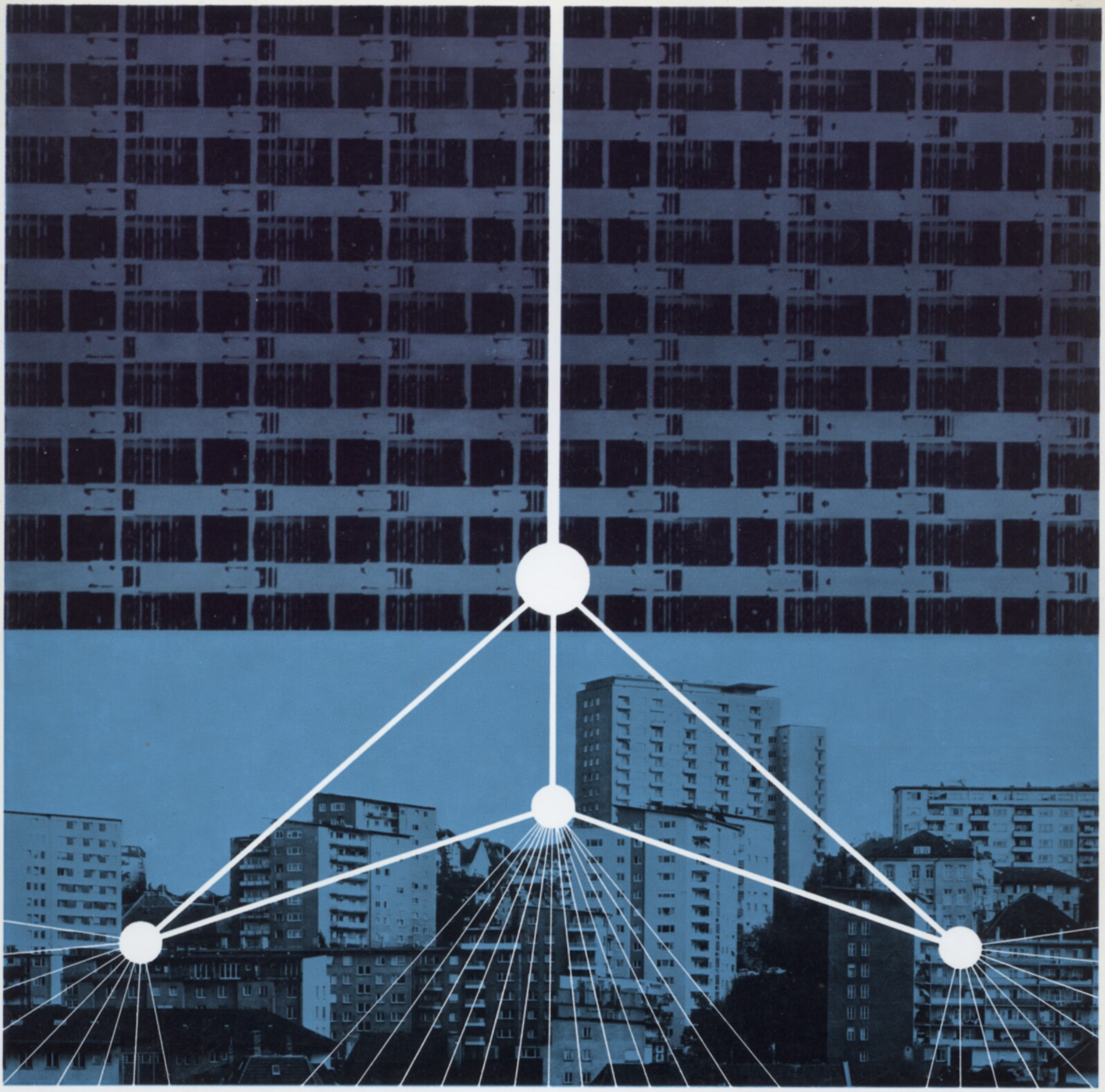


Pentaconta Local Telephone Switching System

General Description

ITT

Contents

Pentaconta switching offers the widest range of facilities and finest quality of service available on the market today. The local telephone system Pentaconta 1000, as described in this brochure, is a highly economic and flexible system, equally suitable for single local exchanges or for multi-office networks, and is readily integrated into nation-wide subscriber dialling.

The modern signalling and control principles of the system ensure high efficiency of operation and also easy interworking with existing and future exchanges of any type. The equipment is easily installed at low initial cost, and this low cost affects neither the capacity for future growth nor the cost of maintenance.

The unique ITT Pentaconta relays and crossbar switches used in this system are manufactured by ITT companies all over the world, and enjoy an established reputation for high standards of design and workmanship. The small and easy-to-handle equipment units, the pre-assembled cables, and the plug-in features not only simplify the initial installation, but also enable future extensions to be installed easily and inexpensively.

ITT representatives will welcome your enquiries and the opportunity to discuss your telephone requirements whether they be large or small.

The Pentaconta Local Telephone Switching System

The Pentaconta local telephone switching system is a common-control crossbar switching system with completely separate speech and control paths. The separate paths enable the speech circuits to be very simple so as to make very reliable connection, while the short holding times of common-control circuits ensure the most efficient use of all equipment. Not only is the control equipment separate from that required for speech, but the information paths are also separate. These information paths are common connections over which information between control elements is transferred in 2-out-of-5 or 2-out-of-6 code.

The Pentaconta local exchange system is a link switching system. The switching network is composed of selection units, each unit having a primary and a secondary stage. The principles of conjugate-selection and mutual-aid are used to ensure the highest efficiency of the selection stage, and to reduce to the minimum the internal blocking inherent in every link system.

Mutual-aid and the interconnections between stages are illustrated in Figure 1. Conjugate-selection ensures that the choice is made of one of all free paths providing access to a free outlet in the required direction. It has the additional advantage of increasing the selection speed by making a single rapid choice of the most suitable path.

Internal connections in the selection units are so arranged that each primary section has access to all secondary sections (a section is a group of selectors having a common multiple). Thus every incoming selector has access to all the outlets which connect to the succeeding circuits. This method results in full availability to all groups of trunks, and increases the traffic capacity of both trunks and internal links, reducing the number required to a minimum.

Mutual-aid complements conjugate-selection. In a system having direct links only between primary and secondary sections, a call will be blocked if all direct links are busy between the primary section receiving the call and the secondary sections which have free outlets, even when there are free links from other primaries. Mutual-aid gives the primary sections links between themselves, so when a primary section receives a call and has no free direct link to the appropriate secondary, it routes the call via another primary. Three-stage selection is thus used in this case.

Figure 2 shows all the main circuits of the Pentaconta local exchange system. The speech path comprises the line and group selection units and the junctors; the control unit consists of the markers, the register and associated access finders, the translators and the senders. The information paths include couplers and connecting circuits.

Figure 3 shows how traffic concentration and expansion in the Pentaconta local system takes place in the line selection units (LU), while distribution takes place in the group selection units (GU). The number of LUs is in direct proportion to the number of subscribers' lines, and the number of GUs, which carry not only local calls but also calls between exchanges, depends on the traffic to be handled. Within these stages traffic is not confined to fixed paths, but can flow over different network combinations depending on the volume of traffic at the time a call is made.

The line and group selection units are each controlled by a pair of markers which, although mounted with the selection units, belong functionally to the control unit.

The control unit is the intelligence of the Pentaconta local telephone switching system, its central circuit being the register/translator, whose logical functions are to receive and analyse digits; to control the setting up of connections; and to dispose control auxiliaries such as senders and receivers for interworking with other exchanges. These auxiliaries are connected for the shortest possible time. Decentralisation of control functions thus forms another outstanding characteristic of the Pentaconta local system whereby control circuits are used with the greatest economy.

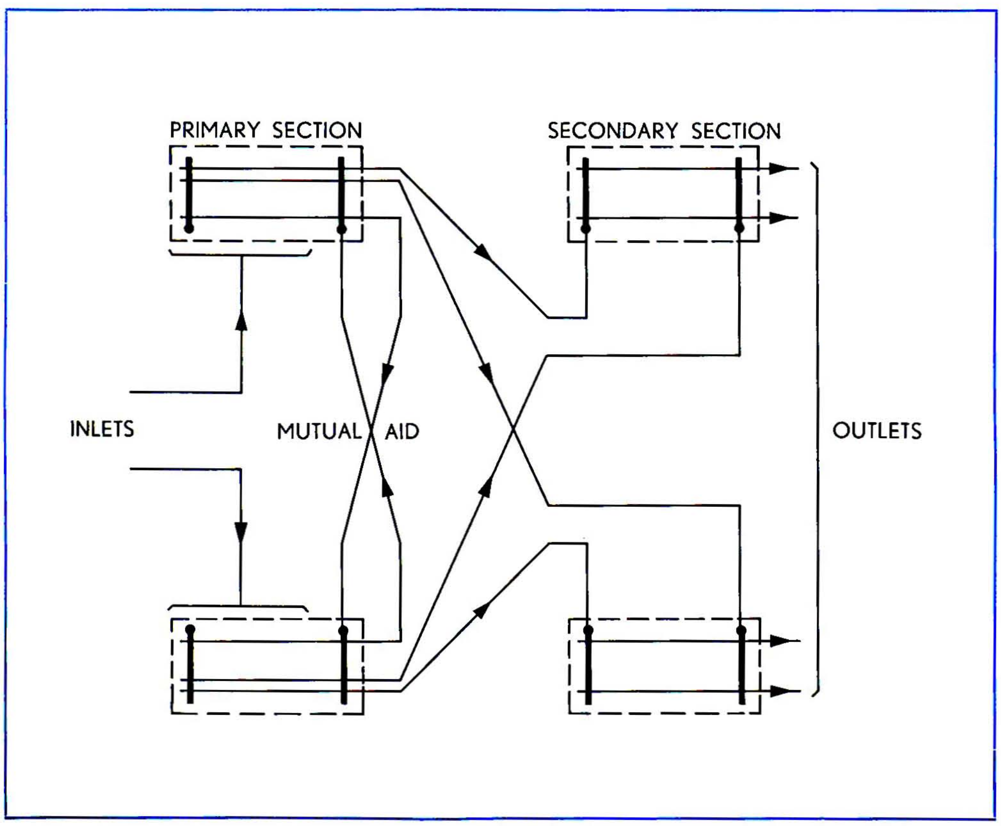


Fig. 1 Two- or three-stage conjugate-selection in the Pentaconta local system

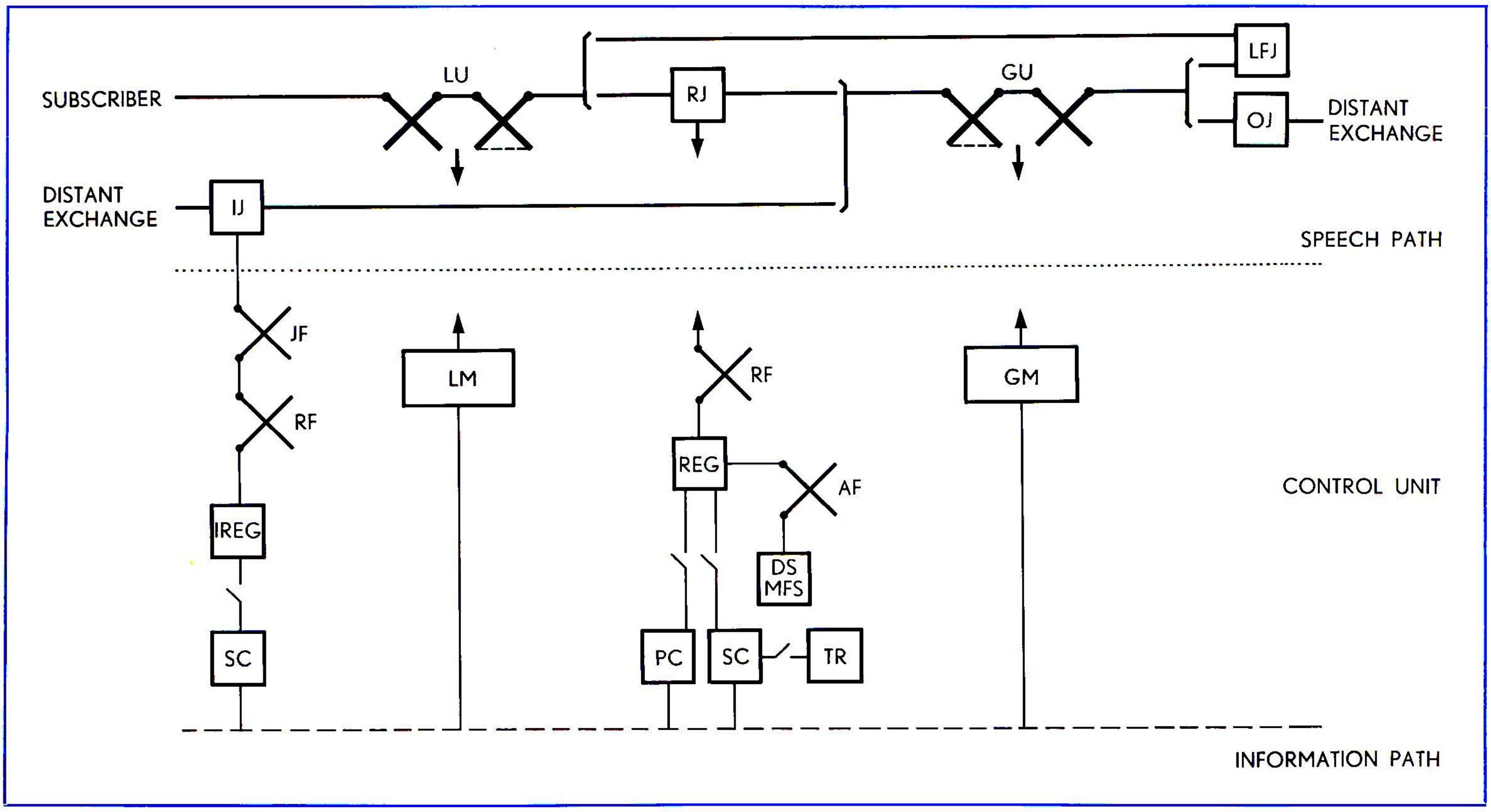
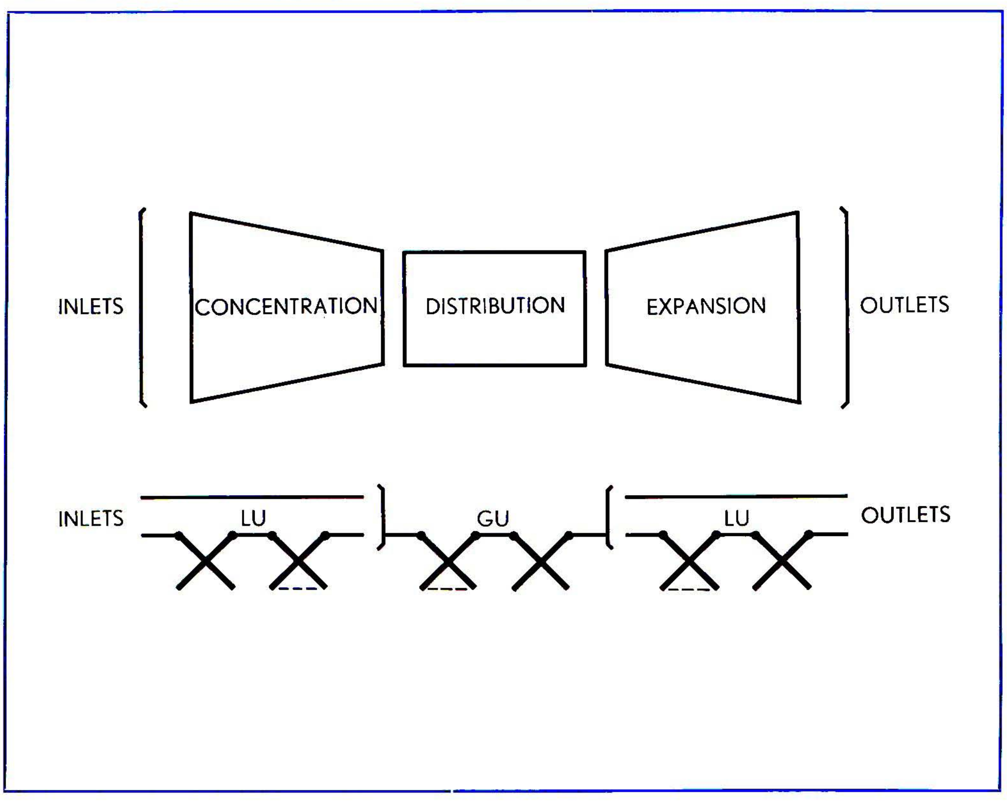
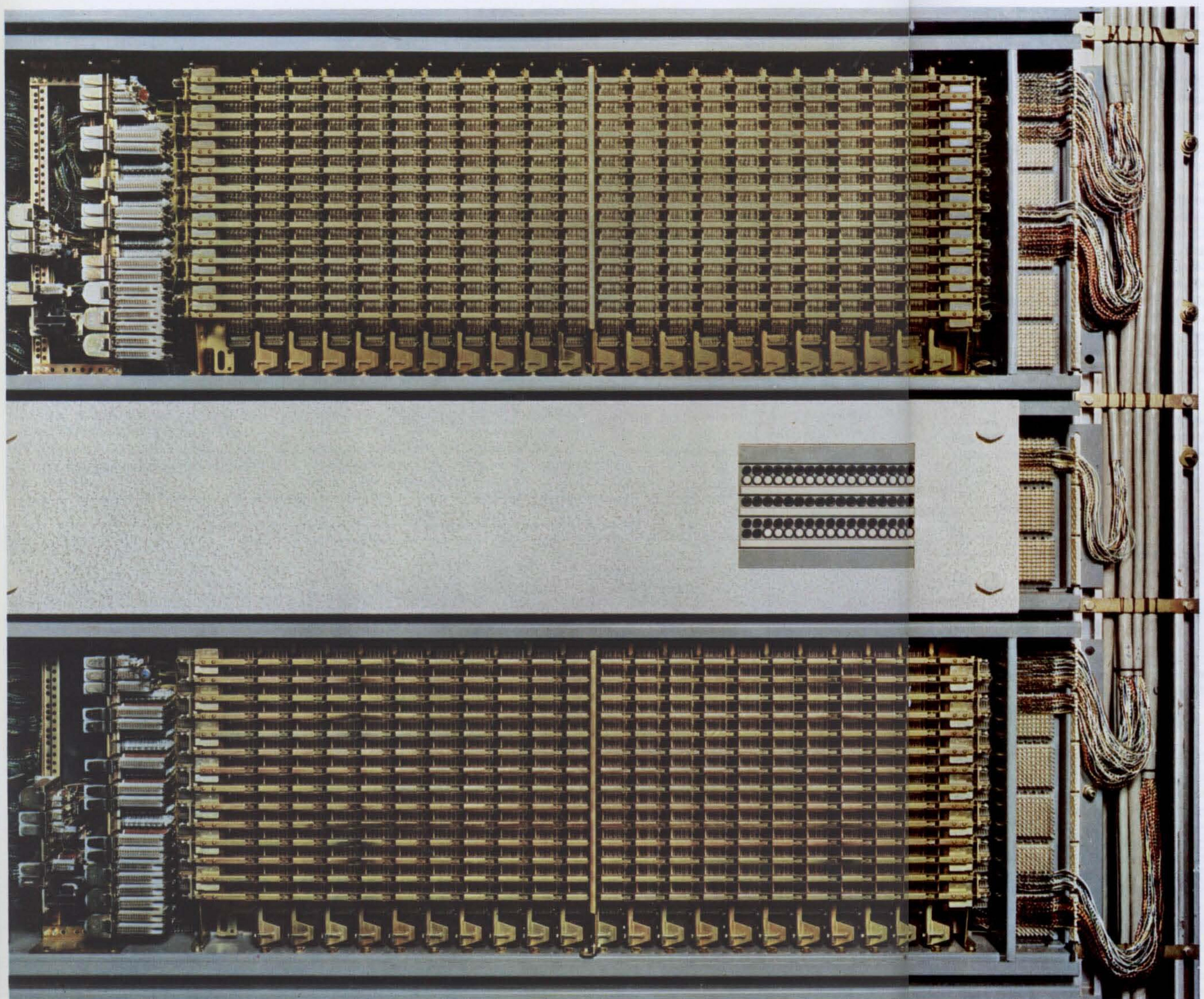


Fig. 2 Basic diagram of the Pentaconta local system

Fig. 3 Concentration, distribution, and expansion of exchange traffic in the Pentaconta system





Main Features

Our engineers have incorporated many customer-oriented features into the Pentaconta local system. Some of these are:

- subscribers' class of service distinction
- regular, coin-box and PBX lines
- party lines
- pushbutton dialling
- line circuit lock-out
- absentee service
- call restriction
- malicious-call tracing
- unrestricted numbering in line groups
- non-consecutive numbering of PBX groups
- PABX in-dialling
- identification of caller's number
- individual message accounting for all lines
- single-fee, multi-fee or time pulse metering
- automatic message recording
- conjugate-selection
- mutual-aid
- full availability of junction groups
- random hunting
- alternative routing
- second attempt selection
- open and closed network numbering
- uni-directional or both-way trunk circuits
- multi-frequency signalling
- end-to-end signalling
- interworking with all types of exchange
- automatic fault recording
- priority distribution
- incoming and outgoing route class of service
- traffic recording
- centralized testing from test desk
- calling party release
- toll offering

Speech path

The circuits engaged during conversation are the appropriate selection units and junctors. These form the so-called speech path or switching network.

Line selection unit

A line selection unit can serve up to 1000 directory-numbered lines. Its primary stage is composed of call finders, penultimate selectors, and mutual-aid selectors, and its secondary stage of terminal selectors. The general arrangement of these two stages is shown in Figure 4.

The primary stage has from four to eleven primary sections. The number of sections is half the number of the terminal selectors fitted in one terminal section of the secondary stage. Each primary section has 22 selectors and 52 outlets, and is assembled with all associated control relays in one frame.

A typical frame has: 2 mutual-aid selectors; 1 penultimate selector convertible into a mutual-aid selector; 7 penultimate selectors; 5 call finders convertible into penultimate selectors; 7 call finders.

Of the 52 primary stage outlets, 42 are used for connections to the terminal selectors, and 10 for mutual-aid.

The secondary stage of the line unit consists of terminal switches, each connected to 74 subscribers. The terminal section is equipped with an even number of terminal selectors ranging from 8 to 22, together with their associated control relays. Each line unit has a capacity for 14 sections, or 1036 lines. The additional 36 lines are used for PBX groups or for other lines not requiring identification by a directory number. The terminal selectors, whose outlets are connected directly to the subscribers' line circuits, carry both originating and terminating traffic.

Terminal selectors are alternately connected to one and two primary sections. A terminal frame with 14 selectors will be connected to 7 primary sections.

Terminal selector	00	01	02	03	04	05	06	07	08	09	10	11	12	13
Individual or common	I	C	I	C	I	C	I	C	I	C	I	C	I	C
Primary section	00	00 01	01	01 02	02	02 03	03	03 04	04	04 05	05	05 06	06	06 00

In the line selection unit, each primary section has a minimum of two, and a maximum of three, mutual-aid selectors, which are multipled over the primary section outlets. For example, mutual-aid selector 00 from primary section 00 is multipled to outlets of primary sections 01 and 02, and mutual-aid selector 03 appears in primary sections 07, 08, and 09.

The following control devices complete the circuitry of the line selection unit:

- a group of common relays per 518 lines to distribute traffic evenly over primary sections
- two markers (three in exceptional cases)
- two sets of marking relays, one set per 518 lines, with associated distribution frames to permit free numbering within a group

The markers have access to both sets of marking relays, so that two calls can be handled simultaneously provided they are in different line groups.

In an originating call, the marker controls the connection of the calling line to a register over a terminal selector, call finder, and register junctor, and transmits the caller's class of service to the register. This operation is known as "preselection".

In a terminating call, the marker receives from the register the last three digits of the called line's directory number. It then controls the connection of the called line (via a terminal selector) to the appropriate penultimate selector, and transmits the called party's class of service to the register. This operation is known as "line selection". When a call is offered by an operator, the register so informs the marker, which controls the through connection, even when the called line is busy.

For very high traffic, a line unit is used catering for 500 directory-numbered lines instead of 1000, and again consists of two stages working in conjugate--selection. The primary sections have 22 selectors and 52 outlets.

The secondary stage consists of ten terminal sections, each section having 52 outlets and a maximum of 22 terminal selectors. This very-high-traffic unit, together with the units already mentioned, will meet the requirements of any subscriber traffic encountered in practice.

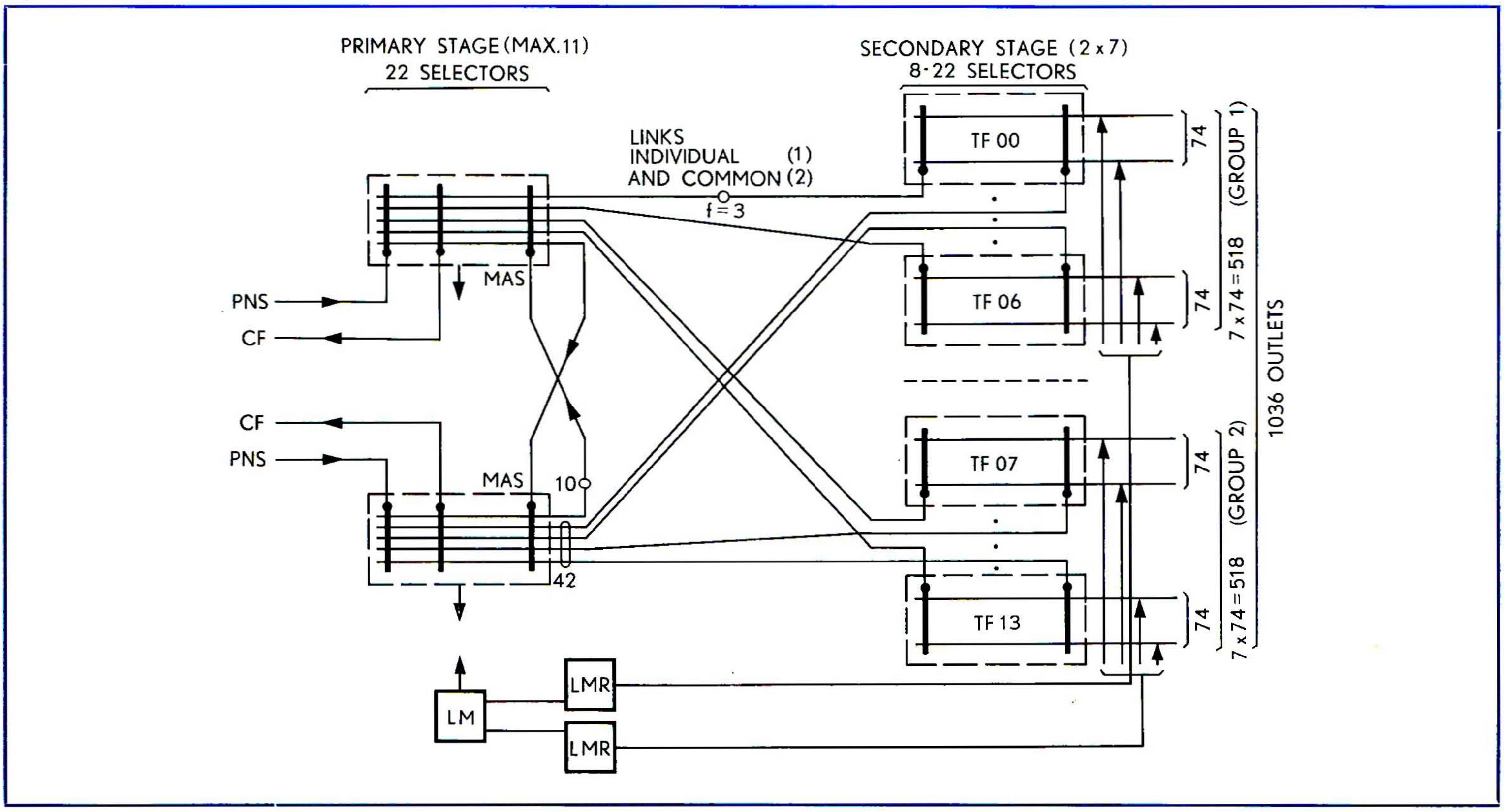
Group selection unit for 1040 outlets

Like the LU, this unit consists of primary and secondary stages working in conjugate-selection and mutual-aid. The important differences from the LU are that the traffic is uni-directional (from the primary to the secondary section), and that a primary section may be composed of more than one switch frame.

The group selection unit is illustrated in Figure 5. The GU accepts calls for all classes of traffic; that is for local, outgoing, incoming, and transit calls. The unit consists of primary, secondary, and mutual-aid selectors; two markers with marking relays; and the necessary common relays.

The number of primary sections per GU varies, the maximum being five. The secondary section has a maximum of ten selectors. The number of links between each primary and secondary section is a minimum of two.

Fig. 4 Line selection unit



A primary section may have one, two or three frames with a common horizontal multiple. Normally there are two frames in a section, but for some small exchanges one frame may be adequate.

Primary section frames have a capacity for 22 selectors. In the first frame these comprise primary and mutual-aid selectors, while the second and third frames are fitted with primary selectors only.

Primary selector inlets are connected to:

- register junctors (originating traffic)
- incoming junctors (for calls from other exchanges or from special services)
- outlets from a preceding GU (when the exchange has two group selection units in series)

Of the 52 primary section outlets, 40 are used for connections to the secondary selectors, and 12 for mutual-aid.

The maximum number of secondary sections is 20, which with 52 outlets per section gives a maximum of 1040 outlets.

Each secondary section consists of a half-frame with a capacity of ten secondary selectors.

The GU constitutes one block, or stage, in the distribution of traffic. A normal composition is 20 secondary sections (each with ten secondary selectors), and five primary sections (each with 39 primary and five mutual-aid selectors). The number of inlets to such a unit is therefore 39 × 5, or 195.

Since traffic is neither expanded nor contracted in the GU, the inlet load must be substantially equal to the outlet load. Thus it may be convenient to group two, three, or four GUs together, thereby obtaining a balanced unit. The number of inlets becomes 195 × n, while the number of outlets remains at 1040.

The control devices which complete the circuitry of the group selection unit are:

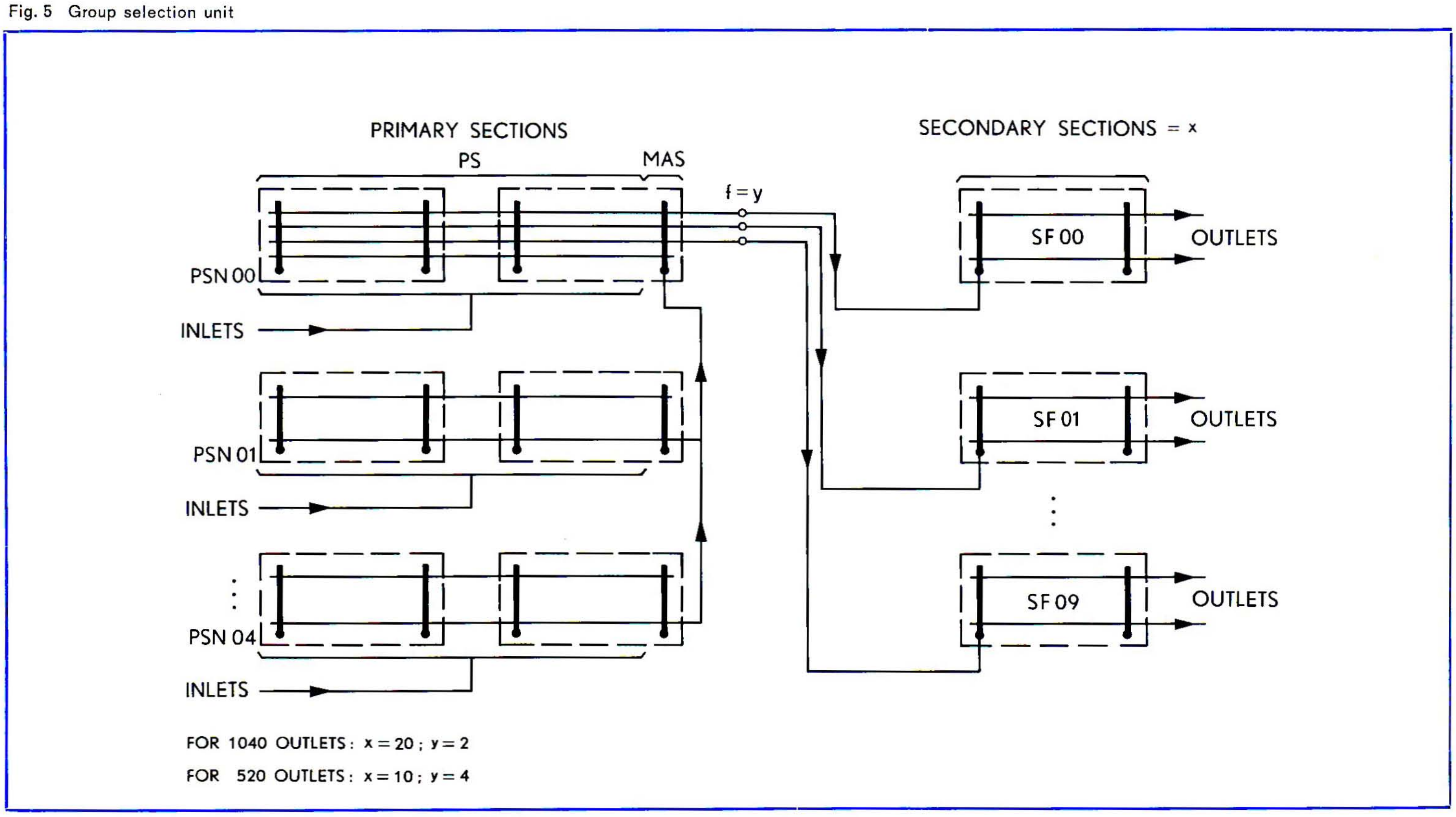
- two markers
- a group of common relays which interpret the route code and any special route information, and distribute traffic evenly over secondary sections
- two sets of marking relays each set of which deals with ten secondary sections of one GU, i. e. for 520 outlets.

The marker receives selection information codes from the register/translator; seizes the common relays; controls the connection of the chosen junctor over a secondary selector to the appropriate primary selector; and transmits the category of the selected junctor (or notification of congestion) to the register.

The 1040 outlets of the GU are used in groups of different sizes appropriate to the various routes and the number of lines per route.

To obtain adequate flexibility with the minimum number of relays, the Pentaconta local system has standardized on a fixed number of marking relays with different contact assemblies.

Fig. 5 Group selection unit



Group selection units for 520 outlets

A unit with only 520 outlets can be used as an alternative to the normal 1040 outlet unit. Instead of having two secondary sections with ten selectors each, and having the outlets of each ten multipled separately, all twenty selectors can be multipled together. This will give only half the number of outlets. The number of primary sections and the number of links remain as in the 1040 outlet unit, but each secondary section now has twenty selectors instead of ten. The maximum number of secondary sections is therefore ten, and only one group of marking relays is required.

Single-stage group selection unit

In some small exchanges a single stage is provided. The distribution of primary and mutual-aid selectors remains unchanged. An arrangement, with a maximum of five sections, is shown in Figure 6.

Group selection unit for 2080 outlets

Large exchanges may use a 2080 outlet GU having a capacity for up to seven primary sections (each with 44 primary selectors of which eight may be used for mutual-aid), and 40 secondary sections (each with seven regular and two secondary mutual-aid selectors).

Junctors

Incoming and outgoing junctors used in the Pentaconta local system combine uniformity of internal signalling between the control unit and the junctors with an adaptability to any kind of external conditions.

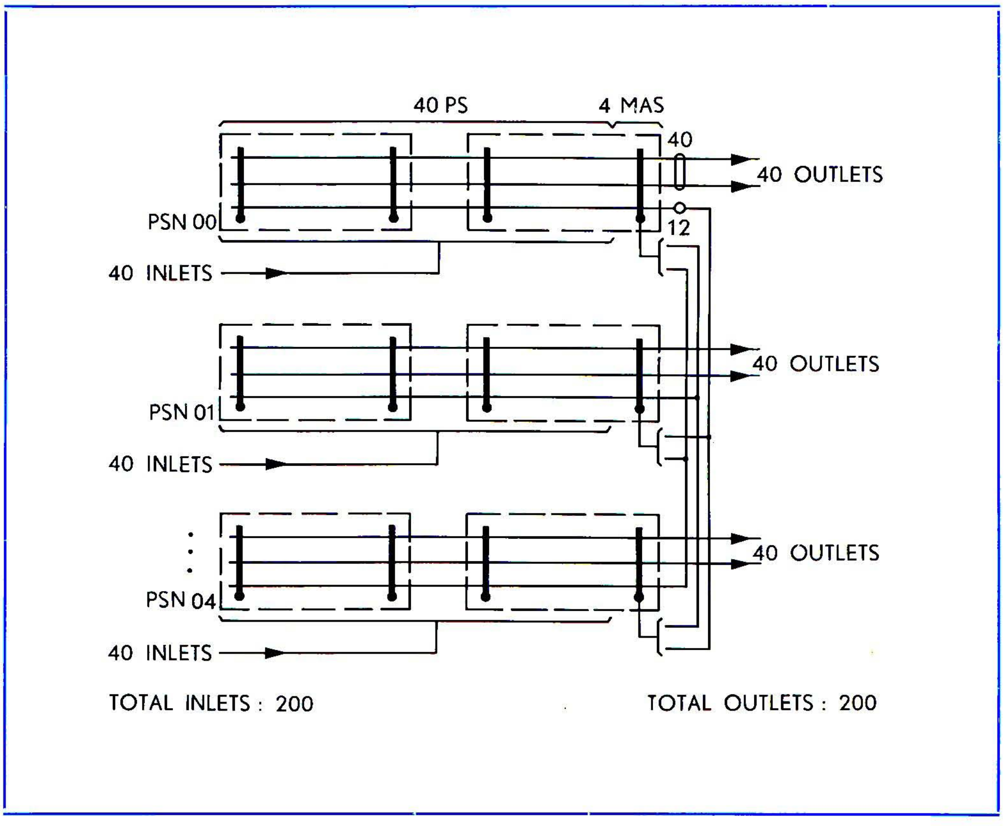
This adaptation is done at the incoming and outgoing junctors, which provide supervision on all but wholly local calls. This ensures separation between the line signals and the circuits internal to the exchange. It is then possible to adapt to any type of line signalling simply by modifying the line side of the incoming or outgoing junctor. The through-metallic connections which can be incorporated in the junctor allow the passage of d. c. pulses or signals through the exchange without having to repeat them. Such signals may also be transmitted to distant exchanges without having to repeat them at the outgoing junctors.

The register junctor has no supervision or adaptation, its function being to provide splitting between the line and group selection units, and to provide connection to the control unit while the call is set up. Local feed junctors are inserted between the group unit outlets and the line unit penultimate selectors. They provide for feed and ringing current, supervision, and metering on local calls.

Type and location of feeding bridges

The normal bridge is based on relays and capacitors, but transformer bridges can be used if required. Inductance bridges can be added if required by working conditions, but these bridges are unusual. To achieve the lowest possible attenuation, the number of bridges inserted in the overall speech path has been reduced to the absolute minimum, which is a single pair of capacitors per exchange. The bridge is located in the local feed junctor for local calls, in the outgoing junctor for

Fig. 6 Single-stage group selection



outgoing and transit calls, and generally in the incoming junctor for incoming calls to a local subscriber. A satellite exchange may in this respect be considered as a local subscriber.

Control unit

The control unit constitutes the intelligence of the exchange, and can be divided into two parts, the control circuits and the information paths (Figure 7). Control circuits receive, store, analyse, and transmit information, while information paths provide channels to carry this information. The control circuits are the markers, registers, access finders, translators, senders and receivers. The information paths comprise connecting circuits, preselection and selection couplers, tariff links, and sender links.

Registers

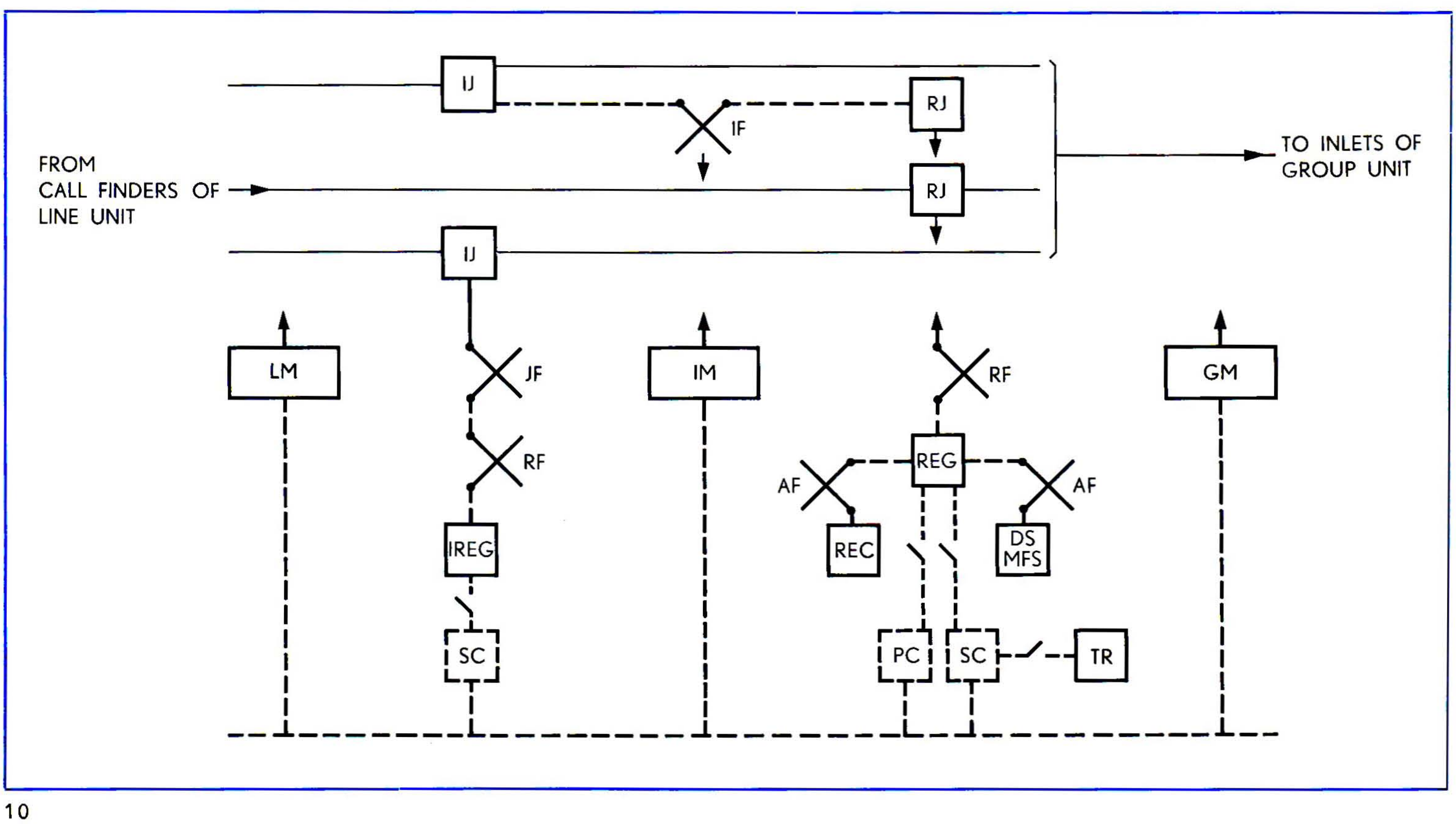
The register is the central control circuit, and can be either universal or of a type with special limited functions. The universal type can deal with every class of call. It can be connected to receivers and senders of every type, and can therefore be used for interworking with any type of distant exchange. However, it is normally more economic to use special local and incoming registers. Local registers deal solely with originating calls, and are connected as required to senders of the type necessary for interworking with a specific system for outgoing calls. Incoming registers are made for one or more types of register signalling. A register for more than one type of signalling has appropriate facilities for connection to each type of receiver.

The functions of the register are receiving and storing of digits; seizure of preselection and selection couplers; control of selection phases; connecting to receivers and senders; interworking with other control circuits; and fault location and indication.

Register finder

This is a crossbar switch having twelve vertical bars arranged in pairs to give access to six local registers from 50

Fig. 7 Control unit (control circuits and information paths)



register junctors. The switch frame also accommodates the associated control relays and register junctor relays.
For distribution over the register finder outlets, the call finders of each primary section are split into half-sections, each half-section being connected to a different register finder frame. An LU with the maximum of eleven primary sections will therefore have 22 half-sections, with accessibility to $22 \times 6 = 132$ registers.

Each LU primary section has a possible maximum of twelve call finders, or six per half-section, and a register finder can have eight or ten call finder half-sections connected to it.

Intermediate finder

The intermediate finder is also a crossbar switch which is provided if local registers are used for incoming traffic. It provides access for incoming junctors to the register finder multiples.

An intermediate finder frame consists of two equal parts, each with 28 outlets and 10 inlets (or selectors). Each intermediate finder of each group of ten goes to a different register finder frame, so that each incoming junctor has access to 60 registers.

Double and single-stage finders

To improve the concentration ratio between incoming junctors and registers, two specialized control units are used, particularly in large exchanges, one unit being suitable for local and outgoing traffic and the other for incoming traffic. Two schemes are used as standard for the connection of incoming registers: a double-stage finder arrangement in which each incoming junctor has access to 80 incoming registers; and a single-stage register finder arrangement with mutual--aid facility in which each incoming junctor has access to 24 incoming registers. The choice between them is dictated by speed and economy.

Auxiliary finders

The senders and receivers used for interworking over trunks to distant exchanges are referred to as auxiliaries. Access to these is by means of an auxiliary finder.

In very small exchanges a single group of finders is used for both receivers and senders, but normally two distinct groups are used.

Senders and receivers

The auxiliary circuits simplify the register by providing separately the apparatus needed to send and receive any special signals required by distant exchanges. There is a different type for every signalling system, such as direct impulsing, revertive pulsing, or multi-frequency codes. The equipment is mounted on standard frames but generators and detectors for multi-frequency codes are mounted separately to facilitate maintenance.

Translator

The translator decodes signals stored in the register and applies the information to routing the calls and determining the tariff. It also notes the subscriber's class of service and the type of call so as to impose any necessary restrictions. An essential feature of the translator is its cross-connecting field, which enables it to translate the register 2-out-of-5 codes into the signal required for the appropriate route or service.

Although the translator functions only in connection with the register, it is made as a separate unit. This is mainly because it is in service for such a short time that a translator can serve several registers.

Markers

The function of the marker is to control the establishment of speech paths through the exchange. Marker operation has already been referred to when describing the selection units (pages 7 and 8).

Information path

Connecting circuits

A connecting circuit is used to transfer information from one control circuit to another. It comprises four information paths which operate independently and simultaneously to give access to 20 control circuits. The speed of operation permits 66000 operations an hour per connecting circuit. The control circuit seizes the connecting circuit, transfers the information rapidly, and then immediately releases the connecting circuit.

An information path consists of 20 wires, permitting simultaneous transmission of four 2-out-of-5 codes. To switch these 20 wires all together, the connecting circuit uses the multiple relay, which is an assembly of 20 relays each having eleven contacts. The moving springs of these contacts are independent, but the fixed springs are bars common to the 20 relays, thus effectively multipling the relay outlets. Two multiple relays provide the channel, and together have the twenty contacts required for one information path plus two extra contacts for control. Four pairs of multiple relays and their associated apparatus form a connecting circuit, and are mounted in a single frame. Should the number of control circuits exceed 20, extension frames can be provided as necessary.

For small exchanges, a single four-channel connecting circuit will suffice for the whole exchange, but in larger exchanges which require several connecting circuits it is customary to allot them to different stages of the exchange. A typical distribution would be one connecting circuit for preselection; one each for group and line selection; and one for senders and tariff computing.

Preselection and selection couplers

Connection from registers to connecting circuits is made by way of couplers so as to concentrate and reduce the access. Preselection couplers are used in one phase of operation only. The selection couplers take part in all other phases of operation such as group selection, line selection, tariff computation, and, eventually, sending.

Sender link

The sender link acts as a tie between the sender and the connecting circuit if some translated selection is necessary, or if special routing information is required by the senders. In the first case the subscriber digits are replaced by another digit, or digits, of which the sender must be informed by the translator over the connecting circuit.

Tariff link

This acts as a tie between the connecting circuit and junctors with multi-tariff facilities, and is the circuit over which the applicable tariff is transmitted from the translator to the junctor.

Ringing, tones, and alarms

Ringing and tone supply can be provided either from rotary machines or from transistorized generators which are normally equipped in duplicate, with automatic change-over in case of failure. The ringing supply is normally 75 V 25 Hz. The standard Pentaconta practice is to use one frequency only, 450 Hz, for all tones (busy tone, dial tone, ringing tone), and to distinghuish between them by different periods of interruption. However, any other frequency or frequencies can be supplied to the requirements of the customer.

An audible and visual alarm system is provided to signal any trouble conditions. The system is arranged to direct the maintenance staff quickly to the source of the trouble. Alarms are locked in position, and continue to give a signal until manually released. In unattended exchanges, immediate trouble signals are given to a distant exchange over a trunk line, indicating at the same time the urgency of the alarm. The local condition can be stored in a special automatic subscriber test circuit, which returns a suitable code giving details of faults when the appropriate number is dialled by the distant exchange test desk operator.

Desks

Although Pentaconta exchange equipment is fully suited for automatic switching for subscribers' toll dialling (STD), operators' switchboards may be required, and for long-distance and inter-continental calls a toll switchboard can be supplied to meet the requirements of the Administration. Toll switchboard positions are fitted with up to seven, or by special request, up to ten cord circuits, with 100-minute timing clocks if required, and with provision for both dialling and keysending.

On toll positions, all key mountings are plug-in, and all face equipment is removable from the front.

Supervisor's desks are standard equipment, and give the supervisor direct access to every position, with monitoring facilities on all calls.

Information desks may be supplied as required by the classification of subscribers' information services.

System Operation

The general operation is best understood by following the sequence of operations for the different classes of call: local, incoming, outgoing, and transit. Reference to the figures given and the indicated paths will enable the sequence to be followed in detail.

Local calls

The operation and setting up of a local call is illustrated in Figure 8.

Preselection

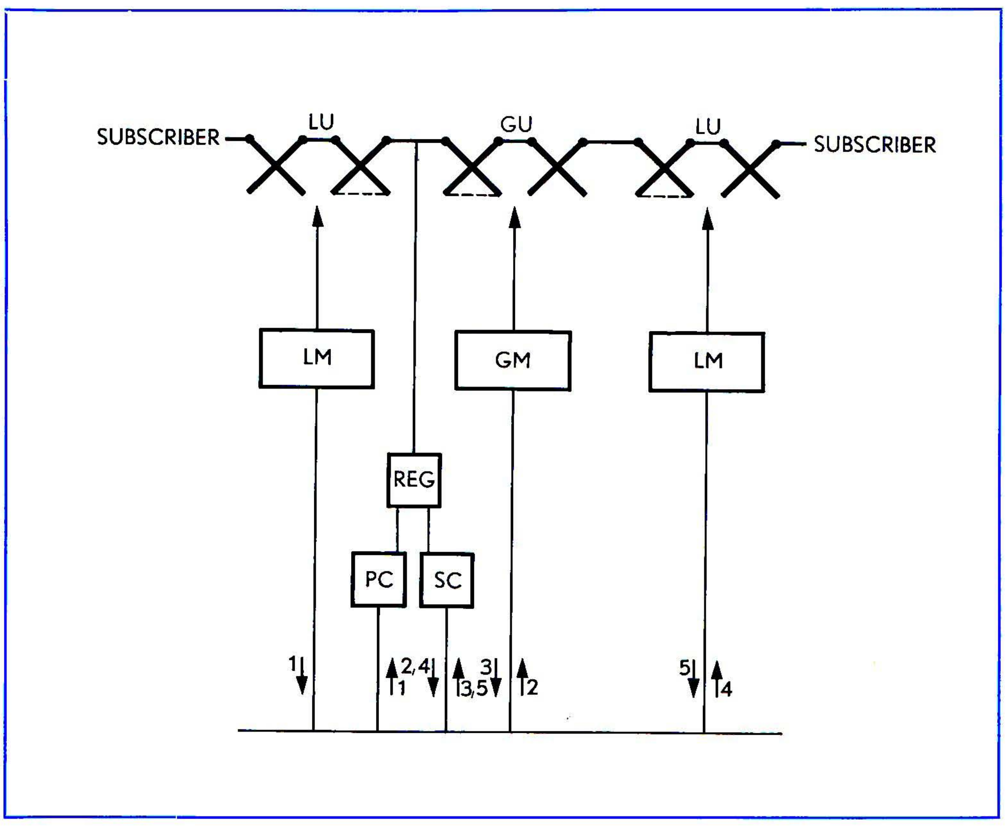
When a subscriber originates a call, a start condition is created in all primary sections having free access to the terminal section to which the calling subscriber is connected. Out of these primary sections, one having access to a free register is then selected to seize this register, which in turn engages a preselection coupler. The primary section then seizes a marker, which it instructs to connect the calling line to the register.

One of the terminal selectors connected to the calling subcriber's line, which has access to the chosen primary section, is then selected.

If no direct link is available between the primary section and the calling terminal section, the marker will select one over a mutual-aid path. The horizontal bar magnets of the primary and terminal sections are then operated. Meanwhile, the marker has seized a connecting circuit whose identity is signalled back to the preselection coupler, which connects itself to the connecting circuit. The marker now transmits the caller's class of service to the register (via the connecting circuit and the preselection coupler – path 1), after which the connecting circuit is released.

On receipt of this information, the register orders the switching by operating the vertical magnets of the call finder and the terminal selector. The horizontal bar magnets and control circuits, including the marker, are released, and the caller receives dial tone from the register.

Fig. 8 Setting up of a local call



Group selection

The dialled digits are received and stored by the register. As soon as the register has enough digits to identify the wanted line unit, it seizes a selection coupler which then engages (via the register junctor) the primary section of the GU to which the register is connected. The primary section seizes a marker, which then seizes a connecting circuit whose identity is signalled back to the selection coupler. The selection coupler connects itself to the connecting circuit, and the register or translator now transmits the route information to the marker (via the selection coupler and the connecting circuit – path 2).

When the route information is stored in the marker, the connecting circuit is released, and the common and marking relays are seized to mark outlets associated with free local feed junctors of the wanted line selection unit. If at least one junctor is free, marking the outlets places the corresponding secondary section in the calling condition, and a free link between this frame and a primary section is selected. If no direct link is available, the marker will select another link over a mutual-aid path. The horizontal bar magnets of the primary and secondary switches are now operated.

The register is then informed (via the connecting circuit, which is being seized by the marker for the second time – path 3) of the category of the junctor, and connects through the GU by operating the selector magnets. The horizontal bar magnets and the GU control circuits then release. In cases of congestion, the register makes a second selection attempt before busy tone is returned to the caller. Some large exchanges have two GUs in series. The first stage is then used to direct the call either to an outgoing trunk route or to the second stage. In this case, the first group selection can start as soon as the register knows whether the call is local or outgoing.

Line selection

Group selection being complete, the register now waits until all digits are received, and then starts the called line selection, which is very similar to group selection. The register engages a selection coupler which seizes the primary section to which the register is connected; this primary section then seizes a marker, and informs the marker that it is required for a calling line selection. The marker then seizes a connecting circuit whose identity is signalled back to the selection coupler which connects itself to this connecting circuit. The hundreds, tens, and units digits of the called number are now transmitted from the register to the marker (via the selection coupler and the connecting circuit – path 4).

The connecting circuit now releases, and the marker transmits the called number to the marking relays which mark the corresponding line. If the called line is busy, either in conversation or in a lock-out condition, the marker again seizes a connecting circuit (path 5) to inform the register that it must release the connection by which the calling line is locked out, returning busy tone to the caller. If the line is free, marking the outlet places the associated terminal section in the calling condition, and a free link between this frame and the primary section is selected. If no direct link is available, the marker will select one over a mutual-aid path, as before.

The horizontal bars are now operated in the primary and secondary sections, and the class of service of the caller is sent by the marking relays to the register (over a connecting circuit seized by the marker for this purpose – path 5). On receipt of the information the register orders the final through-switching by operating the selector magnets. The horizontal bars and all control circuits are then released.

In cases where the called line's class of service shows that the line cannot be called (for example, a changed number), the register cancels and releases all connections, and routes the call to the appropriate information service. When there is internal congestion within the LU, the register will make a second attempt to set up the call by fresh group and line selection. If this second attempt fails, busy tone will be returned.

Having ordered the through-switching, the register establishes the feeding bridge and the ringing condition in the local feed junctor, and then releases. The connection is now held by the local feed junctor, and is released as soon as the calling party clears. Only the called party's line circuit is held until he also clears.

Outgoing calls

Preselection for an outgoing call (Figure 9) is made in the same way as for a local call. When the register receives the discriminating digits and recognizes an outgoing call, it starts the group selection process. The marker tells the register the category of the selected outgoing junctor, which can be either to a Pentaconta or any other type of exchange. The sequence described will be for a call to another Pentaconta exchange.

Since compelled multi-frequency code signalling is the Pentaconta standard, the sender must be selected accordingly. The register connects a suitable sender, and supervises the seizure of the distant incoming junctor. The sender transmits the selection information, and finally receives either information for through-connection of the speech path or a busy indication, and also the called line's class of service. The sender transmits this information to the originating register, which sets up the final connection when the called line is free, and releases itself and all other circuits not required for speech. Ringing tone is returned from the distant exchange.

The call is now held by the outgoing junctor in the originating exchange, and by the incoming junctor in the distant exchange.

If a special tariff applies, the outgoing junctor is connected over a connecting circuit by a tariff link to a translator, from which it receives appropriate information before the selection information commences.

When a called subscriber is busy, the distant exchange advises the originating register, which releases all circuits. Busy tone is returned to the caller over his own line circuit, which is the only circuit still engaged.

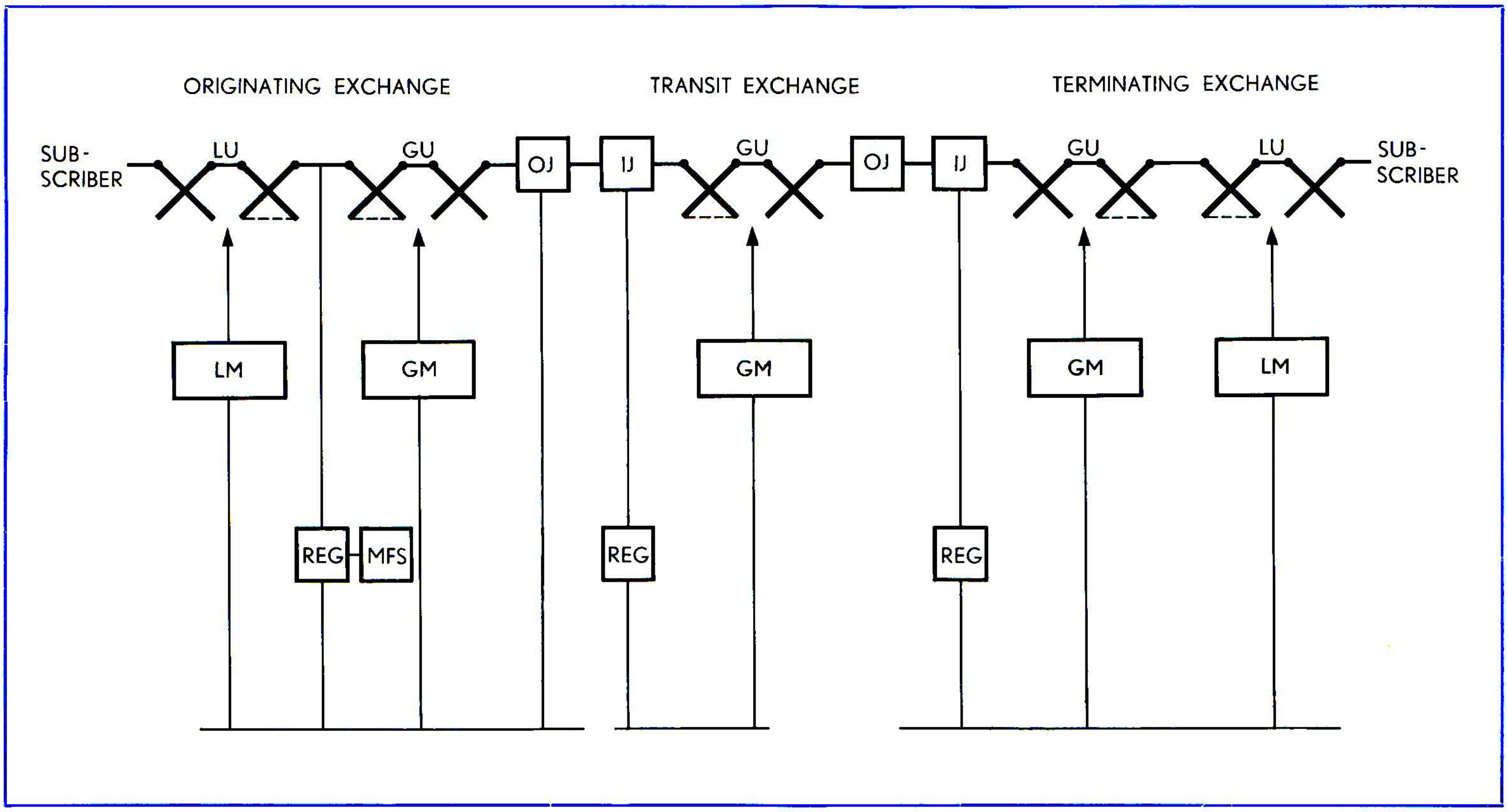
With some types of exchange the called line condition cannot be signalled back to the originating register; ringing or busy tone is then returned from the distant exchange.

Incoming calls

When an incoming junctor is seized, it connects itself to an incoming register. For smaller exchanges it may be more economical to connect to a local register through an intermediate finder and a register finder. A receiver circuit is then connected to the register if necessitated by the type of signalling.

For connection of a trunk from a step-by-step exchange, the time left to connect the register is only a fraction of the inter-digital time. A single-stage, fast-access register finder with mutual-aid is then used. In the case of small exchanges this method may also be an advantage for other types of register signalling. When incoming registers are used, the class of the junctor can be indicated to the register over the finder connection.

Fig. 9 Setting-up of an outgoing, incoming or transit call



When local registers are used the intermediate finders are served by two markers. The incoming junctor classification is transmitted from the marker to the register over a connecting circuit in the same way as the subscriber's class of service is transmitted by a line marker on a local call.

The junctor classification is used to advise the register of the kind of signalling used by the incoming call, so that the register connects itself to the appropriate receiver. It is also used to inform the register of the digit or digits used for selection in a preceding step-by--step exchange so as to permit reconstitution of the complete subscriber number.

As soon as the register has received the necessary digits, it controls group selection in the same way as described for a local call. After selection of an outlet to the thousands group of the called number, and when all digits have been received, line selection takes place as for a local call, and the register receives the class of service and condition of the called line.

If the register signalling method so permits, this information is sent back to the originating register, and the incoming register then completes the connection.

Transit calls

Pentaconta local exchanges can handle transit traffic between automatic exchanges of any type. Incoming transit traffic is handled by the normal incoming junctors and incoming registers. However, if compelled multi-frequency code signalling is used on both incoming and outgoing trunks, the incoming register receives only those digits denoting the code of the required distant exchange, and not the called subscriber's numerical digits. The incoming register will perform the group selection, and will release after it has signalled back to the originating register the digit which is expected by the distant exchange.

In all other cases of signalling the incoming register receives all digits, and acts as a local register for selection and selection transfer. As soon as these functions are complete it connects the speech path, and then releases. The holding of the connection in the exchange is then under the control of the incoming junctor.

Signalling between exchanges

Although Pentaconta exchanges can interwork with other exchanges using any type of signalling, Pentaconta systems have standardised on the European compelled multi-frequency code or MFC system.

Two voice-frequency bands are used, each band having a number of frequencies separated by 120 Hz, with 240 Hz between the two bands (540–1140; 1380–1980 Hz). Five frequencies are normally used. Each signal consists of two frequencies chosen from one band or the other, thus giving a possible total of ten 2-out-of-5 codes. Provision is also made for the use of six frequencies in each band when more than ten codes are required. This then gives a possible total of fifteen 2-out-of-6 codes.

The upper band is used for forward signals, and the lower band for backward signals. The sending of a forward signal must be acknowledged by a backward signal, which remains on the line until the forward signal ceases. No further signal can be accepted while the backward signal persists. The sending of signals is thus fully controlled, and the reception of false signals, due to noise or other transient line conditions, is wholly precluded.

The MFC system has the following outstanding advantages:

- speech circuits require no modification for the signals
- sufficient codes are available to transmit calling and called subscribers' class of service, and call routing information
- rapidity and safety
  no interference with supervisory signals

The system can thus transmit all the necessary information in a manner which permits a flexible, economic, and modern approach to present-day telephone technology.

Grouping Arrangements

The Pentaconta local exchange is very easily adapted to solve problems in the line and group selection units caused by heavy traffic and large groups of trunks. These are considered here separately.

Line selection units

A number of line unit arrangements have been standardized to cater for a wide range of subscribers' traffic, differing in the number of terminal selectors per terminal section and in the number of primary sections. Subdivision of primary selectors into call finders and penultimate selectors can also be made to suit different ratios between originating and terminating traffic. The table lists the available standard arrangements. In this example the traffic capacities are based on a preselection loss ⩽ 0.005, and a selection loss ⩽ 0.005.
For higher subscriber traffic the subscribers are in groups of 52 instead of 74, and line units for 500 subscribers instead of for 1000 are used.

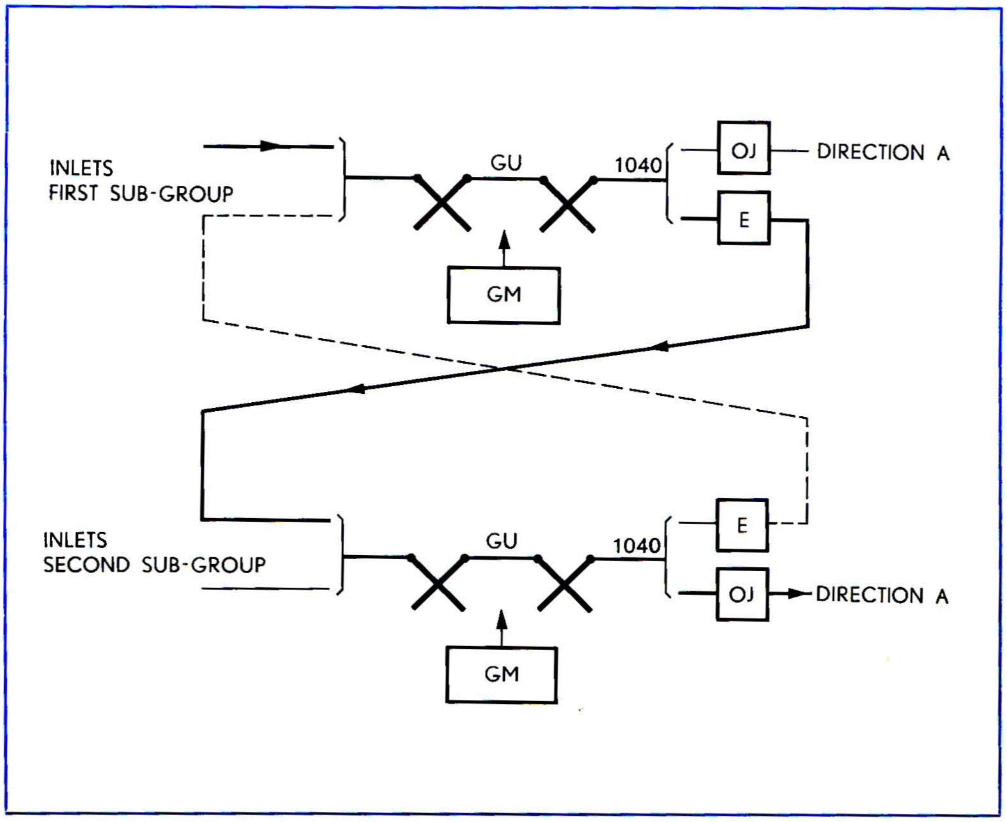
Grade	Code	Traffic capacity (erlangs)	Primary sections	Terminal selectors per 74 subscribers	Total primary selectors
Low	LLU 50	57	5	10	100
	LLU 60	77	6	12	120
	LLU 70	97	7	14	140
Medium	MLU 80	115	8	16	152
	MLU 90	132	9	18	171
High	HLU 100	150	10	20	190
	HLU 110	169	11	22	209

Group selection units

A number of standard arrangements are available for group selection units, which have to handle local, incoming, and transit traffic. Local exchanges of medium size use the 1040 outlet GU. This has capacity for five primary sections (each with up to 55 primary selectors of which five may be used for mutual-aid), and 20 secondary sections (each with ten secondary selectors). The outlets of a number of GUs are multipled together, and the 1040 outlets can be divided into a maximum of 100 directions. In small exchanges, the secondary sections can be omitted; the outgoing circuits are then connected directly to the primary section outlets. When the required number of GU outlets exceeds 1040, the GUs are divided into sub-groups, each with 1040 outlets. The circuits for the outgoing routes are also divided into sub-groups, these latter being distributed over the GU sub-groups. Overflow circuits linking the GU sub-groups ensure full access to all circuits in each outgoing route.

A typical arrangement of sub-groups, which is particularly useful when outgoing routes have a large number of circuits, is shown in Figure 10. When a call, which must be routed to the direction A, enters in a group unit of the first sub-group, and finds no free outgoing junctor, it is routed (via availability cut-off relay) to an inlet of a group unit of the second sub-group where it may find a free outlet in the required direction. Also, calls entering in the second sub-group may be routed to a group unit of the first sub-group when all the outgoing junctors of the required direction are found busy in the second sub-group.

Fig. 10 Typical sub-group arrangement



As previously mentioned, large exchanges use the 2080 outlet GU. These units are multipled together, as for the 1040 outlet GUs, and are divided into similar sub--groups when the required number of outlets exceeds 2080. In some cases it is more economical to provide a separate overflow group of GUs instead of overflow possibilities between the sub-groups themselves. In both cases part of the traffic passes through two selecting stages in series. It is also possible to connect selection units in series for all traffic, and this is done where sufficient lines are concentrated together.

Examples

Two examples are given to illustrate how the foregoing principles of flexibility apply to two cases having widely differing traffic and inter-office data.

The first example is of an isolated exchange of 4000 subscribers, with inter--city calls handled by a toll switchboard located in the same building. The trunking diagram is shown in Figure 11. Toll positions are provided with dials so that incoming toll calls use the local register.

Only one GU stage is required, and all outgoing routes such as toll recording and special services are reached through this stage. For the traffic of 0.11 E per subscriber, a standard LU of the MLU 80 type, shown in the table, is supplied per 1000 lines.

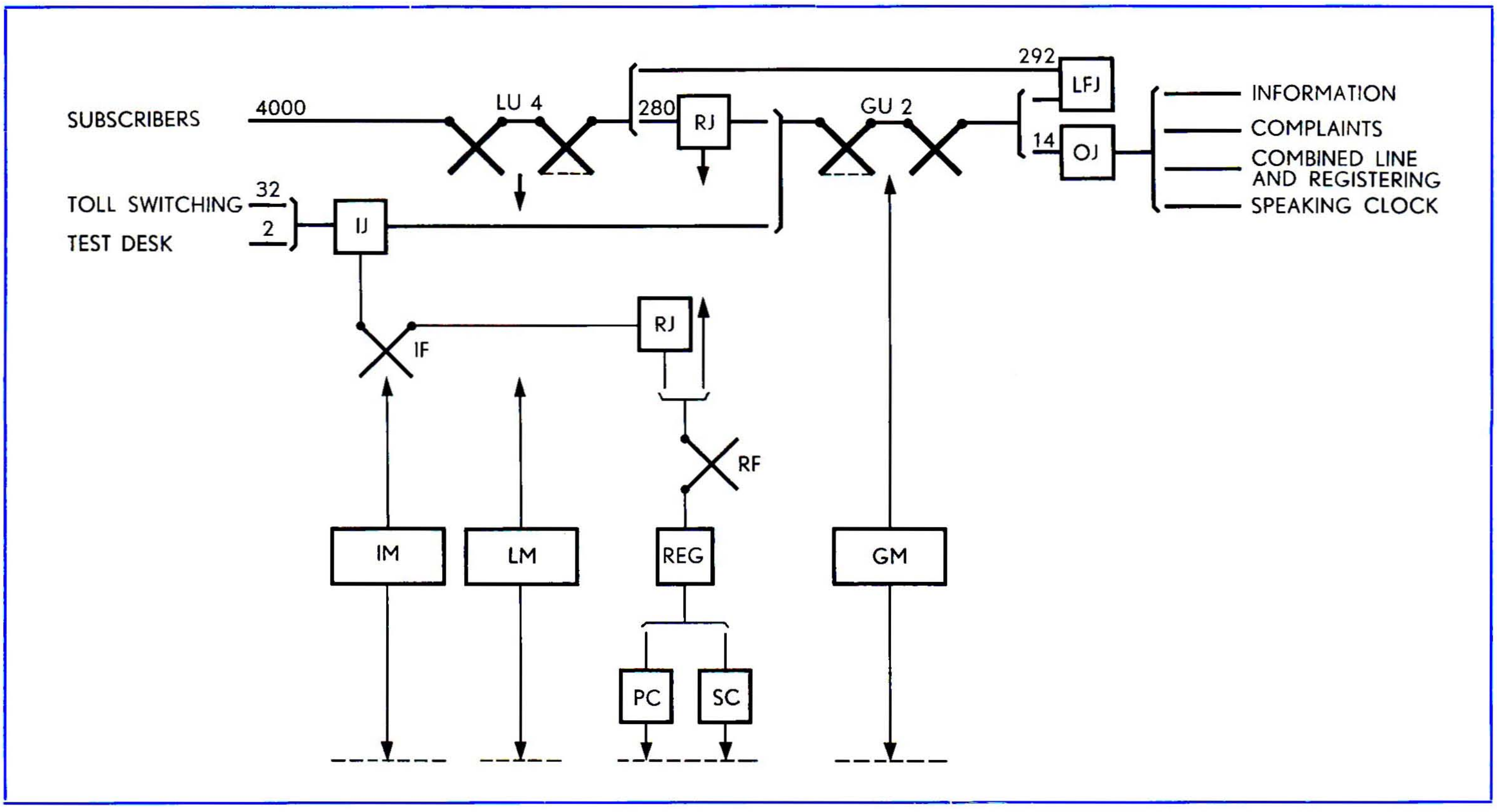
The second example, whose switching diagram is shown in Figure 12, is a local exchange with the high average traffic of 0.16 E per line. This corresponds to the capacity of HLU 110 shown in the table. The switch quantities used are shown in the figure. The exchange interworks with exchanges of two different types in the same local area. One of these uses registers and multi-frequency code signalling, while the other uses the direct system giving selection information in the form of dial pulses. The Pentaconta exchange therefore has two types of incoming register and two types of sender.

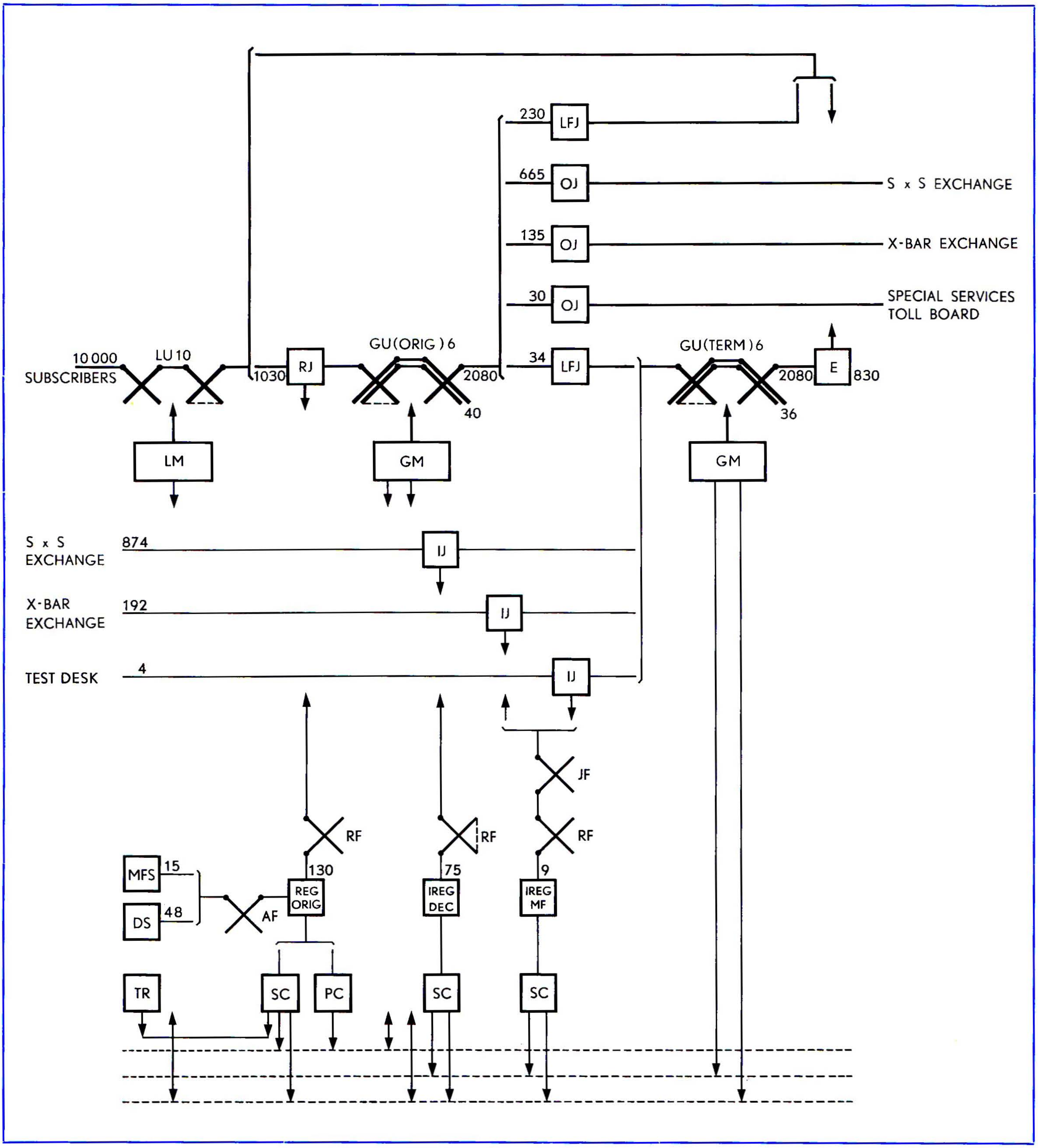
Two separate GU stages are provided to deal with the large number of trunks. An originating stage with six GUs handles originating traffic, and routes it to the required exchange. A terminating stage with six GUs handles incoming traffic. In view of the large number of circuits connected to each stage, and also of the ultimate capacity of the exchange of 20 000 lines, both GUs are of the 2080 outlet type. In an exchange with a final capacity of 10 000 lines the incoming GU is of the 1040 outlet type.

The figure also shows 34 overflow local feed junctors linking the originating to the terminating GUs. This arrangement gives a high efficiency of local feed junctors, and is used where traffic between local subscribers warrants it. A number of first choice local feed junctors are then provided per LU, and are connected to the originating GU multiple. If a call finds all first-choice local feed junctors of the wanted direction busy, it will be routed (via the common group of overflow local feed junctors) to the terminating selection stage. The wanted terminal LU is then accessible via the availability

Fig. 11 Typical grouping arrangement for a small exchange

Fig. 12 Typical grouping arrangement for a large exchange ▶




230
LFJ
665
OJ
S x S EXCHANGE
135
OJ
X-BAR EXCHANGE
30
OJ
SPECIAL SERVICES
TOLL BOARD
10 000
SUBSCRIBERS
LU 10
1030
RJ
GU(ORIG) 6
2080
40
34
LFJ
GU(TERM) 6
2080
E
830
36
LM
GM
GM
S x S
EXCHANGE
874
IJ
X-BAR
EXCHANGE
192
IJ
TEST DESK
4
IJ
JF
RF
RF
RF
130
75
9
MFS
15
DS
48
AF
REG
ORIG
IREG
DEC
IREG
MF
TR
SC
PC
SC
SC

cut-off relays provided for incoming traffic. The diagram further shows the different possible arrangements for interconnecting incoming junctor circuits to incoming registers, and also the information paths.

Incoming register access

Two-stage access from crossbar exchanges is provided using junctor finders and register finders. The control of such an arrangement enables a group of registers to serve up to 840 junctors with full availability.

On incoming calls from direct control systems, the register must be connected within a fraction of the inter-digital time, so a single stage connects the incoming junctor to the incoming registers. The standard arrangement has 14 sections, each providing direct connection between 50 junctors and six registers.

Access from the junctors of any particular section to the registers of 3 other sections is also provided over mutual-aid paths.

The Pentaconta local system is highly flexible with respect to numbering. It can easily be adapted to any network and any special numbering requirements. Neither open or closed numbering nor extended nationwide or international numbering plans cause any difficulties for the Pentaconta system.

The storage capacity of local registers is 10 digits, and thus covers the majority of all national numbering requirements. In such cases where the number of digits exceeds 10, as for example in international subscriber dialling, cyclic storage is used, which means that storage sets become free immediately after transfer of their stored digit, and are re-used to store the eleventh and successive digits. No second dial tone is required in national or international service.

In-dialling to PABXs is another facility included in the Pentaconta local system, the standard practice being to integrate the PABX number into the local and national numbering scheme.

The local registers used in the Pentaconta system are standard prepared for the connection of special pushbutton signalling receivers. This permits the use of push-button telephones as shown in Figure 13, with conventional telephones without any modification in the standard equipment.

It may also be worth mentioning here that due to the analysis and grouping abilities of the register-controlled Pentaconta local system, the number of selection stages is completely independent of the number of digits used.

Fig. 13 Pushbutton telephone used with Pentaconta exchanges

Call Charging and Recording

The metering methods used in the Pentaconta system are simple and reliable. The equipment available ranges from message registers for each subscriber line to centralized automatic equipment which permits detailed information to be recorded for each call.

Bulk recording of charge information

With this feature, all charge information is collected cumulatively in a storage device, such as a simple message register, assigned to each subscriber line. This device is operated by pulses generated by the switching equipment, and the charging method may be either single-fee or multi-fee metering.

With single-fee metering, which is usual for local traffic, one metering pulse is produced per call. For multi-fee metering, the metering pulses are sent to the calling subscriber's message register during the conversation at a frequency which depends on the distance between the networks of the conversing parties.

Bulk recording of charge information results in bulk billing, i.e. the subscriber's bill will show the total number of fee units registered, multiplied by the cost per unit.

Detailed recording of charge information

With this method, a detailed record is provided for each call as is the practice in manual toll service. The Pentaconta system provides adequate equipment to record automatically:

- the directory number of the calling subscriber
- the directory number of the called subscriber
- the time, duration, and date of call.

The tariff rate and the total amount charged may be added to this to facilitate final accounting.

A basic requirement for such recording is identification of the calling subscriber's number. This identification is one of the many features to which the Pentaconta system is readily adapted.

Detailed recording of charge information permits detailed billing. The subscriber's bill thus contains all or part of the information mentioned above, together with the actual charge.

Additional features

- charge suppression: for calls to particular lines, all charging can be suppressed by a special marking on the incoming subscriber's circuit.
- night tariff: at night time, on Sundays, or on holidays, a reduced tariff may be applied to stimulate the private use of the telephone.
- charge indication: a private meter can be installed at the subscriber's premises, controlled simultaneously with the message register in the exchange, to give immediate information on the cost of individual calls. This feature is of particular use to hotels and to PABXs, but is not limited to them.
- charge information: the cost of a particular call may be obtained from the operator after the end of conversation. To permit this, a special access number or a special subscriber's class of service may be used.

Choice of charging method

The flexibility of the Pentaconta charging system allows considerable freedom of choice in billing methods. The choice depends on the Administration's tariff policy and also on the structure of the telephone network and the facilities available in existing exchanges. It also depends on the degree of automation available, or desired, in the processing of charge information, i.e. the accounting procedure, and on the future planning of the whole network. These items will determine the type of recording apparatus, and the various requirements concerning the tariff for each kind of call or facility offered to subscribers. The number of variables usually requires a detailed study to be made of individual cases. There is a Pentaconta solution for each case, and assistance will be gladly given in planning and providing equipment to meet all requirements.

Interworking with other Systems

Interworking is considered separately in respect of line signalling, and of register signalling.

Line signalling

When a Pentaconta local exchange is put into service in an existing multi-office network consisting of exchanges of different types, the main problem is to ensure the minimum of change both to existing exchanges and to the Pentaconta system itself.

Unless the Administration has any special requirements, the first of these points – minimum modifications to existing exchanges – is completely taken care of in the Pentaconta local system, which can work to any method of signalling. Such modifications to other exchanges are therefore nil.

On the second point, the adaptation of the Pentaconta system to existing line signalling systems is realised in the trunk circuit junctors, which convert the line signals received into proper intra-office language.

Register signalling

The different register signalling systems which may exist in a multi-office area can be divided into those using straight pulsing (either under the control of the subscriber's dial or of other equipment not able to detect or interpret a ready-to--send signal), and those using pulsing or multi-frequency signalling under full register control. Outgoing and incoming traffic will be considered separately.

Outgoing traffic

The Pentaconta local system uses various types of sender, each designed to meet the register signalling requirements of the distant exchange to which it is working. There are therefore no special problems involved. A special Pentaconta feature is that pulses (e. g. decadic sending to step-by-step exchanges) are not repeated in the outgoing junctors, because the senders have a through--metallic connection via the outgoing junctors to the distant exchange.
The junctor does not insert the feeding bridge for the calling party and line supervision equipment (for reception of line signals and for holding the distant exchange) until the selection has been completed.

Incoming traffic

The special incoming registers designed to meet the requirements of the existing register signalling system are connected to the incoming junctors.

In the case of decadic pulsing under the control of the dial, the connection with the receiving equipment must be made within a very short time, so that the pulses can be accepted almost immediately upon seizure. In this case the Pentaconta system uses single-stage quick access register finders with mutual-aid facilities. An arrangement consisting of seven frames of these finders may give access from 350 junctors to a maximum of 42 registers.

As this quick access scheme still needs some 100 milliseconds to connect a free register to a calling incoming junctor, the incoming junctors may use the "reversed impulse transfer" method. In this method the first impulse is stored by the incoming junctor. Subsequent impulses are fed directly to the incoming register, and when pulsing is complete, the incoming junctor gives the register the stored first impulse. This enables dial pulses to be accepted 30 milliseconds after seizure of the incoming junctor.

Transmission Characteristics

Transmission levels on calls from Pentaconta local exchanges comply fully with CCITT recommendations. Individual characteristics are as follows:

Transmission loss

Ignoring losses on cables within the exchange, the local call attenuation measured through the exchange circuits from a non-inductive termination of 600 ohms will not exceed 0.5 dB at 800 Hz. In any case the loss measured from MDF to MDF will not exceed 1 dB at 800 Hz.

Impedance and balance to earth

The impedance of any path through the exchange when the distant end of the path has a 600 ohm termination is such that, when measured against a 600 ohm network, the total loss is better than 20 dB at all frequencies. The impedance balance ratio between input and output of any path, when terminated in a 600 ohm impedance, is better than 26 dB at all frequencies, when measured in accordance with CCITT standards.

Crosstalk

Attenuation between any two paths is better than 75 dB between 300 Hz and 3400 Hz, and is better than 80 dB on 90 % of the connections when the two paths are not parallel for their entire length. Crosstalk measured in a Pentaconta crossbar switch is as follows:

- at 300 Hz: −17 nepers minimum
- at 800 Hz: −15.7 nepers minimum
- at 3000 Hz: −14.4 nepers minimum

Contact noise

All contacts on Pentaconta switches and relays are of precious metal, ensuring minimum contact resistance and noise. Current switching on Pentaconta switches is a function of the springset contacts of the vertical bars, and no current is switched by the connecting contacts. Consequently, electrical wear on the connecting contacts is nil.

Noise due to contact resistance variations, induced by the operation of adjacent selectors, has a psophometric voltage level below −12 nepers (−105 dB).

Harmonic distortion and inter-modulation

The total harmonic distortion of any fundamental voice frequency is at least 26 dB below the fundamental. Inter-modulation products, arising from the application of frequencies used for multi-frequency signalling, are at least 40 dB below the fundamental.

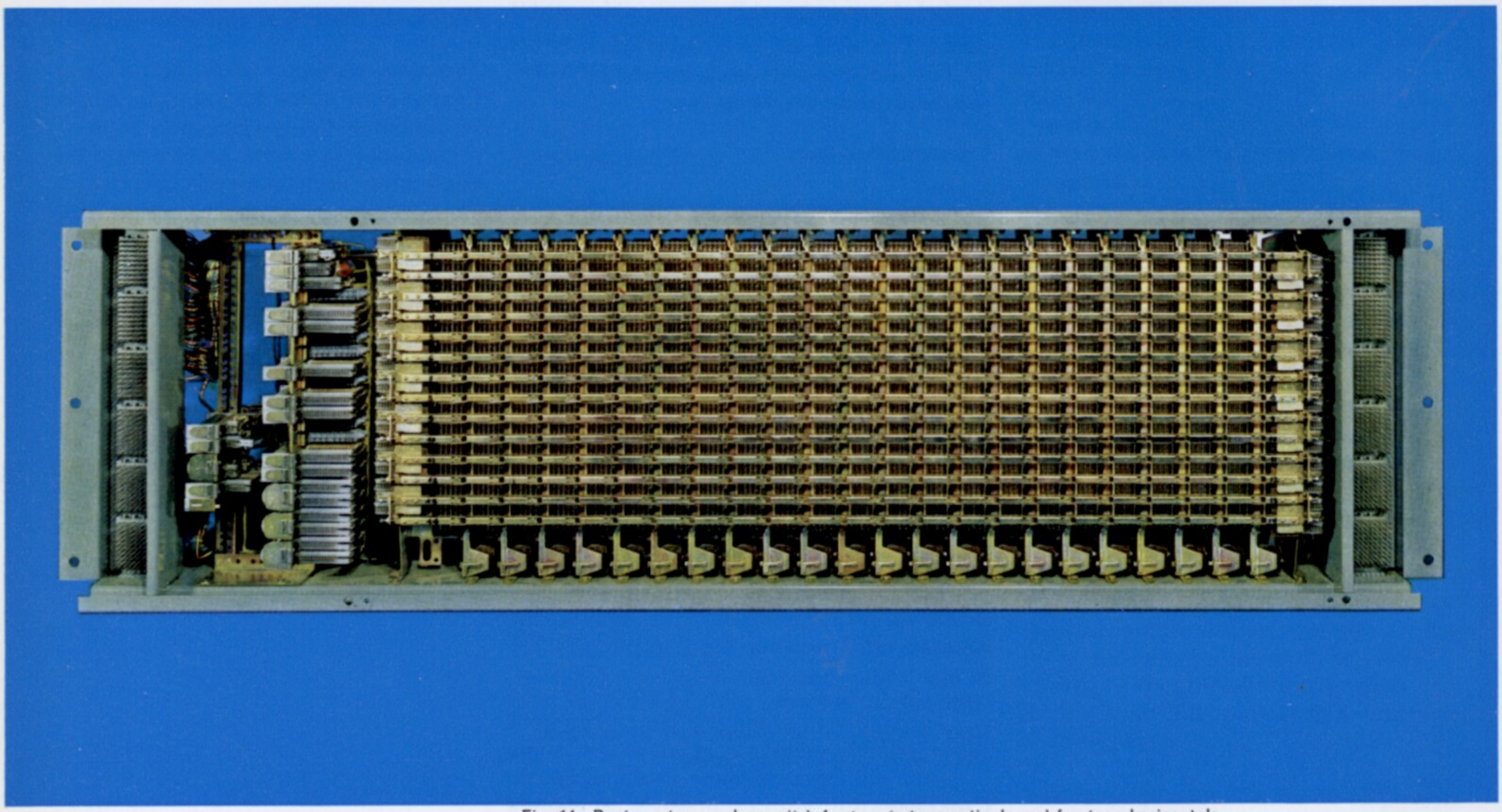
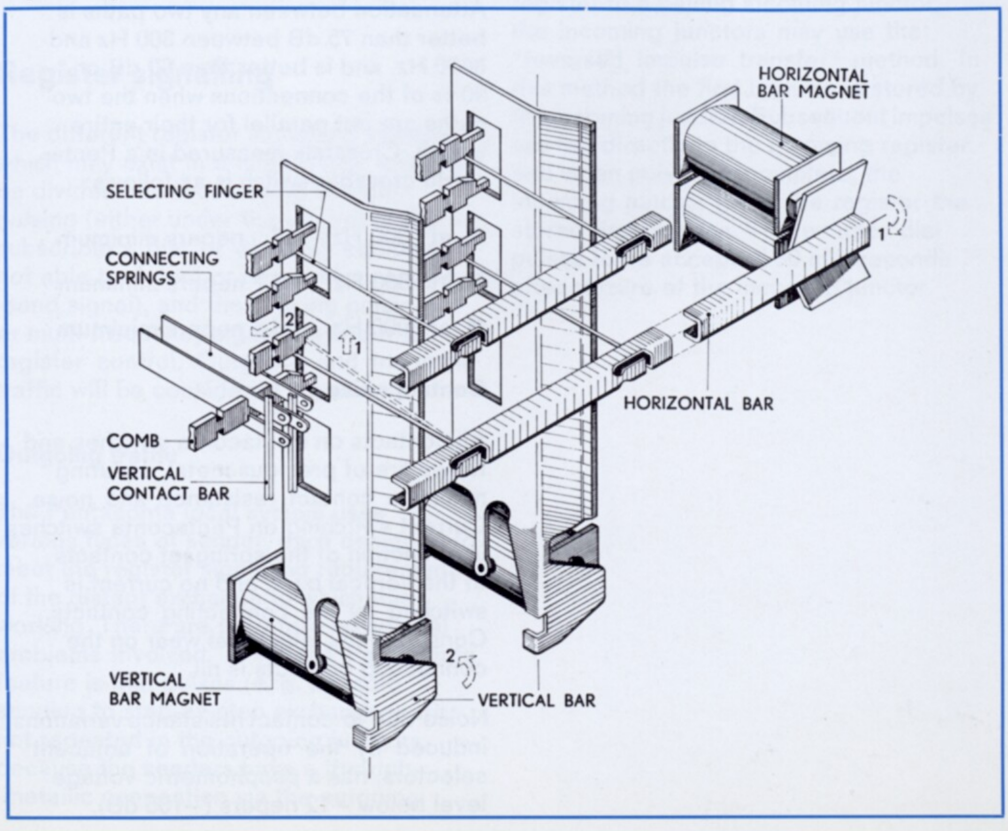
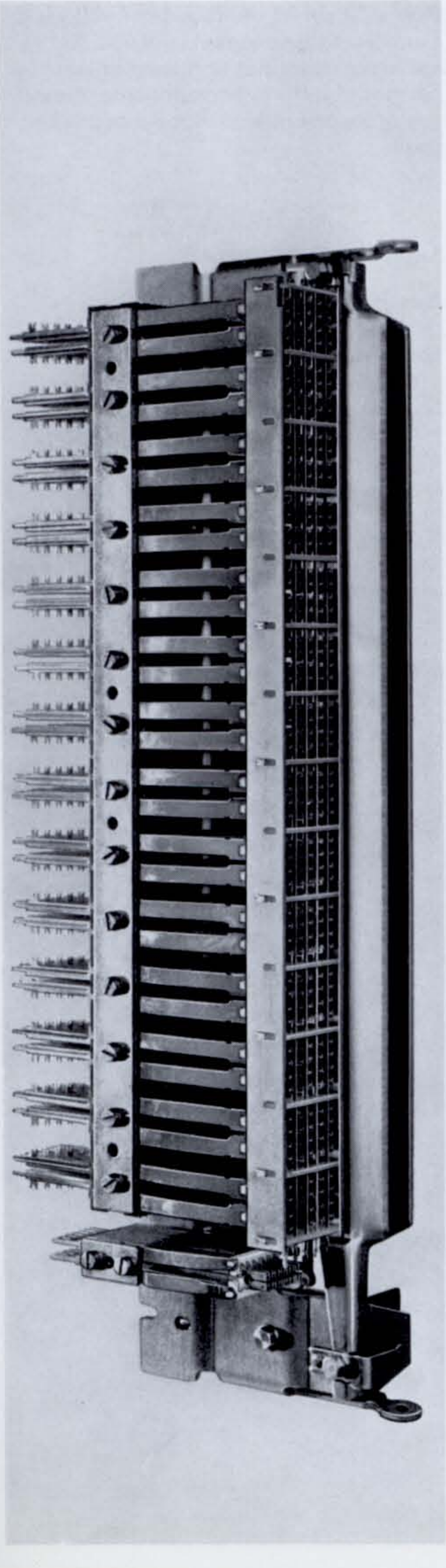


Fig. 14 Pentaconta crossbar switch for twenty-two verticals and fourteen horizontals

Fig. 15 Diagrammatic view of selector operation





The Pentaconta crossbar switch

The crossbar switch used in the Pentaconta local exchange system is shown in Figure 14, with a detailed view of the selector in Figure 16.

The selector is a special relay having 28 movable contacts whose associated fixed contacts are precious metal bars extending over all springsets. The armature is a vertical bar extending over all the springsets, but movement of the armature does not operate them unless a link is provided to bridge a slot in the armature opposite each springset. This link is a selecting finger of stainless steel wire fixed to the horizontal bar, which forms a bridge across the slot. The horizontal bar supports and operates these selecting fingers.

Figure 15 illustrates the method of operation. The magnet of the horizontal bar is first energized, thus causing the selecting finger to engage in the comb of the springset (1). The vertical bar magnet then operates, and the comb drives the movable springs into contact with the vertical contact bars (2). The horizontal bar is then released and returns to normal, taking with it all selecting fingers other than the one which is still held between the vertical bar and the comb, and, being a spring, remains bent until the vertical bar releases.

The Pentaconta crossbar switch used has fourteen horizontal bars and a maximum capacity of twenty-two selectors (or vertical bars) with eight or nine contacts, or nineteen selectors with ten contacts. In the eight- and ten-contact selectors, each vertical has four sets of contacts per horizontal bar. Discrimination between the sets of contacts is made by the operation of the bottom horizontal bar which acts as a doubling bar.

The vertical bar of the nine-contact selector has six sets of contacts per horizontal bar. Discrimination between the sets of contacts is made by operation of either the fourteenth horizontal bar or the lower half of the thirteenth. This operation enables $12 \times 2 \times 3 + 2 = 74$ outlets to be selected.

Fig. 16 Crossbar switch vertical bar

The vertical multiple is provided by the metal bars of the fixed contacts mentioned above. Horizontal multiples between selectors are made by bare wires soldered to the moving-spring tags of all verticals. The special advantages of the crossbar switch are:

- the very small movement, the absence of friction, and the low power involved practically eliminate trouble due to wear and maladjustment, resulting in considerable reduction of maintenance costs. Practical tests have shown the number of operations which can be performed without noticeable wear is over 10 million for the selector and over 40 million for the horizontal bar. These are many times the numbers of operations required during the life of the exchange.

- the Pentaconta switch operates within 30 to 50 milliseconds, which is very rapid by comparison with the operating times of a step-by-step or rotary switch, which may require up to two seconds. This speed enables the number of control devices to be reduced, and their degree of intelligence and technical performance to be improved. The time saving is considerable when a large number of switches are involved.

- all Pentaconta selector contacts are of precious metal. This, combined with absence of mechanical vibration, reduces noise to the absolute minimum.

Relays

Relays used are mainly the standard Pentaconta type, with either a round or an oval coil (Figure 17).

The main advantages of the Pentaconta relays are:

- springsets, which can have up to 33 springs, are interchangeable
- the coupling methods used for both fixed and moving springs eliminate need for adjustment in the field
- coils and springs are standardized and are separately coded
- wear is insignificant
- twin contacts are standard

The fixed and moving springs are mounted symmetrically and without tension, and are fixed with their insulators on a support by two screws. A third screw fixes the complete springset to the yoke, which has guide pins fitting into positioning holes in the springset support.

Springs are operated by a nylon comb, so that the distance between them is unchanged. Owing to the symmetrical arrangement of the fixed and moving springs, one comb is provided for each group. A holding spring presses the fixed comb against the springset support, and a restoring spring acts on the moving comb to return the moving springs when the relay releases.

A support leg, bent for the initial adjustment of the springset, determines the position of the fixed springs. When the relay operates, the end of the armature lever lifts the moving guide, which raises the moving springs to the operated position. The method of mounting ensures equal bending of all springs, since both fixed and moving springs have the same thickness and free length.

Components such as resistors, capacitors, and diodes of the small modern design are frequently mounted in unoccupied springset positions on the Pentaconta relay. This facilitates the grouping of circuit apparatus close to its associated relays.

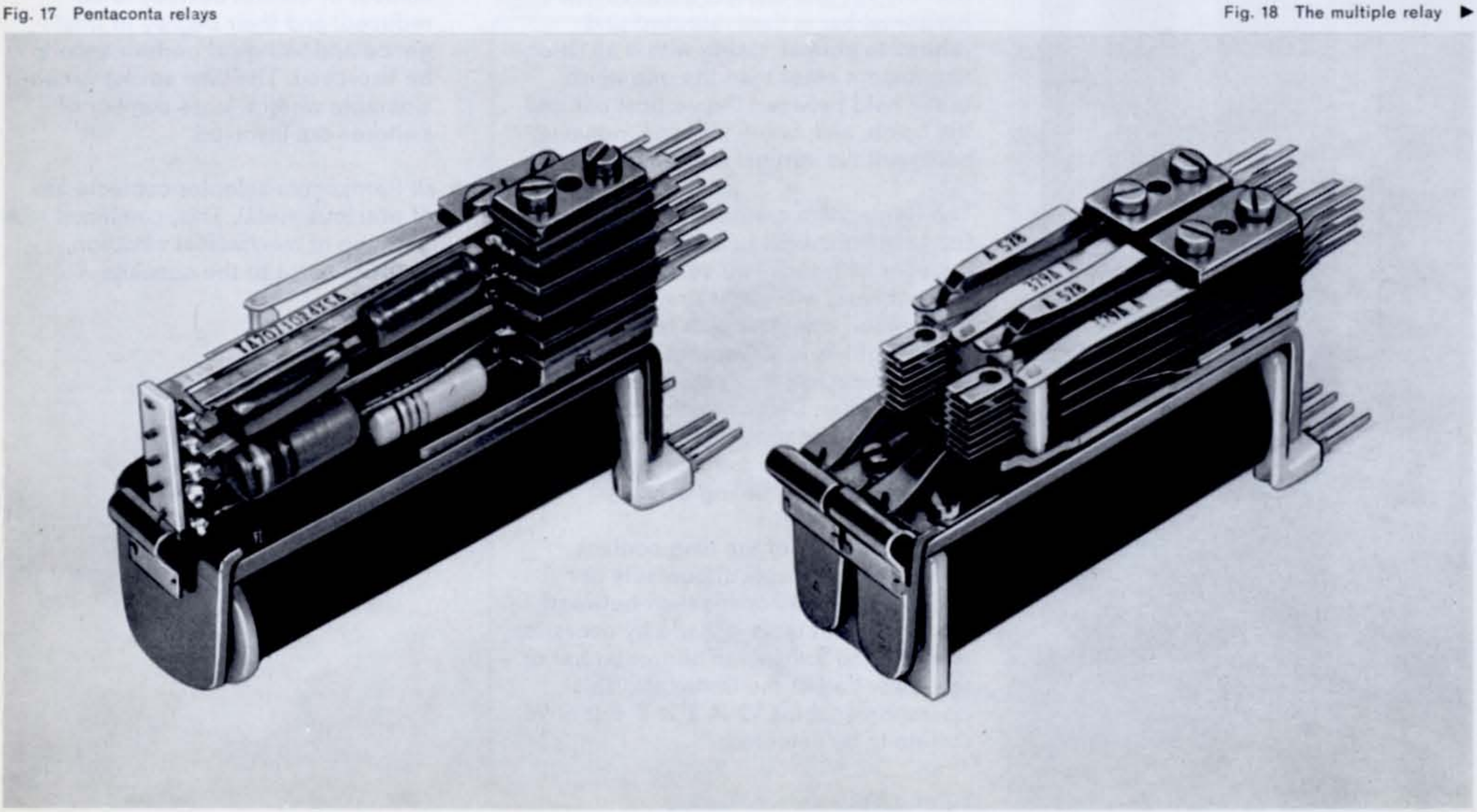
Figure 17 shows the round-coil relay with a small single springset, and with its spare springset position used to mount a number of different components. Almost any arangement of components can be used.

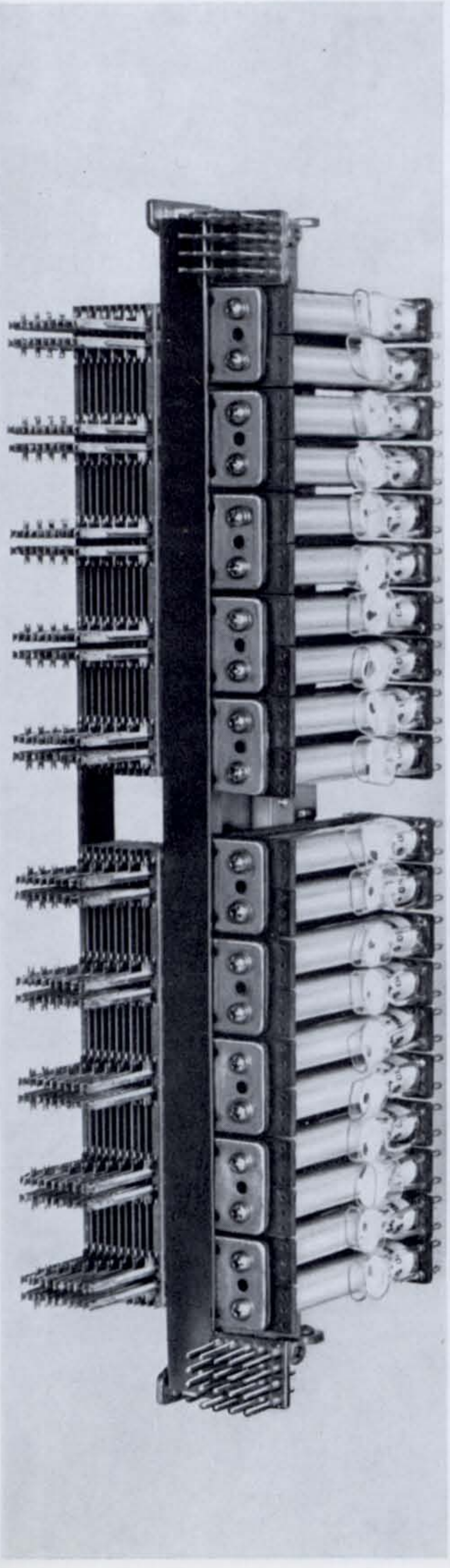
Quintuple relays

The use of the standard relay with its capacity for many contacts is unnecessary in certain cases where a set of single-contact relays is required. A typical case is the registering of digits in 2-out-of-5 code, requiring five relays, each with a single make contact. The plug-in quintuple relay, shown in Figure 19, has been developed to meet this need. It has five relay coils mounted together, with coils and contacts suitably wired internally so that only eight leads are brought out. Since the dimensions of the single coil are quite small, two similar quintuple relays can be mounted on the same base, which occupies no more space than one standard Pentaconta relay.

Fig. 17 Pentaconta relays

Fig. 18 The multiple relay ▶





The multiple relay

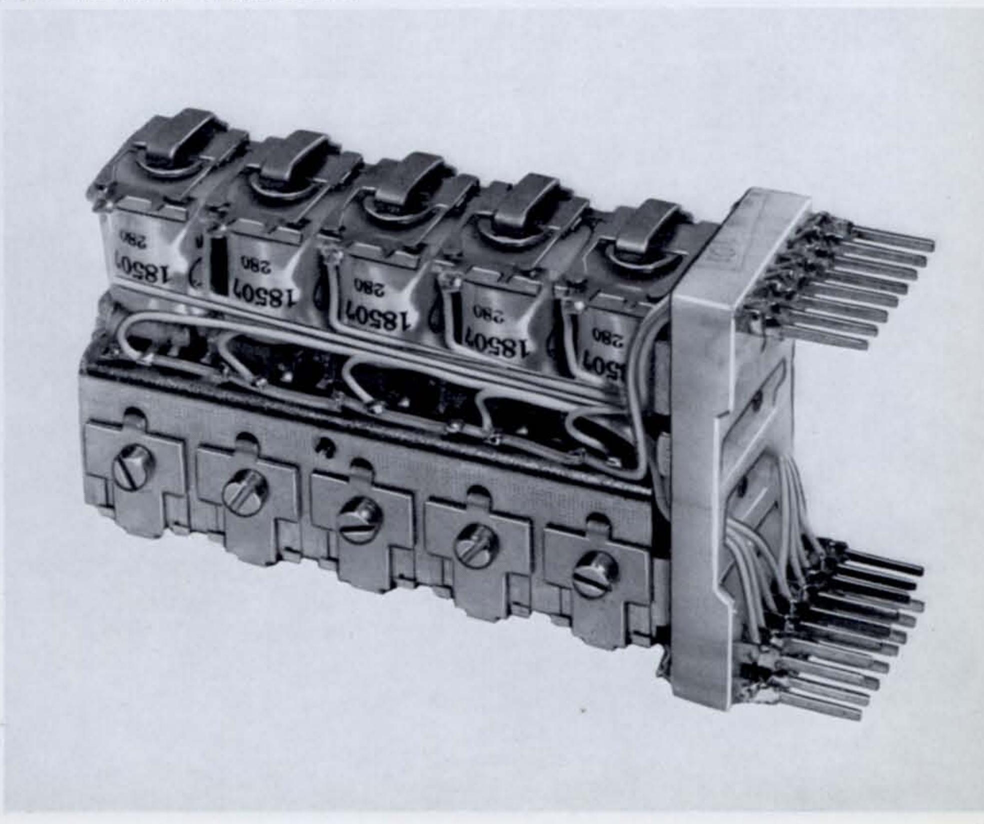
The multiple relay is designed to provide a fast connection which is in use for only a very short time, such as is required for connection to information paths which are released immediately after the information has been transferred. This kind of connection requires an extremely fast connecting matrix.

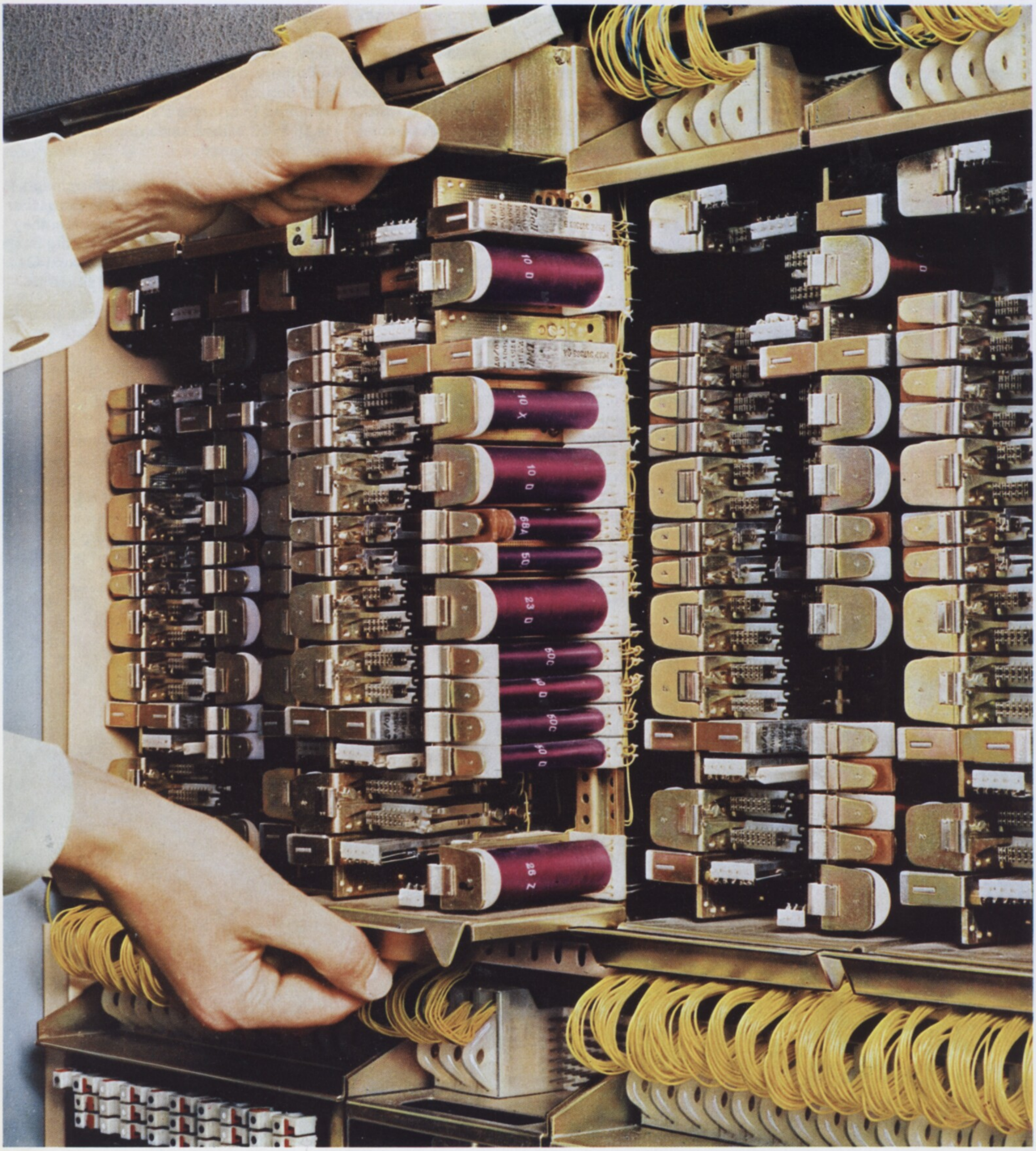
The multiple relay illustrated in Figure 18 meets this requirement by combining the functions of the crossbar switch vertical bar with those of the Pentaconta relay. In construction, it comprises twenty oval coil relays mounted in a vertical pile and independent of each other both electrically and mechanically. Each relay has eleven make contacts, whose moving springs make contact with vertical strips of precious metal. These vertical strips of the multiple relay form the fixed contacts in the same way as on the vertical bar of the crossbar switch. The moving contacts can be commoned horizontally to other multiple relays in the same way as for the horizontal commoning on the crossbar switch.

Several such relays mounted together will provide the necessary lattice formation; and a connection, independent of all others, can be made at each vertical and horizontal crossing in the time required to operate a single relay, which is 15 to 20 milliseconds depending on the coil characteristics.

Multiple relays are mounted in frames identical with those used for the crossbar switch, where, like the vertical bars, they are located in a slot in the stiffening bar and fixed by screws top and bottom. One multiple relay takes the same space as two crossbar switch verticals.

Fig. 19 Two quintuple relays on one base





Equipment Practice

Crossbar switches and other items of apparatus are mounted in frames. Bays are normally 3470 mm high, and take seven frames 390 mm high and one frame 231 mm high. Alternative bays are 3070 and 2560 mm high, and take six and five 390 mm frames respectively instead of the seven on the standard height.

The type of frame used depends on the apparatus to be fitted, such as crossbar switches, supervisory equipment, and IDFs.

Selector bays

The bay consists of uprights, secured top and bottom to continuous tie-bars. One upright is supplied at each end of a suite and another between each bay, the total number of uprights in a suite being the number of bays plus one. Each upright consists of two half-uprights placed symmetrically. Cables to the frames are run in the space thus enclosed within the upright.

A vertical slot is used for securing the frames to the bay. This eliminates the need to drill holes, and gives a universally flexible fixing arrangement. Frames are fixed by two screws on one side and one on the other, thus providing a rigid three-point fixing. Square fixing nuts within the slot can slide, but cannot turn, so do not have to be held during fixing.

The normal width of an upright is 145 mm, but a width of 290 mm is available for use where extra space is required for cables, or to adjust the length of a suite to line up with other suites. Covers matching those on the frames are fitted back and front to provide a uniform flush finish, and are secured by catches for easy removal.

In a typical switch bay the power and supervisory frame is fitted at eye level, with three selector frames below it and four frames above (see page 4). The frame IDF is at the top of the bay.

Switch frame

The horizontal members of the frame are strengthened by spot welded stiffeners, and the rigidity of the whole assembly is ensured by welding all parts together. Six 10×10-way terminal blocks can be mounted on each upright member. Each terminal can take two wrapped connections for factory wiring and two for the installer's cables. Many of the latter, for example ringing and pulse distribution cables, and inter-bay cables of standard length, can be connected at the front of the frame terminal blocks by 30- or 50-way plug-type connectors.

The frame is protected at the front and rear by sheet metal covers, secured by press-and-turn nylon catches. Slots are provided on the same spacing as the catches, and when a cover has to be temporarily removed, it can be hung on the catches of any adjacent cover. These slots are not visible from the outside.

A typical switch frame, fitted with a crossbar switch of 22 four-wire vertical selectors and 14 horizontal bars, is seen in Figure 14. The same frame will also take a switch of 19 five-wire verticals, and two supports may be mounted for the associated relays.

The selectors are located and secured by screws and nylon mouldings which have split studs top and bottom to enable them to fit into universal drillings in the stiffeners of the upper and lower horizontal members of the frame. Positioning of selectors is thus accurately determined, and additional selectors required for extensions can be added from the rear of the frame without the necessity of removing all the horizontal bars.

Relays mounted on selector frames are fitted on units made up of specially shaped vertical bars, secured top and bottom to flanged plates. The method of fixing is the same as for the selector.

Relays can be mounted on small auxiliary frames fitted to the bay uprights behind the switch frames, and hinged to give access to the wiring. Subscribers' line circuit relays are mounted in this way on two small hinged frames at the rear of the associated crossbar switch frame.

A hinged relay frame is illustrated in Figure 21. The figure also shows details of the rear and of the crossbar switch

Fig. 20 Relay bay with one relay unit partly pulled out of the cabling between terminal blocks and selectors.

Frame IDFs

A frame which takes terminal blocks only can be fitted at the top of a bay to give IDF facilities. The frame and the terminal blocks are both of light construction.

A normal frame (231 mm high) has 12 supports fixed across its horizontal members, each support taking three 10 × 10-way terminal blocks, giving 3600 terminals on the frame. A frame 390 mm high provides space for 7200 terminals.

Cables enter at the top, pass through the wire guides, and are connected at the rear of the terminal blocks, leaving the front for jumpers. Each frame has front and rear covers similar to the switch frame covers. When a single IDF frame has insufficient terminals two IDF frames have to be fitted. A switch frame can also be associated with an IDF frame. Suitable cut-outs are provided in the adjacent horizontal frame members for cables and interconnecting jumpers.

In some cases, such as for distribution between group selection units and junctors, frame IDFs are inadequate, and a complete bay has to be used as an IDF by suitable arrangement of terminal strips, cable supports, and jumper rings.

Power and supervisory frames

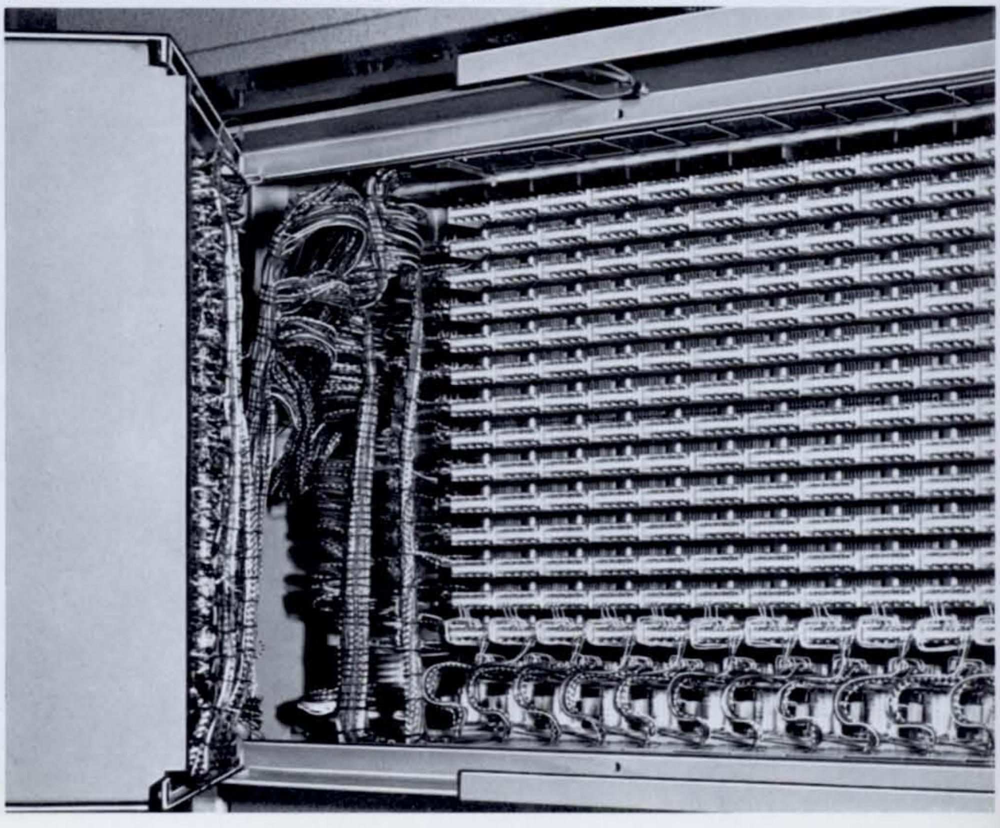
Power feeds and bay supervisory circuits are mounted on a frame 231 mm high and of standard width, fixed at eye level. This frame accommodates lamp, jack, and key strips, e. g. for alarm circuits. It includes also the associated alarm relays, and apparatus for distributing pulses and other services. Distribution fuse panels, ballast lamps, and other power supply items are fitted as required.

Relay Bays

The relay bays are the same height as the switch bays. Two relay bays have the same width as a single switch bay.

Relay units are fitted on separate plug-in assemblies. Instead of separate frames,

Fig. 21 Rear view of line unit terminal selector frame with hinged frame for line relays



the relay bay has eight horizontal members secured to the bay uprights, the space between them providing for seven rows of relay units.
The relay units have a vertical locking arrangement whereby a unit must be drawn forward before it can be lifted out.

Cable frame unit

The relay bay cable frame unit, of which part is shown in Figure 22, consists of:

- a light metal construction; two uprights and horizontal traverses corresponding to the equipment rows of plug-in relay units
- vertical and horizontal plastic wire ducts riveted to the uprights and traverses
- a concentration terminal block composed of 131 terminal strips with 10 terminals each, which are mounted on top of the unit
- 20-way jacks engaging the relay unit plugs
- loose wires connecting the concentration terminal block to the 20-way jacks

The unit is shipped separately, and is bolted to the uprights of the relay bay on site. The uprights and cross members, making part of the switchrack ironwork, have to be erected first on installation, and the cable frame units are fitted at a later and more convenient stage.

Wiring to the plug-in relay units consists of loose wires run within the cable frame from the concentration terminal strips at the top of the bay to jack-ended cable tails at each relay unit position. The cable tails are fed through slots, and terminate on jacks which engage the relay unit plugs.

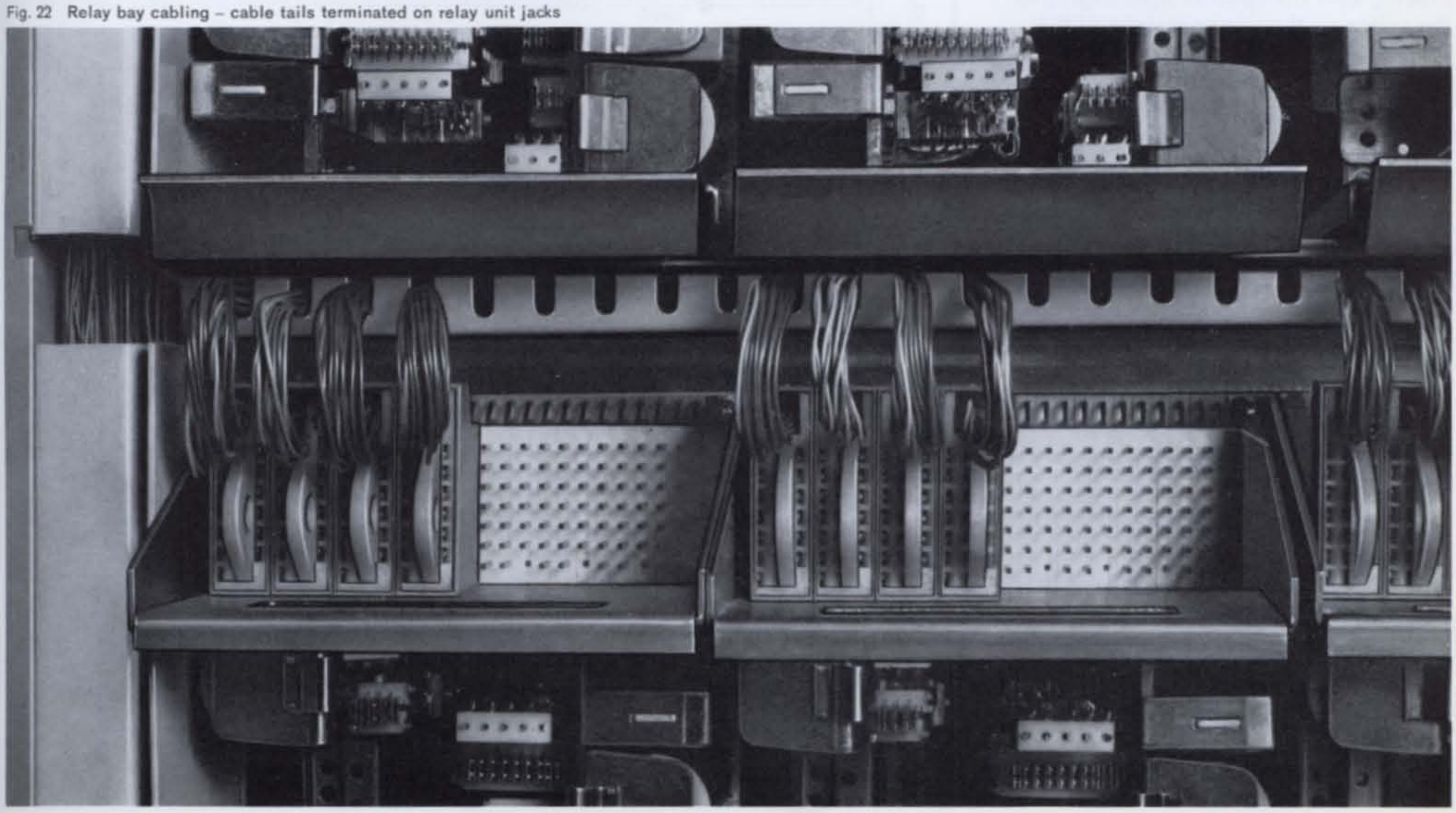
The horizontal and vertical wire runs are not laced together but are carried unlaced in slotted plastic wire ducts.
Wires are wrap-jointed and tested at the same time, so that further installation test is unnecessary.

Power and supervisory units

These plug in and lock into position in the same way as the relay units. Three types of power and supervisory units are provided:

- fuse unit for power distribution
- lamp and jack strip unit for supervision
- supervisory relay unit

Fig. 22 Relay bay cabling – cable tails terminated on relay unit jacks



Arrangement of suites

Suites can be arranged in open formation, and where relay bays are used the bays can be arranged back-to-back or with backs to a wall. Relay bays and selector bays can be lined up together in the same suite. A floor plan layout for an exchange of 10 000 lines is shown in Figure 23, which includes also equipment for inter-working with other Pentaconta and step-by-step offices.

A suite is made of bays as required, the bay uprights being secured top and bottom to steel angle tie-bars. These are supplied in 3-metre lengths and extend over the whole suite, and are joined by rigid fish-plates where necessary. Standard drillings along the whole length eliminate any necessity for drilling on site. Tie-bars extend at one end of the suite to accommodate the power distribution bus-bars and the associated fuse and alarm lamp panel. If desired, they can also be extended further at either end to give support from a wall.

Suites are coupled together by means of bracing bars clamped at right angles to the suites on the upper surface of the tie-bars. The flexibility of the clamping arrangement permits the installer to vary the distance between suites easily in the event of unforeseen obstacles.
These bracing bars are placed regularly to provide correct fixing points for the cable grid mesh referred to on page 34.

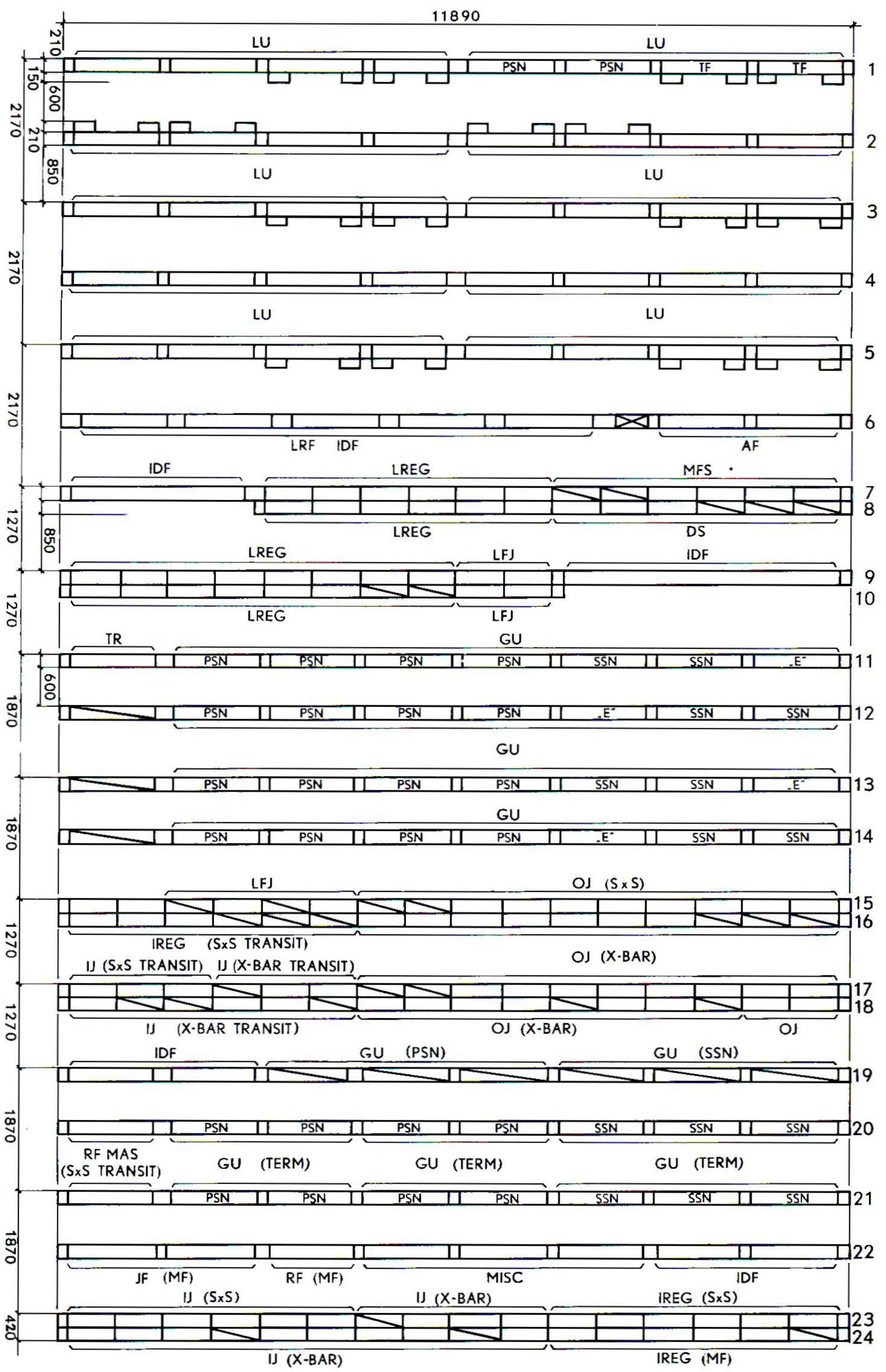


Fig. 23 Floor plan layout for 10 000 line Pentaconta local exchange

Power Requirements

The Pentaconta local system works on a 48 V d. c. supply, the positive pole being earthed.

The equipment works satisfactorily between the limits of 44 to 52 volts. The minimum voltage at the power plant terminals should be high enough to allow for the voltage drop in the power feeders and in the exchange busbars.

Power is usually supplied either by a single or double lead-acid battery floated across a charging rectifier from a. c. mains, with a capacity capable of supplying the exchange for several hours in the event of mains failure.

The thyristor control used in Pentaconta charging rectifiers enables output voltage to be very closely regulated, and the method of control results in considerable overall saving of space and weight.

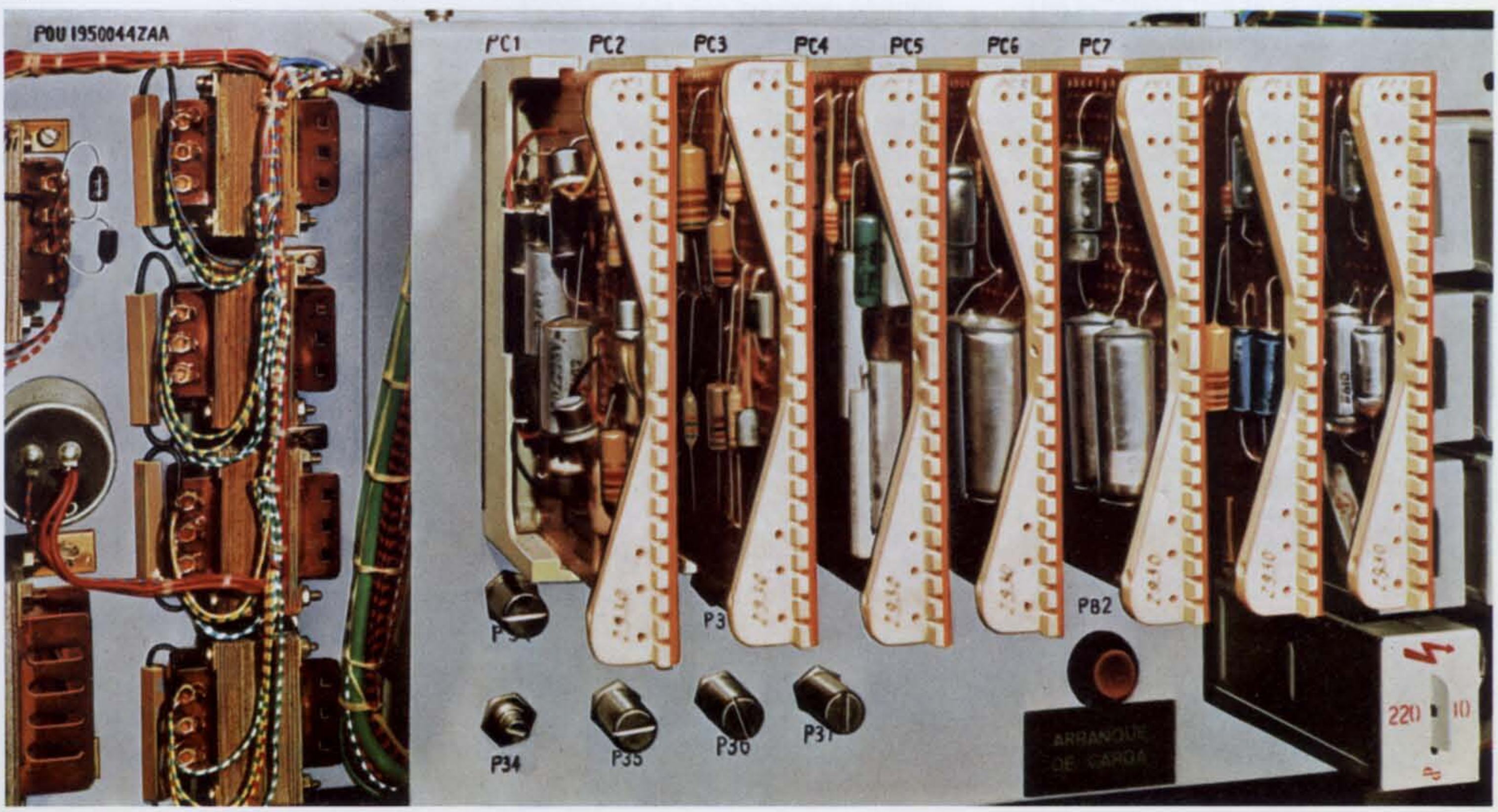
Figure 24 shows a plug-in transistorized printed circuit used in the control circuit for a rectifier.

Auxiliary power supplies are as follows:

- positive 48 V battery for metering and control circuits
- 75 V 25 Hz supply for ringing
- 450 Hz supply for supervisory tones, complete with interrupter for tone distinction

As stated on page 12 any alternative frequency can be supplied for ringing and tones to the requirements of the customer.

Fig. 24 Printed circuit component board for thyristor controlled rectifier



Installation

It will be evident from the description of the apparatus and equipment given in this brochure that everything has been done to make installation as simple as possible.

Equipment is easy to transport, easy to handle, and requires a minimum of effort to erect. The bays on which equipment frames and relay units are fitted are delivered to site in parts which are easy to assemble, and when assembled are very rigid. Equipment frames are locked in position when fitted to the bays, and all relay units are plug-in.

A modern point-to-point cabling method has been developed for use in Pentaconta local exchanges which considerably reduces installation labour costs and requires shorter cable lengths between bays. A welded grid of heavy-gauge steel wire is erected between the upper tie-bars of the suites and the ceiling. Cables are run from the bays and distribution frames up through the grid and thence directly to their destinations, laying on the upper surface of the grid without lacing together or to the grid, as shown in Figure 25.

Installation tests devised to ensure satisfactory operation are carried out by special test sets, which completely test the whole equipment in the shortest possible time. Tests are taken in the following steps:

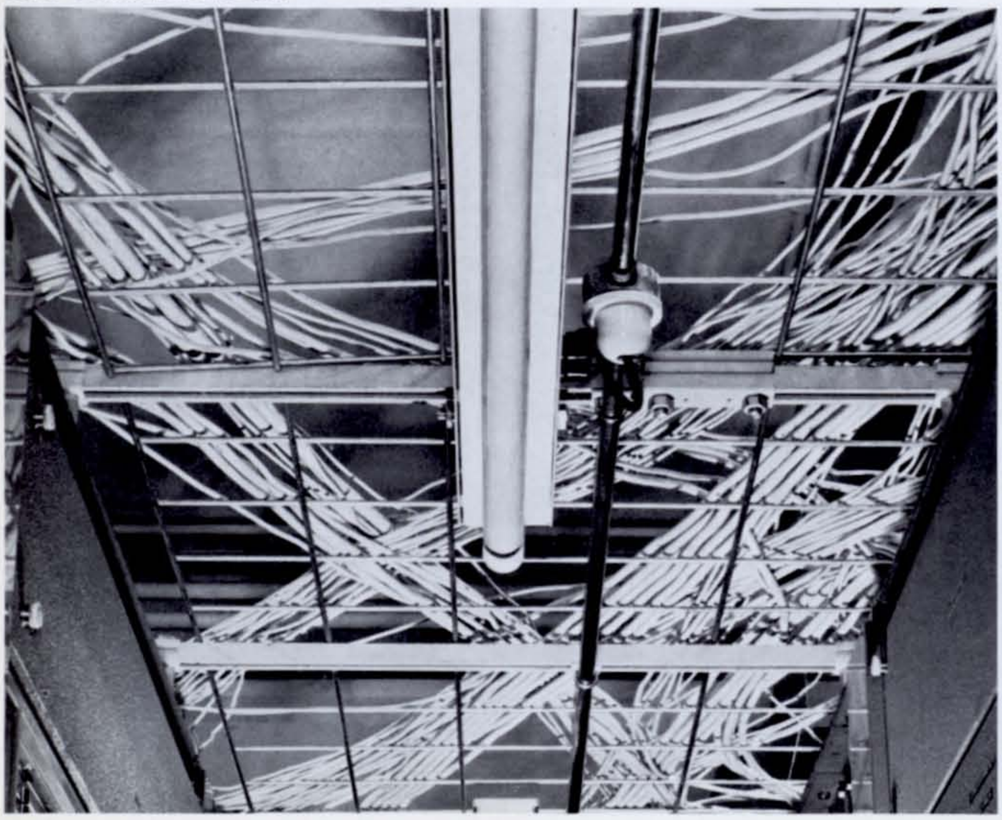
- preliminary tests: checking and continuity test of all cables
- functional tests: line selection units, group selection units, and the control unit are individually tested
- selection tests: tests of interconnections between stages already tested functionally, and call-through tests on trunks
- concentration tests: an automatic concentration test set creates an abnormally severe selection condition

Full information on the use of test sets, together with complete testing programmes, is provided. Where an Administration wishes to undertake the complete installation using its own staff, fully detailed instructions are supplied. Instruction on installation work will be given if required.

Acceptance testing

A call-through test is the normal basis of acceptance, using an agreed maximum fault rate. For local connections, the number of test calls is about four times the number of subscribers' lines, and the acceptable fault rate is normally two per 1000 calls. Trunk lines are tested over dummy lines at the MDF, and over direct physical lines to a distant exchange.

Fig. 25 Point-to-point cable grid



Maintenance

An analysis of time spent on maintenance at a number of exchanges has shown that Pentaconta maintenance requirements are very low. Since traffic conditions change, and components may fail, observation must be kept to ensure that the proper grade of service is maintained, although such failures will not cause a breakdown. Test gear has been developed whose use will enable the original quality of service provided by the Pentaconta exchange to be maintained throughout its lifetime.

Automatic fault recording equipment

An automatic fault recorder can be incorporated into the exchange to provide continuous, automatic monitoring. It supervises normal operating processes, and also provides additional facilities such as automatic false-call tracing and service observation. An adapted electric typewriter, associated with the fault recorder, records all the circuits used in setting up the connection on which a faut occurs, so fault tracing is very simple.

Call robot

A call robot is also available, whereby ten simultaneous local calls can be sent and controlled. This checks the proper working of the exchange by making limited concentration tests during service.

Call routing equipment

This enables calls to be routed through predetermined paths within the exchange. This can also be arranged to work with a recorder, which will provide a printed record of all particulars on such test calls.

Fault observation on registers

All registers can be associated with fault observation equipment, which provides a statistical report on the grade of service of the exchange from the point of view of the registers.

Traffic recorder and traffic measuring equipment

This gives regular traffic and call counts, thus providing a clear picture of the proper functioning of all parts of the exchange. Traffic carried by individual circuits such as junctors, registers and senders can also be measured, and service meters can also be provided to record the total seizures of information paths and markers. Congestion information (i. e. seizures when busy) can also be recorded.

Switch occupancy can be measured by means of a special test set. Where unbalance is observed, the same test set can be used to measure traffic on individual vertical selectors.

Automatic sender

This serves as a test set for call routing purposes, and also as an automatic subscriber able to judge the quality of service offered by the exchange or the network.

Manual test sets

Different test sets are available for testing outgoing and incoming trunks, local feed junctors, and translators. These verify the correct functioning of the circuits under observation.
The translator test set is particularly valuable for ensuring that maintenance modifications to incorporate new translating or routing instructions are correct. The trunk test set also has the important function of testing the state of outside cable plant, and the correct operation of the distant exchanges.

Automatic test equipment

In very large exchanges having many trunk circuits, the Pentaconta system provides for the automatic testing of all junctions in accordance with a sequenced programme.

Training

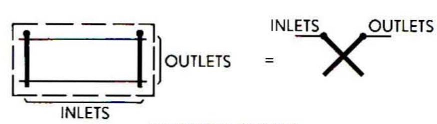
If an Administration wishes to have members of its maintenance staff trained in the use of Pentaconta equipment arrangements can be made for suitable instruction courses.

Technical Data Summary

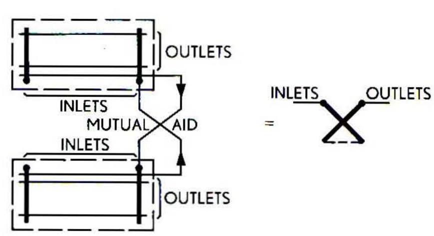
Operating voltage	nominal 48 V (44–52 V positive pole earthed)
Maximum subscriber loop resistance including telephone set	1900 Ω
Minimum insulation resistance between subscriber lines or between one or both speech wires to ground	15000 Ω
Maximum loop resistance for d.c. trunks	2400 Ω
Minimum insulation resistance between trunk wires and ground	30000 Ω
Maximum attenuation at 800 Hz between two line circuits in a local connection	1 dB (0.11 N)
Dial pulse frequency	8 Hz to 22 Hz
Break-to-make ratio	40 : 60 to 75 : 25 at 10 Hz 50 : 50 to 70 : 30 at 20 Hz
Typical current drain during conversation:	
local call	510 mA
outgoing call	320 mA
incoming call	340 mA
Traffic capacity	up to 250 E total per 1000 lines
Floor load	650 kgf/m^2
Equipment bay width	725 mm and 1450 mm
Equipment bay height	3470 mm standard
Equipment bay depth	210 mm
Typical floor space of an isolated local exchange for 10000 lines and a total traffic of 140 E per 1000 lines	176 m^2

Table of Abbreviations

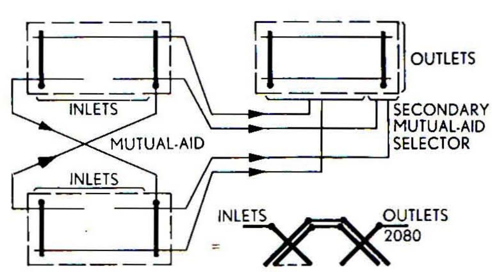
AF	Auxiliary finder
CF	Call finder
DEC	Decimal
DS	Decimal sender
E	Availability cut-off relay
GM	Group marker
GU	Group unit
IDF	Intermediate distributing frame
IF	Intermediate finder
IJ	Incoming junctor
IM	Intermediate finder marker
IREG	Incoming register
JF	Junctor finder
LFJ	Local feed junctor
LM	Line marker
LMR	Line marking relay
LREG	Local register
LRF	Local register finder
LU	Line unit
MAS	Mutual-aid selector
MF	Multi-frequency
MFS	Multi-frequency sender
MISC	Miscellaneous
OJ	Outgoing junctor
ORIG	Originating
PC	Preselection coupler
PF	Primary selector frame
PNS	Penultimate selector
PS	Primary selector
PSN	Primary section
REC	Receiver
REG	Register
RF	Register finder
RJ	Register junctor
SC	Selection coupler
SF	Secondary selector frame
SS	Secondary selector
SSN	Secondary section
S x S	Step-by-step
TERM	Terminating
TF	Terminal selector frame
TR	Translator
TS	Terminal selector
X-BAR	Crossbar



CROSSBAR SWITCH



PRIMARY STAGE WITH MUTUAL-AID



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