	210.00	
9	250 V, Lamp holders, (Brass, Screw type)	56 Nos.	Rs. 7/- each	392.00	
	Suspension type 36 Nos.				
	Batten type 20 Nos.				

Sl.	Description of Materials	Qty.	Rate	Amount in Rs. P.	Remarks
10.	I.C. Switch Boards 100mm × 100 mm with angles	10 Nos.	Rs. 20/- each	200.00	
11.	Machine screws with nuts washes etc. 6mm Φ, 37.5mm length	250 Nos.	Rs. 1.40 each	350.00	
12.	Wood screws No. 8 20mm long 37.5 mm long	100 Nos. 100 Nos.	Rs. 0.33 Rs.0.48 each	33.00 48.00	
13.	T.W. Rawl Plugs	200 Nos.	Rs. 20/- per 100	40.00	
14.	Insulation Tape (5 M length)	10 Rolls	Rs. 9/- each Roll	90.00	
15.	Saddle Clamps 25.4 mm	18 dozs.	Rs. 6/- per doz.	108.00	
16.	Earth wire Copper No. 14	17 Kg.	Rs. 75/- per kg	1275.00	at 29 Kg/KM length
			Total Rs.	13686.00	

Main Switch Board Items :

Sl.	*Description of Materials*	*Qty.*	*Rate*	*Amount in Rs.*	*Remarks*
1.	T.P.I.C. 600V, 100A Main switch with neutral link	1 No.	Rs. 1170/- each	1170.00	Incoming
2.	—do— 32 A, 500 V	2 Nos.	Rs. 370/- each	740.00	one in each bay
3.	D.P.I.C. 16 A, 250 V	9 Nos.	Rs. 180/- each	1620.00	2 in each bay, 3 for passage
4.	Metallic Flexible Conduit 25.4 mm dia	10 M	Rs. 14/- per M	140.00	
5.	Angle Iron Frame 2.0m × 1 0m	2 Nos.	L.S.	400.00	
6.	500 V, 32 A, 6 way, DB	2 Nos.	Rs. 240/- each	480.00	one in each bay
7.	Multi-Strand SWG 7/20, 65/0.3, 4.5 sq. mm 1.1KV grade (For giving Meter Board Connection)	18 M	Rs. 13/- per M	234.00	
8.	Earth Wire Copper No. 8	2 Kg.	Rs. 75/- per kg	150.00	115 Kg/Km.
9.	Earth Pit	1 No.	L.S.	200.00	
10.	Earthing arrangement	1 No.	L.S.	3400.00	
			Rs.	8534.00	

Total Estimate

1. Wiring Material Cost	=	Rs. 13686.00
2. Supply Board Material Cost	=	Rs. 8534.00
Total	=	Rs. 22220.00
Sundries 5%		Rs. 1111.00
Total		Rs. 23331.00
Contigencies 15%		Rs. 3500.00
Total		Rs. 26831.00
Tool charges 3%		Rs. 805.00
Total for materials		Rs. 27636.00
Transport charges 3%		Rs. 829.00
Labour charges as per abstract IV		Rs. 7500.00
Total		Rs. 35965.00
Over head charges 15%		Rs. 5395.00
G. Total		Rs. 41360.00

Example 6. *A factory hall is 80 m × 25 m. An illumination of 15 lum. (candle per square metre). Assuming a suitable space ratio, calculate the number of lamps required and the candle power of each. The utilization factor is 0.4 and the depreciation factor is 0.7. Sketch the arrangement of lamps proposed. Draw a wiring diagram and estimate the quantity of material required. Assume the efficiency of the lamp in lumens per watt.*

Solution.

Area of the factory hall $= 80 \times 25 = 2{,}000$ sq. m.

Total lumens required in the Hall $= 2{,}000 \times 15 = 30{,}000$

Lumen output of the lamps $= \dfrac{30{,}000}{0.4 \times 0.7} = 1.071 \times 10^5$

Let the lamps be at a height of 3 m. from the floor level, if the space height ratio is 1.3.

i.e. $\dfrac{\text{Space}}{\text{height of lamps}} = 1.3$

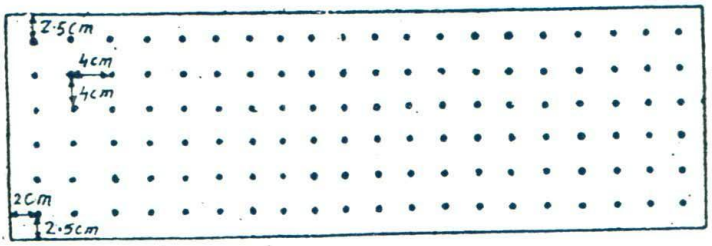
$\therefore$ Space between the lamps $= 1.3 \times 3 = 3.9$, **Say 4 m.**

No. of lamps along the length sides $= \dfrac{80}{4} = 20$ (with 2 m. distance at each end of the row)

No. of lamps along the width $= \frac{25}{4} = 6$ (with $2\frac{1}{2}$ m. distance at the ends)

Total No. of lamps $= 20 \times 6 = 120$

Efficiency of the lamp = 15 lumens per watts



Layout of lamp
Fig. 15.17

Lumen output per watt from these lamps $= 120 \times 15 = 1,800$

Wattage of each lamp $= \frac{1.071 \times 10^5}{1,800} = 59.5,$

Say 60 W.

The scheme of the lamp disposition is given in Fig. 15.17.

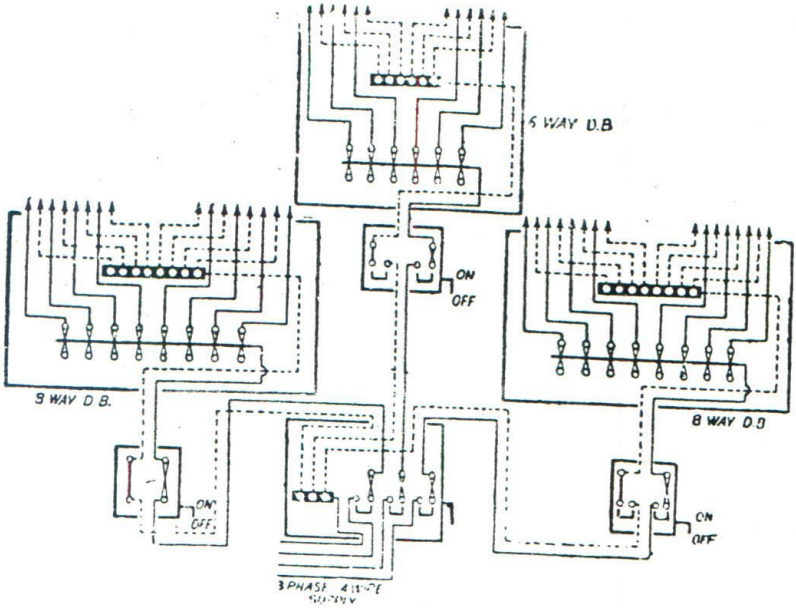
The total wattage of scheme $= 120 \times 60 = 7,200$ Watts.

For this load 3-phase 4-wire system will be most suitable with $\frac{120}{3} = 40$ lamps on each phase.

If the supply voltage is 400 V

Current per phase $= \frac{7,200}{\sqrt{3} \times 400} . [\cos = 1] = 10.4$ A.

So for connection from 3-phase meter to the Main Distribution Board the wire of 10 sq. mm (1/3.55) will be used. From Table 14.1 the current carrying capacity of this cable is 34 amps. From the main distribution board three circuits will be taken out feeding the three sub-main boards with the help of 6 sq. mm (1/2.80) wires. The sub-main distribution boards $S.M.B_1$ and $S.M.B_2$ will be supplying to 7 rows each row having 6 lamps through a 8-way, sub-main distribution board ; the central sub-main distribution board will be supplying to six rows through a 6-way sub-main distribution board.



Arrangement of main distribution board and sub-distribution board

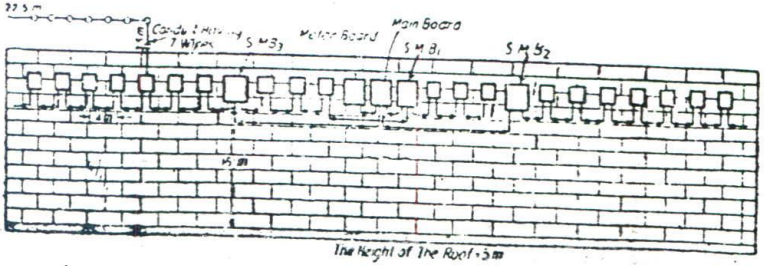
Fig. 15.18

The number of lamps in each circuit = 6

Wattage of each circuit 60×6 = 360 Watts

Although a wire 1.5 sq. mm (1/1.40) will be quite suitable for carrying 5 A, yet for safety purposes, a wire 2.5 sq. mm (1/1.80) will be used. Fig. 15.18 and 15.19 represent the general scheme.

Let for wiring 25.4 mm. heavy gauge conduit be used. The maximum number of wires which can be safely drawn in the conduit

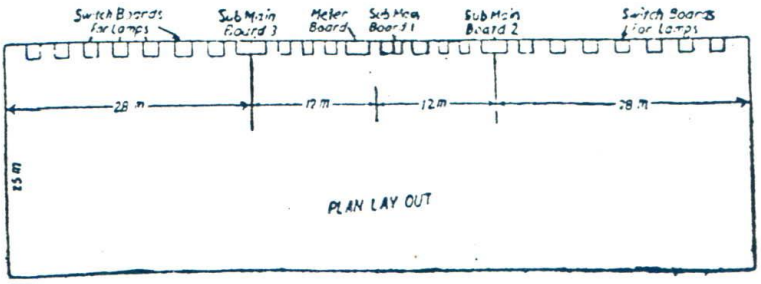


Arrangement of circuits with switches

Fig 15.19

10 sq. mm (1/3.55) wires =5
and 2.5 sq. mm (1/1.80) wires =10

The maximum number of 2.5 sq. mm (1/1.80) wires to be drawn in the conduit are 6 and that 10 sq. mm (1/3.55) are 4, so the said conduit can safely be used.



Representation of Main Switch Boards, Sub Main Boards and Switch Boards
Fig. 15.20

Length of conduit circuit

Length of conduit between Meter Board and Main Board	= 0.5 m
From Main Board to SMB_1	= 0.5 m
Length from SMB_1 to first Switch Board on either side = (4 + 4)	= 8.0 m
Length from Main board to SMB_2	= 9.5 m. app.
Length from Main Board to SMB_3	= 9.5 m. app.
Length from SMB_3 to first Switch Board = (4 + 4)	= 8.0 m
Length from one Switch Board to another = (16 × 4)	= 64.0 m
Length of conduit from one switch board to the lamp in the circuit is (22.5 + 3.5) m. and number of circuits are 20, so total length of conduit used is (20 × 26)	= 520.0 m
	620.0 m
Wastage etc. @ 10%,	62.0 m
	682.0 m

Say 685 m

No. of right angle 25.4 mm. bends = 2 × No. of lengths + 1 × No. of length going to roof
= 2 × 22 + 1 × 22 = 66

No. of inspection circular outlets = No. of bends = 66

Length of V.I.R. 10sq. mm (1/3.55) wire used for Main Distribution Board—

4 × 1 m each = 4 m

Length of V.I.R. 6 sq. mm (1/2.80) wire to be used from Main Board to sub-main board—

For SMB_1	2 × 1 m.	= 2 m
For SMB_2	2 × 12 m.	= 24 m
For SMB_3	2 × 12 m.	= 24 m
		50 m
Wastage etc. @ 10%		5 m
		55 m

Length of P.V.C. 2.5 sq. mm (1/1.80)

From sub-main boards to the individual switch boards 20 × 5 = 100 m.

(One metre extra for connection and through elbows etc.)

For each switch board to the last lamp = [2(22.5 + 3.5 + 2 (extra) = 56]

For all circuits length 20 × 56 = 1120 m

Assuming that 2 m. is the length of wire used in each switch board and each S.M.B. so the total length = (2 × 20 + 2 × 3) = 46 m

1266 m

Wastage (a) 10% 127 m

1393 m

Earth Wire. Since no plug point is to be provided, so there is no necessity of running the earth wire, simply the conduit run should be earthed with the earth provided on the Main Board and care must be taken that the connection between the two individual conduits lengths made must be proper.

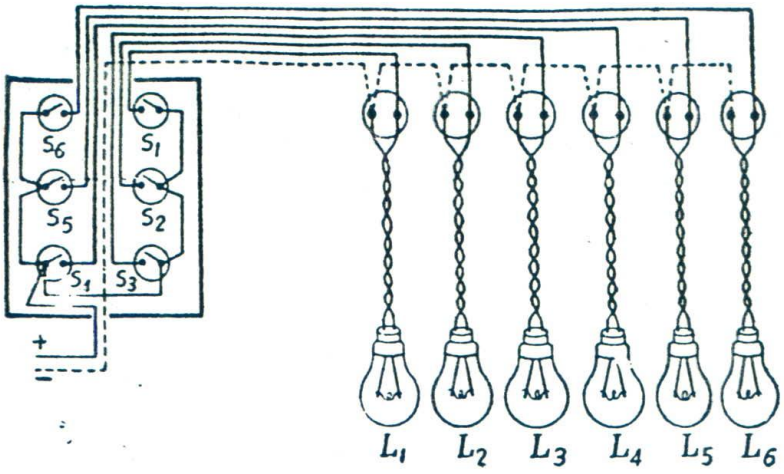


Fig. 15.21.Control of Lamps

The six lamps in one conduit will be controlled by the six individual switches. All the lamps will be of pendant type. Fig. 15.21 represents the circuit for the six lamps. The estimate is given in Table 15.5.

Example 7. *A 7.5 kW, 400 V, 3-phase, 50 c/s motor is to be installed in a workshop, the plan of switch is as shown in Fig. 15.22.*

Show the layout of the wiring and estimate the quantity of material required. The wiring is to be of surface conduit.

Solution.

The wiring can be divided into following sections :

(*a*) Main Board.

(*b*) Main circuit wiring.

(*c*) Starter Board

(*d*) Connections from Starter to Motor.

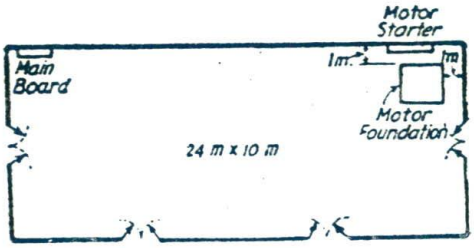


Fig. 15.22

Table 15.5

S. No.	Schedule of Material: Material with specifications	Unit	Qty. reqd.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
1.	Conduit 25.4 mm, dia	m.	685	13	80	m.	9453	00	
2.	P.V.C. 10 sq. mm (1/3.55) 7/18	m.	4	1200	00	coil of 100 m.	48	00	
3.	P.V.C. 6 sq. mm (1/2.80) 7/20	m.	55	720	00	coil of 100 m.	396	00	
4.	P.V.C. 2.5 sq. mm (1.80) 3/22	m.	1400	225	00	coil of 100 m.	3150	00	
5.	Flexible wire 23/.193	m.	240	165	00	coil of 100 m.	396	00	2 m. for each lamp
6.	Right angle bends 25.4 mm with cover	No.	66	30	00	Doz.	165	00	
7.	25.4 mm couplers	No.	240	60	00	Doz.	1200	00	Approx. 1 for every 3 m. length
8.	Circular inspection boxes two-way	No.	66	48	00	Doz.	264	00	To facilitate drawing of the wires
9.	Circular outlet boxes two-way	No.	100	30	00	Doz.	250	00	
10.	Circular outlet boxes as above but with single outlet	No.	20	26	00	Doz.	43	35	
11.	Locknuts 25.4 mm dia.	No.	724	36	00	Gross	181	00	4 for 2-way outlets 8 for Main Board 4 for Sub-Main Board
						C.O.	14466	35	

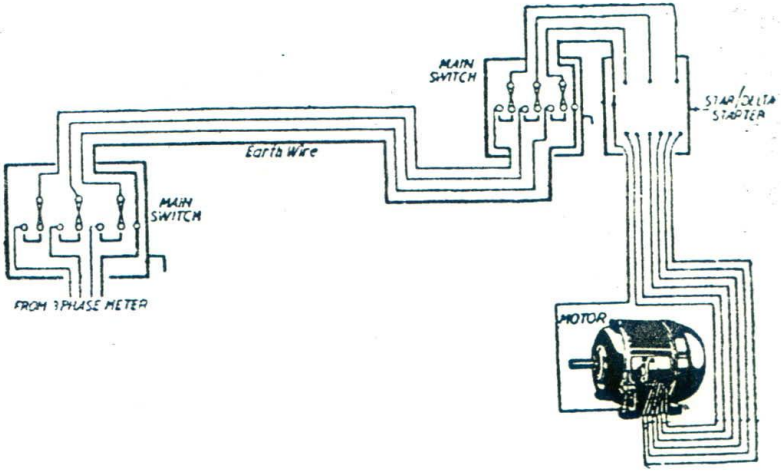
(Contd.)

S. No.	Schedule of Material: Material with specifications	Unit	Qty. regd.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
						B.F.	14466	35	
12.	Bushing 25.4 mm. dia.	No.	362	15	00	100 Nos.	48	30	Half the No. of lock-nuts
13.	Ceiling Rose 2 plate (backelite)	No.	120	48	00	Doz.	480	00	
14.	T-W Round Blocks 8 cm × 2.5 cm.	No.	120	36	00	Doz.	360	00	
15.	5A, tumbler switches (flush type)	No.	120	96	00	Doz.	960	00	
16.	M.S. Box 15 cm × 20 cm. with masonite cover	No.	20	12	00	Each	240	00	To accommodate 6 switches
17.	M.S. Main Board 25 cm × 30 cm.	No.	1	30	00	Each	30	00	
18.	M.S. Sub-Main Boards 20 cm × 30 cm.	No.	3	20	00	Each	60	00	
19.	T.P.I.C. (Triple pole iron clad) Main switch with neutral 500 V 30 A	No.	1	370	00	Each	370	00	
20.	D.P.I.C. Main switch 250 V, 15A	No.	3	100	00	Each	300	00	
21.	I.C. Distribution fuse board 15A, 250 V, 8-way	No.	2	210	00	Each	420	00	
22.	I.C. Distribution fuse board 15A, 250 V, 6-way	No.	1	170	00	Each	170	00	
23.	Wooden screws								
	(a) 2.5" × 10 for boards	Pkt.	1.5	60	00	Pkt of 100 Nos.	90	00	
	(b) 1.5" × 8 for round blocks	Pkt.	1.5	48	00	Pkt of 100 Nos.	60	00	
	(c) 3/4" × 4 for switches	Pkt.	1.5	28	00	Pkt of 200 Nos.	42	00	
						C.O.	17826	75	

S.No.	Schedule of Material Material with specifications	Unit	Qty. reqd.	Cost Rates Rs.	P.	Per	Total cost Rs.	P.	Remarks
24.	Machine screws	Pkt	1.5	6	00	B.F. Pkt. of 100 No.	17826 9	75 00	
	Lump sum provision for cement, sand and other civil engineering materials						300	00	
	Total No. of points 128 Labour at the rate of Rs 20.00 per point, taking board main and sub-main board as two points						2560	00	
	Add contingencies at the rate of 10%						20695 2069	75 57	
	Total						22765	32	
	Hence the estimated cost of wiring is Say Rs. 22765								

Before starting with the estimate, it is necessary to mention here the provisions to be provided with before connection to such installations is made under Rules 51 and 22 of Indian Electricity (Refer Appendix).

The electrical circuit for the scheme is given in Fig. 15.23.



Circuit diagram for the scheme
Fig. 15.23

$$\sqrt{3}\, E I. \cos\phi \times \eta = \text{Motor output}$$

Let the efficiency of the motor be 0.85 and its power factor be 0.8, so the Motor current

$$I = \frac{7.5 \times 1000}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 15.9\text{A}.$$

From Table 14.1 a single core 4 sq. mm (1/2.24) wire will carry safely a current of 17 A, but the momentary starting current is higher about 2 times the full load current, so for safety purposes a P.V.C. wire of 10 sq. mm having a safe current carrying capacity of 31 A will be used. As from the next pages, it will be seen the length of single wire is approx. 43.34 metres and from Table 14.1 the 1 volt drop is there for 5.4 metre run of wire. Thus the voltage drop will be within permissible limits.

The main switch, the motor switch and the starter all will be installed at height of 1.5 m. above floor level ; since there are only 3 wires to be run from main board to motor starter, so 19 mm. conduit is sufficient but for connection between starter and motor 25.4 mm. conduit is to be used since there will be 6 wires :

Length of conduit (19 mm.)—

(*i*) Length from Meter Board to Main Board = 0.25 m

(*ii*) Length from Main Board to Motor Switch = 22.00 m (approx.)

(*iii*) Length from Motor Switch to Starter = 0.25 m

	22.50 m
Wastage etc.	2.50 m
Total	25.00 m

Length of 25.4 mm conduit–

Length from Starter to ground and 0.25 m. below it = 4.25 m

Length up to top of Motor foundations 0.6 m. above floor level = (1 + 0.25 + 0.60) = 1.85 m

	6.10 m
Wastage etc.	0.90 m
Total	7.00 m

Length of 25.4 mm. flexible conduit.—About 1 m. for connecting heavy gauge conduit with motor.

Length of P.V.C. Wire 10 sq. mm (1/3.55)

3 lengths from main switch to Motor Switch = (3 × 22) = 66 m.

3 lengths from Motor Switch to Starter = (3 × 0.5) = 1.5 m.

6 lengths from Starter to Motor (*i.e.*, wire will go through 25.4 mm. conduit and flexible conduit about one metre length) = (6 × 8.5) = 51.0 m.

Total	118.5 m.
Wastage and for terminals @ 10% approx.	11.5 m.
Total length required	1 30 m.

Length of 8 S.W.G. earth wire will be approximately equal to the length of conduit = 25 + 7 = 32 m.

The estimate has been worked out in Table 15.6.

Table 15.6

S.No.	Schedule of Material: Material with specifications	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Per	Total cost Rs.	Total cost P.	Remarks
1.	Heavy gauge 19 mm. dia. conduit	m.	25	10	80	m.	270	00	
2.	Heavy gauge 25.4 mm. dia. conduit	m.	7	13	80	m.	96	60	
3.	Flexible conduit 25.4 mm. dia.	m.	1	14	00	m.	14	00	
4.	Single core P.V.C. Wire 10 sq. mm (1/3.55)	m.	130	1200	00	coil of 100 m.	1560	00	
5.	Conduit bends 19 mm. dia.	No.	2	24	00	Doz.	4	00	
6.	Conduit bends 25.4 mm. dia.	No.	2	30	00	Doz.	5	00	
7.	Conduit saddles 19 mm. dia.	No.	25	9	00	Doz.	18	75	
8.	Conduit saddles 25.4 mm. dia.	No.	7	22	00	Doz.	12	85	
9.	Conduit couplers 19 mm. dia.	No.	9	35	00	Doz.	26	25	approx.
10.	Conduit couplers 25.4 mm. dia.	No.	2	60	00	Doz.	10	00	
11.	Locknut 19 mm. dia.	No.	10	34	00	Doz.	28	35	4 for main board and 2 for motor switches and Starter
12.	Locknut 25.4 mm. dia.	No.	2	36	80	Doz.	6	00	
13.	Flexible pipe joining nipple with Lock Nut	No.	2	2	50	Each	5	00	
14.	Wooden bushings 19 mm.	No.	5	10	00	100 Nos.	0	50	
15.	Wooden bushings 25.4 mm.	No.	3	15	00	100 Nos.	45	00	For Main Board
						C.O.	2102	30	

(Contd.)

S.No.	Schedule of Material: Material with specifications	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Per	Total cost Rs.	Total cost P	Remarks
16.	Angle Iron Board 20 cm × 30 cm.	No.	1	30	00	B.F.	2102	30	
17	Angle Iron Board 30 cm. × 50 cm.	No.	1	45	00	Each	30	00	For Motor Switch and Starter
18.	T.P.I.C. Switch 60 A	No.	1	260	00	Each	45	00	
19.	T.P.I.C. Switch 30 A	No.	1	230	00	Each	260	00	
20.	8 S.W.G.H.D. Bare Copper Wire 30 m. approx.	Kg.	3	16	00	Each	230	00	
21.	Earth Connection					Kg.	48	00	
	(*i*) Copper plate 60 cm. × 60 cm. × 3.18 mm.	No.	1 approx.	250	00	Each	250	00	Since under Indian Electric Rules 2 earths are to be provided, one will be provided by the supplier and other connection will be provided by the consumer.
	(*ii*) 8 S.W.G., hard drawn bare copper 30 m. approx.	Kg.	3	16	00	Kg.	48	00	
	(*iii*) G.I. Pipe 19 mm. dia.	m.	5	12	50	m.	62	50	
	(*iv*) C.I. cover 30 cm × 30 cm.	No.	1	45	60	Each	45	00	
	(*v*) Copper Bolt Nut and Check Nut with washers	No.	2	05	25	Each	10	50	
	(*vi*) Copper lug	No.	1	5	00	Each	5	00	
	(*vii*) Funnel with wire mesh cover	No.	1	3	00	Each	3	00	
	(*viii*) Charcoal	Kg.	10	6	00	Kg.	60	00	
	(*ix*) Salt	Kg.	10	1	50	Kg.	15	00	
	(*x*) Civil Engineering Works and material	–	–	–		–	300	00	Lump sum provision
						C.O.	3511	30	

S.No.	Schedule of Material Material with specifications	Unit	Qty. reqd.	Cost Rates Rs.	P.	Per	Total cost Rs.	P.	Remarks
						B.F.	3511	30	
22.	Lugs for connection of the earth wire with motor	No.	2	3	00	Each	6	00	
23.	Shock Treatment Chart	No.	1	5	00	Each	5	00	
24.	Caution plate and its painting	No.	1	5	00	Each	5	00	
	Lump sum provision for Civil Engineering Works						400	00	
	Labour (assuming that 2 wire men grade 1 and two helpers will furnish the job in 3 days)								
	Wire men grade 1 at Rs. 70 per day						420	00	
	Helpers at Rs. 45 per day						270	00	
							4607	30	
	Contingencies at 10%						460	73	
	Grand Total						5068	03	
	Hence the estimated cost of the work will be Rs. 5068								

Types of Industrial Wiring

Industrial load consists of lighting as well as power load. Accordingly, industrial wiring can be divided into two classes :

1. **Power Wiring.** Power equipment *e.g.* motors (rating more than 2 kW or 3 kW are 3-phase motors and hence require 3-phase supply) installed in an industry requires 3-phase supply. Therefore, power wiring for 3-phase, 3 wire, conduit wiring is done in such cases.
2. **Wiring for Lighting, Fan and Heating.** In industry, light fan and heating circuits are required for obvious reasons and they work on single phase supply. The wiring is done on the same pattern as in domestic installations.

A typical wiring in an industry comprises of

1. 3-phase energy meter
2. Main switch
3. Bus-bar chamber
4. Motor switches
5. Motor starter

Salient features of power wiring :

1. Surface conduit wiring is invariably employed
2. All equipments should be of iron clad construction
3. Every motor should have separate sub-circuit
4. Wood-work should not be used for mounting I.C. switches, control and distribution gear.
5. Double earthing is invariably done.
6. Every motor is provided with a switch placed near it.
7. The length of flexible conduit used for connection between terminal boxes of motors and starters, switches and motors shall exceed 1.25 meters.

Example 8. *An Industrialist is interested to establish an industry as per plan shown in Fig. 15.24. The position of various machines equipment are also shown. Determine the quantity of material required and cost of the same for feeding the power load and as well a for illuminating the factory area.*

Solution.

Details of industrial load are as follows :

South portion of the Industry.

(*i*) **Paint shop** = 10.00 kW

(*ii*) **Black-smith shop** = 25.00 kW

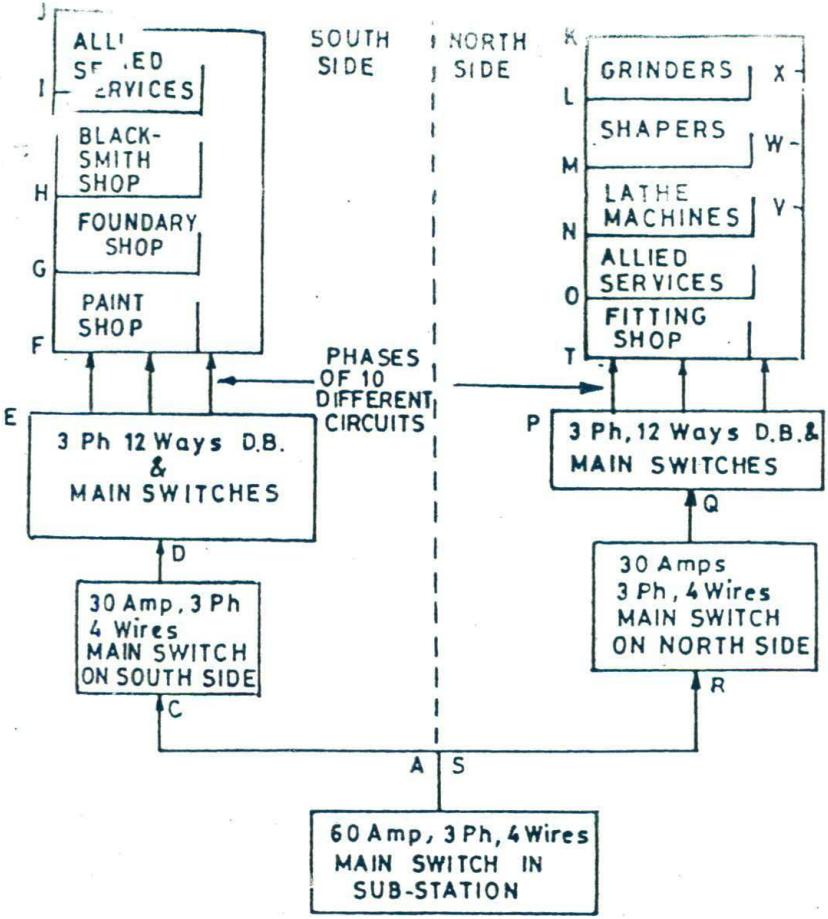


Fig. 15.24. Scheme of Various Work-shops.

(*iii*)	Foundry Shop	= 30.00 kW
(*iv*)	2 motors for allied services	= 45.00 kW
	Total	**110.00 kW**

North portion at the Industry :

(*i*)	Fitting Shop	= 2.00 kW
(*ii*)	Motor for allied services	= 25.00 kW
(*iii*)	Lathes	
	(*a*) 2 kW each, 8 Nos.	= 16.00 kW
	(*b*) 3 kW each, 2 Nos.	= 6.00 kW

(*iv*) Shapers, 3 kW each, 4 Nos. = 12.00 kW

(*v*) grinders, 1.5 kW each, 2 Nos. = 3.00 kW

Total 64.00 kW

Now for designing the electrification scheme assume the following factors :

(*i*) Illumination level = 20 lux

(*ii*) Depreciation factor = 0.75

(*iii*) Utilisation factor = 0.4

(*iv*) Space height ratio = 1.25

In case the height of the electrical fitting is 8 metres from the ground level, then,

$$\text{Nos. of lights fittings along length} = \frac{200}{8 \times 1.25}$$

$$= 20 \text{ Nos.}$$

$$\text{Nos. of lights fittings along width} = \frac{100}{8 \times 1.25}$$

$$= 10 \text{ Nos.}$$

$$\text{Total Nos. of light fittings} = 20 \times 10$$

$$= 200 \text{ Nos.}$$

$$\text{Now flux per fitting} = \frac{20 \times 200 \times 100}{200 \times 0.75 \times 0.4}$$

$$= 6,667 \text{ lumens}$$

Now referring to chapter on illumination, it will be seen that a fluorescent tube of 40 watts have a luminous flux of 2,300 lumens and therefore three Nos. 40 watts tube fittings will be suitable.

∴ The lighting load = **200 × 120 watts = 24 kW.**

In addition 2 Nos. 40 watts pendant fittings is to be provided in each toilet. Hence the total lighting load will be :

$$\text{Total lighting load} = 24 + \frac{5 \times 2 \times 40}{1,000}$$

= 24.4 kW. single phase 230 volts

If these fittings are placed on all the three phase, then total connected three-phase balanced load will be

$$= 110 + 64 + \frac{24.4}{3} = 182.13 \text{ kW}.$$

Assuming 0.8 p.f. for industrial load and unity p.f. for the lighting load.

Total connected KVA = 225.63 KVA

Hence it is suggested that H.T. 11 KV supply may be taken from the State Electricity Department and the same should be stepped down in a substation. The estimate for the sub-station portion has been worked out in the concerned chapter.

Now before starting the calculation for estimating let us assume that there are different feeders or circuits for the following purposes.

(*i*) 150 Amp, three-phase feeder for industrial load on north side of the hall.

(*ii*) 2 feeders of 150 Amps, three-phase for industrial load on south side of hall.

(*iii*) 60 Amp, three-phase, 4-wire feeder for the lighting load.

Power circuits. There will be two feeders separately for south and north portions. It is proposed to use P.V.C. cable running from the substation to the other end of the hall. The cable will be taped in between by a T-joint. From the T-joint the P.V.C. wires in rigid and flexible conduits are taken upon switch and machine or motor respectively. The P.V.C. cable will be tightened along the wall with mild steel clamps of suitable size.

South side.

Total load = 110 kW

Load in amperes $= \frac{110 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 198.5$ amps

As there are to be two feeders for the south side, it is proposed that the feeders should separately feed the following loads :

(1) For feeder or circuit No. 1.

Foundry shop	= 30 kW
Motors for allied services	= 45 kW
Total load	= 75 kW
Load in amperes on feeder No. 1	= 135.3 Amps

From Table 14.8, it will be seen that under ground cable 1,100 volts $3\frac{1}{2}$ core 70 sq. mm will be suitable but considering the high starting current 95 sq. mm cable should be used. The cable from the substation will go towards 20 kW motor through foundry shop. Now, the list of the material to be used to feed the machines and motors will be as follows :

P.V.C. cable $3\frac{1}{2}$ core 95 sq. mm 1,100 volts.

(*a*) From substation to point *A* = 4 metres from feeder panel to the ground + 3 metres a loop + 2 metres from the panel to the wall + 10 metres along the wall towards ceiling + 2 metres upto point *A* + 3 metres for bends.

= 24 metres

(*b*) From point *A* to point *C* = 120 metres

∴ Total length = 144 metres say, 150 metres

(*ii*) *No. of T joints suitable for above cable* = 2 at point *A* and *C*

(*iii*) No. of straight through joint = 1 at point *C*

(*iv*) *P.V.C. wire*

(*v*) *For foundry shop*

$$\text{Load in amperes} = \frac{30 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 54.13 \text{ amps.}$$

From Table 14.1, it will be seen that considering the high starting current *50 sq. mm wire* will be suitable. The length will be

$= 6 \times 5 + 3 \times 15$
$= 30$ metres (in rigid conduit) + 45 metres (in flexible conduit)
$= 75$ metres

For allied services motor 25 kW.

$$\text{Load in amperes} = \frac{25 \times 1,000}{\sqrt{3} \times 400 \times 0.8}$$

$= 46.91$ amps.

From Table 14.1, it will be seen that considering the high starting current, *35 sq. mm* wire will be suitable. The length will be

$= 6 \times 5 + 3 \times 15$
= 30 metres (in rigid conduit) + 45 metres (in flexible conduit)
= 75 metres

(c) For allied services motor 20 kW

$$\text{Load in amperes} = \frac{20 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 36.08 \text{ amps.}$$

From Table 14.1, it will be seen that considering the high starting current, *25 sq. mm wire* will be suitable. *The lengths in the rigid and flexible conduits are same as for (a) and (b) above.*

(*v*) *Conduits*

Purpose	*Length of rigid conduit*			*Length of flexible conduit*		
	51 mm	*38 mm*	*31.8 mm*	*51 mm*	*38 mm*	*31.8 mm*
(*a*) For 50 sq. mm	5	–	–	15	–	–
(*b*) For 35 sq. mm	–	5	–	–	15	–
(*c*) For 25 sq. mm	–	–	5	–	–	15
Total	5	5	5	15	15	15

(*vi*) *Main switches, tripple pole, iron-clad. 100 amps each.* = 3 Nos.

(*vii*) *G.I. wire No. 8* from sub-station to all machines and motors for providing double earth

Length of G.I. wire No 8 = 2(144 + 60) = 408 metres

= 41.17 kg. Say 45 kg.

2. For Feeder or circuit No 2 South side

On this feeder, following load will be connected

(*a*) Paint shop = 10.10 kW
(*b*) Blacksmith shop = 25.00 kW

Total 35.00 kW

$$\text{Total load in amperes} = \frac{35 \times 1,000}{\sqrt{3} \times 400 \times 0.8}$$

= 63.16 amps.

For this load, P.V.C. wire s/c 35 sq. mm will be suitable, but considering the high starting current, P.V.C. wire of 50 sq. mm will used.

Following material will be used on this feeder ·

(i) P.V.C. wire s/c 50 sq. mm.

3×4 metres from the feeder panel to the ground + 3×3 metres as loop + 3×2 metres from the panel to the wall + 3×10 metres along the wall towards ceiling + 3×25 meters from substation to point D + 3×200 metres from point D to F + 3×45 metres from point F to H + 3×15 from point H to J + 3×15 metres as down at points E, G, and J.

Total length = $3 \times 319 = 957$ say 1,000 metres

From Table 14.1, it will be seen that the voltage drop is within the permissible limit, if loaded to the current as calculated above.

(ii) P.V.C. wire 4 sq. mm.

At point E, a main switch tripple pole is to be provided from which connection to 5 kW power hammer are taken.

Current carrying capacity of power hammer

$$= \frac{5 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 9.022 \text{ amps.}$$

From Table 14.1, 4 sq. mm P.V.C. single core wire will be suitable which can also withstand high starting current.

Length of wire = $3 \times 15 + 6 \times 5 = 75$ metres

(iii) P.V.C. wire 25 sq. mm.

At point G, a main switch tripple pole is to be provided from which connection to 20 kW electric oven is taken.

Current carrying capacity of electric oven

$$= \frac{20 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 36.08 \text{ amps.}$$

From Table 14.1, it will be seen that 25 sq. mm. will be suitable.

Length of wire = $3 \times 15 + 6 \times 5 = 75$ metres

(iv) P.V.C. wire 16 sq. mm.

At point J a main switch tripple pole is to be provided, from which connection to 10 kw compressor motor is taken.

Current carrying capacity of compressor motor

$$= \frac{10 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 18.04 \text{ amps.}$$

From Table 14.1, it will be seen that P.V.C. wire single core 16 sq. mm. will be suitable.

Length of wire = $3 \times 15 + 6 \times 5 = 75$ metres

(v) *Conduit length and circular outlet boxes.* Following will be the length of conduit and outlet boxes.

Purpose	*Length of rigid conduit*				*Length of flexible conduit*			*Outlet boxes*	
	51 mm	*31.8 mm*	*25.4 mm*	*19 mm*	*31.8 mm.*	*25.4 mm*	*19 mm*	*2 way*	*Single way*
For 50 sq. mm wire	325 m.	–	–	–	–	–	–	2	1
For 25 sq. mm wire	–	15 m	–		5 m	–	–		
For 16 sq. mm wire	–	–	15 m	–	–	5 m	–		
For 4 sq. mm wire	–	–	–	15 m	–	–	5 m		
Total	325 m	15 m	15 m	15 m	5 m	5 m	5 m	2	1

(vi) *Main switches tripple pole*

(a) Iron-clad main switch tripple pole 15 amps for power hammer = 1 No.

(b) Iron-clad main switch tripple pole 60 amps electrical oven = 1 No.

(c) Iron-clad main switch tripple pole 30 amps for compressor motor = 1 No.

(vii) *G.I. wire No. 8* $= 2(319 + 20 + 20 + 20)$

$= 758$ metres

$= 76.64$ kg. say 80 kg. approx.

North Side

On north side total connected load is 64.00 kW, Feeder or circuit No. 3 is to be run for this purpose

$$\text{Load in amperes} = \frac{64 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 115.40 \text{ amps.}$$

From Table 14.8, it will be seen that PVC 11,00 volts underground cable $3\frac{1}{2}$ core 70 sq. mm. is suitable. The length of the cable is as follow :

(*i*) *P.V.C. cable* $3\frac{1}{2}$ *core 70 sq. mm. 11,00 volts.*

Length =4 metres from feeder panel to ground, +3 metres as loop +2 metres from the panel to the wall +10 metres along the wall towards ceiling +75 metres upto point K + 180 metres up to point T

= 274 metres say 280 metres

(*ii*) *Nos. of T joints for above cable* = 4 Nos. at points L, R, S and T

Now at point L, P.V.C. wire of suitable size will be taken for connection to shapers and lathes. The size of wire to be used is to be calculated as follows :

Loads

Lathes $= 2 \times 6 = 12$ kW

Shapers $= 2 \times 3 = 6$ kW

Total load $= 12 + 6 = 18$ kW

Load in amperes $= \dfrac{18 \times 1,000}{\sqrt{3} \times 400 \times 0.8}$

$= 32.47$ amps.

From Table 14.1, it will be seen that *25 sq. mm* P.V.C. wire single core run in conduit will be used. This size will be run from point L to N.

Length = $3 \times 30 = 90$ metres Say *100 metres*

Now at point M and N, circular outlets are provided and connections for lathes are to be provided

Load at these points $= 4$ kW

Load in amperes $= \dfrac{4 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 7.218$ amps.

From Table 14.1, it will be seen that *4 sq. mm* P.V.C. wire single core run in conduit will be suitable.

Length = 3 × 6 per drop + 3 (10 + 10) for connection to lathes at point M + 3 × 25 for connection to lathes at point M.
= 153 metres Say *160 metres*

Now at point P the connected load is

Lathes	= 2 × 2	
	= 4 kW	
Shapers	= 6 kW	
Total	10 kW	

$$\text{Load in amperes} = \frac{10 \times 1,000}{\sqrt{3} \times 400 \times 0.8} = 18.04 \text{ amps.}$$

From Table 14.1, it will be seen that *10 sq. mm.* P.V.C. wire single core run in conduit is used. This wire will be run upto main switch board at point P.

Length = 3 × 20
= 60 metres Say *75 metres.*

Now from main switch board each machine will be fed by a separate control. The wire size to be used should be *4 sq. mm.*

Length of wire = 3(20 + 30 + 15 + 15)

= 240 metres Say 250 metres.

At point S, control switch for controlling 25 kW motor is to be provided.

$$\text{Load in amperes of this motor} = \frac{25 \times 1,000}{\sqrt{3} \times 400 \times 0.8}$$

= 46.91 amps.

From Table 14.1, it will be seen that *35 sq. mm.* will be most suitable, the length of this wire will be,

Length = 3 (6 + 10 + 4)
= 60 metres, Say *75 metres* including the double run wire from station to motor.

At point T, the loads to be tapped are as follows :

Lathes	= 2 × 3	=	6 kW
	= 2 × 2	=	4 kW
Total		=	10 kW
Shaper	= 2 × 3	=	6 kW
Grinder	= 2 × 1.5	=	3 kW
Total	=		19 kW

$$\text{Load in amperes} = \frac{19 \times 1,000}{\sqrt{3} \times 400 \times 0.8}$$

$$= 34.29 \text{ amperes.}$$

From Table 14.1, it will be seen that P.V.C. single core *25 sq. mm.* will be suitable. The length will be as follows :

Length

From *T* to *X*	= 3 × 30	=	90
From *V* to main switches	= 3 × 8	=	24
From *W* to main switches	= 3 × 8	=	24
From *X* to main switches	= 3 × 8	=	24
			162 metres
			Say *185 metres*

Now from main switches at points *V, W, X,* 3 length of P.V.C. wire single core *4 sq. mm.* to lathes, shaper and grinder is to be given. The length will be as given below :

Length = 3 × 170 = 510 Say *525 metres.*

(including double run of wire from starter to motor)

(*iii*) *Various sizes of P.V.C wire.* The above calculation may be summarised as follows :

(*a*) P.V.C. wire single core 35 sq. mm= 75 metres
(*b*) P.V.C. wire single core 25 sq. mm= 100 +185 = 285 metres
(*c*) P.V.C. wire single core 10 sq. mm= 75 sq. mm.
(*d*) P.V.C. wire single core 4 sq. mm= 160 + 250 + 525
= 935 metres

(*iv*) *Length of conduits.* It will be as follows :

Purpose	*Rigid Conduit*				*Flexible Conduit*			
	38 mm	*31.8 mm*	*25.4 mm*	*19 mm*	*38 mm*	*31.8 mm*	*15.4 mm*	*19 mm*
For 35 sq. mm. wire	20 m	–	–	–	5 m	–	–	–
For 25 sq. mm. wire	–	95 m	–	–	–	–	–	–
For 10 sq. mm. wire	–	–	25 m	–	–	–	–	–
For 4 sq. mm. wire	–	–	–	230 m	–	–	–	80 m
Total	20 m	95 m	25 m	230 m	5 m	–	–	80 m

(v) *Main switches tripple pole iron-clad.* The amperes capacity of these main switches should be as follows :

(a) 15 Amps = *17 Nos.*

(b) 60 Amps = *1 No.*

(c) *G.I wire No. 8*

The length of this wire should be

Length = 2 × 625

= 1350 metres

= 136.7 kg. Say 140 kg.

(vi) *outlet boxes for 31.8 mm dia. conduit*

2-way = 4 Nos.

8-way = 2 Nos.

Now after the quantity of various important items have been determined, the estimate is prepared as shown in Table 15.6.

Internal Lighting Circuits

Total lighting load single phase = 24.4 kw

Load in amperes $= \frac{24.4 \times 1000}{230} = 106.1$ amps.

This load is to be divided on all three phases

∴ Current per phase $= \frac{106.1}{3} = 35.37$ amps.

Referring to Table 14.1, it will be seen that P.V.C. wire single core 600 volts 25 sq. mm. will be suitable as mains. The further distribution is as shown in Fig. 15.26. Now it is desired to take three phase four-wire sub-mains on both sides of the hall. These sub-mains will terminate in 30 amps, three-phase four-wire main switches placed at the centre of both side walls of the hall. Three-phase 12-way Distribution Board are placed on the same board on which 30 amps switches are placed. The sub-circuits are taken from each D. B. Thus there will be in all 20 sub-circuits each feeding 10 fittings. It is economical to feed half of the hall *i.e.* south side hall from one Distribution Board and other half *i.e.* north side from the other Distribution Board.

Table 15.6

S. No.	Schedule of material	Cost							Remarks
	Material with specifications	Units	Qty.	Rate		Per	Total cost		
				Rs.	P.		Rs.	P.	
1.	P.V.C. $3\frac{1}{2}$ core 95 sq. mm 1,100 V cable	m.	150	192	00	m.	28800	00	
2.	Joint Box, T-type suitable for cable at serial No. 1 above.	No.	2	770	00	Each	1540	00	
3.	Joint Box, straight through type suitable for cable at serial, No. 1 above.	No.	1	660	00	Each	660	00	
4.	P.V.C. $3\frac{1}{2}$ core 70 sq. mm. 1,100 V cable.	m.	280	154	00	m.	43120	00	
5.	Joint Box T, Type suitable for cable at serial, 4 above.	No.	4	170	00	Each	680	00	
6.	P.V.C. wire single cor 50 sq. mm 600 volts.	m.	1075	4500	50	100 metre	48375	00	
7.	P.V.C. wire single core 35 sq. mm 600 volts.	m.	150	3320	00	-do-	4980	00	
8.	P.V.C. wire single core 25 sq. mm. 600 volts.	m.	435	2300	00	-do-	10005	00	
9.	P.V.C. wire single core 16 sq. mm. 600 volts grade.	m.	75	1400	50	-do-	1050	00	
10.	P.V.C. wire single grade core 4 sq. mm. 600 volts.	m.	1300	480	00	-do-	6240	00	
11.	Rigid conduit 51 mm. dia. H.G.	m.	330	33	00	-do-	10890	00	
12.	Rigid conduit 38 mm. dia. H.G.	m.	25	19	50	m.	487	50	
						C.O	156827	50	

(Contd.)

S. No.	Schedule of material	Cost							Remarks
	Material with specifications	Units	Qty.	Rate		Per	Total cost		
				Rs.	P.		Rs.	P.	
						B.F.	156827	50	
13.	Rigid conduit 31.8 mm. dia. H.G.	m.	115	16	50	m.	1897	50	
14.	Rigid conduit 25.4 mm. dia. H.G.	m.	40	13	80	m.	552	00	
15.	Rigid conduit 19 mm. dia. H.G.	m.	245	10	80	m.	2646	00	
16.	Flexible conduit 51 mm. dia.	m.	15	30	00	m.	445	00	
17.	Flexible conduit 38 mm. dia.	m.	15	24	00	m.	360	00	
18.	Flexible conduit 31.8 mm. dia.	m.	20	18	00	m.	80	00	
19.	Flexible conduit 25.4 mm. dia.	m.	5	14	00	m.	70	00	
20.	Flexible conduit 19 mm. dia.	m.	85	10	00	m.	850	00	
21.	Circular outlet boxes 2-way for 51 mm. dia. conduit.	No.	2	300	00	Doz.	50	00	
22.	Circular outlet boxes single-way for 51 mm. dia. conduit.	No.	1	280	00	Doz.	23	30	
23.	Circular outlet boxes for 2-way for 31.8 mm. dia. conduit.	No.	4	140	00	Doz.	46	65	
24.	Circular outlet boxes single way for 31.8 mm. dia. conduit.	No.	2	125	00	Doz.	20	85	
25.	Right-angled Bend for conduit dia. 51 mm.	No.	6	150	00	Doz.	75	00	
26.	Right-angled Bend for conduit dia. 38 mm.	No.	4	90	00	Doz.	30	00	
27.	Right-angled Bend for conduit dia. 31.8 mm.	No.	6	65	00	Doz.	32	50	
28.	Right-angled Bend for conduit dia. 25.4 mm.	No.	6	30	00	Doz.	15	00	
						C.O	164021	30	

Table 15.6

S. No.	Schedule of material	Cost							Remarks
	Material with specifications	Units	Qty.	Rate		Per	Total cost		
				Rs.	P.		Rs.	P.	
1.	P.V.C. $3\frac{1}{2}$ core 95 sq. mm 1,100 V cable	m.	150	192	00	m.	28800	00	
2.	Joint Box, T-type suitable for cable at serial No. 1 above.	No.	2	770	00	Each	1540	00	
3.	Joint Box, straight through type suitable for cable at serial, No. 1 above.	No.	1	660	00	Each	660	00	
4.	P.V.C. $3\frac{1}{2}$ core 70 sq. mm. 1,100 V cable.	m.	280	154	00	m.	43120	00	
5.	Joint Box T, Type suitable for cable at serial, 4 above.	No.	4	170	00	Each	680	00	
6.	P.V.C. wire single cor 50 sq. mm 600 volts.	m.	1075	4500	50	100 metre	48375	00	
7.	P.V.C. wire single core 35 sq. mm 600 volts.	m.	150	3320	00	-do-	4980	00	
8.	P.V.C. wire single core 25 sq. mm. 600 volts.	m.	435	2300	00	-do-	10005	00	
9.	P.V.C. wire single core 16 sq. mm. 600 volts grade.	m.	75	1400	50	-do-	1050	00	
10.	P.V.C. wire single grade core 4 sq. mm. 600 volts.	m.	1300	480	00	-do-	6240	00	
11.	Rigid conduit 51 mm. dia. H.G.	m.	330	33	00	-do-	10890	00	
12.	Rigid conduit 38 mm. dia. H.G.	m.	25	19	50	m.	487	50	
						C.O	156827	50	

S. No.	Schedule of material	Cost							Remarks
	Material with specifications	Units	Qty.	Rate		Per	Total cost		
				Rs.	P.		Rs.	P	
						B.F.	179922	90	
41.	Mild steel clamps of sizes made of mild steel 6.35 mm. thickness and 25.4 mm. width.	Nos.	100	4	00	Each	400	00	
42.	Conduit coupler of various sizes	Doz.	3	60	00	Doz.	180	00	
	Work will be completed in 25 days by employing the following labour								
	(a) Electrician 2 Nos. at Rs. 80 per day								
	(b) Wireman Gd. 1 = 2 Nos. at Rs. 70 per day								
	(c) Mazdoor = 6 Nos. at Rs. 45 per day.								
	∴ labour charges						12250	00	
							192751	90	
	Add 10% as cost of Civil engineering items.						19275	19	
	Add 10% as contingencies.						19275	19	
						Total	2,31,302	28	Hence the estimated cost for power wiring will be Rs. 2,31,302.00
						Say	2,31,302	00	

Note. The cost of items at substation including providing double earthing is to included in this estimate. For estimate pretaining to sub-station, the concerned chapter should be referred.

(*i*) *Length of P.V.C. wire 25 sq. mm.*

Length = 4 (4 metres from the feeder panel to the ground +4 metres as loop +2 metres from the panel to the wall +10 metres along the wall towards ceiling +130 metres upto the Distribution Board.

$= 4 \times 150 = 600$ metres

The above length is required on one side, the length of the wire on other side will 4×180

i.e. = 720 metres

∴ Total length of P.V.C. wire *25 sq. mm.* single core,

= 1,320 metres

Keeping in account the wastage,

Total length = *1,400 metres.*

(*ii*) *Conduit 38 mm. dia.*

It will be seen that 4 cables of single core 25 sq. mm. P.V.C. wire can be accommodated in 38 mm. dia. conduit.

Hence Length of *38 mm. dia. conduit* = 150 + 180 = 330 metres
Say 350 metres

(*iii*) *Right-angled Bends 38 mm. dia.*

It will be seen from Fig. 15.24, that 6 Bends are required on each side Hence.

Total nos. Of *38 mm. dia. Right-angled Bends* $= 2 \times 6 = 12$ Nos.

(*iv*) Nos. of 30 amps, 3 phase 4 wire iron-clad main switches = 2 Nos.

(*v*) Nos. of 3 phase, 12-ways D.B. = 2 Nos.

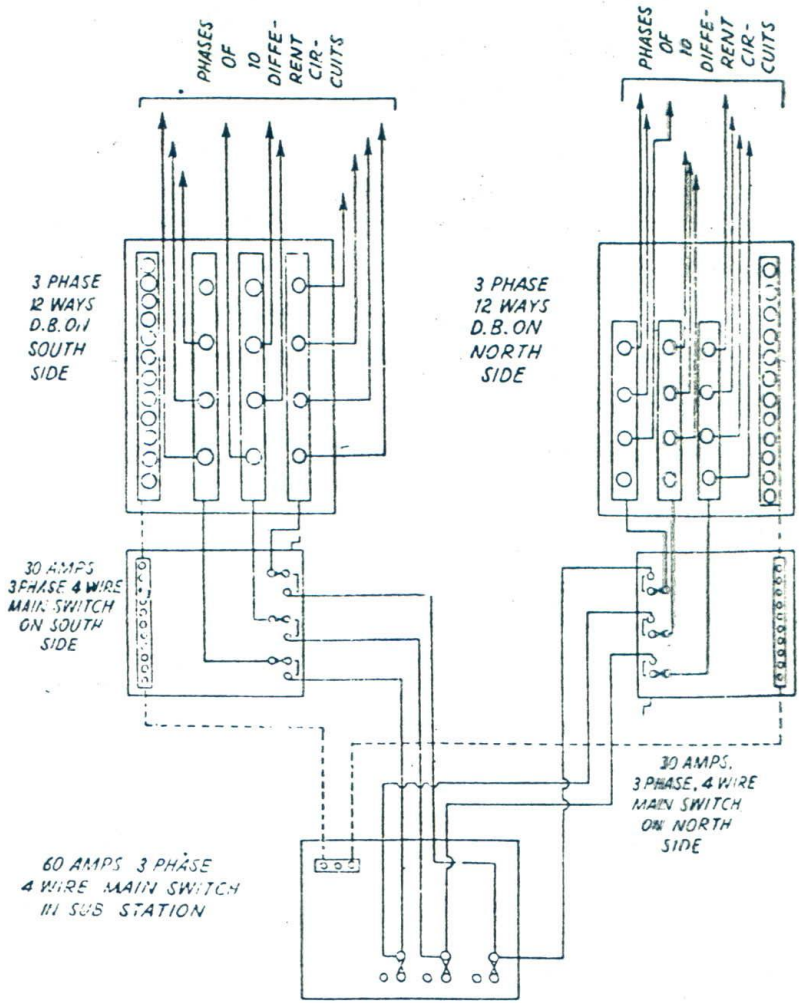
As discussed earlier, that there will be 10 tubes in a sub-circuit. Hence load on each sub-circuit in amperes will be

Load in amperes on each sub-circuit

$$= \frac{10 \times 120}{230} = 5.22 \text{ Amps.}$$

From Table 14.1, it will be seen that the safest size to meet this load will be 2.5 sq. mm of P.V.C. wire. Two wires in conduit are taken to switch boards positions, each switch board should be in a position to accommodate 5 number 5 amps. tumbler switches. These

Boards should be spaced at a distance of 11 metres from each other.



Circuit Diagram for the Scheme
Fig. 15.26

(*vi*) *P.V.C. wire single core 2.5 sq. mm.*

Length up to switch board on one half portion of the north side of the hall

= 2 [5 + 63 metres for the run in conduit from the D.B. towards ceilings (for 9 sub-circuits) + 97 + 87 + 77 + 67 + 57 + 47 + 37 + 27 + 17]

$= 2 \times 581$

$= 1,162$ metres

$\therefore$ Total length of the *2.5 sq. mm. single* core P.V.C. wire

$= 4 \times 1,162$

$= 4,668$ metres Say **5000 metres**

(vii) Conduit 19 mm. dia. This is the smallest size to accommodate two conductors of 2.5 sq. mm. of P.V.C. single core wire.

Length of *19 mm. dia.* conduit

$= 4 \times 581$ upto switch boards.

$= 2,324$ metres Say **2350 metres**

(viii) Right-angled bends for 19 mm. dia. conduit.

The right-angled bends upto switch board will be as follows

$= 2 \times 4 \times 2$

$= 16$ Nos.

Now the remaining part of the problem remains to determine the length of wire and conduit from switch boards to fittings. For this purpose from one switch board the lengths are determined and then the same is multiplied by 20.

(ix) Length of P.V.C. wire 2.5 sq. mm.

(a) *For phase*

Length $= 2 (10 + 20 + 30 + 40 + 50 + 7 \times 7)$

$= 2 \times 199$ metres

$= 398$ Say **425 metres**

(b) *For Neutral*

$= 7 + 50$

$= 57$ Say **75 metres**

Length of wires from 20 Switch boards to fluorescent fittings

$= 20 \times 500$

$= 10,000$ **metres**

Now from the previous explanation, it will be seen that from each switch board, the size of the conduit should be in a position to carry the 6 wires of 2.5 sq. mm. size. This can be carried in 19 mm dia. conduit.

(*x*) Length of 19 mm. dia. conduit

$= 20 (7 + 50) = 1,140$ *metres*

(*xi*) *Right-angled bends for* 19 mm. dia. conduit

$= 20$ *Nos.*

(*xii*) Outlet Boxes 19 mm. dia.

(*a*) 2 outlets $= 20 \times 4 = 80$ *Nos.*

(*b*) Single outlet $= 1 \times 20 = 20$ *Nos.*

After these quantities are worked out, the estimate is prepared as per Table 15.7.

The Total **Estimated Cost** in view of Tables 15.6 and 15.7.

$=$ Rs. 231302 + 155416

$=$ **Rs. 3,86,718**

It should be noted that the estimated cost does not include the cost of material in the substation and their errection and as well as the cost of the tube light fluorescent fittings.

Example 9. *A recently constructed portion of the college building as shown in Fig. 15.27 is to be provided with surface conduit wiring. Number of electrical points required have been marked. Prepare a schedule of items required and also determine the estimated cost.*

Solution.

Following is the detail of the connected load :

(*a*) No. of light points $= 49$ Nos.

Assuming wattage of each lamp as 60, the connected load $= 49 \times 60$

$= 2,940$ watts.

(*b*) No. of fan points $= 14$ Nos.

Assuming wattage of each fan as 60, the connected load $= 14 \times 60$

$= 840$ watts.

(*c*) No. of water-tight fittings $= 2$ Nos.

Assuming wattage of each water-tight fitting as 100 watts, the connected load $= 100 \times 2$

$= 200$ watts.

$\therefore$ Total connected load $= 2,940 + 840 \times 200$

$= 3980$ watts.

Now for providing connection to this building, three-phase four-wire service connection is required from the L.T. mains.

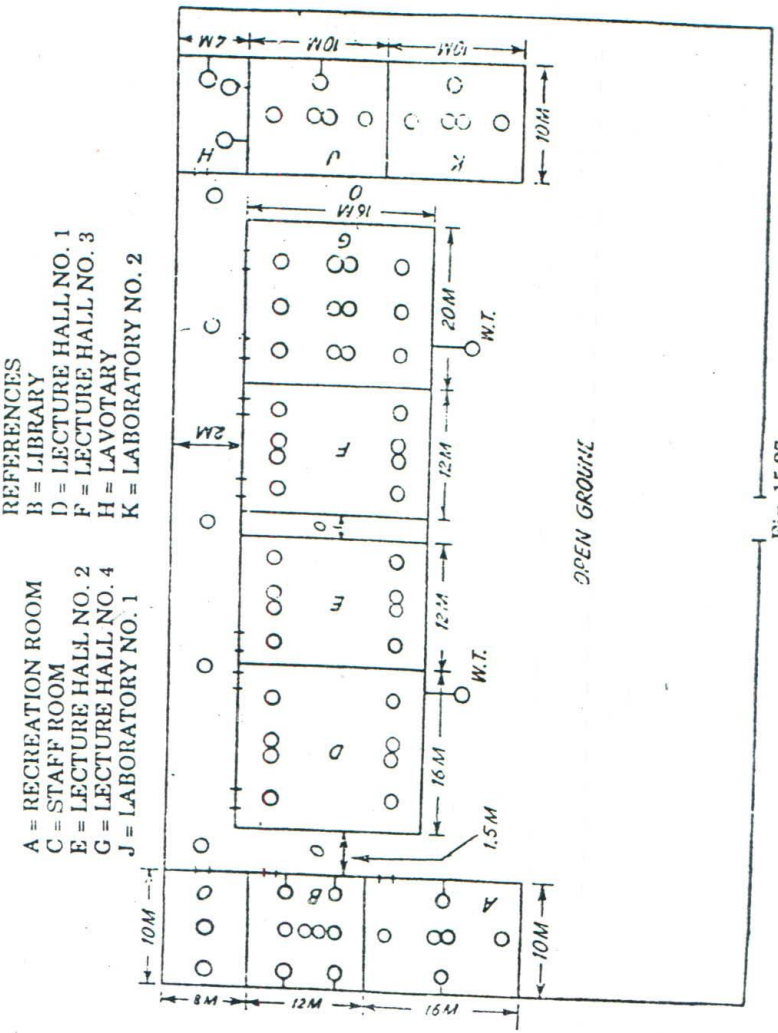

REFERENCES
A = RECREATION ROOM
B = LIBRARY
C = STAFF ROOM
D = LECTURE HALL NO. 1
E = LECTURE HALL NO. 2
F = LECTURE HALL NO. 3
G = LECTURE HALL NO. 4
H = LAVOTARY
J = LABORATORY NO. 1
K = LABORATORY NO. 2
OPEN GROUND
W.T.
W.T.
1.5M
2M
8M
12M
16M
10M
20M
12M
16M
10M
10M
10M
4M

Fig. 15.27

Table 15.7

S.No.	Schedule of material: Material with specifications	Unit	Qty.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
1.	Heavy gauge 38 mm. dia. conduit.	m.	350	16	50	m.	5775	00	
2.	Heavy gauge 19 mm. dia. conduit.	m.	3,490	10	80	m.	37692	00	
3.	P.V.C wire single core 25 sq. mm 600 volts grade.	m.	1,400	2300	00	100 m.	32200	00	
4.	P.V.C. wire single core 2.5 sq. mm. 600 volts grade.	m.	15,000	242	50	100 m.	36,300	00	
5.	30 Amps., 3-phase, 4-wire 500 volts Iron-clad main switch with neutral link.	Nos.	2	370	00	Each	740	00	
6.	3-phase, 12-way Distribution Boards, 15 amps per way.	Nos.	2	450	00	Each	900	00	
7.	Right-angled Bends for 38 mm. dia. conduit.	Nos.	12	90	00	Doz.	90	00	
8.	Right-angled Bends for 19 mm. dia. conduit.	Nos.	36	24	00	Doz.	72	00	
9.	Outlet Boxes for 19 mm. dia. conduit 2 outlets.	Nos.	80	30	00	Doz.	200	00	
10.	Outlet Boxes for 19 mm. dia. conduit having single outlet.	Nos.	20	24	00	Doz.	40	00	
11.	Conduit couplers 19 mm. dia.	Nos.	350	35	00	Doz.	347	00	
						C.O	114356	00	

(Contd.)

S.No.	Schedule of material Material with specifications	Cost Unit	Qty.	Rate Rs.	P.	Per	Total cost Rs.	P	Remarks
12.	Conduit couplers 38 mm. dia.	Nos.	18	96	00	B.F.	114356	00	
13.	Lock nuts 38 mm. dia.	Nos.	2	84	00	Doz.	144	00	
14.	Lock nuts 19 mm. dia.	Nos.	300	34	00	Gross.	1	15	
15.	Wooden bushings 13 mm. Top width	Nos.	700	8	00	Doz.	850	00	
16.	Wooden bushings 19 mm. Top width	Nos.	70	10	00	100 No.	56	00	
17.	Conduit saddles 19 mm. dia.	Nos.	700	9	00	100 No.	7	00	
18.	Conduit saddles 38 mm. dia.	Nos.	70	16	00	Doz.	525	00	
19.	Inspection bends 38 mm. dia.	Nos.	2	100	00	Doz.	93	35	
20.	Inspection bend 19 mm. dia.	Nos.	40	38	00	Doz.	16	65	
21.	Circular inspection boxes with cover 19 mm. dia.	Nos.	40	24	00	Doz.	126	65	
22.	Circular inspection boxes with cover 38 mm. dia.	Nos.	4	175	00	Doz.	80	00	
23.	Angle iron main and D.Bs boards with iron sheet at top and bottom with angle iron double legs each 1 metre long, for fixing on the floor.	Nos.	2	250	00	Each	38	30	
24.	Ceiling Roses two plate 5 amps	Nos.	200	48	00	Doz.	500	00	
25.	5 Amps. tumbler switch single way surface type without cover.	Nos.	200	36	00	Doz.	800	00	
							600	00	
						C.O.	118194	10	

(Contd.)

S.No.	Schedule of material Material with specifications	Unit	Qty.	Cost Rate Rs.	P.	Per	Total cost Rs.	P.	Remarks
						B.F	118194	10	
26.	M.S. Boxes with Masonite cover 10 cm × 18 cm.	Nos.	40	9	00	Each	360	00	
27.	Machine screws 1.90 cm × 0.31 cm.	Pkt.	7	6	00	Pkt of 100 No.	42	00	
28.	Iron screws 1.25 cm × 4 S.W.G.	Pkt	4	18	00	Pkt of 200 No.	72	00	
29.	Flexible cords workshop type twin core 40.193.	m.	300	215	00	100 m.	645	00	
	Work will be completed in 20 days by 3 wiremen Grade I and 6 Mazdoor						119313	10	
	∴ Labour charges						10200	00	
							129513	30	
	Add 10% as cost of Civil Engineering Items.						12951	30	
	Add 10% as contingencies.						12951	60	
						Total	155415	60	
						Say	155416	00	

Note : The estimate does not include the cost of tube light fluorescent fittings.

$$\text{Line current} = \frac{3980}{\sqrt{3} \times 400} \text{ (power factor being unity)}$$

$$= 5.74 \text{ amps.}$$

From Table 14.1, it will be seen that P.V.C. wire single core 2.5 sq. mm. will be most suitable for using as mains for providing connection between energy meter and main switches.

Fig. 15.28 represents the position of various Distribution Boards from three-phase 400 volts main switch, the sub-mains are taken to various single-phase Distribution Boards. Now the loads on various Distribution Boards are calculated for determining the P.V.C. size.

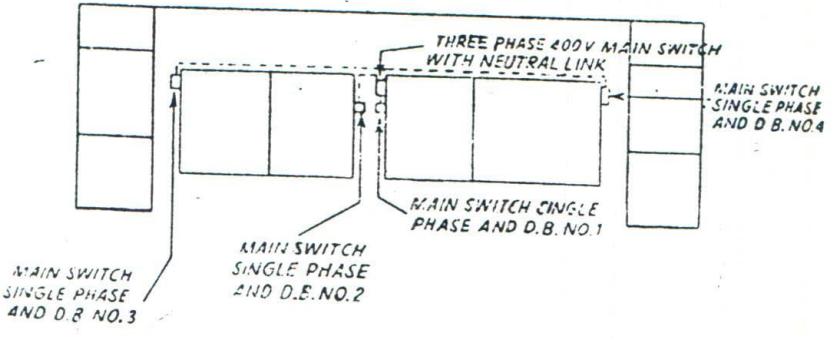


Fig. 15.28

D.B. No. 1 or Circuit No. 1.

Connected load $= 18 \times 60 + 1 \times 100$

$= 1180$ watts

Load in amperes $= \frac{1180}{230} = 5.13$ amps.

From Table 14.2, it will be seen that P.V.C. wire double core 2.5 sq. mm. will be suitable. This size of wire can withstand higher loading upto 15 amps due to short circuit also.

Length = 6 metres

D.B. No. 2 or circuit No. 2.

Connected load $= 13 \times 60 + 1 \times 100 = 880$ watts

Load in amperes $= \frac{880}{230} = 3.83$ amps

From Table 14.2 it will be seen that P.V.C. wire double core 2.5 sq. mm. will be suitable.

Length = 7 + 1 + 7 + 5 + 3 m (for loop) = 23 m Say 25 m.

D.B. No. 3 or circuit No. 3.

Connected load = 13 × 60 = 780 watts

Load in amperes = 3.39 amps

Again, it is suggested to use twin core 2.5 sq. mm. P.V.C. wire

Length = 5 + 5 + 32 + 5 + 5 + 3 (for loop) = 55 m

D.B. No. 4 or circuit No. 4.

Connected load = 19 × 60 = 1140 watts

Load in amperes $= \frac{1140}{230} = 4.96$ amps.

Again it is suggested to use twin core *2.5 sq mm* P.V.C. wire.

Length = 5 + 5 + 28 + 5 + 5 + 3 (for loop) = 51 m **Say 55 m.**

(1) Total length of P.V.C. twin core *25 sq. mm.* = 6 + 25 + 55 + 55
= 141 m **Say 145 m.**

(2) Length of conduit *19 mm. dia.* = **145 m.**

(3) No. of right-angled inspection bends for 19 mm. dia. conduits = 0 + 2 + 5 + 5 = *12 Nos.*

(4) Main switch tripple pole with neutral link iron-clad 15 amps 500 volts = *1 No.*

(5) Main switch single pole with neutral link, 15 amps 250 volts = *4 Nos.*

(6) I.C.D.B., 4-way 250 volts 15 amps per way with four outgoings = *4 Nos.*

(7) Angle Iron main board with iron sheet at top and bottom

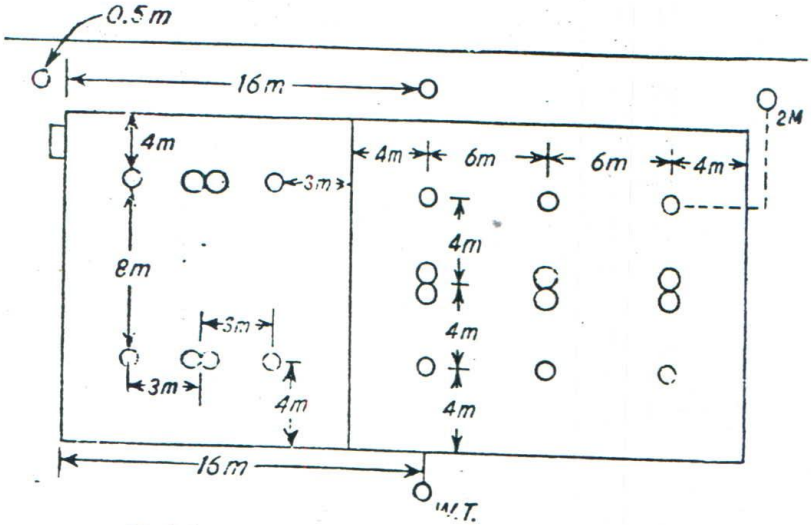
(*a*) *15 cm. × 20 cm. = 1 No.*

(*b*) *25 cm. × 30 cm. = 4 Nos.*

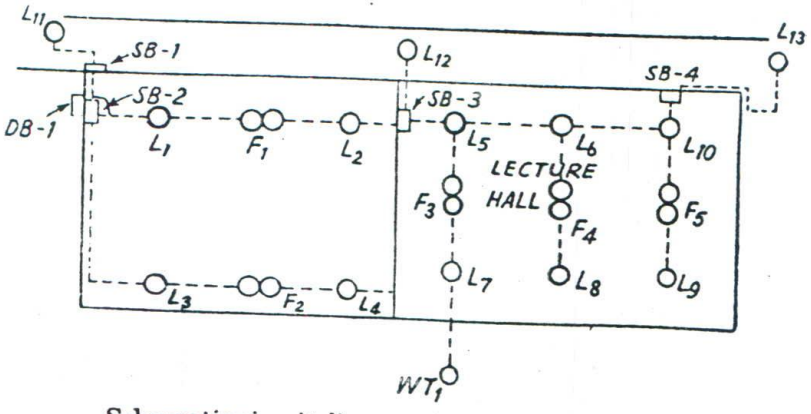
After determining, the material required for the circuits, the material required for various sub-circuit is determined.

Before the quantity of material is estimated, it is necessary that position of various points may be fixed as shown in Fig. 15.29 and

later on the schematic circuit diagram of wiring is drawn as shown in Fig. 15.30. The quantity of material thus required is worked out by consulting Fig. 15.29 and 15.30. However after certain length of experience one does not need to draw these figures, he can work out the quantities from the initial plan of the building marked with electrical fittings.



Position of various points fed from circuit No. 1
Fig. 15.29



Schematic circuit diagram of wiring of circuit No. 1
Fig. 15.30

Material required for connecting various loads to D.B. No. 1 having 4 sub-circuits :

Following will be the loading on each sub-circuit.

Sub-circuit No 1 :- L_1, F_1, L_2 *and* L_{11}

Sub-circuit No 2 :- L_3, F_2 *and* L_4

Sub-circuit No 3 :- L_5, L_6, L_7, L_8, L_{12}, F_3 F_4, *and* WT_1

Sub-circuit No 4 :- L_{10}, F_5, L_9 *and* L_{13}

(*a*) *Conduit 19 mm. dia.*

(*i*)	From *DB*–1 to *SB*–2	= 0.5 m
(*ii*)	From *SB*–1 to L_1, F_1 and L_2	= 16 m
(*iii*)	From *SB*–2 to L_3, F_2 and L_4	= 26 m
(*iv*)	From *SB*–2 to SB_1	= 10 m
(*v*)	From *SB*–1 to L_{11}	= 10 m
(*vi*)	From L_2 to *SB*–3, L_{12}	= 12 m
(*vii*)	From SB_3 to L_5, L_3, F_4 and L_8	= 24 m
(*viii*)	From L_5 to F_3, L_7 and WT_1	= 16 m
(*ix*)	From L_6 to SB_4	= 15 m
(*x*)	From *SB*–4 to L_{12}	= 20 m
(*xi*)	From L_{10} to F_5, L_9 and various loops	= 20 m
	Total	169.50

Say 170 m. (after taking into account wastage)

(*b*) P.V.C. wire single core 1.5 sq. mm.

(*i*) For phase or positive wire

= 2 × 170 m. = 340 m

(*ii*) For neutral wire = 170 m

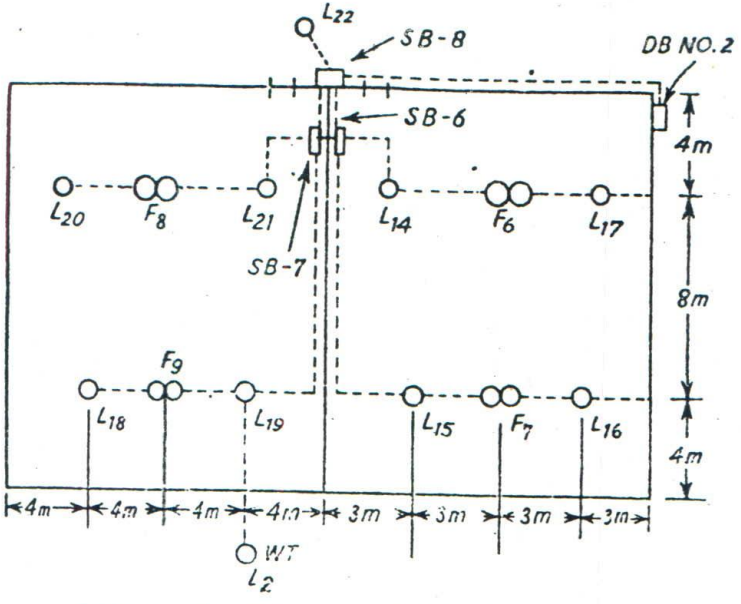
Total = 510 m

(*c*) *Right-angled Bends for 19 mm dia. conduit*= 13 Nos.

(*d*) *Round Junction Box*

(*i*) 3 outlets	= *3 Nos.*
(*ii*) 2 outlets	= *9 Nos.*
(*iii*) Single outlets	= *6 Nos.*

Material required for connecting various loads to D.B. No. 2 from which three sub-circuits are taken.



Schematic circuit diagram of wiring for circuit No. 2.
Fig. 15.31

Fig. 15.31 represents the schematic diagram of wiring on circuit No. 3. Following will be the loading on each sub-circuit.

Sub-circuit No. 1 = L_{14}, L_{15}, L_{16}, L_{17}, F_6 and F_7
Sub-circuit No. 2 = L_{19}, F_9, L_{18}, WT_2, L_{21}, F_8, L_{20}
Sub-circuit No. 3 = L_{22}, L_{49}
Sub-circuit No. 4 = kept unconnected to any load for use at the time of expansion in future.

(*a*) *Conduit 19 mm. dia.*

(*i*)	From *DB*–2 to *SB*–6	= 20 m
(*ii*)	From *SB*–6 to L_{14}, F_6 and L_{17}	= 16 m
(*iii*)	From *SB*–6 to L_{15}, L_{16} and F_7	= 27 m
(*iv*)	From *SB*–6 to *SB*–8 and L_{22}	= 16 m
(*v*)	From *SB*–7 to L_{20}, F_8 and L_{21}	= 30 m
(*vi*)	From *SB*–7 to L_{19}, L_{18}, F_9, and WT_2	= 28 m
(*vii*)	Down at water-tight point	= 7 m
	Total	=144 m

Say 150 m.
(after taking into account wastage)

(*b*) P.V.C. wire single core 1.5 sq. mm.

(*i*) For phase or positive wire = 2 × 150 = 300 m.

(*ii*) For neutral wire = 150 m.

Total 450 m.

(*c*) *Right-angled Bends for 19 mm. dia. conduit*

= 13 Nos.

(*d*) *Round Junction Box.*

(*i*) 3 outlets = 1 No.

(*ii*) 2 outlets = 7 Nos.

(*iii*) Single Outlet = 6 Nos.

Material required for connecting various loads to DB No. 3 from, which four sub-circuits are taken.

Following will be the loading on each sub circuit :

Sub-circuit No. 1 = L_{23}, L_{24}, L_{25}, L_{26}, L_{27} and F_{10}.

Sub-circuit No. 2 = L_{28}, L_{29}, L_{30}, L_{34}.

Sub-circuit No. 3 = L_{31}, L_{32}, L_{33}, and L

Sub-circuit No. 4 = L_{35}, L_{36}, L_{37}, L_{38} and F_{12}.

(*a*) *Conduit 19 mm. dia.*

(*i*) From *DB*–3 to *SB*–9 and *SB*–10 = 15 m

(*ii*) From *SB*–9 to L_{23} = 9 m

(*iii*) From *SB*–10 to L_{27}, L_{26}, F_{10}, L_{25}, L_{24} and F_{10} = 33 m

(*iv*) From *DB*–3 to *SB*–11 and *SB*–12 = 22 m

(*v*) From *SB*–11 to L_{34} = 15 m

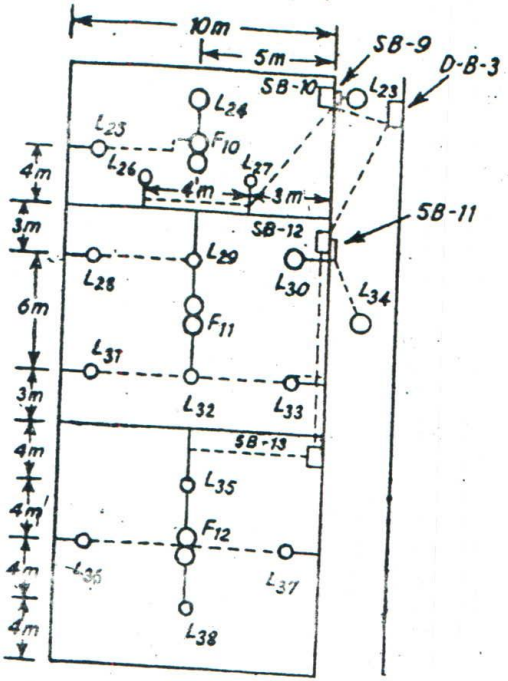
(*vi*) From *SB*–12 to L_{30}, L_{33}, L_{32}, L_{31}, F_{11}, L_{28} and L_{29} = 36 m

(*vii*) From L_{33} to *SB*–13 = 11 m

(*viii*) From *SB*–13 to L_{35}, F_{12}, L_{38}, L_{37}, L_{36} = 28 m

Total 169 m.

Say **175 m.** (after taking into account the wastage)



Schematic circuit diagram of wiring of circuit No. 3.
Fig. 15.32

(b) P.V.C. single core 1.5 sq. mm. wire

(*i*) For phase	= 175 × 2 =	350 m
(*ii*) For neutral	=	175 m
Total		525 m

(c) Right-angled Bends for 19 mm. dia. conduit
= 11 Nos.

(d) Round Junction Box

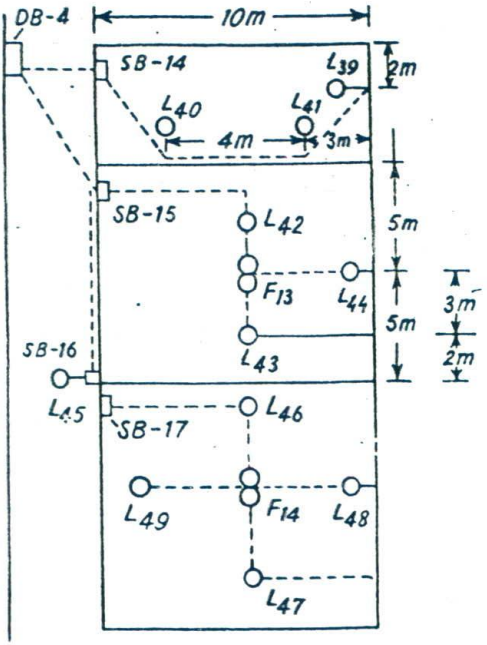
(*a*) Four outlets	= 1 No.
(*b*) 3 outlets	= 3 Nos.
(*c*) 2 outlets	= 5 Nos.
(*d*) Single outlets	= 10 Nos.

Material required for connecting various loads to DB No. 4 from which four sub-circuits are taken

Fig. 15.33 represents the schematic diagram of wiring of circuit

No. 4. Following will be the loading on each sub-circuit :

Sub-circuit No. 1 = L_{39}, L_{40} and L_{41}
Sub-circuit No. 2 = L_{42}, L_{43}, L_{44} and F_{13}
Sub-circuit No. 3 = L_{46}, L_{47}, L_{48}, L_{49} and F_{14}
Sub-circuit No. 4 = L_{45}



Schematic circuit diagram of wiring of circuit No. 4
Fig. 15.33

(a) Conduit 19 mm. dia.

(*i*)	From *DB*–4 to *SB*–14	=	16 m
(*ii*)	From *SB*–14 to L_{40}, L_{41}, L_{39}	=	23 m
(*iii*)	From *DB*–4 to *SB*–15	=	20 m
(*iv*)	From *SB*–15 to L_{42}, F_{13}, L_{43} and L_{44}	=	25 m
(*v*)	From *SB*–15 to *SB*–16	=	25 m
(*vi*)	From *SB*–16 to L_{45}	=	8 m
(*vii*)	From *SB*–16 to *SB*–17	=	1 m
(*viii*)	From *SB*–17 to L_{46}, F_{14}, L_{48}, L_{47} and L_{49}	=	21 m
		Total	139 m.

Say 150 m. (after taking into account the wastage)

(b) *P.V.C. wire single core 1.5 sq. mm.*

(i) For positive wire = 150×2 = 300 m

(ii) For neutral wire = 150 m

Total length 450 m.

(c) *Right-angled Bends for 19 mm. dia. conduit* = 12 Nos.

(d) *Round Junction Box*

(i) 3 outlets = 2 Nos.

(ii) 2 outlets = 4 Nos.

(iii) Single outlets = 6 Nos.

The details of items and estimated cost have been worked out in Table 15.8

Example 10. *A factory building measuring 100 m. × 45 m. is required to be electrified. Assuming the following factors (i) design the illumination scheme and (ii) determine the estimated cost of providing the wiring.*

(a) Spacing to height ratio = 1

(b) Clear height = 4 m

(c) Height of working = 1 m

(d) Coefficient of utilization = 0.5

Solution.

Spacing between two light points

= Height of the fittings above working plane

= 4–1 = 3 m.

Nos. of fittings, lengthwise $= \frac{100}{3}$

$= 33-1 = 32$

Nos. of rows $= \frac{45}{3} - 1 = 14$ Nos.

Total nos. of light points $= 14 \times 32 = 448$ Nos.

Hence, flux output of each fitting $= \frac{200 \times 100 \times 45}{448 \times 0.5}$

= 4,018.4 lumens

Table 15.8

S. No.	Schedule of Material: Material with specifications	Unit	Qty. reqd.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
1.	Conduit H. G. 19 mm. dia.	m.	790	10	80	m.	8532	00	
2.	Right-angled Bends for 19 mm. dia	Nos.	61	24	00	Doz.	122	00	
3.	P.V.C. single core 250V grade 2.5 sq. mm.	m.	290	225	00	100 m.	652	50	
4.	Main switch 15 amps. tripple pole with neutral link, 500 volts.	Nos.	1	275	00	Each	275	00	
5.	P.V.C. single core 250V grade 1.5 sq. mm.	m.	1,735	175	00	100 m.	3036	25	
6.	Circular Round Junction Box with 4 outlets for 19 mm. dia. conduit.	Nos.	1	38	00	Doz.	38	00	
7.	Circular Round Junction Box with 3 outlets for 19 mm. dia. conduit.	Nos.	9	36	00	Doz.	27	00	
8.	Circular Round Junction Box with 2 outlets for 19 mm. dia. conduit.	Nos.	25	30	00	Doz.	62	50	
9.	Circular Round Junction Box with single outlet for 19 mm. dia conduit.	Nos.	2º	24	00	Doz.	56	00	
10.	Locknuts 19 mm. dia.	Nos.	108	34	00	Gross	25	50	
11.	Ceiling Rose 2 plate (Bakelite)	Nos.	47	48	00	Doz.	188	00	
12.	T.W. Round Block 7.5 cm. × 2.5 cm.	Nos.	17	36	00	Doz.	51	00	
						C.O.	13065	75	

(Contd.)

S. No.	Schedule of Material: Material with specifications	Unit	Qty. reqd.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
						B.F.	13065	75	
13.	M.S. Box 15 cm. × 20 cm. with masonite cover.	Nos.	12	12	00	Each	144	00	
14.	M.S. Box 7.60 cm. × 7.60 cm. with mosonite cover.	Nos.	6	6	00	Each	36	00	
15.	5 Amps. tumbler switches flush type.	Nos.	63	96	00	Doz.	504	00	
16.	5 Amps. water-tight switches.	Nos.	2	15	00	Each	30	00	
17.	Water-tight bracket with glass shade.	Nos.	2	30	00	Each	60	00	
18.	Bracket fancy.	Nos.	15	15	00	Each	225	00	
19.	I.C. D.B. 250 volts 4 ways, 15 amps. per way.	Nos.	4	125	00	Each	500	00	
20.	D.P.I.C. main switch 15 amps. 250 V.	Nos.	4	100	00	Each	400	00	
21.	Flexible wire 23/193.	m.	50	165	00	Per 100 m.	82	50	
22.	Wooden screws								
	(a) 1/2" × 10 S.W.G.	Pkt.	3/4	18	00	Pkt. of 100 Nos.	13	50	
						C.O.	15060	75	

(Contd.)

S. No.	Schedule of Material: Material with specifications	Unit	Qty. reqd.	Cost: Rate Rs.	Rate P.	Per	Total cost Rs.	Total cost P.	Remarks
						B.F.	15060	75	
	(b) $1\frac{1}{4}$" × 8 S.W.G.	Pkt.	1	38	00	Pkt. of 100 Nos.	38	00	
	(c) 3/4" × 4 S.W.G.	Pkt.	3/4	28	00	Pkt of 200 Nos.	21	00	
23.	Machine screws 1.90 cm. × 0.31 cm.	Pkt.	1.5	6	00	Pkt of 100 Nos.	9	00	
24.	Wooden guttics for 19 mm. dia. conduit.	Nos.	800	20	00	100 Nos.	160	00	
25.	Mild steel galvanized plate 60 cm. × 60 cm. 6.33 mm.	No.	1	250	00	Each	250	00	
26.	8 S.W.G. G.I. wire 30 m approx.	Kg.	3	16	00	Kg.	48	00	
27.	G.I. pipe 19 mm. dia.	m.	5	12	50	m.	62	50	
28.	Charcoal	Kg.	20	6	00	Kg.	120	00	
29.	Angle iron main board with iron sheet at top and bottom 25 cm. × 30 cm.	No.	1	55	00	Each	55	00	
	Labour :-2 wire men grade I 4 mazdoors for 15 days						4800	00	
							20622	75	
	Add 10% for item of civil engineering						2062	28	
	Add 10% for contingencies						2062	28	
						Total	24947	31	Say 24947
	Hence the estimated cost is Rs. 24947								

From 'chapter on illumination' it will be seen that one 40-watt fluorescent tube has an output of 2,300 lumens. Thus it is proposed to use an industrial type of fitting with two nos. of fluorescent tube of 40 watts.

Total load $= 40 \times 2 \times 448 = 35{,}840$ watts
$= 35.84$ kW

Load in amperes $= \dfrac{35.84 \times 1{,}000}{\sqrt{3} \times 400}$

$= \mathbf{51.56\ amps.}$

Hence 100 Amp 3-phase 4-wire with neutral link iron-clad main switch 500 volts will be suitable.

Further it is desired that each sub-circuit should feed 7 fluorescent tube light fittings. Hence,

Load on each sub-circuit $= 7 \times 80 = 560$ watts.

As the supply voltage is 230 volts, hence,

Load in amperes $= \dfrac{560}{230} = 2.43$ Amps.

From Table 14.1, it will be seen that P.V.C. *wire single core of size 1.5 mm^2. 250 V grade will be suitable for concession from the distribution board to light fittings.*

P.V.C. 1,100 volts grade cable will be used for providing connection between energy meter and iron-clad 100 amps 500 volts 3-phase, 4-wire main switch. Size of this cable can be found out by referring Table 14.8. It will be seen that 35 sq. mm. three and half core cable will be suitable to take the load.

Length of 35 sq. mm. $3\frac{1}{2}$ core P.V.C. 1,100 volts grade cable = 10 m.

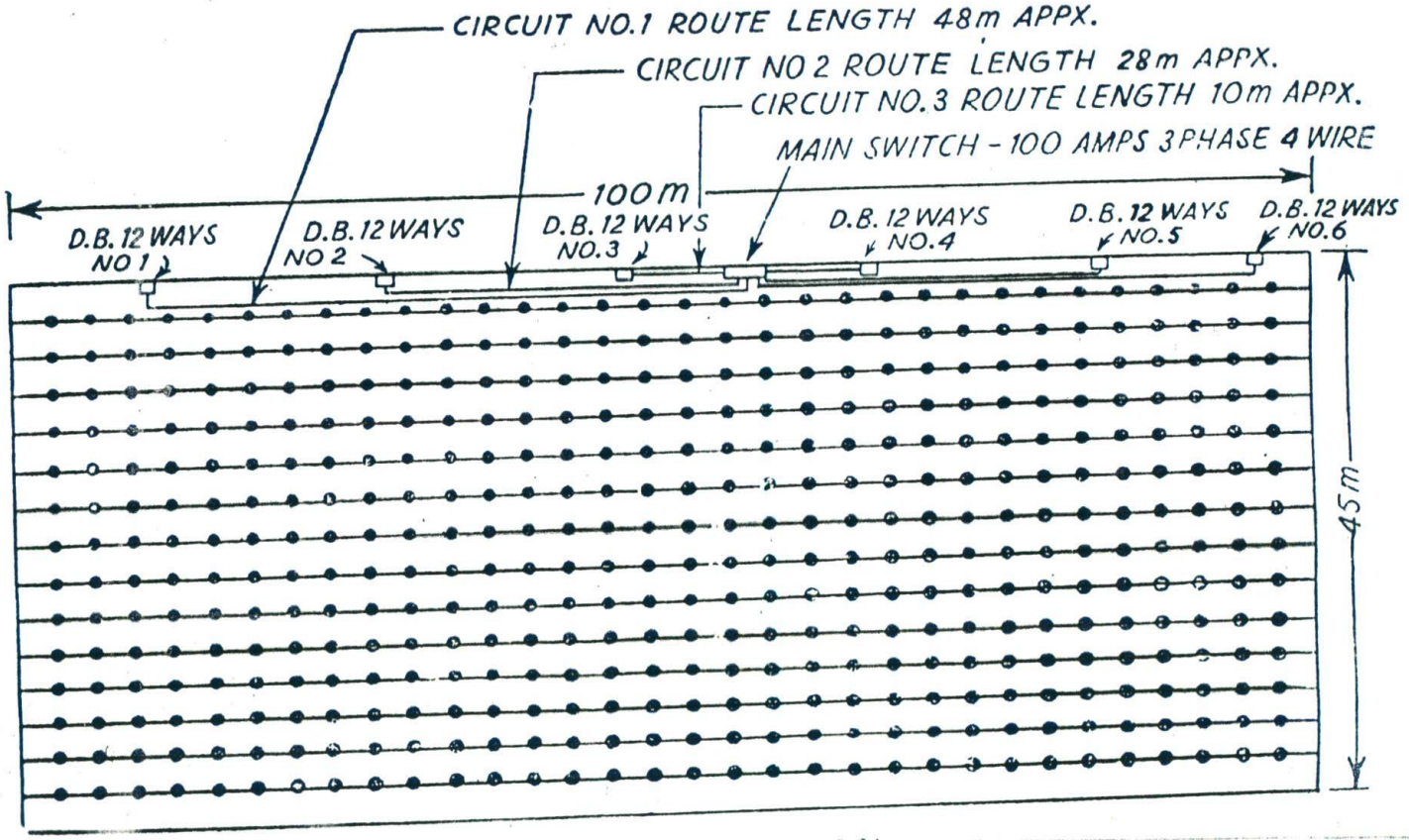
12-way, 3-phase D.B. having current carrying capacity of 15 amps. way will be used.

Therefore on each D.B.

Load in amperes $= \dfrac{12 \times 7 \times 80}{\sqrt{3} \times 400}$

$= 9.701$ *amps.*

From Table 14.1, it will be seen that P.V.C. wire single core 6 sq. mm. will be used. The positions of distribution boards are shown in Fig. 15.34.


CIRCUIT NO.1 ROUTE LENGTH 48m APPX.
CIRCUIT NO 2 ROUTE LENGTH 28m APPX.
CIRCUIT NO.3 ROUTE LENGTH 10m APPX.
MAIN SWITCH - 100 AMPS 3PHASE 4 WIRE
100m
D.B. 12 WAYS NO 1
D.B. 12 WAYS NO 2
D.B. 12 WAYS NO.3
D.B. 12 WAYS NO.4
D.B. 12 WAYS NO.5
D.B. 12 WAYS NO.6
45m

From the figure it will be seen that route length of circuits will be as follows.

(*i*)	Circuit No. 1	=	48 m
(*ii*)	Circuit No. 2	=	28 m
(*iii*)	Circuit No. 3	=	10 m
(*iv*)	Circuit No. 4	=	10 m
(*v*)	Circuit No. 5	=	28 m
(*vi*)	Circuit No. 6	=	42 m
	Total route length	=	166 m.

Taking into accounts the drop of 3 m the total length will be,

$$= 166 + 3 \times 12$$

$$= 202 \text{ m.} \quad \text{Say } 210 \text{ m.}$$

After, an Engineer gains experience in estimating, it is not necessary to draw a list of items required for wiring. By virtue of his experience he will draw out a list of various jobs to be performed, the cost of which is known to him due to length of his service. In Govt. departments schedule of various jobs indicating the cost of each job, are used for ready reckoner. This estimate has been prepared in Table 15.9 in accordance with the way explained above.

Example 11. *In a six storeyed Govt. building, it is proposed to install an automatic push button type lift which should be in a position to accommodate 6 persons at a time and should move at a speed of 1 m/sec. If three phase, 400 volts, 50 c/s a.c. supply is available in the building at a distance of 20 m. from machine room, determine the estimated cost of installing the lift.*

Solution.

For traction purposes d.c. motors are most suitable and in case of lift, d.c. compound wound motor is used. Motor generator set will be used for conversion of a.c. to d.c. supply.

10 h.p. d.c. 220 volts d.c. compound wound motor will be most suitable for this purpose.

10 kW 220 volts d.c. generator coupled to a.c. three-phase, 400 volts, 50 c/s. 15 h.p. motor will be used to feed the d.c. compound wound 10 hp. motor.

Now 400 volts a.c. three-phase 50 c/s supply is available at a distance of 20 m. from 15 h.p. a.c. motor. From Table 14.12, this

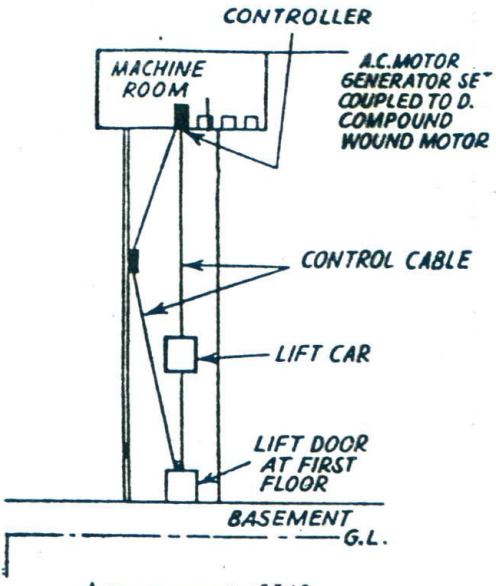
Table 15.9

S. No.	Schedule of material: Material with specification	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Total Cost Rs.	Total Cost P.	Remarks
1.	Supplying and laying of conduit 25.4 mm. H.G. on the wall surface including the cost of gutties, clamps, screws and cement, the cost of Bends is also included.	m.	210	18	00	3780	00	
2.	Supplying and stretching P.V.C. wire 6 sq. mm, 600 volts grade in conduit of size 25.4 mm. for providing 3-phase, 4-wire connections to Distribution Boards.	m.	840	885	00	7434	00	
3.	Supplying and fixing angle iron main board having iron sheet at top and bottom (including cost of gutties, cement and screws. Size 30 cm. × 50 cm	Nos.	7	55	00	385	00	
4.	Supplying and fixing T.P.I.C. 500 V with neutral link, 100 amps. Main Switch including cost of bolts and nuts.	Nos.	1	1270	00	1270	00	
5.	Supplying and fixing 12-way I.C.D.B. 500 V. 15 amps/way including cost of bolts and nuts.	Nos.	6	750	00	4500	00	
6.	Supplying and fixing T.P.I.C. 500 V. with neutral link Main Switch 15 amps. (including cost of screws, bolts and nuts).	Nos.	6	240	00	2040	00	
					C.O.	19409	00	

(Contd.)

S. No.	Schedule of material: Material with specification	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Total Cost Rs.	Total Cost P.	Remarks
					B.F.	19409	00	
7.	Supplying all material and providing point wiring with 1.5 sq. mm. P.V.C. wire in 19 mm. dia. H.G. conduit. The cost of conduit, wires, clamps, bends, round junction boxes, lock nuts, gutties, screws and cement and switch bend etc. is included.	Nos.	448	150	00	67200	00	
8.	Supplying and fixing Ceiling Roses 2 plate bakelite.	Nos.	448	10	00	4480	00	
9.	Supplying and fixing 5 amps, Tumbler Switches.	Nos.	448	10	00	4480	00	
10.	Supplying and fixing flexible wire from ceilings roses to tubes.	m.	448	10	00	4480	00	
11.	Supplying and laying 35 sq. mm. $3\frac{1}{2}$C P.V.C. cable between energy meter and 100 Amp. switch.	m.	10	11000 per 100 m	00	1100	00	
12.	Providing earthing with G.I. wire S.W.G. 8, the galvanized iron plate of size 60 cm. × 60 cm. × 6.30 mm. should be placed vertically at a depth of 2 m. and should be covered with charcoal by a thickness of 15 cm. below, above and on all sides. The G.I. wire should be brought out to the Main Board and connection to it and conduit is to be provided. The earth resistance will be tested for continuity from any point of the installation which should not be more than 5 ohms.	Nos.	1	2400	00	2400	00	
	Add 10% contingencies					103549 10354	00 90	
						113903	90	Say Rs. 113904

Note :- The estimate does not include the provision of fluorescent tube fittings.



Arrangement of Lift
Fig. 15.35

motor will draw 22 amps load from the mains. In view of Table 14.1, 25 sq. mm. P.V.C. single core 660 volts grade will be suitable to meet the load, 4-wire of 25 sq. mm. can be accommodated in H.G. conduit of dia. 38 mm.

After working the above details, the estimated cost is worked out as shown in Table 15.10.

Examples 12. *An auditorium, the plan of which is shown in Fig. 15.36 is to be provided with electrical wiring. Suggest the number of points and determine the total connected load of the auditorium. Draw neat connection diagram and also determine the estimated cost of providing internal electrification including cost of electrical fittings and fans. The cost of wiring at first floor which is being used by a commercial organisation is not to be included.*

Solution.

The load of the auditorium in accordance with the level of illumination required has been worked out in Table 15.11. The coefficient of utilization has been taken as 0.35 to 0.4 while calculating the requirement.

In addition, emergency lighting system in case of failure of supply received from State Electricity Deptt. will be used. These lights will work at 24 V and for this purpose standby batteries will be used.

Table 15.10

S. No.	Schedule of material: Material with specification	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Total Cost Rs.	Total Cost P.	Remarks
1.	Supplying and Laying of conduit 38 mm. H.G. recessed in the wall including bends, screws, cement and sand.	m.	20	26	00	520	00	
2.	Supplying and fixing T.P.I.C. 500 volts, 50 amps main switch including the cost of bolts and nuts.	No.	1	675	00	675	00	
3.	Supplying and fixing T.P. star delta starter capacity 50 amps on angle iron main board.	No.	1	2250	00	2250	00	
4.	Supplying and fixing angle iron main board size 30 cm × 50 cm. with sheet at top and bottom (cost of gutties, cement and screws is included).	No.	1	55	00	55	00	
5.	Supplying and stretching P.V.C. wire single core 25 sq. mm. in solid/flexible conduit of size 38 mm/51 mm.	m.	100	25 per 100 m	00	2500	00	
6.	Making connection to 15 H.P. motor from starter by 25 sq. mm wire (6 lengths to be carried through flexible conduit of 51 mm. dia). The cost of 5 metres length of 51 mm. dia. flexible conduit is also included.	m.	5	100	00	500	00	
7.	Providing and extending G.I. wire S.W.G. 8 for providing double earth connection to all equipment in the machine room.	Lump	Sump	—	—	400	00	
					C.O.	6900	00	

(Contd.)

S. No.	Schedule of material: Material with specification	Unit	Qty. reqd.	Cost: Rates Rs.	Cost: Rates P.	Cost: Total Cost Rs.	Cost: Total Cost P.	Remarks
					B.F	6900	00	
8.	Supplying and erecting motors generator set of following specification on a common cast iron or channel iron base plate. A.C. Motor B.H.P. = 15 Type = A.C. 3-phase Voltage = 400 volts Make = Kirloskar/G.E.C. Generator (d.c) Outlet = 10 kW Voltage = 220 Volts Make = G.E.C. or any other standard make approved by I.S.I.	Set	1	40000	00	40000	00	
9.	Supply and erecting 220 volts 10 H.P. d.c. compound wound motor of any approved make	No.	1	25000	00	25000	00	
10.	Supplying and installing electronically operated controller with relays and protective device for automatic operation of the car.	Set	1	60000	00	60000	00	
					C.O.	131900	00	

(Contd.)

S. No.	Schedule of material: Material with specification	Unit	Qty. reqd.	Cost: Rates Rs.	Rates P.	Total Cost Rs.	Total Cost P.	Remarks
						B.F		
11.	Supplying and fixing counter weight, guide rails and ropes and control cable from the controller.	Set	1	30,000	00	131900 30,000	00 00	
12.	Supplying and fixing lift car made out of steel and spaced to accommodate 6 persons complete with fluorescent tubes, 2 Nos. of 20 watts, each cabin fan and emergency alarm. The cost of the buffer springs, various push buttons for operation and wiring is also included	No.	1	37,500	00	37,500	00	
13.	Supplying and fixing suitable wiring from controller to all floors for indication lamps.	Lump	Sump	4,000	00	4,000	00	
14.	Supplying and fixing indication lamps at all floors.	Set of 5 lamps	5	25	00	125	00	
	Add 10 contingencies					203525 20352	00 50	
					Total Rs.	223877	50	
	Hence the estimated Cost is Rs. 2,23878/-							

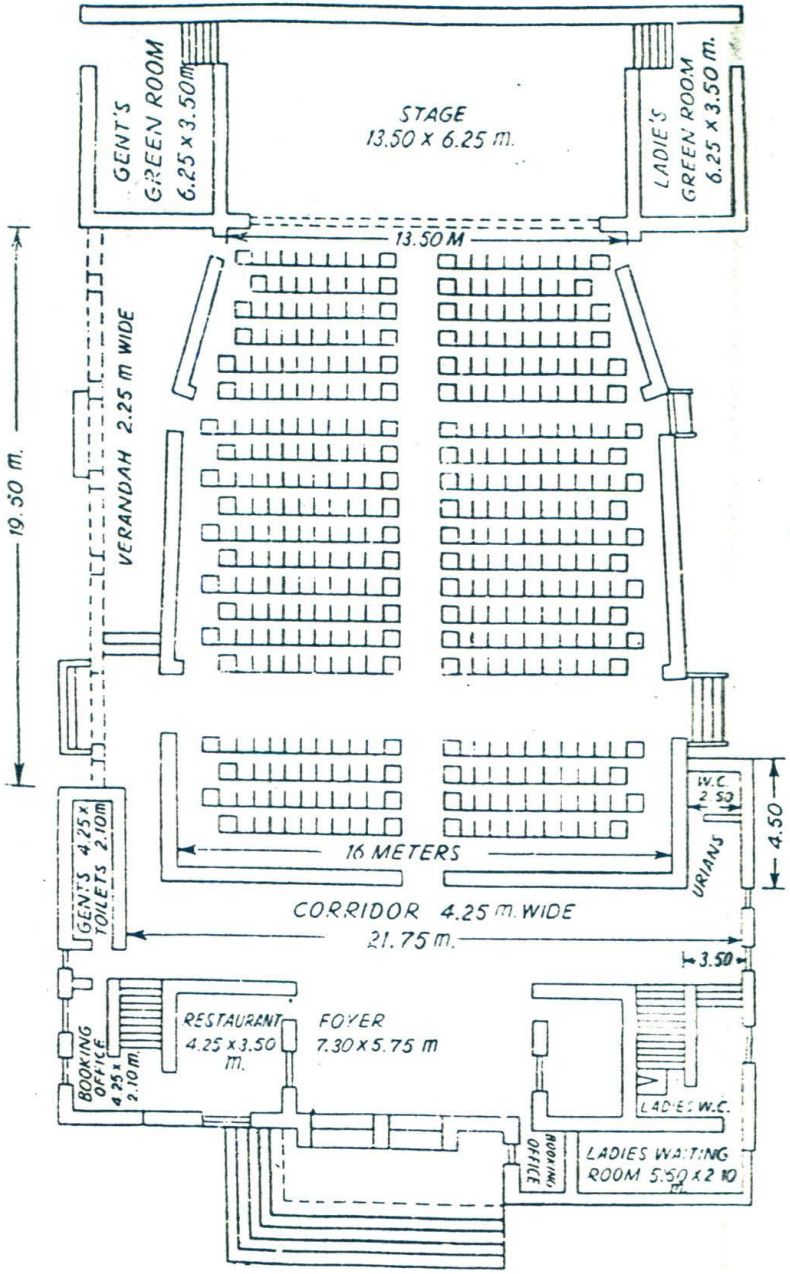

GENT'S GREEN ROOM 6.25 x 3.50m.
STAGE 13.50 x 6.25 m.
LADIE'S GREEN ROOM 6.25 x 3.50 m.
13.50 M
19.50 m.
VERANDAH 2.25 m WIDE
W.C 2.50
URIANS
4.50
GENTS 4.25 x TOILETS 2.10m
16 METERS
CORRIDOR 4.25 m. WIDE
21.75 m.
3.50
BOOKING OFFICE 4.25 x 2.10m.
RESTAURANT 4.25 x 3.50 m.
FOYER 7.30 x 5.75 m
LADIES W.C.
BOOKING OFFICE
LADIES WAITING ROOM 5.50 x 2.10

Fig. 15.36

Table 15.11

Place	Dimension	Recommended level of illumination	Details of Lamp/Fitings				Total lighting load in wats	Otther loads in watts	Total loads in watts
			Type	Wattage	Available lumens per lamp fitting	Nos. of lamps /fitting recommended			
1	2	3	4	5	6	7	8	9	10
Main Hall	$\frac{13.50 + 16.0}{2} \times 21.00$ = 309.75 sq. m.	80 Lux	Incandescent lamps, 2 Nos. in each chandellier fittings	200 × 2 = 400	2,562	10	4,000	(*i*) Fans, 142 cm., sweep 16 Nos. Load = 16 × 60 = 960 watts (*ii*) Exhaust Fan 380 mm. sweep 10 Nos. Load = 10 × 120 = 1,200 watts. (*iii*) Exit Light (*a*) 2 × 4 × 25 = 200 watts. (*b*) 2 × 3 × 25 from d.c. Batteries = 150 watts. (*iv*) Speaker = 4 Nos. Load is taken into consideration while determining the load of a stage.	(*a*) 6,360 (*b*) Load on batteries = 150 watts

(*Contd.*)

1	2	3	4	5	6	7	8	9	10
								(*ii*) Four light plugs for connecting micro-phone/amplifier system. Load =400 watts.	
Basement to be used as switch room and duty room for the electrician	14.30 × 5.75 = 82.23 sq. m. approx.	Lux 100	Fluorescent tube light fitting 122 cm. long	40	920	10	400	Exhaust fans two Nos. 305 mm sweep, Load =2 × 60 = 120 watts	520
Gents green room	6.25 × 3.50 = 21.88 sq. m. approx.	300 Lux	(*i*) Fluorescent tube light fittings containing 2 tubes of length 122 cm.	80	1860	3	240	(*i*) Fan 142 cm. sweep, 2 Nos. Load =2 × 60 = 120 watts	(*i*) 1,480
			(*ii*) Fancy brackets two Nos. one should be above dressing table collapsible type.	60	336	2	120	(*ii*) Two power plugs 15 Amps for appliances Load =1,000 watts	(*ii*) 25 from d.c. battery.
								(*iii*) One 25 watts emergency light fed from d.c. battery.	
Ladies green room	–do–	–do–	–do–	–do–	–do–	–do–	–do–	–do–	–do–
								Total Load (*i*) On 230/400 mains	30,500 watts
								(*ii*) On d.c. Battery	275 watts

1	2	3	4	5	6	7	8	9	10
								(*iii*) Plug for table lamp, 1 No. Load = 100 watts.	
Booking Office	4.25 × 2.10 = 8.93 sq. m. approx.	125 Lux	(*i*) Fluorescent tube light 122 cm. long, 40 watts.	40	920	1	40	(*i*) Ceiling fan 122 cms. sweep, 1 No. Load = 60	(*i*) 100 "
								(*ii*) Emergency light from d.c. battery = 25	(*ii*) 25 from d.c. battery
Toilet, urinals and w.c.	4.50 × 2.10 + 4.50 × 2.50 + 1.5 × 1.5 = 22.95 sq. m. approx.	50 Lux	(*i*) Fluorescent tube lights 61 cm. long	20	380	3	60	Exhaust fans 305 mm. Sweep 2 Nos. Load = 2 × 60 = 120 watts	240
			(*ii*) One mirror light in ladies w.c. with collapsible bracket	10	–	1	60		
Ladies waiting room and booking office	5.50 × 2.10 + 0.75 × 2.10 = 13.13 sq. m. approx.	150 Lux	Fluorescent tube lights 61 cm. long	20	380	4	80	(*i*) Ceiling fan 122 cm. Sweep 1 No. Load = 60	140
								(*ii*) Emergency Light from d.c. battery 25 watts.	25 from d.c. Battery
Stage	13.50 × 6.25 = 84.38 sq. m. approx.	1000 Lux	Flood light Fittings.	1000	8,000	10 Nos.	10,000	(*i*) Power plugs each suitable for 1 kw. load, for throwing rays of coloured lights on the stage Load = 4,000	14.400

(*Contd.*)

1	2	3	4	5	6	7	8	9	10
								(*ii*) Four light plugs for connecting micro-phone/amplifier system. Load =400 watts.	
Basement to be used as switch room and duty room for the electrician	14.30 × 5.79 = 82.23 sq. m. approx	Lux 100	Fluorescent tube light fitting 122 cm. long	40	800	10	400	Exhaust fans two Nos. 305 mm sweep, Load =2 × 60 = 120 watts	520
Gents green room	6.25 × 3.50 = 21.88 sq. m. approx.	300 Lux	(*i*) Fluorescent tube light fittings containing 2 tubes of length 122 cm.	80	1860	3	240	(*i*) Fan 142 cm. sweep, 2 Nos. Load =2 × 60 = 120 watts	(*i*) 1,480
			(*ii*) Fancy brackets two Nos. one should be above dressing table collapsible type.	60	336	2	120	(*ii*) Two power plugs 15 Amps for appliances Load =1,000 watts	(*ii*) 25 from d.c. battery.
								(*iii*) One 25 watts emergency light fed from d.c. battery.	
Ladies green room	-do-	-do-	-do-	-do-	-do-	-do-	-do-	-do-	-do-
								Total Load	
								(*i*) On 230/400 mains	30,500 watts
								(*ii*) On d.c. Battery	275 watts

It is proposed to use basement as switch room and duty cabi for the electrician.

Details of load are given in a Table 15.11.

Category A

(*i*) Lighting load for illumination and exit light = 17,660 watts
(*ii*) Ceiling fans load = 1,500 watts
(*iii*) Exhaust fans load = 1,440 watts
(*iv*) 5 Amps plugs load = 100 watts

Total 20,700 watts

Category B

(*i*) Advertisement load = 1,400 watts
(*ii*) Power plugs load = 8,000 watts
(*iii*) Amplifiers load = 400 watts

Total 9,800 watts

Category C

(*i*) Load for emergency light = 275 watts

For this load, service connection from existing 3-phase, 4-wire mains will be taken through an underground cable. The meter will be installed in basement. As the connection to the auditorium will be a commercial one, thus there is no need of obtaining two connection separately one for lighting and other for power load. In this case the lighting load will be also be considered as purely commercial. However there will be separate circuits for lighting and power.

$$\text{Lighting and Fans load in Amps} = \frac{20,700}{\sqrt{3} \times 400} = 29.88 \text{ Amps}$$

$$\text{Power load in Amps} = \frac{9,800}{\sqrt{3} \times 400 \times 0.8}$$

$$= 17.68 \text{ Amps}$$

$$\text{Total load in Amps} = 47.56$$

Consulting Table 14.8, it will be seen that $3\frac{1}{2}$ core 35 sq. mm P.V.C. 1100 volts grade cable will be suitable.

(*i*) Length of this cable from meter to main switch = 15 m.

(*ii*) 100 Amps 3 phase 500 V.I.C. main switch with neutral link = 1 No.

(*iii*) Aluminium strip 25.4 mm × 6.30 mm for bus bar = 20 m.

(*iv*) Length of P.V.C. 1100 volts grade $3\frac{1}{2}$ core 35 sq. mm. = 10 m.

A suitable cover for bus bars will be made by using G.I. sheet.

The proposal is to take connection from the bus bar for every circuit.

(1) Light, Fans and Exhaust Fans load.

The total load is 20,700 watts, 29.88 Amps. It will be better if the following circuits are provided :

(*a*) Main Hall = 2 circuits sharing half the load *i.e.* 3,180 watts (4.59 Amps in 3-phase (Supply)

(*b*) Gents green room and half of stage = 1 circuits to feed 5,480 watts (7.91 Amps on 3-phase supply)

(*c*) Ladies green room and half of stage = 1 circuit to feed, 5,480 watts (7.91 Amps).

(*d*) Restaurant, booking office = 1 circuit, 1060 watts (4.61 Amps. office, gents toilet on single phase supply) and verandah.

(*e*) Foyer, corridor, Manager's office, Ladies waiting room, w.c. and basement. = 1 circuit, 2320 watts (3.349 Amps) on three phase supply

In view of the above, particulars of materials for the circuits as shown in Table 15.12, is selected.

(2) Power and Advertisement load.

The total power load is 9.8 kW (17.68 Amps). For this load following circuits will be provided.

(*i*) One circuit for corridor, foyer, Verandah and Restaurant. = 3,400 watts (6.140 Amps)

(*ii*) One circuit for stage and greens room. = 6,400 watts (17.675 Amps)

In view of this particulars of material as shown in Table 15.13 selected.

(3) Emergency Lighting (d.c.)

The emergency load is 275 watts at 24 Volts (11.46) amps, there will be only one circuit in the basement. The particulars of material required are shown in Table 15.14.

After the size of various types of mate rials are determined, the circuit diagram as shown in Fig. 15.37 is drawn. The estimated cost of this work has been calculated vide Table 15.15.

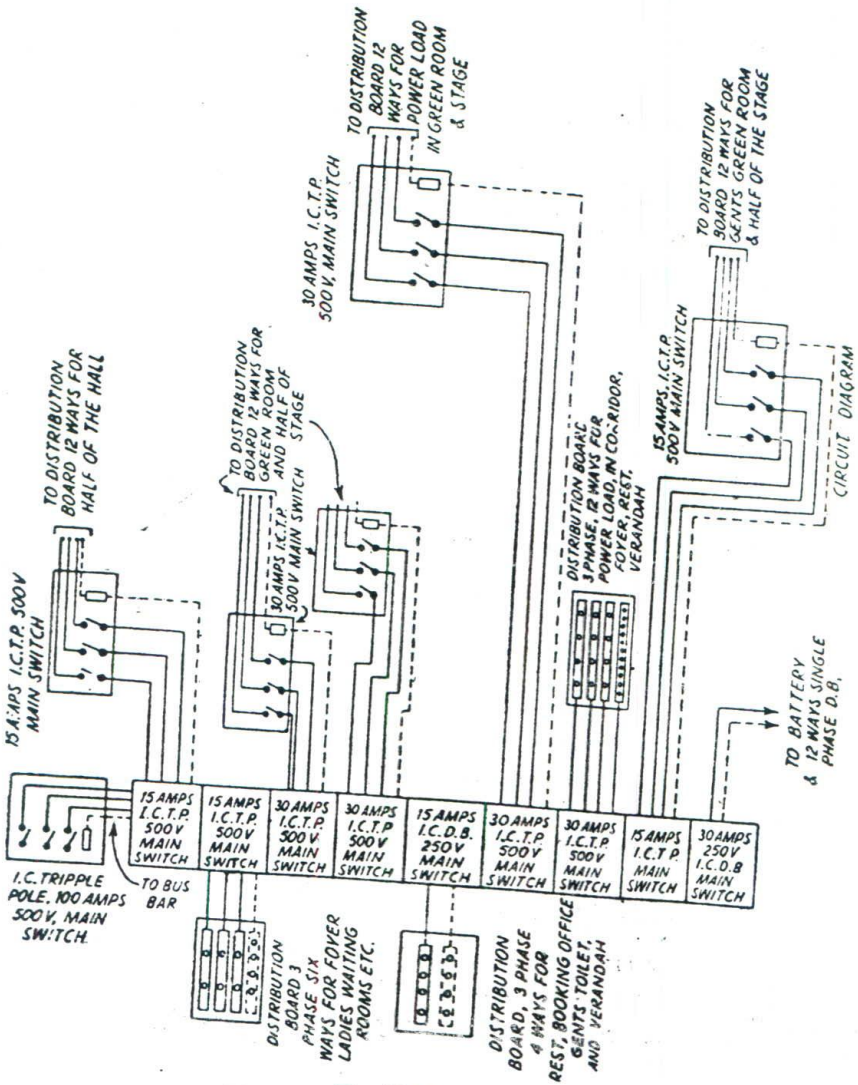


Fig. 15.37

Table 15.12

S. No.	Size and Nos. of I.C. tripple pole or single phase with neutral link main switch	Size and Nos. of I.C. D.B.	Position of I.C.D.B.	Size and length of P.V.C. wire	Size and length of conduit	Size and Nos. of Angle iron main board	Remarks
1.	For main hall 15 amps, 500 volts = 4 Nos.	3 phase, 500 V 12-way, 15 Amps = 2 Nos.	On left and right side of the front gate of the hall	Single core 660 V grade 2.5 sq. mm route length 20 m Total length = 80 m.	19 mm. dia. Length = 20 m.	30 cm. × 50 cm. = 4 Nos.	
2.	For Gents green room and half stage 30 Amps, 500 V = 2 Nos.	3 phase, 500 V 12-way 15 Amps/way = 1 No.	Outside the green room.	Single core 6 sq. mm Route length = 45 m Total length = 4 × 45 = 180 m.	25.4 mm. dia. Length = 45 m.	30 cm. × 30 cm. = 2 Nos.	
3.	For Ladies green room and half stage 30 Amps, 500 V = 2 Nos.	-do-	-do-	-do-	-do-	-do-	
4.	For Restaurant Booking office, Gents toilet and Verandah I.C. single phase 250 V, 15 Amps. = 1 No.	Single phase 4-way I.C. pole 15 amps/way = 1 No.	In the basement	Single core 660V grade 2.5 sq. mm. Route length = 10 m Total length = 20 m.	19 mm. dia. Length = 10 m.	25 cm. × 30 cm. = 1 No.	
5.	For foyer, corridor, Manager Office, Ladies waiting room w.c. and basement. 15 Amps, 500 V. 1 No.	3-phase 500 V Six-way I.C.D.B. 15 Amps per way, = 1 No.	-do-	Single core 660 V grade 2.5 sq. mm. Route length = 10 m Total = 40 m. Length	-do-	30 cm. × 50 cm. = 1 No.	

Table 15.13

S. No.	*Size and Nos. of I.C. tripple pole or single-phase with neutral link main switch*	*Size and Nos. of I.C. D.B.*	*Position of I.C.D.B.*	*Size and Length of V.I.R wire*	*Size and Length of conduit*	*Size and Nos. of Angle iron Main Board*	*Remarks*
1.	For Corridor, Foyer, Verandah and Restaurant 30 Amps, 500 V = 1 No.	12-way, 3-phase 500 Volts, 15 amps. way = 1 No.	In Basement	Single core 660 V grade, 4 sq. mm. Route Length = 10 m. Total Length = 10 × 4 = 40 m.	25.4 mm. dia. Length = 10 m.	30 cm. × 50 = 1 No.	
2.	Stage and Green Room, 30 Amps, 500 V = 2 Nos.	12-way, 3-phase 500 volts, 15 amps. way = 1 No	Near the Stage	Single-phase 660 V, grade 16 sq. mm. Route Length = 45 m. Total Length = 4 × 45 = 180 m.	31.8 mm. dia. Length = 45 m.	30 cm. × 50 cm. = 2 Nos.	

Table 15,14

1.	30 Amps,. 250 V, Single phase 1 No.	12-way, Single phase 250 V, 15 Amps/way = 1 No.	In Basement	Single core 660 V, grade 6 sq. mm. Route Length = 10 m. Total Length 20 m.	19 mm. dia. Route Length = 10 m	25 cm. × 30 cm. = 1 No.	

Table 15.14

S. No.	Details of items	Unit	Qty.	Rate		Total cost		Remarks
				Rs.	P.	Rs.	P.	
1.	Supplying and fixing $3\frac{1}{2}$ core P.V.C. cable 35 sq. mm. on the wall or in the trench, including material *viz.* clamps, screws, sand etc.	m.	25	11000 per 100 m	00	2750	00	
2.	Supplying and fixing 100 Amps, 3-phase with neutral link, 500 V, main switch on suitable angle iron main board to be fixed on the wall.	No.	1	1270 per pc.	00	1270	00	
3.	Supplying and fixing aluminium strip 25.4 mm. × 6.30 mm. to form bus bar on a suitable Angle Iron and G.I. sheet framework with insulators.	Nos.	20	45 per pc.	00	900	00	
4.	Supplying and fixing 3-phase with neutral link, 500V, 30 Amps Main-Switch on suitable Angle Iron Main Board fixed on the bus bars frame on the wall.	Nos.	7	475 Per pc.	00	3325	00	
5.	—do—but of 15 Amps. capacity.	Nos.	5	340 Per pc.	00	1700	00	
6.	Supplying and fixing single phase 15 Amps, 250V, Main Switch on suitable Angle Iron Board to be fixed on the bus bars frame.	Nos.	1	135 Per pc.	00	135	00	
7.	—do—but of 30 Amps capacity.	Nos.	1	280 Per Pc.	00	280	00	
8.	Supplying and fixing 3-phase, 12-way Distribution Board, capacity 15 Amps/way.	Nos.	6	750 Per pc.	00	4500	00	
9.	—do—but of 6 ways.	Nos.	1	225 Per pc.	00	225	00	
10.	Supplying and fixing single phase, 4-way 15 Amps/way Distribution Board, capacity 15 Amps/way.	Nos.	1	150 Per pc.	00	150	00	
					C.O.	15235	00	

(Contd.)

S. No.	Details of items	Unit	Qty.	Rate		Total cost		Remarks
				Rs.	P.	Rs.	P.	
					B.F.	15235	00	
11.	—do—but of 12-way.	Nos.	1	580	00	580	00	
12.	Supplying and fixing 19 mm. dia. pipe in the recessed wall or ceiling and completely repairing the wall.	m.	20	Per pc. 16	00	320	00	
13.	Supplying and fixing 25.4 mm. dia. conduit Pipe in the recessed wall or ceiling and completely repairing the wall.	m.	10	18	00	180	00	
14.	Supplying and fixing 31.8 mm dia. conduit Pipe on the recessed wall or ceiling and completely repairing the wall.	m.	45	20	00	900	00	
15.	Supplying and stretching single core 600 V grade 2.5 sq. mm P.V.C. wire in conduit with copper wire of 14 S.W.G. as continuous earth.	m.	140	365 (per 100 m.)	00	511	00	Item No. 1 to No. 18 are for providing the connections upto Distribution Boards.
16.	—do— but P.V.C. wire of size 4 sq. mm	m.	40	570 (per 100 m.)	00	228	00	
17.	—do— but P.V.C. wire of size 6 sq. mm	m.	110	885 (per 100 m.)	00	973	50	
18.	—do—P.V.C. wire of size 10 sq. mm	m.	180	1300 (per 100 m.)	00	2340	00	
19.	Supplying and fixing light points recessed conduit type) in conduit pipe including the cost of conduit, switches, ceiling roses, pendant holder, flexible cord, bends, Inspection boxes, holders and shades, and switch boards for light fans or exhaust fans points with 1.5 sq. mm. P.V.C.	Nos.	124	150	00	18600	00	Light point = 61 Nos Fans Point = 25 Nos. Exhaust point = 27 Nos. Electric bell Point = 1 Nos. Advertisement = 10 No.
					C.O.	39867	50	

(Contd.)

S. No.	Details of items	Unit	Qty.	Rate		Total cost		Remarks
				Rs.	P.	Rs.	P.	
					B.F.	398667	50	
20.	—do—but with 2.5 sq. mm. P.V.C. wire.	Nos.	10	180 (per pc.)	00	1800	00	Light Point = 10 Nos.
21.	—do—but with 4 sq. mm. P.V.C. wire.	Nos.	10	200 (per pc.)	00	2000	00	Light Point = 10 Nos.
22.	Supplying and fixing 15 Amps plugs controlled by a 15 Amps flush type tumbler switch with P.V.C. wire of 4 sq. mm size including the cost of conduit, switches, boards, plugs, conduit, bends, Inspection boxes, and G.I. wire of 14 S.W.G.	Nos.	10	270 (per pc.)	00	2700	00	
23.	Supplying and fixing 5 Amps plugs controlled by a 5 Amps flush type tumbler switch with P.V.C. wire of 1.5 sq. mm including the cost of conduit, switches, switch boards, plugs, conduit bends, Inspection boxes and copper wire of 14 S.W.G.	Nos.	5	155	00	775	00	
24.	Supplying and fixing light points (recessed conduit type) in conduit pipe, including the cost of conduit, switches, ceiling roses, switch board, flexible cord, bends, Inspection boxes for light points with P.V.C. wire single core 1.5 sq. mm from d.c. source of supply.	Nos.	11	170	00	1870	00	
25.	Supplying and fixing point for neon sign board in conduit with P.V.C. wire of 4 sq. mm. including the cost of switch, ceiling rose, bends, inspection boxes etc.	Nos.	1	1120	00	1120	00	
26.	Providing earthing G.I. plate of size 60 cm. × 60 cm. × 6.3 mm. plate S.W.G. 8, including the cost of charcoal, earth plate G.I. wire etc.	Nos.	1	950	00	950	00	
					C.O.	51082	50	

(Contd.)

S. No.	Details of items	Unit	Qty.	Rate		Total cost		Remarks
				Rs.	P.	Rs.	P.	
					B.F.	51082	50	
27.	Supplying and fixing fancy brackets complete with suitable B.C. holder, and fancy glass shade.	Nos.	6	190	00	1140	00	
28.	Supplying and fixing fancy bracket collapsible type complete with suitable B.C. Holder and fancy shade.	Nos.	3	175	00	525	00	
29.	Supplying and fixing chandelier with 2 holders and beautiful shades.	Nos.	12	900	00	10800	00	
30.	Supplying and fixing chandelier with 4 holders and beautiful shades.	Nos.	1	1000	00	1000	00	
31.	Supplying and fixing fluorescent tube light fitting with glass shades and 2 × 40 watt fluorescent tube.	Nos.	6	300	00	1800	00	
32.	—do—but with 1 × 40 watt fluorescent tube.	Nos.	22	200	00	4400	00	
33.	—do—but with 2 × 20 watt fluorescent tube.	Nos.	17	205	00	3485	00	
34	—do—but with 1 × 20 watt fluorescent tube.	Nos.	7	150	00	1050	00	
35.	Supplying and fixing flood light fittings suitable for accommodating 1,000 watt lamps with glass shade and lamp as specified.	Nos.	14	900	00	12600	00	
36.	Supplying and fixing 4 Nos. amplifier system connection to four speakers placed in the hall all as specified including the cost of speakers.	Nos.	4	2000	00	8000	00	In this estimate, the cost of all fittings, fixtures fans and lamps have been taken into consideration.
37.	Supplying and fixing electric bell in the Manager's room.	Nos.	1	95	00	95	00	
					C.O	95977	50	

(Contd.)

S. No.	Details of items	Unit	Qty.	Rate		Total cost		Remarks
				Rs.	P.	Rs.	P.	
					B.F.	95977	50	
38.	Supplying and fixing electric fans of any make and S.I. approved, sweep 142 cm.	Nos.	18	950	00	17100	00	
39.	—do—but of sweep 122 cm.	Nos.	5	700	00	3500	00	
40.	Supplying and fixing of exhaust fans single phase 380 mm. dia.	Nos.	10	725	00	7250	00	
41.	—do—but of sweep 305 mm. dia.	Nos.	4	550	00	2200	00	
42.	Supplying and fixing electric lamps of following wattage.						00	
	(a) 200 watts	Nos.	20	16	00	320	00	
	(b) 100 watts	Nos.	11	10	00	110	00	
	(c) 60 watts	Nos.	11	9	00	99	00	
	(d) 25 watts	Nos.	19	7	00	133	00	
				Total		126689	50	
		Add 10% Contingencies				12668	90	
						139358	40	Say Rs. 139358/-

Example 13. *In a factory of area 30 m × 12 m the following machines are to be erected. Estimate the cost for the power and lighting wiring.*

(*i*) *Two Lathes of 1 HP. 3ϕ 416 V each.*
(*ii*) One Grinding machine of 0.5 HP, 220 V, 1ϕ
(*iii*) *One Drilling machine of 0.5 HP, 220 V, 1ϕ*
(*iv*) *One Shaper machine of 5 HP, 416 V, 3ϕ and*
(*v*) *One Welding machine of 10 KVA, 416 V, 3 phase.*

Industrial type double tube fitting may be used for lighting

Solution : In this estimate, 50% of floor area is used for Office, Supervisory Staff and for Consumer's enquiry chamber. In the remaining 50% of floor area, the machines are suitably located. The roof trusses are at 3.0 M spacing and the bottom of trusses have a clearance of 5.0 M from Ground.

Assumption Made

POWER WIRING CIRCUIT

1. The Machines are located as shown in the sketch.
2. For Grinding and Drilling machines, *Surface Conduit* System is proposed.
3. For Shaper machine, Lathes and Welding U.G. Cable system is proposed.
4. The trench is 1.0 m deep.
5. The trench is covered with heavy concrete slabs.
6. (*a*) Main Panel Board is at a height of 1.35 M above the ground level and is located as shown.
   (*b*) The Starter and Main Switches are erected for each individual machine at a height of 1.35 M, on a floor mounted angle iron frame, at the arms stretch of the operator. The cost of starter and switches are included in the cost of machines.
7. The Surface Conduit Wiring is done 2.5M above the ground level.
8. The Cable sizes are selected basing on the designing current and its association voltage drop.
9. 24 Nos. 5/15A plugs 1 KW each are provided

As per rule, double earthing is done for all machines using SWG 8 copper,

Shaper M/C Length of 4 core cable required

From DB to GL to Trench to A M/C to starter

1.35 + 1.0 + 3.0 + 1.0 + 1.0 + 1.35 = 9.70+ 2.00 loop = 11.70

wastage = 1.70

= 13.40 or 14 M

Cable size calculation

Name plate detail : 5 HP, 416V, 3Φ, 0.707 lag

Assuming $\eta = 0.8$,

line current = $\frac{5 \times 735.5}{\sqrt{3} \times 416 \times 0.8 \times 0.707} = 9.02$ Amps.

The designing current = $\frac{9.02 \times 1.5}{0.8} = \cong 17$ Amps.

Selecting 2.5 mm^2, 1/1.80, 20 A, 4 core, 15 mV/A/M (Non metal sheathed) insulated with Butyl Rubber - (Table 14*a*)

The voltage drop = $15 \times 10^{-3} \times 17 \times 14 = 3.57$ volts.

This is well within permitted drop and hence this cable is selected.

2. (*ii*) LATHE (1)

Length of 4 core cable required

From DB to GL to Trench to B to C to M/C starter

1.35 + 1.0 + (1.0 + 1.5 + 1.5 + 1.5 + 1.50) + 3.0 + (1.0 + 1.35)

= 14.70 + 2.00 loop = 16.70

Add 10% = 1.67

Total = 18.37 or say 18.5

Cable size calculation

Name plate detail : 1 HP, 416 V, 3ϕ, 0.7 lag

Assume $\eta = 0.8$,

line current = $\frac{1 \times 735.5}{\sqrt{3} \times 416 \times 0.7 \times 0.8} = 1.82$ Amps.

The designing current = $\frac{1.82 \times 1.5}{0.8} = 3.4$ Amp.

Selecting 1.0 mm², 1/1.12 amp, 37 mV/A/M 4 Core cable (Non-Metal sheathed) insulated with Butyl Rubber.

The drop = $37 \times 10^{-3} \times 3.4 \times 18.5 = 2.34$ volts.

This is well within limits and hence this size can be selected.

***(ii)* LATHE (2)**

Length of 4 core cable required

From DB to Trench to D to E to M/C to starter

1.35 + 1.00 + (1.0 + 1.5 + 1.5) + 3.0 + 1.00 = 13.00 + 1.35 = 11.00 + 2.00 loop

Add 10% wastage = 1.32

14.32 or Say 15.0 M

Since Lathe No 2 also has the same Name plate detail, we select the same 1.0 mm², 1/1.12, 10Am, 37mv/A/M 4 core cable (Non metal sheathed) insulated with Butyl Rubber

Total length of cable required : 18.5 + 15.0 = 33.5 or say 34.0 m,

(3) WELDING SET

Length of cable required

From DB to F to G to M.S.

2.35 + 12.0 + 5.0 + 2.35 = 21.70 + 2.00 loop = 23.70

wastage = 2.37

26.07 or 26.0 mts

Cable Size Calculation

Name plate detail : 10 KVA, 416V, 3ϕ, 0.8 lag

Assuming η = 0.9

$$\text{line current} = \frac{10 \times 10^3}{\sqrt{3} \times 416 \times 0.9 \times 0.8} = 19.2 \text{ Amps.}$$

$$\text{Designing current} = \frac{19.2 \times 1.5}{0.8} = 36.14 \text{ Amps.}$$

Selecting 4 core. 10 mm²; 7/1.40, 41 Amp, 3.7 mv/A/M.

(Non, metal - sheathed) Ethylene–Propelene insulated.....

Voltage drop = $3.7 \times 10^{-3} \times 36.14 \times 26 = 3.48$ volts

This is well within limits and hence can be selected.

4. DRILLING M/C

Length of Cable required :

From DB to (up) H. to I to J to K to $SB^{drilling}$

(up) 2.65 + 10.5 + 3.0 + 3.0 + 2.65 (down) =24.18
= 21.80 + 2.38 loop

wastage = 2.41

26.78 or say 27.0 M

Cable size calculation :

A single cable for both drilling and Grinding is drawn up to point J from where connection to Grinding m/c is tapped off.

∴ Current in the line is the sum of current due to Drilling and Grinding m/c.

Total power = 1.0 HP, 220V, 1ϕ, 0.65 say η = 0.8 lag

$$\text{Line current} = \frac{1 \times 735.5}{220 \times 0.65 \times 0.8} = 6,42 \text{ Amp.}$$

$$\text{The designing current} = \frac{6.42 \times 1.5}{0.8} = 12.05 \text{ Amp.}$$

This is the current up to J

∴ Length of cable up to J = 2.65 + 10.5 = 17.76
+ 3.0 = 16.15 + 1.61 loop

wastage = 1.77

19.53 or say 20.0 m

Selecting Twin core, 1.0 mm^2, 1/1.12, 12 Amp, 43 mv/A/M. cable.....

∴ **Voltage drop up to 20.0M.** = $43 \times 10^{-3} \times 12.05 \times 20.0 = 10.32$ volts.

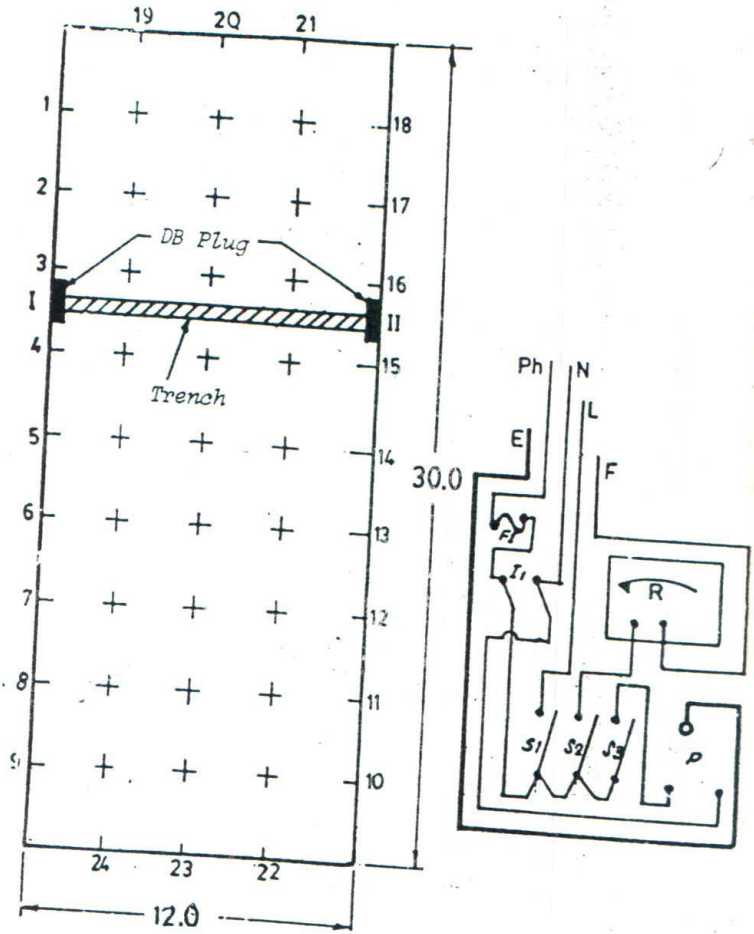
This is far greater than the permitted.

Selecting Twin core 4mm^2 1/2.24, 27 Amp, 12mv/A/M up to 20.0 m length,

The drop = $11 \times 10^{-3} \times 12.05 \times 20.0 = 2.64$ volts.

From J to K to L (SB Drilling m/c,)

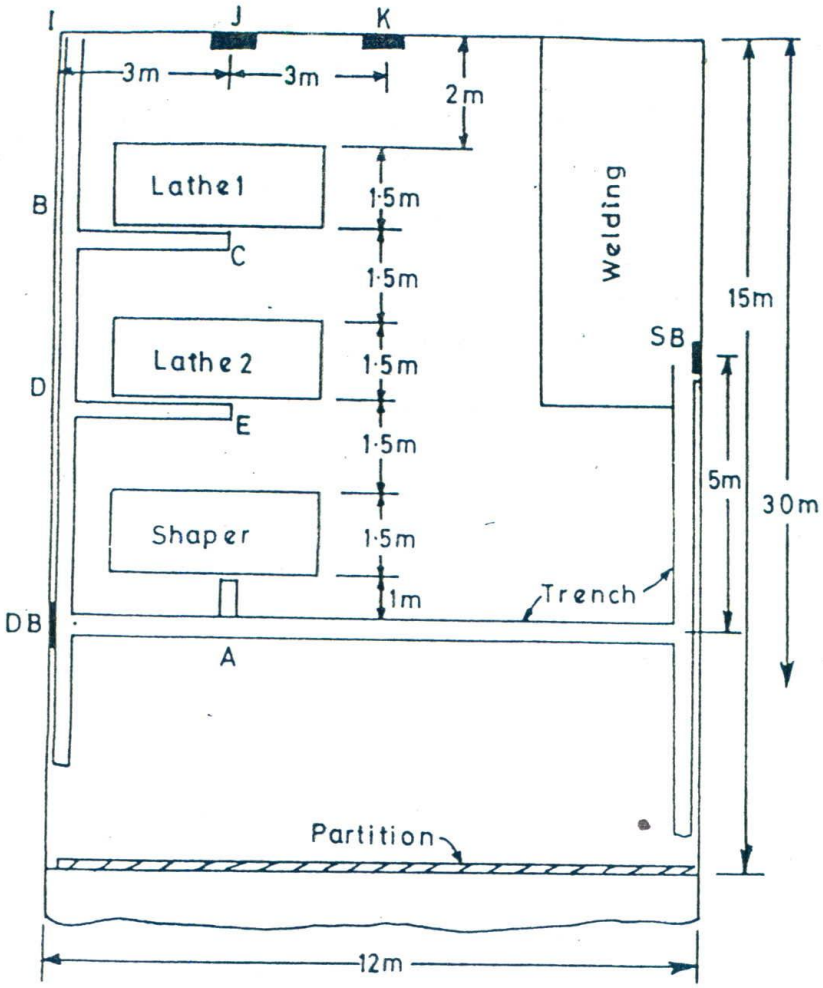
Switch board for controlling of 11amp, 1fan and 1 3-pin plug.



+Position of T.L. fittings plugs on the walls are at height of 1.35 metres and T.L.S. on the walls are at a height of 2metres down from roof trusses.

F1-Fuse
I1-Indicating lamp
P -Plug point
R -Fan regulator
S1, S2, S3-Switches

All dimensions in metres



Note: Point H is at the height of 2.65 metre above DB from K to L (SB drill)=2.65 metre

length = 3.0 + 2.65 = 5.65 + 0.56 loop = 6.21

wastage = 0.62

Total = 6.83 or say 7.0 M

Selecting Twin 1.0mm^2, 1/1.12, 12A, 43 mV/A/M cable.....

The total drop from DB = 2.64 + 1.80 = 4.64 volt which is less than the permitted and hence can be designed like this.

5. Grinding m/c

Voltage drop up to J = 2.64 volt

Length of cable from J to M (SB Grinding) = 2.65

drop for this length for the same 1.0mm^2 cable $43 \times 10^{-3} \times 6 \times 2.65 = 0.688$ volt

Hence 1 mm^2 Twin core is selected from J to SB.

6. Plugs

Each plug 1 KW, 1ϕ, 230 V. Total 24 Nos. as shown in sketch. Separate individual connection is proposed from supply DB to each plug.

Supply from DB (Plug 1)

Plug 1. From DB to trench to P_1

1.35 + 1.0 + 7.5 + 1.0 + 1.35 = 12.20 + 1.00 loop = 13.20

Wastage = 1.32

Total = 14.52

or say 14.5 M

Ref. Table 14a

Selecting 1.5 mm^2, 1/1.40, 15A, 29 mV/A/M

Drop in this section = $29 \times 10^{-3} \times 8.15 \times 14.5 = 3.4$ volts.

This is within limits and can be accepted.

Plug 1: =14.5 M

Plug 2 : Deduct 3.0 M from P_1 =11.5 M

Plug 3 : Deduct 3.0 M from P_2 = 8.5 M

Total =34.5 M

Plug 4, 5, 6 same as P_1, P_2, P_3 =34.5 M

Plug 7 : DB to P-7 (1.35 + 1.0 + 1.5 + 9.0 + 1.00 + 1.35) = 15.20

Loop = 1.00

Total = 16.20
Wastage = 1.62
Total = 17.82

or say 18.0 M

Drop in this section : $29 \times 10^{-3} \times 8.15 \times 18.0 = 4.3$ volts.
Hence 1.5 mm^2 cable can be accepted.

Plug 8 : Add 3.0 M extra with Plug 7 = 21.0 M

Plug 9 : Add 3.0 M with Plug 8 = 24.0 M

The drop with this cable is 5.67 volts - (high)

∴ Select 2.5 mm^2, 1/1.80, 20 A, 17 mV/A/M-the next higher size.

Plug 21 : DB to trench to P 21.

1.35 + 1.0 + 10.5 + 9.0 + 1.0 + 1.35 = 24.20 + 1.52 = 25.72 loop

Acid 10% wastage = 2.57

Total = 28.57

or say 28.5 M

Ref. Table 14 a and Select 2.5 mm^2, 1/1.80, 20 A, 17 mV/Amp.

Drop = $17 \times 10^{-3} \times 8.15 \times 28.5 = 3.94$ volts (accepted)

∴ **Plug 21**

Plug 20 deduct 3.0 M from P21 = 25.5
Plug 16 deduct 3.0 M from P20 = 22.5

Total = 76.5 M

Supply to DB (Plug II)

From DB (Plug I) to opposite side through trench

1.35 + 1.0 + 12.0 + 1.0 + 1.35 = 16.70 + 1.00 Loop 17.70 M

Wastage 10% = 1.77

= 19.47

Say 20.0 M

Current in this cable = $12 \times 8.15 = 97.47$ Amps.
(assuming all the plugs are loaded simultaneously.)
Selecting 4 core, 35 mm^2, 7/2.50, 100 Amp. 1.1 mV/A/M.
Drop in this section = $1.1 \times 10^{-3} \times 97.8 \times 20 = 2.15$ volts
From DB (Plug II) 1.5 mm^2, Twin core cable.

P-16, P-17, P-18, P-15, P-14, P-13, P-12, P-11 = 34.5 + 34.5 + 18.0 + 21.0

(Same as P-1 to P-8) =108.0 M

P-10 2.5 mm^2 Twin core =24.0 M

Plug 22 : DB (Plug II) to P-22

1.35 + 1.0 + 19.5 + 3.0 + 1.35 = 27.20 + 2.00 =29.20 Loop

Add = 2.92

=32.02 or say 33 M

Drop using 2.5 mm^2 cable $8.15 \times 17 \times 35.0$ = 4.43 volts (accepted)

Plug 23 : Add 3.0 M with Plug-22 = 35.0 M

Drop : $8.15 \times 17 \times 35.5 \times 10^{-3}$ = 4.85 (accepted)

Plug 24 : Add 3.0 M extra with plug 23

Drop : $8.15 \times 17.0 \times 38 \times 10^{-3}$ = 5.26 volts higher.

∴ **Plug 22** : to plug 24 : 32.0 + 35.0 + 38.0 = 105.0 M

ABSTRACT

Cable Requirements : Ref. Table—14 a,

1) Shaper Machine : 4 core, 2.5 mm^2, 1/1.80, = 14.0 M
20A, 15mV/A/M

2) Lathes I & II : 4 core 10 mm^2, 1/1.12, 10A, = 36.0 M
37 mV/A/M 18.5 + 17.0 = 35.5 say 36.0 M

3) Welding : 4 core 10 mm^2, 7/1.40, 41A, 3.7 = 26.0 M
mV/A/M

4) Drilling & Grinding : 4 core, 4 mm^2, 1/2.24, = 20.0 M
27 A, 11mV/A/M

2 core 1.0 mm^2, 1/1.12, 12A, = 10.0 M
43mV/A/M—(7 + 2.65) = 9.65 or say 10M

5) Plugs : 2 core, 1.5 mm^2, 1/1.40, 15A, =216.0 M
29mV/A/M

P-1 to P-8/34.5 + 34.5 + 18.0 + 21.0 = 108.0

P-11 to P-18 = 108.0

Total = 216.0 M

2 core 2.5 mm^2, 1/1.80, 20A, 17mV/A/M = 230.0

P-9 to P-10 24.0 + 24.0		= 48.0	
P-19 to P-21		= 76.5	
P-22 to P-24		=105.0	
	Total	=229.5	or say 230.0 M

From DB (Plug I) to DB (Plug II)

4 core 35 mm², 7/2.50, 100A, 1.1 mV/A/M =20.0 M

LIGHTING SCHEMES

Assumptions

(1) A uniform illumination of 150 flux ie. 150 lumens per sq. m. is provided.

(2) Depreciation Factor = 0.70 for Tube light.

(3) Utilisation Factor = 0.40

(4) Assume a moderate lumens of 1900 lm for 40 W for Flourescent Lamps, 1900/40 = 47.5 lm/watt.

(5) Surface conduit type of wiring is proposed.

(6) Space Height ratio is 1 : 2.

(7) The total lighting load : 7 KW. (including external lighting corridor, verandah, factory out door areas like main & exit roads, car parks etc.

(8) Exhaust fans 24 Nos. are provided
(9 Nos. in each 30.0 M side & 3 Nos. in each 12.0 M side)

(9) T.Ls. are suspended 2.0 M from Roof Trusses.

Calculation :

$$\text{Total lumens required inside the shop} = \frac{\text{Area in Sq. m} \times \text{Required level of illumination}}{\text{Coefficient of utilisations} \times \text{depreciation factor}}$$

$$= \frac{30 \times 12 \times 150}{0.4 \times 0.7} = 192.85 \times 10^3 \text{ lumen}$$

$$\text{No. of Lamps} = \frac{\text{Total luminous flux required}}{\text{Luminous flux per lamp}} = \frac{192.85 \times 10^3}{1900}$$

$$= 101.5 \text{ or say } 102 \text{ lamp. of 40 volts T.L.}$$

$$\text{No. of fitting} = \frac{1102}{2} = 51 \text{ No. (Twin T.L./fitting)}$$

Distribution : 27 Nos. are suspended from the roof trusses as 9 rows & 3 columns

Also 9 No fitted on each 30.0 M side wall and 3 No fitted on each 12.0 M side wall.

Total wattage : 102 lumps × 40 watts/lamp = 4080

Add = 2900 watts (exterior)

Total = 6980 watts or 7.0 K.W.

For Exhaust fans : 24 × 60 watts = 1.4 K.W.

For the lighting, of exhaust fans

Supply is taken thro' 4 core 10sq. mm 7/1.40, 48A, 3.7mV/A/M (table 14a) from main DB to the opposite wall side and a separate DB (light) is erected.

From main DB to trench to opposite side to DB (lighting)

1.35 + 1.0 + 12.0 + 1.0 + 1.35 = 16.70 + 2.00 loop + 1.00 Bending = 19.70

wastage 10% = 1.97

21.67 say 22.0 M

Note : Further calculation like positioning of switch, length of cable required for each lamp/exhaust fan is left to the reader as an exercise, since already one calculation has been done under factory lighting scheme.

LABOUR CHARGES :

For civil works preparing trench with concrete cover 0.5 M width, 1.0M deep for a length of (7.0 + 3.0 + 3.0 + 12.0 + 5.0) = Rs.30.0 M

Lump sump Rs. 2000.00

Preparing angle iron frames for fixing main switches, circuit breaker etc. = Rs. 1000.00

For Electrical works :cable jointer—1 at Rs. 100 per day = Rs. 100.00

Electrician—2 at rs. 70 = Rs. 140.00

Helper's—3 at Rs. 45 each = Rs. 135.00

Total = Rs. 375.00

for 5 days = Rs. 1875.00

Total = Rs. 1875.00

DETAILED ESTIMATE

S. No.	Description	Qty.	Rate in Rs.	Amount Rs. / P.	Total in Rs.
1.0	**CABLES**		Per Mtr.		
(a)	4 core 35 mm², 7/2.5, 100 Amps	20 M	Rs. 120/-	2400.00	
(b)	4 core 10 mm², 7/1.4, 41 Amps	26 M	Rs. 60/-	1560.00	
(c)	4 core 2.5 mm², 1/1.80, 20 Amps	14 M	Rs. 38/-	532.00	
(d)	4 core 1.0 mm², 1/1.12, 10 Amps	36 M	Rs. 22/-	792.00	
(e)	2 core 1.5 mm², 1/1.40, 15 Amps	216 M	Rs. 16/-	3456.00	
(f)	2 core 2.5 mm², 1/1.80, 20 Amps	230 M	Rs. 20/-	4600.00	13340.00
2.0	**Main Supply Board Items**		**each**		
(a)	Circuit Breaker. 200 Amps.	1 No.	14500.00	14500.00	14500.00
(b)	Main switches 600 V, 100 A TPIC (N) (Incoming supply	1 No.	1500.00	1500.00	
	500 V 60 A TPIC (N) (Welding)	1 No.	900.00	900.00	
	500 V 30 A TPIC (N) (Shaper)	1 No.	370.00	370.00	
	500 V 15 A TPIC (N) (Lathes)	2 No.	280.00	560.00	
	250V 15A ICDP (Grinder & Drilling)	2 No.	120.00	240.00	3570.00
(c)	Main DB, 500V, 60A, 12 way	1 No.	1700.00	1700.00	1700.00
(d)	1800 V grade, 25mm² multistrand single core	100 M.	8800.00	8800.00	8600.00
(e)	Earth Link - 6 Way	1 No.	Rs. 30/-	30.00	
	Plugs 5/5A, 250 V with switch	24 No.	Rs. 35/-	840.00	
	Fuse indicating Lamp.	20 kg.	Rs. 75/-	1500.00	
	Copper 8 SWG	10 kg.	Rs. 22/- per Kg.	220.00	2590.00
	Screws Bolts & Nuts etc.			Total	
				Sundries 5%	2225.00
				Total	46725.00
				Contingincies 15%	7008.75
					53733.75
				Tool charges L.S.	1.000.00
				Total	54733.75
				Transport 3%	1642.00
				Labour as detailed	1875.00
				Total	58250.00
				Over head charge 15%	8737.62
				Total	66988.37
				OR Say Rs. 66990/-	

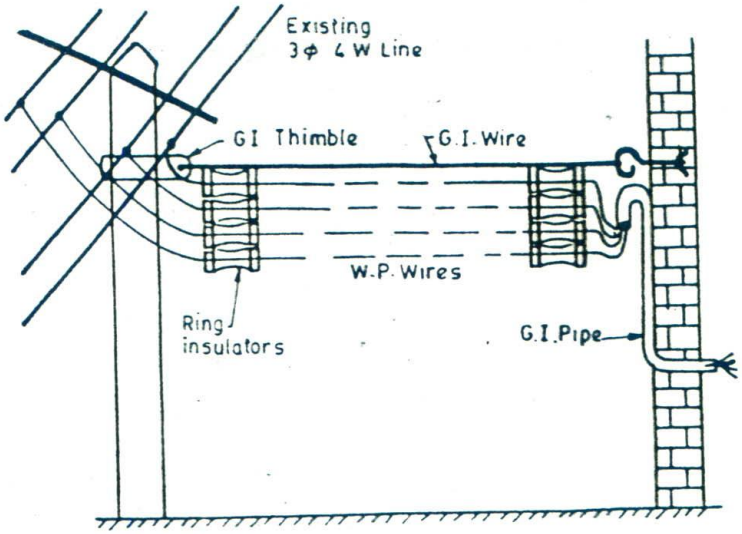
For lighting—it is left to the reader.

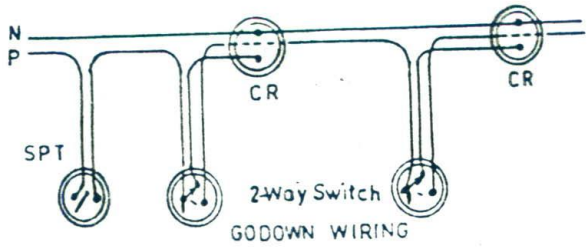
Example 14. *An induction motor of 5 HP has to be erected for pumping water for irrigation. Estimate the total cost of installation; including a pump set.*

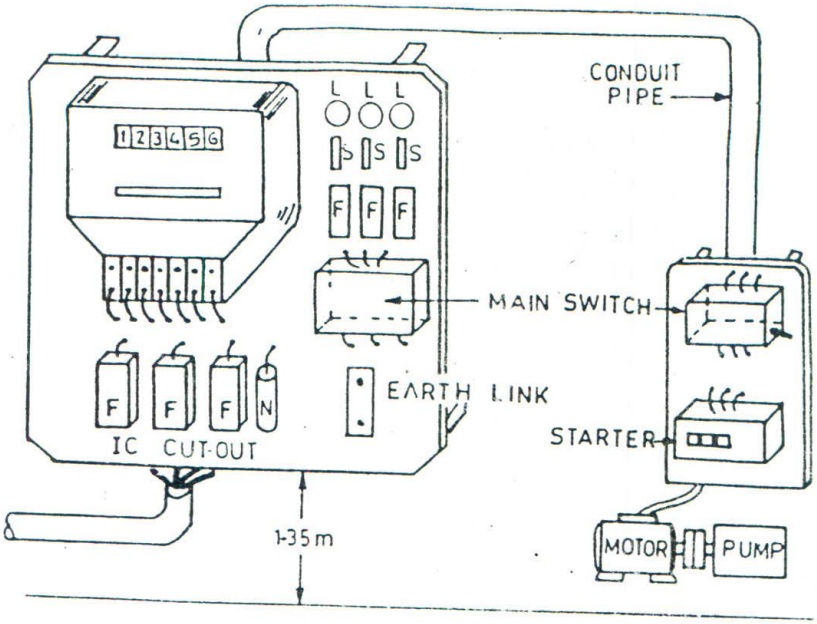
The distance between the supply pole and switch room is 10m. and the distance between the switch room and motor is 8M. provide G.I. conduit between the pole and the pump room. Assume suitable data.

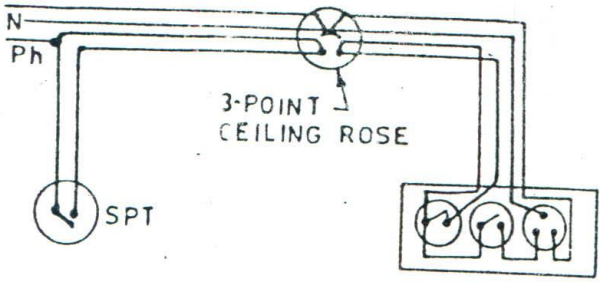
DETAILED ESTIMATE

S. No.	Description	Qty.	Rate per	Amount Rs. P.	Total Amount in Rs.
1.0	**Materials from Post to Consumer's Board**				
(a)	1100V Grade, single core 4sq.mm Weather proof cable	72.0 m	Rs. 830/- per 100 m	597.60	
(b)	G.I. wire SWG 8	3 Kg.	Rs. 16/- per Kg.	48.00	
	SWG 14	2 Kg.	Rs. 18/- per Kg.	36.00	
(c)	G.I. Thimble	2 No.	Rs. 5/- each	10.00	
(d)	Ring Insulator (porcelain)	120 No.	Rs. 2/- each	240.00	
(e)	Wooden Nipple	2 No.	Rs. 2/- each	4.00	
(f)	G.I. Pipe 38 mm. 18 SWG	2.2 m	Rs. 60/- per m	132.00	
(g)	G.I. Bend 38 mm. 18 SWG	4 No.	Rs. 20/- each	80.00	
(h)	G.I. Coupler	1 No.	Rs. 10/- each	10.00	
(i)	Saddles	6 No.	Rs. 9/- per doze.	4.50	
(j)	Stay set for G.I. pipe	1 No.	L.S.	290.00	
(k)	Earth lead Cu. SWG 8	1/2 Kg	Rs. 75/- per Kg.	37.50	1489.60
2.0	**Main Supply Board Items**				
(a)	Teak Wood Board 1m × 0.7 m	1 No.	Rs. 40/- each	40.00	
(b)	I.C. Cut out 30A, 500V	3 No.	Rs. 24/- each	72.00	
(c)	T.P.I.C. Main Switch 30 A, 500 V	1 No.	Rs. 360/- each	360.00	
(d)	Neutral Link, 500V, 30A	1 No.	Rs. 10/- each	10.00	
(e)	15 A, 500V, Fuse unit	4 No.	Rs. 30/- each	120.00	
(f)	5A, 250v, Tumbler Switch (Flush)	3	Rs. 96/- doz.	36.00	
(g)	Batten Lamp holder (brass)	3	Rs. 6/- each	18.00	
(h)	V I R 6 Sq mm multi-strand 7/1.12 cable	15 m	Rs. 7.20/- per m	108.00	for mtr. board connection
				764.00	


Existing
3φ 4W Line
GI Thimble
G.I. Wire
W.P. Wires
Ring
insulators
G.I. Pipe


N
P
CR
CR
SPT
2-Way Switch
GODOWN WIRING


CONDUIT PIPE
L L L
1 2 3 4 5 6
S S S
F F F
MAIN SWITCH
F F F N
EARTH LINK
STARTER
IC CUT-OUT
1·35 m
MOTOR
PUMP


N
Ph
3-POINT CEILING ROSE
SPT

S. No.	Description	Qty.	Rate per	Amount Rs. P.	Total Amount in Rs.
(i)	Earth wire Cu. SWG 8	1 Kg.	Rs. 75/- per Kg	75.00	
(ii)	Earth link, 4 Way	1 No.	Rs. 30/- each	30.00	869.00
3.0	**Motor Connection Materials**				
(a)	Metallic Flexible Hose-pipe 38 mm Φ	3 M	Rs. 24/- per M	72.00	
(b)	C.I. Conduit 18 SWG 38 mm Φ (0.7 + 1.5 + 8 + 2 + 0.8 + wastage)	14 M	Rs. 19.50 per M	273.00	
	C.I. Bends with covers 38mm Φ	4 No.	Rs. 8/- each	32.00	
	Saddles 38 mm Φ	36 No.	Rs. 16/- per doz.	48.00	
(c)	T.P.I.C. 500 V, 30 A Switch	1 No.	Rs. 360/- each	360.00	
(d)	4mm², 7/0.73, 1100 V, Silicone Rubber Insulated 3 Φ 4 core multi-strand cooper cable	20 M	Rs. 83/- per M	1660.00	
(e)	T.W. Board 0.6m × 0.4 m	1 No.	Rs. 25/- each	25.00	
(f)	Copper No. 8 SWG for earth	2.5 Kg.	Rs. 75/-	187.50	2657.50
4.0	**Lighting Items**				
(a)	C.I. Conduits 19 mm Φ	20 mts.	Rs. 10.80 per m	216.00	
	Jn. Box, 50mm × 50mm	1 No.	Rs. 14/- each	14.00	
	Bends 19 mm Φ	6 Nos.	Rs. 2/- each	12.00	
	Saddles 19 mm	36 Nos.	Rs. 9/- doz.	27.00	
(b)	500 V, 15A, Main Switch	1 No.	Rs. 275/-	275.00	
(c)	250 V, 5A, Tumbler Switch	5 Nos.	Rs. 6/- each	30.00	
(d)	250 V, 5A Plug with switch	1 No.	Rs. 20/- each	20.00	
(e)	T.W. Box 30 cm × 25 cm.	1 No.	Rs. 25/-	25.00	
(f)	Bulk head fitting;	4 Nos.	Rs. 60/- each	240.00	
(g)	Ceiling Roses ' plate 250V, 5A, Bakelite	4 Nos.	Rs. 4/- each	16.00	
(h)	1 mm² Cu. cable, Silicone Rubber Insulated, 500 V Grade single core	40 mts.	Rs. 2/- per m	80.00	955.00

Note : 1. The wiring is for the 4 Nos. B.H. fitting on the 4 sides of the walls and one No. light is fixed on the jn. box for internal lighting.

2. The Main Switch Board is fixed at the entrance of room, on the outside wall, under the sun shade of the door.

Cost of Materials

Material from Post to Consumers Board	=	Rs. 1489.60
Main Supply board items	=	Rs. 869.00
Motor connection materials	=	Rs. 2657.50
Lighting items	=	Rs. 955.00
Foundation for Motor Bed (L.S.)	=	Rs. 200.00
Total =		Rs. 6171.10
Sundries 10% =		Rs. 617.11
Total =		Rs. 6788.21
Contigenceis 15% =		Rs. 1018.23
Total =		Rs. 7806.44
Tool Charges 3% =		Rs. 234.19
Total =		Rs. 8040.63
Labour 15% =		Rs. 1206.10
Total =		Rs. 9246.73
Transport 5% =		Rs. 462.34
Total =		Rs. 9709.07
Over head charges 15% =		Rs. 1456.36
Grand Total =		Rs11165.43
Say Rs. 11165.00		

16

Installation and Estimates for Service Lines

The service line is that which brings the electric energy from the supplier's lines to the consumer's building. The service line feeding a building can be of the following types :

(1) *Overhead* which can further be subdivided on the basis of the wires coming through the conduits or with the help of a service entrance cable.

(2) *Underground.*

The service line is terminated at supplier's Main Board, which is a property of the supplier and the consumer has no access to it. According to Indian Electricity Rules, the consumer usually has his own Main Board adjacent to supplier's Main Board.

Rule 58. "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 consumer's premises."

When the service line is provided with the help of an overhead line, it must have fixed minimum clearance above ground of the lowest conductor and a definite clearance must be provided from the adjacent buildings. These are controlled by *Indian Electricity Rules 77 and 79* which are quoted below.

Rule 77. "(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	...	5.795 m
(*b*)	for high voltage lines	...	6.10 m

(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 line ... 5.490 m

(*b*) for high voltage lines ... 5.795 m

(3) No conductor of an overhead line, including service line, 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 11000 volts, if bare ...4.575 m

(*b*) for low, medium and high voltage lines up to and including 11000 volts, if insulated ...3.965 m

(*c*) for high voltage line above 11,000 volts ...5.185 m

(4) For extra-high voltage line the clearance ground shall not be less than 5.185 m. plus 0.305 m. for every 33,000 volts or part thereof by which the voltage of line exceeds 33,000 volts.

Provided that the minimum clearance along or across any street shall not less than 6.10 m.

Rule 79. (1) Where a low or medium voltage overhead line passes above or adjacent to or terminates on any building ; the following minimum clearance from 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 2.44 m. from the highest point.

(*ii*) when the line passes adjacent to building, a vertical clearance of 1.22 m. from the nearest point, and

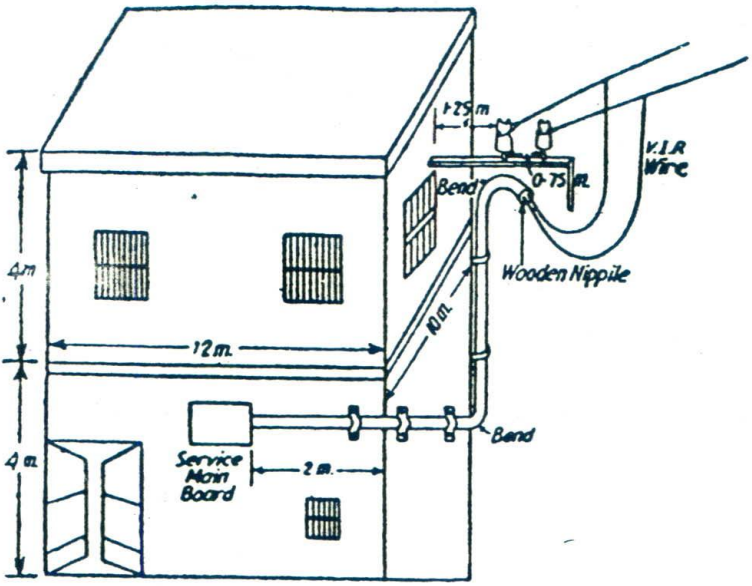
(*b*) for pitched roof—

(*i*) when the line above the building, a vertical clearance of 2.44 m. immediately under the lines, and

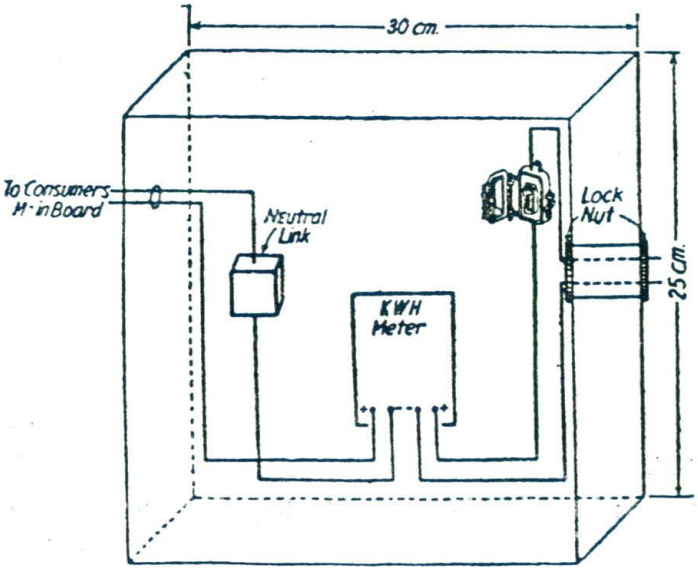
(*ii*) when the line passes adjacent to the building, a horizontal clearance of 1.22 m.

(2) Any conductor so situated as to have 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 317.52 Kg.

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



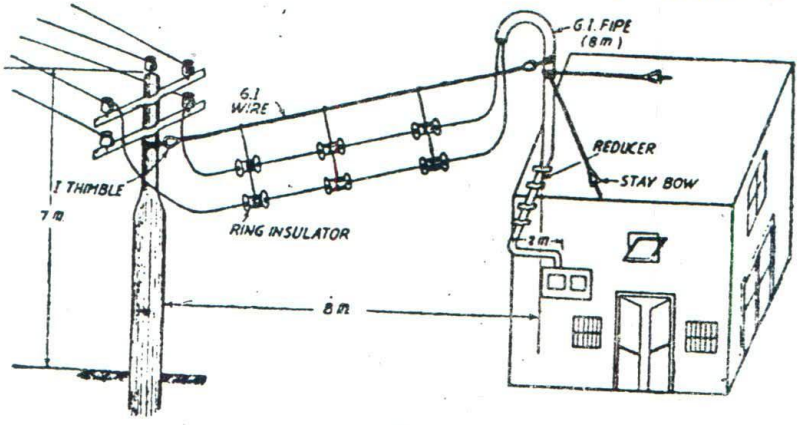
Service line connection with angle Iron Bracket for a double-storey building.
Fig. 16.1



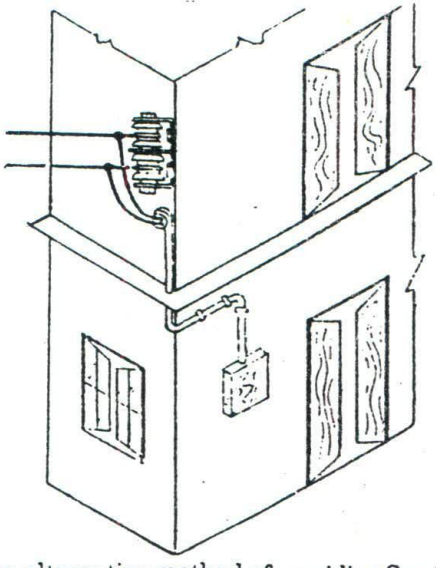
Arrangement for kWH meter and cutout at consumer's permises.
Fig. 16.2

Overhead Service Mains. The overhead service main can be had in a number of ways depending upon the conditions prevailing. Some of the typical methods are detailed below :

(1) *Service Mains for a Double Storey Building.* Fig. 16.1, 16.2, 16.3 and 16.4 represent the two methods of having a service mains



Service line connection with G.I. Pipe to a single-storey building.
Fig. 16.3



Represents an alternative method of providing Service Mains.
Fig. 16.4

when the connection from overhead bare Aluminium conductors are brought to the building side by weather-proof cable P.V.C. cable.

Example 1. *Estimate the cost of providing service line connection for a double-storey building having a connected load of 2.00 KW. The L.T. mains pole is at a distance of appx. 20 m. from the building and the service line is to be laid as per Fig. 16.1.*

Solution.

$$\text{Load in Amps} = \frac{2 \times 1000}{230}$$

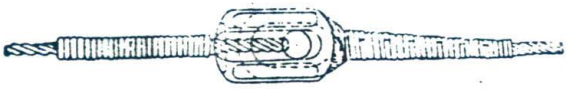
$$= 8.7 \text{ amp. approx.}$$

In view of Tables 14.1 and 14.2, twin. core P.V.C. and single core 6 sq. m m. P.V.C. 660 volts grade will be suitable. The cost has been estimated in Table 16.1.

Service Mains for Single-Storey House. When an overhead is to be given to a single-storey house, a G.I. pipe is a necessity in order to cover the Indian Electricity Rule 77. Fig. 16.3 represents the method for providing service connection to a single-storey building. The G.I. pipe is required to be supported with stay wire. Fig. 16.5 represents the connection of stay wire, I-thimble and stay insulator.



Connection of stay wire and stay insulator.
(*a*)



Connection of stay wire and I-thimble
(*b*)
Fig. 16.5

4. Underground Service Main. When a number of buildings are side by side, for providing a service connection to all such buildings it is always convenient to bring the main from the service pole underground by means of a cable terminating it at the main board of one building. The main board of the second building is looped to this main board, similarly the main board of the third buildings is looped to the second main board as shown.

Table 16.1

S.No.	Schedule of Material	Unit	Qty. Req.	Rate Rs.	Rate P.	Total cost Rs.	Total cost P.	Remarks
1.	Pin Insulator with spindle.	Nos.	4	12	00	48	00	Two Nos. on P.C.C., L.T. pole and two Nos. for angle iron bracket.
2.	B. Bracket for P.C.C. pole.	No.	1	15	00	15	00	
3.	Angle iron bracket, 51 mm. × 51 mm. × 6.35 mm. and 2.5 m long.	No.	1	82	50	82	50	To carry the pin insulators.
4.	25.4 mm, heavy gauge conduit pipe.	m.	16.50	13	80	227	70	
5.	Bends for 25.4 mm. conduit pipe	Nos.	3	8 (per Doz.)	00	2	00	One at top, one at bottom and one at corner.
6.	Conduit locknut 25.4 mm.	Nos.	2	1	40	2	80	
7.	Conduit bushings 25.4 mm.	No.	1	0	50		50	
8.	P.V.C. single core 600 volts grade 6 sq. mm.	m.	50					
9.	P.V.C. wire single core 600 volts grade 6 sq. mm.	m.	40	720 (coil of 91.44)	00	708	65	
10.	M.S. main board 30 cm × 25 cm.	No.	1	30	00	30	00	
11.	I.C. kit-kat 15 Amps with cover having provision to fix the seal.	No.	1	15	00	15	00	
12.	Neutral link	No.	1	2	00	2	00	
13.	G.I. wire S.W.G.8 = (20 + 2.5 + 4 + 10 + 2 = 38.5) Say 45 m. including wastage.	Kg.	16	16	00	256	00	
14.	Pole fuse 15 amps, 250 V.	No.	1	2	50	2	50	
					C.O.	1392	65	

(Contd.)

S.No.	Schedule of Material	Unit	Qty. Req.	Rate Rs.	Rate P.	Total cost Rs.	Total cost P.	Remarks
					B.F.	1392	65	
15.	Black adhesive tape 19 mm.	m.	5	55 (Roll of 50 m.20 (for 100 No.)	00	275	00	
16.	Wooden gutties (T.W. plugs) 2.5 cm. sq. × 1.9 cm.	Nos.	36		00	7	20	
17.	Wooden screws,							
	(a) 5.08 cm × 10 S.W.G.=4 Nos.	Nos.	36	L.S.		11	00	
18.	(b) 1.80 cm × 8 S.W.G.=32 Nos.							
19.	Saddles for 25.4 mm dia. conduit.	Nos.	32	22 (for a doz.)	00	58	65	
20.	Ring insulators and G.I. wire S.W.G. 16 lump sump.	—	—	—	—	22	00	
21.	Cement and sand lump sump.	—	—	—	—	52	00	
	Labour Cost (with the assumption that one line man grade I and two mazdoors will complete the job in two days).					320	00	
						2138	00	
	Lineman Gd. I at Rs. 70/- per day. Mazdoors at Rs. 45/- per day.			Contigencies @ 10%		213	80	
	Add 10% Contingencies.			**Total**		2351	80	
								Say Rs. 2352.00

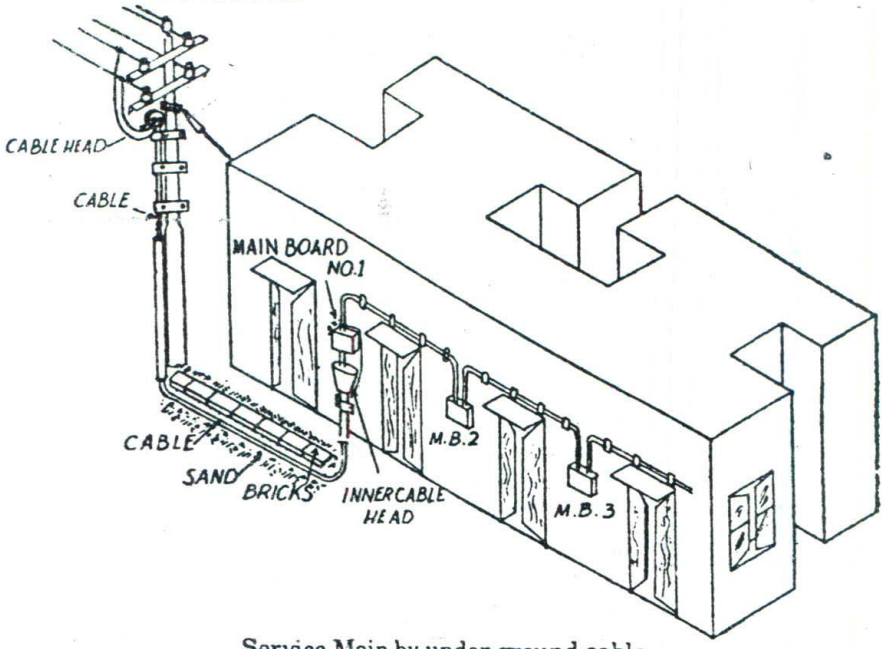
The underground service mains also become a necessity when the owner of the building does not want to spoil the beauty of the building by having an overhead service connection. For laying a cable a trench about 1 m. deep is made, and the run of the cable should be as straight as possible. At bends longer radius sweeps should be made. The cable along the pole should be fixed with the help of clamps, and at least 3 metres from the ground must be run in a G.I. pipe of ample size.

Example 2. *Estimate the cost of providing a service line connection to a single-storey building the position of the tubular steel pole and meter board may be assumed as shown on Fig. 16.4. The connected load of the building is 3 kW.*

Solution. Load in Amperes = 13 Amps.

From Tables 14.1 and 14.2, it will be seen that P.V.C. twin core 6 sq. mm. will be suitable. The estimated cost has been worked out in Table 16.2

Example 3. *Estimate the cost of providing a service line connection for the scheme as shown in Fig. 16.6. The total load on each meter is 15 Amps. The distance of supply pole from the first Main Board position is 10 m. The horizontal distance between two adjacent Meter Boards is 15 m.*



Service Main by under ground cable
Fig. 16.6

Table 16.2

S. No.	Schedule of Material	Cost							Remarks
		Unit	Qty. req.	Rate Rs.	P.	Per	Total cost Rs.	P.	
1.	G.I. Wire (8 + 19 + 3) m. long	kg.	30 m length of weight approx. 4 kg.	16	00	k.g.	64	00	8 m. for actual span. 3 m. winding to thimble, 19 m. with G.I. and conduit pipe.
2.	I-thimble	No.	4	4	00	each	16	00	2 for connecting G.I. wire to pole and G.I. pipe and 2 for stays.
3.	Pole Clamp	No.	1	4	00	each	4	00	For fixing thimble to pole.
4.	Pipe Clamp	No.	2	3	00	each	6	00	One for fixing thimble to G.I. pipe, the other is required for the two stays.
5.	51 mm. G.I. pipe	m	8.0	29	00	m	232	00	
6.	Ring Insulators and G.I. wire S.W.G. 16.	Lump Sump	Lump Sump	Lump Sump	Lump Sump	each	32	00	(5 × 2) insulators per metre for a length of 3 m.
7.	Stay wire 7/10 about 12 m. long.	Kg.	18	18	00	Kg.	324	00	Stay wire consisting of 7 strands of 10 S.W.G. for 2 stays as above.
8.	Stay Bows	No.	2	30	00	Each	60	00	
9.	Stay Rod with bolts and Stay Baulks.	No.	2	95	00	Each	190	00	Details provided in Fig. 12.5.
10.	Stay Insulators.	No.	2	9	00	Each	18	00	
11.	25.4 mm. heavy gauge conduit pipe.	m.	11	13	80	m.	151	80	
12.	Reducing Socket 51 mm. to 25.4 m.	No.	1	36	00	Each	36	00	
						C.O.	1,133	80	

S. No.	Schedule of Material	Cost							Remarks
		Unit	Qty. req.	Rate Rs.	P.	Per	Total cost Rs.	P.	
						B.F.	1,133	80	
13.	Corner bend for 25.4 mm. conduit pipe.	No.	1	12	50	Each	12	50	
14.	25.4 mm. conduit Locknut.	No.	2	1	40	Each	2	80	
15.	25.4 mm. Conduit Bushing.	No.	1	0	50	Each	0	50	
16.	M.S. 30 cm. × 25 cm. Main Board	No.	1	30	00	Each	30	00	
17.	I.C. Kit Cat 15 Amps with cover having provisions for sealing.	No.	1	15	00	Each	15	00	
18.	Neutral link	No.	1	3	00	Each	3	00	
19.	Twin Core L.C.C., 6 sq. mm	m.	25	41	00	m.	1025	00	Including 10% as wastage and provisions for jumpers and loop.
20.	Cement.	Kg.	4	3	00	Kg.	12	00	
21.	Yamuna Sand.	LUMP SUMP	LUMP SUMP	L.S.	L.S.	L.S.	14	00	
21.	P.V.C. Twin core 600 V grade 6 sq. mm.	m.	12	16	95	m.	203	40	including 10% wastage and provision for Jumpers.
22.	Wooden Gutties 2.5 cm. sq. × 1.9 cm.	Nos.	14	20	00	100 No.	2	80	
23.	Rag Bolts 2.54 cms. dia. and 20 cm. long.	Nos.	4	24	00	Each	96	00	
24.	Saddles for 25.4 mm. conduit.	Nos.	12	10	00	Doz.	10	00	
25.	Lump Sump provision for screws and black adhesive Tape.	—	—	—	—	—	32	00	
						C.O.	2590	80	

S. No	Schedule of Material	Cost							Remarks
		Unit	Qty. req.	Rate Rs.	P.	Per	Total cost Rs.	P.	
						B.F.	2590	80	
	Labour (Lump sump provision for labour on the assumption that 2 Linemen Gd. I one mazdoors and 2 amazons will complete the job in one day).						330	00	
	Lineman at Rs. 70/- Majdoor at Rs. 45/- Mason at Rs. 100/-						2920	80	
	Contingency charges at 10%						292	08	
						Total Cost	3112	88	

Hence the Estimated Cost is Rs. 3113/-

Solution.

Total load in amps on the underground cable = 45 Amps. From Table 14.5 it will be seen that Twin core 25 sq. mm. will be suitable.

From table 14.1, it will be seen that single core P.V.C. wire will be suitable for connecting *MB*—1 and *MB*—2 and 10 sq. mm. will be suitable for connecting *MB*—2 and *MB*—3.

17

Estimates for L.T. Distributors and Street Light Feeders

Example. 1. *A pole and stay assembly as shown in Fig. 17.1 are to be erected. Determine the volume of excavation required to be done and also draw a list of materials which will be used to provide such an arrangement.*

Solution.

Total volume of excavation = Excavation for stay pit + Excavation for pole pit

Excavation for stay pit $= 0.91 \times 0.61 \times 1.22 = 0.6772$ cu. m.

Excavation for pole pit $= 0.91 \times 0.61\ (0.60 + 0.75 + 0.45)$

$= 0.91 \times 0.61 \times 1.80 = 0.9991$ cu. m.

Total volume of excavation $= 0.6772 + 0.9991.$

Ans. $= \mathbf{1.6763\ cu.\ m.}$

Now, volume for which P.C.C. Block is to be provided

= Volume of P.C.C. in stay + volume of P.C.C. in pole

Volume of P.C.C. in stay $= 0.91 \times 0.61 \times 1.22 = 0.6772$ cu. m.

Volume of P.C.C. in pole = (0.91 × 0.61 × 0.60) – (Volume occupied by the pole)

Assuming that pole has an area of cross-section as 0.23 × 0.23 sq. m.,

Volume of P.C.C. in pole $= (0.91 \times 0.61 \times 0.60) - (0.23 \times 0.23) \times (0.60 - 0.15)$

$= (0.91 \times 0.61 \times 0.60) - (0.23 \times 0.23 \times 0.45)$

$= 0.3331 - 0.02380$

0.3093 cu. m.

Total volume for which 1 : 4 : 8 P.C.C. is to provided

$= 0.6772 + 0.3093 = 0.9865$ cu. m

$\therefore$ Volume of cement $= \frac{1}{13} \times 0.9865$

$= 0.0759$ cu. m.

Now 1 cu. m. cement contents weigh 2,060 kg. approx.,

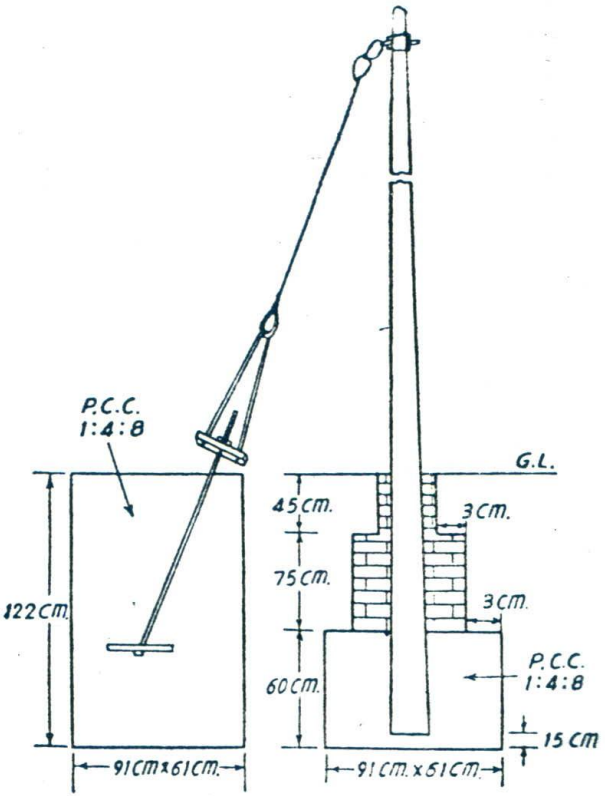


Fig. 17.1

Hence, weight of cement required = $2060 \times 0.0759 = 156.35$ kg.

Volume of sand $= \frac{4}{13} \times 0.9865 = 0.3036$ cu. m.

Volume of 28 mm. graded stone or brick aggregate

$= \frac{8}{13} \times 0.9865 = 0.6072$ cu. m.

Volume of Brick work = (Volume for the first step + volume for the second step.)–(Volume of pole)

$= 0.85 \times 0.55 \times 0.75) + (0.79 \times 0.49 \times 0.45)$
$-(0.23 \times 0.23 \times 1.20)$
$= (0.3506 + 0.1742 - 0.0635$
$=$ **0.4613 cu. m.**

Assuming that 500 bricks are used for 1 cu. m. volume,

Nos. of bricks required $= 500 \times 0.4613 = 230.65$ say **231 Nos.**

Assuming that 95 kg. cement is required to provide the brick masonry work with cement and sand having ratio as 1 : 4 for one cu. m. volume or with 500 bricks, the

Weight of cement required $= 95 \times 0.4613 =$ **43.82 kg.**

Volume of sand required to provide 1 : 4 brick masonry

$$= \frac{43.82}{2060} \times 4 = \textbf{0.0866 cu. m. appx.}$$

∴ Total quantity of cement required for providing P.C.C. and brick masonry

$= 156.35 + 43.82 = 200.17$ say **210 kg.**

(including the quantity required for plastering the top surface of the brick masonry)

Total quantity of sand required for P.C.C. Block and brick masonry

$= 0.3036 + 0.0866 = 0.3902$ say **0.4 cu. m.**

(including the quantity of sand required for plastering the top surface of the brick masonry).

List of materials required has been given in Table 17.1.

Example. 2. *An overhead line for various loads as shown in Fig. 17.2 is to be constructed. Determine the approximate cost of erecting the same.*

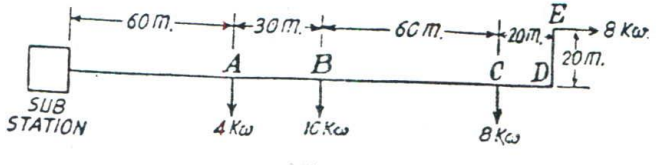


Fig. 17.2

Solution. It is seen that the load on the line varies. The permissible voltage drop at point E is limited to 5% of the declared voltage.

Hence permissible voltage drop at point E

$$= \frac{5}{100} \times 400 = 20 \text{ V}.$$

Table 17.1

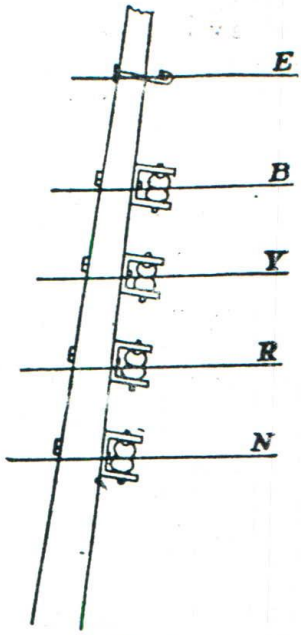
S. No.	Description of Material	Unit	Quantity
1.	P.C.C. Pole 9.15 m. long	No.	1
2.	Stay plate 6.30 mm. thick and of size 30 cm. × 30 cm. with 19 mm. dia. hole	No.	1
3.	Galvanised Stay or Anchor Rod 19 mm. dia., 60 cm. long	No.	1
4.	Stay Bow of Galvanised Iron 15 mm. dia. and 37.5 cm. long	No.	1
5.	Galvanised Thimble	No.	2
6.	Strain or Stay Insulator	No.	1
7.	Stay Collar of 3 mm. thick Flat Iron	No.	1
8.	Stay wire 7/8 (7 strands of G.I. wire of size 8 S.W.G.)	kg.	10 Taking length as 7 m. approx.
9.	M.S. Bolts and Nuts having Round Neck and Hexagonal Head 50 mm. × 15 mm.	Nos.	2
10.	M.S. Washers 15 mm.	Nos.	2
11.	Cement	kg.	210
12.	Sand	cu. m.	0.4
13.	Graded stone or Brick aggregate of size 28 mm.	cu. m.	0.6072

Now consulting Table 14.15, the size of conductor upto various loading point can be ascertained. It is advisable that voltage drop and available voltage at various loading points be tabulated as shown in Table 17.2.

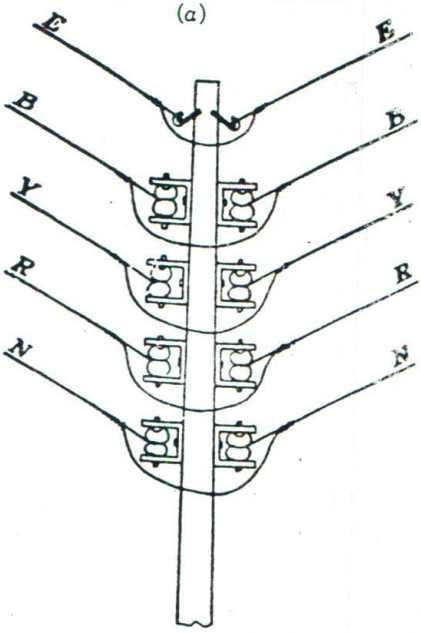
Table 17.2

S. No.	Load in KW	Load in Amperes	Section	Size of conductor recommended	Length in m.	Voltage drop	Voltage available at far end
1	30	43.33	*OA*	4 of squirel (6/1 × 2.11)	60	7.902 V	392.098 V
2	26	37.52	*AB*	–do–	30	3.424 V	389.674 V
3	16	23.09	*BC*	–do–	60	4.214 V	385.460 V
4	8	11.55	*CE*	–do–	40	1.405 V	384.055 v

Now the next step is to select the arrangement of conductors. Assuming that there is no residential accommodation, so near to the conductors to make them accessible, vertical formation as shown in Fig. 17.3 (*a*) is selected. The arrangement of conductors at point D will be as shown in Fig. 17.3 (*b*).



Arrangement of Conductors.
(*a*)



Arrangement of Conductors on pole at point D.
(*b*)

Fig. 17.3

(*a*) P.V.C. cable $3\frac{1}{2}$ core 35 sq. mm., 1100 volts grade is selected for obtaining the connection from substation.

Length = 10 m. inside the substation in the concrete ducts + 5 m. outside the substation under ground + 6 m. (over the pole) = **21 m.**

(*b*) **Length of squirrel conductor 6/1 × 2.11**

Length = 4 × (60 + 30 + 60 + 20 + 20) = 760 m.

From the table in chapter on overhead lines, it will be seen that the weight of this conductor is 85 kg. per km.

Hence equivalent weight

$$= \frac{85 \times 760}{1000}$$

= 66.88 kg. or say **74 kg.** (including 10% wastage)

(*c*) **P.C.C. pole 9.15 m. long.** After every 50 m. but one at the turning pt. *D* and one at end are to be provided

∴ Nos. of poles = 6

∴ There will be five spans.

(*d*) **G.I. wire S.W.G. for continuous earth**

Length = 60 + 30 + 60 + 20 + 20 = 190 m.

Keeping a margin for wastage and provision for 12 guards and 3 ground earths, the Length

= **250 m.** = 25 kg. approx.

After working the above details, the estimated cost is arrived in a manner shown in Table 17.3.

Example. 3. *In a congested colony in old Delhi, it is proposed to run an overhead line, by using weasel conductor (6/1 × 2.59) for phases and squirrel ; (6/1 × 2.11) for neutral. The continuous earth wire is to be of G.I. wire S.W.G. No. 8, the distance of the poles from the residential accommodation is 50 cm. and the width of road is 2.8 m. Suggest a method to erect the line to meet the requirement of Indian Electricity Rule No. 79 to avoid the accessibility. Also chalk out the list of materials used on each pole.*

Solution. In accordance with Indian Electricity Rule No. 79, the minimum clearance from the building on the basis of maximum

Table 17.3

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
1	P.C.C. poles 9.15 m. long	Nos.	6	2200	00	13200	00	
2	Shackle Insulators medium 500 volts with straps and bolts.	Nos.	28	12	00	336	00	4 Nos. for each pole except for pole at pt. *O* where 8 Nos. are required.
3	Flat Iron 6 mm. *D*-clamp suitable to accommodate item at serial No. 2	kg.	9	16	25	146	25	
4	Eye bolt 20 cm. × 1.25 cm. with nut	Nos.	8	25	00	200	00	
5	P.V.C. cable 1,100 volts grade $3\frac{1}{2}$ core 35 sq. cm.	m.	21	95	00	1995	00	
6	A.C.S.R. 6/1 × 2.11 (Squirrel).	kg.	74	54	00	3996	00	
7	G.I. wire S.W.G. 8.	kg.	25	16	00	400	00	
8	Bobin Insulators	Doz.	1	10	00	10	00	
9	Binding wire	kg.	2	16	00	32	00	
10	Aluminium thimbles	Nos.	4	10	00	40	00	
11	Stay plates M.S. 6.30 mm. thick and of size 30 cm. × 30 cm. with 19 mm. dia. hole	Nos.	3	110	00	330	00	For one stay at each end and one at the corner.
12	Galvanised stay or anchor rod 19 mm. dia. 60 cm. long	Nos.	3	115	00	345	00	
13	Stay bow of galvanized iron 15 mm. dia. 37.5 cm. long	Nos.	3	30	00	90	00	
14	Galvanised Thimble	Nos.	6	4	00	24	00	
15	Strain or stay insulators	Nos.	3	9	00	27	00	
16	Stay collar of 3 mm. thick Flat Iron	Nos.	3	10	00	30	00	

(*Contd.*)

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
17	Earth plate G.I. 60 cm. × 60 cm. × 6.30 mm.	Nos.	3	250	00	750	00	Earthing is to be provided at the beginning and end poles and in addition every 5th pole is to be earthed.
18	G.I. pipe 19 mm. dia.	m.	20	12	50	250	00	For carrying the ground earth wire.
19	Charcoal	kg.	300	6	00	1800	00	
20	Cement	Bags	25	10	00	2500	00	20 Bags for grouting and 5 Bags for plinthing.
21	Sand	Bags	100	4	00	400	00	
22	Stone Blast 10 mm.	Bags	30	9	00	270	00	
23	Bricks	Nos.	1000	900 per 1,000 Nos.	00	900	00	
24	Stay wire 7/8	kg.	15	18	00	270	00	
	Labour Charges : Assuming that the following technicians and labourers employed for 10 days will complete the job.				Rs.	28341	25	
	Lineman gd. I = 2 Nos. at Rs. 70/- per day				Rs.	5900	00	
	Mazdoors = 10 Nos. at Rs. 45/- per day.					34241	00	
	Add 10% contingencies.					3424	25	
					Total	37665	35	Say Rs. 37665/-

Hence the Estimated cost will be Rs. 37665/-

deflection should be more than 1.22 m. In view of the foregoing, it is suggested that the conductors should be supported on projected bracket as shown in Fig. 17.4.

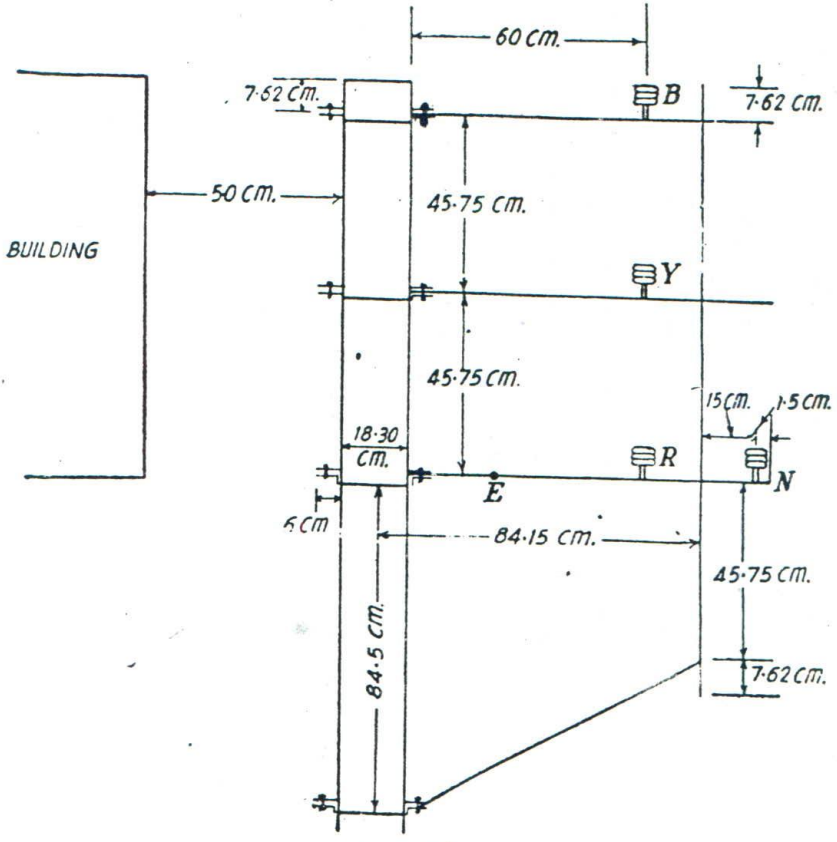


Fig. 17.4

Top width of the pole = 18.30 cm.

Hence the distance of phase conductor from the edge of the pole should be

$$= 122 - (50 + 18.30) = 53.60 \text{ cm.}$$

Cons.dering the safe limit due to deflection it is desired to place the bare phase conductor at a *distance of 60 cm. from the edge of the pole*. These conductors will therefore automatically will be at a safe distance from the accommodatin of the other end of the road. Placing the neutral conductor at one of the projected Angle Iron at a distance of 30 cm. from the phase conductor, the length of *Angle Iron for Projected Bracket will be :*

(*a*) Length = 3 [60 cm. + 1.5 cm. (projection from the insulator for neutral conductor.) + 18.30 cm. (To cover the width of the pole) + 6 cm. (projection on the other end of the pole) + 30 cm. (distance between the phase and neutral conductors)]

$$= 3 (60 + 1.50 + 18.30 + 6 + 30)$$
$$= 3 \times 115.80$$
$$= 347.40 \text{ cm.}$$

Now to support this projected Angle Iron bracket, a vertical Angle Iron piece as shown in Fig. 17.4. The length of piece as can be seen from Fig. 17.4 will be :

Length of Angle Iron vertical piece = $7.62 + 3 \times 45.75 + 7.62 = 152.49$ cm.

Now this piece is required to be supported by a brace as shown in Fig. 17.4. It will be seen that equilateral triangle is to be found the length will therefore be :

Length of Brace $= \sqrt{(84.15)^2 + (84.15)^2} = 118.8$ cm.

Hence, Total length of Angle Iron 60 mm. × 60 mm. × 6 mm.

$= 347.40 + 152.49 + 118.8 = 618.69$ cm.

Assuming 10% wastage = 640 cm. approx. = **6.40 m.**

Weight at 5.40 kg. per metre

= **34.56 kg.**

Flat Iron 63 mm. × 6 mm.

Length for each clamp = (6 + 18.30 + 6) = 30.30 cm.

Length for 4 clamps = $4 \times 30.30 = 121.20$ cm.

Assuming 10% wastage = 133.32 cm. say 130 cm. = 1.30 m.

Weight at 3 kg. per metre = **3.90 kg.**

The list of material is given in Table 17.4.

Table 17.4

S. No.	*Details of Material*	*Unit*	*Qty.*	*Remarks*
1.	Angle Iron 60 mm. × 60 mm. × 6 mm.	kg.	34.56	
2.	Flat Iron 63 mm. × 6 mm.	kg.	3.90	
3.	M.S. bolts and nuts having round neck and hexagonal head 50 mm. × 15 mm.	Nos.	2	For clamps at brace,
4.	-do- 40 mm. × 15 cm.	Nos.	6	For clamps at projected Angle Iron bracket.
5.	-do- 60 mm. × 15 cm.	Nos.	4	For joining the vertical Angle Iron pieces and Brace.
6.	M.S. washers 15 cm.	Nos.	24	

Example. 4. *A road as shown in Fig. 17.5 is required to be illuminated by providing street lighting. Assuming the width of road as 4 m. design a street lighting scheme and estimate the cost if the scheme is to be estimated for obtaining minimum level of illumination as 0.6 lux.*

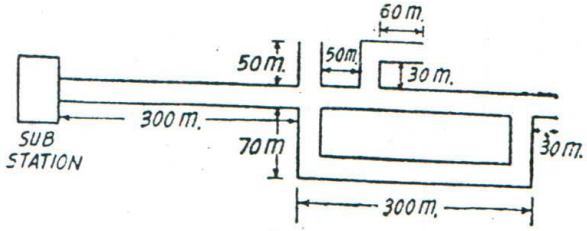


Fig. 17.5

Solution. While designing the street lighting scheme, the following points need consideration :

(*i*) As far as possible, the design should be such that Luminous Intensity should be uniform.

(*ii*) The distance between the two street light points should not be more than 35 m. to obtain a space height ratio within the limit and to obtain uniform level of illumination.

(*iii*) All crossings and turns should be provided with a street light point.

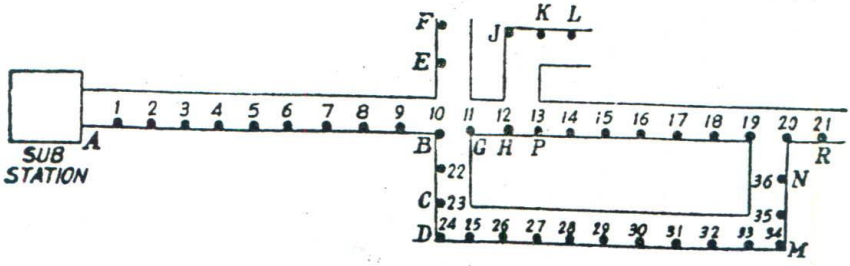


Fig. 17.6

Proposals

(1) Between A = 9 spans spaced at 30 m. apart

(2) Between BC = 2 spans 25 m. apart

(3) Pole D = Pole D at a distance of 25 m. from pole C

(4) BE and EF = 27 m. span distance

(5) BG and GH = 27 m. span distance

(6) HJ = 34 m. span distance

(7) JK and KL = 30 m. span distance

(8) DM = 10 spans 30 m. apart

(9) MN = 2 spans 30 m. span distance

(10) HP = 1 span 33 m. apart

(11) PR = 8 spans 30 m. apart.

In view of the above, the position of the poles to carry street light fittings is marked as shown in Fig. 17.6. The distance between various poles is also shown therein. It will be seen that maximum distance between two poles is 34 m.

Now, minimum level of illumination required is 0.6 lux. Let us assume the height of lamp as 7 m. and considering that 100 watt lamps are used for the purpose.

Referring to chapter on Illumination, the luminous flux out put of this lamp is 1630 lumens.

$$\text{Candle Power of each, 100 watt lamp} = \frac{1630}{4\pi}$$

Taking co-efficient of utilisation as 0.3, the C.P. will be

$$I = \frac{1630}{4\pi} \times 0.3$$

From Fig. 17.7 it will be seen that the maximum level of Illumination will be at the centre of the two poles.

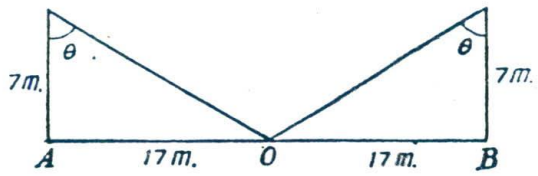


Fig. 17.7

$$\text{Level of Illumination, } E = \frac{I}{h^2}\cos^3\theta \times 2$$

(as from both sources, it will be added)

$$\text{From Fig. 17.7. } \tan\theta = \frac{7}{17} = 0.4118$$

$$\cos\theta = 0.9258$$

$$\cos^3\theta = 0.7936$$

$$E = 2 \times \frac{1630}{49} \times \frac{0.7936}{4 \times \pi}$$

$$= 4.1$$

As coefficient of utilisation is 0.3, therefore

Level of Illumination = $4.1 \times 0.3 =$ **1.23 lux.** which is maximum.

The minimum level of Illumination will be near points *A* and *B*, which can be determined by taking cos θ of one light as unit and *O* for the other light.

Level of Illumination at pt. *A*

$$0.3 \times \frac{I}{h^2} \times \frac{1}{4\pi} = 0.3 \times \frac{1630}{4\pi} \times \frac{1}{49}$$

$$= 0.7938 \text{ lux.}$$

Hence 100 watts lamps will be suitable.

(*i*) Nos. of poles = 41

(*ii*) Nos. of street light fittings = 41 **Nos.**

(*iii*) Nos. of anchored stays

= one at pole 1 + one at pole 10 + one at pole 24 + one at pole 34 + one at pole 36 + one at pole 12 + one each at pole 21, *F*, *J* and *L* = 10 Nos.

(*iv*) *Conductor Size.* For calculating the conductor size the load on the line is to be considered. The load is 4.1 kW for this load and length of feeder squirrel conductor is suitable.

(*v*) Length of squirrel conductor (6/1 × 2.11), in view of Figs. 17.5 and 17.6. = 2 (300 + 70 + 300 + 60 + 30 + 50 + 60 + 30) = 1,800 m.

Weight at 85 kg. per km. = 153 kg. say **160 kg.**

(considering sag and wastage)

(*vi*) G.I. wire S.W.G. 8 = **100 kg. approx.** (considering sag and wastage and provision for 10 earths and guards.)

(*vii*) P.V.C. cable 2 core 35 sq. mm. = **30 m.**

The estimated cost and schedule of items has been worked out in Table 17.5.

Table 17.5

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
1	P.C.C. poles 9.15 m. long	Nos.	41	2200	00	90200	00	
2	Shackle Insulators medium 500 volts with straps and belts	Nos.	94*	12	00	1128	00	* 2 Nos. at each pole except pole No. 10 where 6 Nos. are to be fixed. At. poles 24, 35, 39, and 12, 4 insulators are to be fixed.
3	Flat Iron 6.0 mm., *D* clamp suitable to accommodate item at serial No. 2	Nos.	94	16	25	1527	50	
4	Eye Bolts 20 cm. × 1.25 cm. with nut	Nos.	47	25	00	1175	00	3 Nos. at pole No. 10, 2 Nos. at poles No. 24, 34, 39, and 12, One No. on other poles.
5	P.V.C. cable, 1100 volts grade 2 core 35 sq. mm.	m.	60	95	00	5700	00	
6	A.C.S.R. 6/1 × 2.11 (squirrel)	kg.	160	54	00	8640	00	
7	G.I. wire S.W.G. 8	kg.	100	16	00	1600	00	
8	Bobin Insulators	Doz.	10	10	00	100	00	
9	Binding wire	kg.	10	16	00	160	00	
10	Aluminium Thimbles	Nos.	2	10	00	20	00	
11	Stay plate M.S. 6.30 mm. thick and of size 30 cm. × 30 cm. with 19 mm. dia. hole.	Nos.	10	110	00	1100	00	
12	Galvanised stay or Anchor rod 19 mm. dia. 60 cm. long.	Nos.	10	115	00	1150	00	
13	Stay Bow of Galvanised Iron 15 mm. dia. and 37.5 cm. long	Nos.	10	30	00	300	00	
14	Galvanised Thimble.	Nos.	24	4	00	96	00	
15	Strain or Stay Insulators.	Nos.	10	9	00	90	00	
16	Stay Collar of 3 mm. thick Flat Iron	Nos.	6	10	00	60	00	
17	Earth plate G.I. 60 cm. × 60 cm. × 6.3 mm.	Nos.	10	250	00	2500	00	

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
18	G.I. pipe 19 mm. dia.	m.	65 m.	12	50	812	50	
19	Stay wire 7/8 S.W.G.	kg.	150	18	00	2700	00	
20	Charcoal.	kg.	90	6 per kg	00	540	00	
21	Cement	Bags	80	100	00	8000	00	
22	Sand	Bags	320	40	00	1280	00	
23	Stone Blast 10 mm.	Bags	180	9	00	1620	00	
24	Bricks	Nos.	2,500	900 (per 1,000 nos.)	00	2250	00	
25	Street light fitting complete with single core P.V.C. wire 10 m. long. G.I. pipe 12 mm. dia. 3 m, street light shade and 100 watts lamp.	Nos.	41	100	00	4100	00	
26	Street Lighting Feeder breaker 10 KVA capacity complete automatic switch unit ammeter and kWh meter.	Nos.	1	12,800	00	12,800	00	
27	Time Switch 250 V, 50 c/s, low tension pole mounted 15 amps, S.P. complete with automatic winding mechanism.	Nos.	1	1440	00	1440	00	
28	M.S. Board 30 cm. × 25 cm. with cover	No.	1	30	00	30	00	
29	Labour Charges (assuming that the following technicians and mazdoors will complete the job during 30 days)					151119	00	
						34200	00	
	(*i*)Linemen g. I, 2 Nos. per day at Rs. 70/-					185319	00	
	(*ii*)Mazdoors 20 Nos. per day at Rs. 45/-							
	(*iii*)Mason 1 No. at Rs. 100 per day							
	Add 10% Contingencies							
	Hence, the estimated cost is Rs. 2,03,851/-					18531	90	

Example. 5. *A proposed colony as shown in Fig. 17.8 is to be electrified. There are four identical phases. Total number of quarter and the connected load is given below. Design and estimate the cost of electrification scheme proposed by you.*

The provision of street lighting is also to be taken into account assuming minimum level of Illumination required as 0.3 lux and co-efficient of utilisation as-0.3.

TYPE	*Nos.*	*Connected load in each Quarter.*
1	120	1.5 kW
2	96	1.0 kW
3	160	0.5 kW

Solution. Total connected residential load on the substation

$$= 120 \times 1.5 + 96 \times 1.0 + 160 \times 0.5$$

$$= 180 + 96 + 80 = 356 \text{ k.W.}$$

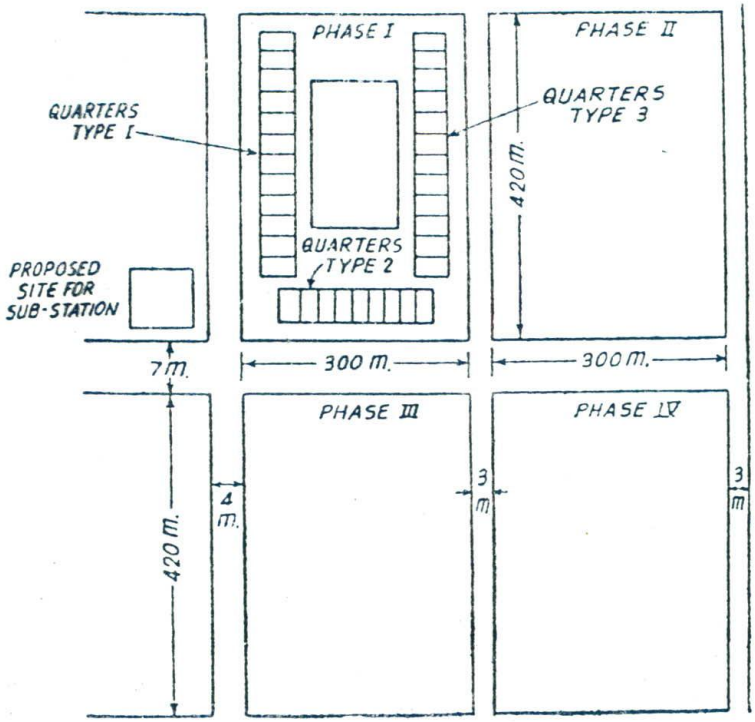


Fig. 17.8

Assuming the load factor as 0.5, the residential load on the substation will be = 356 × 0.5 = 178 kW.

Now for this load, two feeders, one for phases I and II and other for phases III and IV are recommended.

Load in amperes on each feeder

$$= \frac{178}{2} \times \frac{1,000}{\sqrt{3} \times 400 \times 1} = 128.4 \text{ amps.}$$

Lay out of feeders No. 1 and 2 is shown in Fig. 17.9. The poles are essentially required to be placed at position *A*, *A*-1, *B*, *B*-1, *C*, *C*-1, *D*, *D*-1, *E*, *E*-1, *F*, *and F*-1. Considering feeder No. 1, the requirement of various items has been worked out in the following lines. The total requirement except that of underground cable will be double.

1. Poles. The span is to be kept in the neighbourhood of 35 m. as the street lights are to be provided.

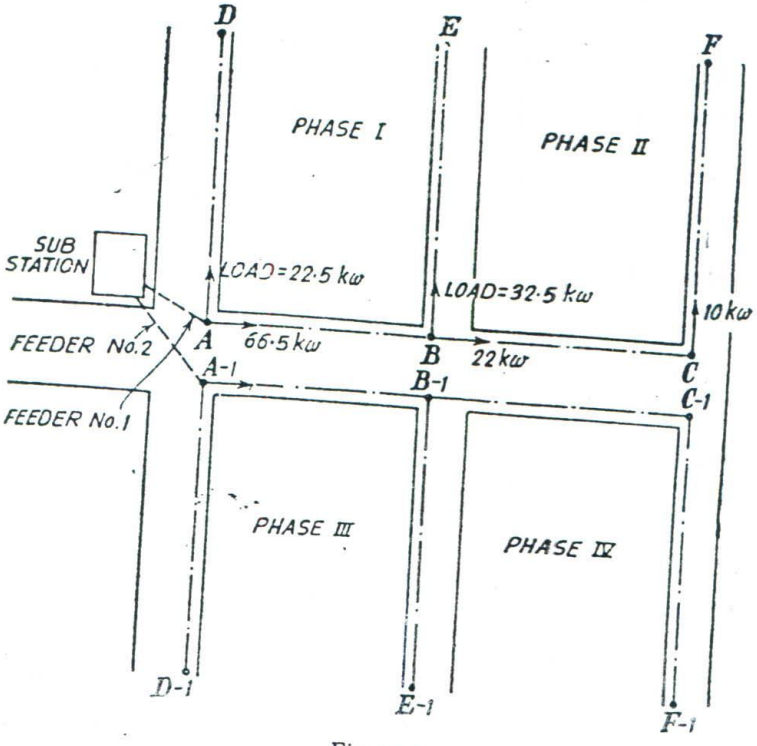


Fig. 17.9

(*i*) Span between *AD* $= \frac{420}{30} = 14$

∴ No. of poles = 14 (excluding pole at position *A*)

(*ii*) Spans between *AB* $= \frac{300}{30} = 10$

∴ No. of poles = 10 (excluding pole at position *B*).

(*iii*) Spans between *BC* $= \frac{300}{30} = 10$

∴ No. of poles = **11** (including poles at positions *B* and *C*)

(*iv*) Spans between *BE* and *CF*

$$= \frac{420}{30} = 14$$

∴ No. of poles = 14 on each lane excluding poles at positions *B* and *C*

Total No. of poles required

$$= 2\,(14 + 10 + 11 + 14 + 14) = 126.$$

2. Size of PVC underground cable

Load in amperes on each feeder

$$= \frac{128.4}{2} = 64.2 \text{ Amps.}$$

From Table 14.8, it will be seen that aluminium conductor P.V.C. 1,100 volts grade 50 sq. mm. $3\frac{1}{2}$ core will be suitable

(*i*) **Feeder No. 1.**

Length = 5 m. (Inside Substation) + 5 m. (underground) + 10 m. (on the pole) + 5 m. for the loop = **25 m.**

(*ii*) **Feeder No. 2.**

Length = 5 m. (Inside Substation) +9 m. (underground) + 10 m. (on the pole) + 5 m. for the loop = 29 m., say **30 m.**

Total length of P.V.C. 1,100 volts grade 50 sq. mm. $3\frac{1}{2}$ core cable = 30 + 25 = 55 m.

3. Size and weight of A.C.S.R. Conductors

Consider various Sections in Feeder No. 1 and determine the size of conductor required for various sections, by consulting Table 14.15. The total length for both the feeders will be double. As the transformers are usually designed for adjustable tapping to vary the voltage by ±7.5% or ±5%; therefore the voltage at the substation has been taken as 420 V.

(*i*) Length of A.C.S.R., **Rabbit (6/1 × 3.33)**

$$= 2\ \{3(420 + 420)\} = 5{,}040 \text{ m.}$$

∴ Weight at 214 kg./km.

= 1078.56 kg. or say **1100 kg.** considering sag and wastage.

(*ii*) Length of A.C.S.R., **Weasel (6/1 × 2.59)**

$$= 2\ \{(420 + 420)\} = 1{,}680 \text{ m.}$$

Weight at 128 kg./km.

= 215.04 kg., say **225 kg.** considering sag and wastage.

(*iii*) Length of **Leopard (6/1 × 5.28)**

$$= 2\ \{3(300 + 420 + 303)\} = 6{,}138 \text{ m.}$$

Weight at 493 kg./km.

= 3026.034 kg., say **3,100 kg.** considering sag and wastage

(*iv*) Length of **Beaver (6/1 × 3.99)**

$$= 2\ (300 + 420 + 303) = 2{,}046 \text{ m.}$$

Weight at 303 kg./km. = 619.94 kg.

say **640 kg.** considering sag and wastage

4. Calculations for Street Lighting. There will be two Street Light Feeders, one for main road and phases I and II and the other for main road and phases III and IV. On the main road, the poles on both sides will be provided with street light fittings. It is proposed that 40 watt fluorescent tube light fittings will be installed. The level of illumination should be calculated for positions *A*, *B*, *C* and *D* as shown in Fig. 17.10 (*a*), (*b*), (*c*) and (*d*).

(*i*) **Level of Illumination for position A**

Level of Illumination *E*

$$= \frac{I}{h^2} \cos^3 \theta \times 2 \times \text{coefficient of utilization}$$

where $I = \frac{2,300}{4\pi}$,

(by consulting chapter on Illumination)

$h = 8$ m.

$\theta = \tan^{-1}\frac{8}{22.2}$

$= \tan^{-1} 0.3603$

$\therefore \quad \theta = 19° 49'$

$\cos\theta = 0.941$

$\therefore \quad E = \frac{2,300}{4\pi} \times \frac{0.3}{64} \times 2 \times (0.941)^3$

$= \mathbf{1.427\ lux.}$

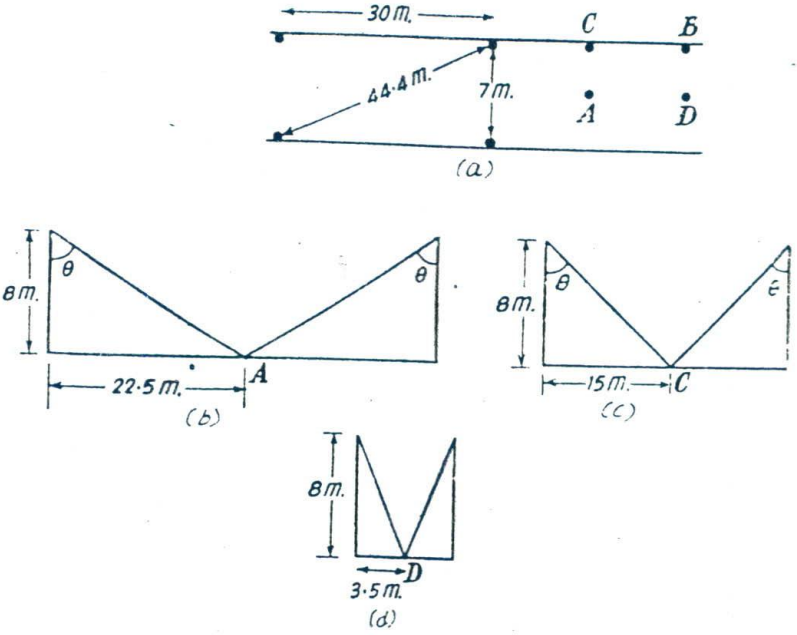


Fig. 17.10

(*ii*) Level of illumination for position B

For position B, only effect of one light will be taken into consideration.

Level of Illumination

$$E = \frac{I}{h^2} \times \text{coefficient of utilization}$$

$$= \frac{2300}{4\pi \times 64} \times 0.3 = 0.858 \text{ lux.}$$

(*iii*) Level of Illumination for position C

$$\theta = \tan^{-1} \frac{8}{15}$$

$$= \tan^{-1} 0.5334$$

$$= 28° 5'$$

$$\cos^3 \theta = (0.8836)^3$$

$$= 0.6901$$

$$\therefore \quad E = 2 \times \frac{I}{h^2} \times \text{co-efficient of utilization} \times \cos^3 \theta$$

$$= 2 \times \frac{3300}{4\pi} \times \frac{0.3 \times 0.6901}{64}$$

$$= 1.184 \text{ lux.}$$

(*iv*) Level of Illumination for position D

$$\theta = \tan^{-1} \frac{8}{3.5} = 66° 42'$$

$$\cos \theta = 0.3955$$

$$\cos^3 \theta = 0.06184$$

$$\therefore \quad E = 2 \times \frac{I}{h^2} \times \text{co-efficient of utilization} \times \cos^3 \theta$$

$$= \frac{2 \times 2300}{4\pi \times 64} \times 0.3 \times 0.06184$$

$$= 0.1071 \text{ lux.}$$

In view of the above, it will be seen that level of Illumination at point *D* will be lower than requirement but if the calculations are made for various points between *DB*, it can be found that pt. *D* will have the minimum level of Illumination. *As all points on the road except a particular pt. D will have the level of Illumination more than the requirement, the selected fitting will be suitable.*

5. Conductor Size and Weight of Conductor for Street Light Feeder.

(*a*) *Nos. of fitting on Street Light Feeder I*

= 14 (along *AD*) + 14 (along *BE*)

+ 21 (along *AC*) + 14 (along *CF*) = 63.

∴ Total Nos. of Fittings on both Feeders = 126

Load on Feeder No. 1

= 63 × 40 watts.

= 2.520 kW.

Load in amperes = 10.956 Amperes

(Hence 15 Amps. Time Switch will be suitable)

Load on *AD* = 560 watts.

Load in amperes on AD side

$$= \frac{560}{230}$$

= 2.435 Amps.

Load on *AF* side = 1.960 kW.

Load in amperes on *AF* side

= 8.521 Amps.

Route Length from *A* to *F* the farthest point

= 300 + 303 + 420

= 1023 m.

Consulting table 14.14, the impedance of squirrel A.C.S.R. conductor is 1.4 ohm/km. The voltage drop upto pt. F will therefore be 12.78 V. approx. and hence the available voltage will be within the limits. The conditions on Street Light Feeder 2 will be similar. Hence squirrel A.C.S.R. conductor is selected.

∴ Total Length of squirrel A.C.S.R. conductor (6/1 × 2.11)

= 2 (420 + 300 + 420 + 303 + 420)

= 3,726 m.

(c) *Weight at 85 kg/km.*

= 316.71 kg. or say

= **325 kg.** (including sag, wastage etc.)

(d) *Length of two-core PVC cable 10 sq. mm.*

= 25 + 30

= **55 m.**

6. Stays

(i) *Anchor Rod Stays*

= **6 Nos.** (At pst. *D*, *D*-1, *E*, *E*-1, *F*, and *F*-1)

(ii) *Flying Stays*

= **6 Nos.** (At pts. *A*, *A*-1, *B*, *B*-1, *C* and *C*-1)

7. Pole Earthing. 11 on each feeder

Total Nos. = **22 Nos.**

8. Nos. of Shackle Insulators. Vertical formation as shown in Fig. 17.3 is to be made.

(i) **Shackle Insulator 1,100V for phases**

= **420 Nos.**

3 Nos. for each pole except for poles shown below whence more number are required.

(a) *A*, *A*-1, *C* and *C*-1

= 6 Nos. on each pole

(b) *B*, *B*-1 = 9 Nos. on each pole

(ii) Shackle Insulator 500 volts for neutral and street light phase.

= **268 Nos.**

The estimated cost has been worked out in Table 17.7.

Table 17.6

S.No	Section	Load in KW	Size of Feeder Recommended	Length in m.	Voltage drop	Available voltage	Remarks
1..	AD	22.5	3 of Rabbit (6/1 × 3.33) / 1 of Weasel (6/1 × 2.59)	420	18.24 V	401.76 V	Available voltage at pt. D will be 401.76 V
2.	AB	66.5	3 of Leopard (6/1 × 5.28) / 1 of Beaver (6/1 × 3.99)	300	24.34 V	395.66 V	Available voltage at pt. B will be 395.66 V
3.	BE	32.5	—do—	420	14.60 V	381.06 V	Available voltage at pt. E will be 381.06 V
4.	BC	22	—do—	303	6.81 V	388.85 V	Available voltage at pt. C will be 388.85 V
5.	CF	10	3 of Rabbit (6/1 × 3.33) / 1 of Weasel (6/1 × 2.59)	420	8.11 V	380.74 V	Available voltage at pt. F will be 380.74 V

Table 17.7

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
1.	P.C.C. pole 9.15 m. long	Nos.	126	2200	00	277200	00	
2.	P.C.C. pole 8.54 m. long for Flying stays	Nos.	6	1800	00	10800	00	
3.	Shackle insulator large 1,100 volts with straps and bolts	Nos.	402	22	00	8844	00	
4.	Shackle insulator medium 500 volts with straps and bolts	Nos.	268	12	00	3216	00	
5.	Eye bolts 20 cm. x 1.25 cm. with nut	Nos.	134	25	00	3350	00	
6.	P.V.C. cable, 1,100 volts grade $3\frac{1}{2}$ core 50 sq. mm.	m.	55	124	00	6820	00	
7.	P.V.C. cable 1,100 volts grade 2 core 10 sq. mm.	m.	55	45	00	2475	00	
8.	A.C.S.R. (6/1 x 2.59) Weasel	kg.	225	53	00	11925	00	
9.	A.C.S.R. (6/1 x 5.28) Leopard	kg.	3,100	57	00	176700	00	
10.	A.C.S.R. (6/1 x 3.99) Beaver	kg.	640	57	00	36480	00	
11.	A.C.S.R. (6/1.33) Rabbit	kg.	1,100	57	00	62700	00	
12.	A.C.S.R. (6/1 x 2.11) Squirrel	kg.	325	54	00	17550	00	
13.	G.I. wire S.W.G. 8. (3,726 + 274) m. including provisions for guards, wastage or say = 400 kg. approx.	kg.	400	16	00	6400	00	
14.	Bobin Insulators	Doz.	20	10	00	200	00	
15.	Binding wire	kg.	20	16	00	320	00	

(Contd.)

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
16.	Aluminium thimbles	Nos.	8	10	00	80	00	
17.	Stay plate M.S. 6.30 mm. thick and of size 30 cm. × 30 cm. with 19 mm. dia. hole	Nos.	12	110	00	1320	00	
18.	Galvanised stay or anchor rod 19 mm. dia 60 cm. long	Nos.	12	115	00	1380	00	
19.	Stay bow of galvanized Iron 15 mm. dia and 37.5 cm. long	Nos.	12	30	00	360	00	
20.	Galvanised thimble	Nos.	24	4	00	96	00	
21.	Strain or stay insulators	Nos.	12	9	00	108	00	
22.	Stay wire 7/8	kg.	250	18	00	4500	00	
23.	Flat Iron 63 mm. × 6 mm. for stay clamps, *D* clamps, clamps for fixing street light fitting and underground cable on the pole = 100 m. and weight at 3 kg. per metre = 300 kg.	kg.	300	16	25	4875	00	
24.	M.S. bolts and nuts having hexagonal head 50 mm. × 15 mm.	Nos.	300	5 each	00	1500	00	
25.	M.S. washers 15 mm dia. hole	Nos.	900	0	20	180	00	
26.	Earth plate G.I. 60 cm. × 60 cm. × 6.3 mm.	Nos.	22	250	00	5500	00	
27.	G.I. pipe 19 mm. dia.	m.	150	12	50	1875	00	
28.	Charcoal	kg.	1080	6 per kg	00	6480	00	
29.	Cement	Bags	250	100	00	2,5000	00	

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
30.	Sand	Bags	1,000	4	00	4000	00	
31.	Stone Blast 10 mm.	Bags	180	9	00	1620	00	
32.	Bricks	Nos.	8,000	900 (per 1,000 Nos.	00	7200	00	
33.	Street light fittings 40 W. fluorescent tube, complete with twin core PVC 1.5 sq. mm. 10 m. length, G.I. pipe 12 mm. dia. 3 m. long and sbade	Nos.	126	200	00	25200	00	
34.	Time switch, 250 V, 50 c/s, pole mounted 15 Amps. Single Phase. Complete with automatic winding mechanism.	Nos.	2	1440	00	2880	00	
35.	M.S. Board 30 cm. × 25 cm. with cover	Nos.	2	30	00	60	00	
	Labour charges (assuming that the following technicians and mazdoor will complete the job during the Nos. of days shown against each)					719194 86800	00 00	
						805994	00	
	Designation **Nos.** **Rate** **Day** (*i*)Linemen Gd. I 4 Nos. 70.00 40 (*ii*)Blacksmith 1 No. 60.00 10 (*iii*)Mason 1 No. 100.00 30 (*iv*)Mazdoors 40 45.00 40							
	Add 10% contingencies					80599	40	
	Hence the estimated cost of the work is Rs. 88,6593/-				Total	886593	40	Say Rs. 886,593.00

Example 6. *A feeder as shown in Fig. 17.11 is to be erected. Determine the schedule of material and estimate cost of the same.*

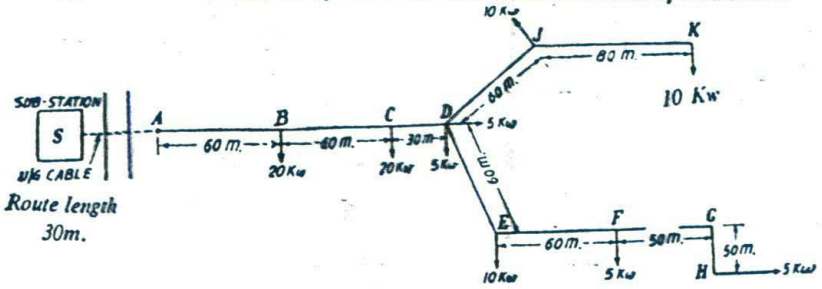


Fig. 17.11

Solution. The load on the lines varies, as can be seen from Fig. 17.10. As the declared voltage is 400 volts, therefore,

$$\text{Permissible voltage drop} = \frac{400 \times 5}{100} = 20 \text{ Volts}$$

i.e. the available voltage at the far end should be

$$= 400 - 20 = 380 \text{ volts}$$

Now assuming the available voltage at the L.T. side of the transformer as 415 volts. the size of the conductor upto various loading points can be determined by consulting Table 14.38. The voltage drop in various lengths of the distributor and the available voltage at various loading points has been tabulated in Table 17.8

Total load on the line $= 20 + 20 + 5 + 10 + 5 + 5 + 10 + 10 = 85$ *KW*.

$$\text{Load in amperes} = \frac{85 \times 1,000}{\sqrt{3} \times 400 \times 1} = 122.7 \text{ amps.}$$

Consulting Table 14.8, the above current can safely be carried by 150 sq. mm. $3\frac{1}{2}$ core P.V.C. 1100 volts grade underground cable. The resistance of this cable as can be seen from Table 14.11 is 0.2088 ohms/km.

∴ Resistance of the underground cable

$$= [10 \text{ m. (inside the sub-station)} + 30 \text{ m (underground)} + 10 \text{ m. (on the pole)}] \times \frac{0.2088}{1,000}$$

$$= \frac{50 \times 0.2088}{1,000} = 0.01044 \text{ ohms}$$

∴ Voltage drop $= \sqrt{3} \times 122.7 \times 0.01044 = 2.218$ volts

Hence the available voltage at pt. *A* = 415 −2.218 = 412.782 V.

Details of various items required are as under :

Leopard (6/1 × 5.28)

Length = 3 (60 + 60 + 30) = 450 m
Weight at 493 kg/km = 221.85 kg. Say **230 kg.** (including wastage and sag)

(2) Beaver (6/1 × 3.99)

Length = 60 + 60 + 30 = 150 m
Weight at 303 kg/kW = 45.45 kg Say **50 kg.** (including wastage and sag)

(3) Squirrel (6/1 × 2.11)

Length = 4 (60 + 80 + 60 + 60 + 100) = 1440 m
Weight at 85 kg/km = 122.4 kg Say 130 kg (including wastage and sag)

(4) P.C.C. poles 9.15 m long :

The numbers of poles can be determined restricting the span in the neighbourhood of 35 m. assuming that street lights may be fixed in near future.

(*i*) Between *AD* = 6 Nos.–including poles at *A* and *D*
(*ii*) Between *DK* = 5 Nos.–excluding pole at *D* but including pole at position *K*
(*iii*) Between *DH* = 8 Nos.–excluding pole at *D* but including pole at position *H*
Total = **19 Nos.**

(5) Anchor Stays

(*i*) At pole on position *A* = 1 No.
(*ii*) At pole on position *D* = 1 No.
(*iii*) At pole on position *J* = 1 No.
(*iv*) At pole on position *K* = 1 No.
(*v*) At pole on position *E* = 1 No.
(*vi*) At pole on position *G* = 1 No.
(*vii*) At pole on position *H* = 1 No.

Total 7 Nos.

(6) Pole Earthing

(*i*) Between portion *AD* = 2 Nos.
(*ii*) Between portion *DH* = 2 Nos.
(*iii*) Between portion *DK* = 1 No.

Total 5 Nos.

Schedule of materials and estimated cost has been worked out in Table 17.9.

Table 17.8

S. No.	*Load in K.W.*	*Section*	*Length in m*	*Size of conductor recommended*	*Voltage drop in volts*	*Available Voltage at pt. in volts*
1.	85	*AB*	60	3 of Leopard(6/1 × 5.28) 1 of Beaver (6/1 × 3.99)	5.457	Pt. *B* = 412.782–5.457 = 407.325
2.	65	*BC*	60	–do–	4.173	Pt. *C* = 407.325–4.173 = 403.152
3.	45	*CD*	30	–do–	3.852	Pt. *D* = 403.152–3.852 = 399.30
4.	20	*DJ*	60	4 of squirrel (6 × 1/2.11)	5.268	Pt. *J* = 399.30–5.268 = 394.032
5.	10	*JK*	80	–do–	3.512	Pt. *K* = 394.032–3.512 = **390.52**
6.	20	*DE*	60	–do–	5.268	Pt. *E* = 399.30–5.268 = 394.032
7.	10	*EF*	60	–do–	2.634	Pt. *F* = 394.032–2.634 = 391.398
8.	5	*FGH*	100	–do–	4.390	Pt. *H* = 391.398–4.390 = 387.008 Say 387 V

Table 17.9

S. No.	Schedule of Items	Unit	Qty.	Rate		Total		Remarks
				Rs.	P.	Rs.	P.	
1.	P.C.C. poles 9.15 m. long	Nos.	19	2200	00	41800	00	
2.	Shackle Insulators large 1,100 volts with straps and bolts	Nos.	24	24	50	588	00	For poles between *A* and *D*.
3.	Shackle Insulators medium, 500 volts with straps and bolts	Nos.	72	12	00	864	00	8 Nos. at poles positioned at *D*, 8 Nos. each at poles positioned *J*, *E G* 4 Nos. on remaining poles between *DK* and *DH*.
4.	Flat Iron 63 mm. × 6 mm. for *D* clamps, stay clamps and clamps for fixing the cable 35 sq. mm., weight 3 kg. per metre.	kg.	100	16	25	1625	00	
5.	Eye bolts 20 cm. × 1.25 cm. with nuts	Nos.	24	25	00	600	00	
6.	P.V.C. cable, 1,100 volts grade $3\frac{1}{2}$ core 150 sq. mm.	m.	50	278 per m	00	13,000	00	
7.	A.C.S.R. 6/1 × 5.22 (Leopard)	kg.	230	57	00	13110	00	
8.	A.C.S.R. 6/1 × 3.99 (Beaver)	kg.	50	57	00	2850	00	
9.	A.C.S.R. 6/1 × 2.11 (squirrel)	kg.	130	54	00	7020	00	
10.	G.I. wire S.W.G. 8	kg.	60	16	00	960	00	
11.	Bobin Insulators	Doz.	4	10	00	40	00	

(Contd.)

						203850	90	Say, Rs. 2.03851-/

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	

(Contd.)

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*					26870	00	
	(*i*) Lineman Gd. I 2 70.00 30					124025	00	
	(*ii*) Mazdoors 15 45.00 30							
	(*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

Example. 7 : In a street, there are 12 tubular lamp posts of height 7 mts. with a span of 30 M, each post has one 4 feet fube with outdoor type fittings. Estimate the cost for the entire installation by assuming suitable data. Under ground cable may be used.

Solution : For this street light service, the following is assumed.

Given Data : Height of post 7 m ; span : 30 mts. ; No. of posts : 12

Assumption Made :

1. One No. switch 15 A, 250 V, is provided at post No. 1, to *control* ALL the 12 lamps.
2. Supply to this MS is taken from the *nearest* pillar box, 8 M away.
3. The pillar box is at a hieght of 0.5 M above the ground.
4. The service cable is RUN 1.0 M below the ground.
5. The MS is placed 1.35 M above the ground
6. 1/6 of Post Height i.e. 7/6 = 1.166 M is below the ground.
7. Coping for the post is done above the ground, for a height of 0.7 M. This is to eliminate stay sets for the posts.
8. We use 2 core 1 mm^2, 1/1.2 cu cable for tapping from 6mm^2 to the lamp
9. All the 12 lamps are on one side of the street.

Voltage Drop Calcuation :

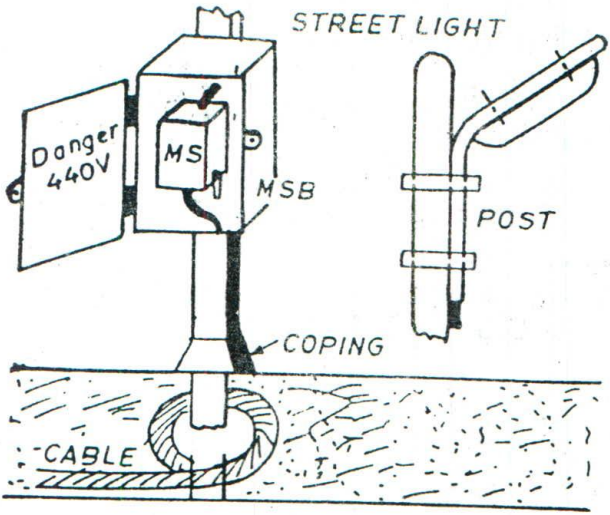
Current in each bulb of 40 W = 40/230 = 0.173 Amps.

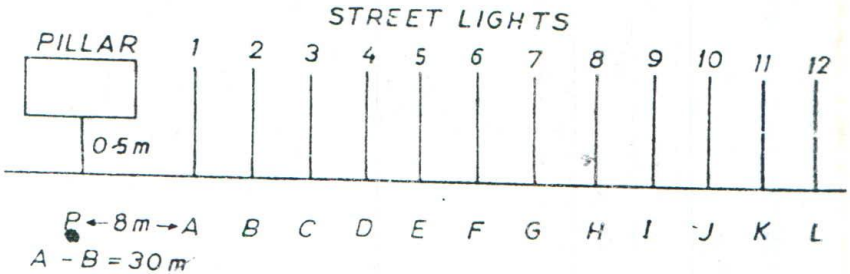
The designing current = $0.173 \times \frac{1.5}{0.8}$ = 0.326 Amps.

Distance from pillar to th 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 mV/Amp./M. single phase, twin core copper cable (Multi-strand Sheathed, Insulated with BUTYL RUBBER).



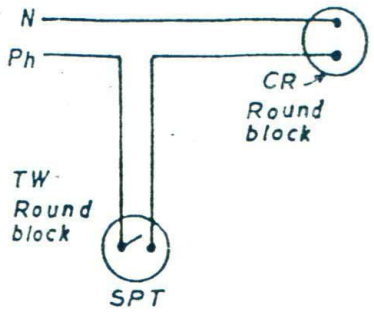


STREET LIGHTS

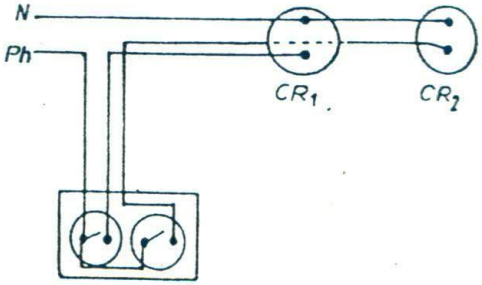
The Currents and associated Voltage drop in each section are shown below :

Sl. No.	Section	Distance	Current Amps	Voltage drop Volts	Total
1.	PA	8 M	3.912	0.428	
2.	AB	30 M	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

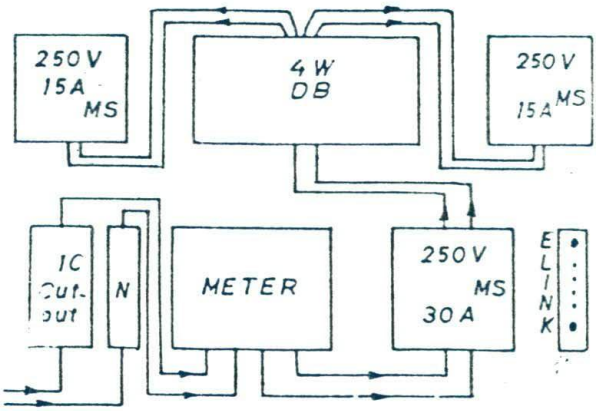
(This drop is within limits)



Single lamp controlled by single switch



Two lamp controlled by two switches from same place



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 errection 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. Errection 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 days at Rs. 80.00 per day — Rs. 160.00
   Helper - 2 No - 2 days at 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

DETAILED ESTIMATE

Sl. No.	Description of Materials	Qty.	Rate in Rs.	Amount Rs. p.	Remarks
1.	6 mm², 7/1.12, Twin core multi-strand, Metalic Sheathed 1100 V grade, U.G. Cable, Copper	381 m	Rs. 51/- per m.	19431.00	
2.	1mm², 1/1.12, Twin Core, Metalic Sheathed 600 V grade, U.G. Cable Copper. (Height of each post + 3 m loop + wastage) × 12	130 m	Rs. 20/- per m	2600.00	Post 1 7–1.166–1.35 = 4.84 Post 2–12, 10 × 11 = 110.00

(Contd.)

Sl. No.	Description of Materials	Qty.	Rate in Rs.	Amount Rs. p.	Remarks
3.	Cable junction box, suitable for 6 mm^2 Cable L.T. boxes	11 No.	Rs. 142/- each	1562.00	
4.	Bituminous Black Compound for L.T.	50 Kg	Rs. 16/- per Kg	800.00	
5.	Varnished Tape 25 mm	60 m	Rs. 2/- per M	120.00	
6.	Black adhesive Tape 25 mm	100 m	Rs. 3/-per M	300.00	for the joints at fitting
7.	Cotton Tape 25 mm	55 m	Rs. 1/-per M	55.00	
8.	Cable clamps 4 Nos. for each post	48 Nos.	Rs. 10/- each	480.00	
9.	Street Ligth T.L. fitting, 1 × 40 W	12 No.	Rs. 200/- each	2400.00	
10.	Copper No. 8 for Earth	7 Kg	Rs. 75/- Kg	525.00	for earthing the fittings
11.	Cement, Sand Bricks etc. for Civil work		L.S.	1000.00	
			Total	29273.00	
	Sundries 10%			Rs. 2927.30	
	Total			Rs. 32200.30	
	Contingencies 15%			Rs. 4830.00	
				37030.30	
	Tool Charges 3%			Rs. 1110.91	
	Total			Rs. 38141.21	
	Labours as detailed			Rs. 5565.00	
	Transport 3%			Rs. 43706.21 1311.19	
	Total			Rs. 45706.21	
	Over head Charges 15%			Rs. 6752.61	
	Grand Total			Rs. 51770.00	or say Rs. 51800.00

Sd/-.....
Chief Engineer in Charge

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% = 34.6 m

Total 381.2 m

Or say 381/- Mts.

18

Estimates For 11 K.V. Feeders And Sub-Stations

Example 1. Determine the quantity of material required and cost for erecting 300 KVA 0.4/11 KV. substation. Assuming that 400 volts generator pannel is at a distance of 50m in an adjoining power house.

Solution.

Load in amperes on L.T. cable

$$= 300 \times 1000$$

$$= 400 \times \sqrt{3}$$

$$= 433 \text{ amps.}$$

Load in amperes on H.T. cables

$$= \frac{300 \times 1000}{11,000 \times \sqrt{3}}$$

$$= 15.75 \text{ amps.}$$

Consulting tables 14.8 and 14.9, following cables are selected.

(*i*) **L. T.** —PVC 1,100 volts, Aluminium conductor $3\frac{1}{2}$-crore 400 sq. mm underground cables.

= 60 m (5 m loop will be given on each side)

(*ii*) **H. T.** —Screened Aluminium conductor Lead alloy sheathed double steel tape single wire armoured 11 KV, 3-core 25 sq. mm underground cable = 20m.

Equipment in the substation will be connected with two separate earths. Following items are required in each set of earth :

(*i*) Copper strip 40 mm. × 6.30 mm.=20 m

(*ii*) G.I. pipe 80 mm. dia. = 10 m

(*iii*) Cast iron galvanized 60 cm. × 60 cm. × 6.30 mm. = 1 No.

(*iv*) Charcoal = 10 Bags

(*v*) Bolts and Nuts required size = 4 Nos. approx.

Each set as given above will cost Rs. 2500.00 approx. Labour cost will be extra.

Schedule of items and estimated cost has been given in Table 18.1.

Table 18.1

S. No.	Schedule of Items	Unit	Qty.	Rate		Total	
				Rs.	P.	Rs.	P.
1.	P.V.C. 1,100 volts, aluminium conductor, three and half core 400 sq. mm. underground cable.	m.	60	700 per m	00	42000	00
2.	Screened aluminium conductor Lead alloy sheathed, double steel tape/single wire armoured 22 KV, 3-core, 25 sq. mm. underground cable.	m.	20	348 per m	00	6960	00
3.	Transformer step up 0.4 KV to 11 KV, 300 KVA capacity, 3-phase 50 cycles, core type double wound suitable for indoor use and having no load ratio of 0.4/11 KV with copper winding connected in star/delta. H.V. side provided with ±2.5%, ±5%, ±5%, ±7.5% tappings and the tappings are brought upto an externally hand operated off circuit tap changing switch with suitable indicator and locking device and with transformer oil for first filling and standard accessories.	No.	1	200002 each	00	2,00002	00

(*Contd.*)

S. No.	Schedule of Items	Unit	Qty.	Rate		Total	
				Rs.	P.	Rs.	P.
(i)	Metal clad indoor type Air Circuit breaker 400/440 volts, 3-phase, 4-wire 50 cycles 500 amps having repturing capacity 10 MVA and fitted with : 3 Nos. H.D. H.C. Electrolytic Copper Busbars mounted on porcelain Busbar supports, rating 250 amps.						
(ii)	1 No. H.D. H.C. Electrolytic Copper Busbars mounted on porcelain Busbar supports, rating 250 amps.						
(iii)	3 Nos. C.T. Ratio 500/5 amps						
(iv)	1 No. voltmeter 500 volts range with a 3-way on and off voltmeter selector switch.						
(v)	1 No. Ammeter 1,000 amps. scale with a 3-way on and off Ammeter Selector Switch.						
(vi)	1 set of protective fuse for voltmeter.	No.	1	47590	00	47590	00
	High Voltage AC metal-clad floor mounting extensible unit type, 11 KV, 3-phase, 3-wire, 50 cycles/sec. Switch Board having breaking capacity of 250 MVA. Unit should comprise of the following : (i) **Incoming Panel having:** (a) 1 No., 400 amps, vertical drop down drawout free handle mechanism oil circuit breaker with standard equipment. (b) 3 Nos. 5 amps overload trips calibrated 100/200% (c) 3 Nos., enclosed time limits fuse (d) 3 Nos., (Ts of ratio 40/5 amps, 15 VA for protection and indication instruments (e) 1 No. ammeter, 40 amps scale with a 3-way on and off ammeter selector switch (f) 1 No. voltmeter range 15 KV, with selector switch (g) Set of red and green indicating lamps for operation on 110 volts.						

Schedule of Items	Unit	Qty.	Rate	Total
			Rs. P.	Rs. P.
(h) 3-phase horizontal dropout oil immersed potential Transformer ratio 11,000/110 volts, 100 VA out put per phase with fuses on H.V. and L.V. sides.				
(i) Cable end Box suitable for cable at item No. 2 above.				
(j) Metal clad air insulated Busbars chambers having 3 Nos., 500 amps Busbars.				
(ii) **Outgoing Feeder Panel 2 Nos. each equipped with :**				
(a) 1 No., 400 amps vertical drop down drawout free handle mechanism oil circuit breaker unit.				

S.No.	Schedule of Items	Unit.	Qty.	Rate	Total
				Rs. P.	Rs. P.
	Fitted with : (a) 3 Nos. 5 amp. over load trips Calibrated 100/200%. (b) 3 Nos. CTs of ratio 40/5 amps. 15 VA output for protection and indication Instruments (c) 1 No. Ammeter range 40 amps. with Selector Switch. (d) 1 Set of green and red indication lamp. (e) Cable Boxes, 2 Nos. Suitable for Cable at Item No. 2 above (f) Metal clad air Insulated Busbar Chamber having 3 Nos. 500 amps. Busbars.	No.	1	474000.00	474000.00
6.	Black Bituminous cable Compound Suitable for voltage 11 KV.	kg.	50	50.00	2500.00
7.	Black adhesive tapes 25 mm. wide 50 m. length.	Roll	20	900.00	1800.00
8.	Varnished or Empire Tape 25 mm. wide 50 m. length.	Roll	15	30.00	450.00
9.	Cotton Tape 25 mm. wide 50 meter length.	Roll	15	15.00	225.00
10.	Earthing Complete	Sets	2	2250.00	4500.00
11.	Lump sump provision for Cement Sand, Bricks and bolts etc.				3300.00
	Transportation Charges L.S.				
	Labour charges, assuming the following Technicians and labourers will finish the job within 20 days (includes, testing Commissioning and erection)				5300.00

(Contd.)

S.No.	Schedule of Items	Unit.	Qty.	Rate	Total
				Rs. P.	Rs. P.
	(a) Electrician = 1 No. at the rate of Rs. 80 per day. (b) Mason = 1 No. at the rate of Rs. 100 per day. (c) Mazdoors 10 Nos. at the rate of Rs. 45 per day. add Contingencies at 10% Hence the estimated cost of the work is Rs. 8,81350			 Total	 Rs. 12600.00 Rs. 801227 Rs. 80122.70 Rs. 881349.70 Say Rs. 881350.00

Example 2. *Estimate the quantity of material and the cost of erecting 75 KVA pole mounted sub-station by extending the existing 11 KV overhead line which is existing at a distance of 500 m. The sub-station is to be used for lighting load having 2 Feeders sharing equal load on L.T. side.*

Solution. Load in Amperes

$$= \frac{75 \times 1,000}{\sqrt{3} \times 11,000} = 3.937 \text{ Amps.}$$

Squirrel (6/1 × 2.11), A.C.S.R. is selected for the purpose of overhead line, consulting Table 14.14, the impedance of this cable is 1.4 ohms/km.

Therefore voltage drop in. 500 m. span

$$= \sqrt{3} \times \frac{1.4}{2} \times 3.937$$

= 4.773 volts which is very much within the limits

Length of conductor squirrel (6/1 × 2.11)

$$= 3 \times 500 = 1,500 \text{ m.}$$

Weight at 85 kg./km. = 127.5 kg.

Considering wastage and sag the weight will be = **140 kg.**

Pole P.C.C. 11 m. long

Nos. of spans $= \frac{500}{50} = 10$

∴ Nos. of poles =16 Nos. (2 Nos. each for poles structur and 4 Nos. for 4 pole structure)

25 sq. mm. 3-core 11 KV cable

Length =10 m. on the pole + 10 m. as four pole structure + 10 m. loop on each side

= 30 m.

G.I. wire No. 8 =140 kg., including earthing of poles and quarding.

Fig. 18.1 (*a*) represents the arrangement on poles except on the end two-pole structure and on the pole where shackle of point is provided.

Fig. 18.1. (*b*) represents the arrangment of one phase on a D.D switch.

Schedule of Items and the estimated cost has been worked out in Table 18.2.

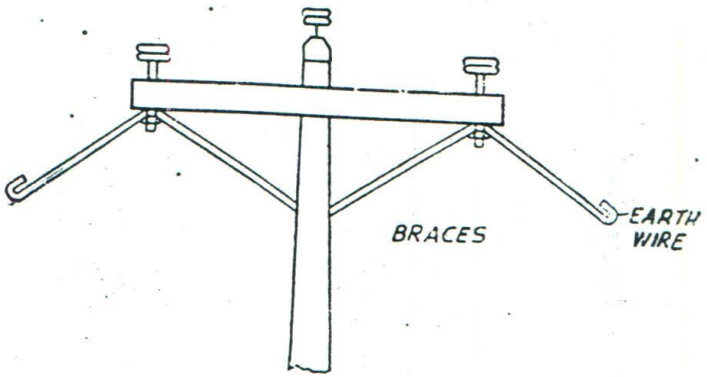


Fig. 18.1

Example 3. *Estimate the quantity of material required and cost of erecting the overhead H.T., 11 KV line and substation for feeding the factory load as given in Example 15.6. H.T. overhead line 11 KV is to be extended from a point as shown in Fig. 18.2.*

Solution. Total connected load = 225.63 KVA

$$\text{Load in amperes on L.T. side} = \frac{225.63 \times 1,000}{\sqrt{3} \times 400} = 318.1 \text{ amps}$$

$$\text{Load in amperes as H.T. side} = \frac{225.63 \times 1,000}{\sqrt{3} \times 11,000} = 11.84 \text{ amps.}$$

Table 18.2

S.No.	Schedule of Items	Units	Qty.	Rate	Total	Remarks
				Rs. P.	Rs. P.	
1.	P.C.C. pole 11 m. long	Nos.	16	3000.00	48000.00	
2.	Lightning Arrestors 11 KV	Sets	2	1850.00	3700.00	
3.	Gang operating switch complete 11 KV drop-down fuse units 3 Nos., with clamps for P.C.C. pole and fitted on channel iron.	Sets	2	11000.00	22000.00	
4.	A.C.S.R. squirrel (6/1 × 2.11) conductor	kg.	140	54.00	7560.00	
5.	Teakwood Cross Arm Bracket 150 cm. long with clamps for P.C.C. pole 11 m. long	Nos.	12	25.00	300.00	
6.	3-way 11 KV pin insulator spindle	Nos.	36	12.00	432.00	
7.	H.T. disc type insulators 11 KV	Nos.	12	225.00	2700.00	3 Nos. for end two pole structure and 6 Nos. for shackle of point provided on a two pole structure in between the route of the line
8.	Flat Iron 25 mm. × 6 mm for braces and for projection to carry earth wire and clamps	kg.	20	16.25	325.00	
9.	G.I. wire SWG 8	kg.	140	16.00	2240.00	
10.	Platform for housing the transformer with channel iron and the platform is covered with G.I. sheet.	No.	1	4450.00	4450.00	
11.	Transformer step down 11/0.4 KV, 75 KVA capacity, 3-phase core type double					
				C.O	91707.00	

S. No.	Schedule of Items	Units	Qty.	Rate	Total	Remarks
				Rs. P.	Rs. P.	
				B.F.	91707.00	
	wound suitable for outdoor use and having no load ratio of 11/0.4 KV with copper windings connected in delta/star L.V. side provided with 2.5% ± 5% and ± 7.5% tappings which are brought out to an externally hand operated off circuit tap changing switch with suitable indicator and locking device, complete with transformer oil for first filling and standard accessories	No	1		200002.00	
12.	Screened Aluminium Conductor, Lead alloy sheathed double steel tape/single wire armoured 11 KV 3 core 25 sq. mm. under cable	m	30	348.00	13440.00	
13.	Out-door cable end box 11 KV for cable at S.No. 12 above	No.	2	1525.00	3050.00	
14.	Stay plate M.S. 6.30 mm thick, 30 cm × 30 cm.	No.	8	110.00	880.00	Two stays at both ends of the Feeder and Four at middle two pole structure
15.	Galvanised stay or Anchor Rod 60 cm. long 19 mm. dia.	Nos.	8	115.00	920.00	
16.	Stay Bow of Galvanised Iron 15 mm dia. and 37.5 cm. long.	Nos.	4	30.00	120.00	
17.	Galvanised thimble	Nos.	16	4.00	64.00	
18.	Strain or stay insulators	Nos.	8	9.00	72.00	
19.	Stay. Collar of 3.80 mm thick flat iron	Nos.	8	10.00	80.00	
20.	Earth plate G.I. 60 cm. × 60 cm. × 6.30 mm.	Nos.	2	250.00	500.00	
21.	Stay wire 7/8 SWG	kg.	60	18.00	1080.00	
22.	Charcoal for pole earthing	Bags.	120	6 per kg.	720.00	
				C.O.	3,12,635.00	

(Contd.)

S. No.	Schedule of Items	Units	Qty.	Rate Rs. P.	Total Rs. P.	Remarks
				B.F.	3,12,635.00	
23.	Transformer Earthing complete in all respect	Nos.	4	1250.00	5000.00	
24.	Cement	Bags	40	100.00	4000.00	
25.	Sand	Bags	40	4.00 per Bag	160.00	
26.	Bricks	Nos.	15,00	900.00 (per 1000 Nos.)	1350.00	
27.	L.T. main I.C.T.P. switch with neutral link 200 amps., 500 volts	Nos.	1	600.00	600.00	
28.	L.T. main I.C.T.P. switch with neutral link, 100 amps 500 volts	Nos.	2	1170.00	2340.00	
29.	P.V.C. cable, aluminium conductor 1,100 volts grade single core 50 sq. mm.	m.	20	45.00 per m	900.00	
30.	P.V.C. cable, aluminium conductor 1,100 volts grade single core 35 sq. mm.	m.	30	33.00 per m	990.00	
31.	Anticlimbing Devices	Nos.	16	25.00	400.00	one on each pole
32.	Danger plate	Nos.	16	30.00	480.00	
33.	H.T. beads for insulating the jumpers Lump Sump.	Nos.	1,800	1.00	1800.00	
34.	Black Bituminous compound 11 KV	Kg.	20	50.00 per kg	1000.00	
35.	L.S. provision for Black tape, Empire tape, cotton tape and Binding wire				500.00	
	Labour Charges, considering that following technicians and labourers will complete the job during the nos. of days shown Designation-Nos. Days Rate Electrician 1 10 80.00 Lineman Gd.I 1 20 70.00 Mason 1 10 100.00 Blacksmith 1 15 60.00 Mazdoor 20 45.00 5 for 10 days 15 for 20 days				19250.00	
					351405.00	
	Add 10% Contingencies				35140.50	
				Total	386545.50	
	Hence the estimated cost of the work will be Rs. 3,86,546.00			Say	386546.00	

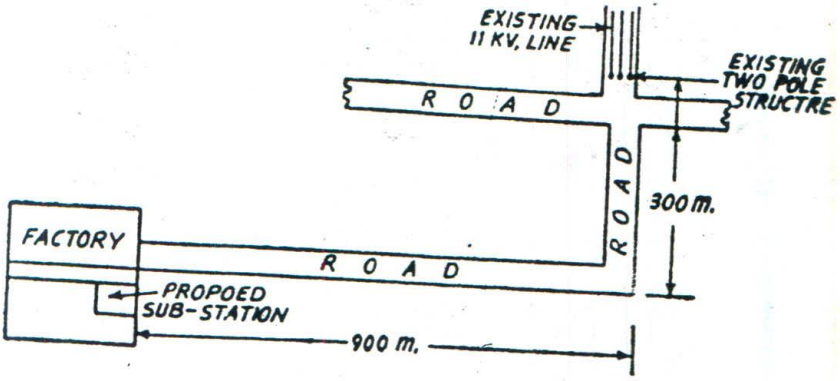


Fig. 18.2

(*i*) **A.C.S.R. conductor for overhead line.** Consulting table 14.14, it will be seen that the impedance of squirrel conductor (6/1 × 2.11) is 1.4 ohms/km.

Hence the voltage drop upto end point of overhead feeder

$= \sqrt{3} \times 1.4 \times 1.2 \times 11.84 = 34.45$ volts.

Hence it is suitable Length $= 3 \times 1,200 = 3,600$ metres

Weight at 85 kg./km. $= \dfrac{85 \times 3,600}{1,000} = 306$ kg.

Keeping provision for sag and wastage, Weight of A.C.S.R, squirrel (6/1 × 2.11) = 320 kg.

(*ii*) **Underground cable H.T.**

Length of screened, Aluminium conductor Lead alloy sheathed, double steel tape/single wire armoured 11 KV, 3 core 25 sq. mm. underground cable. = 40 m.

(*iii*) **Underground L.T. Cable**

Length of P.V.C. $3\frac{1}{2}$ core 185 sq. mm. 1,100 volts aluminium conductor underground cable = 50 m.

(iv) **Pole, P.C.C. 11 m. long.**

$$\text{Nos. of spans} = \frac{1,200}{50} = 24 \text{ Nos.}$$

Nos. of two poles structure : One at the corner and one at the end of overhead 11 KV feeder.

$\therefore$ Nos. of poles = 26 Nos.

Quantity of material required and cost has been worked out in Table 18.3.

Table 18.3

S. No.	Schedule of Items	Unit	Qty.	Rate Rs. P.	Total Rs. P.	Remarks
	A. SUB-STATION					
1.	Transformer Stepdown 11/0.4 KV, 300 KVA capacity, 3-phase, 50 cycles, core type double wound suitable for indoor use and having no load ratio of 11/0.4 KV with copper windings connected in star/delta, L.V. side provided with 2.5%, ±5%, ±5%, ±5%, ±7.5%, tappings which are brought upto an externally hand operated off circuit tap changing switch with suitable locking device and with transformer oil for first filling and standard accessories.	No.	1	2,00002.00	2,00002.00	
2.	High voltage A.C. metal clad floor mounting 11 KV, 3-phase, 3-wire 50 cycles 250 MVA Breaking Capacity, vertical drop down drawout free handle mechanism O.C.B. with following accessories : (a) 3 Nos. 5 amps. overload trips calibrated 100/200%. (b) 3 Nos. enclosed time limit fuse. (c) 3 Nos.CTs. of Ratio 40/5 amps., 15 VA, for protection and indication Instrument. (d) 1 No., Ammeter, 40 amps. scale with a 3-way on and off Ammeter Selector Switch. (e) Set of red and green indicating lamps for operation on 110 volts.	No.	1	3,52000.00	3,52,000.00	
				C.O.	5,52,000.00	

(Contd.)

S. No.	Schedule of Items	Unit	Qty.	Rate Rs. P.	Total Rs. P.	Remarks
					B.F 5,52,000.00	
	(*f*) Energy meter.					
	(*g*) 3-phase horizontal drop out oil immersed Potential Transformer, ratio 11,000/110 volts, 100 VA output per phase with uses on H.V. and L.V. side.					
	(*h*) 2 Nos. cable end Boxes suitable for 25 sq. mm.					
	11 KV underground cable at serial No. 4.					
3.	Metal clad indoor Industrial pattern floor mounting type L.T. Distribution Board suitable for operation on 400/440 volts, 3-phase, 4-wire 50 cycles system and equipped with the following :	Set	1	1,35,000.00	1,35,000.00	
	(*a*) **Busbar units :**					
	(*i*) 3 Nos. H.D.H.C. Electrolytic copper Burbars rated 300 Amps. for phases mounted on porcelain supports.				5,52,002.00	
	(*ii*) 1 No. H.D.H.C. Electrolytic Busbars rated 150 amps. for neutral mounted on porcelain Busbar Supports.					
	(*b*) **Incoming**					
	300 amps., 400 volts, tripple pole trip free, horizontal drawout type O.C.B. with an estimated rupturing capacity of 15 MVA at 400 volts and provided with.					
	(*i*) C.T. operated, overload trips with oil Dash Pot for time lag.					
	(*ii*) 1 No. under voltage release.					
	(*iii*) 1 No. Neutral Link					
	(*iv*) 1 No. Mechanical on and off Indicator.					
	(*v*) 1 No. Emergency trip Lever.					
	(*vi*) 1 No., Ammeter range 500 amps. with a 3-way on and off selector switch.					
	(*vii*) 3 CTs. ratio 300/5 Amps.					
	(*viii*) 1 No. voltmeter range					
				C.O.	6,87,002.00	

(Contd.)

S.No.	Schedule of Items	Unit	Qty.	Rate Rs. P.	Total Rs. P.	Remarks
				B.F.	6,87,002.00	
	500 volts with 3-way on and off Selector Switch. (ix) 1 Set of voltmeter protective fuse. (x) 1 No. Cable Box suitable for L.T. cable at serial No. 5. (c) **Outgoing :** (i) 3 Nos :- 150 amps. 500 volts I.C.T.P. and Neutral Link, H.R.C. Combination tape fuse switch units complete with a set of 3 fuse cartridges, ammeter 200 amps. range and Selector Switch, CTs. ratio 150/5 amps 3 Nos. a cable end Box. (ii) 1 No.—do—but of 60 amps. and with C.Ts. ratio 60/5 amp. The above unit should be complete with all necessary interconnections, small wiring, oil for OCB and earthing strip.					
4.	Screened Aluminium Conductor, Lead alloy sheathed double steel tape/single wire armoured, 11 KV, 3-core 25 sq. mm. underground cable.	m	40	73.00 per m.	2920.00	
5.	P.V.C., $3\frac{1}{2}$ core 1,100 voltes, 185 sq. mm. Aluminium conductor underground cable.	m	50	342.00 per m	17100.00	
6.	Black Bituminous Compound suitable for voltages 11 KV	kg.	30	50.00 per kg	1500.00	
7.	—do—but suitable for 1,100 volts	kg.	50	40.00 per kg	2000.00	
8.	Varnished or Empire tape 25 mm. wide 50 m. length	Rolls	20	30.00 per roll	600.00	
9.	Cotton tape 25 mm. wide 50 m length	Rolls	20	15.00 per roll	300.00	
				C.O.	7,11,422.00	

(Contd.)

S.No.	Schedule of Items	Unit	Qty.	Rate Rs. P.	Total Rs. P.	Remarks
				B.F.	7,11,422.00	
10.	Black adhesive tape 25 mm. wide, 50 m. length	Rolls	30	90.00 per roll	2700.00	
11.	Earthing complete	Sets	4	2250.00	9000.00	
12.	Lump Sump provision for Cement. Sand, Brick-Bolts and outdoor cable end Box for 25 sq. mm. 22 KV cable				4500.00	
	Transportation charges (Lump /Sump)				5300.00	
	Labour charges, assuming the following technicians and labourers will finish the job in 20 days (testing, commissioning and erection)					
	(a) Electrician = 1 No. at the rate of Rs. 80 per day					
	(b) Mason = 1 No. at the rate of Rs. 100 per day					
	(c) Mazdoor = 10 Nos. at the rate of Rs. 45 per day				12600.00	
					745522.00	
	Add 10% contingencies				74552.20	
	Hence the estimated cost of the substation is Rs. 8,20074.00			Total	8,20074.20	

Example 4. Prepare a list of materials required with cost, for installation of a substation at a H.T. Consumer's premises. The details of the load are as follows :

1. Compressor motor 3Φ 440V - 75 H.P.
2. Furnace 3Φ 440V - 110 KW
3. Washing Machines 3Φ440V - 10 H.P. - 1 No.
   3Φ 440V - 1.5 H.P. - 1 No.
   3Φ 440V - 1.0 H.P. - 1 No.
4. Grinder Machines 3Φ 440V - 2 H.P. - 1 No.

The cost should be covered for Transformers, Structures, Control Room with O.C.B. and M.V. panel. The feeding must be thro' U.G. cable.

Solution.

This is a problem, pertaining to erection of a H.T. Sub-station at the Consumer's premises. It is assumed that 3Φ 110 KV Transmission line passes 2 KM away from his premises. Therefore,

a separate extension line is errected up to his premises. A sub-station 110/11 KV & 11 KV/400V is errected at 100M away from this consumer and supply is taken to this consumer thro 2 core 33 KV U.G. Cable inside the premises and a 11KV/440 Tr. is errected.

Load in the factory :

1. **Compressor Motor**—3 Φ 440 V—75 H.P.

Assume $\eta = 0.8$ and p.f. = 0.7

$$\text{Load in KVA} = \frac{75 \times 0.7355}{0.8 \times 0.7} = 98.5 \text{ KVA}$$

2. **Furnace** 3Φ 440 V—110 KW

Assume $\eta = 0.95$ p.f. = 1

$$\text{Load in KVA} = \frac{110}{0.95 \times 1} = 115.78 \text{ KVA}$$

3. **Washing Machines**

(*i*) 3 Φ 440 V—10 H.P.

Assume $\eta = 0.8$ p.f. = 0.7

$$\text{Load in KVA} = \frac{10 \times 0.7355}{0.8 \times 0.7} = 13.13 \text{ KVA}$$

(*ii*) 3 Φ 440—1.5 H.P.

Assume $\eta = 0.75$ p.f. = 0.68

$$\text{Load in KVA} = \frac{1.5 \times 0.7355}{0.75 \times 0.68} = 1.57 \text{ KVA}$$

(*iii*) 3 Φ 440 V—10 H.P.

Assume $\eta = 0.72$ p.f. = 0.65

$$\text{Load in KVA} = \frac{1.0 \times 0.7355}{0.72 \times 0.65} = 2.16 \text{ KVA}$$

(*iv*) **Grinder M/c**—3 Φ 440 V—2 H.P.

Assume $\eta = 0.9$ p.f. = 0.82

$$\text{Load in KVA} = \frac{2 \times 0.7355}{0.9 \times 0.82} = 2 \text{ KVA}$$

Total Connected Load = (*i*) + (*ii*) + (*iii*) + (*iv*) = 233.14 KVA.

Note : 1. Assume a capacitor bank of 50 KVA is connected.

2. Assume a lighting load of 10 KW, Hence Total connected load = 293.14 KVA With future expansion in mind, we select a 500 KVA 11KV/440V, Δ/Y, Transformer.

DETAILED ESTIMATE

For Erection of 110 KV Sub-Station

Sl. No.	*Details of work*	*Qty.*	*Rate in Thousands Rs.*	*Amount in Thousands Rs.*	*Total Amount in Thousands*
1.0	**Grounds & Building**				
(*a*)	Grounds		LS	800.00	
(*b*)	Building		LS	400.00	
(*c*)	Quarters		LS	150.00	1350.00
2.0	**Structures**				
(*a*)	110 KV structures line & Transformer Bays-Single Bus arrangement.	2 Nos.	70.50	141.00	
(*b*)	11 KV Bays (including bus-bar, insulators, etc.)	2 Nos.	35.60	71.20	
(*c*)	Tapping structure	1 Nos.	5.50	5.50	
2.1	**Erection of Bus Bar, Insulators etc.**				
(*a*)	110 KV		LS	230.00	
(*b*)	11 KV		LS	35.00	482.70
3.0	**Switch Gears Erected**				
(*a*)	110 KV Circuit Breaker (OMCB/ABCB/SF$_6$) with C.T.S.	1 No.	460.00 each	460.00	
(*b*)	110 KV Isolator with Earthing Blade	1 No.	25.30 each	25.30	
(*c*)	110 KV P.T.	1 set	60.00 each	60.00	
(*d*)	110 KV LAs (stn. type)	3 sets	55.00 per set	165.00	
(*e*)	11 KV Circuit Breaker with C.T.	1 set	60.05 per set	60.05	
(*f*)	11 KV Isolator	1 No.	2.50 each	2.50	
(*g*)	11 KV LAs (station type)	1 set	5.50 per set	5.50	
(*h*)	11 KV LAs (Distn. type)	1 set	1.00 per set	1.00	
(*i*)	11 KV P.T.S.	1 No.	5.50 each	5.50	
			Total	784.85	
	Sundry Labour and Transport 5%			39.24	824.09

Sl. No.	Details of work	Qty.	Rate in Thousands Rs.	Amount in Thousands Rs.	Total Amount in Thousand
4.0	**Power Transformers Erected**				
(a)	110/11 KV, 10 MVA, Power Transformer	1 No.	2000 each	2000.00	
(b)	11 KV/440V, 500 KVA, Distribution Transformer	1 No.	125.15	125.25	
(c)	Erection of Transformer Rail Track etc.		LS	20.75	
			Total	2146.00	
(d)	Plinth, Labour and Transport 10%		LS	214.60	2360.60
5.0	**Station Auxiliaries Erected**				
(a)	110KV, 100AH Battery with Charging Equipments and Distribution Board including A.C. plant	1 No.	LS	100.00	
(b)	110 KV Line plant	1 No.	35.60	35.60	
(c)	110 KV Transformer panel	1 No.	14.30	14.30	
(d)	Relays and Control panel etc. for 110 KV/11 KV/440 V SS	1 No.	LS	175.25	
(e)	Synchroscope	1 Nos.	LS	15.25	
(f)	Annunciation Panel	1 Nos.	45.30 each	45.30	
(g)	Fire Fighting Equipment		LS	40.00	385.70

(Sundries, Transportation and Labour for the above, have been included in each item).

ABSTRACT

No.	Particular	Amount (Rs. in Thousands)
1.	Grounds and Building	1350.00
2.	Structures Erected	482.70
3.	Switch Gears Erected	824.09
4.	Power Transformers Erected	2360.60
5.	Station Auxiliaries Erected	385.70
	Sub Total	5403.09
	Contingencies 15%	810.46
	Tool charge 3%	162.09
	Total for works	6375.64
	Estt. and supervision charges 15%	956.34
	Gross Total	7331.98

No.	Particular	Amount (Rs. in Thousands)
	B.F.	7331.98
	Overhead charges 15%	1099.79
	Total	8431.77

[Rupees Eighty Four Lakhs, Thirty One Thousand and Seven-hundred and Seventy seven only]

"Sanctioned"

Sd. .....

Chief Engineer In-charge.

Note : This is the expenditure to be incurred by the Electricity Board, for the S.S. erection for this consumers as well as for future expansion.

DETAILED ESTIMATE

ESTIMATE FOR 11 KV/416 Volts S.S.

Sl. No.	Details of work	Qty.	Rate in Thousands	Amount in Thousands	Total Amount in Thousands
1.0	**Grounds & Buildings**				
(a)	Ground		LS	130.00	
(b)	Building 4 M × 5 M		LS	54.00	184.00
2.0	**Structures Erected**				
(a)	11 KV Bags (including bus-bar insulator etc. structure only)	1 No.	35.60	35.60	
(b)	Erection of Bus-bar Insulators etc.	LS	35.00	35.00	70.60
3.0	**Switch Gears Erected**				
(a)	11 KV circuit breaker with C.T.	1 Set	57.55	57.55	
(b)	11 KV isolator	1 No.	2.50	5.00	
(c)	11 KV LAs(station type)	1 Set	5.50 per set	5.50	
	—do— (Distin. type)	1 set	1.00 per set	1.00	
(d)	11 KV P.Ts.	1 No.	5.50 each	5.50	
	Labour & Transport 5%			3.72	78.27

(Contd.)

No.	Particular			Amount (Rs. in Thousands)	
4.0	**Power Transformer Erected**				
(a)	11 KV/440V, 500 KVA Distribution Transformer	1 No.	125.15	125.15	
(b)	Erection of Transformer, Rail Track etc.,		LS	20.75	
				145.90	
(c)	Plinth, Labour & Transport 10%		LS	14.59	160.49
5.0	**Station Auxiliaries Erected**				
(a)	100AH, 110V Battery with charging equipment	LS		15.00	
(b)	11 KV Line panel	LS		25.00	
(c)	11 KV Transformer panel	LS		25.00	
(d)	Relays & Control panels etc. for 11 KV/416 V S.S.	LS		37.00	
(e)	Fire fighting equipment	LS	25.00	25.00	127.00

ABSTRACT

No.	Particular	Amount (Rs. in Thousands)
1.	Grounds and Building	184.00
2.	Structures Erected	70.60
3.	Switch Gears Erected	78.27
4.	Power Transformers Erected	160.49
5.	Station Auxiliaries Erected	127.00
	Sub Total	620.36
	Contingencies 15%	93.05
	Total	713.41
	Tool charge 3%	21.40
	Total for works	734.81
	Estt. and supervision charges 15%	110.22
	Gross Total	845.03
	Overhead charges 15%	126.75
	Total	971.78

[Rupees Nine Lakhs Seventy one Thousand and seven hundred and Eighty only.]