See TI C3 Q 0040 203

POWER SUPPLY TO SUBSCRIBERS' INSTALLATIONS

General Principles and Provision of Plant Supplying Not More than 4 Ah Per Day at 15–30V

★**1. Scope of Instruction.**—This Instruction describes the principles of the various methods of supplying power up to 4 Ah per day to subscribers' installations and states the factors which should be examined to determine the best method to adopt in any particular circumstance. Power-units are dealt with in S 1051.

★**2.** Generally the types of installation requiring power up to 4 Ah per day will be non-multiple P.M.B.X.s and house exchange systems. Where two switchboards are used together and the daily load exceeds 4 Ah power plant described in S 1212 or S 1320 should be used.

★**3. Contents.**

★**4. General.**—Installations requiring not more than 4 Ah per day, calculated between the limits 15–30V, which come within the scope of this Instruction are:—

(*a*) Switchboards AT 3796

(*b*) „ CB 873

(*c*) „ CB 935

(*d*) „ CBS N 934

(*e*) „ N 1070

(*f*) House exchange systems (*NOTE:*—Any reference to house exchange systems in this Instruction is only concerned with diagrams in the range Q 100–299)

(*g*) Order tables, multiphone switchboards and similar installations.

★**5.**—Power may be supplied to these installations by the use of:—

(*a*) All-mains power-units (see S 1051)

(*b*) Direct power lead

(*c*) Single-battery float charging from a power lead

(*d*) Single-battery float charging from a.c. mains

(*e*) Primary cells.

6. Economic considerations.—The method chosen for any particular installation should normally be the most economical of those available. If a more expensive method is adopted at the request of a subscriber, he should be called upon to pay an additional rental based on the difference in annual costs between the method adopted and the method chosen by the P.O.

The annual charges for the various methods of supplying power are given in S 0901.

DIRECT POWER LEADS

7. Definition and method of working.—The term 'direct power lead' is used to describe a power lead connected directly to the apparatus which it supplies, as distinct from a power lead which is used to float-charge a battery at the subscriber's premises. A direct power lead is a conductor or group of conductors used for supplying electrical energy from a common battery (at the main exchange or other central point) to one or more P.M.B.X. switchboards or other subscribers' installations. It is operated on an earth return basis, being connected between the negative busbars at the P.M.B.X. and at the main exchange. The positive busbar at the P.M.B.X. is earthed in accordance with PROTECTION, General, S 3901 (see Dgm. N 962).

Where a polythene-sheathed distribution cable serves the subscriber's premises a power lead should only be used if other methods are not possible. At such installations the positive busbar at the P.B.X. should be earthed at the main exchange via conductors in the cable, similar to the power lead itself. The loop resistance of the circuit so formed must not exceed the values given in Table 3.

★**8. Conditions of use.**—The preferred method of supply is by a power-unit, subject to the limitations stated in S 1051. A direct power lead might be found more economical for a cordless switchboard very close to the exchange but where any doubt exists a cost comparison should be made. Power leads must never be used to supply 'preference' subscribers (see S 1001).

If there is a shortage of underground plant, unnecessary appropriation of cable pairs for power leads should be avoided. The freeing of underground cable pairs for revenue-earning service may justify the excess annual cost for an alternative method of power supply.

9. Voltage at the main exchange.—The nominal power lead voltages available at various types of main exchange are shown in Table 1.

These voltages may be used for power lead calculations although the voltage across the busbars at the main exchange may occasionally fall below these nominal values.

10. To secure the greatest economy in line plant and power plant, the permissible resistance (see pars. 14 and 15), and consequently the number of conductors used for a direct power lead, should be based on the highest voltage supply available at the main exchange (but see par. 11). If the resistance of available conductors is sufficiently low however, the lower voltage supply should be used. If the load current carried by an existing direct power lead is increased beyond the limit determined by its resistance at the lower voltage, the supply should be transferred to the higher voltage, subject to the limitations given in pars. 11 and 12.

11. Direct power leads must not be connected to a 50V or 60V supply at the main exchange if the bunched line resistance is less than 150 ohms (50V) or 200 ohms (60V). The application of these higher voltages to direct power leads of lower resistance entails the risk of fire at the subscriber's premises. The maximum permissible voltage supply to direct power leads serving Switchboards CB 873, AT 3796 and N 1070 is 30V (see Table 3).

★**12. Voltage at subscriber's premises.**—The maximum and minimum voltages permissible at subscribers' installations are given in Table 2. For direct power leads to house exchange systems only the 30V supply from the main exchange is suitable.

13. 'Hypothetical and actual maximum current.'—The current which flows when the estimated maximum number of simultaneous connexions is set up at the specified minimum voltage is termed the 'hypothetical current.' This current has been calculated for various installations, and the figures are given in column 4 of Table 3. The hypothetical current figures are not based on the maximum possible number of connexions on an installation, because this condition is exceptional. The hypothetical current figure is used for determining the maximum permissible resistance of a power lead and for determining the current rating required for power lead fuses (par. 20).

The actual value of the maximum load current for a particular installation varies with local conditions. If the hypothetical figure is too small due to local circumstances, the actual value should be used. For this purpose the values of current per connexion on non-multiple P.B.X.s given in TELEPHONES, P.B.X.s, B 1030, B 1040, and B 1050 should be used.

★**14. Resistance.**—The maximum permissible resistances for direct power leads serving non-multiple switchboards or house exchange systems carrying normal traffic are given in Table 3. These figures are based on the hypothetical current demand. If the load exceeds the hypothetical demand or if several P.M.B.X.s are served from one power lead, the maximum permissible resistance may be calculated from the formula:—

$$R = \frac{E-V}{I}$$

where R is the permissible resistance of the power lead (ohms) including the resistance of the earth return

E is the nominal power lead voltage at the main exchange (volts)

V is the minimum permissible voltage at the subscriber's premises (volts)

I is the estimated maximum load current (amp).

The power lead resistance includes that of the earth connexion which should be kept as low as practicable.

The resistance of the earth connexion may be found approximately by deducting the resistance of the bunched metallic circuit from the total power lead resistance, measured as described in par. 16. A precise method of measuring the resistance of the earth connexion is given in TESTS & INSPECTIONS, General, B 1053.

If several subscribers' installations within a short radius of the D.P. are served from a common power lead it may be assumed that the load is concentrated at the teeing point and that the minimum subscribers' voltage is to be maintained at that point. Curves relating the maximum permissible resistance of a power lead to the load current at 15V for all power lead supply voltages are given in Dgm. N 630. Thus, knowing the total load current, which is the sum of the hypothetical and/or actual individual load currents at 15V (see par. 13), the value of resistance can be read off the appropriate curve.

15. Resistance values to be used in calculations.

(*a*) *Underground cable.* Because both wires of an underground pair are connected in parallel when used for a power lead (see par. 18) the resistance of such a lead from the exchange to the D.P. will be one-quarter of the line loop resistance. The resistance values shown in Table 4 may be used if a special calculation is necessary.

(*b*) *Overhead wire.* The resistance of an overhead lead of Wire, Cadmium-copper, P.V.C. which terminates an underground circuit may be ignored if it is less than 100 yards in length except for power leads to house exchange systems, Switchboards AT 3796 and Switchboards N 1070. For these types of installation (and for other types if more than 100 yards of overhead wiring is necessary) the resistance of the overhead wires should be calculated from the value given in Table 4. The length of wire used in the calculation should include that of any overhead earth conductor (see PROTECTION, General, S 3901).

(*c*) Form A 669 should be used within the T.M.'s office for inquiries as to the availability of a power lead of the required resistance.

★TABLE 1

Type of main exchange	Power lead voltages available
C.B. manual 22V	22 and 30
,, ,, 24V	24 and 30
,, ,, 40V	30
Automatic 50V	30 and 50
,, 60V	30 and 60
U.A.X.s Nos. 7 and 14	30 and 50
Other U.A.X.s	None

TABLE 2

Type of installation	Minimum voltage	Maximum voltage
Non-multiple switchboards	15 (Notes 1 and 3)	30 (Note 2)
House exchange system	18 (see par. 17)	28 (see par. 17)

NOTE 1:—If higher minimum voltages are required (such as for signalling over long inter-switchboard circuits e.g. see Dgm. N 705), or if Units, Auxiliary Apparatus or divided-feed cord-circuits are installed to allow higher extension resistance limits to be tolerated (see TELEPHONES, P.B.X.s, B 3001) or where S.T.D. private meters of the cyclometer type are fitted (Note 4), consideration should be given to the use of a power unit or a single-battery float equipment operated from a.c. mains or from a power lead.

NOTE 2:—The nominal maximum for non-multiple switchboards is 30V, but this may be exceeded during periods of light load subject to the restrictions mentioned in par. 11. Other measures to limit the actual maximum voltage applied to these switchboards are unnecessary.

NOTE 3:—Earlier issues of this Instruction gave minimum voltages of 12V. Retrospective action should not be taken to raise the voltage at an existing installation unless trouble has been experienced due to low voltage.

NOTE 4:—S.T.D. private meters of the cyclometer type, e.g. Meter No. 20A, require a minimum of 20V for satisfactory operation. At installations where the power supply is below 20V the feeds to the meters may be boosted by using dry cells.

★TABLE 3. MAXIMUM PERMISSIBLE RESISTANCE FOR DIRECT POWER LEADS

Switchboard		Power requirements		Maximum permissible resistance of direct power lead supplies at a nominal main exchange voltage of:—			
				22	30	50	60
Type	Size	Minimum permissible busbar P.D. (*volts*)	Hypo-thetical current at minimum permissible busbar P.D. (*amp*) (Note 1)	(*ohms*)	(*ohms*)	(*ohms*) See par. 11	(*ohms*) See par. 11
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CB 935 See par. 8	$\frac{1+3}{4}$	15	0·068	103	220	510	660
	$\frac{2+4}{6}$	,,	,,	,,	,,	,,	,,
	$\frac{3+9}{12}$	,,	0·135	52	110	260	330
CB 873	$\frac{5+20}{25}$	15	0·26	27	58	Not permitted	
AT 3796	$\frac{10+30}{65}$	15	0·44	16	34		
	$\frac{10+50}{65}$	,,	0·54	13	28		
	$\frac{10+60}{180}$	,,	0·63	11	24		
	$\frac{10+30}{65}+\frac{10+30}{65}$	,,	0·88	8	17		
	$\frac{10+30}{65}+\frac{10+50}{65}$	,,	0·98	7	15		
	$\frac{10+50}{65}+\frac{10+50}{65}$	,,	1·08	6·5	14		
	$\frac{10+60}{180}+\frac{10+60}{180}$	,,	1·25	5·5	12		
N 1070	$\frac{10+30}{65}$	15	0·66	10·5	23	Not permitted	
	$\frac{10+50}{65}$	,,	0·81	8·5	18·5		
	$\frac{10+60}{180}$	,,	0·95	7·5	15·5		
	$\frac{10+30}{65}+\frac{10+30}{65}$	,,	1·32	5	11		
	$\frac{10+30}{65}+\frac{10+50}{65}$	,,	1·47	4·5	10		

TABLE 3 (*contd.*)

Switchboard		Power requirements		Maximum permissible resistance of direct power lead supplies at a nominal main exchange voltage of:—			
				22	30	50	60
Type	Size	Minimum permissible busbar P.D. (*volts*)	Hypothetical current at minimum permissible busbar P.D. (*amp*) (Note 1)	(*ohms*)	(*ohms*)	(*ohms*) See par. 11	(*ohms*) See par. 11
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
N 1070 (*contd.*)	$\frac{10+50}{65}+\frac{10+50}{65}$	15	1·62	4	9	Not permitted	Not permitted
	$\frac{10+60}{180}+\frac{10+60}{180}$	,,	1·88	3·5	8		
CBS N 934 See par. 8	$\frac{1+3}{4}$	15	0·048	145	310	730	940
	$\frac{2+4}{6}$	,,	,,	,,	,,	,,	,,
	$\frac{3+9}{12}$	,,	0·069	100	220	510	650
House exchange systems	1+5	18	0·5	†	24	†	†
	2+10	,,	0·9	†	13	†	†

† Unsuitable (see par. 12)

NOTE 1:—If the load is abnormal, see pars. 13 and 14.

TABLE 4. RESISTANCE OF CONDUCTORS USED FOR POWER LEADS

Type of plant	Conductor gauge (*lb. per mile*)	Resistance of one mile of one underground pair with both wires bunched, or one single overhead wire (*ohms*)
Underground	4	110
	6½	68
	10	44
	20	22
	40	11
Overhead 70 lb. (cadmium-copper)	70	15

★**16. Measurement of power lead resistance.**—The resistance of a direct power lead (including the earth return) may be ascertained without interference to the service by observing, at a suitable point, the voltage before and after the application of a load resistance. The test may be made irrespective of whether the power lead is already carrying current or is on open circuit, and the applied artificial load may be stated either in ohms or amperes.

If R = the power lead resistance up to the point of testing (ohms)

E = the power lead supply voltage at the main exchange (measured, not nominal, value) (volts)

V_1 = the voltage at the point of testing without additional load (volts)

V_2 = the voltage at the point of testing with additional load (volts)

r = resistance of additional artificial load (ohms)

or I = current taken by additional load (amp)

Then $R = \frac{E\ (V_1-V_2)}{V_1\ V_2} r = \frac{E\ (V_1-V_2)}{I\ V_1}$ or, for the open circuit condition

$$R = \frac{(E-V_2)}{V_2} r = \frac{E-V_2}{I}$$

Dgm. N 905 contains alignment charts for 22V and 30V supplies from which the value of the power lead resistance, R, can be read directly for any corresponding values of V_1 and V_2, using an additional load resistance (r) of 40 ohms. An explanation of the method of testing is also given on the diagram.

★**17. Special test for house exchange systems.**—Verify by test that the voltage at the subscriber's premises does not fall outside the limits of 18–28V at full and light load.

Such tests should be made when the system is initially installed and when service faults occur which could be attributed to the power supply voltage being outside the above limits.

(*a*) Full-load conditions may be reproduced by connecting artificial load resistors between the power lead and earth, as follows:—

1 + 5 system. A 36-ohm resistor, e.g. a Coil, Testing, No. 1 using terminals 4 and 5

2 + 10 system. A 20-ohm resistor, e.g. a Coil, Testing, No. 1 using terminals 4 and 6. (This test should be of brief duration to avoid overheating the coil.)

(*b*) Light-load conditions may be considered to exist when the handset of one extension is raised from the gravity switch and the LOCAL key is depressed to the CALLING position to call another extension.

If the full-load test fails (i.e. the voltage is below 18V)—which will occur on a 1 + 5 system if the power lead resistance exceeds 24 ohms or, on the 2 + 10 system, exceeds 13 ohms—additional bunched pairs must be used to reduce the power lead resistance or, alternatively, a single-battery plant float-charged from a.c. mains or from a power lead should be installed.

If the light-load test fails (i.e. the voltage is above 28V)—which will only occur on very short power leads—a resistance pad, Resistor, Coil, No. 9, 4 ohms, should be connected in series with the power lead.

★**18. Connexions of power leads** should be in accordance with Dgms. N 962, N 963 and N 964, and with INTERNAL WIRING, Stations, A 3020. When power leads are routed in underground cable, both wires of the pair used should be bunched and used for the power lead. Earth connexions should be provided in accordance with PROTECTION, General, S 3901.

19. Direct power leads serving more than one installation.

(*a*) Not more than one house exchange system should be connected to one power lead but, if there is a non-multiple P.M.B.X. in the same building as the house exchange system, one power lead may be used to serve both installations, provided the voltage limits of the house exchange system can be maintained on the power lead, and the provisions of Dgms. N 963 and N 964 allow.

(*b*) If several non-multiple P.M.B.X. switchboards are situated in the same building, or are within short distances of the common distribution point serving them, calculations should be made as indicated in par. 14 to determine whether power lead conductors could be saved by connecting several installations to a common power lead (of several pairs bunched if necessary). For example, three pairs bunched might be satisfactory for two P.M.B.X.s each of which would require two pairs bunched if served separately. The restrictions as to bunching shown in Dgms. N 963 and N 964 must be observed and power leads should not be combined if there would not be a resulting economy in line plant.

★(*c*) In buildings which contain several P.M.B.X.s and where accommodation is available it may be economic to provide a float-charged battery at a central point and to use power leads from this battery to the individual P.M.B.X.s.

★**20. Fuses** for power leads should be provided and connected in accordance with Dgms. N 963 and N 964. The fusing arrangements on the exchange power lead fuse-panel are designed to prevent, as far as practicable, the undue loading of conductors in the event of an earth fault occurring at any point in a power lead circuit; normally one 1-amp fuse per ampere of hypothetical current, as shown in Table 3, should be provided. If, however, a power lead that is to be fed from an exchange battery of 22V or 30V

(*a*) via one fuse, has a resistance of less than 12 or 20 ohms, respectively

or (*b*) via two or more fuses, has a resistance of less than 1 or 5 ohms, respectively

then the maximum current carried, due to the small voltage drop in the power lead, may exceed the fusing current of the fuse(s) which would normally be fitted. In such cases, fuses should be provided on the exchange power lead fuse-panel at the rate of one per ampere calculated from the following formula:—

$$I = \frac{E}{R + \frac{V}{H}} \text{ amp}$$

where E = maximum power lead supply voltage at main exchange (volts)

R = power lead resistance (ohms)

H = hypothetical current (amp)—(Table 3, column 4)

V = minimum voltage at subscriber's premises (volts)—(Table 3, column 3)

Not more than one fuse on the exchange power lead fuse-panel may be connected to one conductor; consequently, additional conductors will be required if the revised current exceeds 2 amp per pair, though they may not be required on resistance grounds alone.

21. Protectors and heat coils.—Protectors should be provided on power leads on the same basis as for ordinary subscribers' lines served by the same routes. Heat coils should be replaced by dummy heat coils.

22. Smoothing.

(*a*) *House exchange system.* Two 4-μF capacitors, e.g. two Capacitors, M.C., No. 103, should be connected in parallel between the power lead and earth at the subscriber's premises.

(*b*) *P.M.B.X.s.*

(i) Two 4-μF capacitors, usually two Capacitors, M.C., No. 103, connected in parallel between the negative and positive busbars are included in all 24V non-multiple P.M.B.X.s.

(ii) When teleprinter working is required over a Tariff D private circuit terminated on a P.M.B.X. switchboard served by a direct power lead, the resistance of which exceeds 5 ohms, additional capacitors should be provided in accordance with TELEGRAPHS, P.W.s & Telex., D 3901.

(iii) When interference due to the operation of the audible alarm is caused at a P.M.B.X. served with others from a common power lead, or served from an individual power lead, the bell circuits should be modified to conform in principle to Dgm. N 946, Fig. 1 (TELEPHONES, P.B.X.s., B 3001 refers).

23. Records.—Power leads are numbered consecutively on the fuse panels at the main exchange and a card A 617 should be kept for each lead (see TELEPHONES, General, D 6002, and TELEPHONES, Automatic, H 6901).

The hypothetical current for each installation (see Table 3), or the maximum current calculated for abnormal installations (see par. 13), should be entered on the card under the heading 'Estimated maximum load.' The sum of the separate load currents should be shown in the column headed 'Total load' and should not, as a rule, be allowed to exceed the maximum permissible value (calculated from the formula given in par. 14) corresponding to the resistance of the power lead. Exceptionally, if the traffic conditions of a number of installations served by one lead are such that periods of maximum load current do not coincide, discretion may be exercised as to the actual loading, but care must be taken to ensure that the minimum permissible voltage is maintained at all times.

24. Annual charges.—The annual charges to be used in comparing the cost of power supply by a direct power lead with that of other methods are the total of:—

(*a*) the annual charges for the line plant used (see S 0901), and

(*b*) the annual charges for the energy supplied from the main exchange battery (see S 0901).

★**25.** The route milage of underground leads is the milage of a pair multiplied by the number of pairs used for the power lead.

The milage of overhead wires, including any overhead earth conductor, may be taken as 0·05 mile as an average value if the route distance from the D.P. is less than 100 yards. In other cases the actual wire milage, including any overhead earth lead, should be used for the calculation.

26. Energy supplied from main exchange battery.—The daily load in ampere-hours with the minimum permissible voltage on the busbars of the subscriber's installation has been calculated for installations carrying normal traffic and is shown in col. 4 of Table 5. For installations carrying abnormal traffic, the daily load in ampere-hours at the minimum permissible voltage should be calculated specially.

27. In practice, the voltage at the subscriber's premises is above the minimum for long periods of the day and may be assumed to average the values shown in line 2 of Table 5. The daily load is therefore greater than it would be if a constant minimum voltage were maintained at the installation busbars and, to allow for this, a correction factor must be applied to determine the energy supplied from the main exchange battery. The correction factor, K, is given by:—

$$\frac{\text{Average voltage at subscriber's premises (Table 5, line 2)}}{\text{Minimum permissible voltage at subscriber's premises (Table 5, column 3)}}$$

28. The watt-hour drain per day from the main exchange battery is therefore given by E × (Ah per day at minimum volts) × K, where E is the nominal power lead voltage at the main exchange. This figure should then be multiplied by 0·3 to obtain the kilowatt-hours supplied per year by the main exchange battery. The calculated values for normal installations are shown in columns (5) to (8) of Table 5.

★TABLE 5. ENERGY SUPPLIED FROM DIRECT POWER LEADS

1. Nominal power lead voltage at the main exchange	22	30	50	60
2. Assumed average voltage at subscriber's premises	17	22	35	42
3. Daily load correction factor for power leads serving 15V (min.) P.M.B.X.s (see Note 1)	1·13	1·47	2·33	2·8

Switchboard		Minimum permissible voltage	Daily load at minimum permissible voltage (*Ah*)	Energy supplied from main exchange battery (*kilowatt-hours per year*)			
Type (1)	Size (2)	(3)	(4)	22V (5)	30V (6)	50V (7)	60V (8)
CB 935	$\frac{1+3}{4}$	15	0·044	0·33	0·58	1·54	2·22
	$\frac{2+4}{6}$	,,	0·063	0·47	0·83	2·21	3·18
	$\frac{3+7}{12}$	,,	0·11	0·83	1·45	3·86	5·55
	$\frac{3+9}{12}$	,,	,,	,,	,,	,,	,,
CB 873	$\frac{5+20}{25}$	15	0·44	3·3	5·83	Not permitted	Not permitted
AT 3796	$\frac{10+30}{65}$	15	1·31	9·85	17·8	Not permitted	Not permitted
	$\frac{10+50}{65}$	,,	1·6	12·1	21·2		
	$\frac{10+60}{180}$	,,	1·88	14·1	24·9		
	$\frac{10+30}{65}+\frac{10+30}{65}$	,,	2·6	19·5	34·4		
	$\frac{10+30}{65}+\frac{10+50}{65}$	,,	2·9	21·8	38·6		
	$\frac{10+50}{65}+\frac{10+50}{65}$	,,	3·3	24·8	44		
	$\frac{10+60}{180}+\frac{10+60}{180}$	,,	3·75	28·2	50		

TABLE 5 (*contd.*)

Switchboard		Minimum permissible voltage	Daily load at minimum permissible voltage (*Ah*)	Energy supplied from main exchange battery (*kilowatt-hours per year*)			
Type (1)	Size (2)	(3)	(4)	22V (5)	30V (6)	50V (7)	60V (8)
N 1070	$\frac{10+30}{65}$	15	1·97	14·8	26		
	$\frac{10+50}{65}$	,,	2·4	18·1	31·8		
	$\frac{10+60}{180}$	,,	2·82	21·2	37·4		
	$\frac{10+30}{65}+\frac{10+30}{65}$	,,	3·9	29·4	51·5	Not permitted	Not permitted
	$\frac{10+30}{65}+\frac{10+50}{65}$	,,	4·35	32·7	57·5		
	$\frac{10+50}{65}+\frac{10+50}{65}$	,,	4·95	37·2	65·5		
	$\frac{10+60}{180}+\frac{10+60}{180}$	,,	5·63	42·4	74·5		
CBS N 934	$\frac{1+3}{4}$	15	0·02	0·15	0·26	0·7	1·08
	$\frac{2+4}{6}$	,,	0·038	0·29	0·5	1·3	1·93
	$\frac{3+9}{12}$	,,	0·052	0·39	0·69	1·82	2·62
House exchange systems	1+5	18	0·14	—	1·4	Unsuitable	Unsuitable
	2+10	,,	0·31	—	3·1		

NOTE 1:—The correction factor for 30V power leads to house exchange systems (at 18V min.) is 1·22

BATTERY-FLOAT EQUIPMENT WORKING FROM A POWER LEAD

★**29. General.**—This is an indirect method of supplying power to a house exchange system or P.M.P.X. using a power lead whose resistance is too great for feeding power direct to the installation; it avoids the necessity for bunching conductors. The method is one by which a battery of secondary cells is connected between the negative and positive (earth) busbars at the subscriber's premises so that, if the current required by the installation during busy periods is greater than can be obtained from the power lead, the excess current is drawn from the battery. The battery is recharged from the power lead during periods when the current required by the installation is low.

This method must not be used for 'preference' subscribers.

30. Equipment of this type, capable of supplying 4 Ah per day, is described in S 1211; installation details are given in S 3211. With this equipment (Battery-unit, N 634) the nominal voltage of the battery at the subscriber's premises is 22V.

★**31. Restrictions.**—This method should not be used if a single pair of underground conductors will provide a direct power lead of suitable resistance; nor should it be used if an a.c. mains supply can be obtained (see pars. 37 to 41), because a power unit or battery-float working from a.c. mains is generally more economical. If an a.c. mains supply cannot be obtained, the choice of the method of supply will depend on an economic comparison, subject to the availability of line plant for power lead working (see par. 8).

32. The power lead serving a battery-float installation may not be used to feed other installations unless these are equipped with similar apparatus.

★**33.** Because the voltage of the battery at the subscriber's premises is nominally 22V, only a power lead supply of 30V or higher is suitable. Power leads may be connected to 50V or 60V supplies only if the power lead resistance is too great to permit connexion to the 30V supply. The risk of fire is not incurred by the use of a high-voltage supply to the power lead because the voltage is limited by the 22V battery at the subscriber's premises and, therefore, it is not necessary to impose a minimum resistance limit for the power lead. The information given in pars. 18, 20, 21, and 23 on connexions, fuses, protection, and records for power leads should be followed so far as they apply to this system.

34. Resistance of power lead and earth connexion.—The maximum permissible resistances for power leads serving installations equipped with Battery-unit N 634 are given in S 3211.

The total resistance of the power lead (which includes the earth return) may be ascertained by the method given in par. 16. For this test the power lead should be on open circuit, i.e. with the P.B.X. battery temporarily disconnected. The resistance of the earth return may then be deduced as described in par. 14.

35. Annual charges.—The annual charges for power supply by battery-float equipment working from a power lead are the total of:—

(*a*) annual charges on the line plant (see S 0901)

(*b*) annual cost of energy supplied by the main exchange battery (see S 0901)

(*c*) annual charges on the power plant at the subscriber's premises (see S 0901)

★**36. Energy supplied from the main exchange battery.**—The energy in kilowatt-hours per year supplied by the main exchange battery is determined from the following:—

The daily load in ampere-hours at the minimum permissible voltage is obtained from Table 5, column 4, then corrected for 22V battery working, increased by 20% to allow for battery losses, multiplied by the voltage, E, of the power lead supply and, finally, multiplied by 0·3 to give the energy supplied annually in kilowatt-hours.

Thus, for example, for a Switchboard AT 3796, $\frac{10+50}{65}$ the daily load at 15V is given in Table 5 as 1.6 Ah

$\therefore$ Daily load at $22\text{V} = 1{\cdot}6 \times \frac{22}{15}$ Ah per day

which, allowing 20% for battery losses, becomes $1{\cdot}6 \times \frac{22}{15} \times \frac{120}{100}$ Ah per day.

$\therefore$ Energy supplied per day by the main exchange battery in watt-hours $= 1{\cdot}6 \times \frac{22}{15} \times \frac{120}{100} \times 30$,

where 30 is the voltage of the power lead supply.

$\therefore$ Energy in kWh per year

$$= 1{\cdot}6 \times \frac{22}{15} \times \frac{120}{100} \times 30 \times 0{\cdot}3$$

$$= 25{\cdot}3 \text{ kWh per year.}$$

BATTERY-FLOAT EQUIPMENT WORKING FROM A.C. MAINS

37. General.—If an a.c. mains supply is available this method is frequently more economical than a direct power lead or battery-float equipment working from a power lead. Compared with the use of a power lead, it has the advantages of dispensing with the necessity for utilizing cable pairs (which may at the time, or later, be required for subscribers' lines) and of affording a more constant voltage for the operation of the subscriber's installation. The method consists of floating a battery of secondary cells in parallel with the load across the output of a rectifier unit which is energized from the a.c. mains supply. When the load current is greater than the rectifier output current the difference is supplied by the battery. During periods of light load the rectifier output current is in excess of the load current and the battery is automatically recharged.

★**38.** Equipments of this type comprise a Rectifier No. 33B and a Battery-unit N 634, which are described in S 1211.

These items are to be superseded for new work by Rectifier No. 93A with Battery-unit No. 1A (see S 1212). The Rectifier No. 93A has a larger output than the Rectifier No. 33B and the combination is suitable for installations requiring up to 6 Ah per day at a nominal 24V. Rectifier No. 93A with Battery-unit No. 1A will be issued instead of Rectifier No. 33B with Battery-unit N 634 when stocks of the latter are exhausted. It should be noted that Battery-unit N 634 will still be used for power lead working as Battery-unit No. 1A is unsuitable for this purpose.

39. Conditions of use.—Form A 188, which defines the technical requirements of the P.O. for the provision of an a.c. mains supply by the subscriber, should be supplied to the subscriber by the T.M. (Eng. Divn.) in all cases, during the negotiations for the supply of power.

★**40.** The subscriber must supply the necessary electrical energy free of cost to the P.O. The mains energy required by the plant described in S 1211 and S 1212 is approximately 45 B.O.T. units (kWh) per year.

41. The subscriber must install free of cost to the P.O., close to the position chosen for the power plant, a 3-pin, B.S. wall-socket wired to the a.c. supply with an efficient earth connexion; PROTECTION, General, S 3901 refers.

42. Annual charges.—The annual charges on the power plant required for battery-float from a.c. mains supply, described in S 1211, are given in S 0901. The cost of the electrical energy supplied is borne by the subscriber (see par. 40).

PRIMARY CELLS

43. Conditions of use.

★(*a*) *Cordless P.M.B.X.s.* Primary cells are an economical method of supplying electrical energy with a battery to Switchboards CB 935 and CBS N 934 but if the route distance from the exchange is less than three-quarters of a mile, a direct power lead will usually be more economical.

★(*b*) *Switchboards CB 873.* A cost comparison will be necessary to determine whether a power unit, primary cells, a direct power lead, or battery-float equipment (working either from a power lead or a.c. mains supply) will be most economical. If this comparison shows that the choice rests between primary cells and battery-float from a.c. mains supply it is preferable to provide the latter, even though the annual charges are more than those for primary cells.

★(*c*) *Switchboards AT 3796.* Primary cells are more expensive than a power unit or battery-float equipment working from a.c. mains and should not be used if a suitable a.c. mains supply can be secured.

(*d*) *House exchange systems.* Primary cells should not be used if another method of power supply is available.

44. Type of battery.—Table 6 lists the battery to be provided. The annual charges to be used for cost comparisons are given in S 0901.

★TABLE 6. SIZES OF PRIMARY BATTERIES

Switchboard (1)	Minimum voltage (2)	Type of cell (3)	Type of container (4)	Number and arrangement of cells (5)
CB 935, CBS N 934, (1 +3, 2 +4, 3 +7, 3 +9)	15	R40	2 Boxes, Battery, No. 10	18 in series
CB 873 (3 +10, 5 +20)	15	DS1	3 Boxes, Battery, Leclanché, WK2, 5-cell	18 in series
AT 3796, N 1070 (10 +30, 10 +50, 10 +60)	15	DS1	6 Boxes, Battery, Leclanché, WK2, 5-cell	2 parallel sets each of 18 in series
H.E.S. (1 +5, 2 +10)	18	DS1	3 Boxes, Battery, Leclanché, WK2, 5-cell	18 in series

NOTE 1:—The specified number of cells should be fitted without battery boxes if they can be accommodated in a cupboard.

NOTE 2:—Column 2 gives the minimum voltage at which the P.B.X. can be expected to function satisfactorily.

45. Installations carrying abnormal traffic.—If the actual current taken by the installation appreciably exceeds the hypothetical current (see par. 13) it may be necessary to maintain the specified minimum voltage by fitting an additional set of cells in parallel with the battery specified in Table 6. The annual charges will increase proportionately.

46. Additional cells in series with the battery specified in Table 6 may be necessary in certain installations, e.g. for signalling over long inter-switchboard circuits.

★**47. Connexions** of a primary battery serving a P.M.B.X. should be in accordance with Dgm. N 962 and INTERNAL WIRING, Stations, A 3006.

48. Smoothing capacitors should be fitted as detailed in TELEGRAPHS, P.W.s & Telex, D 3901 at a P.M.B.X. switchboard served by primary cells on which is terminated a Tariff D private-wire circuit used for teleprinter working.

References:—S 0901, S 1001, S 1051, S 1211, S 1212, S 1320, S 3211
(S3) INTERNAL WIRING, Stations, A 3006, A 3020
PROTECTION, General, S 3901
TELEGRAPHS, P.W.s & Telex., D 3901
TELEPHONES, General, D 6002
Automatic, H 6901
P.B.X.s, B 1030, B 1040, B 1050, B 3001
TESTS & INSPECTIONS, General, B 1053

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