*The*

# Telecommunication Journal of Australia

VOL. 8, NO. 4 — Registered at the General Post Office, Melbourne, for transmission by post as a periodical. — JUNE, 1951

## CONTENTS



THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

## BOARD OF EDITORS:

C. J. GRIFFITHS, M.E.E., A.M.I.E.E., A.M.I.E.(Aust.).
N. M. MACDONALD, B.Sc., A.M.I.E.(Aust.).
R. W. TURNBULL, A.S.T.C.

## SUB-EDITORS:

C. R. ANDERSON, A.M.I.E.(Aust.). (Queensland Representative).
M. A. BOWDEN.
L. M. HARRIS, B.Sc.
J. L. HARWOOD, M.I.R.E.(Aust.).
R. D. KERR.
A. W. McPHERSON.
J. W. POLLARD, B.Sc., A.M.I.E.(Aust.).
E. SAWKINS, B.Sc. (N.S.W. Representative).
W. R. TRELOAR.

## SECRETARY:

R. D. KERR.


### POLICY:

THE object of the Postal Electrical Society of Victoria is to promote diffusion of knowledge in the communication services of the Post Office.

In advancing this object by the publication of this Journal the Board of Editors is not responsible for the statements made or the opinions expressed in any of the articles in this Journal, unless such statement is made specifically by the Board.

Editors are welcome to use not more than one-third of any article provided credit is given at the beginning or end, thus:—From "The Telecommunication Journal of Australia."

### BACK COPIES:

A number of applications for copies of Journals, Vols. 1 to 6, have been received, but stocks are now exhausted. If any readers have copies of Journals which they do not require, the Society is prepared to purchase complete sets or individual copies, at 3/- per copy.

### DISTRIBUTION:

This Journal is available to members of the Postal Electrical Society of Victoria without charge. Non-members may obtain copies of all publications of the Society on the payment of 10/- p.a. Single copies of this Journal are available at 4/- each.

## COMMUNICATIONS:

All communications should be addressed to:—


Hon. Secretary,
Postal Electrical Society of Victoria,
G.P.O., Box 4050, Melbourne.


All remittances should be made payable to "The Postal Electrical Society of Victoria," and endorsed "Not negotiable."

*The*

# Telecommunication Journal of Australia

*Vol. 8, No. 4* *June, 1951*

## ENGINEERING FEATURES IN THE DESIGN OF EXCHANGE BUILDINGS

*E. J. Bulte, B.Sc. and C. McK. Lindsay*

Since the end of World War II demands for telephone service have broken all previous records and a tremendous expansion in existing facilities has become necessary to cope with this demand and to reduce the large volume of deferred applications for telephone service. This expansion has involved a large programme of new exchange buildings and extensions to existing buildings at a time when heavy calls are being made on the building industry for the erection of housing, factories and other essential building projects.

As this situation introduces an intensive design problem for the limited engineering and architectural staff available, considerable thought has been given to the standardisation of exchange buildings in order to limit the design effort on individual exchange projects. At the same time, such standardisation simplifies the field planning and building requirements. Associated with this examination has been a detailed study of the various engineering facilities in exchanges, and the arrangement of these facilities to conform to uniform standard assemblies.

In this paper a description is given of the various engineering features in the design of exchange buildings and the manner in which these have been related to various standard layouts. A complementary paper published elsewhere in this issue deals with the general building features of the standard layouts described in this paper.

### Analysis of Space Requirements

As far as space requirements are concerned, there are two main categories, namely, metropolitan and country, and it is of major importance to know the relation of space provision to equipment occupancy or "space to lines" ratio at any given date, so that a defined programme of exchange building provision can be established. As discussed later, this ratio is also of value in planning for total equipment requirements.

### Metropolitan Areas

The main problem in the metropolitan areas is to cater for the development offering, including the reduction of the formidable list of deferred applications for subscribers' service. The majority of the exchanges in the metropolitan areas are automatic, and plans are reasonably well advanced to convert the comparatively few remaining areas to automatic working. The amount of equipment required to meet development may be estimated from a study of past growth, present trends, and the number of deferred applications held. The number of services to be provided for must then be related in some way to exchange space requirements.

A study of past growth in subscribers' lines (net) in metropolitan areas indicated that in the ten year period 1929-1939, the total overall growth was approximately 80,000 lines representing an average annual growth of 8,000 lines. The depression occurred during this period, resulting in some losses. The highest annual increase occurred in 1935, when nearly 21,000 lines were added. During the following ten years, that is, from 1939 to 1949, the total growth was approximately 165,000 lines, or more than double that of the 1929-1939 period. The average annual growth for 1939 to 1949 has built up gradually and the record figure of 41,000 lines were connected during 1950, this being more than half the total lines increase in the ten year period from 1929 to 1939.

The authors have made a study in an attempt to assess the equipment space implications of these figures. From this study it has been found that in 1939 the amount of equipment space available in exchange buildings was sufficient to accommodate approximately 580,000 lines, whereas 299,000 lines were connected. This represents a space to lines ratio of 1.95/1. Taking this as a basis, in conjunction with a general knowledge of the adequacy of building space to meet development offering at that time, it may be assumed that a space to lines ratio of about 2/1 represents a condition where development in the metropolitan areas can be reasonably well met.

In examining the figures available of growth of lines connected compared to building space provided in the years 1942-1950, the graph indicated in Fig. 1 has been compiled. From this it is seen that the space provided during these years has fallen short of requirements, based on the use of the space to lines ratio of 2/1 mentioned in the foregoing, even taking into account the fact that during this period a considerable number of "temporary" exchange buildings have been provided. Actually, the permanent space to lines ratio had fallen to 1.7 at the end of 1950.

For space requirements to meet future growth, an annual increase of approximately 40,000 lines has been assumed. In addition, there are at present approximately 90,000 metropolitan deferred applications. Assuming these arrears are overtaken in the next five years, a total increase of about 300,000 lines must be met during that period. In order to accommodate these lines, in addition to providing for conversions from manual to automatic working, replacing temporary structures, etc., buildings to a total capacity of about 700,000 lines will be required in the next five years.

There are at present 290 metropolitan exchanges to which are connected about 520,000 lines. The average size of exchange is therefore approximately 1,800 lines, and the equivalent average exchange building is large enough to accommodate somewhat over 3,000 lines (1.7 x 1800). Taking 700,000 lines as a basis, it is likely that approximately 200 new exchange buildings, having an average capacity of about 3,500 lines, will be required during the next five years to meet development in the metropolitan areas. These figures are generally confirmed by a detailed study of each metropolitan area.

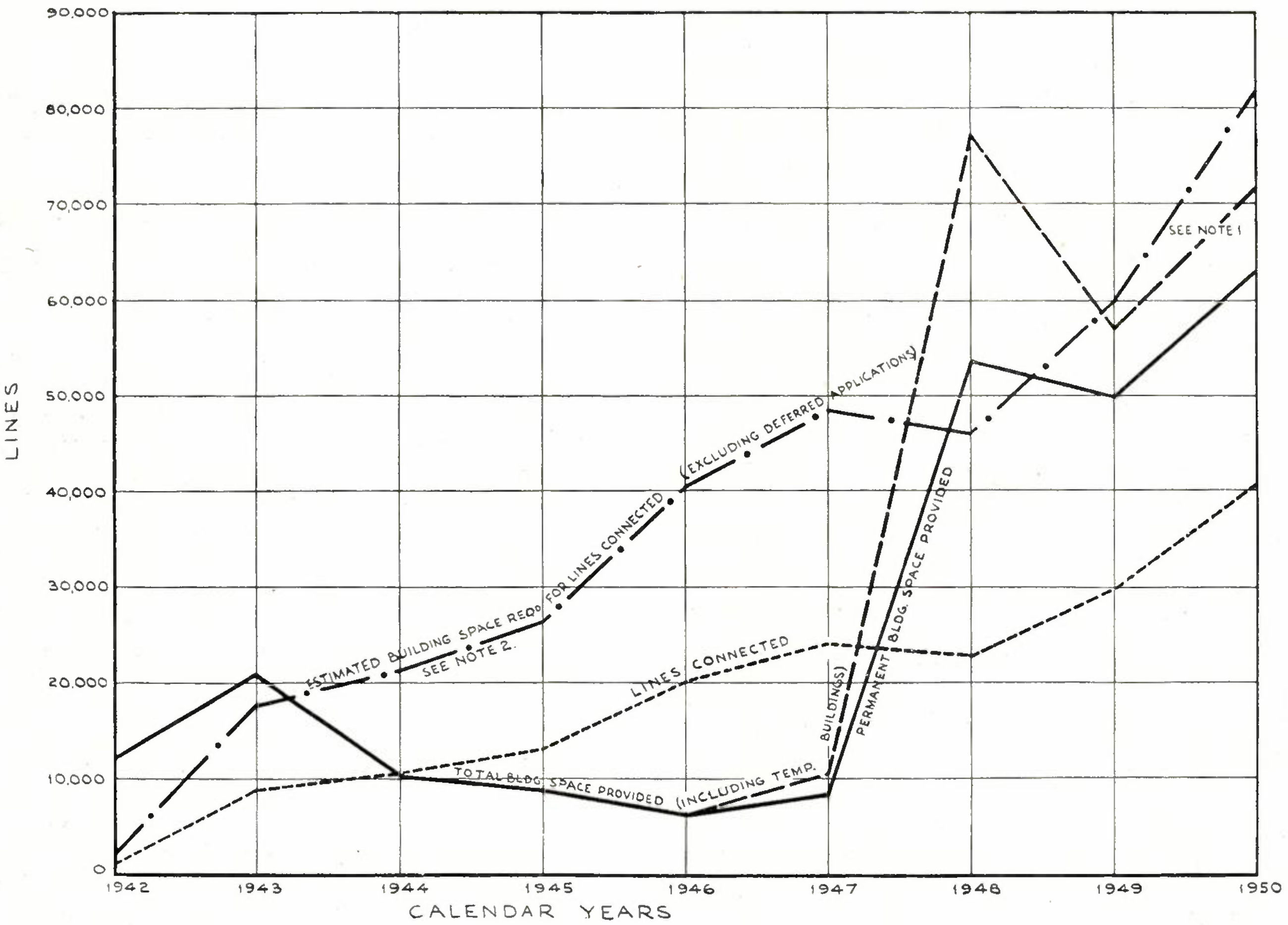



**Fig. 1.—Metropolitan Areas—Annual Provision of Exchange Lines and Building Space.**
Note 1.—67,800 lines of equipment were installed during 1950.
Note 2.—Based on a space/lines connected ratio of 2/1.

### Country Areas

In the country areas, the building problem is influenced by two main factors, namely, the need to meet development and the desirability to convert the exchanges to automatic working. Another factor is the constant need to extend and improve the trunk line services, resulting in demands for long line, 2 V.F. and trunk switching equipment space. The rise in immigration and the rapid development of national projects are both tending to the rapid expansion of country areas.

In an effort to assess the future space requirements for exchange services in the country areas, the graphs in Fig. 2 have been prepared. From with metropolitan area problems, coupled with overall shortages of automatic equipment, the majority of automatic equipment space provided in the country areas has been of the R.A.X. type. Details of interim measures to relieve the position by the provision of C.B. equipment have been give in "C.B. Manual Exchanges for Country Areas," by R. W. Turnbull and A. W. McPherson, which appeared in Vol. 8, No. 1, June, 1951, issue of this journal. The space provided in these cases

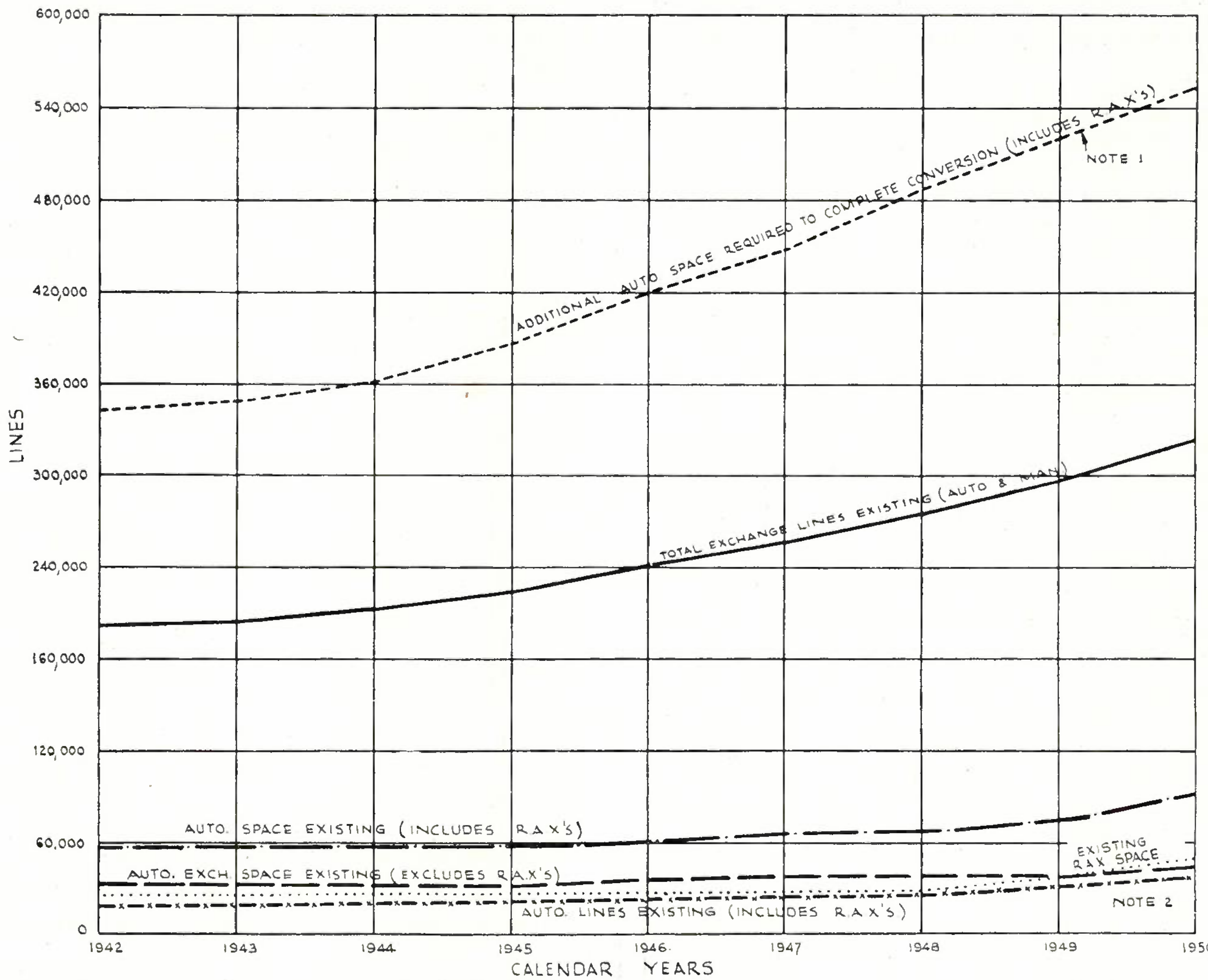



**Fig. 2.—Country Areas Conversion Programme.**
**Details of Exchange Lines and Building Space.**
**Note 1.—22,000 lines were connected to C.B. Exchanges during 1950**
**Note 2.—Based on space/lines ratio of 2/1.**

these it is seen that, apart from catering for deferred applications (which at present total approximately 25,000 in the country areas), the amount of space required to convert all country exchanges to automatic working is in the vicinity of 560,000 "lines space units." This figure is arrived at using the space to lines ratio of 2 as for the metropolitan areas. The graph indicates that during the years 1942-1950, the space demand has grown by over 200,000 lines space units. During this period, due to pre-occupation has, however, been very largely of a temporary nature, and permanent space will ultimately be needed in many cases where C.B. equipment has been installed.

Summarising the country space requirements, for complete conversion to automatic working in the next 10 years, approximately 1,000,000 lines space units will need to be provided. The graphs in Fig. 2 refer to exchange services only. In designing buildings for country areas, consideration must be given also to the inclusion of "space units" for automatic trunk switching equipment using 2 V.F. signalling and long line services such as carrier terminal and repeater stations. It is estimated that automatic trunk switching equipment will need an additional provision approximating to 25 per cent. of the exchange service areas, or 250,000 space units in all.

No attempt has been made to assess the "space unit" requirements for long line services, but there is no doubt that a relatively large provision of space will also be involved for this purpose.

## Development of Standard Type Metropolitan Exchange Buildings

The analysis of space requirements set out in the foregoing stresses the need for the development of standard types of equipment buildings, so that planning and building techniques can be streamlined, and the overall effort reduced. Only in this way will it be practicable to meet within a reasonable period, the huge programme involved.

For this purpose metropolitan exchange buildings can be subdivided into four main categories:

(a) Main city buildings and telecommunication centres.
(b) Metropolitan main exchanges.
(c) Branch exchanges.
(d) "Fringe" exchanges.

Although the same general principles apply to all these cases, it is proposed to deal principally with (c) in the present paper, as in this class there is the greatest call for equipment space, and consequently there is the greatest gain to be achieved by standardisation. Types (a) and (b) will no doubt form the subject of a subsequent article.

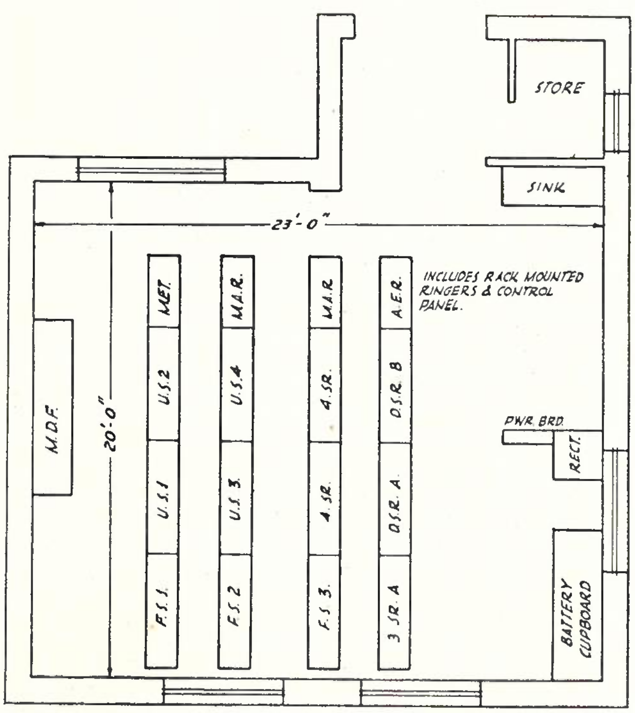



Fig. 3.—Layout of 1200 Lines in a Double Garage Building.

Due to the fact that conditions vary in the locations where exchanges are to be established, sites of equal area or shape are not obtainable in all cases. Consequently, it has been necessary to cater for different general types of buildings. These are in three main types:—

(a) Single storey.
(b) Mezzanine.
(c) Double storey.

The first two types are designed as 9,600 line buildings, but may be erected initially with a

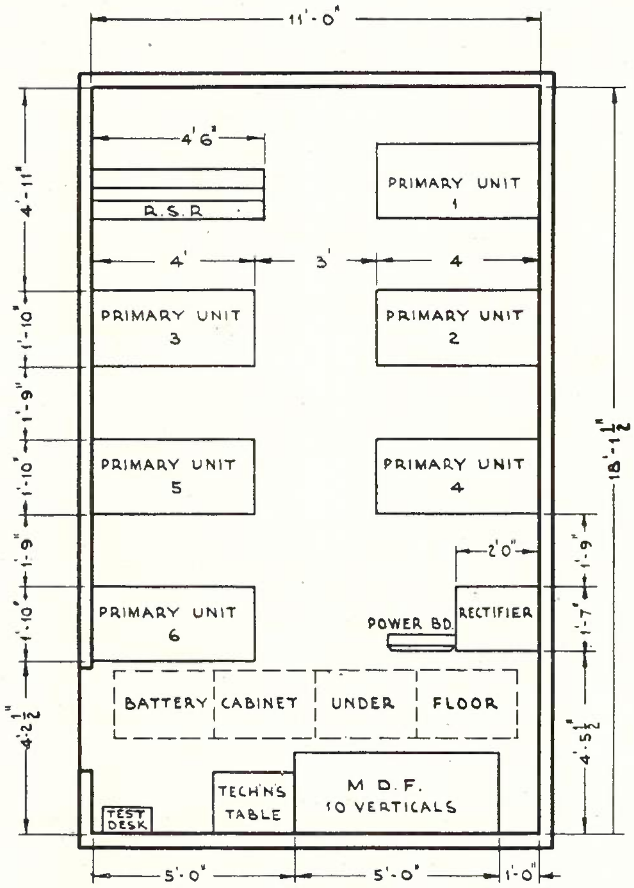



Fig. 4.—Layout of 600 Line Portable Exchange Building.

capacity of 4,800 lines. The double storey type must, because of its design features, be erected initially as a 9,600 line unit, and generally finds its greatest use in densely reticulated areas, such as those containing multi-storey flats, etc. In "fringe" areas in the outer part of the unit fee network, where growth is small and future trends uncertain, present requirements can often be met by the temporary installation of equipment in garage or portable units until such time as the development makes the erection of a major building necessary when the temporary building reverts to other uses. A typical layout of a double garage housing 1,200 lines of equipment is shown in Fig. 3, and a layout of a 600 line portable exchange is shown in Fig. 4.

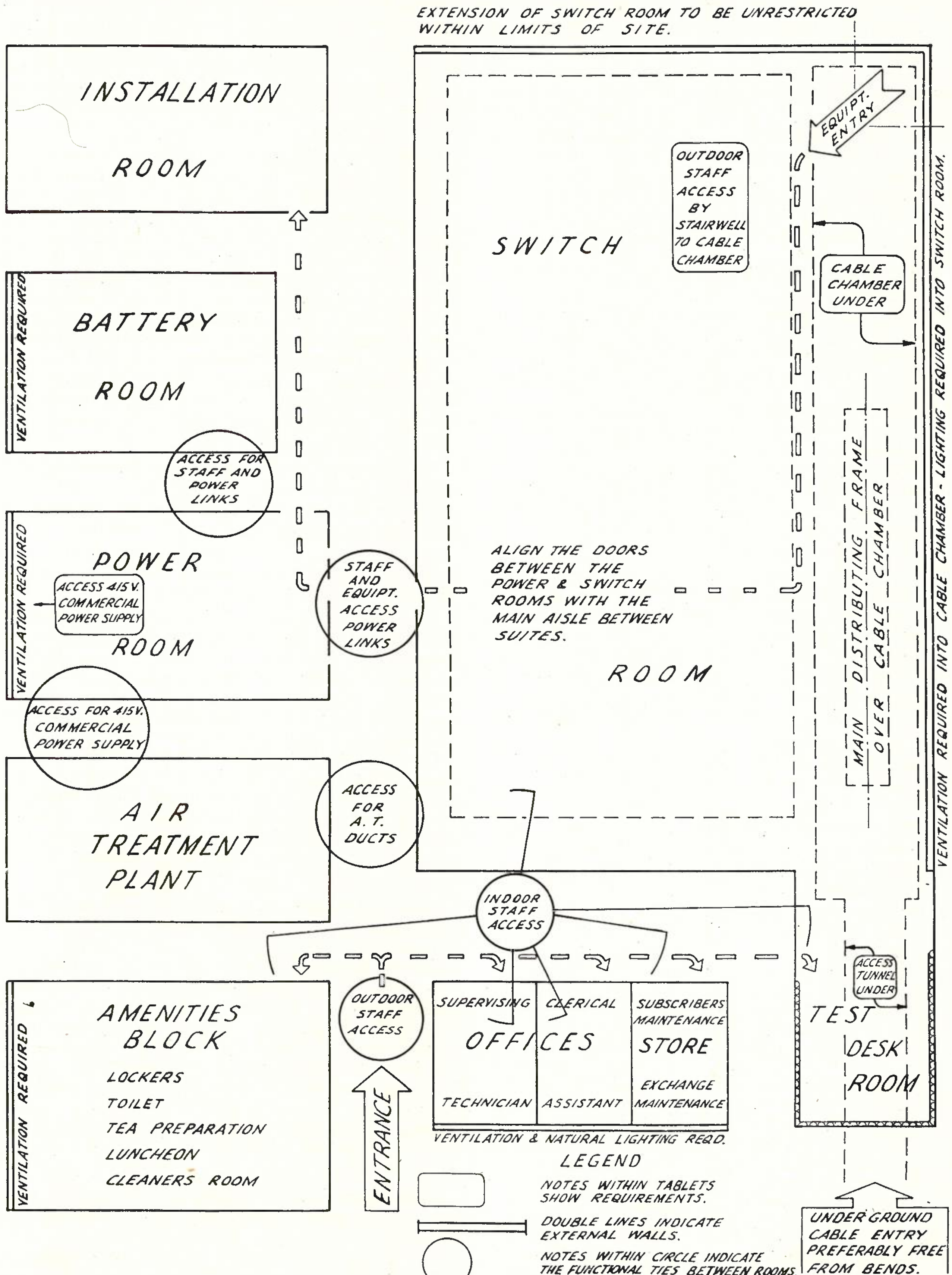



**Fig. 5.—Exchange Building, Branch Automatic, Single Storey, 4800-9600 lines. Principles of Functional Layout.**

### Design Principles of Exchange Buildings

Experience in the past has shown that the design principles of exchange buildings must follow certain accepted axioms so that the best maintenance features are incorporated, that the installation of the equipment can be carried out on recognised principles of plant layout, and so that extensions to the building are unhampered by bad design features. This has led to the need for setting down the principles which, if followed, will provide a building capable of meeting these requirements.

Referring to Fig. 5, which indicates a functional layout diagram of a typical single storey suburban branch exchange building, the relativity of the switch room to other rooms is illustrated, and some comment on desirable features is given in the notes which follow.

**Main Switch Room.** This is the most important room in an exchange building, and consequently its position and orientation on the site will usually be decided upon first, and the other rooms designed about it.

(a) It should be so located on the block that its extension is unrestricted within the limits of the site and limits of the exchange.

(b) Its size is based on accepted standard layout conditions indicated in Fig. 6, which sets out standard dimensions for designed capacities of 4,800 and 9,600 lines either 6 or 7 figure working.

(c) Natural lighting should be provided along the whole length of at least two walls of the switch room.

(d) The placement of adjacent rooms, etc., should be such that the main distributing frame may be located near the outer wall of the building.

(e) Artificial lighting shall be provided to give suitable illumination at the lowest switch, that is, approximately 2′ 6″ from floor level.

This is supplemented by portable lamps which are required because of the difficulties of providing adequate light intensity for certain fine adjustment and apparatus checking by means of a general illumination system. Details of other electrical services such as power points for low voltage and emergency lighting are indicated when completing the requisitioning form in Table No. 1, which is described later.

**Testing Area.** This space contains the test desk suite and subscribers' plant record data. This area should be so located that general supervision of tests on the M.D.F. is unrestricted. The test room walls, and possibly the ceiling also, should be treated with sound-absorbing material to facilitate transmission and other tests.

**Auxiliary Rooms—Power, Battery, Air Conditioning and Standby Plant.** These rooms should be placed in such a position that cabling and duct provision costs from the power and air conditioning rooms to the switch room are kept to a minimum. They are placed in such a position relative to one another that the most satisfactory linkage between the services provided in each is obtained, bearing in mind the staff usage, maintenance routines, cost of inter-room cables, busbars, etc.

**Cable Entry.** The main underground cable entry should preferably be provided free from bends from the front of the block. The access tunnel from the switchroom should be extended to the street manhole, where the distance from building to the street is 15 feet or less. Where this distance is exceeded a conduit run should be provided. The provision of adequate facilities for underground cable handling, jointing, and exchange lead in conditions generally is a matter to which considerable attention in detail has been given recently. A comprehensive description of the particular needs of this aspect is outside the scope of this article and will form the basis of a separate paper at a later date.

**General Staff and Equipment Movement Facilities.** The notes on the drawing in Fig. 5 indicate the main facilities to be provided. In addition, the following points are worthy of attention.

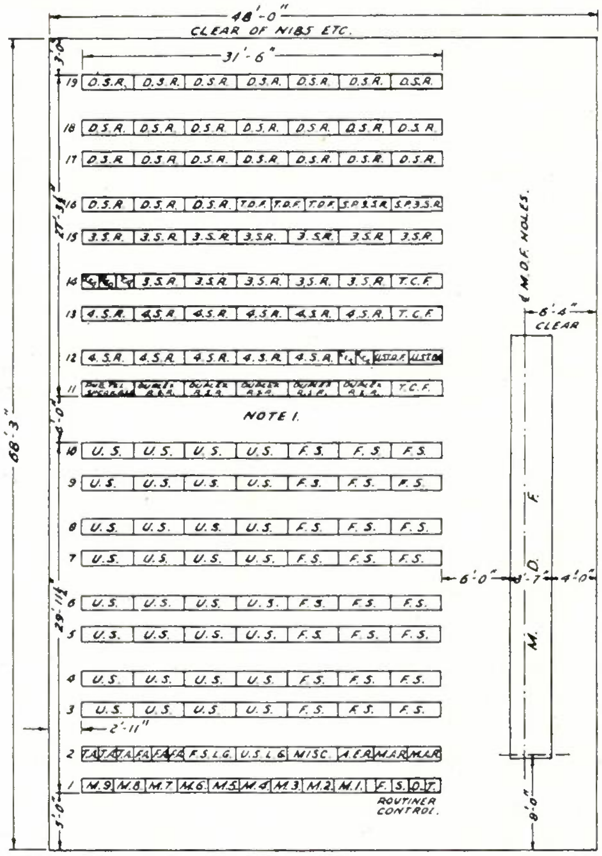
(a) An external entrance to the cable tunnel should be provided to permit staff access and to facilitate cable hauling operations.

(b) An area for staff movement between the test desk suite and the M.D.F. is necessary. In single storey buildings the space in the cable tunnel below this area permits the return air duct to be turned from its position in the cable tunnel towards the air conditioning room without interference to rising underground cables.

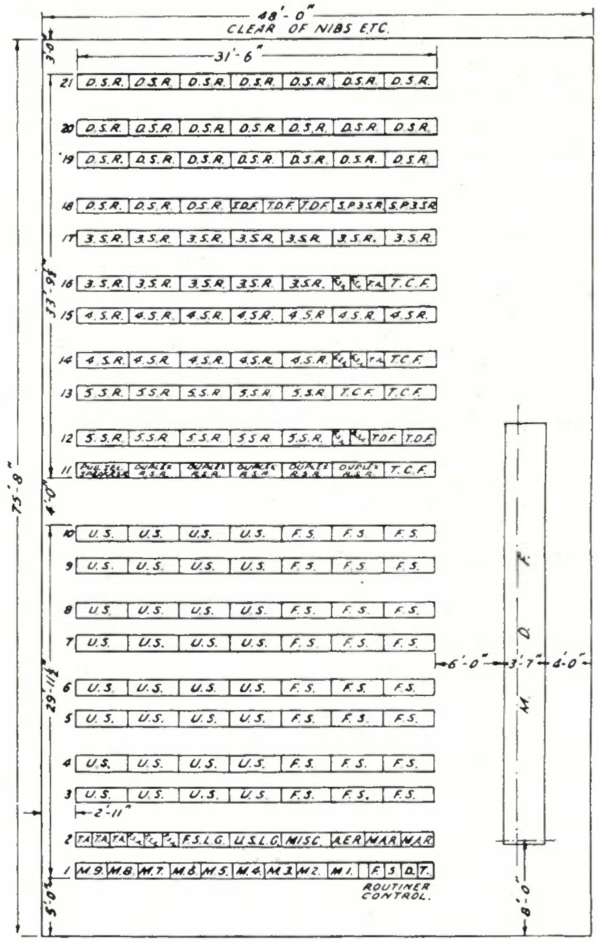
(c) The main equipment entry to the switchroom with its associated cathead should be chosen so that the delivery of equipment is not restricted by the equipment in the switchroom when installed in accordance with the standard layout or by the location of any stairwell necessary to give access to the cable tunnel.

**Administration Staff and Store Rooms.** The position of the supervisory offices is selected so as to provide oversight of the staff and public entrances. In addition, they are close to the main switchroom and, where appropriate, have window space located so that the main switchroom can be seen. The stores are located convenient to the clerical assistant and the main entrance to permit issue of equipment where necessary to outdoor staff and thus obviate the need for the latter to traverse the main switchroom area. These areas are arranged to fit in with accepted standards of accommodation for the size of exchange being built.

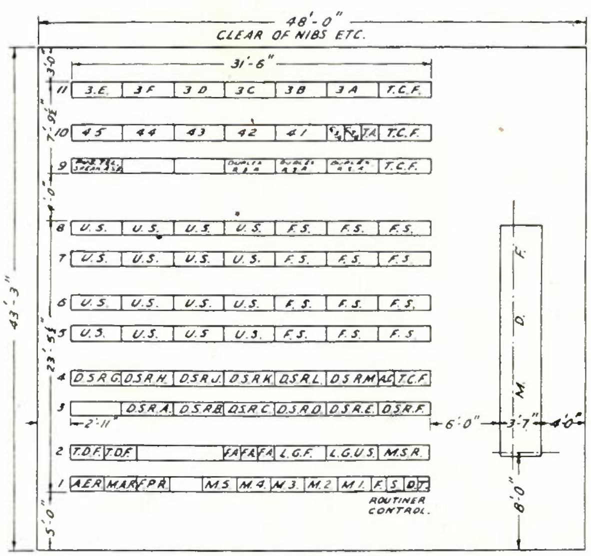
**Installation Room.** This should be located adjacent to the main switchroom and placed conveniently to the latter, so that periodical extensions to the equipment may be carried out therefrom with a minimum of interference with the maintenance activities of the exchange.



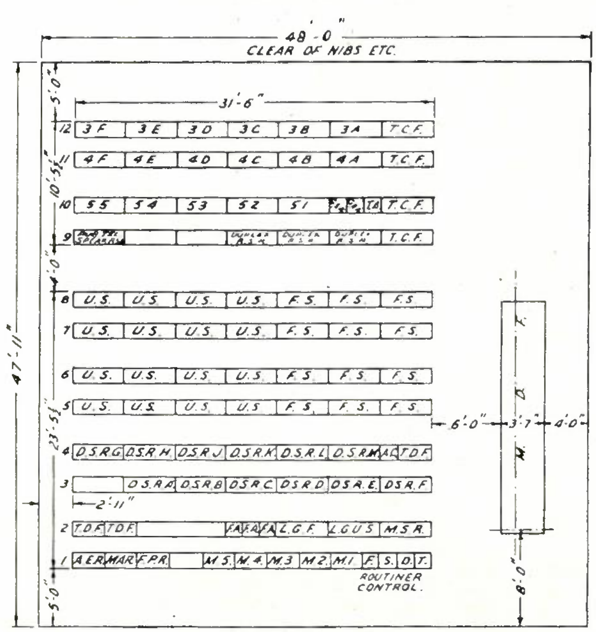

LAYOUT Nº 1.
9600 LINES - 6 FIGURE NUMBERING.




LAYOUT Nº 2.
9600 LINES - 7 FIGURE NUMBERING.




LAYOUT Nº 3.
4800 LINES - 6 FIGURE NUMBERING.



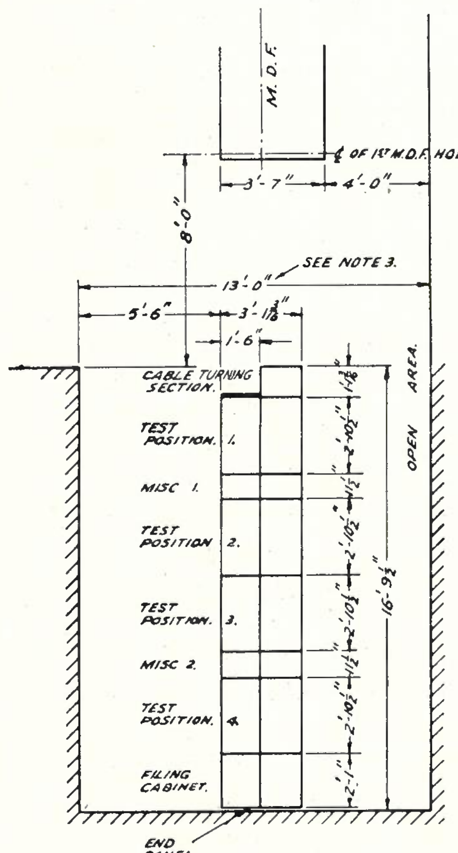

LAYOUT Nº 4.
4800 LINES - 7 FIGURE NUMBERING.

**Fig. 6.—Metropolitan Branch Exchange—Equipment Layouts.**

### Space Requirements for Equipment and Facilities

Figs. 6 to 9 indicate standard layouts for the switching equipment, test desk suite, power and ringing equipment and battery plant, respectively. The following comments are relevant for these layout drawings.

**Fig. 6, Exchange Equipment.** Fig. 6 gives typical layouts for 6 and 7 figure numbering schemes, the capacities in each case being for 4,800 and 9,600 lines respectively. The reason for the choice of the two sizes of switchroom is based on the assumption that if the expected development 20 years after cutover date is greater than 5,000 lines, a building having a capacity for a full "level" of 9,600 lines of equipment will be provided. This is based on the fact that there is a comparatively small difference in building cost for buildings of capacities in the range of 5,000 to 10,000 lines. If the 20 year development figure lies between about 1,200 and 5,000 lines, the economy of a "half-sized" switchroom is worthwhile; consequently, the layout for 4,800 lines has also been given. All layouts are based on 7-rack suites, which give 1,200 line groupings of the uniselector and final selector units, thus providing for economy and ease of inter-rack cabling. Space is provided for a proportion of duplex services. Aisle spacings, which are in general acceptance, are indicated, including the provision of a transverse dividing aisle approximately midway in the 9,600 line layouts to facilitate staff and equipment access from the power room to the opposite side of the switchroom.




NOTES:- 1. TOTAL HEIGHT OF TEST DESK 4'-9½"
HEIGHT TO SURFACE OF DESK 2'-6"
2. SOUND PROOFED WALLS SHOWN THUS. /////
3. 13'-0" IS DESIRABLE TO GIVE CLEAR VIEW OF M.D.F. FACE FROM TEST DESK POSITIONS. THIS DIMENSION CAN BE REDUCED TO 11'-0" IF NECESSARY.

**Fig. 7.—Metropolitan Branch Exchange—Test Desk Room Layout.**

**Fig. 7, Test Desk Suite.** In this layout the assumption is made that a separate test desk room or annexe will be provided, usually clear of the main switchroom. This allows for better maintenance conditions, including improved facilities for transmission tests and allows for the easy provision of sound-proof treatment. In addition, the clearing of the main equipment space facilitates the provision of symmetrical layouts in the switchroom, thus allowing simpler cabling arrangements, etc. The layout shows the ultimate size of test suite for a 9,600 line branch exchange and gives recognised clearances for cabling and staff movement in this activity of the exchange. Figs. 10 and 11 are photographs of an early installation of this type from which the Fig. 7 details have been developed.

**Fig. 8, Power and Ringing Equipment.** The layouts shown include motor generator charging conditions based on accepted clearances between adjacent machines and aisle spacing. The provision of two ringing machines of an adequate size is allowed for. Space is provided in the power panel suite for change-over facilities for the A.C. supply, on the assumption that a standby alternator set may be installed with or without automatic start and changeover. This layout is for a 9,600 line exchange.

In addition, layouts for 4,800 and 9,600 lines are shown, based on the use of rectifier charging. In Fig. 12 a perspective view of a power room using rectifiers is shown. The alternative layouts cater for the present day trend to the static type of plant, which has advantages of space saving, better efficiencies at light loads, easier parallel working of units, automatic overload protection and less maintenance attention. Moreover, costs favour the present day dry plate rectifiers, which are easier to install and are well suited to unattended operation as, amongst other advantages, they do not need to be reset or restarted after power shutdowns and have no high starting current surges to be catered for when decisions as to the size of standby alternator plants are being considered.

It is of interest to mention here that plants have been designed with rectifiers which float the exchange at 50 volts and at the same time trickle charge an exchange battery, which can have 24, 25 or 26 cells at a voltage of 2.2 volts per cell. Should the mains supply fail the 23-cell battery takes over immediately, and within a fraction of a second the end cells are connected automatic-

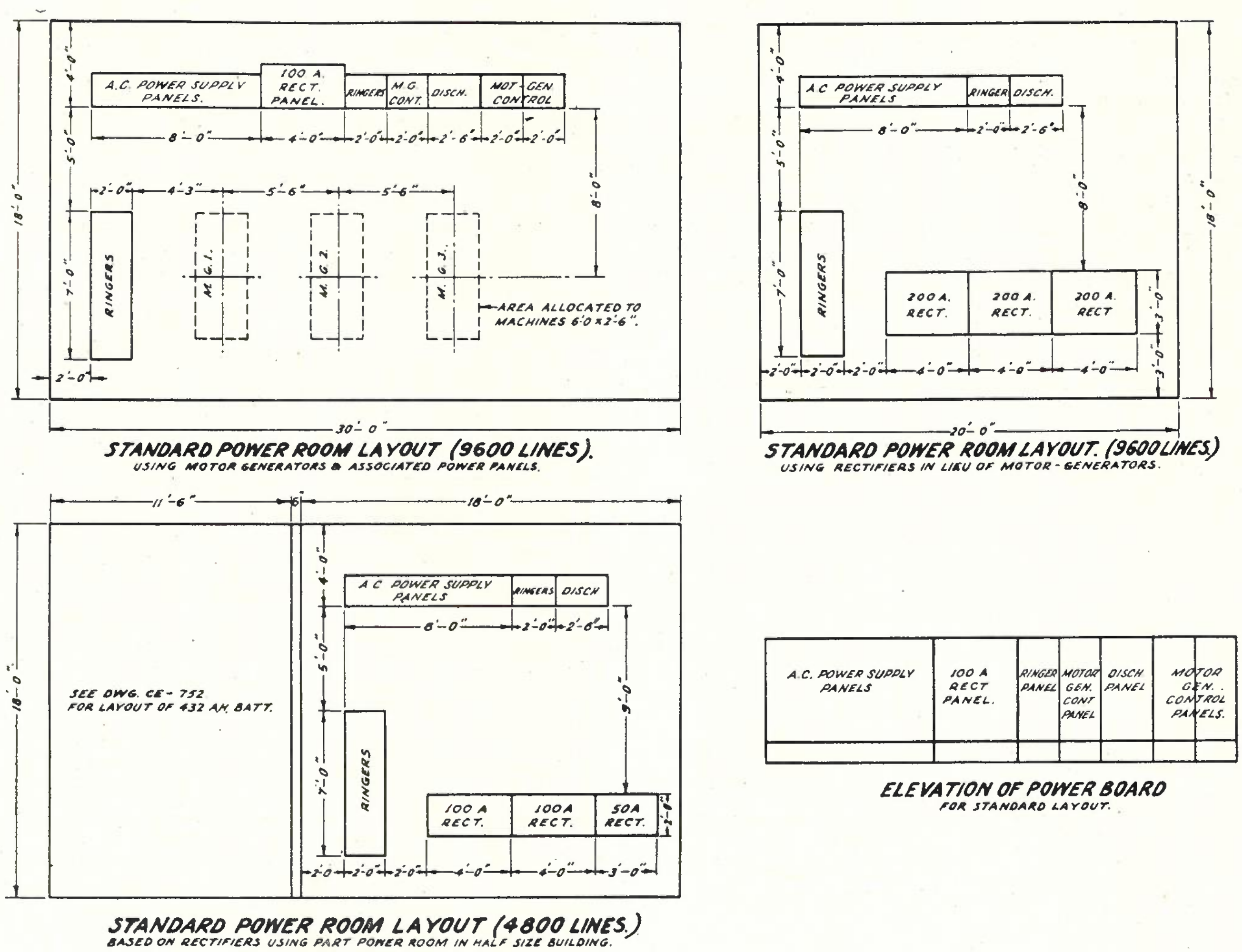



**Fig. 8.—Metropolitan Branch Exchange—Power Room Layout.**

ally. Upon restoration of A.C. supply the exchange again floats at 50 volts while a booster charge up to 2.4 volts per cell is given to the battery. All the necessary switching is done automatically, including the switching on and off of parallel connected rectifiers to fit in with the exchange load, the necessary control being derived from current transformers in the A.C. inputs to the various rectifiers. One such plant recently considered had three 500 amp. units capable of handling an exchange load of 1500 amps.

A recent interesting development in ringing and tone arrangements which may influence future layouts is electronic generation of ringing and tone current. Present models, while not altogether suitable for the largest exchanges, give promise that this equipment may finally be of such a nature that it could be better located in the main switch room for maintenance and installation reasons. In addition, due to the silent operating characteristics, combined with the physical design of rectifier cubicles, consideration may need to be given in the future to the desirability of locating the rectifiers in the switchroom. This in turn could lead to more flexibility and economy in overall space provision due to the possibility of eliminating the conventional power room. In fact, it is of interest to note that some overseas administrations mount the conventional type ringing machines on standard racks in the main switchroom. Examination has been made of the possible application of this principle to Australian exchanges, and it is proposed to arrange for future purchases of ringing machines for branch exchanges to be of the dynamotor type. These are smaller, cheaper, quieter running and more efficient. They will be mounted on standard 2′ 9″ equipment racks in the vicinity of the alarm equipment rack. The associated control panel will also be mounted on the same or an adjacent rack, thus eliminating all ringing equipment from the power room. The control panel will be equipped with an A.C. voltmeter and loud speaker unit for checking the ring and tones generated by the machines. Automatic changeover facilities will be applicable to both machines, thus increasing the flexibility from the operational and maintenance aspects.

The comments in the foregoing relating to changing layout conditions in the power room stress the need to provide facilities for inter-unit cabling which can be modified readily without detracting from the orderly appearance of this room. In this regard, local and some overseas practice tends towards the use of a false floor, without machine piers, in the power room, and the running of the inter-unit and panel to charging unit wiring, etc., in the between floor space. This aspect is also illustrated in Fig. 12. A further point which assists in the appearance as well as the maintenance aspects of the power room is the tendency to colour machines and panels with a light finish. In this regard, recently manufactured rectifiers are finished in high gloss light grey colours with steel face panels. Dead front type switches are being provided on these models. The logical conclusion to this trend, which improves the overall room lighting by changing over from the poor light reflecting black sindanyo panels, is the introduction of grey steel panels with "dead front" switches for the ringer, D.C. discharge and A.C. panels. Development work is proceeding with a view to introducing these additional features into future power rooms.

**Fig 9, Battery Room.** Layouts are given indicating the two practices of using wooden vat type cells to form a double battery installation, and the alternative of using glass box type cells which

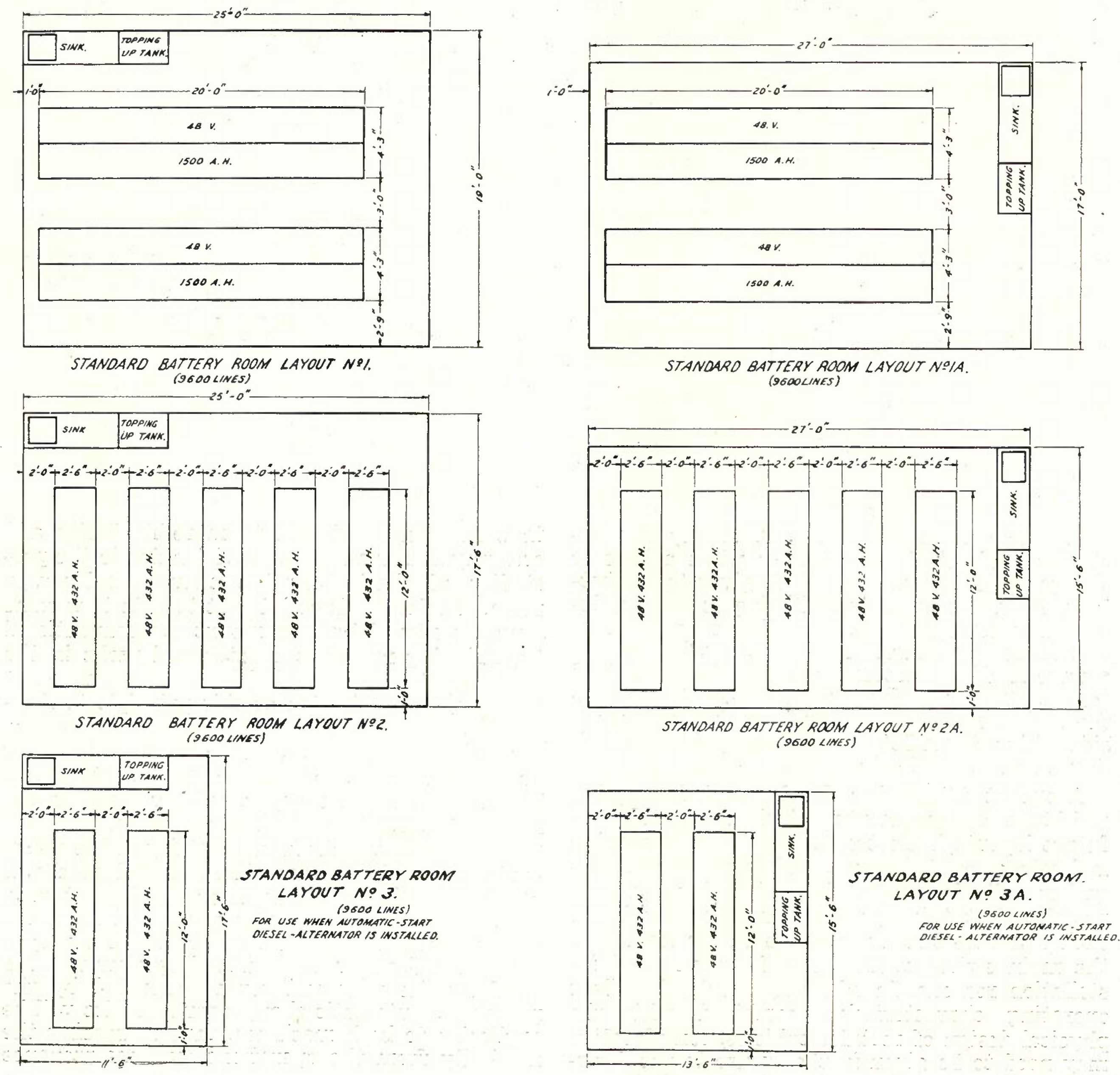



Fig. 9—Metropolitan Branch Exchange—Battery Room Layout.

have bolted inter-cell connections, and grouping batteries in parallel to obtain the requisite capacity. A photograph of a typical parallel battery installation using glass box type cells is shown in Fig. 13.

A smaller glass box installation is also shown in Fig. 9 for use in a 9,600 line installation, on the

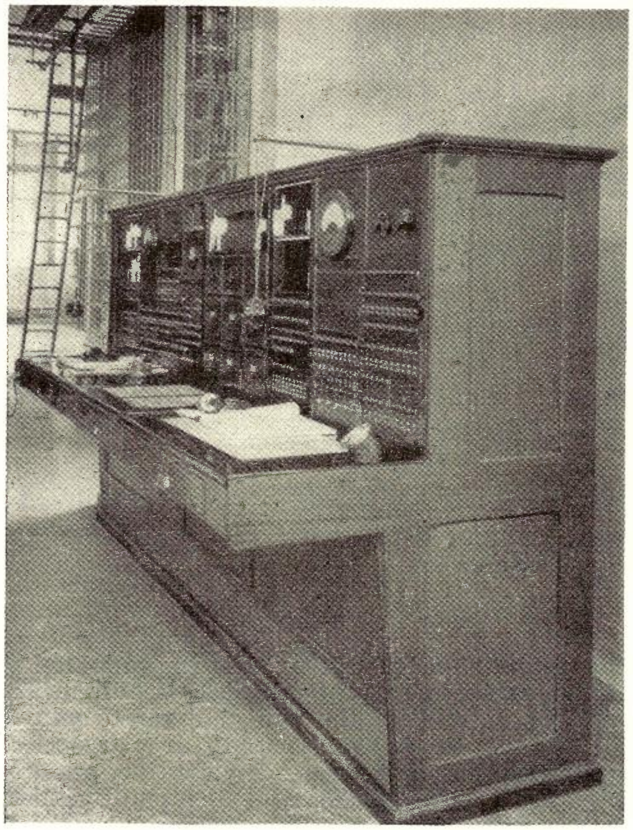


Fig. 10.—View of Test Desk Looking Towards M.D.F.

assumption that the main standby power source available is an automatic start and stop diesel alternator set. Such a set would be of the semi-portable, self-contained type, probably using combined exciter and automatic voltage regulation of the magnicon or amplidyne type. Aisle spacings shown are those in general use. A sink is provided to facilitate battery maintenance together with storage facilities for topping up water. The space-saving and maintenance advantages of special large enclosed type cells for exchange use are at present being investigated. Such cells are in use overseas, and may have some application here. The plate grids of some of this type of cell have been made of lead cadmium in lieu of the usual lead antimony alloy, in an effort to give longer service life.

It is also of interest to mention that a review is also being made of the possibility of using nickel cadmium cells in some of our exchanges. Such cells have some maintenance and operational advantages which could make them adaptable for installation in rooms which also house switching equipment. The fact that they do not use lead, of which there is a world-wide shortage, also makes a detailed examination of the possibilities of their use worth while. Should they prove satisfactory, the final incorporation of the batteries into the switchroom area could well prove a practical proposition.

**Tabulation of Main Engineering Requirements.** The foregoing describes the dimensions of equipment areas for various capacities and layout conditions in metropolitan branch exchanges. The assembly of this information for the preparation of plans for the required type of exchange building is simplified by listing in the form shown in Table No. 1.

### Prefabrication

The tendency at the moment to provide some exchange buildings with prefabricated units will have the effect of varying the dimensions of the rooms or areas shown in Figs. 6 to 9, by bringing these into line with structural dimension of the wall panel used in their erection; for example, the battery shown as 19′ x 25′ may need to be 20′ x 24′. Prefabricated buildings have the important advantage that space can be provided more quickly than with the conventional building methods, particularly under present conditions. To facilitate erection, the cable entry has been re-

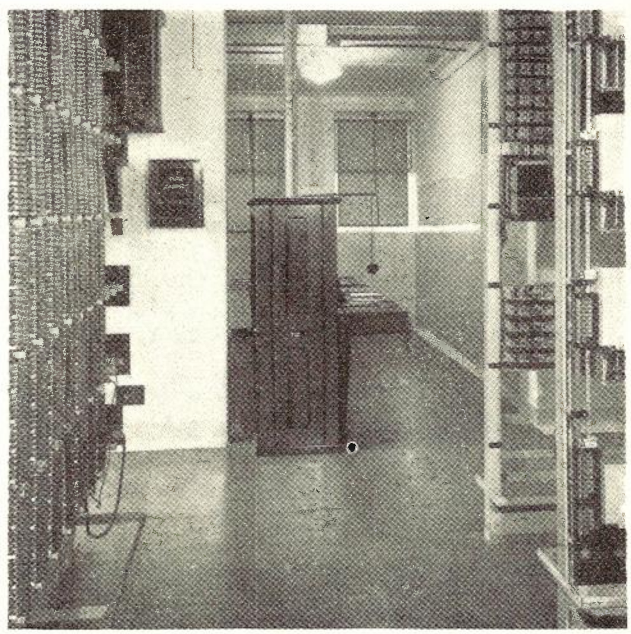


Fig. 11.—View of Test Desk Showing its Location in Quiet Room.

designed to provide for termination of the underground cables on racking parallel with the M.D.F. in lieu of the conventional cable tunnel. This is illustrated in Fig. 14. This change in cable entry will also alter the equipment room layouts to some extent, and as soon as the prefabricated building

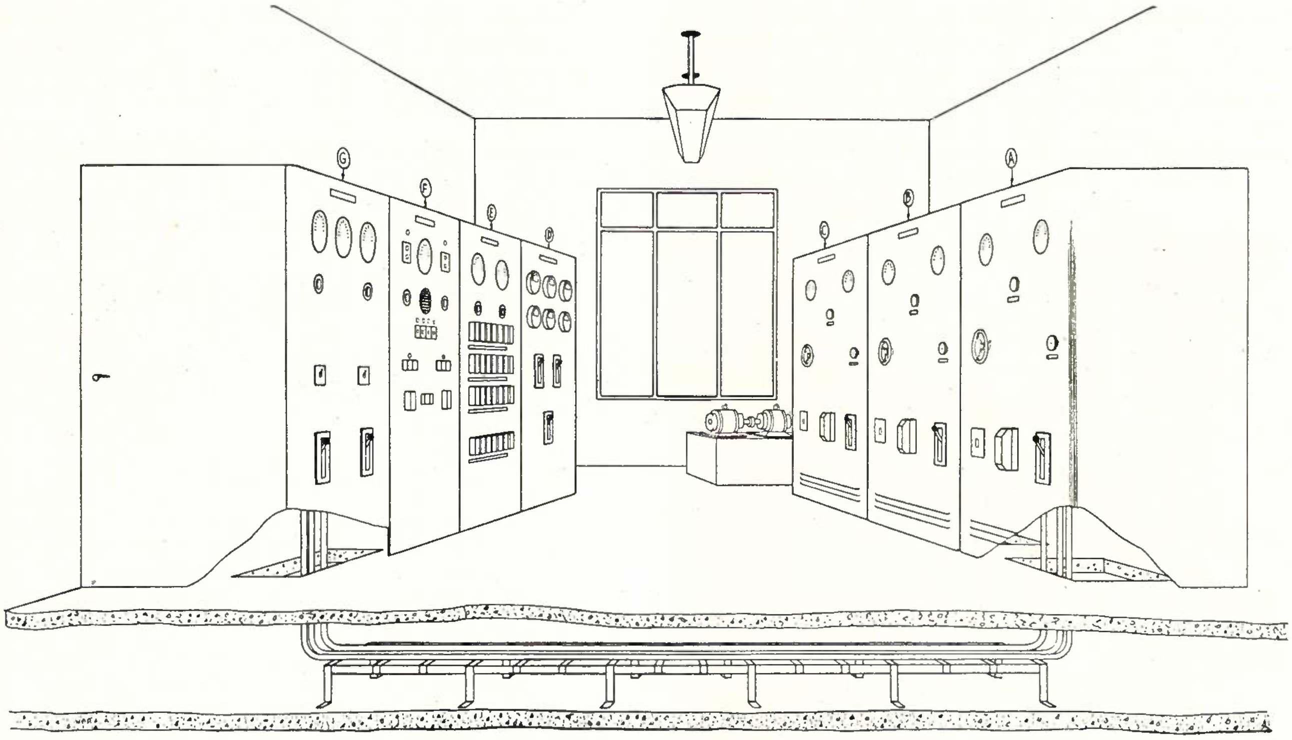



**Fig. 12.—Perspective view of Rectifier Type Power Room.**
**Panels A, B and C.—Rectifier Cubicles.**
**Panel D.—A.C. Supply, Incoming and Metering.**
**Panel E.—Main A.C. Distribution.**
**Panel F.—Ringer.**
**Panel G.—Discharge.**

designs have been stabilised, the amendments to equipment layouts will be made the subject of a further article.

### Development of Standard Type Country Buildings

The design of metropolitan branch exchanges as described in the foregoing, deals only with the provision of one main equipment facility, namely, automatic telephone equipment, the limit of size being the 9,600 line unit. The development of country exchange buildings however, introduces new features which call for the co-ordination of many engineering equipment space requirements, and also introduces the special requirements of the manual exchange services and associated accommodation problems. In addition, country buildings have to be designed to cater for different exchange capacities. These can be grouped in the following categories:—

(a) R.A.Xs.
(b) Exchanges with maximum capacities of 800/1,200 lines.
(c) Exchanges with capacities from 1,200 to 3,600 lines.
(d) Exchanges above 3,600 lines.

Cases (b) to (d) may also have to include long line equipment, automatic trunk equipment and radio links. The country engineering space problems therefore involves a study of the requirements of the following types of equipment:—

(a) Automatic exchange.
(b) Manual exchange.
(c) Automatic trunk exchange.
(d) Automatic trunk manual suite.
(e) Carrier and long line equipment.
(f) Radio link.

In addition to the foregoing factors, postal building requirements and site conditions often call for special investigation before the actual building or position of the building can be developed to serve the telecommunication needs. Space does not permit a full description of all

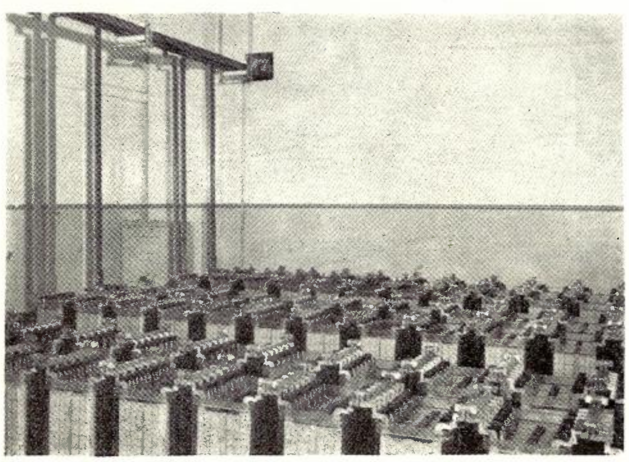


**Fig. 13.—Typical Parallel Battery Installation.**

**PROPOSED BRANCH AUTOMATIC EXCHANGE BUILDING—INFORMATION TO BE FURNISHED TO THE SUPERINTENDENT OF BUILDINGS BY THE SUPERINTENDING ENGINEER.**

1. The erection of a branch automatic exchange building is required at........................................................................
The site is required to be located within the area indicated on an attached sketch, which also shows the location of existing and proposed main conduit routes in or near this area.

2. The following details are submitted for your information:—

| Item | Initial building | Ultimate building. |
|---|---|---|
| Type of standard building preferred. | Drawing................................<br>Sheet.................................. | Drawing....................................<br>Sheet........................................ |
| **Switchroom.**<br>1. Equipment capacity required. | ........................ subscribers' lines<br>........................figure working | ........................subscribers' lines<br>........................figure working |
| 2. Equipment space requirements in accordance with | Drawing..............................<br>Layout No........................... | |
| 3. Height from floor of bolts in wall securing tie-bars from—<br>(a) Rack suites<br>(b) M.D.F. | ............ft............inches<br>............ft............inches | |
| 4. Gas points required. | Number........................;<br>Location.............................................<br>.................................................................. | |
| **Test Desk Room.**<br>Equipment layout in accordance with | Drawing.................................... | |
| **Power Room.**<br>1. Equipment to be accommodated<br>2. Equipment layout in accordance with | Drawing...............Layout No............ | Drawing...............Layout No............... |
| **Battery Room.**<br>1. Batteries to be accommodated<br>2. Distilled water storage required<br>3. Equipment layout in accordance with | Drawing...............Layout No............ | Drawing...............Layout No............... |
| **Cable Chamber.**<br>1. Reference design preferred | Drawing....................................<br>Sheet............................................ | |
| 2. Ironwork layout in accordance with | Drawing....................................<br>Sheet............................................ | |
| **Storerooms.**<br>1. For exchange maintenance<br>2. For substation maintenance | | |
| **Staff.**<br>To be provided for (on duty simultaneously) | | |
| **Bicycle Accommodation.**<br>Required for | ........................bicycles | |

3. When a site selection has been made, and preliminary discussions held on the building plans, sketches will be supplied showing details of:—
(a) Location in switchroom of tie bars from racks to walls, and of main busbar entry;
(b) location and size of holes for main power leads through walls between power room and (i) battery room, (ii) switchroom, and (iii) air treatment room;
(c) footway entrance manhole;
(d) number and configuration of cable entrance ducts to meet ultimate requirements of buildings involved;
(e) location of wall anchors in access tunnel;
(f) ironwork required in access tunnel;
(g) ironwork required in cable chamber proper and spacing of stanchions;
(h) test benches for switchroom adjustment space;
(i) shelving required in storerooms.

**Table No. 1.—Branch Exchange Building—Engineering Requisition.**

types of reference plans for country areas and discussion will be confined to separate engineering buildings.

The principles for all engineering and other services outlined for metropolitan branch exchanges in general can be applied to the country engineering building, but there are some special points of difference and additional principles of layout which must be observed. Consideration must be given to other engineering aspects not taken into account when dealing with metropolitan branch exchanges. As a result the development of a co-ordinated plan for country exchange buildings is a more complex problem than the design of a metropolitan branch exchange.

From an inspection of the many types of buildings required to serve the varying capacities of each service, it has been found that the buildings in greatest demand, apart from R.A.X's and smaller country offices, are those which have to provide for capacities of equipment for exchange services in the range of 1,200 to 3,600 lines—stallations, and one of 10′ for other services. An examination of the areas required under low and high ceiling levels will show that a balance is achieved when the area required for rack equip-

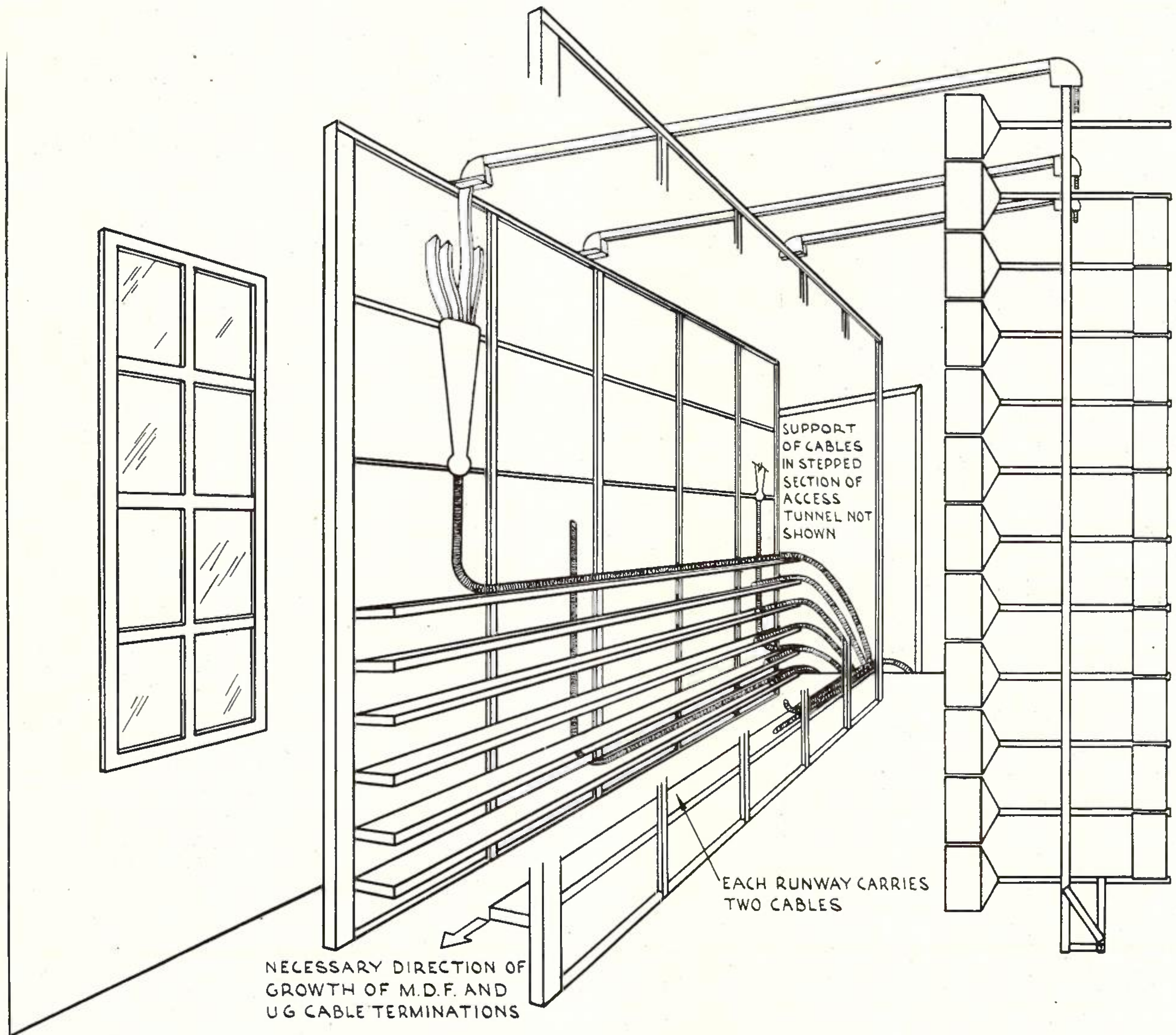



Fig. 14.—Prefabricated Exchange Building. Cable Entry to M.D.F.

category (c). This group has been selected to illustrate the principles of design involved.

The main points to be covered in the country exchange buildings where standard types can be applied are:—

(i) Ability to provide extensible areas for three different services, namely, automatic exchange, automatic trunk and long line equipment.

(ii) The expansion of a manual switchroom.

The special needs previously referred to, together with the associated services of power, battery, air conditioning, amenities, etc., and the economics and availability of sites, have indicated that two-storey buildings are more suitable for country exchange purposes. Two basic ceiling heights are used; one of 13′ 6″ for equipment in-ment is located on the first floor and the low ceiling height rooms are grouped on the ground floor level.

Fig. 15 illustrates diagrammatically the methods of meeting development in the four main types of equipment based on the average rate of growth under the present conditions. From a study of the principles outlined in Fig. 15, two basic designs have been evolved. One is of rectangular shape with expansion on the site to both front and rear corresponding with Fig. 15 (a). The other is of "L" shape with expansion to the rear and to one side, a corner site being an ideal location for this type of building—see Fig. 15 (b). Either type of building can be erected on combined exchange and Post Office sites of suitable shape and dimensions or on separate sites. The rectangular building can be extended rearwards in some instances and sometimes expansion can be arranged at the front, but if this is not possible the plans should provide for additional

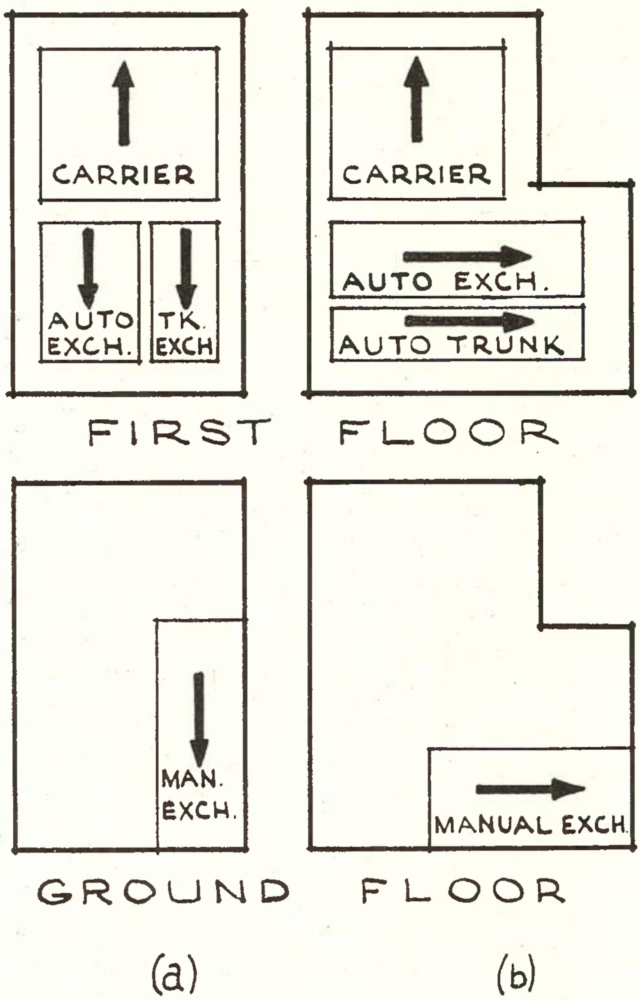



Fig. 15.—Country Exchange Building—Direction of Expansion.

floors in future. The "L" shaped building, however, providing the site is adequate, offers a better solution as extension of areas for each service can be met more satisfactorily.

### Design Principles of Country Exchange Buildings

Referring to Fig. 16, which indicates a functional diagram of a typical "L" shaped building, the relative positioning of all services is given, and some comment on the most desirable features are included in the accompanying notes. The following additional design principles to those included in the comments on branch exchange should be taken into account in studying the problem of providing country buildings if future development is to be adequately catered for.

**Main Switch Room.** The switch room provides for three engineering space units:—

(a) Long line is catered for as a separate unit area.

(b) Automatic exchange and automatic trunk should be designed in one area with parallel growth for each. C.B. exchange equipment space, if necessary, can be provided initially. Fig. 17 illustrates dimensions for 1,200, 2,400 and 3,600 lines with parallel automatic trunk equipment.

(c) The M.D.F. treatment differs somewhat in that due to the manual exchange and associated amenities being located on the ground floor, it is not possible to provide a cable chamber parallel with the side walls. Generally it can be placed across the centre of the building with jointing facilities for underground cable to lead covered indoor cable tails in a cable chamber directly underneath the M.D.F.

**Testing Area.** The sound-proof room may not be as large as that required for a branch exchange. In some instances it may be convenient to combine this facility with the long line equipment testing area.

**Programme Room.** A sound-proof room is usually provided for monitoring of broadcast transmissions.

**Staff.** Staff rooms for both male and female employees are required in country exchange buildings.

**Administrative Staff and Store Rooms.** Generally these are best located central to both engineering service areas. This also allows for a sound barrier area between the long line equipment and the noisier switching apparatus.

**Stairs and Lifts.** Where these are necessary their placement should be selected so that expansion of engineering services or the manual exchange is unrestricted and also so that irregular shaped equipment rooms are avoided. In addition, they should be so placed that staff movement between floors to the various rooms is facilitated.

### Space Requirements for Equipment and Facilities

The following comments are made on Figs. 17-21, which indicate standard layouts for C.B. and/or automatic exchange, together with automatic trunk equipment, manual exchange and trunk switchboard, carrier equipment, power and ringing equipment and battery plant respectively. Figs. 20 and 21 should be read in conjunction with Tables Nos. 2 and 3.

**Fig. 17, Local C.B. and Automatic Local and Automatic Trunk Equipment.** The layouts shown are for 1,200, 2,400 and 3,600 lines respectively, together with provision for automatic trunk switching equipment based on the use of 2 V.F. signalling equipment. To allow for varying proportions of trunks to local lines, switchroom widths of either 43′ or 48′ are catered for. A 4-rack suite is used for the local automatic equipment, and either a 2 or 3-rack suite for the accompanying automatic trunk equipment. Allowance is also made for the interim installation of C.B.

**Panel Data D.C. (Control)**

| Volts | Panel required | Width | Number required |
|---|---|---|---|
| 48 | Discharge | 2' 6" | 1 |
| | Charge | 2' 0" | Only required for M.G. sets |
| | Ringer | 2' 0" | 1 |
| 24 | Discharge | 2' 6" | 1 |
| | Charge | 2' 0" | Only required for M.G. sets |
| 130 | Discharge | 2' 6" | |

Miscellaneous panel at end of board to be specified as to type and purpose.

**Machine Data**

| Volts | Amps | Width | Length | Number required |
|---|---|---|---|---|
| 50/65 | 250 | 2' 0" | 6' 0" | |
| 24/35 | 200 | 2' 0" | 5' 0" | |
| 24/35 | 400 | 2' 0" | 6' 0" | |

**Rectifier Data**

| Volts | Amps | Width | Depth | Number required |
|---|---|---|---|---|
| 50/65 | 30 | 2' 0" | Max. 2' 0" | |
| 50/65 | 50 | 3' 0" | ,, | |
| 50/65 | 100 | 4' 0" | ,, | |
| 50/65 | 200 | 4' 0" | Max. 3' 0" | |
| 50/65 | 500 | 8' 0" | ,, | |
| 24/35 | 30 | 2' 0" | Max. 2' 0" | |
| 24/35 | 50 | 2' 0" | ,, | |
| 24/35 | 100 | 3' 0" | ,, | |
| 24/35 | 150 | 4' 0" | ,, | |
| 24/35 | 200 | 5' 0" or 4' 0" | ,, 3' 0" | |
| 130/180 | 5 | 2' 0" | Max. 2' 0" | |
| 130/180 | 10 | 2' 0" | ,, | |
| 130/180 | 30 | 3' 0" | ,, | |

**Notes:**

The installation shall provide the following facilities—
1. A.D.C. Control Switchboard.
2. A Rectifier Bay.
3. Machine charging where D.C. mains only are available.
4. Public and standby A.C. power supply switchboard.
5. Ringing and tone machine with associated control panel.

**Table No. 2.—Country Exchange Building—Power Room Equipment.**

plant in the layout. Whilst by long experience the design of the local C.B. and automatic exchange equipment has become well established, more experience is required with the trunk automatic plant before similar definite principles of design can be laid down. However, the layouts shown may be regarded as reasonably typical at this stage. As a general guide a figure of five square

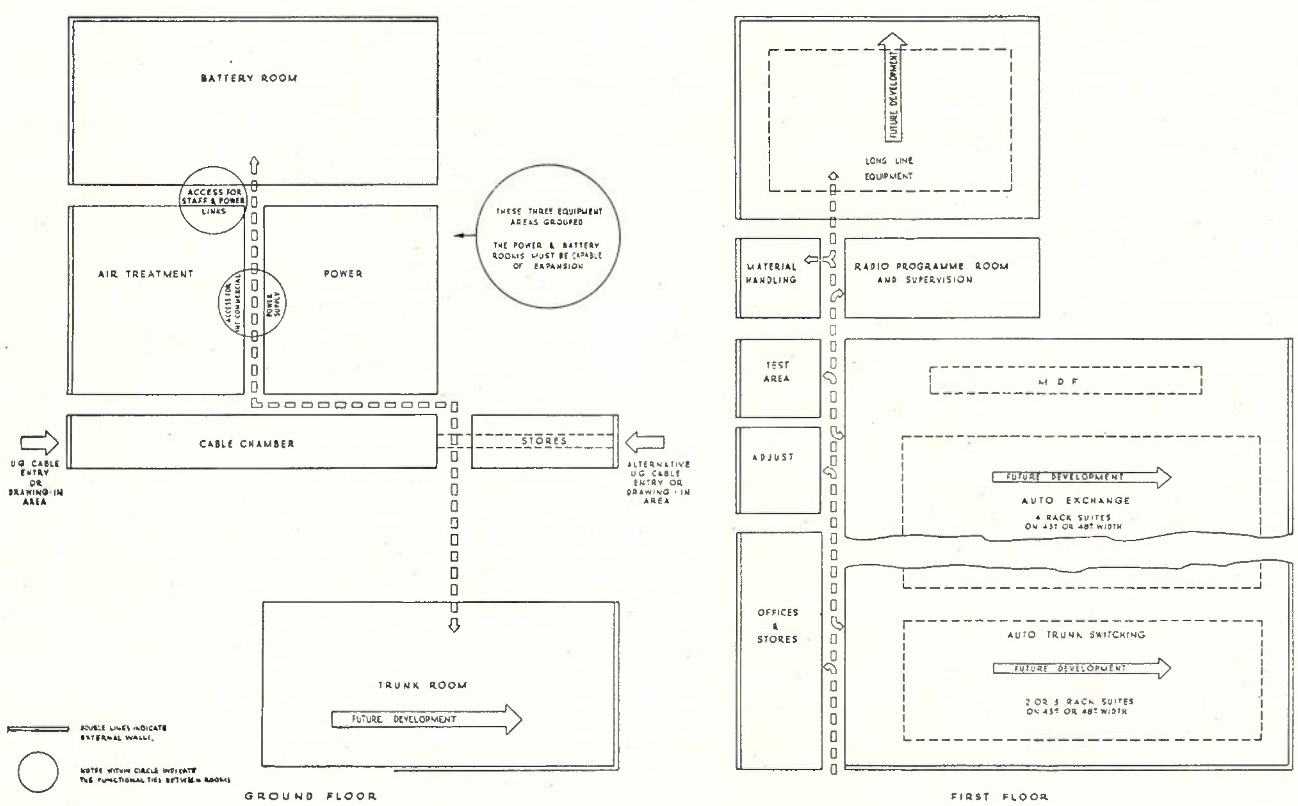



**Fig. 16.—Country Exchange Building. Functional Layout.**

**Note 1.—Double lines indicate external walls.**
**Note 2.—Notes within circle indicate the functional ties between rooms.**

feet per trunk line can be used as a space unit in the equipment room; that is, the total area available divided by five will provide aisle space as well as racking space.

**Manual Switch Room, Fig. 18.** The layouts shown are based on the use of multiple type switchboard carcases in lieu of the turret cordless type, as it is general current practice to use the latter only for buildings of larger types than those now being discussed. The layouts are developed around a comparison of the areas required for C.B. multiple exchanges up to a maximum of 2,400 lines, with subsequent development under automatic conditions to 3,600 lines. The incidence of trunk working may, of course, vary the areas, but average conditions have been shown. One trunk position per 100 automatic local lines has been shown to be a reasonable figure upon which to base the layouts. This ratio has been arrived at as the result of a study of various locations. Further research is being made in an attempt to set down a firm method for assessment. The overall length of the rooms shown in this figure should be increased by an amount of two feet to enable the supervisors' desks to be placed outside the area enclosed by the manual positions.

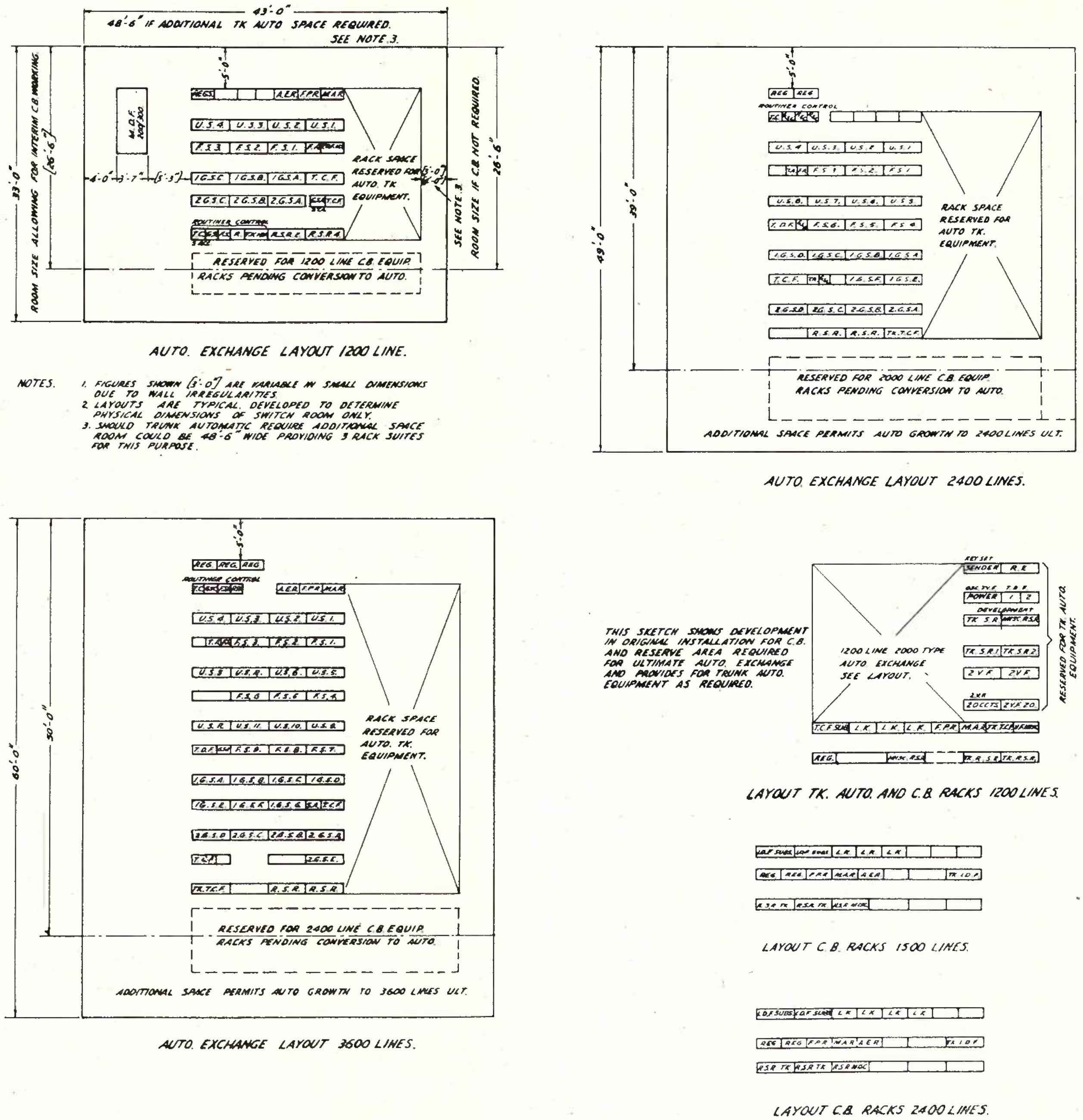



Fig. 17.—Country Building Automatic Exchange and Automatic Trunk Layouts.

**Fig. 19, Carrier Layout.** The carrier layout

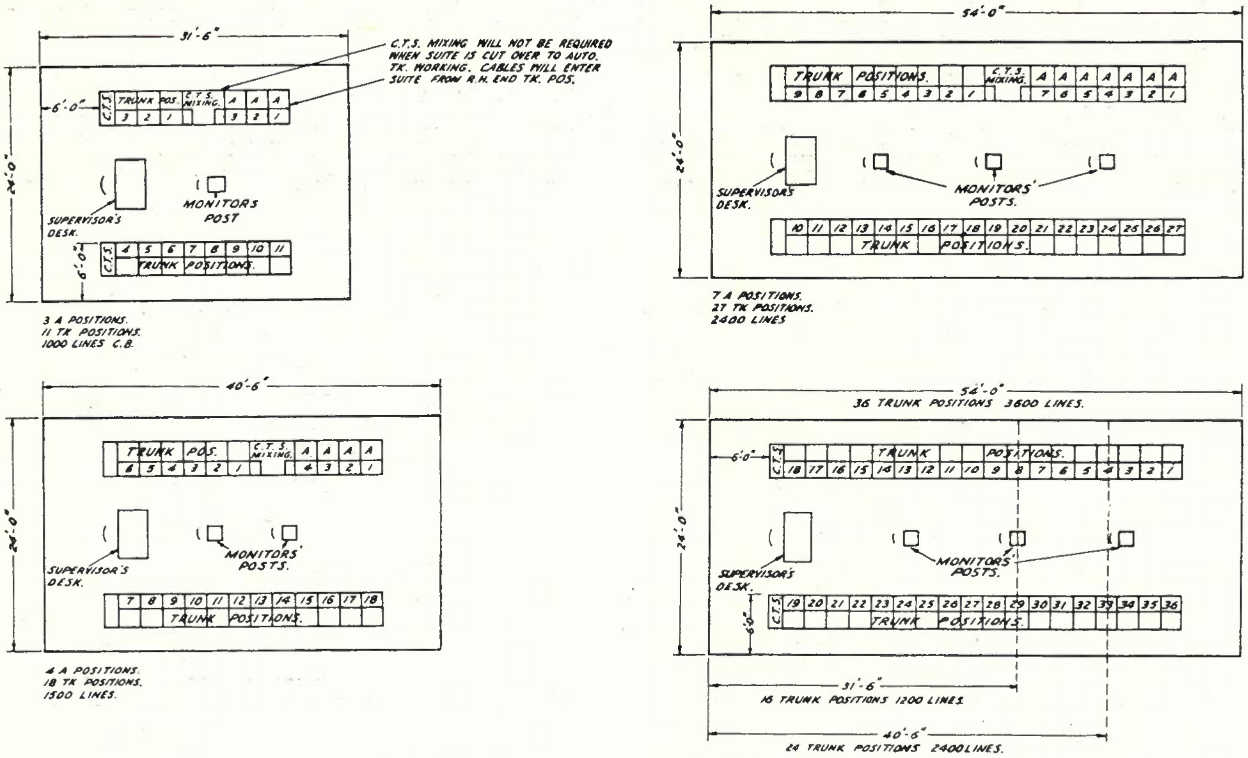
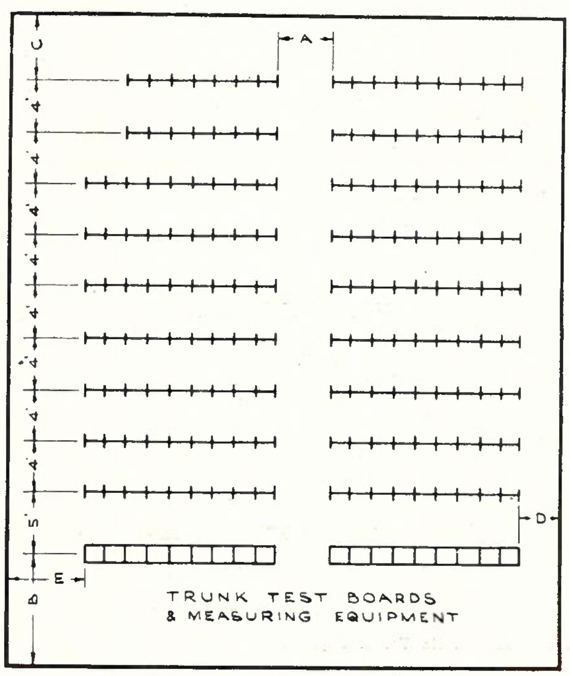



Fig. 18.—Country Building Manual Switch Room Layout.

shown mainly indicates accepted rack and aisle spacing conditions. The length of the carrier room




DIMENSIONS — BASED ON 43'-0" WIDTH

| | | | | |
|---|---|---|---|---|
| A | MAX 6'-0" | MIN 4'-0" | PASSAGE | BUILDING OF LESS WIDTH |
| B | " 8'-0" | " 6'-0" | " | THAN 43'-0" REDUCES NO |
| C | " 5'-0" | " 4'-0" | " | OF CARRIER RACKS IN |
| D | " 4'-0" | " 3'-0" | " | SUITES ACCORDINGLY |
| E | " 6'-0" | " 4'-0" | " | |

Fig. 19.—Country Exchange Building, Carrier Room Layout.

must be determined from a close study of the service to be provided and the manner in which various types of lines will be treated to obtain the most economical use of plant, having in mind the practical aspects, etc. The amount of carrier and long line equipment depends very much on the location of the particular town relative to the trunk systems, physical geographical features, etc., in contrast to the local automatic plant, which is based mainly on the size of the particular town concerned.

**Fig. 20 and Table No. 2, Power and Ringing Equipment.** Similar comments apply in general to that indicated under the equivalent heading for the metropolitan exchange. In this case, however, provision of 24, 48 and 130 volt power supplies is necessary. The layout plan includes mostly data applicable to rectifier charging, but some reference is made to cover the eventuality of having to use motor generator sets. This can occur in cases where the public power supply is D.C. The number of towns in Australia having this type of power supply is comparatively small and the number is being gradually decreased due to conversions to A.C. supply. The majority of the cases include comparatively small towns, so that in most instances there will be only long line equipment conditions to be catered for to any large extent. The main emphasis is therefore on rectifier plant and the typical layouts shown are for this type of charging.

**Fig. 21 and Table No. 3, Battery Room.** In this case also it is necessary to cater for the 24, 48

| Voltage | Type of Battery | Capacity Amp-hour | Stand Dimensions | | No. of Batteries | Remarks |
|---|---|---|---|---|---|---|
| | | | Width | Length | | |
| 48 | Wooden vat | 900<br>1200<br>1500 | 3′ 0″<br>3′ 6″<br>4′ 3″ | 20′ 0″<br>20′ 0″<br>20′ 0″ | 2<br>2<br>2 | 24 cells arranged in 2 parallel rows of 12 cells each. Rows 6″ apart. |
| 48 | Glass jar | 432 | 2′ 6″ | 12′ 0″ | 2 | 24 cells arranged in 2 parallel rows of 12 cells each. Rows 6″ apart. |
| 24 | Wooden vat | 1200 | 3′ 6″ | 10′ 0″ | 2 | 12 cells arranged in 2 parallel rows of 6 cells each. Rows 6″ apart. |
| 24 | Glass jar | 432 | 2′ 6″ | 6′ 0″ | 2 | As for 24V. wooden vat type. |
| 132 | Glass jar | 108 | 2′ 6″ | 12′ 0″ | 3 | 36 cells. |
| 132 | Enclosed | 100 | 2′ 3″ | 10′ 6″ | 3 | This stand accommodates 3/66 cell batteries. |

**Notes:**

1. Wall of battery room to be adjacent to power board passageways to provide full width + 6″ for extraction, preferred minimum width 3 feet. Place passageways at end of batteries remote from power board.
2. The layout selected may be based on size and shape of space available. Layouts Nos. 5 and 6 should be considered for use when an automatic start diesel alternator plant is installed.
3. The reserve battery capacity required may vary at different locations, and the actual layout may differ somewhat from those indicated, due to the use of different sizes of cell.

**Table No. 3.—Country Exchange Building—Battery Room Plant.**

and 130 volt power supplies in addition to providing in some instances a third battery for carrier telegraph system working. Various layouts have been shown to cater for the possibilities of different shaped rooms being used in particular buildings. Different battery capacities are also indicated to take into account the need for varying reserve capacities having in mind the relative reliability of the public supply, the importance of the station, etc., and the possibility of having automatic starting standby alternator plant available.

**Underground Cable Entry.** Because of the two-storey treatment and the relative balance of space requirements on the ground and first floors, a cable room or chamber has been provided on the ground floor for the termination of the underground cables and connection to the lead-covered indoor cables leading to the M.D.F. In many cases special attention is necessary to provide suitable entry conditions for underground trunk cables. These cables often enter separately and terminate on a special trunk rack located in the long line equipment room.

## Prefabrication

Similar problems in general arise in country buildings as were discussed under this heading for the metropolitan ones. The effect of using prefabricated units of the type at present available in the country is somewhat different however to the metropolitan case. This is due to the fact that the country buildings discussed in the foregoing are basically two-storey structures. As the present types of prefabricated buildings available do not permit of a two-storey treatment, the total area required must be provided at ground level.

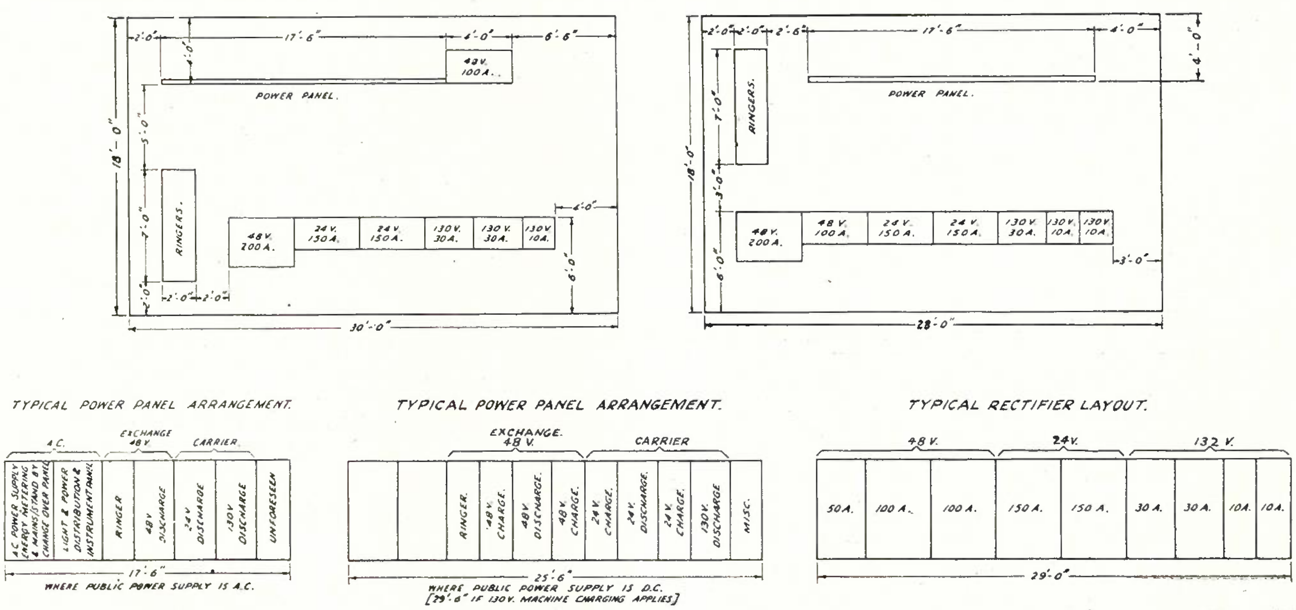



**Fig. 20.—Country Exchange Building Power Room Layouts.**

Further details will be given at a later date of the variations in layout conditions necessary in the country prefabricated buildings.

## Conclusion

As will be gathered from the foregoing, the design of engineering equipment buildings is governed by reasonably well defined principles. If complete attention is paid to the listing of all requirements, both from an equipment and staff basis, the resultant building should give a structure closely approaching the ideal for present and future needs.

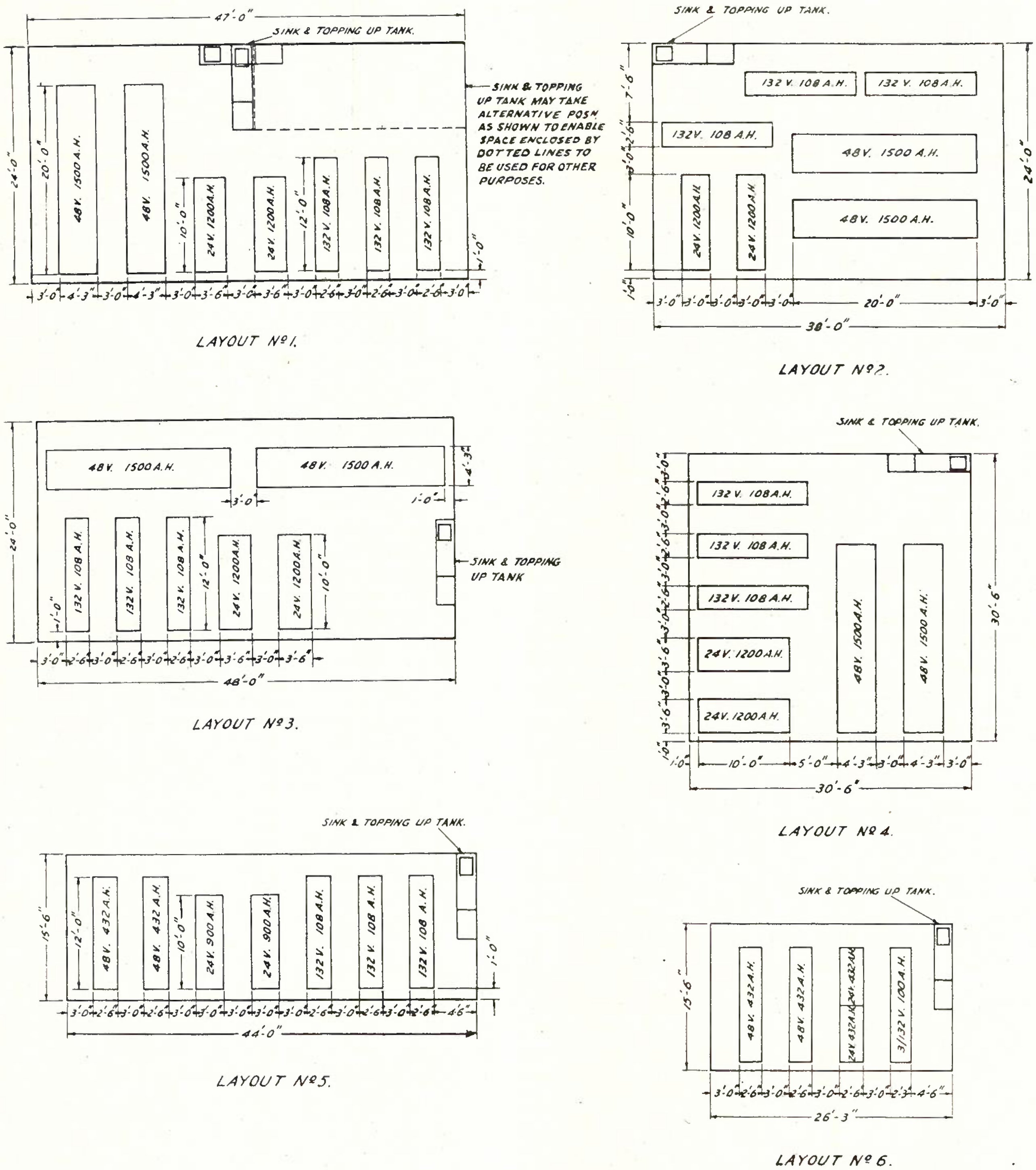



Fig. 21.—Country Exchange Building. Battery Room Layouts.

# NEW METHOD OF REGULATING AERIAL WIRES

C. H. Hosking, B.Sc.

### Introduction

The transposition schemes for an aerial trunk route, to enable twelve channel carrier systems to be operated on a number of pairs of wires, require the installation of a much greater number of transpositions than has previously been necessary on trunk routes in Australia. The regulation of the wires must, in addition, be accurate enough to keep the difference between the sags of the wires of a pair to close limits. Methods of erecting and regulating wires which have been used in this country up to the present make the correct sagging of wires difficult under these conditions.

### Existing Methods

The existing methods of regulating wires have been described in a previous article in this Journal (1). With these methods, regulation is carried out over sections of route, the length of sections being controlled by the distance between transpositions. In each section the wire is pulled up by means of wire grips until the required sag is obtained in the centre span of the section. This sag is set by one of a number of methods, described in the article referred to above.

The procedure becomes very tedious when there is a transposition pole every second pole or even every pole. In addition, to set sag accurately by one of the existing methods requires the employment of specially trained or skilled staff, and even then it is probable that it would not be possible to ensure regulation to the accuracy required for twelve channel carrier working.

### Method Devised by Bell System

A new method of regulating aerial wires, which is much faster and more accurate, has been developed and introduced in the U.S.A. by the Bell System Laboratories (2). The Bell System plan of operation is briefly as follows:—

(a) Each pair of wires is run out straight and placed on the crossarm in lengths of from one-half to three-quarters of a mile.

(b) The tension is applied to the wires by a chain hoist. The tension in the wires of a pair is equalised by connecting each wire to the ends of a short rope which is passed round a pulley connected to the chain-hoist. A dynamometer is introduced to enable the tension to be read directly.

(c) Transpositions are then inserted and so as to preserve the correct tension in each wire, as transpositions are inserted the chain hoist is released three links, thus introducing approximately three inches of slack into each wire, this being the additional length required to place the wires around the insulators on the transposition plate with 8 inch wire spacing. Each transposition is actually inserted by attaching "snubbing clamps" to the transposition plate to clamp the wires in the direction of the completed construction. Slack is released at the distant chain-hoist and is pulled to the transposition point by means of slack puller operating through an equalising pulley to ensure that each wire is pulled the same amount. The wires are then placed around the insulators and the slack in excess of the amount required to make the transposition is taken up by the chain-hoist. to restore the wires to the prescribed tension. The clamps are then removed and the transposition is complete.

### Tests Conducted in Australia

Tests were carried out on a route in Victoria using the Bell System method, but as a dynamometer with a suitable range was not available, a lever system had to be devised to enable the dynamometer which was available to be used.

In the absence of a suitable dynamometer, tests were also carried out using weights to apply the tension to the wire instead of a chain hoist and dynamometer. These tests were very satisfactory and field tests on a much wider scale are being extended throughout the Commonwealth. The weights method has the following advantages over the Bell System dynamometer method:

(a) One problem which arises with both these methods is that when the tension is first applied the tension in the wires decreases as the distance from the tensioning end increases, due to the friction at the points where the wires slide over the crossarms. It has been discovered that the tension can be satisfactorily distributed over the whole section by momentarily increasing the tension at the tensioning end. This can be done simply and effectively in the weight method by pushing the weights down a distance depending on the distance to the point where the wires are clamped.

(b) The weights ensure constant tension at all times, but it would be necessary to check the accuracy of a dynamometer regularly.

(c) Less operations are involved in the weights method and it is simpler; thus, highly trained staff is not required, and less supervision is necessary.

### Regulation of Aerial Wires Using Weights

A detailed description of the method using weights follows. The sections over which the wires are to be regulated are first selected after consideration of the following aspects:

(a) The use of longitudinally stayed poles as end poles for regulating sections offers advantage as the provision of temporary stays is avoided.

(b) Along straight and level portions of route the regulating sections may be up to one mile in length. The length is governed by the extent of horizontal and vertical angles in the route.

(c) The inclusion of angle poles within a regulating section is undesirable because of the frictional effects introduced. Two slight angles can generally be allowed in a section without any special arrangements being made, but it is considered preferable that at all angles included in a tensioning section, snatch blocks, fitted with ball-bearing pulleys, should be provided to overcome these effects.

It is most convenient to start tensioning the wires of a particular route from the cable terminal pole at one end and work from section to section to the cable terminal pole at the other end. This, however, is not possible when two or more parties are working on the same route and independent tensioning operations may be required over separate portions of the route. In both cases it is necessary to provide temporary stays from the relevant crossarms on the end poles of the first section being tensioned. At the tensioning end stays are also required from the crossarm on the adjacent pole in the next section from which the weights are suspended. In addition, where the poles are not stayed, temporary pole stays are provided as shown in Fig. 1. Temporary stays are required at the fixed end when the wires in the previous section have been tensioned until prestressing has been completed, after which these wires provide the necessary support for the crossarms and poles. However, depending upon the number and disposition of the wires being tensioned, temporary stays may be omitted. Prestressing refers to the application of a load to the wires approximately twice the working tension, and is designed to obviate subsequent changes in behaviour causing inequality in sags.

After spindles, insulators and transposition plates have been fitted, the wires, where practicable are run out on the ground and lifted on to the crossarm in readiness for tensioning, or where there is no alternative, are drawn out over the crossarms using such precautions as are necessary to avoid damage to the wire. The wires of a pair are placed on the crossarm on either side of a spindle. Before tensioning begins all stays are checked to ensure the stability of the route. The terminal stays and angle stays are tightened, using a lifting jack and short pike against the pole, so that when the wires are tensioned the stays will prevent any movement of the poles.

At the cable terminal pole the wires to be tensioned are terminated, but until the prestressing in the first section is completed the wires are held in wire grips, otherwise the terminations will pull tight during prestressing. After the prestressing is completed, the wire grips are removed so that the wires take up their normal position at the termination.

If the first section to be tensioned is not adjacent to the cable terminal pole, the wires are either clamped to a transposition plate on the end pole of the section by means of the clamp illustrated in Fig. 2, or if there is no transposition plate, are held in a clamp similar to the transposition plate clamp which is fixed directly to the crossarm.

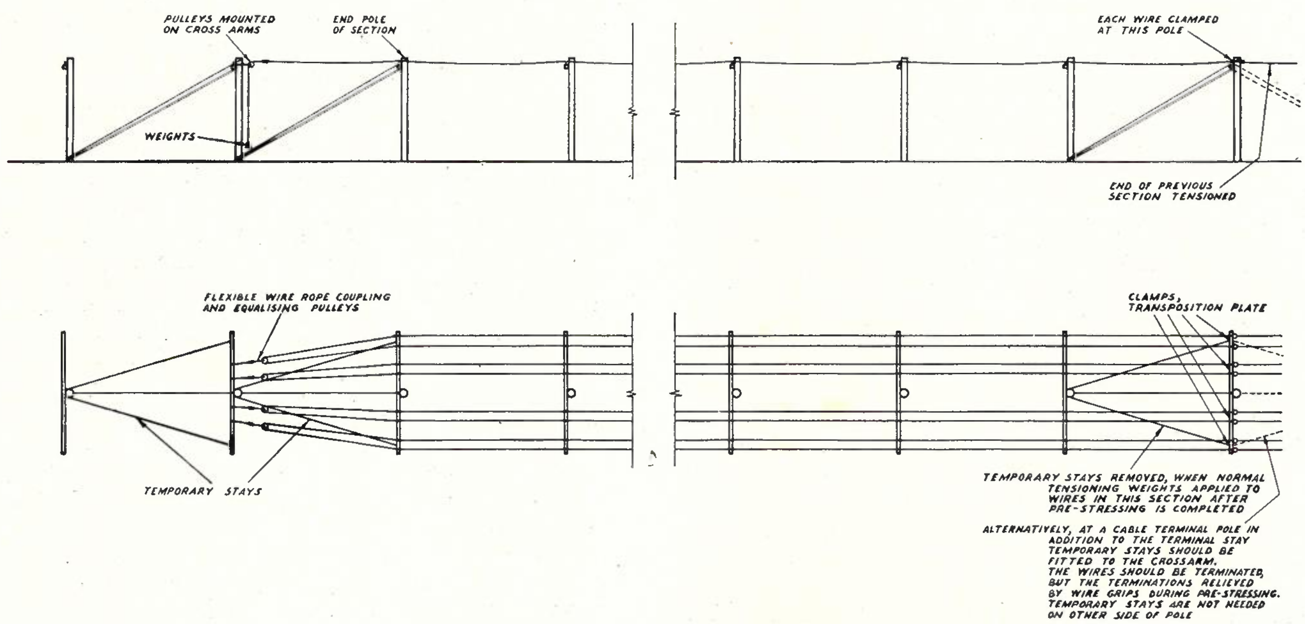



**Fig. 1.—Preparation of Route for Tensioning Operations.**

At the tensioning end of the section the arrangements are as shown in Fig. 3, the wires of a pair being coupled together by means of a piece of flexible wire rope, which is attached to the line wires by wire grips (minus straps) and which passes around a ball-bearing pulley. This equalising pulley is attached to a longer length of flexible wire rope which passes over a pulley mounted on or attached to the crossarm, and has attached to the other end a rod with a stay plate welded to it as a mounting for the weights. The latter pulleys are mounted on or attached to the crossarm as close in to the pole as practicable,

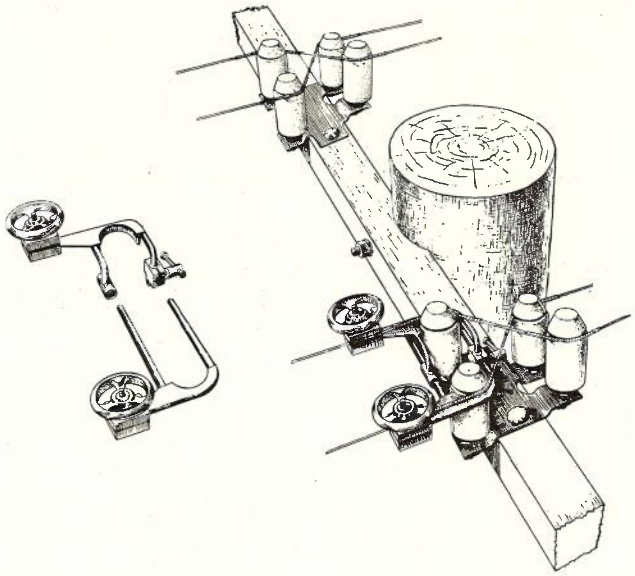


Fig. 2.—Transposition Plate Clamp.

leaving only sufficient clearance for the weights to swing or spin freely without fouling the pole.

The pair of wires is then prestressed by placing weights equal to twice the prestressing tension (that is to cater for two wires) on the stay plate mounting. After two applications of the prestressing weights, each application being of one minute's duration, the correct tension is then applied to each pair of wires via the equalising pulley by adjustment of the weights on the stay plate mounting, allowance being made for the shade temperature. At this stage, the grips at a cable terminal pole are removed.

In order to distribute the tension as evenly as possible over the whole section, the man at the tensioning end then depresses the weights. At the fixed end one man places one hand on the wires being tensioned. The man at the tensioning end then pushes the weights down a distance, depending on the length of the section, and allows them to restore. This complete operation is referred to as "depressing the weights." When the length of the section is 1 mile it is necessary to push the weights down approximately 12 inches. It is sufficient if, at the fixed end, a pulse in the wires is detected by the man with his hand resting on the wires. Care has to be taken to ensure that the weights are not depressed so far that the head of the pole to which the wires are clamped is moved. It is preferable to underestimate the depression at first and repeat pushing the weights down a little further each time until advice is received from the fixed end that the pulse in the wires has been detected.

Starting from the fixed end, the transpositions are now inserted. As each transposition is inserted, a second cross is automatically placed in the pair of wires. These crosses are worked ahead and the wires are finally straightened out in the span beyond the end pole at the tensioning end of the regulating section. This is best arranged by having one man climb each pole in advance of the men actually inserting the transpositions at the transposition plates. Considering, for simplicity, one pair of wires only—

(a) This man starts from the fixed end and at the pole beyond the first transposition plate he reverses the wires as they lie on either side of the spindle by passing the left hand wire over the right-hand wire as viewed from the fixed end. This leaves one cross behind him, which is absorbed when the transposition is inserted at the plate, and also another in the span ahead of him.

(b) He now climbs each successive pole and moves the cross into the span ahead of him by reversing the wires, again by passing the left hand wire over the right hand one.

(c) At the first pole past the second transposition pole he moves the existing cross into the span ahead of him and, in addition, gives the wires a further reversal to leave another cross in the span behind him to be absorbed when the transposition is inserted. This leaves two crosses in the span ahead.

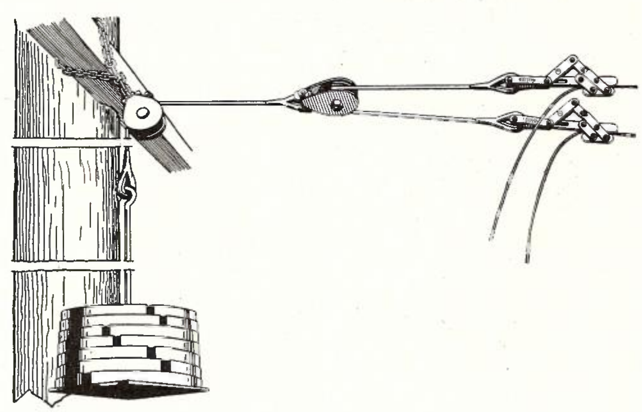


Fig. 3.—Arrangements at Tensioning End.

(d) As this man moves towards the tensioning end, for every transposition plate he passes, there will be one additional cross placed in the wires. All these reversals must be moved along to the tensioning end of the wires.

It has been found convenient to arrange for the man referred to in the preceding paragraphs to fit the tapes to the wires as he proceeds.

Following this man are those inserting the transpositions—

(a) At the first transposition a clamp of the type shown in Fig. 2, is attached to the transposition plate, and the wires back towards the fixed end are clamped.

(b) Sufficient slack is taken up in the wires on the other side of the plate to enable the transposition to be inserted. This can be done using a standard wire grip, as shown in Fig. 4.

(c) After the transposition has been inserted and the wire grip has been removed, the man at the tensioning end is signalled to depress the weights in order to even the tension over the whole section.

(d) The clamps are then removed and the transposition party proceeds to the next transposition pole, where the same procedure is followed.

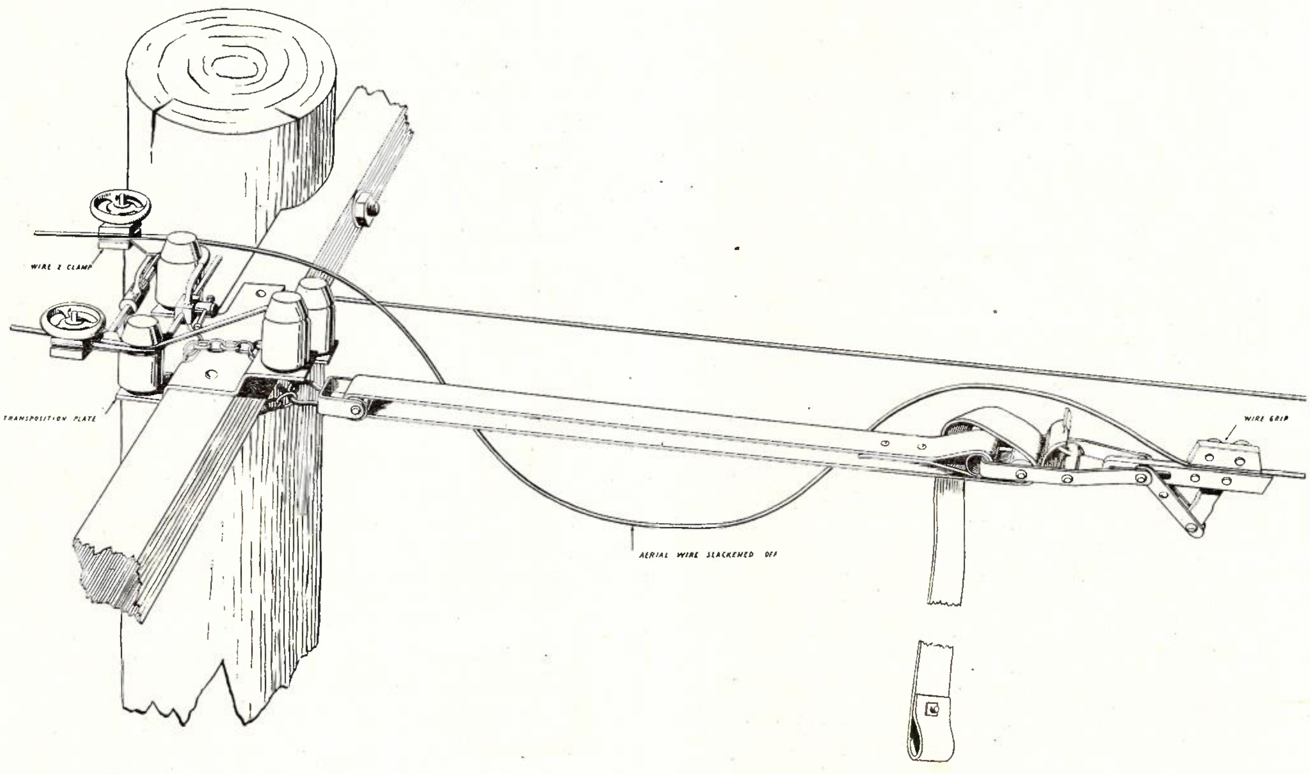



**Fig. 4.—Taking up Sleck in Wire.**

(e) In order to check the equalisation of tensions in the wires of a pair after the insertion of each transposition, and after the transposition plate clamp has been removed, the two wires are drawn together between the thumb and fingers at a point about 12 to 16 inches from the crossarm in the span behind. By pulling the hand down quickly the two wires are released simultaneously and a travelling wave is set up in each wire. These waves are reflected from the far end of the span and if the tensions are equal they will travel to and fro in synchronism. If the two waves return in phase five times, the difference in tensions can be disregarded, but if the wave in one wire lags conspicuously, an adjustment to that, the slacker, wire is necessary. In this case a small amount of slack in this wire is forced from the span tested around the insulators on the transposition plate into the next span using a wire grip until this "pair oscillation" test proves that the tensions are equal. After an adjustment of this kind is made it will be necessary to refit the transposition plate clamp, to clamp wires and have the weights depressed again to re-equalise the tensions in the spans towards the tensioning end.

When the last transposition has been inserted, the wires are left secure on the end pole of the section, either in a transposition plate clamp if there is a transposition plate on the pair on that pole, or otherwise in a crossarm clamp. At this stage the weights are removed and the wires in the span beyond the end pole of the section lowered and the grips removed. The crosses in the wires which have been moved into this span are now straightened out, and the ends of the wire jointed to the wires in the next section to be tensioned.

The tensioning in the next section is now carried out in a similar manner. The clamps on the end pole of the previous section are removed after the pre-stressing has been completed and the normal tensioning weights are applied and the weights have been depressed. The temporary stays at the end of the previous section are also removed at this stage.

### Conclusion

The weight method is in use in Victoria and in slightly modified forms in other States. Good results have been obtained, no difficulty being experienced in obtaining sags within one inch of the desired sags and in keeping the difference in sags between the wires of a pair to less than half an inch.

Manhour rates of from 16 to 22 manhours per mile for the erection of wire have been obtained. However, no direct comparison can be made between the new and old methods of erection and regulation because very little wire has been erected with the intensive transposing required now for J 12 routes using the old methods of regulation. These manhour rates, however, are very satisfactory when compared with the rates obtained using the old method for routes not so intensively transposed.

No doubt improvement can and will be effected as more experience is gained, but the method as it exists is a considerable improvement of previous methods and will result not only in a saving in the cost of erecting J 12 carrier routes, but in a higher standard of construction.

### References

1. "Aerial Line Construction—Part 5, Wires and Wiring," A. S. Bundle, Telecommunication Journal of Australia, Volume 4, No. 1, June, 1942, page 39.

2. "Tensioning Open Wire for J Carrier Systems," J. A. Carr, Bell Laboratories Record, January, 1945, page 8.

# POSTAL ELECTRICAL SOCIETY OF VICTORIA ANNUAL REPORT, 1950-51

In arranging the bi-monthly lecture programme for the 1950-51 year, the Society was fortunately able to hear talks by Mr. P. Permewan, of the Melbourne Technical College Radio Theatre, and Mr. S. H. Witt, Life Member of the Society, whilst home for a brief visit from Geneva, as well as Messrs. E. G. Boraston, T. Allen, C. E. Skuse, F. Brownless, W. King and R. G. Spratt, members of the Society.

The lectures continue to be held in the Radio Theatre, Melbourne Technical College, by the courtesy of the authorities, to whom we are also indebted for their help in preparation of film strips, services of projectionist, etc.

The Committee has, with regret, accepted the resignations of Mr. W. H. Walker, Honorary Secretary and Mr. F. A. Waters, Honorary Treasurer, during the past year. On behalf of the members of the Society, the Committee extends its thanks to these gentlemen for their diligent service, and pays tribute to the work they have done. Messrs. R. D. Kerr and D. T. Ottrey, respectively, have acted in these positions for the remainder of the year.

The growth in circulation of the Journal, now well over 2,500 copies, has considerably increased the permanent administrative work of the Society. The Committee has been able to retain the services of Mr. Walker in the new position of Circulation Manager of the Journal, which is a great help in the administrative work associated with the distribution of the Journal.

Much to the regret of the Board of Editors and Committee, the appearance of recent issues of the Journal have been delayed by continued publishing difficulties. It would be appreciated if any member willing to contribute an article would communicate with one of the Sub-Editors or Editors.

The financial position of the Society is becoming rather perturbing with the rising costs of publishing the Journal. A payment of £355 during the past year has been granted by the Department, representing approximately one-third of the Society's total revenue for the year.

The Committee expresses its thanks to the authors of articles, members of the Drafting Staff who have freely given a good deal of time and effort in preparing diagrams and illustrations for the Journal, and to those members who have assisted in the collection of subscriptions and distribution of Journals during the past year.

# TELECOMMUNICATIONS AT VERY HIGH AND ULTRA HIGH RADIO FREQUENCIES

*A. H. Kaye, B.Sc., A.M.I.E. (Aust.), S.M.I.R.E. (Aust.)*

In this paper it is the author's intention to make only a very general introductory survey of the subject with the object of indicating the potentialities of VHF and UHF radio systems in telecommunication networks. Therefore, although it is necessary to deal briefly with techniques and features of such systems, no apology is made for lack of precise discussion or for absence of technical details.

To introduce the subject, attention is first directed to Fig. 1, which is the well-known dia-

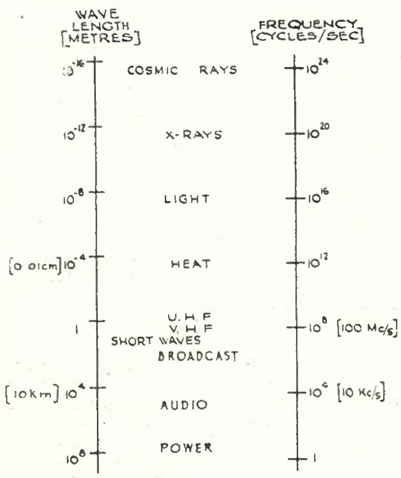



**Fig. 1.—Electro-Magnetic Spectrum.**

gram showing the electro magnetic spectrum. Consideration of this spectrum will draw attention to some differences from, and some similarities to, other parts of the radio frequency spectrum with which many may be more familiar. From the point of view of fundamentals, there is no difference between electro magnetic waves in the various parts of the spectrum—for example, Clerke Maxwell's equations apply at all frequencies—but because of frequency differences, in engineering and other practical problems, different methods of approach are adopted. It will be seen that the very high frequency and ultra high frequency regions are, roughly, midway between the frequencies used for power distribution and the frequencies of light, and it is therefore to be expected that some of our concepts and some properties of VHF and UHF waves may be similar to the concepts and properties usually associated with light or heat. In dealing with some problems, this approach proves profitable.

For telecommunication purposes we can, for simplicity, consider a voice frequency channel as 3kc/s wide, and Fig. 2 indicates the number of channels which are potentially available in the various parts of the radio spectrum. The point to note is that the number of channels available in the various regions is proportional to the frequencies of those regions. The terms "Medium Frequency," "High Frequency," "Very High Frequency," and "Ultra High Frequency," are very convenient general descriptions of the various regions, as the behaviour of radio frequency waves fall generally into such groups but, of course, there is considerable overlapping at the borders of the several regions.

Multi-channel telephone systems occupy several or, in some cases many times the unit band width of 3 kc/s, and it is desirable with such systems to conserve the use of the lower frequency part of the spectrum and favour the use of higher frequencies where more channel space is available. In general, a high frequency should be used where possible and resort made to the lower frequencies only if this is essential. Sharing of frequencies, i.e., common channel working, is also more readily arranged at the higher frequency end of the spectrum, thus the basic number of telephone channels available can be multiplied, resulting in further advantage in the use of the higher frequencies; there will be more further comment on this point at a later stage.

## Propagation

It has just been shown that there is potentially a very large number of radio telephone channels in the VHF and UHF regions, and the next consideration is the problem of transmitting a radio wave of these frequencies from one point to another.

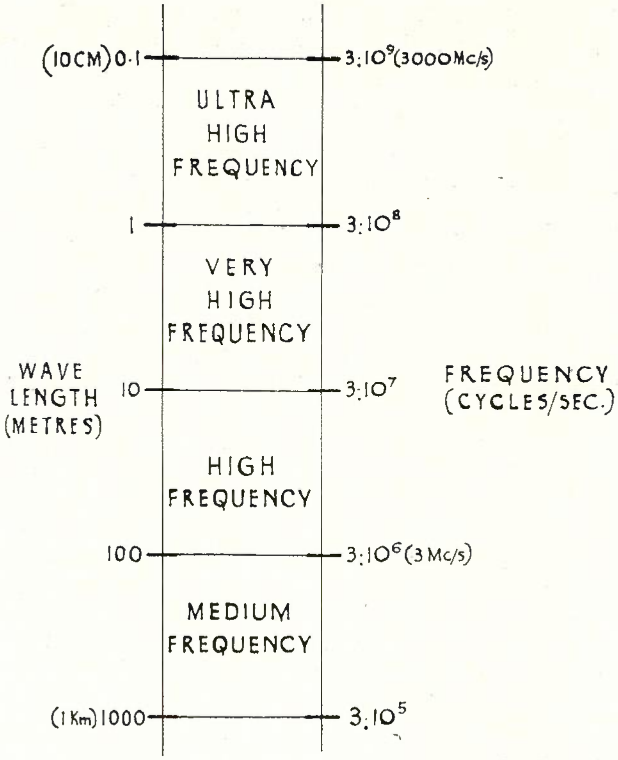
Any current along a conductor has an associated electro magnetic field which varies with variations of the current, and this electro magnetic field can be caused to radiate by using an appropriate configuration of conductors. Propagation of such radiated electro magnetic fields may take place in three ways:—

(i) By direct transmission as in the case of a direct beam of light or transmission from ground to an aircraft overhead. This is termed "free space" propagation.

(ii) By reflection from the earth, the ionosphere, from mountains, buildings, etc.

(iii) Along the ground by diffraction. This wave is guided and confined to the earth's surface.

The received signal at a remote point will be the vector sum of these three waves and the magnitudes of each of the component waves will depend on the operating radio frequency; at any one frequency or band of frequencies, some of the components may be very small and may be neglected. These three methods of propagation are illustrated in Fig. 3.




| BAND | BAND WIDTH | N° OF 3000 CYCLE/SEC. CHANNELS |
|---|---|---|
| MEDIUM FREQUENCY | 2,700 Kc = 2·7 Mc. | 900 |
| HIGH FREQUENCY | 27,000 Kc = 27 Mc. | 9,000 |
| VERY HIGH FREQUENCY | 270,000 Kc = 270 Mc. | 90,000 |
| ULTRA HIGH FREQUENCY | 2,700,000 Kc = 2700 Mc | 900,000 |

Fig. 2.—Part of Radio Frequency Spectrum.

In the medium frequency region as used for "standard" broadcasting, the ground wave is of first importance with reflection from the ionosphere as a second factor very frequently being only a nuisance. In the high frequency region, reflection from the ionosphere is the most important factor and long distance, such as transoceanic, transmission depends on this mode of propagation. For the VHF region, transmission is by free space, by reflection from the ground and along the surface of the ground by diffraction. In the UHF region, propagation is by free space and by reflection from the earth's surface. It is not meant that the other components may always be entirely ignored, particularly where the various regions overlap, but the above are the main considerations.

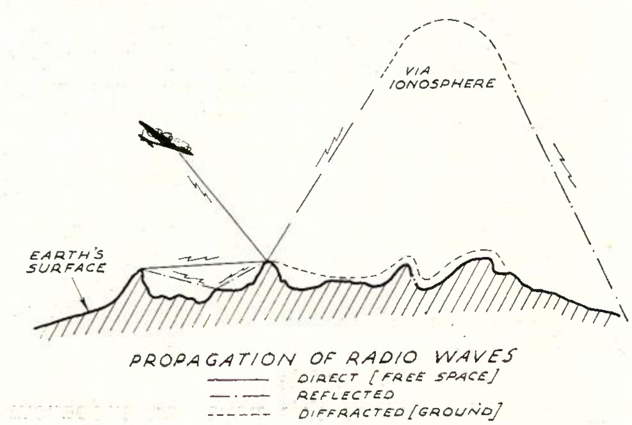



Fig. 3.—Propagation of Radio Waves.

In the VHF region, it is sometimes said that an optical path giving "free space" transmission is necessary, but this is not so. The availability of an optical path can be regarded as making transmission certain (assuming suitable equipment), but transmission is also quite practicable beyond the optical horizon and there is no abrupt cut off at the horizon. This is a result of diffraction along the surface of the earth and by refraction of the direct (optical path) wave in the lower layers of the atmosphere resulting in a bending downwards of this wave. Propagation by diffraction decreases as the frequency is increased since the size of obstacles becomes greater by comparison with wave length, but even at the high frequencies of light, some diffraction occurs. A detailed discussion of this problem is beyond the scope of this paper, but the points to be made are that optical paths are not essential, and that there are methods of calculation to determine whether or not transmission is practicable for paths beyond optical.

In the UHF region, there is less diffraction than at lower frequencies and for practical purposes optical paths are essential, although transmission is feasible beyond the optical horizon because of bending of the wave (refraction) in the lower atmosphere.

The wave reflected from the earth's surface between transmitting and receiving points may be comparable in magnitude with the direct wave, and will, therefore, interfere either to assist or degrade the received signal depending on the phase difference between the two components which, in turn, depends on the geometry of the path. It might be noted here that the magnitude of the signal reflected from the earth is related to the "smoothness" and electrical constants of the earth at the reflection point.

Refraction in the lower atmosphere, which is one reason for transmission of VHF and UHF waves beyond the optical horizon, is due to differences in the composition of the atmosphere from the ground upwards resulting in a bending of the wave. The amount of refraction depends on meteorological conditions and affects the magnitude of the received signal, whether the receiver is within or beyond the geometrical horizon. Meteorological variations may, therefore, cause fading but, provided the fading is not so great as to cause the signal to fall to too low a value for useful results, the fading can be taken care of by use of automatic volume control and/or limiters in the receiving equipment. In general, a well-mixed atmosphere, i.e., one in which there are no well defined layers, causes refraction such as to enable satisfactory transmission to a distance which is termed the "radio horizon," this being about 15% further from a transmitting point than the geometrical horizon. Much greater distances are frequently covered.

The attenuation of a wave depends on the composition of the atmosphere, and from the propagation point of view it is interesting to attempt to determine the upper limits of frequencies which can be used for communication purposes. Attenuation due to water vapour, oxygen and rain in the atmosphere increases with increasing frequency, and it appears probable that frequencies up to about 20,000 Mc/s could be used for transmission over a path of about 20 miles, and frequencies up to 50,000 Mc/s if the path length is reduced to about 5 miles. These figures apply to temperate climates and somewhat lower frequencies or shorter paths would be necessary in tropical areas subject to very heavy rainfall. This assumes that equipment will be developed for operation at such frequencies, but it is likely that for some time to come the highest frequencies in general use for communication purposes will be of the order of 4000 to 6000 Mc/s.

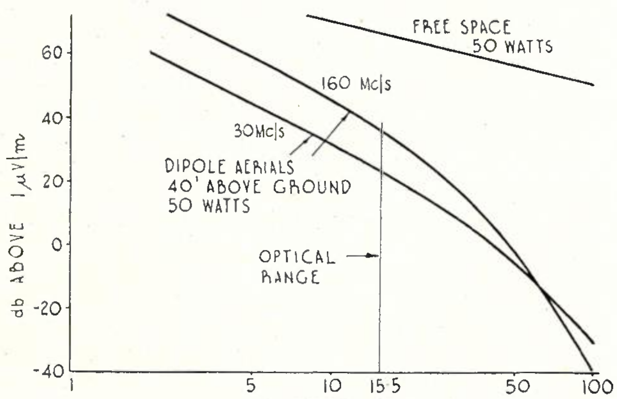



Fig. 4.—Propagation (ideal) over Flat Country.

Attenuation of the wave results from transmission through trees and the attenuation increases with increasing frequency or with greater density of foliage such as in a jungle. At very high frequencies radiating systems should preferably be above tree tops and this is essential for practical purposes at ultra high frequencies.

The limit of satisfactory transmission is determined by the level of noise at or in the receiving equipment. Atmospheric static decreases with increasing frequency and is usually very small at the frequencies under consideration; ignition noise from motor vehicles and the like may be serious, particularly at the lower of the very high frequencies. The limit is determined by relating the received signal strength to thermionic noise in the first stage of the radio receiver, and making allowance for the fact that in practice the noise generated in the receiver is some decibels above this theoretical minimum.

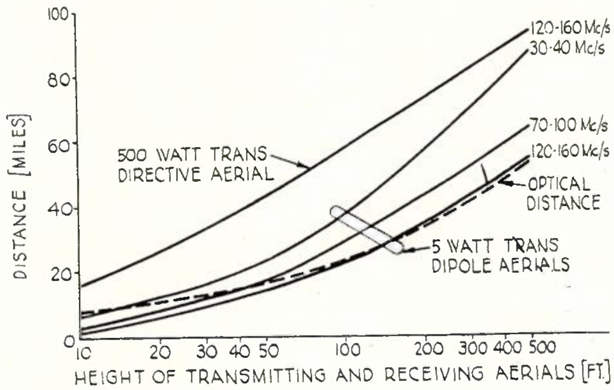



Fig. 5.—Typical Useful Ranges over Flat Country.

It was mentioned in the foregoing that sharing of frequencies thus increasing the availability of channels, could be widely used at the frequencies under examination. This is because transmission or propagation is not possible in general much beyond the optical horizon, assuming that the frequency is sufficiently high to avoid ionospheric propagation, i.e., above about 60 or 70 Mc/s. The potential number of channels in the VHF and UHF regions is thus many times greater than is indicated by simply dividing spectrum space by channel width.

Fig. 4 illustrates how signal strength varies with distance for typical frequencies in the VHF range. Fig. 5 illustrates the service ranges which may be expected under typical conditions, and shows the advantage of locating stations on eminences to increase the distance to the optical horizon.

### Aerials

In the early part of this paper an endeavour has been made to show:—

(a) that the VHF and UHF regions of the radio spectrum offer the opportunity of establishing telecommunication channels on a very large scale; and

(b) such frequencies can be transmitted over useful distances.

The next point to examine is the means by which the signals may be radiated at the transmitting end and received at a remote point, i.e., the types of aerial system which will be required.

It is well known that for efficient radiation on the one hand and efficient reception or capture on the other, it is necessary that the dimensions of the aerial systems used be comparable with the wave length, and it is immediately apparent that suitable aerials for the higher frequencies will be smaller physically than those for lower frequencies and have, therefore, advantages in respect of engineering and cost. The order of the dimensions of the various types of aerial can be deduced from Fig. 2.

Two main classes of radio service have to be considered:—

(i) communication between two fixed points in the manner required for trunk line telephone channels, and

(ii) communication from a central point to a receiver or receivers located in any or all directions from that central point—such a service would be broadcasting in the commonly used sense of the word, and telephone communication to mobile units as cars, ships and aircraft.

The former class of service presents the greater opportunity for the use of very efficient aerials by exploiting the directional properties which can be achieved by appropriate design. The object here is to radiate from the transmitter only in the wanted direction, that is, to concentrate the whole of the available power into a beam, while, at the receiving end, a similar aerial will increase the power captured, and at the same time reduce or eliminate unwanted transmissions (including noise) from other directions. Many types of aerials have been developed for this purpose, the fundamental consideration being that for any given degree of power concentration or beaming, the size of the aerial assembly is proportional to the wave length, and hence, as we progress from low to higher frequencies, we are enabled to use more and more efficient aerial systems of practicable and economical dimensions. This enables the required distance to be spanned using less power or (subject to propagation conditions being satisfactory ) to span greater distances with the same power. A commonly used and useful measure of aerial efficiency is the "power gain" which is the ratio between the power which would have to be used with a simple omni-directional aerial having no beaming or concentration, to the power used with the aerial being considered, to give the same signal intensity in the required direction. Power gains of about 12 db at 150 Mc/s or 30 db at 4000 Mc/s are quite practicable.

Concentration of power may be effected in the horizontal or in the vertical plane or in both, and the figures just quoted refer to concentration in both planes as would be suitable for fixed point to point services. For omnidirectional aerials of the broadcast type and assuming that receiving points are at ground level, a useful improvement may be achieved by concentration of the power along or near the ground and power gains of the order of 6 db at 150 Mc/s are feasible.

Commonly used directional aerials for the VHF range employ dipoles or groups of dipoles as the active element with reflecting elements behind and sometimes with directing elements in front in the direction of transmission; another commonly used system is the wave aerial, a good example of which is the rhombic.

In the UHF region, because of the shorter wave length and therefore smaller dimensions, improved reflectors can be devised, the most commonly used being the parabolic reflector, similar to that used in a searchlight. The aerial proper could be a half wave dipole located at the focus of the parabola, which thus radiates the power in a very narrow beam. It will be seen that the technique of directing the UHF wave is similar to that employed in directing light as was forecast in discussion on the position of these radio frequencies in the electro magnetic spectrum. It will be recalled that in the field of optics, light is frequently focussed or concentrated by means of a lens and, as might be expected, lenses for directing radio frequency energy in the UHF field have been and are being developed.

### New Concepts

Before undertaking discussion of the equipment and plant used in the establishment of telecommunication services at UHF and VHF frequencies, it is desirable to examine some fundamental concepts as an aid to understanding the reasons for differences from the equipment used at audio and lower radio frequencies with which most are more familiar. No new fundamental laws are involved, but because of the higher frequencies, some factors which were unimportant at lower frequencies now become important and vice-versa. As was seen in connection with aerials, some types which were unwieldy and impracticable at lower frequencies become useful for VHF and UHF services.

An examination of the simple parallel resonant circuit brings one important factor to light. The formula relating resonant frequency to the inductance and capacity forming the common resonant circuit is well known to be:—

$$^1/_2\,\pi\,\sqrt{LC}$$

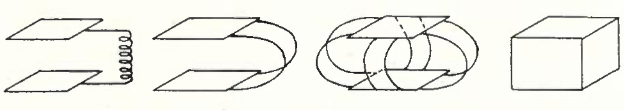
and in Fig. 6 values of inductance and capacity for several typical frequencies have been set out. The values shown would not necessarily be used in practical resonant circuits, but the table brings out the point that at UHF and VHF we are dealing with very small inductances and capacities. The obvious direct result is that a length of wire which at lower frequencies would have negligible reactance, has, at these higher frequencies, a very significant reactance; similarly, stray capacities between circuit elements assume increasing importance as the frequency is increased.

| FREQUENCY CYCLES/SEC. | $\sqrt{LC}$ | INDUCTANCE "L" | CAPACITANCE "C" |
|---|---|---|---|
| 100 | $1 \cdot 59 \times 10^{-3}$ | 2·53 HENRIES | 1 MICROFARAD |
| 10,000 [=10KC] | $1 \cdot 59 \times 10^{-5}$ | 2·53 MILLI HENRIES | 0·1 " |
| 1,000,000 [=1MC] | $1 \cdot 59 \times 10^{-7}$ | 2·53 " " | 10 MICRO MICRO FARADS |
| 100,000,000 [=100MC] | $1 \cdot 59 \times 10^{-9}$ | 2·53 MICRO HENRIES | 1 " |

**Fig. 6.—Simple Resonant Circuit.**
$f = 1/2 \pi \sqrt{LC}$

Another property of electric circuits which assumes increasing importance at the higher frequencies is "skin effect," where the current flow in a conductor tends to be concentrated at the surface rather than inside the body of the conductor. In the UHF region, the current flow becomes negligible a few thousands of an inch below the surface and the current is better regarded as being on the surface of the conductor instead of through that conductor.

At UHF it is frequently more convenient to consider concepts of electric and magnetic field rather than current and voltage. This is not fundamentally new, and is the only effective method of visualising any radiated electro magnetic wave, and in dealing with circuits in the same manner, it is only a matter of approach to the problem rather than a fundamental change. With this viewpoint, the surfaces of conductors carrying charges and currents may be looked upon as limits betwen which fields exist or as boundaries enclosing regions in which fields exist. With this idea in mind, we revert to the resonant circuit and attention is drawn to Fig. 7. In this im-



(a) (b) (c) (d)

**Fig. 7.—Development of Resonant Cavity from Simple Resonant Circuit.**

portant fact that ultra high frequency waves do not appreciably penetrate the conductors, there is the answer to the problem of constructing circuit elements so that the loss of energy by radiation is minimised. This is done by making the circuit element self-enclosing, and the practical realisation is the circuit element known as the resonant cavity. In Fig. 7 an attempt has been made to develop the resonant cavity from the well-known resonant circuit.

(a) Illustrates the conventional diagram for a parallel resonant circuit, giving a high impedance at the appropriate frequency.

(b) Shows an inductance of a single turn which will have a sufficiently high reactance for UHF.

(c) Several inductances are connected in parallel across the plates of the condenser.

(d) The number of single turn inductances is increased to fill the gaps giving a totally enclosed cavity—this cavity may be excited in any one of a number of ways, but it has a resonant frequency determined by the dimensions, and at this frequency there will be a high electric field between the condenser plates and high currents through the inductances, i.e., on the sides. It should be noted in passing, though the matter will not be examined in detail, that such a cavity may frequently be caused to resonate in several different modes. It is often convenient to visualise resonant conditions which will apply inside the cavity as somewhat similar to the conditions under which sound waves may cause resonance in an enclosed room. It is well known that for the production of standing waves or resonances in such a room, the separation between walls must be a half wave length for the appropriate frequency or a multiple of a half wave length.

It is desirable to use self-enclosing transmission lines at VHF and UHF, and coaxial cable is the commonly used transmission line for VHF purposes. For receiving purposes, an advantage is the screening by the outer (usually earthed) conductor of the inner conductor from interference. As the frequency rises into the UHF range, a stage is reached where the wave length is so short that the method of dealing with fields inside enclosures, as with resonant cavities, can be applied to transmission lines leading to wave guides. This method of transmission might be regarded as using a tube or pipe to guide a radio frequency wave, radiated from a source such as a probe or loop at the transmitting end. Electro magnetic fields may be formed in the wave guide in a number of modes depending on the relationship between physical dimensions and wave length and there is a minimum frequency (or maximum wave length) beyond which it is impossible to transmit power along any particular wave guide due to the field or wave being unable to fit into the space available.

A further factor to be discussed in this section is "electron transit" time. In dealing with the operation of valves at the lower frequencies, it is known that a change in grid voltage or plate voltage, or both, affects the space charge around the cathode and the current flow between electrodes. It is assumed that these changes are instantaneous and the time taken for the space charges to be effected or the plate current to change to a new value is ignored, and at lower frequencies this is quite satisfactory. Obviously, however, electrons do take some time, admittedly very small, to travel from cathode to anode and, if the controlling voltage on the grid is changing sufficiently rapidly as in UHF applications, the time available before the grid voltage sets up new conditions may be insufficient for the electron system to change its character, e.g., change of anode current. As the operating frequency is increased, therefore, consideration must be given in the design and use of valves to the time taken for electrons to move across the inter-electrode space, i.e., the transit time, and valves which may be quite satisfactory at lower frequencies cease to be useful at much higher frequencies.

Using the common form of valve, there are two evident methods of attempting to reduce this transit time:

(i) by increasing the velocity of the electrons by using higher working voltages, and/or

(ii) by decreasing the distance to be travelled.

Both these methods are used, and it is fairly well known that valves for VHF and UHF purposes are much smaller in general than the valves used in similar circumstances at medium frequencies, say, in standard broadcast band. The use of these methods is limited by physical considerations in that breakdown of insulation may occur and it is difficult to reduce the size of components to sufficiently small dimensions. In many cases, therefore, the problem is approached in a different manner in that use is made of transit time rather than endeavour to reduce it, thus introducing new techniques in valve design and manufacture.

Fig. 8 illustrates diagramatically the principle of operation of the velocity modulation tube. In

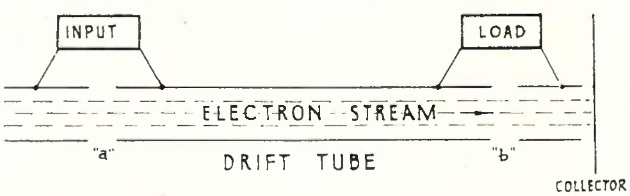



Fig. 8.—Principle of Velocity Modulation Valve.

this valve, the stream of electrons is generated by a cathode and accelerated by a high voltage, and then set travelling at constant velocity along a tube which shields it from external fields. At the point indicated by "a", the shield is broken and a high frequency field introduced across the gap, and, being alternating, accelerates some electrons and decelerates others as they pass; this causes some electrons to catch up to others, and the electron system develops dense regions and rarefied regions. Thus the original uniform density or D.C. beam of electrons becomes a modulated beam with A.C. and D.C. components. At some distance down the shielding tube, sometimes spoken of as the "drift" tube, there is a second gap and as the modulated beam passes this gap, a field corresponding to the A.C. component is formed across the gap and used to supply power to an output load. The electron system passes on to a collector electrode at the end of the tube. Thus in the output circuit, there is a high frequency current of the same form as at the input, and as very little power input can influence the electron stream and as the output field depends on the density of the passing electron stream, amplification can be arranged. By inter-connecting the output and input circuits and arranging dimensions, voltages, and resonant circuits appropriately, the tube becomes the oscillator. An important point to note here is that in this case it is necessary that the electrons should travel slowly by comparison with the rate of change in voltage across the control gap, since otherwise the electrons would travel beyond the tube output circuit before the modulated beam is formed—in other words, this type of tube is making use of transit time. It should be noted also, that the electron stream in this case passes both input and output circuits acting as a bearer of energy, but the electrons are not collected by the output circuit.

### Practical Applications

The practical advantages of the types of the radio systems which have been generally discussed all arise from the one fundamental advantage that radio communication has over other methods, that is, no physical connection is required between two terminals. For point-to-point services, therefore, radio is particularly suitable where line construction is very difficult or very costly, as across large bodies of water, rough country, or desert. In respect to the omni-directional type of service, radio is suitable where a very large number of locations are concerned as in broadcasting services, or where transmitting and/or receiving points are mobile, as in communication between vehicles.

It was pointed out earlier that the availability of channels increases with increase of radio carrier frequency, and that the use of VHF and UHF permits sharing of carrier frequencies. In the interests of conserving radio channels and as it is already difficult to accommodate all services in the M.F. and H.F. parts of the radio spectrum, it is most desirable that VHF and UHF (preferably the latter) be used wherever practicable, which also gives other advantages as, for instance, small aerial systems. This matter of conserving spectrum space is very important with wide band services as multi-channel telephone systems, television and the like.

However, V.H.F. and U.H.F. have only a limited range, particularly the latter, where optical ranges are the limit for practical purposes, and to overcome the limited range, repeaters are employed for fixed point-to-point systems for trunk telephone purposes and television relaying. This system is illustrated in Fig. 9. For a projected point-to-point telephone or similar system, the use of radio instead of open wire or cable (including coaxial cable) requires a detailed examination and economic comparison of the various alternatives, but, in general, it is reasonable to expect that the cost of providing a multi-channel radio telephone system (say 20 telephone channels) over a long distance and, therefore, involving repeaters, will be comparable with the cost of providing the same number of telephone channels by other means. It is probable that radio system costs will be reduced by comparison with other methods in the future and it seems likely that, as equipment is developed, it may prove economical to use UHF radio systems for such purposes as providing junctions in exchange networks.

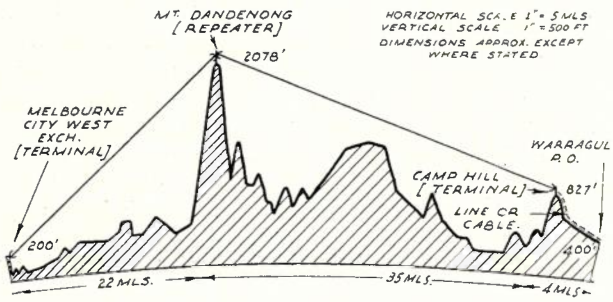



Fig. 9.—Profile Diagram Typical U.H.F. Radio Telephone System.

For a single, isolated telephone channel, it is generally the experience that, though the radio equipment proper is very cheap, other factors such as the cost of providing buildings on eminences, power for equipment operation, and the necessity for skilled attendance for maintenance are the more important considerations. As at the present stage of development UHF is generally uneconomical for this type of service and as propagation path conditions are less restrictive, the most suitable arrangement will generally be to use VHF, with a preference for the higher frequencies and a progress to lower frequencies if this is necessary to exploit the greater ability to pass obstacles.

With omni-directional services as broadcasting or mobile telephones, radio is the only effective means of providing service and the M.F. and H.F. bands are used extensively for this purpose. Again, with the main object of conserving radio channels in these parts of the spectrum, the trend is to use much higher frequencies, but as the service range is less limited by optical path requirements and because of greater ability to pass round hills, buildings, and other obstacles, services of this type generally use VHF rather than UHF. The use of repeaters, in the sense in which the word is used with trunk telephone services, is obviously not practicable in these cases, but inter-connection of a number of stations results in extension of the service area covered by a system, and assists in reducing the number of locations in which communication would otherwise be poor, due to excessive shadowing, and this arrangement could be regarded as a type of repeatered system. This is illustrated in Fig. 10.

**Systems Engineering**

In examining any communication project for which a V.H.F. and/or a U.H.F. radio system appears suitable, the first matter to be considered is the band width (or, in the case of the telephone service, the number of channels) required. The greater the band width, the more desirable does it become to operate at higher frequencies. For wide band projects, the initial examination is, therefore, directed towards the use of U.H.F. involving optical paths; the actual frequency is not very important at this stage, as it will usually be determined by other factors such as availability of equipment and the portion of the spectrum allocated for the type of service being considered. For narrow band purposes such as single channel telephone systems, the necessity of conserving spectrum space is rather less important though it should not be overlooked.

For omnidirectional services such as broadcasting or mobile, it is obvious that topographical conditions will, in general, preclude the securing of optical paths between all points concerned, and, therefore, services of this type are best accommodated in the V.H.F. range again with a preference for the higher frequencies of that range.

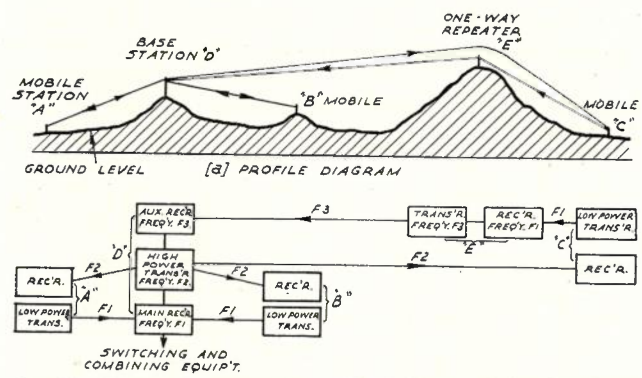



Fig. 10.—Typical Arrangement for U.H.F. Mobile Radio Telephone System.

It will be apparent from the foregoing that, since optical paths between terminals and/or repeaters are essential for U.H.F. systems and decidedly advantageous for V.H.F. systems, the first step in the engineering of such radio systems involves a study of the topographical conditions between the points concerned, and that stations should, where practicable, be on eminences giving commanding views in the required directions. From a study of maps, likely locations for stations may be selected, and then a profile drawing of the country between the selected points prepared to ascertain whether or not optical path conditions apply. Suitable maps are 4 miles to the inch for preliminary examination and 1 mile to the inch for detailed study. Fig. 11 illustrates a typical profile drawing. For practicable purposes at the present stage of development, U.H.F., systems should be planned to give a clearance of about 100 feet of intervening country in addition to the bare optical path, and the distance between stations should, as an objective, be not more than 35-40 miles.

Where optical paths are not practicable, V.H.F. should be considered as previously stated, and the distance spanned depends on the extent of shadows caused by obstacles. The calculation of the range of service is beyond the scope of this paper,

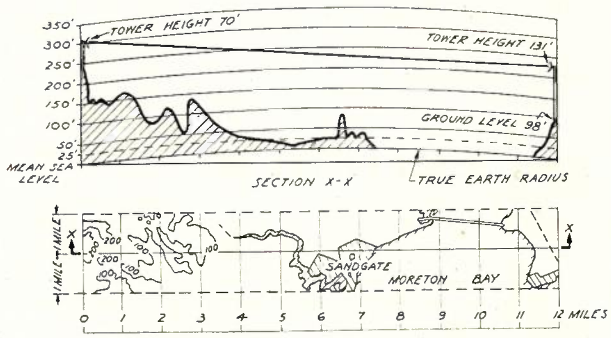



Fig. 11.—Typical Profile Plan.

but it is probably enough to say that calculations can be made to a sufficient degree of accuracy to enable systems to be planned in a satisfactory manner.

In conjunction with this map study, consideration has to be given to other practical aspects such as access, suitability of land for construction of buildings and towers which may be required to provide extra height to clear unavoidable obsctacles, trees, etc., in the vicinity of the station, connection to a telephone exchange if this is the type of service being examined, availability of power and like matters, so that it is usually necessary to compromise in the final determination of sites. Field investigation will be necessary to confirm the selection of sites as well as aid the detailed planning of stations, and in many cases it will be necessary to check paths by survey methods, heliographs, or signal lamps, since many Commonwealth maps are not sufficiently accurate. Radio frequency tests may be necessary in some cases.

Having planned the location of stations, i.e., the route, the next matter to be dealt with is the type of plant to be used, which depends, of course, mainly on the service required. This is a very big subject and it is not proposed to go into details in this paper.

However, it may be of interest to readers to mention briefly the more important of the V.H.F. and U.H.F. radio systems, apart from experiment on trial installations, in use or to be brought into use in the near future by the Department.

### (a) Trunk Telephone System.

(i) Single channel system operating at frequencies near 40 Mc/s and near 160 Mc/s. The number of operating frequencies available is not great (particularly as regards the "lower" frequencies) and a considerable distance may be allowed between stations sharing the same frequency. It is probable that, in the main, extension of this class of system will be confined to serving isolated towns in remote localities, and islands.

(ii) Multi-channel systems involving superposition of conventional carrier telephone system (s) on the radio "bearer," and using frequencies near 40, 60, 160, 400, 900 and 4000 Mc/s. For the reasons previously discussed, the future use of the lower frequency systems will be limited, and such systems should be confined to projects for which the higher frequencies are not suitable because of the impracticability of obtaining suitable propagation paths as, for example, over large bodies of water.

Greater bandwidths, and, therefore, more superimposed telephone channels, can be arranged at the higher frequencies. The 400 Mc/s and 900 Mc/s systems furnish a band-width of approximately 60 kc/s, permitting the superposition of a 12 channel carrier system, and it is to be expected that many systems of this type will be used.

At 4000 Mc/s, Australian systems are at present giving a bandwidth of 150 kc/s (30 telephone channels) approximately, but it would be desirable to achieve greater bandwidth to justify the relatively high cost of equipment designed for this high frequency and this is being done in other parts of the world.

(iii) Multi-channel systems using the pulse technique to derive the telephone channels and on frequencies near 2000 Mc/s (22 channels) and 5000 Mc/s (8 channels). This type of system does not fit as neatly into the line and cable (with carrier) network as the wide band class of system mentioned under (ii), but there should be many applications for the type for spur lines, and a probable future for junctions and similar requirements where radio stations and terminal exchanges are close together.

### (b) Broadcast Type Systems.

(i) Mobile systems serving vehicles providing connection as for telephone subscribers into the general telephone network and operating at frequencies near 160 Mc/s. Again the number of operating frequencies may limit extension of this class of system, and the use of higher frequencies may be essential despite the increasing difficulty due to propagation path requirements.

(ii) Fixed subscribers' services using frequencies near 40 Mc/s. This system is similar to the above and similar remarks apply.

## Bibliography

There have been numerous articles in the technical press in recent years on this subject, and the following few have been selected as the most suitable for a general study of the subject:—

1. "Radio Propagation at Frequencies above 30 Megacycles," K. Bullington, Proceedings of the Institution of Radio Engineers (America), October, 1947.

2. "Microwave Repeater Research," H. T. Friis, Bell System Technical Journal, April, 1948.

3. "Introduction to Microwaves," Simon Rama, book published by McGraw-Hill.

4. "The Elements of Pulse Time Modulation," J. D. Campbell, Telecommunication Journal of Australia, October, 1946.

5. "A New V.H.F. Multi-circuit Radio Telephone System," J. J. E. Aspin, G.E.C. Telecommunication, Volume 4, No. 2, 1949.

6. "Carrier Power Requirements for Long Distance Communication by Microwaves," A. G. Clavier, Electrical Communication, March, 1950.

7. "A Microwave Relay Communication System," G. G. Gerlach, R.C.A. Review, December, 1946.

## MR. W. H. WALKER, B.E., A.M.I.E. (AUST.)

It is with considerable regret that the Society records the retirement of Mr. W. H. Walker from the position of Honorary Secretary. In 1942, Mr. W. H. Walker took over the secretarial duties of the Postal Electrical Society of Victoria in succession to the late Mr. A. R. Gourley, and since that date has been closely associated with the affairs of the Society, which now has members or subscribers in all States of the Commonwealth as well as in many overseas countries.

The success of the Society over the last nine years has been due in no small measure to the splendid and untiring work carried out by Mr. Walker, both in the organisation of the regular bi-monthly lectures held in Melbourne and the publication of the Journal. During the critical war years many difficulties were experienced in organising lecture programmes, overcoming problems of paper rationing and co-ordinating the work of the Committee, Editors and Sub-Editors. In the post-war period, and contrary to expectations, the problems increased rather than decreased. Pressure of Departmental work, further material shortages and rising costs have increased considerably the difficulties of the secretarial work and the Society owes a great debt of gratitude to Mr. Walker for the manner with which he has coped with the many problems during this difficult period.

After actively participating in the work of the Society for nine years, Mr. Walker felt that he should relinquish the secretarial duties. His resignation was accepted with regret by the Committee, and a resolution was adopted placing on record the appreciation of all members for the work carried out by Mr. Walker. At a subsequent committee meeting Mr. Walker was unanimously elected a life member of the Society, a distinction held by only a few members.

The Society is fortunate that it will not lose Mr. Walker's services and the benefit of his long and valuable experience in the administration of the Society's affairs. He has agreed to retain control of the important work associated with the position of Distribution Manager for the Journal, and will, in this capacity, continue this phase of the work that he has carried out so efficiently during his period as secretary.

All readers of the Journal will join in expressing the appreciation of Mr. Walker's services and in wishing every success to Mr. R. D. Kerr, who has taken over the position of secretary.

# THE DESIGN OF BUILDINGS FOR BRANCH AUTOMATIC EXCHANGES AND COUNTRY CENTRES

J. L. Skerrett and W. C. Kemp

## Introduction

It is generally appreciated that in the post-war era in Australia there has been a serious shortage of building materials and labour. This situation has arisen primarily because normal building activities lapsed during the war years, efforts being then directed to projects related to the war effort. Since 1945, there has been an unprecedented demand for homes, and, despite the fact that the erection of homes has been stepped up year by year, there is still a serious shortage. Coupled with the demand for homes, there is a constant drain on building materials and manpower to meet the needs of industry and commerce as well as National Service projects, Immigration hostels and important developmental schemes.

The shortages coincide with the largest building programme ever undertaken by the Australian Post Office. Naturally the increase in population and the general development is reflected in increased demand for telephone service. The opening up of entirely new areas, the building up of capital city and inner metropolitan areas, and the trend towards decentralisation of industry are factors which cause demands for new exchanges and additional trunk lines. The provision of suitable accommodation is an essential pre-requisite, and it is necessary for the building construction rate to keep pace with cable and equipment installation programmes if the best results are to be achieved.

A large proportion of space available in existing exchanges has already been occupied, and many major extensions are in progress to provide further floor areas. The greatest task, however, lies in the provision of new buildings for new exchange areas. As well as the shortage of materials and manipulative labour, the associated professional effort needed on a large building programme, in the form of architects, engineers, and quantity surveyors, is today in excess of staff availability.

It has become essential, therefore, in order to obtain results in the shortest possible time, to standardise as far as practicable, on designs and techniques, so that the maximum in equipment space may be obtained with the minimum expenditure of effort and material. To assist in conserving building materials in short supply, imported prefabricated units of special design are also being utilised as much as possible.

As a result of conferences during 1949, between representatives of the Buildings Branch, the Engineering Branch and the Department of Works and Housing (which is the constructional authority for all Commonwealth buildings), reference plans for standard types of buildings for branch automatic exchanges and country engineering buildings were prepared. The general constructional requirements and the functional arrangements have been specified, and the application of these plans and principles should enable economy to be effected in the work of planning and designing staffs and will permit of buildings being advanced more rapidly to the constructional stage than was previously possible when detailed working drawings and specifications had to be prepared individually for each building.

As a principle, it is obvious that a course should be chosen that will avoid either a large number of small building extensions at too frequent intervals or conversely extravagant provision of space at a high capital value which may be unoccupied for a lengthy period. Such a choice requires wise discrimination which is best acquired from the pooling of experience, and this was the fundamental purpose of the 1949 conference. In the complementary paper in this issue by E. J. Bulte and C. McK. Lindsay, details are given of the standardisation achieved in the design of the engineering features of exchange buildings, and an indication will be given in this article of the building designs which have been developed to meet the functional needs of the telecommunication equipment which they will house.

It is possibly interesting to record that at present 33 new automatic exchange buildings are either in course of construction, or at the contract stage, in the city and metropolitan networks of the various State capitals, whilst at the same time major extensions are proceeding at a further 15 existing exchanges. These buildings, when completed, will provide space for 200,000 lines of automatic equipment. In addition, plans are well advanced for a further 51 automatic exchange buildings, including a large number of prefabricated units, and these should be advanced to the constructional stage within the next 12 months. These buildings range from limit height city structures, to main and branch exchanges of 10,000 lines capacity, down to small "fringe" exchanges of 1,000 lines.

Because of variations in the supply of essential building materials, notably structural steel, cement and bricks, it is difficult to predict with accuracy the number of lines of equipment that can be installed each year from this building programme, but telephone development is being closely analysed so that the more urgent needs can be satisfied. The building programme must be closely related to engineering proposals so that the provision of accommodation is co-ordinated with supplies of equipment and cabling schemes in each particular area.

Considerable space relief can be anticipated when the imported prefabricated units are erected to house exchanges, and this will enable equipment installation staffs to be employed whilst larger conventional buildings are proceeding to completion. As explained later, these prefabricated units will provide permanent buildings and will be erected wherever conditions are suitable to their use. Supplemented with prefabrication, the standardisation of buildings is designed to provide accommodation in each metropolitan area in accordance with the cable and equipment available.

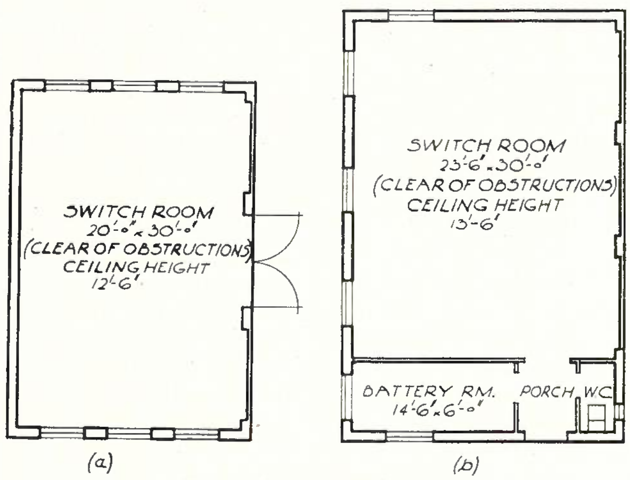



Fig. 1.—Garage Type Buildings.

## Metropolitan Areas—Branch Automatic Exchanges

The following information outlines the guiding principles which are to be applied in designing buildings for branch automatic exchanges. The application of these plans and principles will enable considerable economies to be effected. It is also expected to expedite planning work and to ensure that any future growth necessary in such buildings will be unimpeded by obstacles which wise planning should eliminate. An example of such obstacles would be the placing of toilet or air treatment blocks in such a position that their removal with the associated plumbing or duct work is an expensive first step to the extension of the equipment switchroom.

The information set down forms a guide to the size, shape and relationship of rooms required within an exchange building, so that the final form of the structure will enable it to satisfy efficiently the required functional needs. In the words of the eminent American architect, Frank Lloyd Wright, "Form follows function."

### Basic Planning

The designs are so arranged that the essential rooms can be extended in future years without difficulty or undue expenditure. As most building requirements vary with time, and the conditions obtaining in the locality served, an attempt has been made to answer the important questions of when to build and how large. The basic planning period is 20 years, and the fundamental sizes in terms of exchange capacity, are 1200, 4800 and 9600 lines. This determines how large the original building should be and when and how it should be extended. It is desirable to avoid building too small at first, and then be forced to extend at frequent intervals and conversely to build too elaborately initially and incur an unjustifiable capital outlay which is unreasonable for the purpose of the structure and so have accommodation lying idle. This is particularly true today, when building materials and labour are in short supply, costs are high, and it is important in the interests of national economy to limit public works to urgent and essential requirements.

Standard reference plans have, therefore, been prepared for four basic standard types of buildings for branch automatic exchanges and in order of cost they are as follows:—

(a) **Garage type building** (1,200 lines capacity). A temporary building normally on the same allotment as the future permanent exchange building. It may be converted subsequently to a three-vehicle garage. The choice of location of such a building on the site is important

| Telephone development in subscribers' lines—20 years. (See note 1.) | Details of building. | Type | Overall size of building. | |
|---|---|---|---|---|
| | | | Width | Length |
| Less than 1,000 (See note 2.) | Building of 1,200 lines capacity for future conversion to three-vehicle garage to serve the ultimate permanent exchange building. | Fig. 1. (a) | 22′ | 32′ |
| | | (b) | 25′ 6″ | 38′ 6″ |
| 1,000-4,800 (See notes 3 and 4) | Part section of ultimate single-storey or mezzanine building, comprising half-size switchroom of 4,800 lines capacity and certain full-sized auxiliary service rooms. | Single-storey Fig. 2. | 82′ | 90′ |
| | | Mezzanine Fig. 3. | 52′ | 92′ |
| Greater than 4,800 (See note 4) | Ultimate size building for 9,600 lines, single-storey, mezzanine or double-storey type. | Single-storey Fig. 2. | 83′ | 118′ |
| | | Mezzanine Fig. 3. | 52′ | 120′ |
| | | Double-storey Fig. 4. | 52′ | 105′ |

Table No. 1.—Branch Automatic Exchanges—Standard Types.

and is dealt with in more detail later.

(b) **Single-storey building** (4,800 lines initial—9,600 lines ultimate capacity).

(c) **Mezzanine type building** (4,800 lines initial—9,600 lines ultimate capacity).

(d) **Double-storey building** (9,600 lines initial—ultimate capacity).

Table No. 1 summarises the salient features in choosing the type of building for a particular application.

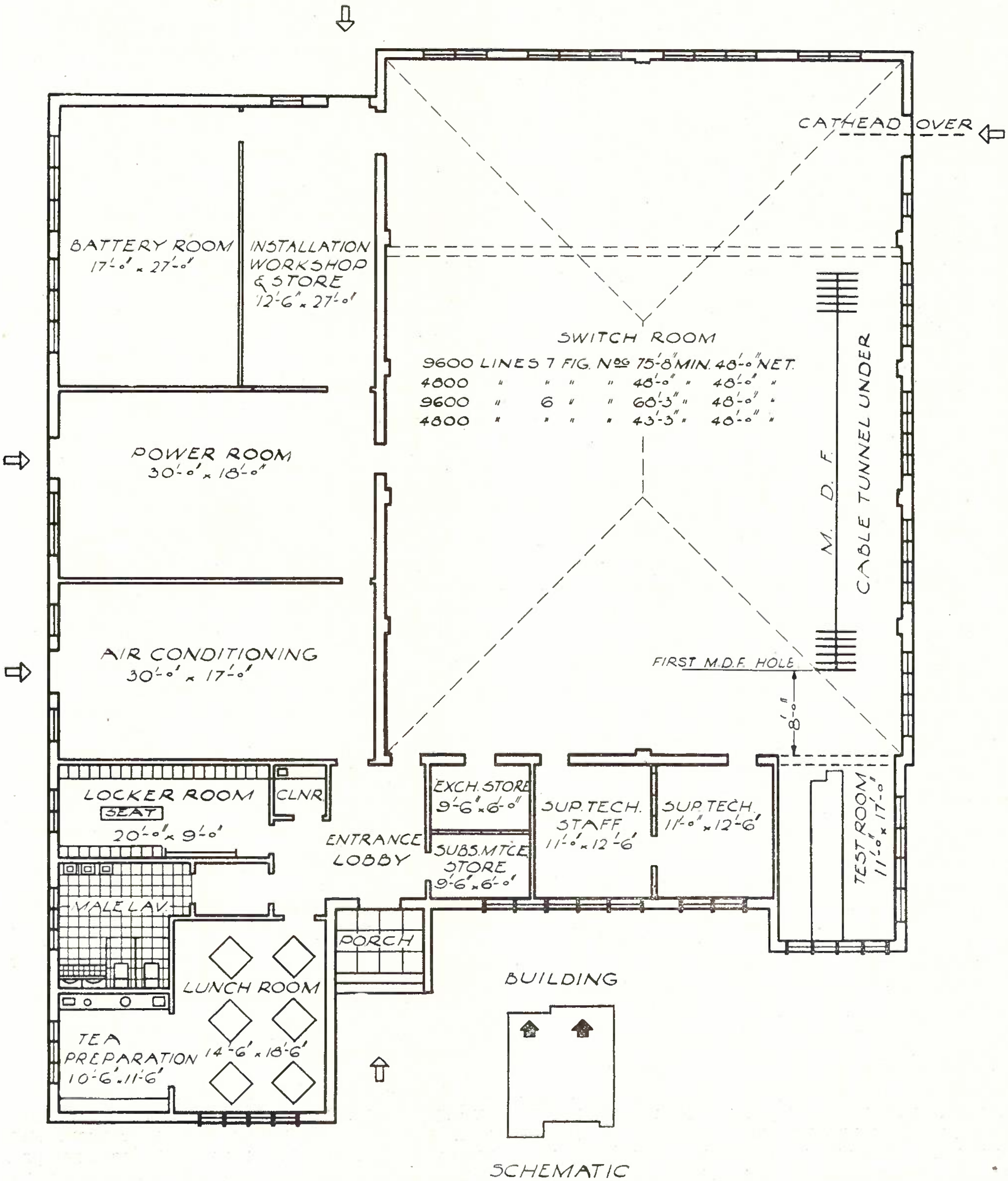



Fig. 2.—Branch Automatic Telephone Exchange, Single Storey Type.

### Notes

1. Calculated from the date at which it is estimated the initial equipment installation will be cutover.

2. In outlying areas a building providing temporary accommodation should be provided, either designed and located to permit conversion to form part of the garage unit for the future permanent exchange building; or of the portable type, capable of being removed to another site after serving its purpose.

For metropolitan "fringe" type exchanges the buildings are usually required to meet urgent requirements for the interim period before the permanent exchange building can be provided. Where it can be anticipated that the permanent building can be expected within ten years, the garage type building should be reduced to utmost simplicity, with a view to providing the switchroom only within a 20′ x 30′ structure with at least one pair of the garage doors, preferably the centre, provided initially, to admit equipment. This type is

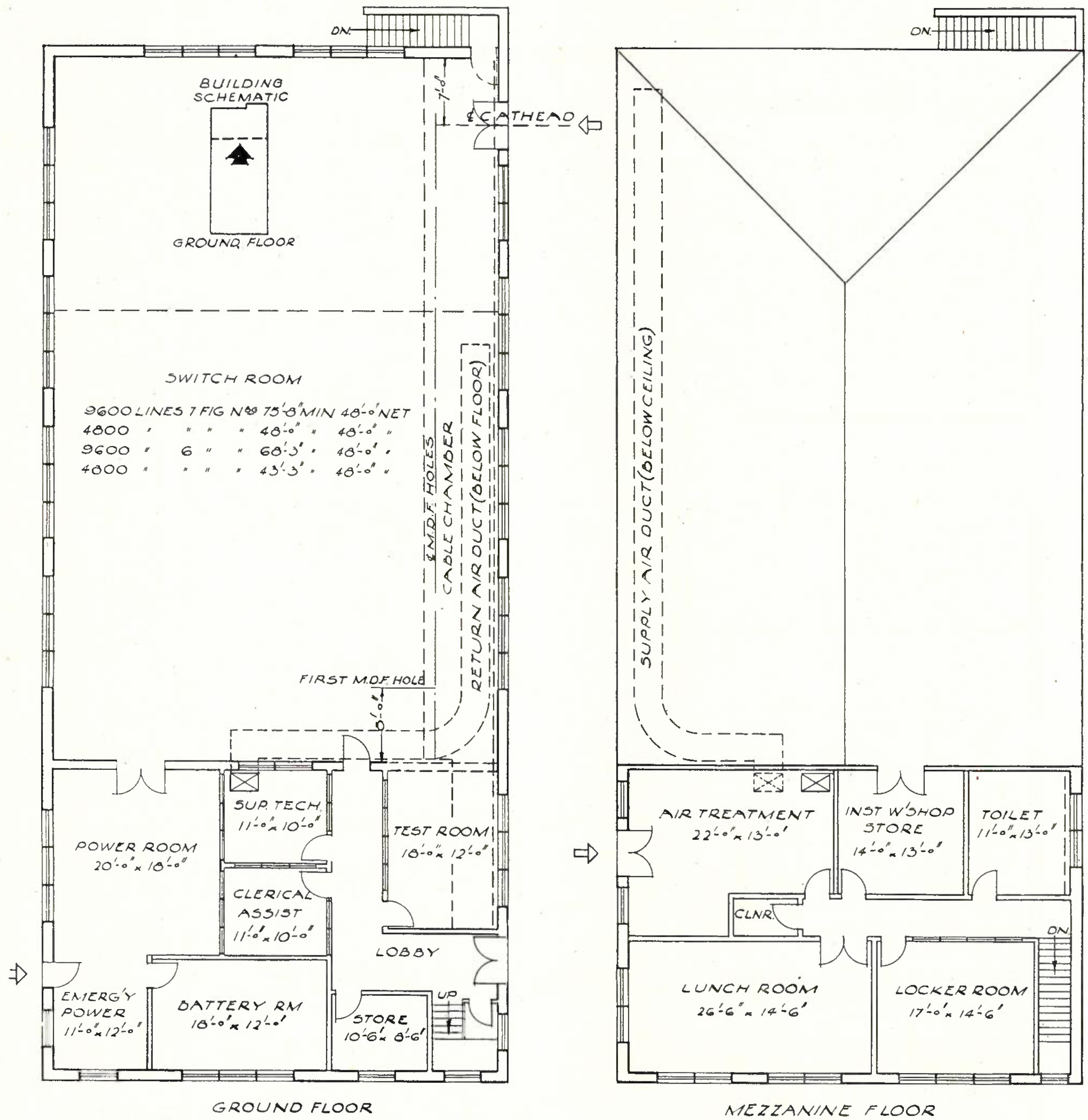



**Fig. 3.—Branch Automatic Telephone Exchange, Conventional Type Building—Mezzanine Type.**

shown in plan in Fig. 1 (a). The cable entry will influence the location, but the building should be placed in the rearmost corner of the exchange allotment in such a position that the erection of the future exchange permanent building will not be impeded. In this regard, the free space required for foundation and cable chamber excavations, together with normal operations incidental to building erection should not be ignored. Location of conventional traditional type buildings on minimum allotments is illustrated in Fig. 5, which indicates the principles described. It is proposed that the auxiliary rooms such as battery and power should, if necessary, due to development, take the form of either skillion construction or separate external structures which may be of portable type and capable of re-employment elsewhere in due course. Observing this principle will enable the switchroom to be fully occupied by switching equipment. The plans show in each case the full 9,600 line building, but in most cases where the garage type building is used initially, the conditions of development will be satisfied with a 4,800 line building as the second stage, and it is likely that there will be room on the allotment for the garage and outbuildings as well as the 4,800 line unit during its construction.

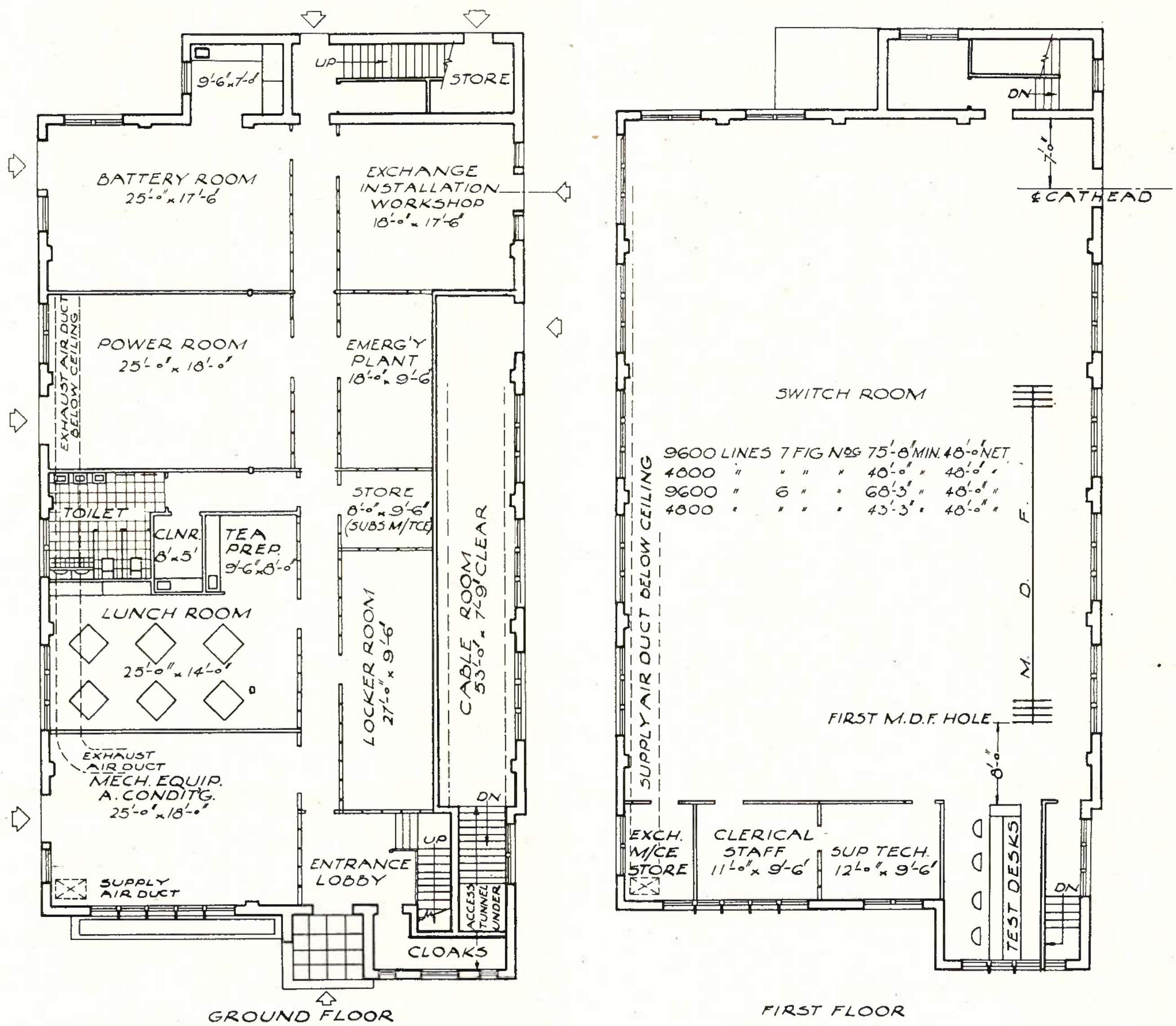



Fig. 4.—Branch Automatic Exchange. Conventional Type Building—Double Storey, 9,600 lines capacity.

Fig. 1 (b) illustrates the more elaborate type of garage building, which is suitable where the anticipated life of the building, as an exchange, is likely to exceed 20 years. Therefore, its function as an exchange should not be subordinated to its future use as a garage, but the principles outlined for the simpler building should be applied where practicable. It will be seen that this building (Fig. 1(b)) is larger than the simpler (Fig. 1 (a)) type and occupies more space on the allotment. Should this appear as a possible obstacle to orderly development of the ultimate building scheme, consideration should be given to the use of the smaller building supplemented by additional skillion construction or the use of external auxiliary rooms as described earlier.

3. Where the 20-year development figure is greater than 1000 lines, but where this figure will not be reached for ten to fifteen years, a garage type building should be provided initially. The permanent exchange building on the same allotment should be provided when the development demands it.

4. The choice of the type of building, whether single-storey, mezzanine or double-storey, is dependent mainly upon the capacity of the exchange smaller site is required. (This may not apply, however, where the subsoil is yielding and increased foundations are necessary. In such cases a mezzanine type may be more suitable as the frontage is the same as that required for a double-storey building.) The principal elements of these three designs are shown in Fig. 6 (a), (b) and (c).

### Site Requirements of Buildings

**Location.** On account of the high cost of underground plant the location of the site should be as close as possible to the copper centre subject to availability of suitable areas of land in the vicinity. In order to reduce underground plant costs it is desirable that the site shall be so located that the diversion of cables will avoid new crossings under railways, tramways and main roads.

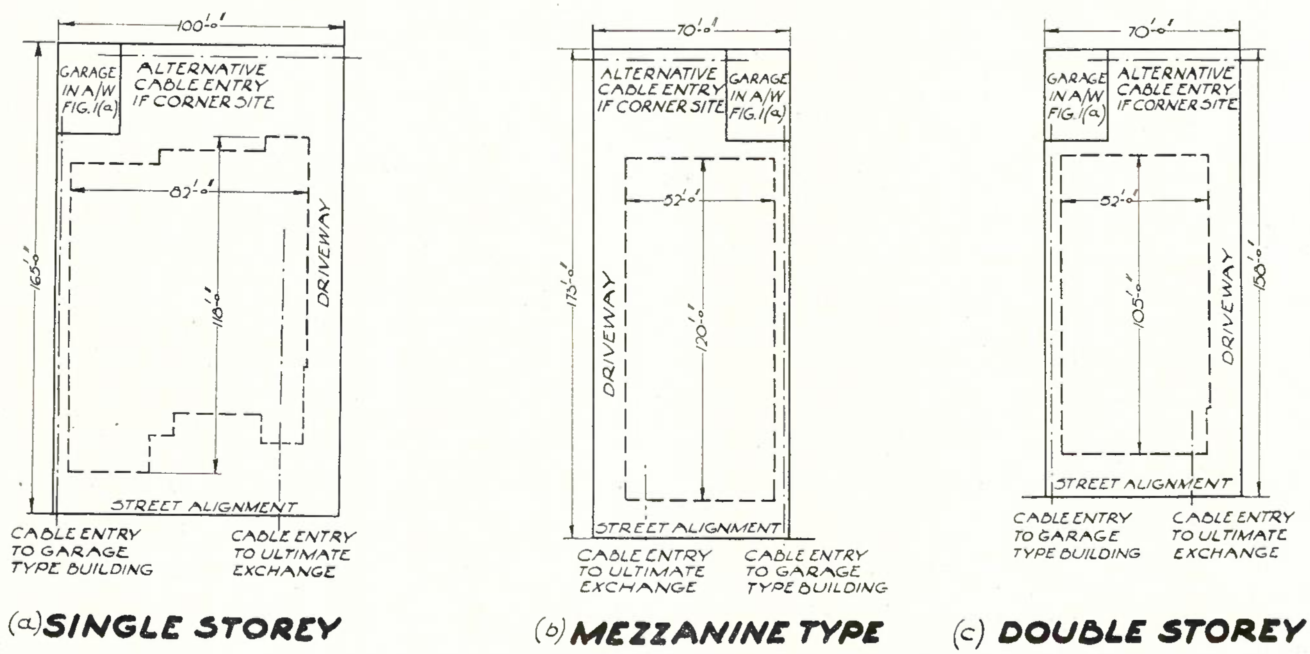



Fig. 5.—Branch Automatic Exchanges, Conventional Type Buildings—Site Layouts. For recommended building clearances refer Table No. 2.

to be erected initially, the dimensions and the slope and nature of the site. A single-storey building may be preferred where there is no difficulty in obtaining an allotment 100 to 110 feet in frontage and of adequate depth, suitably situated from an engineering economics point of view. A mezzanine building lends itself particularly to a site sloping towards the front. A double-storey building, however, may be erected only when the ultimate (9,600 line) size building is justified at the outset, that is when the 20-year development figure exceeds 4800 lines. In certain places, such as inner-suburban localities, a 9600 line capacity building may be justified initially. Of the three standard types on a 9600 line basis, a financial study may favour the double-storey building due to the lower excavation cost for the type of cable entry required in this type, particularly if rocky substrata is encountered, and the simpler cable entry construction needed subsequently. Also a

**Excavation (Refer. Fig. 6 (d) and (e)).** The cost of excavating the cable chamber may be reduced if the site is not on an embankment above street level with a sharp difference in levels, and the site has a transverse slope.

**Drainage (Refer. Fig. 6(f)).** It is desirable that the site shall be on the high side of the street with an even fall toward it. This assists drainage towards the cable chamber in single-storey and mezzanine type buildings.

**Allied Activities.** Because dust must be excluded from the switchroom, it is undesirable to have any other activities, such as line depots or cable storage accommodated in the exchange grounds. Treatment of the building surrounds should aim at minimising dust and facilitating drainage.

**Building Clearances.** The dimensions in Table No. 2 define the passageways and setback from

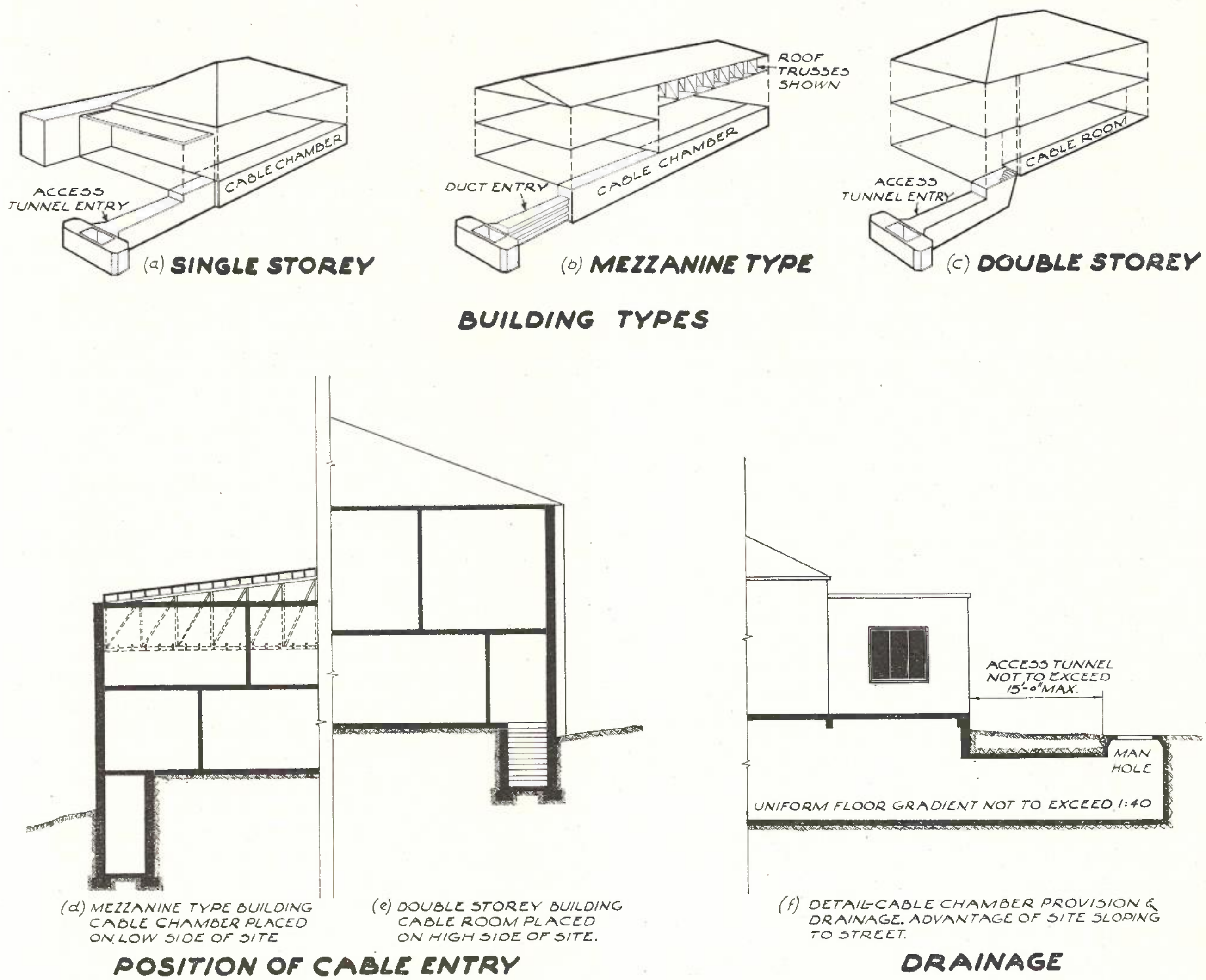



Fig. 6.—Elements of Conventional Exchange Building Design.

the street alignment, which should be observed in the location of exchange buildings.

**Note 1.** In front of the garage a paving depth of 20 feet is only suitable if a roller type or retractable door is used. If swing doors are provided, say 5 feet in width, the area should be increased in depth by a similar amount. The distance quoted in Table No. 2 may have to be varied to conform to local building regulations, but generally should be not less than the minimum shown, to improve lighting and reduce fire risk. In business, industrial and low grade congested residential areas, it may not be necessary to set the building back from the street alignment for aesthetic reasons. With single-storey and mezzanine type buildings the overall width or length will be affected by the position of stairwells to the cable chamber. This position will be decided by the contour of the site and the shape of the allotment, and so may be located at either side or at the rear of the building. The dimensions given should be clear of such features.

## Orientation of Buildings on Sites

As well as preceding factors, the principles set out in the following notes should be observed:—

**Aspect.** As air treatment is provided for the

| Item | Minimum (feet) | Optimum (feet) |
|---|---|---|
| Clear width of driveway | 12 | 15 |
| Clearance from side of building to boundary, other than driveway | 6 | 12 |
| Setback of building from street alignment | 15 | 25 |
| Clear aisle, if necessary, for manoeuvring vehicles between building and garage—(See note 1). | 20-25 | 27 |

Table No. 2.

switchroom only, it is undesirable to have the outer walls of this room, and in particular its longitudinal wall, exposed to the hottest aspect as the load on the air treatment plant will be increased. If this is unavoidable, however, there should not be unduly large areas of glazing, as the insulating quality of glass is greatly inferior to that of brickwork. For single-storey and mezzanine type buildings, placing the cable chamber on the low side reduces the excavation needed and assists natural lighting and ventilation in the cable chamber. In the double-storey building, placing the cable room on the high side simplifies provision of the access tunnel to the cable chamber leading into the cable room on the ground floor. Any of the standard layouts may be mirrored to suit the conditions of a site.

**Architectural.** The side or sides of the building facing the street should have the best architectural aspect. In select residential areas consideration should be given to refinements such as retractable cathead hoists and setting the building well back from the frontage in harmony with surrounding structures. The latter-mentioned feature requires special entrances with suitable paving or garden treatment. Single-storey types on corner allotments are usually improved by placing the auxiliary rooms rather than the switchroom on the street alignment. Examples of each type of building are shown in Figs. 7-12.

**Cable Entry.** Cable lead-in arrangements and conduits should be planned so that all conduits and manholes are clear of power, water, gas, sewerage and other underground reticulations. Manholes should be clear of all driveways, including those of adjoining properties, conduit runs should avoid driveways as far as possible and changes in direction of conduits, which necessitate additional manholes should also be avoided.

**General.** In the location of garage type buildings providing temporary equipment accommodation, the garage should be located on the site so as to permit the erection of the future permanent exchange building with minimum inconvenience to the existing exchange facilities. For the same reason cable ducts to the garage building should be laid close to a boundary of the site in a position remote from the future building foundations, and preferably clear of the future permanent driveway.

The temporary driveway to the garage should, where practicable, be clear of the future building. The garage type building should be erected with an orientation appropriate to its future function as a garage for the permanent building and should, therefore, not occupy a prominent position on the block. In certain cases it is necessary to place it on the boundary and this requires brick parapet walls.

## Design Principles

**Disposition of Rooms.** Where departure from the layouts shown is necessary, it is essential that the principles of relationship inherent in the standard reference plans should be observed in order that the advantages to be derived therefrom should not be lost.

**Siting.** As the largest and most important room, the switchroom should form the central nucleus of the branch automatic exchange building arrangement. The main distributing frame (M.D.F.) and its position in this room is of major importance as it forms the link between the external underground cable plant and the internal exchange equipment. The M.D.F. should preferably be placed at right angles to the street from which the underground cables will enter the building to facilitate cable hauling operations. Conjointly, the main frame in conventional buildings should be adjacent and parallel to an outer wall of the building.

To suit the foregoing conditions, the exchange building may be orientated so that the switchroom is located longitudinally or transversely on the allotment. The plans shown herewith of exchange buildings are suitable for mirroring to meet the requirements of particular aspects or shape of allotment. Generally, the M.D.F. will extend from the first cable hole toward an external wall of the building to facilitate future extension of both the frame and the switchroom.

**Switchroom.** This should be located to receive as much natural lighting as practicable and hence there should be windows along at least two walls, which should be external. In the case of a double-storey building, the switchroom should occupy the first floor to obtain best natural lighting and reduce the excavation required for the cable entry. In certain areas, this may also be a safeguard against flooding.

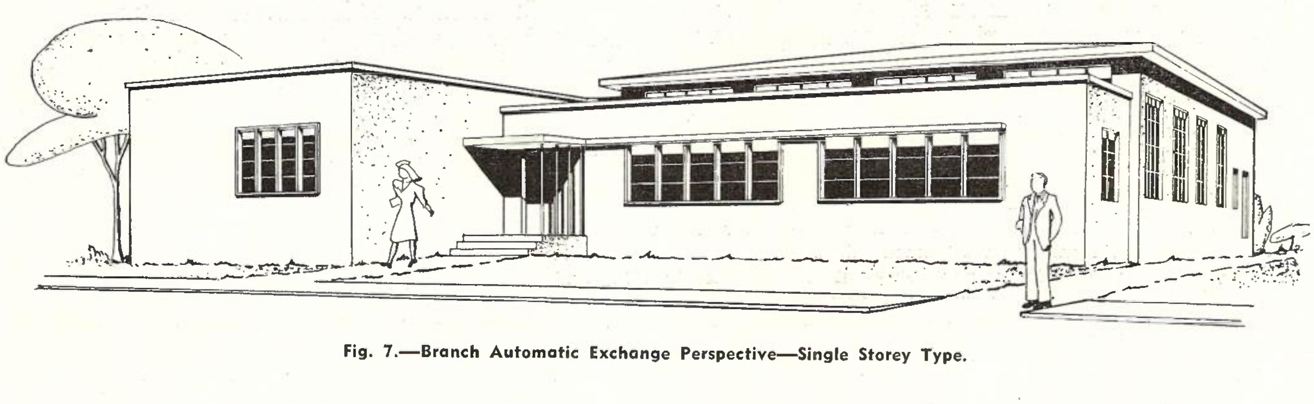


Fig. 7.—Branch Automatic Exchange Perspective—Single Storey Type.

**Floor.** The floor should be of reinforced concrete and designed to carry a loading of 200 lb. per square foot and cement rendered to a level, hard, smooth surface. That portion forming the roof of the cable chamber should for preference be a reinforced concrete slab of uniform thickness to permit regular spacing of cable holes at $6\frac{3}{4}$ inches centres beneath the M.D.F. In double-storey buildings, however, this arrangement may not be practicable, and the size and spacing of particular M.D.F. holes may require to be varied, due to the incidence of transverse beams. The floor is usually covered with high quality inlaid linoleum. Experiments are being made with alternate treatment using mastic tiles. Hospital corners should be provided between the walls and floor in all rooms except the storerooms and cable chamber. The radius should be 3 inches, with a suitable step at floor level to provide for the laying of linoleum or other floor covering.

**Ceiling.** The height of the ceiling is 13 feet 6 inches. The ceiling construction should be dust-tight and fireproof. The butt joints should be sealed over with calico or linen strips glued on before the cover strips are fixed. The building should be designed without internal supporting columns in the switchroom wherever practicable, and the building designs developed for 48 feet switchrooms provide for clear spans without internal columns. Where columns are necessary in switchrooms, naked steel sections should be used, restricted to a minimum and located so that they stand in the lines of equipment racks, either at the end of a suite or between adjacent racks, flush with the equipment face. Generally, such columns will require to have their centres spaced at multiples of 6 feet 6 inches relative to the equipment suites along the length of the switchroom. No special provision is made in the ceiling or roof design for the support of ceiling hangars for cable runways, but the ceiling joists should be located to allow for the installation of standard runway hangars. The ceiling is to be suitably insulated to assist the operation of the air treatment plant or help in temperature control where such plant is not installed.

**Cathead.** The ceiling should be constructed to support a retractable cathead over the external doorways for admitting equipment. This doorway is either in the end or side outer wall of the switchroom and should provide an opening not less than 5 feet wide extending to the ceiling. The cathead and hoist should be capable of lifting $1\frac{1}{2}$ tons, and is centred over the equipment doorway in each type of exchange. In the double-storey type, the installation workshop door is also centred under the cathead. Its location should provide the trucks delivering equipment with a clear driveway space to manoeuvre clear of stairwell entrances and for equipment to be deposited from the monorail clear of equipment suites. The cathead doors should open inwards clear of rack-work. On upper floors suitable external removable crossbars should be provided to safeguard personnel during opening of cathead doors.

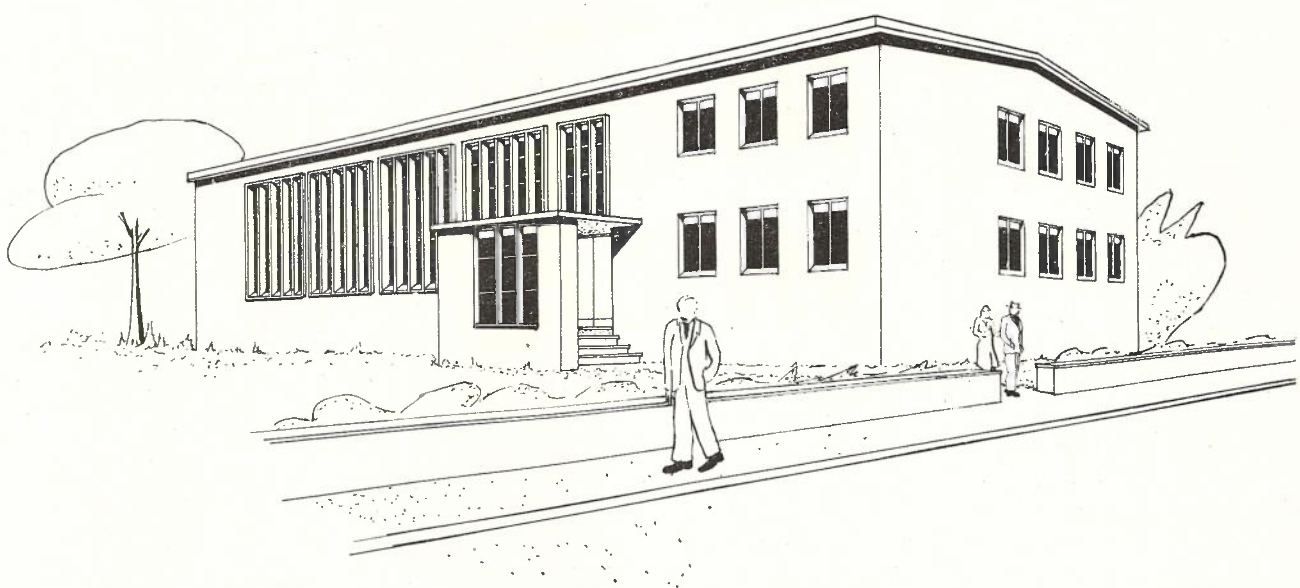


Fig. 8.—Branch Automatic Exchange Perspective—Mezzanine Type.

The range of the monorail should be from 6 feet outside the building to 10 feet inside the switchroom. In single-storey switchrooms the hoist should be hand-operated, but an electrically operated type should be provided in double-storey buildings. Generally, if a stairwell is at the end of a building the cathead should be at the side, and vice versa.

**Windows.** Where windows to the switchroom are on the north or west elevations and exposed to the sun (that is not under wide eaves or some alternative shade) they should be suitably shielded, frosted, sandblasted, or fitted with nonactinic glass. In order to assist in the control of switchroom temperatures, the total area of glazing in a wall should not exceed one-third of the area of that wall. For the same purpose, and to exclude dust, most windows should be fixed, but about 10% of the glazed area should be capable of opening to meet emergencies.

The heads of windows in switchroom walls adjacent to the M.D.F., or in either of the walls parallel to the equipment suites, should be low enough to leave a clear wall space above for the attachment of tie bars from the equipment rack work. The tie bars from the M.D.F. are secured by bolts approximately 12 feet 10½ inches, and those from the suites 10 feet 9½ inches from the floor. Window construction should be steel-framed, with reinforced glass to reduce fire risk and possibility of damage to equipment from missiles. Hopper type windows should not be used, but wooden frames may be necessary in localities where corrosion is severe. Internal sills should be tiled or similar smooth finish and sloped at 30° to prevent dust and/or material accumulating. Windows are not provided in the section of the switchroom walls above the auxiliary rooms where this provision interferes with satisfactory roof treatment.

**Gas Supply.** The provision of gas points in the switchroom is limited to not more than three points. When provided, two are near the M.D.F. and one elsewhere for general use. These gas points are flush-inset in the inner face of the external walls of the switchroom with suitable ventilation outlets.

**Test Desk Room.** The test desk room is formed by a special bay off the switchroom nearest the end of the M.D.F. The room is not partitioned off from the working area as it is desirable to provide unrestricted access to the M.D.F. from the testing positions. In order to limit the effect of switchroom noise, the ceiling of the testing area is treated with suitable acoustic material. If necessary, this material may be extended down over portion of the walls.

**Staff Rooms.** The Supervising Technician's office should be conveniently accessible from the main entrance to the building and adjacent to the switchroom and test desk room. There should be ready access to the switchroom and an intervening window giving a clear view of the equipment area. The clerical assistant's office should adjoin the Supervising Technician's office with ready access to it and, if practicable, the exchange maintenance piece parts storeroom. If necessary, the staff rooms may be provided as partitioned off sections within the switchroom. The staff rooms have a combined floor area of the order of 200 to 250 square feet.

Fig. 9.—Branch Automatic Exchange Perspective—Double Storey Type.

**Power Room.** The dimensions of this room will be governed by the decision as to whether motor generators or rectifiers are to be employed as a means of converting A.C. to D.C. power for battery charging. In single-storey and mezzanine type buildings, the power room should be adjacent to the switchroom with ready access therefrom, but should not be on the M.D.F. side of the switchroom, nor on the end at which the switchroom may be extended. In all types of building, the power room should be on the ground or subground floor. (The latter-mentioned position applies in single-storey buildings where there is a difference in floor level between the switchroom and auxiliary rooms.)

The internal doorway providing access from the switchroom should preferably enter the aisle in front of the power-board suite. An equipment entrance doorway is necessary into the power room. This should be through an external wall if the driveway permits. Otherwise, an internal door should be provided, so located as to enable power plant to be brought in through the building. The most convenient arrangement is for the door to be in line with the dividing aisle across the equipment room.

The recommended design for the power room floor consists of a brick or concrete well below the main floor level to run cables and to provide flexibility in the layout of power plant. There should be a 2 feet clearance from the underside of the main floor to the paved floor of the well, and trapdoor access is provided from behind the powerboard. The well is to be sealed to render it damp, dust and vermin-proof, and is provided with drainage facilities. The main floor over the well should be supported on brick or concrete piers, and may be of timber or reinforced concrete. If timber, hardwood should be used, secret nailed, sanded and wax polished to a gloss finish. The width of the floor-boards should not exceed three inches.

All plant (including ringer tables and motor generators) should be mounted direct on the main timber or concrete floor. The practice of providing concrete bases for machines is being discontinued. A 4 inch diameter pipe line should be provided below floor level during construction of the building, extending from the rear of the power board to the cable chamber as a conduit for the earth lead.

**Battery Room.** The size of the battery room required will be governed by the reserve capacity to be provided in the batteries. The battery room should preferably be located toward the rear of the building, and against an outer wall to facilitate natural ventilation. If ventilation through an external wall is not practicable, then forced ventilation through a duct from the battery room to the outside air is essential. In all types of buildings this room should be on the lower floor. If future building extensions are anticipated it should be suitably located to facilitate expansion. Internal doors are made fume tight, and a suitable acid-proof sink and drainer is provided. The floor should be of concrete, properly graded and drained to a sump which can pass effluent to a neutralising chamber. The floor covering should be acid resistant. Floor chases which could cause a break in this covering must be avoided. Connections between the batteries and power boards may be by busbars, otherwise an earthenware conduit may be provided under the floor from the power room.

**Cable Chamber.** In orthodox construction the cable chamber proper is located beneath the switchroom floor, immediately below and in line with the M.D.F., and where excavated shall extend the full length of the building. This is necessary for entry of underground cables at the street end, for hauling of cables at the far end, and, in the event of building extensions, to avoid having to excavate underneath an existing structure.

As it is undesirable to lay conduits for cable lead-in purposes beneath foundations, due to the risk of damage by subsidence, an access tunnel is preferred, extending at least from the external wall of the building to enter the cable chamber proper. At present, an excavated cable chamber is necessary for single-storey and mezzanine type buildings. For the double-storey building, a ground-floor cable room is provided with limited excavation for an access tunnel only. It is not essential for this cable room to extend the full length of the building provided that no fixed installation is in the line of its future possible extension. Generally, an external entrance should be provided in the far end of the cable chamber to permit staff entry and cable haulage. Trapdoor access from the switchroom is being discontinued.

The simplest and cheapest method of draining the cable chamber is by gravity, but where this is not practicable an automatically controlled electrically driven centrifugal pump is most suitable for the purpose. Its intake should be fed from a sump in the lowest section of the cable chamber. Syphon pumps or valve controlled pumps ejecting into the sewerage system should be avoided except under special circumstances. Drainage of street manholes into the cable chamber must not be permitted.

**Air Treatment Room.** The general dimensions of the air treatment room are indicated in Fig. 13. Further space may be required if it is intended to locate emergency power plant in this room. The layout of the mechanical services room is a matter which must be associated with the design of the plant, having in mind the locality of the exchange and the design requirements. In the layout shown, separate items of equipment have been indicated, but the refrigeration compressor, the condenser and the conditioner may be combined in a single unit, which is then termed a self-contained unit conditioner. No provision has been made for a separate return air fan in the layouts, and the compressor space allows for a unit of 13 tons refrigeration capacity. The condenser and conditioner provide for capacities of approximately 20 tons. The arrangement permits replacement of conditioner tubes which would be withdrawn from the side facing the compressor. Condenser tubes would be withdrawn from the end nearest to the centre of the room. Sufficient space is allowed for access to the compressor for overhaul, and also for maintenance of the diesel engine. The oil-fired boiler capacity is approximately 240,000 B.T.U. In the layout, provision has been made for a commercial electric supply panel to be included in the mechanical services room. The size of the room is the minimum which can accommodate the equipment shown.

Present policy provides for emergency plant to be installed at certain branch exchanges where difficulties in continuity of commercial power supplies are expected, but, due to power restrictions, the provision of this plant may be extended to further cases. As it will generally be practicable to install emergency power plant in the air treatment room, suitable space reservation should be made unless local factors necessitate an individual room, either in the exchange building or in a separate block on the allotment. The latter course has the advantage of removing a possible source of vibration, noise and fumes from the main building, although modern types of emergency plant are much improved in these respects. For purposes of planning new building layouts, a size of 27 feet x 17 feet may be assumed for full air treatment and emergency plant, but this must be finally determined by consultation of the interested parties in individual cases.

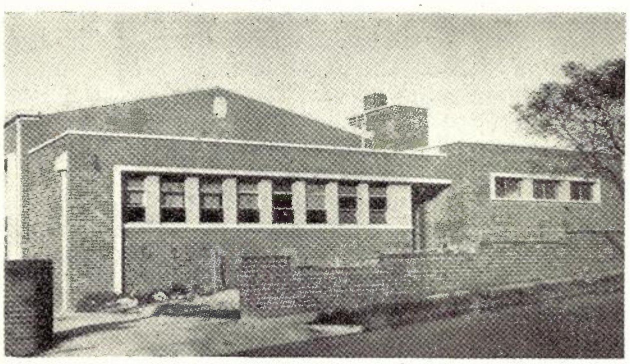


Fig. 10.—Single Storey Type Branch Automatic Exchange.

**Exchange Installation Workshop and Storeroom:** When combined, this room should have a minimum floor space of 250 square feet. It should be provided for the use of the exchange installation staff, because their work, such as unpacking creates dust, and it is undesirable to carry out fabrication and similar tasks within the switchroom. The installation room should be located convenient to the switchroom, preferably at the rear of the building. In double-storey buildings, it is desirable to locate the external equipment entry doors of the two rooms vertically above each other and on the same centre line as the cathead. This enables the hoist to unload equipment first into the workshop, and later to raise and deposit it in the switchroom.

**Storerooms.** Storage space is provided for exchange and subscribers' maintenance material. Residual space with an area of 100 to 150 square feet is suitable. This room should be adjacent to the switchroom and the Supervising Technician's office. When sub-station maintenance is involved the room should be located near the main entrance to permit the outside maintenance staff access without the necessity of passing through other rooms in the building.

**Amenities.** The space required for staff amenities provision will be determined by the ultimate staff estimated for the exchange when it reaches 9,600 lines capacity. This estimate will not be the same for all branch exchanges, as it will depend upon local factors. The following figures may be accepted as a guide to the staff occupancy in the general case:—

| | |
|---|---|
| Exchange maintenance (including trainees) | 23 |
| Sub-station maintenance | 4 |
| Exchange installation | 6 |
| Cleaners and assistants | 4 |
| Total | 37 |

The maximum staff on duty simultaneously in such a case would be about 25 officers.

The general provision of the luncheon, locker and toilet rooms must be carefully considered to ensure that the provision is adequate but not extravagant. The amenities block is usually best placed at the front of the building, as this prevents it forming an obstacle to future building extensions which usually are towards the rear of the site. The toilet room, however, should not be placed so that the louvre windows or external plumbing features are on the front facade of the building. Placing the locker room near the front entrance permits personnel to reach it readily, and it is an advantage to have the staff rooms in close proximity so that the supervision exercised acts as a safeguard against the entry of unauthorised persons. A locker should be provided for each member of the staff, and the area occupied by each locker now measures 15 inches x 15 inches in plan.

Fig. 11.—Double Storey Type Branch Automatic Exchange.

Luncheon accommodation will not be required for the full staff as only a proportion of those on duty will be at lunch simultaneously, and it is usually found that only about 75% of these use the luncheon facilities. The fittings include a sink and drainer, and food heating facilities.

| FLOORS | | SINGLE | | | | | | | | MEZZANINE | | | | | | | | | | DOUBLE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LINES | | 4800 | | | | 9600 | | | | 4800 | | | | | 9600 | | | | | 9600 | | | | |
| No. | Room | Min. Req't | Length | Width | Ceiling Height | Min. Req't | Length | Width | Ceiling Height | Min. Req't | Length | Width | Ceiling Height | Floor (note 23) | Min. Req't | Length | Width | Ceiling Height | Floor (note 23) | Min. Req't | Length | Width | Ceiling Height | Floor (note 23) |
| (a) | (b) | (c) | (d) | (e) | (f) | (g) | (h) | (i) | (j) | (k) | (l) | (m) | (n) | (o) | (p) | (q) | (r) | (s) | (t) | (u) | (v) | (w) | (x) | (y) |
| 1 | Switch room 6 Fig. Numbrg. 7 " " (note 1) | 48' wide by 43' 3" by 48' 0" | 44' 0" 48' 0" | 48' 0" net | 13' 6" min. | 48' wide by 68' 3" by 75' 8" | 69' 0" 76' 0" | 48' 0" net | 13' 6" min. | 48' wide by 43' 3" by 48' 0" | 44' 0" 48' 0" | 48' 0" net | 13' 6" min. | G | 48' wide by 68' 3" by 75' 8" | 69' 0" 76' 0" | 48' 0" net | 13' 6" min. | G | 48' wide by 68' 3" by 75' 8" | 69' 0" 76' 0" | 48' 0" net | 13' 6" min. | 1 |
| 2 | Cable room or chamber | | Switch room (notes 2 and 3) | 7' 9" min. | 11' 6" max. | | Switch room (note 3) | 7' 9" min. | 11' 6" max. | | Switch room (note 3) | 7' 9" min. | 11' 6" max. | SG | | Switch room (note 3) | 7' 9" min. | 11' 6" max. | SG | | Switch room (notes 3 and 4) | 7' 9" min. | 11' 6" max. | G G |
| 3 | Access tunnel | Length equal to test desk room | 17' 0" (notes 6 and 8) | 4' 6" min. | 7' 0" min. (note 5) | Length equal to test desk room | 17' 0" (note 6) | 4' 6" min. | 7' 0" min. (note 5) | | 34' 0" (note 6) | 4' 6" min. | 7' 0" min. (note 5) | SG | | 34' 0" (note 6) | 4' 6" min. | 7' 0" min. (note 5) | SG | | 17' 0" (note 7) | 4' 6" min. | 7' 0" min. (note 5) | SG |
| 4 | Test desk (note 9) | 4 pos'ns 11' wide 17' long | 17' 0" | 12' 0" | (note 10) | 4 pos'ns 11' wide 17' long | 17' 0" | 12' 0" | (note 10) | 4 pos'ns 11' wide 17' long | 18' 0" | 12' 0" | (note 10) | G | 4 pos'ns 11' wide 17' long | 18' 0" | 12' 0" | (note 10) | G | 4 pos'ns 11' wide 17' long | 17' 0" | 11' 0" | (note 10) | 1 |
| 5 | Staff Supg. Techn. Clerical asst. (note 11) | 100 sq. ft. " " | 12' 6" 12' 6" | 11' 0" 11' 0" | " | 100 sq. ft. " " | 12' 6" 12' 6" | 11' 0" 11' 0" | " | 100 sq. ft. " " | 11' 0" 11' 0" | 10' 0" 10' 0" | " | G | 100 sq. ft. " " | 11' 0" 11' 0" | 10' 0" 10' 0" | " | G | 100 sq. ft. " " | 12' 0" 11' 0" | 9' 6" 9' 6" | " | 1 |
| 6 | Battery | | 18' 0" | 11' 6" | (note 12) | 27' long 17' wide | 27' 0" | 17' 0" | (note 12) | 17' 6" long 11' 6" wide | 18' 0" | 12' 0" | (note 12) | G | 17' 6" long 11' 6" wide | 18' 0" | 12' 0" | (note 12) | G | 25' long 17' 6" wide | 25' 0" | 17' 6" | (note 12) | G |
| 7 | Air treatment | (note 15) | 17' 0" Part ultimate area | 15' 0" | (note 13) | (note 15) | 30' 0" | 17' 0" | (note 13) | (note 15) | 22' 0" | 13' 0" (note 14) | (note 13) | 1 | (note 15) | 22' 0" | 13' 0" (note 14) | (note 13) | 1 | (note 15) | 25' 0" | 18' 0" | (note 13) | G |
| 8 | Power Rectifier Motor gen'r | | 18' 0" | 18' 0" | (note 10) | | 20' 0" 30' 0" | 18' 0" 18' 0" | (note 10) | | 20' 0" | 18' 0" | (note 12) | G | | 20' 0" | 18' 0" | (note 12) | G | | 25' 0" | 18' 0" | (note 10) | G |
| 9 | Emergency power | | | | | Accommodate in air treatment room | | | | | 12' 0" | 11' 0" | " | G | | 12' 0" | 11' 0" | " | G | | 18' 0" | 9' 6" | (note 12) | G |
| 10 | Installation (Exch. eqpt.) | Provide in part of air treatment space (sub-divide) | | | | | 27' 0" | 12' 6" | (note 16) | | 14' 0" | 13' 0" | " | 1 | | 14' 0" | 13' 0" | " | 1 | | 18' 0" | 17' 6" | (note 16) | G |
| 11 | Store space Exchange mtce. Subscribers' mtce. (note 17) | 100–150 sq. ft. | 9' 6" 9' 6" | 8' 0" 8' 0" | (note 12) | 100–150 sq. ft. | 9' 6" 9' 6" | 8' 0" 8' 0" | (note 12) | 100–150 sq. ft. | 10' 6" | 8' 6" | " | G | 100–150 sq. ft. | 10' 6" | 8' 6" | " | G | 100–150 sq. ft. | 10' 0" 9' 6" | 7' 0" 8' 0" | (note 12) " | 1 G |
| 12 | Luncheon | | 18' 6" | 14' 0" | (note 10) | | 18' 6" | 14' 6" | (note 10) | | 26' 6" | 14' 6" | " | 1 | | 26' 6" | 14' 6" | " | 1 | | 25' 0" | 14' 0" | (note 10) | G |
| 13 | Locker | (note 18) | 20' 0" | 9' 0" | " | (note 18) | 20' 0" | 9' 0" | " | (note 18) | 17' 0" | 14' 6" | " | 1 | (note 18) | 17' 0" | 14' 6" | " | 1 | (note 18) | 27' 0" | 9' 6" | " | G |
| 14 | Toilet (note 19) | | 12' 0" | 10' 6" | " | | 12' 0" | 10' 6" | " | | 13' 0" | 11' 0" | " | 1 | | 13' 0" | 11' 0" | " | 1 | | 11' 0" | 10' 6" | " | G |
| 15 | Cleaners (note 20) | | 5' 0" | 5' 0" | (note 12) | | 5' 0" | 5' 0" | (note 12) | | 7' 0" | 4' 0" | " | 1 | | 7' 0" | 4' 0" | " | 1 | | 8' 0" | 5' 0" | (note 12) | G |
| 16 | Garage 2 Vehicle 3 Vehicle | 10' x 20' per vehicle | 20' 0" 30' 0" | 20' 0" 20' 0" | (note 21) | 10' x 20' per vehicle | 20' 0" 30' 0" | 20' 0" 20' 0" | (note 21) | 10' x 20' per vehicle | 20' 0" 30' 0" | 20' 0" 20' 0" | (note 21) | | 10' x 20' per vehicle | 20' 0" 30' 0" | 20' 0" 20' 0" | (note 21) | | 10' x 20' per vehicle | 20' 0" 30' 0" | 20' 0" 20' 0" | (note 21) | |
| 17 | Building overall layout | | 90' | 82' | | | 118' | 82' | | | 92' | 52' | | | | 120' | 52' | | | | 105' | 52' | | |
| 18 | Site allotment required (note 22) | | 127' | 100' | | | 165' | 100' | | | 135' | 70' | | | | 173' | 70' | | | | 158' | 70' | | |

**NOTES**

1. Widths are net of any nibs or columns and are related to an M.D.F. 3' 7" wide. Lengths are governed by functional requirements. Actual lengths will be determined by structural grid and roof truss module details.
2. Switch room plus any future extension of building.
3. External entrance excluded.
4. Less any length not required for M.D.F. extension.
5. Floor usually common with cable chamber proper.
6. Longer if extended to street.
7. Includes stepped section.
8. Plus thickness of external wall if penetrated.
9. 13' 0" width desirable but 11' 0" min. can suffice if necessary.
10. Preferably 10' 0" but may be reduced to 9' 0" if necessary.
11. Combined area 200–250 sq. ft.
12. Not less than 9' 0" if on ground floor and not less than 8' 6" if on first or mezzanine floor.
13. As note 12 but may be modified due to duct requirements.
14. In mezzanine type buildings 10' 0" by 4' 6" alcove is available if required.
15. Air treatment requirements vary widely according to location and type of equipment.
16. Preferably 13' 6" to permit handling of jigged racks.
17. Store space may be provided in suitable residual areas.
18. Locker sizes are 1' 3" by 1' 3" in plan and 6' 0" high.
19. The building facade should not reveal plumbing features.
20. Cleaners' cubicles may be located in suitable residual areas preferably adjacent to toilets.
21. Not less than 8' 0" when approach is level. This provides for Morris panel van overall height 7' 5½".
22. The areas shown are minima and should be extended where possible to provide greater clearances or to meet local requirements.
23. G—ground floor, SG—sub-ground floor, 1—first floor.

**Table No. 3. Design Dimensions—Branch Automatic Telephone Exchange Buildings**

The dimensions of the switch room, test desk, power, battery and air treatment rooms are related to layouts of equipment and where shown in columns (c), (g), (k), (p) and (u) the dimensions are the minimum to accommodate the required present day equipment satisfactorily. The dimensions in the remaining columns have been taken from reference drawings of standard building plans and may, of course, be varied to suit individual building designs as long as the equipment layout requirements are met.

**Dimensions.** Table No. 3 summarises the requirements and sets out the dimensions of the various rooms provided in each of the reference plans.

### General

**Light and Power.** The general light and power treatment for automatic exchange buildings, including the provision of rack lighting and emergency lighting, involves a combination of fluorescent and incandescent lighting. The fluorescent fittings are provided over all important equipment, working areas and adjustment benches. The amount of illumination for the various areas throughout the building is specified, and this governs the spacing and size of fittings. Power points are provided at strategic points throughout the building for use with portable vacuum cleaners and other plant. The commercial power supply panel is usually located in the power room and should, where practicable, line up and match with the exchange power board suite. A separate earthing system for commercial supply should be provided at least 30 feeet from the exchange earth and should conform with the regulations of the local supply authorities.

**Fire Fighting Facilities.** The provision of fire fighting appliances in exchange buildings is based

Fig. 12.—Mezzanine (composite) Type Branch Automatic Exchange.

upon the installation of an automatic thermal alarm system, hydrants, and the provision of carbon tetrachloride extinguishers. The location of fire hydrants and portable appliances is important, and every care must be taken to ensure that they are readily accessible and that extinguishers are properly charged. In double-storey buildings provision is made for suitable fire escape stairways.

**Doorways—Equipment Entry.** Doorways, both internal and external, to admit equipment should provide clear openings preferably 5 feet and not less than 4 feet wide, 7 feet 6 inches high, except the cathead and air treatment room doors. The latter will be decided by the type and size of air treatment equipment employed and maintenance considerations of the emergency plant. External doors should effectively exclude wind, dust and rain, and should be suitably finished to prevent wind-borne water driving under. Kerbs should be weathered where this will not cause a hazard to personnel.

**Roof.** Roof gutters are to be avoided over the switchroom and on all walls adjoining this room. Water tanks must not be mounted above the switchroom ceiling. Primarily the roof should be watertight, dustproof and provide insulation against excessive heat and cold. Experience definitely favours a roof structure which is adequately and continuously pitched over its full extent, and finished with overhanging eaves. As well as assisting waterproofing the eaves reduce exposure of walls and this is important where extreme summer conditions or torrential rainfall may be experienced. Where avoidance of box gutters is impracticable, the top of the rainhead receiving the outflow should be located below the level of the bottom of the gutter. This prevents back pressure developing during abnormal rainfall and flooding from box gutters overflowing on to the roof. An external vent in the rainhead is also provided as further relief under extreme conditions.

**Internal Treatment.** Following modern practice pastel tonings generally are preferred for the internal colour schemes of exchanges. The colour scheme should be carefully chosen to blend

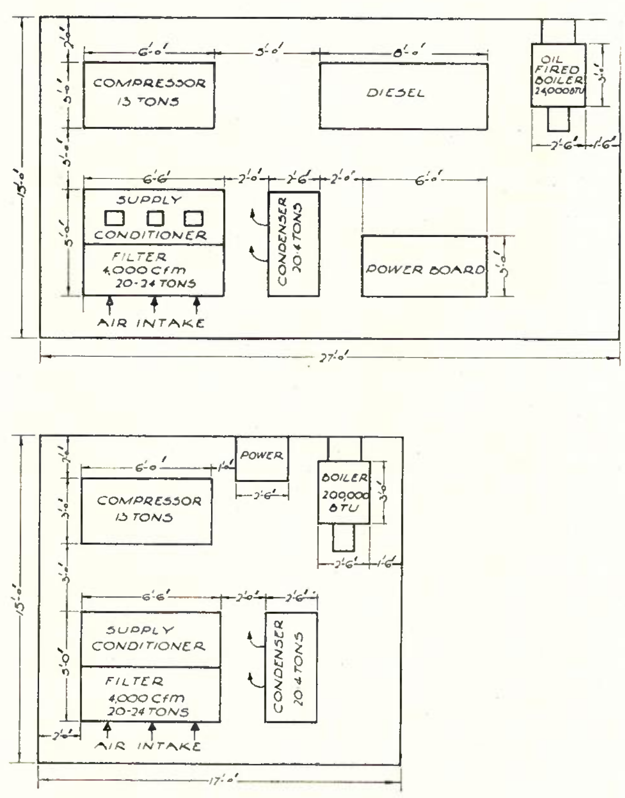



Fig. 13.—Layout of Mechanical Equipment.

throughout and the tonings used should assist in obtaining maximum efficiency from the lighting installation. Usually painting is deferred until the initial installation of equipment is completed.

### Country Centres

In country centres, the building problem becomes much broader in concept, and the space requirements cannot be confined to a consideration of the number of lines of equipment required for local services. The stepping up of immigration, decentralisation of industry, expansion of primary production and national projects are all contributing to the rapid development of many country areas. This increases the pressure for modern postal and communication facilities with an attendant demand for the necessary building space which should be properly designed to facilitate future development.

The problem of meeting the space requirements is a complex one, requiring a careful study and appreciation of a number of factors, chief of which are:—

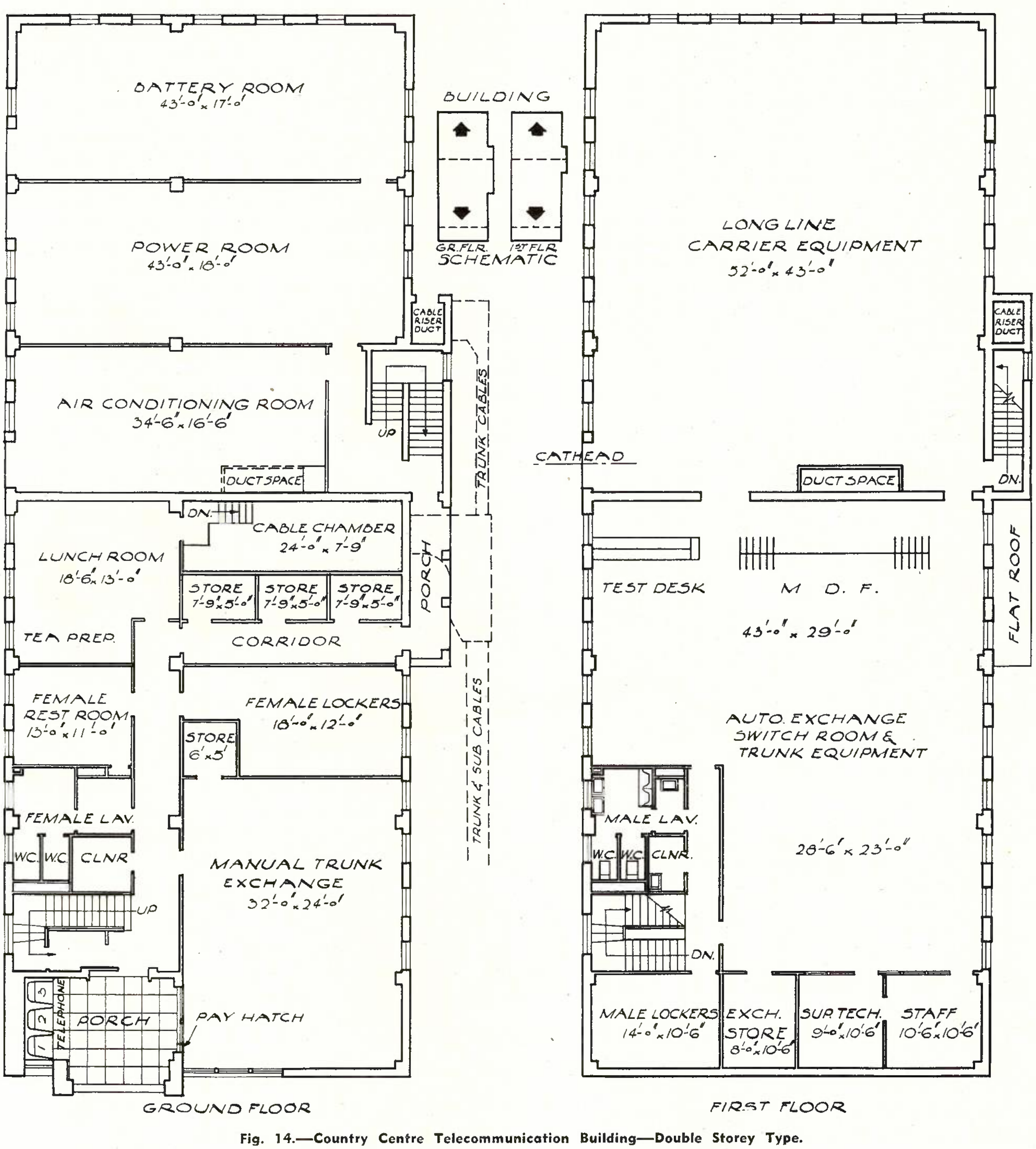



Fig. 14.—Country Centre Telecommunication Building—Double Storey Type.

(1) Provision of a combined post office and communication building or separate buildings.
(2) Conversion of the local exchange equipment to automatic working.
(3) Provision necessary for trunk line service involving:—
  (a) manual trunk exchange and associated female amenities area;
  (b) long line equipment;
  (c) automatic trunk switching equipment.

At the larger centres consideration must also be given to requirements for the following:—

(4) (a) Provision for telegraph and phonogram installations;
  (b) accommodation for regional administrative staffs;
  (c) provision for training and Postal Institute activities.

It is a difficult matter to reconcile the space requirements for a number of facilities and combine them into a building or buildings in such a way that future growth can be catered for without expensive rearrangements of plant and disruption to services. Proper planning of the functional layout of country buildings, and a study of all the needs in a particular area, can do much to rationalise the problem and time devoted to this aspect is well spent. Due to the wide variation in the size of country centres and the differences which exist as between industrial and primary producing areas, it is impracticable to prescribe building designs which will meet all cases. However, by the judicious use of reference plans and close adherence to certain functional principles of layout, the planning problem can be greatly simplified and buildings can be designed which provide satisfactory accommodation for a number of facilities, and at the same time allow for future growth to be met in an orderly and economical manner.

In smaller centres, the provision of separate buildings for postal and communication centres cannot always be economically justified. An empirical formula, which is applied as a rough guide only, indicates that a combined building is in many cases satisfactory where the estimated local telephone development in the area does not exceed 800 lines at the 20-year period. Reference plans have been developed for both single-storey or double-storey buildings on this basis, providing accommodation for postal services, local exchange and trunk line services. The functional layouts are arranged so that expansion of postal and communication services can be met, each within its defined area, by extension of the building without encroachment on the space required for other services.

Where separate post office and communication buildings are justified, it is desirable that they should be erected on the same site, where this is practicable and economical. Advantages which are derived from adjoining buildings are economy in amenities provision, convenience of concentration from the public viewpoint, simplification of supervision and scope for a better architectural treatment. In many important country towns, the post office and communication building block forms an important part of the civic centre.

Many variables have to be taken into account in designing buildings for country centres. In deciding whether communication services will be combined with postal activities, consideration must first be given to the engineering economics, particularly in relation to the copper centre of the locality and the leading-in of trunk cables. The availability of suitable sites and the relative costs of sites must also be considered, and whilst the concentration of all services at a central point has the advantages previously stated, these may in

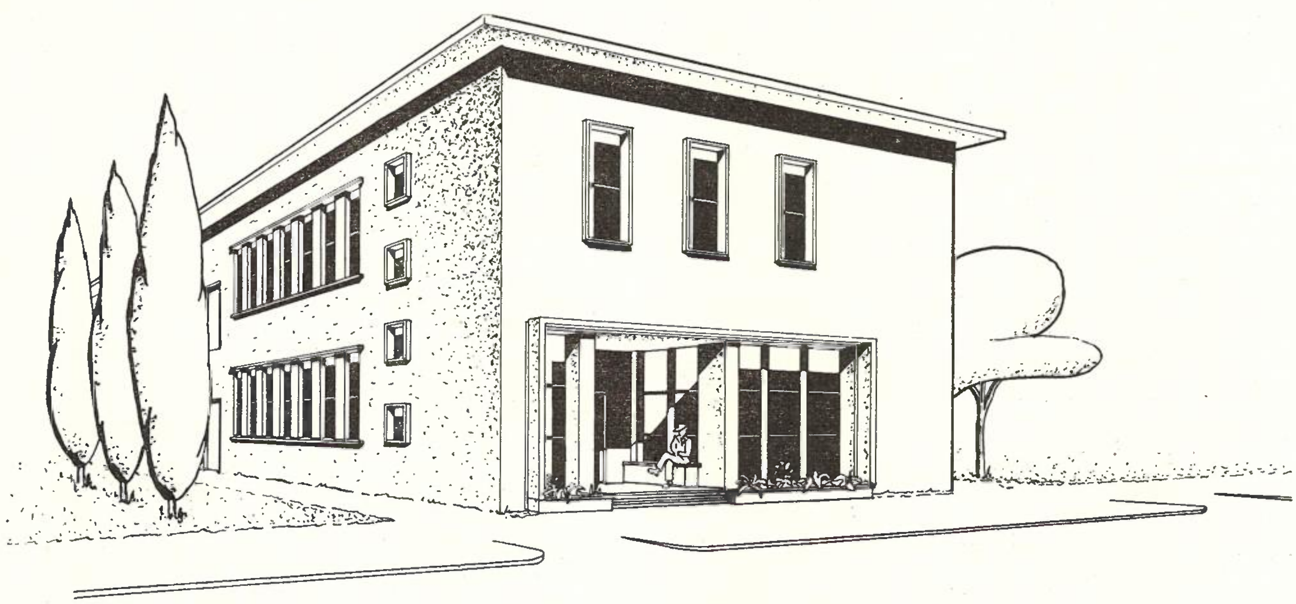


Fig. 15.—Country Centre Telecommunication Building— Perspective, Double Storey Type.

some instances be outweighed by economic factors.

A description of all the reference plans developed to meet the requirements of country centres is beyond the scope of the present article, but a brief outline will be given of some plans developed for communication buildings at larger centres. The basic features incorporated in one type of double storey building, which provides accommodation for local and trunk line equipment are illustrated in Fig. 14. This building is suited to a relatively narrow site, and future equipment requiring a 10 feet ceiling clearance on the ground floor. This includes the manual trunk exchange, arranged in double suites, the associated female amenities area, together with the cable room, power, battery and air treatment rooms. All rack mounted equipment requiring 13 feet 6 inches ceiling height is located on the first floor. This arrangement permits the most economical building construction. The amenities areas on the respective floors are conveniently grouped for maximum economy in the provision of plumbing fixtures and entrances are kept clear

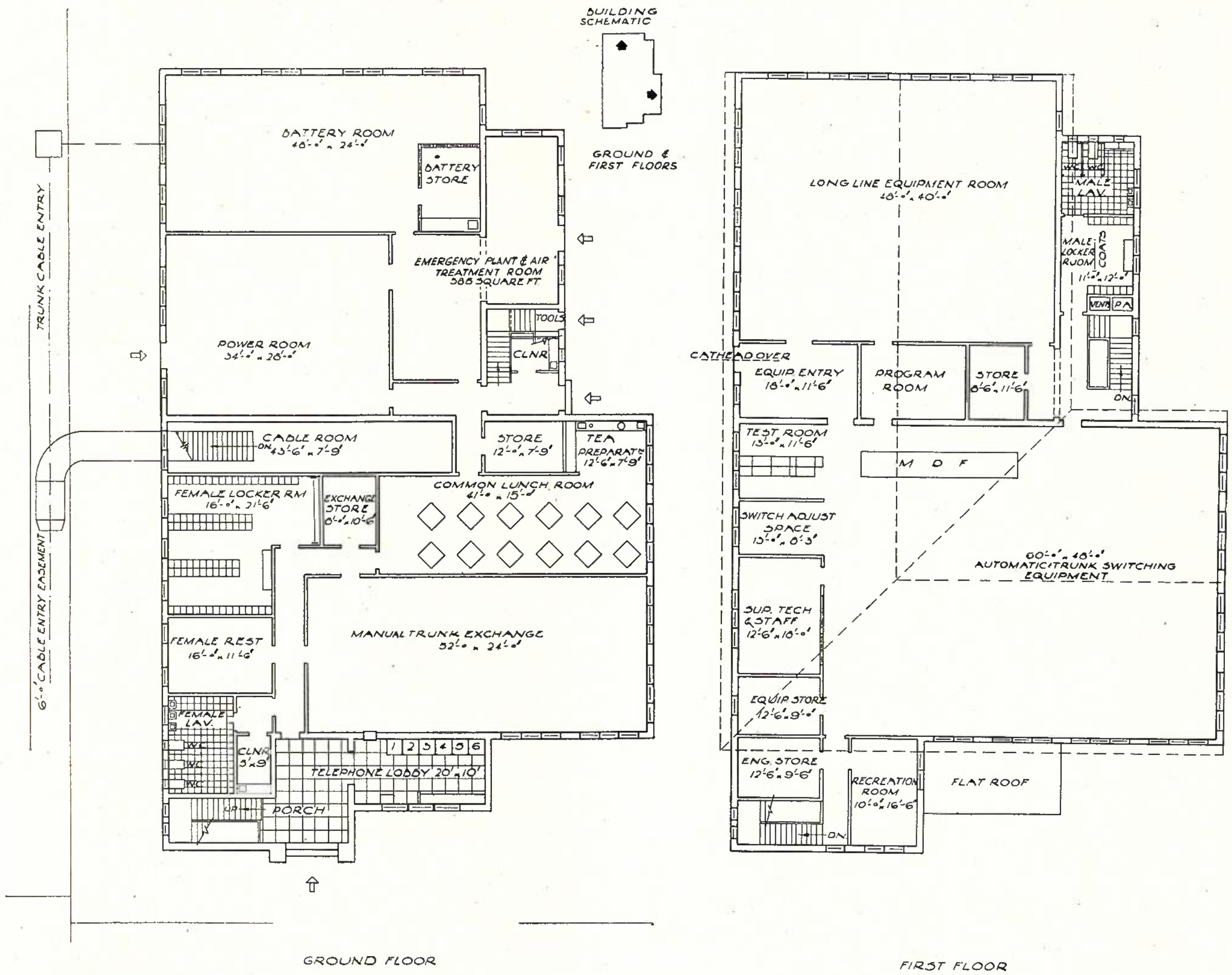



**Fig. 16.—Country Telecommunication Building, Double Storey L-shaped Development.**

growth for the three most important service units, namely, (1) automatic equipment for local subscribers and automatic trunk switching equipment; (2) long line equipment associated with trunk circuits; and (3) the manual trunk switchroom, beyond the areas provided in the initial building, is met by extension of the building to both the front and rear of the site. This involves setting the building back initially a distance of the order of 25 feet from the frontage. Balance of the layout has been ensured by locating the of the principal rack equipment areas. The general treatment of the various equipment and other service areas throughout the building is similar to that described for branch automatic exchanges.

It will be noted that the long line equipment area is partitioned off from the automatic switching equipment to restrict noise and provide a quiet area for trunk testing and programme monitoring. The automatic exchange equipment for local service and the automatic trunk switching equipment layouts develop on suites of racks running parallel. The light partitions separating the office block at the front end of the first floor from the equipment can be easily removed if future growth should necessitate the equipment developing into this area. An alternative position for the office block is to locate it as a buffer area towards the centre of the first floor between the long line and automatic equipment. A perspective impression of this building is shown in Fig. 15.

veniently subordinated to the more important functional areas required for equipment installations.

An example of planning which provides for the association of tele-communication and postal activities on the one allotment, with shared amenities areas yet, at the same time, providing for effective separation of the communication and postal working areas is shown in Fig. 17. This

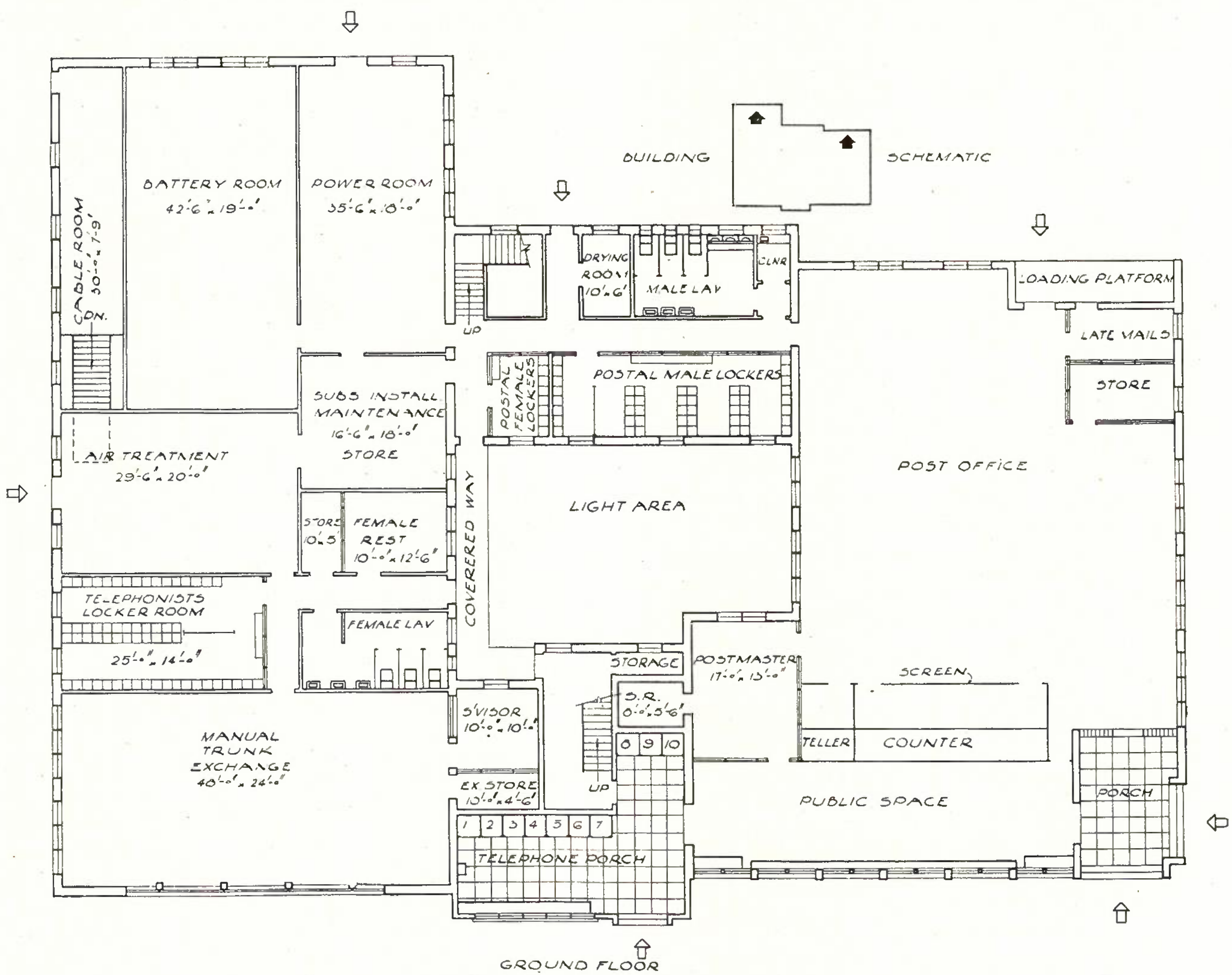
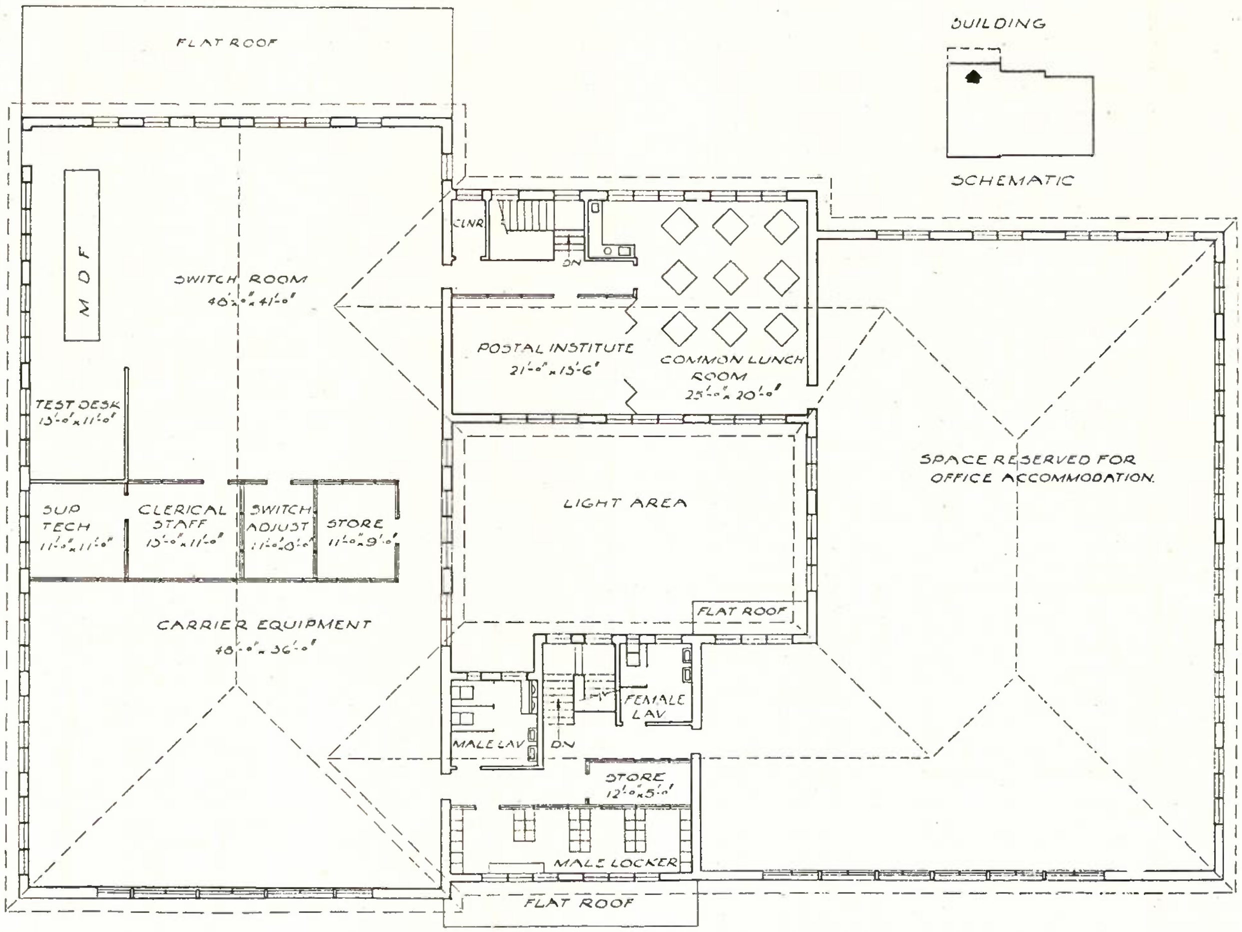



**Fig. 17.—Country Centre Post Office and Telecommunication Building—(a) Ground Floor.**

Another method of treatment for a site with a greater width is depicted in Fig. 16. In this L-shaped design the problem of meeting development of the principal equipment areas beyond that provided in the initial building is even more readily achieved than is the case when the building is confined to a narrow site. The automatic exchange equipment and the automatic trunk switching equipment rack layouts run parallel and at right angles to the long line equipment racks, and each is contained in a 48 foot width module capable of being readily extended. Again, it will be noted that amenities areas, service facilities, offices and access stairs have been conveniently subordinated to the more important

arrangement cannot be regarded as a hard and fast reference plan, and a number of variants have been developed to suit the requirements of particular centres. In the communication building the basic principles are the same as those outlined in the previous plans for separate buildings, in that the grouping provides a 10 feet ceiling clearance on the ground floor. The rack mounted equipment is confined to the first floor, where a 13 feet 6 inches clearance is necessary. Usually in large projects of this type, the communication wing is erected some years in advance of the post office and administrative office wing, and it is practicable when developing the latter section, to take account of any adjustments which may be necessary to provide additional space for exchange or trunk line equipment. The allotment should be adequate to provide for future extensions to meet unforeseen development, and it is preferable that the location of the building on site should permit both longitudinal and lateral expansion of the engineering wing in particular.




FIRST FLOOR

**Fig. 17.—Country Centre Post Office and Telecommunication Building—(b) First Floor.**

tional buildings can be erected. Imported prefabricated buildings, using aluminium alloy components, which have been specially adapted to meet the functional needs of telecommunication equipment, are in a different category, in that they can be regarded as permanent structures. The components are precision made, of good quality and long-life materials and should be regarded as

### Prefabricated Buildings

The part that prefabrication is playing today in the Post Office building programme cannot be covered in this article, but it is expected that the principal details as they effect telecommunication buildings will be featured in the next issue of the Journal. It is interesting to note that approximately £2,000,000 will be spent on the supply and erection of prefabricated structures in the next twelve months.

In New South Wales, the provision of relief at a number of country centres has been achieved by erecting timber frame, asbestos cement sheet exchange buildings. These, however, are in the nature of temporary buildings, designed to meet the pressure for service until the larger conven-

permanent buildings in just another building medium. These prefabricated buildings are designed on unit construction principles, and are available in a number of different module systems. Wall panels are available in 4 feet, 6 feet 6 inches and 8 feet $1\frac{1}{4}$ inches modules. The spans range from 16 feet to 48 feet in 8 feet multiples, whilst the ceiling heights range from 9 feet to 14 feet. They are confined to single-storey construction. The adaption of these buildings to telecommunication needs places some limitations on the designs illustrated in reference plans for conventional structures because of the necessity to work within the prefabrication module systems. Limitations are also imposed by the fact that only certain combinations of the units or panels can be attached to each other. In addition, it is desirable to confine prefabricated buildings to sites having reasonably even contours, so that the use of local building materials and manpower can be restricted to the barest minimum.

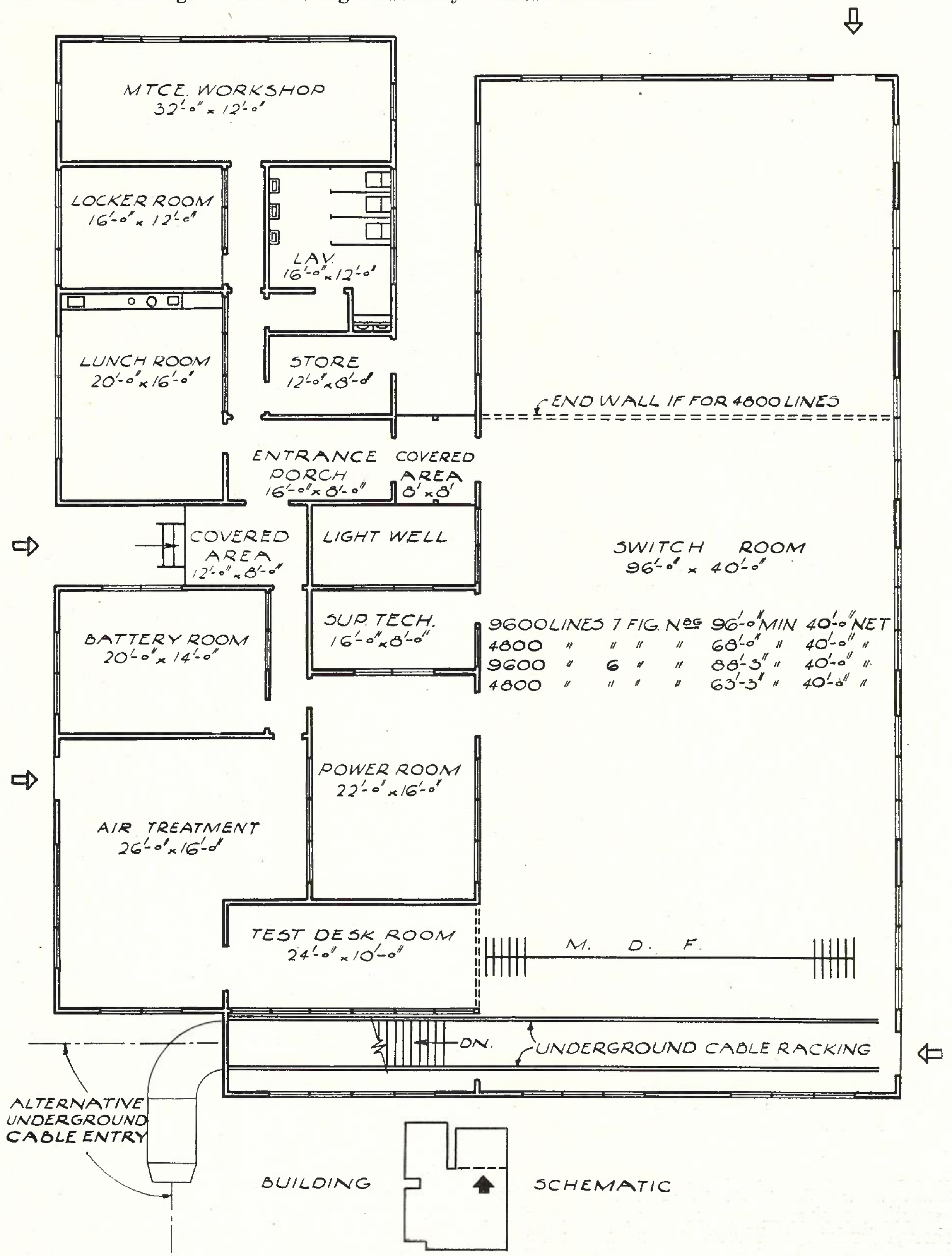



Fig. 18.—Aluminium Prefabricated Branch Automatic Exchange Building. 9600 lines ultimate capacity.

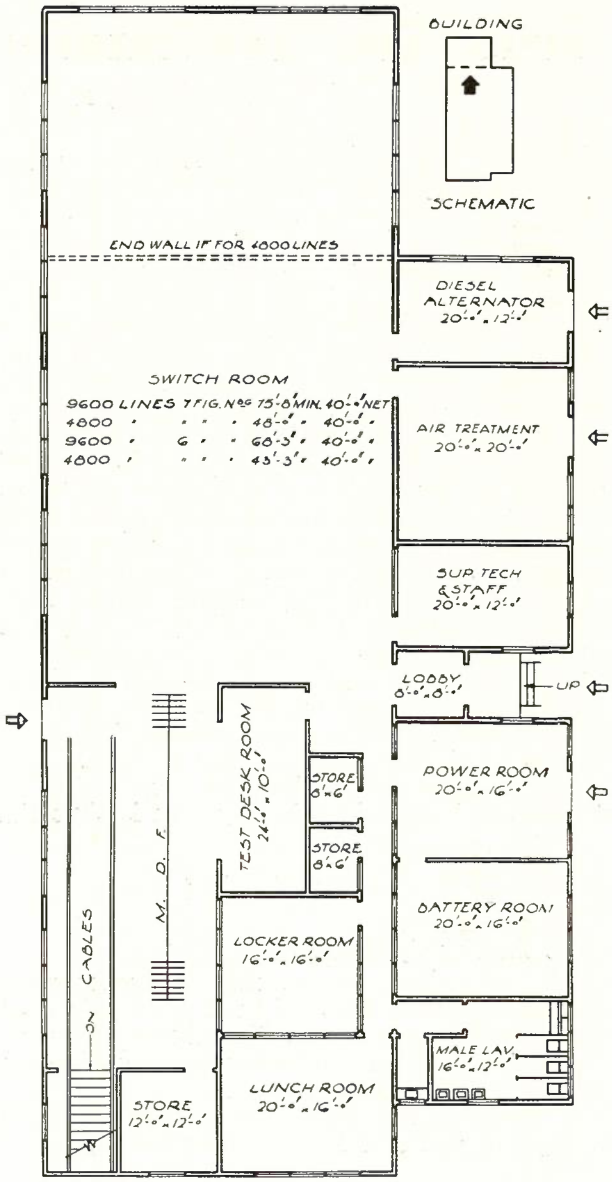



Fig. 19.—Country Centre Prefabricated Telecommunication Building.

An important feature of their design is a change from the conventional method of cable entry in single-storey structures. In order to reduce the need for excavation, the cable chamber under the M.D.F. has been eliminated. A scheme has been developed which provides for entry of the underground cables through a small access tunnel and stairway into the switchroom. A self-supporting double-sided framework mounted on the switchroom floor supports the potheads, and from this point the distribution cables are led to the top of the line side of the M.D.F. Some increase in floor area of the switchroom is necessary to accommodate the double-sided framework, but the constructional costs of the building are reduced and cement, which is in short supply, is conserved. In areas where the cement shortage is acute timber floors are also being provided in the switchroom instead of concrete floors.

By careful design, a very close approach can be made to the functional arrangements already described for conventional buildings, and in view of the fact that components can be secured and erected in a small fraction of the time required to erect a conventional structure of comparable dimensions, they offer an attractive solution to the problem of providing sufficient space for some automatic exchange installations, and for relief in country areas. An indication of designs already adapted for automatic exchange purposes is given in Figs. 18 and 19.

## Bibliography


**1. Buildings Branch Instructions—Engineering Services.**

(a) Provision of Electric Lighting Facilities—General. EK.0001.

(b) Provision of Electric Lighting Facilities in 2000 Type Automatic Telephone Exchange Buildings. EK.0002.

(c) Standardisation of Lighting Facilities—P.M.G Buildings EK.0003.

(d) Provision, Maintenance and Inspection of Fire Fighting Facilities. F.0001.

(e) Air Treatment (including provision in new buildings) AT.0001.

# DETERMINATION OF CABLE SIZES FOR SUBSCRIBERS' DISTRIBUTION

*I. McDowell, B.A., B.Sc.*

**Introduction:** With the rapid development encountered at the present time, it is often necessary to plan cable distribution schemes in areas where no cable has been laid before. A characteristic of such an area is that it contains houses which might be treated as equally likely ultimately to possess a telephone service. On the basis of this characteristic, a system of determination of cable sizes for all feeds can be defined, which is in harmony with the two basic requirements of reticulation network provision.

These requirements are that as far as possible service be made available to every potential subscriber, and that economy in the expenditure of public moneys be exercised. Other considerations such as standards of service have been laid down, and need not be considered here.

It is immediately obvious that to ensure service to every applicant in an area in the worst possible case, there would be involved provision of somewhat in excess of one cable pair to every house exclusively to provide for exchange lines, extensions, and private lines. However, in some typical areas, the probability of a house requiring service is only one in five; hence it is seen, that if the above action is taken for a large area, four fifths of the pairs provided will be wasted. In the interests of economy, this should not be allowed to occur. However, it must be stipulated that enough cable pairs be provided to render it as highly probable that service can always be given. In the remote case where this is not possible, it is still likely that some major change will take place in the area at a later stage, necessitating alteration in plant in any case.

**Application of Probability Theory:** In any new homogeneous area, each house can be considered to have the same probability "a" of requiring service in a given period. The value of this probability can be determined by consideration of the number of telephone services provided or applications received in large areas of a similar type which have been established previously.

If the new area under consideration is to contain N houses, it can be shown that the probability of there being exactly r applications for service in the given period is:—

$$ {}_N C_r\, a^r (1\text{-}a)^{N-r} $$

$$ \text{where } {}_N C_r = \frac{N!}{r!(N\text{-}r)!} $$

The method of obtaining this result is indicated in the attached appendix.

Now, if n cable pairs are provided to serve the area for the period under consideration, it will be seen that the probability that the number of applications for service will exceed the number of cable pairs provided is

$$ \sum_{r=n+1}^{r=N} {}_N C_r\, a^r (1\text{-}a)^{N-r} = B $$

B will be the "probability of not being able to give service," Arbitrary values for this probability might be 1 in 100 or 1 in 1000, and would mean that there would be only a 100 to 1 or a 1000 to 1 chance respectively that the cable serving the area would become full in the planning period. This probability is similar to the "grade of service" in automatic switching. The actual value selected for design purposes would depend, among other things, on the relative costs of providing a low or high grade service, and on material supply considerations. Thus, in a time of acute cable shortage, it might be expedient to reduce the size of new cables provided to the extent that there would be, for example, a 50 to 1 chance that the cables would become full, if this resulted in an appreciable saving of cable.

The criterion for the determination of the size of cables to be provided in any area is thus that

$$ \sum_{r=n+1}^{r=N} {}_N C_r\, a^r (1\text{-}a)^{N-r} $$

is less than or equal to B.

This, of course, applies only to homogeneous areas and assumes that only one cable pair would be required at any house. Should more than one pair be required, an equivalent number of houses could be added to allow for this.

To illustrate the use of the criterion in determining the size of distribution cables in, for ex-

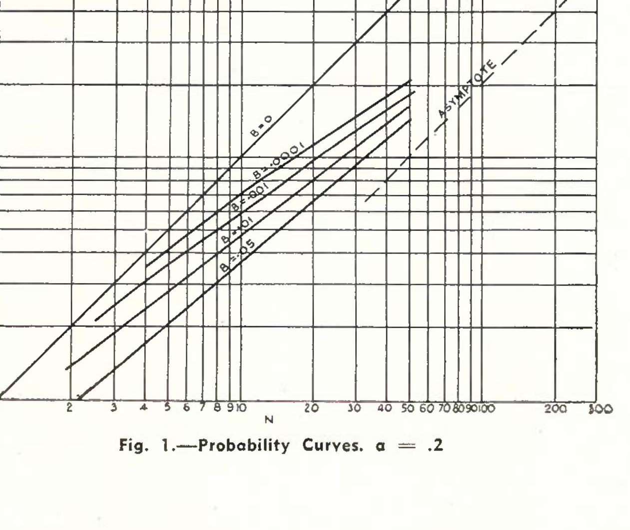



Fig. 1.—Probability Curves. a = .2

ample, a pillar area, the following examples are quoted for the case where the probability that service will be required at any house is 1 in 5, and for a probability that service cannot be provided to any house of not more than 1 in 100.

To any one house, one pair must be made available, since the probability that service will be required is 1 in 5, which is in excess of 1 in 100.

To any two houses, two pairs must be made available, since the probability that service will be required to both is 1 in 25.

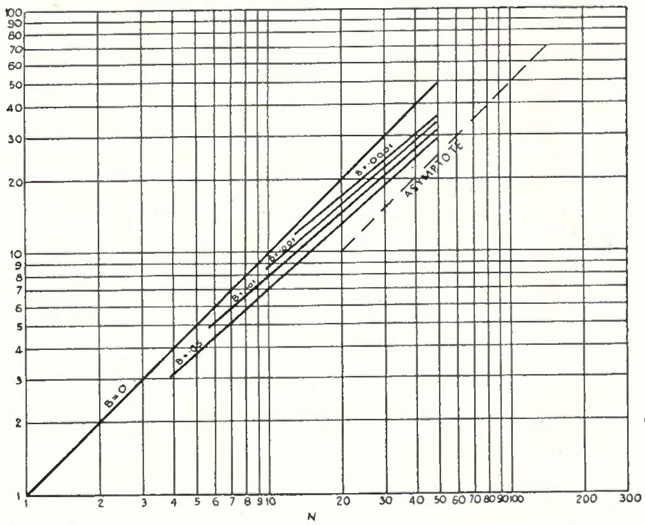



Fig. 2.—Probability Curves. a = .5

To any three houses, two pairs must be made available, for though the probability that service will be required to all three is 1 in 125, the probability that service will be required to two of them is:

$3(^1/_5)^2(^4/_5)$ or 12 in 125, which exceeds 1 in 100.

To any four houses, three pairs must be made available, since the probability that these will be sufficient is 1 in 625, whereas the probability that two pairs would have sufficed, is:

$(^1/_5)^4 + 4(^1/_5)^3(^4/_5)$ or 17 in 625.

Three pairs will also suffice for service to any five houses, with probability:

$(^1/_5)^5 + 5(^1/_5)^4(^4/_5)$ or 21 in 3125, which is equal to 1 in 149, whereas two pairs would suffice only to probability:

$(^1/_5)^5 + 5(^1/_5)^4(^4/_5) + 5.4/2(^1/_5)^3(^4/_5)^2$ or 341 in 3125, which is untenable.

Cases with different probabilities can be calculated in a similar manner and typical results are given in Figs. 1-3. Calculations for all but small values of N and r are tedious, and it is fortunate that values of the probability function have been tabulated (1), making it a simple matter to obtain values for n for any values of a, N and B.

**Examples of Application:** Current practice is that the minimum size of cable to be laid in a street is 5 pairs. In addition to this, the fact that cable is supplied in certain defined sizes, renders it impossible to apply the results of such calculations exactly to a given frontage. For the arbitrary probabilities of 1 in 5 and 1 in 100 taken previously, it has been worked out that the following houses might be served by the cable sizes shown:—

| Number of houses. | Cable size (pairs) |
|---|---|
| 0 - 10 | 5 |
| 11 - 16 | 7 |
| 17 - 26 | 10 |
| 27 - 44 | 15 |

To avoid the feeling that these cable sizes might be too small, it should be kept in mind that the probability that any house will require a service is taken as only 1 in 5. A value of 2 in 5

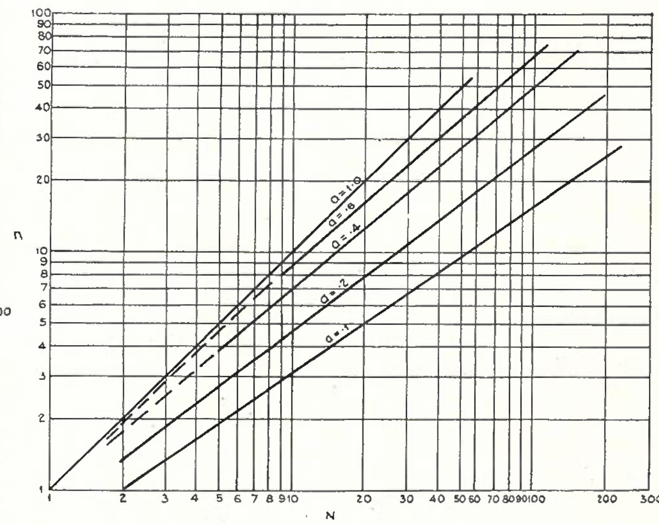



Fig. 3.—Probability Curves. B = .01

would give much higher requirements for pairs. Furthermore, no unseen changes have been provided for.

Frontages can now be laid out in accordance with these figures. Higher telephone probabilities over small frontages, such as groups of shops in the area, can be given appropriate probabilities and their own frontages laid out accordingly. However, the simple case of a frontage is shown in Fig. 4, reference to which will show that the number of pairs required are made available to any number or combination of houses.

As the cable sizes increase, and lateral cables enter, multiple jointing will be encountered. The above concepts must then be taken into account. A case is considered (refer to Fig. 5) of a 10-pair cable feeding 26 houses meeting 5 and 10-pair cables feeding 8 and 18 houses respectively. Under the 1 in 5 probability specified, a 10-pair cable will feed the total number of houses in each case. The effect of fixed cable sizes becomes apparent here, as on the country side of the multible joint, the cables have more pairs than necessary. This is, of course, unavoidable, and it is simply necessary to number the lateral so that the number of pairs required are made available to the houses fed by it.

In case "A," in which the lateral takes the low numbering, it is seen that there are 18 houses which have access to only 5 pairs. This is clearly

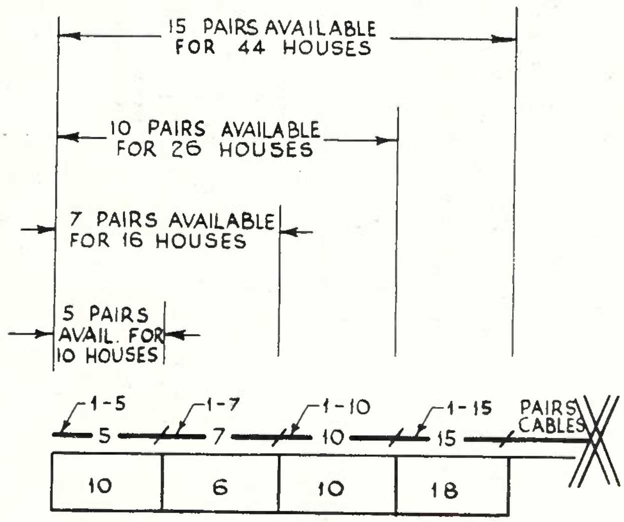



Fig. 4.—Frontage Layout. Numbers of Houses are shown in Rectangles.

untenable, since the maximum number of houses in the case considered which can be fed by the 5 pairs is 10. In case "B," however, in which the small lateral takes the high reading, 10 houses are fed by 5 pairs and 26 by 10 pairs as the figures require.

In cases of greater complexity considerable overlap may occur, an example of which is given in Fig. 6. In these instances adjustments must be made so that the limiting figures are rigidly observed. This is done by ensuring that a total of 10 houses are served by the 1 to 5 numbering;

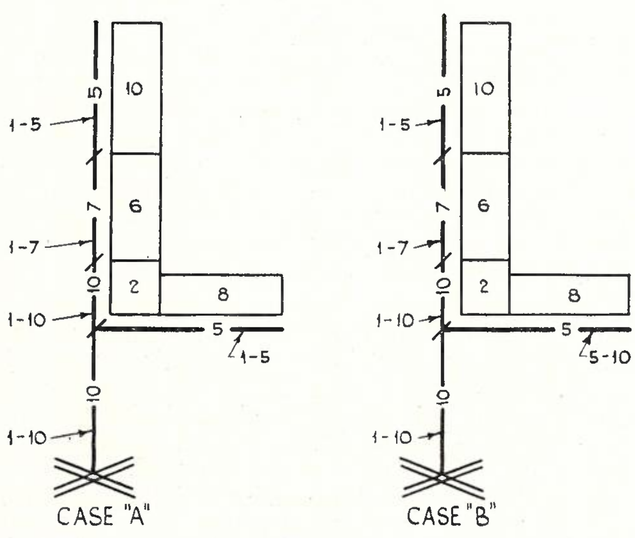



Fig. 5.—Multiple Layout—1.

a total of 16 houses are served by the 1 to 7 numbering; a total of 26 houses are served by the 1 to 10 numbering; and so on.

These examples are by no means exhaustive, but are merely intended to initiate a line of thought. They cover fully in essence the principles involved. The formulation of more difficult situations, and the successful treatment of them by the reader, is left as an exercise.

Over the layout of an entire area, successive increases in cable size must occur. The cables considered previously are of the size which conform to 20 year development requirements. At an optimum size, it becomes economical to provide cable to a development figure over 8 years, and provide relief at this time. In the gathering up of a large number of small areas such as the one illustrated previously, no cable distribution pillar would be required until the breakdown point of 8 to 20 year cables is reached, since distribution cable has been provided to every house in such a way that there is only a 100 to 1 chance that pairs at any house will be insufficient to meet the application. A pillar would be provided at such a point since distribution pairs would some-

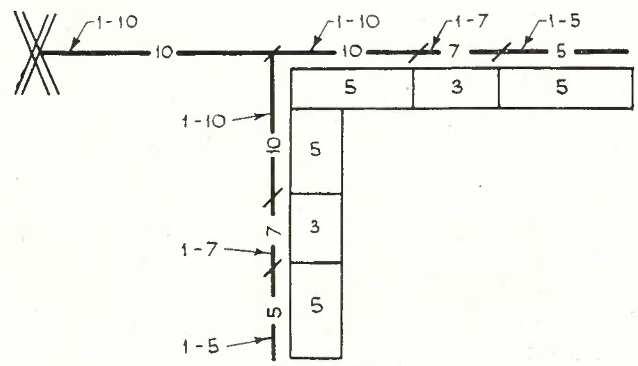



Fig. 6.—Multiple Layout—2.

what exceed main pairs, that is at which the probability basis for pair provision changes. Hence, as far as the reasoning on which this paper has been based is correct in practice, pillars are required only at the meeting place of 8 and 20 year cables, provided the 20 year cables conform to this theory. The effect of other factors is outside the scope of this paper.

**Application to Established Area:** Although the method of cable distribution described previously would have its most important application in the provision of service to new areas, for example, new housing estates, it might also be applied with resulting economy to established areas. In these cases, of course, cable pairs would be allocated to existing services, but additional pairs for future development would conceivably be provided on a probability basis. In this case, a detailed house to house survey to determine future development would not be necessary, and surveys would be concerned primarily in determining a general probability for expansion in subdivided areas.

This procedure would be supported somewhat by the fact that in these times of housing shortage and high wages the demand for telephone service is not always related to the class of house in an area.

### APPENDIX

**Probabilities of various numbers of applications for telephone service being received in an area:**

In a uniform area containing N houses, if the probability that telephone service would be required at any house is a, the probability that the first r houses would all apply for telephone service would be $a^r$. The probability that the remaining N-r houses would not apply for service would be $(1-a)^{N-r}$, so that the probability that the first r houses would apply and the remainder would not apply is $a^r(1-a)^{N-r}$. There would be the same probability that the first N-r houses would not apply for service, and the last r houses would apply for service, and, in fact, that any combination of r of the N houses would apply for service and the remainder would not. As the number of different combinations of the N houses taken r at a time is $_NC_r = \frac{N!}{r!(N-r)!}$ the total probability that exactly r of the N houses would apply for service is $_NC_r\, a^r(1-a)^{N-r}$.

(1) Tables of the Binominal Probability Distribution—U.S. Bureau of Standards, 1950.

# ANSWERS TO EXAMINATION PAPERS

*The following answers generally give more detail than would be expected in the time available under examination conditions. The additional information should be helpful to students.*

**EXAMINATION Nos. 3101, 3106 and 3107—SENIOR TECHNICIAN, TELEPHONE; RADIO AND BROADCASTING AND RESEARCH.**

**(a) ELECTRICAL THEORY AND PRACTICE.**

**C. J. Peady**

**Q. 5.—The reactance of each of two coils at a certain frequency is 400 and 300 apparent ohms and the resistance 300 and 400 ohms respectively.**

**(a) What is the power absorbed if each coil is connected in turn across a 200 volt A.C. supply of that frequency?**

**(b) What is the power absorbed if the two coils are connected in series across the supply?**

**A.**—(a)

| | Case (1) | Case (2) |
|---|---|---|
| Impedance, $Z = \sqrt{R^2 + X_L^2}$ | $= \sqrt{300^2 + 400^2}$ | $= \sqrt{400^2 + 300^2}$ |
| | = 500 ohms. | = 500 ohms. |
| Current I = E/Z | = 200/500 | = 200/500 |
| | = 0.4 ampere. | = 0.4 ampere. |
| Tan $\theta = X_L/R$ | = 400/300 = 1.333 | = 300/400 = 0.75 |
| From tables Phase angle $\theta$ | = 53° 4′ | = 36° 52′ |
| Cos $\theta$ | = 0.6027 | = 0.8014 |
| Power = EI cos $\theta$ | = 200 × 0.4 × 0.6 | = 200 × 0.4 × 0.8 |
| | = 48 watts. | = 64 watts. |

(b) In this case—

$$\text{Impedance, } Z = \sqrt{R^2 + X_L^2} = \sqrt{700^2 + 700^2} = 700\sqrt{2} \text{ ohms.}$$

$$\text{Current, } I = \frac{E}{Z} = 200/700\sqrt{2} = 2/(7\sqrt{2})$$

$$\text{Tan } \theta = X_L/R = 700/700 = 1$$

$$\therefore \text{ Phase angle } \theta = 45°$$

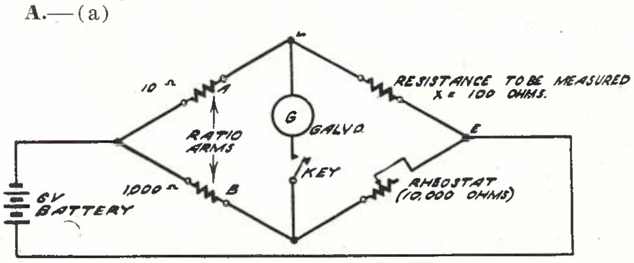
$$\text{and } \cos\theta = 0.7071$$

$$\text{Power} = \text{E.I. } \cos\theta = 200 \times 2/(7\sqrt{2}) \times 0.7 = 40/1.414 = 28.3 \text{ watts.}$$

**Q. 6.—(a) Draw a schematic circuit of a Wheatstone Bridge, showing all the necessary components and indicate the values of the resistance in the Ratio Arms and Rheostat when a resistance of 100 ohms is being measured for greatest accuracy and the Bridge is balanced.**

**(b) What are the currents flowing in each arm of the Bridge when it is balanced for the above test, and a 6 volt battery of negligible internal resistance is used?**

**A.**—(a)




Q.6, Fig. 1.

(b) When the bridge is balanced there is no current flow through the galvanometer.

Current in A arm and resistance X

$$X = \frac{E}{R} = 6/(10 + 100) = 0.05454 \text{ ampere.}$$

Current in B arm and rheostat

$$= \frac{E}{R} = 6/(1000 + 10000) = 0.0005454 \text{ ampere.}$$

**Q. 7.—(a) Explain what takes place in a lead-acid accumulator cell during its charge and discharge, and why the Specific Gravity of the electrolyte is an indication of the state of charge.**

**(b) Show with the aid of curves how the voltage of such a cell varies during charge and discharge, and explain the differences in the two curves.**

**A.**—(a) The active elements in a lead-acid accumulator are as follows:—

Positive plate—lead peroxide ($PbO_2$)
Negative plate—lead (Pb)
Electrolyte—sulphuric acid ($H_2SO_4$)

The reaction which takes place during the discharge of the cell is given by the formula—

| + Plate | — Plate | Electrolyte | |
|---|---|---|---|
| $PbO_2$ | + $Pb$ | + $2H_2SO_4$ | — $\Phi$ |

$\Phi$ —$PbSO_4$ + $PbSO_4$ + $2H_2O$ (water)

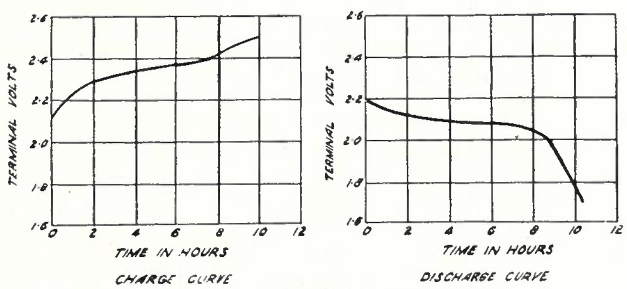
Thus, lead sulphate is produced at each plate, and part of the electrolyte is reduced to water. The discharge, however, never goes on to completion, so that some lead peroxide still exists in the positive plate and some lead in the negative plate. Owing to the removal of sulphuric acid from the electrolyte during discharge, its specific gravity decreases. During the charging of the cell the lead sulphate is converted into lead at the negative plate, and into lead dioxide at the positive plate.

| + Plate | — Plate | Electrolyte | |
|---|---|---|---|
| $PbSO_4$ | + $PbSO_4$ | + $2H_2O$ | — $\Phi$ |

$\Phi$ — $PbO_2$ + $Pb$ + $2H_2SO_4$

The sulphuric acid removed from the electrolyte during the discharge is thus returned, with a consequent rise in its specific gravity. The change in specific gravity of the electrolyte is proportional to the ampere-hour discharge or charge, and, therefore, gives a reliable indication of the state of charge of the cell.

(b) See Fig. 1. During charging, the voltage of a cell rises rapidly at first, then gradually over the majority of the charging period until a voltage of approximately 2.35 volts is reached, when the rise in voltage is more rapid, and is accompanied by gassing.




Q.7, Fig. 1.

The voltage of a cell drops initially on discharge and remains practically constant over the major part of the discharge. Towards the end of the discharge the voltage drops rapidly, due mainly to the increase in internal resistance owing to the dilution of the acid in the pores of the plates. It is not due to exhaustion of the active materials.

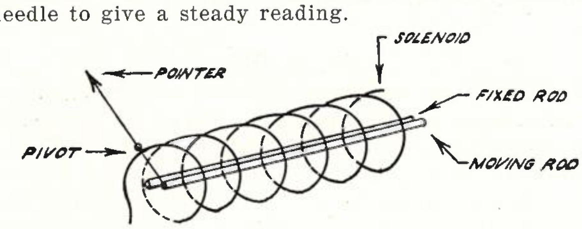
The discharge curve is always lower than the charge curve, as on discharge the voltage drop across the internal resistance of the cell subtracts from its terminal voltage, while on charge this voltage adds to the terminal voltage.

**Q. 8.—(a) Explain with the aid of a sketch the principle of any moving iron ammeter used for A.C. measurements.**

**(b) It is desired to measure a D.C. voltage of 250 with a moving iron ammeter having a resistance of 2,500 ohms and which requires of current of 25 milli-amperes to give a full scale deflection. How would you adapt the instrument to this purpose and how would your answer be modified if the instrument were to be used to measure an A.C. voltage of 250?**

**A.**—(a) Fig. 1 shows the principle of operation of the "repulsion" type moving iron ammeter.

When a current passes through the solenoid coil, the two soft iron rods are magnetised to the same polarity, and repel each other. The separation of these rods causes the needle to be deflected. If the current is reversed, repulsion still takes place, so that the instrument may be used for A.C. measurements as well as D.C., provided that some form of damping is used to enable the needle to give a steady reading.




Q.8, Fig. 1.

(b) For a current of 25 milliamps, the total resistance in the circuit must be $(250 \times 1000)/25$ or 10,000 ohms. Therefore, it is necessary to connect a resistance of 10,000 — 2,500, or 7,500 ohms in series with the instrument.

For A.C. measurements, the resistance must be wound non-inductively, and allowance must be made for "position" error, and the error due to hysteresis in the iron rods. Also, errors may be introduced when measuring alternating currents with differing wave forms and frequencies.

**Q. 9.—(a) Briefly describe the construction, and explain the action, of one type of electrolytic condenser.**

**(b) Why is the capacity of this type of condenser, as compared with other types of approximately the same physical dimensions, relatively high, and why must its use be confined to direct currents?**

**A.**—(a) The "dry" type of electrolytic condenser has for its electrodes two aluminium sheets, one of them being "formed." With a cotton or linen gauze separator impregnated with the electrolytic paste, they are rolled tightly into a cylinder and placed in the container, from which they are insulated. The electrodes are brought out by wire connections.

The electrode is formed by passing a current through the electrolyte until a layer of aluminium oxide is formed on the anode and further current flow is prevented. Thus the formed plate and the electrolyte are actually the plates of the condenser.

(b) Aluminium oxide has a high dielectric constant and the layer formed is very thin, so that a relatively high capacity results.

A current in the opposite direction to the forming current would destroy the aluminium oxide coating by reverse electrolytic action, therefore this type of condenser cannot be used in an alternating current circuit.

**Q. 10.—A transformer is designed and constructed to step down from 500 volts to 250 volts. The magnetising current in the primary winding is 2.5 amperes. Calculate the primary current and power factor for the following secondary loads:—**

**(a) 20 amperes at unity power factor.**

**(b) 20 amperes at 0.5 power factor (inductive load).**

**A.**—(a) The primary current consists of two components—

(i) The magnetising current $I_M$, lagging by 90°

(ii) The load component due to the current in the secondary circuit, $I_1$, in this case in phase with the primary voltage.

$$I_M = 2.5 \text{ A}$$
$$I_1 = 20/2 = 10 \text{ A.}$$

$$\text{Primary Current, } I_p = \sqrt{I_M^2 + I_1^2}$$
$$= \sqrt{2.5^2 + 10^2}$$
$$= \sqrt{6.25 + 100}$$
$$= \sqrt{106.25}$$
$$= \sqrt{10.31} \text{ amperes.}$$

Power factor = cosine of phase angle $\theta$

$\tan\theta = 2.5/10 = 0.25$

$\therefore \theta = 14° 2'$ and $\cos\theta = 0.9704$ } from tables.

$\therefore$ Power factor = 0.9704

(b) The power factor is 0.5, corresponding to a phase angle of 60°. The load component of the primary current, $I_1$, is in antiphase to the secondary current, and equals 20/2 = 10 amperes. This may be resolved into an "in phase" component, $I_A$, and a component 90° out of phase $I_B$.

$$I_A = \cos 60° \times I_1$$
$$= 0.5 \times 10$$
$$= 5 \text{ amperes.}$$
$$I_B = \sin 60° \times I_1$$
$$= 0.866 \times 10$$
$$= 8.66 \text{ amperes.}$$

The total primary current is obtained by the vestor sum of $I_A$, $I_B$ and $I_M$.

$$I_p = \sqrt{I_A^2 + (I_B + I_M)^2}$$
$$= \sqrt{5^2 + 11.16^2}$$
$$= \sqrt{150}$$
$$= 12.25 \text{ amperes.}$$

Power factor = $\cos\theta = I_A/I_p = 5/12.25 = 0.4$

## SECTION 1.—LONG LINE EQUIPMENT EXAMINATION No. 2906—ENGINEER—TRANSMISSION.

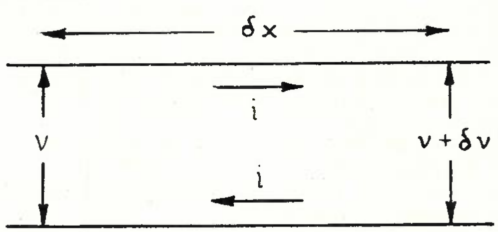
**W. GIBBERD, M.Sc., A.M.I.E. (Aust.).**

**Q. 1.—Develop from fundamental principles the general mathematical expressions for the propagation coefficient and characteristic impedance of a uniform transmission line.**

**A.**—Consider a uniform transmission line with the following primary constants:—

R. the resistance per unit length in ohms.
L. the inductance per unit length in henries.
G. the leakance per unit length in reciprocal ohms.
C. the capacity per unit length in farads.

Consider an elementary section of line of length as shown in Fig. 1.




Q.1, Fig. 1.

Let the voltage from wire to wire be $v$ and the current flowing be i and let $\delta v$ be the small change in voltage over the length $\delta x$.

We have

$$-\delta v = iR\delta x + \frac{\partial i}{\partial t}L\delta x$$

and in the limiting case when $\delta x$ tends to zero

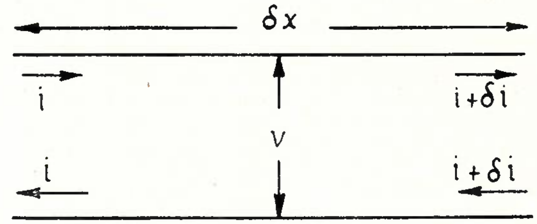
$$-\frac{\partial v}{\partial x} = iR + L\frac{\partial i}{\partial t} \quad \text{.... .... .... .... .... A}$$

Similarly consider the change in current over a small length $\delta x$ as in Fig. 2.

We have

$$-\delta i = vG\delta x + \frac{\partial v}{\partial t}C\delta x$$

$$-\frac{\partial i}{\partial x} = vG + C\frac{\partial v}{\partial t} \quad \text{.... .... .... .... .... B}$$




Q.1, Fig. 2.

(A) and (B) are the pair of partial differential equations governing the behaviour of the line.

From experience with linear systems we are led to try the solution

$$v = V.e^{j\omega t}$$
$$i = I.e^{j\omega t}$$

where V and I are functions of the variable x only.

Substituting in equation A we have

$$-\frac{dv}{dx}.e^{j\omega t} = Ie^{j\omega t}.R + L.Ij\omega.e^{j\omega t}$$

$$-\frac{dv}{dx} = (R + jL\omega)I \quad \text{.... dividing by } e^{j\omega t}$$

$$= zI \text{ where } z = R + jL\omega$$

and similarly by substituting in equation B and dividing by $e^{j\omega t}$ we have

$$-\frac{dI}{dx} = yV \text{ where } y = G + jC\omega$$

We now have

$$\frac{dv}{dx} = -zI \quad \text{.... .... .... .... .... .... .... .... C}$$

$$\frac{dI}{dx} = -yV \quad \text{.... .... .... .... .... .... .... .... D}$$

Differentiating equation (C) with respect to x we have

$$\frac{d^2V}{dx^2} = -z\frac{di}{dx} = z.y.V = \alpha^2V$$

and similarly

$$\frac{d^2I}{dx^2} = -y\frac{dv}{dx} = y.z.I = \alpha^2I$$

where $\alpha = \sqrt{y.z} = \sqrt{(R + jL\omega)(G + jC\omega)}$

Solving these two equations we have

$$I = Ce^{\alpha x} + Be^{-\alpha x}$$
$$V = Ae^{\alpha x} + De^{-\alpha x}$$

Consider an infinite line and let Vs and Is be the voltage and current respectively at the sending end (x = o).

We have Vs = A + B

At x = ∞, V = o and therefore A = O.

$$\therefore V = V_s e^{-\alpha x}$$

The propagation constant is defined as the ratio of the amplitude at distance x to that at distance x + 1 and hence the **propagation constant**

$$= \alpha = \sqrt{(R + jL\omega)\ (G + jC\omega)}$$

$$\text{Now } \frac{dV}{dx} = -\alpha V_s e^{-\alpha x}$$

$$\text{and } I = -\frac{1}{z}.\frac{dv}{dx} = \frac{\alpha}{Z}.V_s e^{-\alpha x}$$

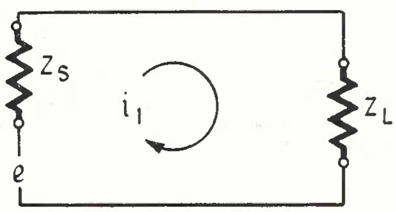
$$\therefore I_s = \frac{\alpha}{z} . Vs$$

and hence the **characteristic impedance**

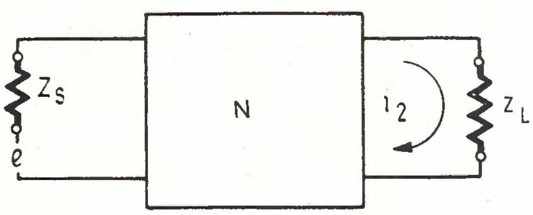
$$= \frac{V_s}{I_s} = \frac{z}{\alpha} = \sqrt{\frac{R + jL\omega}{G + jC\omega}}$$

**Q. 2.—Define the meaning of the term "Insertion Loss." Calculate the values of the series and shunt elements of an H type attenuator having a characteristic impedance of 600 ohm and a loss of 60 decibels.**

**A.**—The insertion loss of a network when introduced between a source and a load is defined in terms of the power P1 which was transferred to the load before the introduction of the network and that P2 transferred to the load after the introduction of the network. If L is the insertion loss then $L = 10 \log_{10} P_1/P_2$ decibels.



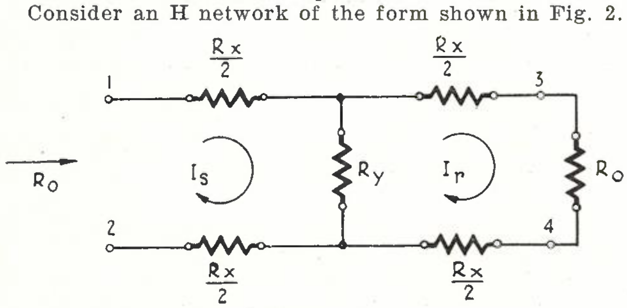

Q.2, Fig. 1 (a).




Q.2, Fig. 1 (b).

The insertion loss produced by the network N in Figs. 1a and 1b above is $20 \log \frac{i_1}{i_2}$ decibels.

Consider an H network of the form shown in Fig. 2.




Q.2, Fig. 2.

The two conditions to be satisfied are:—

(1) An impedance of Ro shall be seen at terminals 1 and 2 when terminals 3 and 4 are terminated in an impedance Ro.

(2) $i_s/i_r = K$ where $20 \log K = N$ the attenuation in db.

Assume a sending voltage $e_s$ across terminals 1 and 2, then we may write

$$e_s = i_s R_x + i_r (R_x + R_o)$$

But from the first condition

$$e_s = i_s R_o$$

$$\therefore i_s R_x + i_r (R_x + R_o) = i_s R_o$$

$$\therefore KR_x + R_x + R_o = K R_o$$

$$\therefore R_x (K + 1) = R_o (K - 1)$$

$$\therefore R_x = R_o \times (K - 1)/(K + 1)$$

We may also write

$$e_s = i_s R_o = i_s R_x + (i_s - i_r) Ry$$

$$\therefore KR_o = KR_x + (K - i) Ry$$

$$\therefore KR_o [1 - (K - 1)/(K + 1)] = (K - 1) Ry$$

$$\therefore KR_o \times 2/(K + 1) = (K - 1) Ry$$

$$Ry = R_o \times 2K/(K^2 - 1)$$

Hence for an H network of Fig. 2 with an attenuation of N decibels

$$R_x - R_o \times (K - 1)/(K + 1)$$

$$Ry = R_o \times 2K/(K^2 - 1)$$

where $20 \log K = N$.

For an attenuation of 60 db

$$\log K = 3$$

$$K = 1000$$

$$Rx = 600 \times 999/1001$$

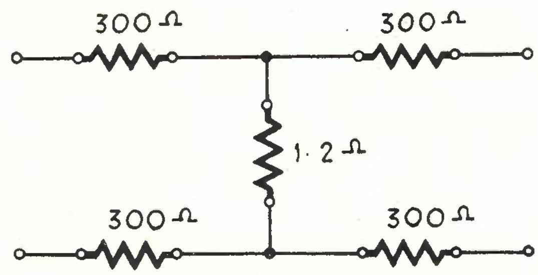
$$= 599 \text{ ohms}$$

$$Ry = 600 \times 2000/(10^6 - 1)$$

$$= 600 \times 2/1000$$

$$= 1.2 \text{ ohms}$$

The final attenuator will be




Q.2, Fig. 3.

**Q. 3.—It is desired to prepare a specification governing the manufacture of 3 channel carrier telephone terminals. List the principal physical and electrical features you would include in the specification and briefly state the points you would cover in each.**

**A.**—The following list covers the principal physical features to be included in a specification for a three-channel system.

(a) The rack on which the equipment is to be mounted shall be specified in accordance with the Department's standard 10' 6" x 20¼" rack. Details are shown on a standard drawing.

(b) Modern systems can be mounted on one rack and, therefore, it should be specified that each system, together with automatic gain control equipment shall not require more than one rack.

(c) Departmental drawings exist for standard panels and covers and reference should be made to these.

(d) The finish shall be specified to ensure that all equipment has a high grade finish and is suitable for use under all Australian climatic conditions.

(e) The quality and colour of the paint work shall be specified.

(f) High grade components and variable controls shall be specified.

(g) The quality of the wire used and of the methods of wiring shall be specified.

(h) Miscellaneous equipment such as jacks, plugs, keys, terminal strips, lamps and fuses shall be related to the standard Departmental drawings.

The following are some of the principal electrical features to be specified.

(a) Carrier frequencies and side band ranges.

(b) Transmitting level to line.

(c) The gains required in terminals in the receive direction and in repeaters.

(d) The terminating conditions, impedances and levels required at the V.F. circuits shall be specified, i.e., the channels shall be capable of four-wire connection and shall operate at the standard levels of

—13db and +4db relative to the switchboard level. A drawing showing switching conditions should be included.

(e) The power handling capacity and distortion of common amplifiers shall be specified.

(f) The impedance at the line terminals is important and its return loss against 600 ohms should be specified.

(g) The return loss against 600 ohms at the voice frequency terminals shall be not less than 20 db.

(h) Each channel shall be equipped with volume limiters so that overloading of the common amplifiers is avoided.

(i) The overall frequency response, noise, distortion and overload point required of each channel shall be specified.

(j) The maximum allowable values of interchannel interference and crosstalk shall be specified.

(k) The maximum allowable value of carrier leak shall be specified.

(l) The stability of the system with particular reference to oscillator frequency and amplifier gains shall be specified for the voltage variations expected in Departmental power supplies and for temperature variations which may be encountered under Australian conditions.

### EXAMINATION No. 2906—ENGINEER, LINE CONSTRUCTION

**Q.1.—What are the main specification requirements of wooden crossarms?**

**Under what circumstances are the various sizes and types used?**

**Explain the need for adequate and proper seasoning of crossarm timber before use.**

**A.**—The main specification requirements for wooden crossarms refer primarily to the class and quality of timber used for the manufacture of the crossarm, subject to adherence to the pattern and dimensions required for the various arm sizes.

The class of timber should be such that it possesses the inherent properties which give the greatest relative freedom from—

(a) Decay and termite attack.

(b) Liability to splitting, checking, twisting, collapse, shrinkage, or other deformation,

and for this purpose it is usual to restrict purchases to those classes of timber which are known to be suitable.

The quality of the timber used in the manufacture of the crossarms is specified as being of sound structure, not having been affected by termites, grubs, borers, fungus or other injurious condition; and except that blemishes may be permitted within certain limits, it should be free from large or loose knots, splits or shakes, long or wide gum veins or other defects which would reduce the strength or appreciably alter the shape of the crossarm.

The following are the general specification requirements covering the quality of the timber used for any crossarm.

(1) **Gum Veins.** Tight gum veins under $^{1}/_{16}$″ in width are permitted, provided—
  (a) No gum vein exceeds 18″ in length.
  (b) The combined lengths on any face do not exceed 36″.
  (c) The gum veins do not emerge through edges or ends of the arm.

(2) **Knots.** Not more than two sound tight small knots (not over ½″ diam.) are permitted, and these should not be closer than 10″ or within 6″ of the centre bolt hole or within 2″ of any spindle hole. A number of smaller knots up to ½″ diam. may be permitted, but the maximum number must not exceed six.

(3) **Checks.** Small surface checks are permitted provided that they do not exceed 4″ in length and are of no appreciable depth.

(4) **Shakes and Splits.** Crossarms must be entirely free of shakes and splits.

(5) **Grain.** The crossarm timber should be generally straight grained, with the grain approximately in the same direction as the length of the arm. The maximum inclination of the grain to any face should not exceed a slope of one in 30 or an angle of approximately 2°.

(6) The timber should be wholly solid truewood, and no sapwood, bark, or heart should be present in any crossarm.

**Cutting and Finish of Crossarms.**

In cutting and finishing crossarms the completed article should be sawn with adjacent sides at right angles and free from splinters or split edges. The ends of the crossarms must be sawn at right angles to the sides and should be free of splits. Crossarms cut from unseasoned timber subject to shrinkage, should have increased cross sectional dimensions to compensate for the shrinkage. In this case the standard dimensions 3″ x 3″ should be increased to 3⅛″ x 3⅛″.

(b) The various sizes and types of crossarms in use by the Department are designed to meet the requirements in respect of—

(a) The expected development of circuits on a route.

(b) The class or type of circuit to be erected.

The sizes of arms, types of arms and the purposes for which they are designed are summarised as follows:—

52″ arm.—To be used where the number of wires which may be erected in the life of the poles will not exceed four. Use generally restricted to trunk routes in isolated country districts.

80″ arms.—For minor trunk routes when the number of wires will be between 4 and 6 within the life of the poles. Bored for 6 pin positions. For general use on subscribers' pole routes when the arms may be bored for 10 wires at 7″ spacing, or for 8 wires at 9″ spacing if used on routes where long spans are necessary.

108″ arm. (i) For use on main trunk routes when the number of trunk wires will exceed 6 in the life of the poles.

108″ arms are of the following types:—

(a) bored for 9″ and 14″ wire spacing and may be used for either spacing. Provides for a total of 8 wires and used for main TK routes where 9″ carrier spacing is not immediately necessary.

(b) bored for 9″-18″-9″ wire spacing only. Provides for a total of 8 wires, and used where 9″ carrier spacing is necessary immediately.

(c) bored for 6″-22″-6″ wire spacing. Provides for a total of 8 wires and used on new carrier routes where a pole spacing of 44 yds. is adopted, and all circuits are required for 12-channel carrier working.

(d) bored for 6″-16″-6″-8″-6″ wire spacing. Provides for a total of 12 wires and used below 6″-22″-6″ arms on carrier routes for minor trunk and subscribers' circuits.

(ii) For use on main trunk routes to carry subscribers' circuits when erected below 108″ trunk arms. When used for subscribers' circuits the 108″ arm is bored for a total of 14 wires with a spacing between spindle holes of 7″.

All of the above types of arms have cross sectional dimensions of 3″ x 3″, and are bored either with $1^{1}/_{16}$″ holes for wooden spindles or with $^{11}/_{16}$″ holes for steel spindles. The wooden spindle arms are used for normal construction where the pull on the spindle does not exceed 80 lbs. The steel spindle arms are used on angle poles where the lateral stress on the spindle exceeds 80 lbs.

**108″ Terminal Arms.**

Each of the types of 108″ arm described above are manufactured in a heavier timber section which is 6″ x 3″ over 1′ 16″ of the middle section and tapers to 3″ x 3″ at the ends. These are bored for fitting steel spindles only and are used for terminating wires on 108″ arm routes.

**Seasoning of Crossarm Timber.**

Timber is normally cut direct from green or wet logs in the mills for the ultimate purposes for which it is required, and except for special uses is not further cut or dressed. As the moisture in the timber drys out shrinkage occurs which reduces the overall dimensions and tends to produce deformation, due to unequal stresses set up in the timber fibres during the drying out process, unless this is controlled. Crossarm timber should, therefore, be properly stacked in the open to permit a uniform circulation of air, and to provide an adequate restraint on the movement of any section of the timber during the period of drying. Adequate seasoning of the crossarms in this manner ensures that the arms, when erected, will not suffer a further appreciable shrinkage, which would cause a loosening of bolts and fittings attached to the arm. The distortion or warping of the arms under the effects of normal loading stresses is also avoided to a large extent.

## PART A.—GENERAL

**Q.2.—Indicate the objects of making a telephone survey and describe the methods of making such a survey.**

**A.**—The object of a telephone survey is to determine the probable future requirements of a street, district or town for telephone facilities.

Together with the records of existing subscriber services the results of such a survey make it possible to:—

1. Determine the number, sizes and most suitable locations for subscribers' exchanges in a telephone system.
2. Utilise existing plant to the best advantage.
3. Design external plant installations in the most economical manner.
4. Prepare a programme for the provision of plant on the most economical basis.

Reliable forecasts of growth cannot be made beyond a period of 20 years, but up to this time reasonable accuracy can be obtained. In practice, forecasts are made of the 20 year development and an earlier predetermined period or periods, such as 8 year and/or 12 year.

The survey should give separate figures for the forecasted exchange lines and miscellaneous lines not requiring exchange switching facilities. The former figures will be used by the equipment engineer for consideration in the provision of buildings and switching plant, and the combined figures by the lines engineer for provision of the necessary line plant.

The survey will be a record of field observations in the area and will be used in conjunction with:—

1. Studies of past telephone growth in relation to the growth of population.
2. Studies of the probable commercial, public and private development of the area.

Prior to undertaking a survey two up-to-date sets of maps or street plans should be obtained covering the whole area to be surveyed. One of these sets of maps will be used to record field work results, and the other for final recording of the survey and forecast data.

On the field maps a clear indication should be made of the location and class of service of all existing installations. Doubtful locations should be confirmed during the field work.

After a quick tour of the area to clarify general impressions the surveying officer should work from the business centre of an area towards the outskirts, so that, when considering vacant blocks in the outer part of the area a knowledge of the business characteristics will enable a more reliable assessment to be made.

The surveying officer should traverse each road, street, etc., and assess for each existing property the probability of the occupier requiring the provision of telephone facilities within the 20 year period. Similar assessment should be made for any vacant land blocks.

To facilitate recording and calculation of the survey assessments, it will be found desirable to use a development value figure for each possible subscriber and vacant property block considered as a future possible subscriber location.

A simple method of valuation for entry on the field map is as follows:—

| | Value |
|---|---|
| Residential properties of a type which should require a telephone within 20 years .... .... .... .... | 5 |
| Residential properties of type of which 4 out of 5 should require a telephone within 20 years .... | 4 |
| Residential properties of type of which 3 out of 5 should require a telephone within 20 years .... | 3 |
| Residential properties of type of which 2 out of 5 should require a telephone within 20 years .... | 2 |
| Residential properties of type of which 1 out of 5 should require a telephone within 20 years .... | 1 |

Different symbols should be used to indicate types of property assessed, such as:—

Vacant residential blocks—X beside the value, thus 4X.
Business properties—brackets round the value, thus (4)
Vacant business sites—brackets round the value and a cross, thus (5X)

It will be seen from the above, that in any street or area, if all values are added together and the total divided by 5 the result will give the number of telephone services likely to be required in the street or area within 20 years. From this figure and the total of existing services, as each road or part of a road is surveyed, an assessment should be made of the number of the possible subscribers likely to require the services before or at the earlier predetermined period.

Use of the survey data will be facilitated if the field maps are marked to outline cable distribution areas, and total forecast figures may be entered within each such area thus:—

62 (Existing)
———
133 (Early period forecast)
———
257 (20 year forecast)

Similarly, later calculation of the theoretical centre may be made easy by division of the area into suitable small squares by marking them on the map and adding separate forecast totals within each square.

Large building properties on small city blocks require a separate treatment, and survey results may best be recorded in book form.

The surveyor should treat each building or floor in large buildings separately, and enter details of any vacant floor space as would be done for vacant blocks in less congested areas.

Useful information may be obtained from property owners, agents and civic authorities on the possibility of policy changes envisaged which could alter the trend of telephone development, both in the outer areas and within the congested city buildings.

Results of calculations made from data recorded in the field maps and city area books should be transferred to the office record map, which also should be marked to show the cable distribution areas and the small squares mentioned previously.

Assessment of probable numbers of miscellaneous services is difficult in the smaller street blocks, and experience has shown that this may best be done on a percentage basis based on the ratio of existing exchange lines and existing miscellaneous services.

### ERRATA

Vol. 8, No. 3, Page 186:

Last line of column 1 should read:
x c/s which create a beat tone equal to 2 x c/s.

The Ruskin Press
123 Latrobe Street
Melbourne