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RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

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CONTENTS

On cover: One of the large parabolic reflectors at Santa Elena, Colombia, 2,800 metres above mean sea level.

Long Distance Telephone Network in Colombia

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A comprehensive long distance telephone network with circuits between Colombia's most important cities has been built by the L M Ericsson Telephone Company for the Empresa Nacional de Telecomunicaciones. At the same time a large number of the long distance exchanges have been mechanized using L M Ericsson's crossbar switch systems. The country's telecommunications facilities have thereby been significantly improved, a factor which actively contributes to rapid economic development.

1. Radio and Carrier Equipment

General

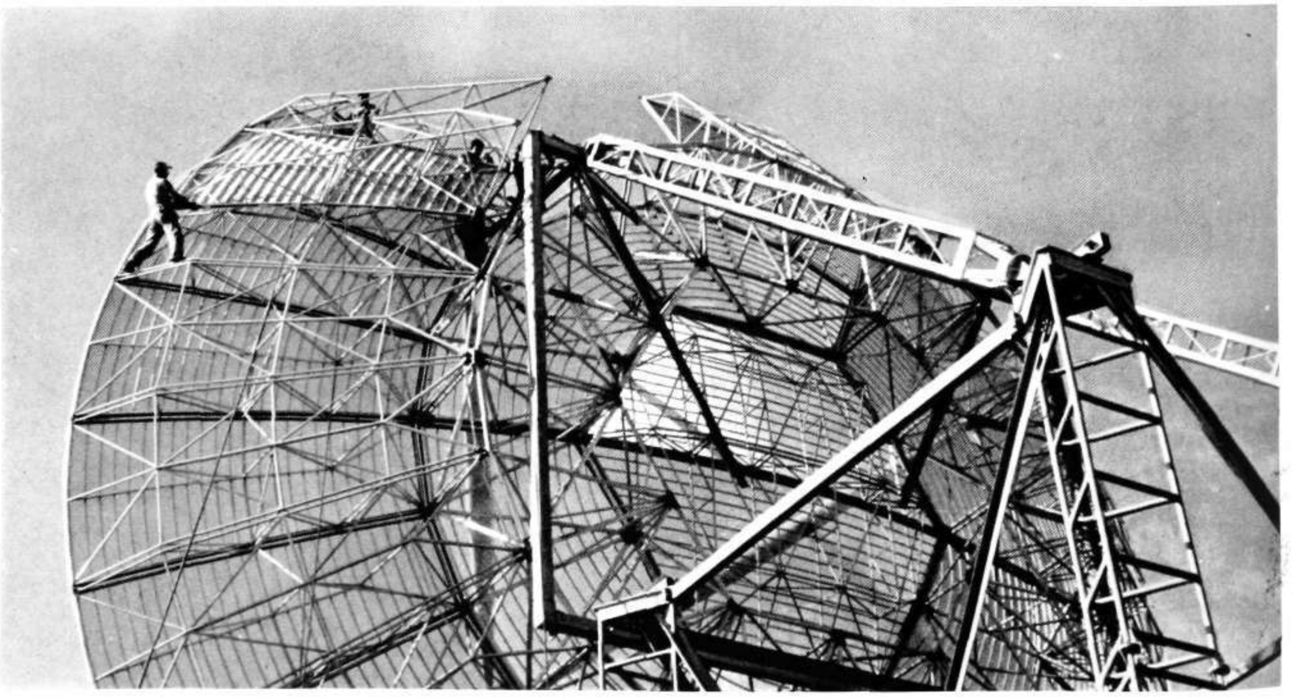
Starting already 1948, L M Ericsson had built the greater part of the Colombian long distance network i.e. the circuits between the country's most important cities. All these circuits use radio links in the VHF range as bearers, with associated multiplex equipment for up to 96 telephone circuits. Certain telephone channels are used for telegraphy.

The first VHF link was put into service in 1950 between Bogotá and Medellín and then Bogotá–Cali followed in 1954, Bogotá–Barranquilla in 1956, etc. All this work has been carried out under several contracts which over the course of years have been made between the Colombian State Telephone Administration (Empresa Nacional de Telecomunicaciones) and L M Ericsson.

The improvements in telecommunications facilities are appreciable. For example, it can be mentioned that before the commissioning of the radio link in 1956, the important route Bogotá–Barranquilla consisted of only two short-wave radio-telephone circuits, giving only moderate speech quality,

Fig. 1
Parabolic reflector

X 7896



which was to be expected of this type of circuit. Although the route today contains 60 high quality circuits there is a demand for an appreciable increase in number in the near future. The traffic demand on the other routes has also grown so rapidly that a transition from 96-circuit VHF links to 960-circuit SHF links is imminent on some of the most important ones.

The radio equipment installed by L M Ericsson was supplied by the Radio Corporation of America (RCA) and operates in the frequency range 235–300 Mc/s. The transmitter output power is 50 W. The equipment is duplicated and is provided with an automatic changeover facility from main to stand-by, a fault warning system and a service channel.

The multiplex equipment for telephony and v.f. telegraphy was supplied and installed by L M Ericsson. 96-circuit carrier systems are used for telephony and any telephone channel can carry 18 v.f. telegraph channels.

L M Ericsson has also installed the power supply equipment for the intermediate repeater stations of the radio links. This equipment was supplied by the Allmänna Svenska Elektriska AB (ASEA, Sweden) and is provided with flywheel generator sets with no-break changeover to the stand-by equipment. Most repeater stations, i.e. those not supplied from the public power supply mains, are provided with three diesel generator sets.

Some of the roads to the repeater stations have been built by L M Ericsson. This is also the case with some of the buildings for radio and power supply equipment.

In certain cases, cables have been used instead of radio links for the entrance arrangements to cities. These cables in which a frequency band of 300 kc/s is used have been installed by L M Ericsson.

All contracted guarantees concerning the technical performance of the equipment have been fulfilled with a good margin when making acceptance tests.

For the three longest circuits, the guarantee values of the signal-to-noise ratio were

Bogotá–Barranquilla, west route	51 db
Bogotá–Barranquilla, east route	54 db
Medellín–Barranquilla	56 db

According to the contract, these guarantee values were to apply at the acceptance tests for a period of three arbitrarily selected hours during each of seven consecutive days and be fulfilled for 99 % of the total time of 21 hours. The radio baseband was loaded with + 8 dbm0 white noise during these tests. According to the contract, the transmission tests were to be carried out during a period of 28 days and during this time the performance figures were to keep within the limits stipulated in the contract.

Among other gurantee values it can be mentioned that the maximum variation of circuit equivalent was not permitted to exceed ± 1.5 db including the variation due to changing over from any main radio equipment to its stand-by. As the circuits were provided with compandors, this meant that the variation of equivalent was not permitted to exceed ± 0.75 db.

Radio Equipment

The radio link network consists of different types of radio stations depending on whether these act as terminals or as repeaters with or without branching.

The radio system is composed of main and stand-by equipment for the respective directions. Each terminal station consists of three bays in a row.

The outer bays contain duplicated sending and receiving equipment with individual power supply. The middle bay contains equipment for automatic changeover between these two and further a fault warning system, a service channel and certain amplifier panels for patching the different speech directions.

The antennas used are of different designs depending on the hops to be covered. The types used vary from a simple Yagi to parabolic mirrors of up to 18 metres diameter, see fig. 1. The antennas are fed by an air-insulated coaxial cable having a low attenuation of about 0.02 db/metre. Transmitters and receivers have a common antenna and the system is therefore provided with directional filters. These filters are designed as cavity resonators in order to meet the high attenuation requirements placed on them due to the large difference in level between transmitter output and receiver input. The sending side is provided with a filter of band-pass type for the transmitted band and stop filter for the receiving frequency while the receiving side has only a stop filter for the sending frequency.

The multiplex baseband is sent directly to the transmitter frequency modulator. This modulator consists of two reactance tubes connected in parallel across the oscillator circuit so that one tube acts as an inductive reactance and the other as a capacitive reactance. The frequency modulated oscillator is provided with automatic frequency control governed by a reference crystal.

The modulated signal and therefore the frequency is multiplied 16 times during its passage through four doubler stages. It is then tripled, i.e. the original frequency is multiplied 48 times, before being applied to the output stage. The antenna absorbs 50 W output power in the VHF band.

The receiver, which transposes the signals from the VHF band to the baseband, consists of a low-noise RF amplifier followed by a crystal controlled mixer stage giving an intermediate frequency of 32 Mc/s. This is amplified and then limited using diodes. The baseband is finally obtained from a staggered discriminator. To compensate the changes of level which can occur with different reception conditions, the baseband level is maintained constant with the help of an automatic level regulator controlled by a 308 kc/s pilot frequency which is injected into the baseband. The regulator is followed by a baseband amplifier from which the multiplex terminal is fed.

At repeaters, the received signal is applied to the next transmitter at intermediate frequency, thereby avoiding demodulation to baseband. The discriminator and frequency modulator are, however, used for the service channel. At stations where no branching is expected, the frequency modulator is replaced by a crystal controlled phase modulated driver stage.

Changeover from main to stand-by equipment is carried out automatically when there is a fault on a transmitter or receiver and the action is remotely reported to the terminal station using an automatic code signal. In this way, the faulty repeater can be located directly at the terminal. In addition to the reports which come from the radio equipment itself, other information can be remotely reported, e.g. changeover of power supply, abnormal temperature rise etc.

The panels are provided with measuring instruments for checking tube cathode currents, incoming v.f. signals, power output to the antenna etc.

The frequency bands used in the system and the location of the antennas and their polarization have been studied in detail with regard to the interference which can occur between different links, especially at such places as El Ramo and El Picacho, where seven and six transmitters respectively operate simultaneously.

Carrier Equipment

The carrier plant of the long distance network consists of telephone equipment required for frequency translation between the speech band and the radio baseband, and also telegraph equipment for translation of d.c. pulses to v.f. pulses in the speech band. Trunk test boards with built-in measuring equipment and bays containing separating filters for splitting up the radio baseband and distribution in different directions are also included in the equipment. The required branching of the network has been obtained at quite low cost with the help of these filter bays.

A number of rearrangements of the existing equipment have been carried out in connexion with the installation of the carrier terminals, so that this equipment together with new equipment form a unified repeater station with centralized station alarm, trunks etc.

The carrier equipment is mounted on standardized frames and is designed in the form of plug-in units.

Each bay is provided with its own power supply unit which converts the mains supply voltage to the requisite bay voltages. These are distributed to the bay units via fuses in a current distribution panel. A blown fuse causes a bay and station alarm to be given, indicated by a bell and lamps. All tube currents can be read off on a meter situated in the current distribution panel.

The frequency translation between the speech band and the radio baseband normally occurs in four stages of modulation. The required carrier frequencies are derived from a crystal controlled master oscillator having a frequency stability better than 1 part in 10^6. The crystal is located in a thermostatically controlled oven, the temperature of which is maintained constant to within $\pm 1^\circ$ C. The carrier frequencies are generated in harmonic generators, separated in highly selective band-pass filters and amplified. A complete station is usually fed from a single oscillator equipment which if greater reliability is required is duplicated to give a regular and a stand-by set. When a fault occurs on the regular oscillator, automatic changeover to the stand-by is carried out and an alarm is given simultaneously. The changeover occurs rapidly and does not cause any interference to traffic in progress.

A signalling repeater is provided on the exchange side of each circuit. The circuits are normally built for four-wire operation. At certain small exchanges with manual operation, each signalling repeater is connected two-wire to the exchange.

The bays have been provided with level measuring equipment for measuring transmission, pilot and carrier levels, which covers the normal requirements of maintenance and operation. Voice frequency measurement is carried out using a test tone.

Talking, monitoring and signalling from any channel translating bay can be carried out with the help of a monitoring panel. Several trunk lines are included to permit interconnexion between bays and the trunk test board and also between rows of bays. The trunks are provided with lamps for denoting when they are engaged.

The telegraph equipment of the carrier network permits 18 frequency modulated telegraph channels to be accommodated in the band afforded by a telephone channel. The equipment is subdivided into three groups of six channels. Conversion of d.c. pulses to v.f. pulses occurs in the channel oscillator, the frequency of which is changed at $\pm$ 30 c/s in step with the impulsing, by using static relays. The equipment follows the CCITT recommendations and is intended for a normal teleprinter speed of 50 bauds, but can be used up to 80 bauds. Interference-free transmission is obtained as the frequency modulation permits amplitude limitation on the receiving side.

The telegraph currents can be read off on instruments in the bay and these currents can be adjusted to the prescribed values by using built-in potentiometers, therby obtaining at the same time the correct frequency shift on the sending side. A pulsing direct current is obtained from a generator which is also built into the bay, thereby permitting a rapid check of a telegraph channel to be carried out.

Power Supply Equipment

Eleven important junctions in the radio link network situated at heights varying from a few hundred metres up to 4,000 metres are so inaccessible that they cannot be supplied from a power line reasonably economically. They have therefore been provided with individual diesel electric generator sets. At each of these stations there are three identical sets, one of which supplies power continuously, one is on stand-by and the third can, if necessary, be undergoing maintenance. When it is not undergoing maintenance, it is also on stand-by and if due to a fault the first set stops or must be stopped, the other two sets start up and the first of these to reach the operating voltage takes over the load while the other stops again. In this way the power supply system is made very reliable.

Between the load (radio transmitters, etc.) and the three generator sets feeding a common three phase busbar there is a flywheel motor generator set. Because of its inertia and its rapid-acting, accurate voltage regulator, the flywheel set isolates the radio equipment from short-term disturbances on the generator side. Sufficient energy is also stored in the flywheel to bridge over the starting time of the diesel generator sets without any interruption, should there be a disturbance in the regular set leading to changeover to one of the stand-by sets. The flywheel set consists of a flywheel and axle running in two bearings. Connected to each end of the axle there is an armature rotating in a stator secured to the bedplate. One of the assemblies forms a 3-phase asynchronous motor operating from the motor generator busbars. The other assembly forms a single phase synchronous generator supplying power to the radio equipment. The flywheel is sufficiently large to supply full power to the radio equipment for 30 seconds should there be a changeover or fault on the diesel generators. During this time the voltage is maintained constant whereas the frequency falls continuously from 60 c/s down to 48 c/s.

There is no stand-by for this no-break power unit, but when compared with the diesel motors, it is extremely reliable and has very long operating time between overhauls. On the rare occasions when it has to be taken out of service, the radio equipment can be connected directly to the diesel generator busbars which also have sufficiently close voltage regulation, about $\pm 2\,\%$, for the purpose.

The whole power supply equipment including the no-break power set is completely automatic and provided with a comprehensive coarse regulating system which makes it practically foolproof.

Power plant has been installed by L M Ericsson at a few additional places where the radio link system is fed from the local supply mains. At these places there is only one diesel generator set as stand-by for the local mains, but otherwise the equipment is the same. When the diesel generator set, which of course is only the stand-by, has to undergo its periodic overhaul, it is replaced by a mobile set, thus ensuring a permanent stand-by.

All the stations are fully automatic. The voltage and frequency are controlled by sensitive regulators but are also supervised by special units to ensure that their values always lie within certain stated limits. In a well designed system, certain functions are checked so that when there are disturbances in the power system no values of frequency or voltage occur which can be dangerous for the flywheel generator set or radio equipment. It has therefore been arranged that any diesel generator is stopped immediately the permissible limits of frequency, r.p.m. or motor temperature are exceeded or if the oil pressure in the bearings falls below an acceptable value. Fault warnings are sent over the radio link to attended supervision points in the network. The sizes of the power plant vary from 6 kVA to 25 kVA. Having regard to the energy needed to reaccelerate the flywheel generator set after a fault and the frequently high operating altitude, however, the diesel motors must be made for considerably higher output powers. Thus, the nominal power of a diesel motor driving a 25 kVA flywheel set at 4,000 metres altitude is about 100 h.p.

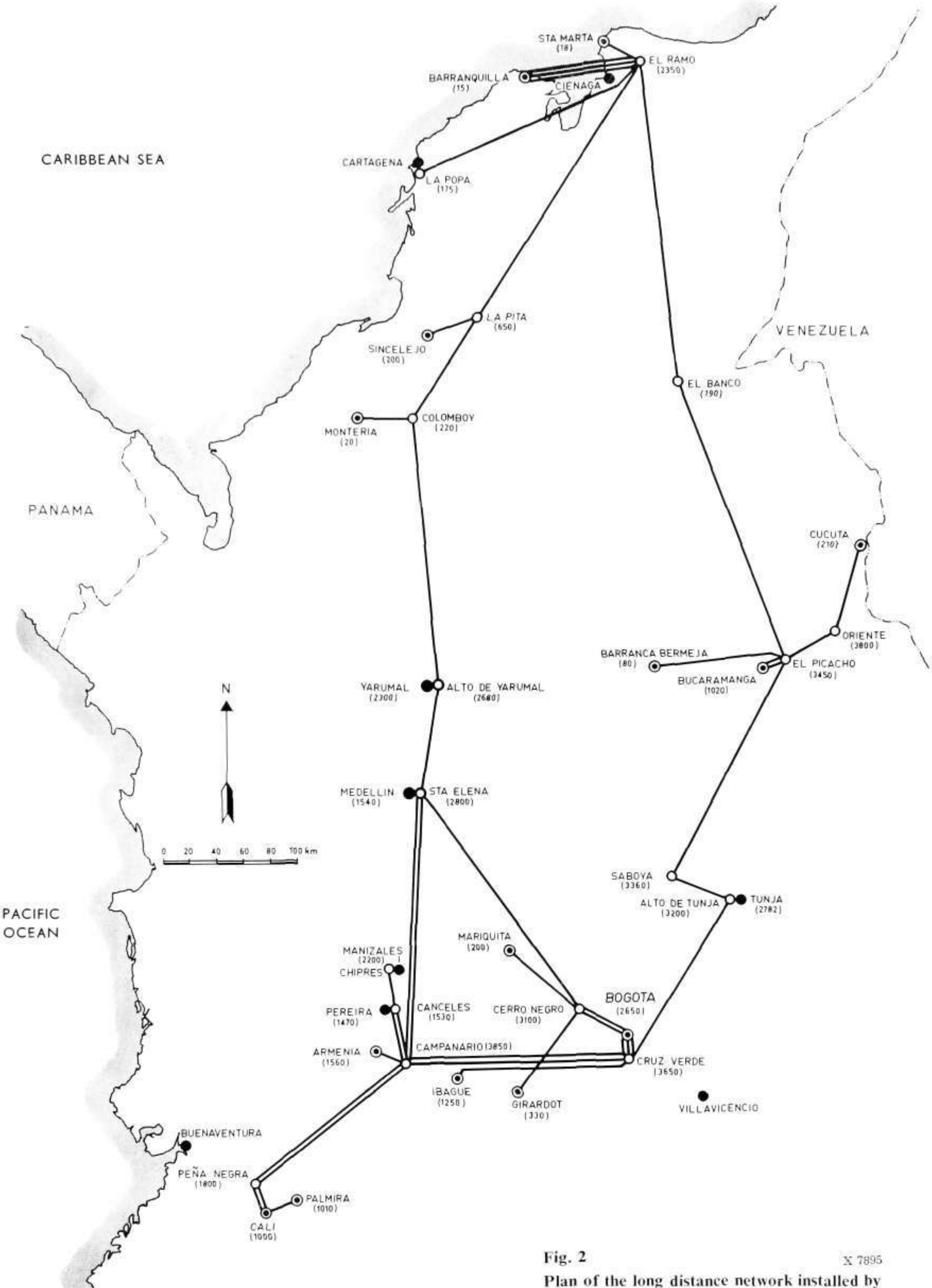


Fig. 2 X 7895

Plan of the long distance network installed by L M Ericsson in Colombia

——	Radio link
⊙	VHF radio and carrier terminal
○	VHF radio repeater or terminal
●	Carrier terminal
●○	Cable circuit
(18)	denotes height in metres above mean sea level

2. Automatization of the Long Distance Network

Introduction

A large part of the Colombian long distance network has been automatized in recent years. This was made possible both through the installation of the radio links and carrier equipments referred to in the first part of this article and through the acquisition by Empresa Nacional de Telecomunicaciones of a number of automatic trunk equipments for the larger and more important places in the country. The planning of the long distance network has been based on the traffic facilities offered by the automatic trunk exchanges.

Since 1961 a successive conversion has taken place from manual to outgoing semiautomatic service with automatic transit traffic on the more important trunks. Twenty-five of the largest towns had been linked up with the semiautomatic system by 1963.

Subscriber-dialled long distance traffic has also started and will be successively extended as new trunk circuits are installed and as the many local exchanges not belonging to Empresa Nacional de Telecomunicaciones are provided with the necessary circuits to the trunk exchanges and with trunk charging equipment.

The new trunk equipments have been supplied by L M Ericsson. They comprise automatic equipments of system *ARM 20* for places with large transit traffic and manual equipments of system *AFA 10* for areas with chiefly terminating traffic. The *AFA 10* exchanges are, however, equipped for automatic incoming and semiautomatic outgoing traffic.

Extent of the Automatic Network

System *ARM 20* automatic trunk exchanges have been installed in the following towns:

Bogotá	Switch	capacity	2,200	lines
Cali	»	»	1,200	»
Medellín	»	»	1,000	»
Barranquilla	»	»	1,000	»
Bucaramanga	»	»	400	»
Pereira	»	»	400	»
Armenia	»	»	400	»
Tunja	»	»	200	»

Trunk exchanges of system *AFA 10* have been supplied to 17 places as marked on the map in fig. 3.

The first step in the conversion is to semiautomatic operation. The reason why Empresa Nacional de Telecomunicaciones decided on this intermediate phase before going over to subscriber-dialled long distance traffic was chiefly that almost all local exchanges in the country belong to other administrations and that they require large numbers of junctions to the trunk exchanges as well as trunk charging equipment before subscriber-dialled operation can be introduced. An extensive alteration of the tariffs is also required.

The introduction of semiautomatic trunk traffic in the first stage requires only minor additions to the local equipments and allows the local administrations better time to procure the equipments needed for long distance subscriber dialling. At the same time better opportunities will be afforded for studying

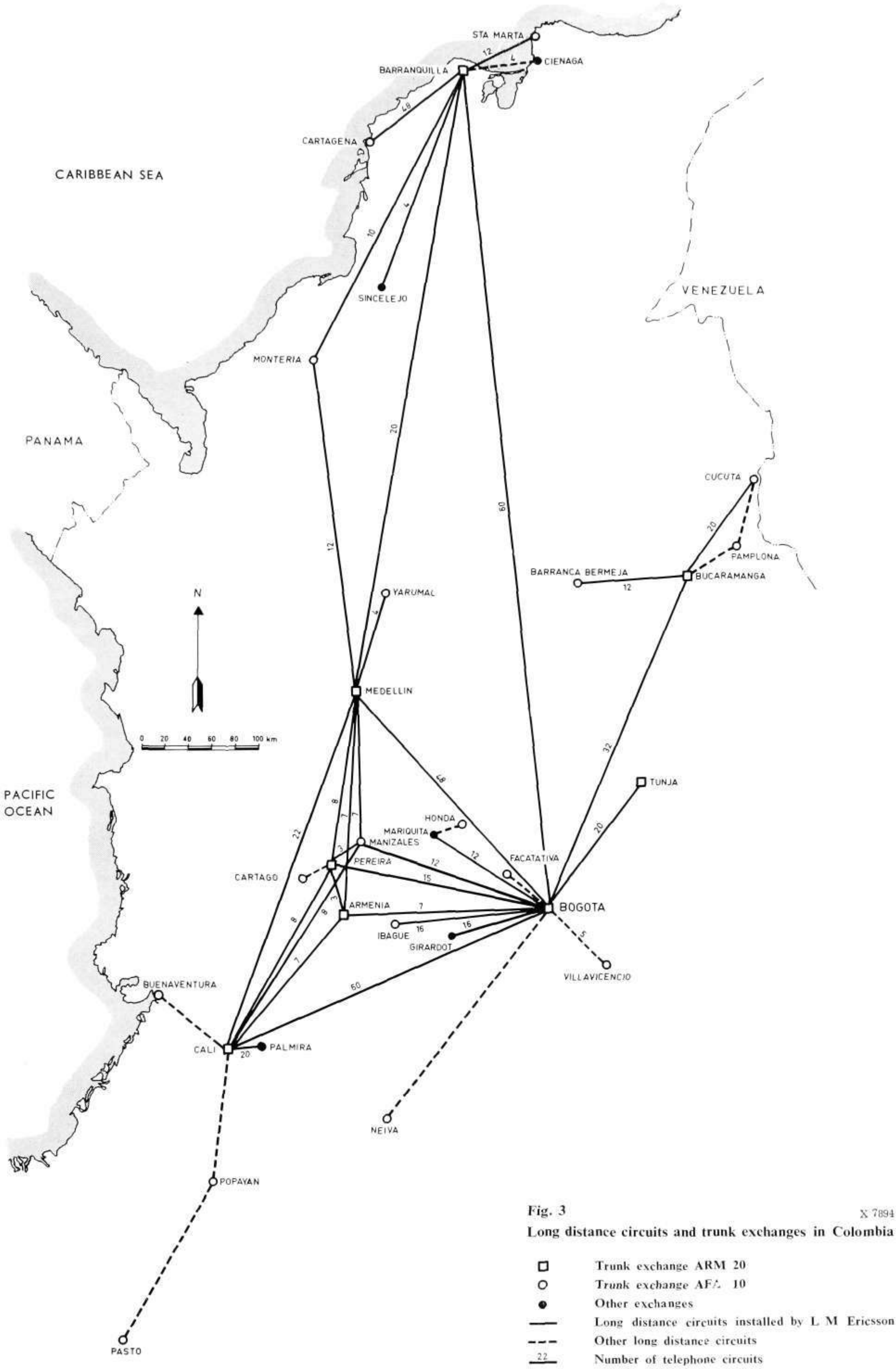


Fig. 3 X 7894

Long distance circuits and trunk exchanges in Colombia

- □ Trunk exchange ARM 20
- ○ Trunk exchange AFA[?] 10
- ● Other exchanges
- —— Long distance circuits installed by L M Ericsson
- - - - Other long distance circuits
- (22) Number of telephone circuits

Fig. 4
The operators' positions at Bogotá

X 8455

the tariff questions and the methods of settlement between Empresa Nacional de Telecomunicaciones and the local administrations, as well as the traffic requirements of the long distance network.

The semiautomatic traffic will be handled on a demand basis on the record circuits insofar as the capacity of the trunk network allows, and verification of the calling subscriber will be used only for a small number of connections.

The *ARM 20* exchanges have cordless positions for all classes of traffic requiring an operator, i.e. outgoing semiautomatic long distance, manual long distance, and in Bogotá also the international traffic. All incoming traffic and the transit traffic from the semiautomatic trunk circuits will be handled on an automatic basis. The *ARM* exchanges are prepared for subscriber-dialled traffic and require only the addition of junction equipments which can receive numerical information from the local exchanges and send metering pulses to them.

The *AFA 10* exchanges have been installed at places with chiefly terminating traffic. They are equipped with cord positions. The incoming traffic is switched automatically to the local subscriber without operator assistance. The very small transit traffic that may occur at these places will be handled manually. This type of exchange as well can be supplemented for subscriber-dialled traffic.

As regards transmission and classification of trunk calls, numbering, metering and traffic questions, and to some extent administrative questions, the Colombian network is divided into regions, zones and group areas. The automatic trunk exchanges have been installed in the planned regional centres, and in some cases in zone centres with high transit traffic.

Technical Facilities of the Automatic Trunk Switching System ARM 20

Transit calls are switched automatically and always on a four-wire basis between two long distance circuits. All circuits are therefore connected on four wires to the exchange equipment. The existing two-wire physical circuits have hybrid repeaters and in some cases terminal repeaters.

Long distance calls are register-controlled and numerical information is sent on the trunk circuits in multifrequency code, 2 out of 6, between the registers. The originating long distance register is connected to the circuit during the entire switching time and sends the necessary information to the transit and terminal registers concerned, i.e. the area code is repeated to all transit points and the local subscriber's number is sent only after connection has been established with the remote terminal exchange.

For line signalling, i.e. the supervisory signals before and after setting up of the connection, discontinuous single-frequency signals are used in the speech band, but the exchange equipments also allow connection to systems with outband signalling.

A survey of the signal elements for line signalling at 2,400 c/s and of the register signalling frequencies is shown in fig. 5.

The trunk exchanges incorporate alternative routing. Apart from direct trunks, the system has facilities for selection of four other alternative routes in a predetermined order. The alternative routing has permitted an improved economic structure of the long distance network. Direct trunks can be introduced to a considerable extent and be designed for high utilization since the overflow traffic is directed to alternative routes common to several direct routes. The latter will thus be economical even for small groups of circuits. Alternative routing increases the total traffic capacity of the network since the traffic on the alternative routes is composed of the overflow traffic from a large number of direct routes; the traffic peaks on different routes, moreover, will probably not coincide even within coincident busy hours, and the busy hours on certain groups of routes occur at different times of the day. This means that the alternative routes need not be designed for the traffic peak of each single route. Should a breakdown occur on certain routes, the traffic should to a large extent flow normally by being automatically redirected to an alternative route.

Long distance connections can be switched over a number of circuits in series, and the system is therefore equipped with devices which prevent switching to and fro on the same route. The controlling register also checks that the predetermined maximum number of circuits of different classes is not exceeded.

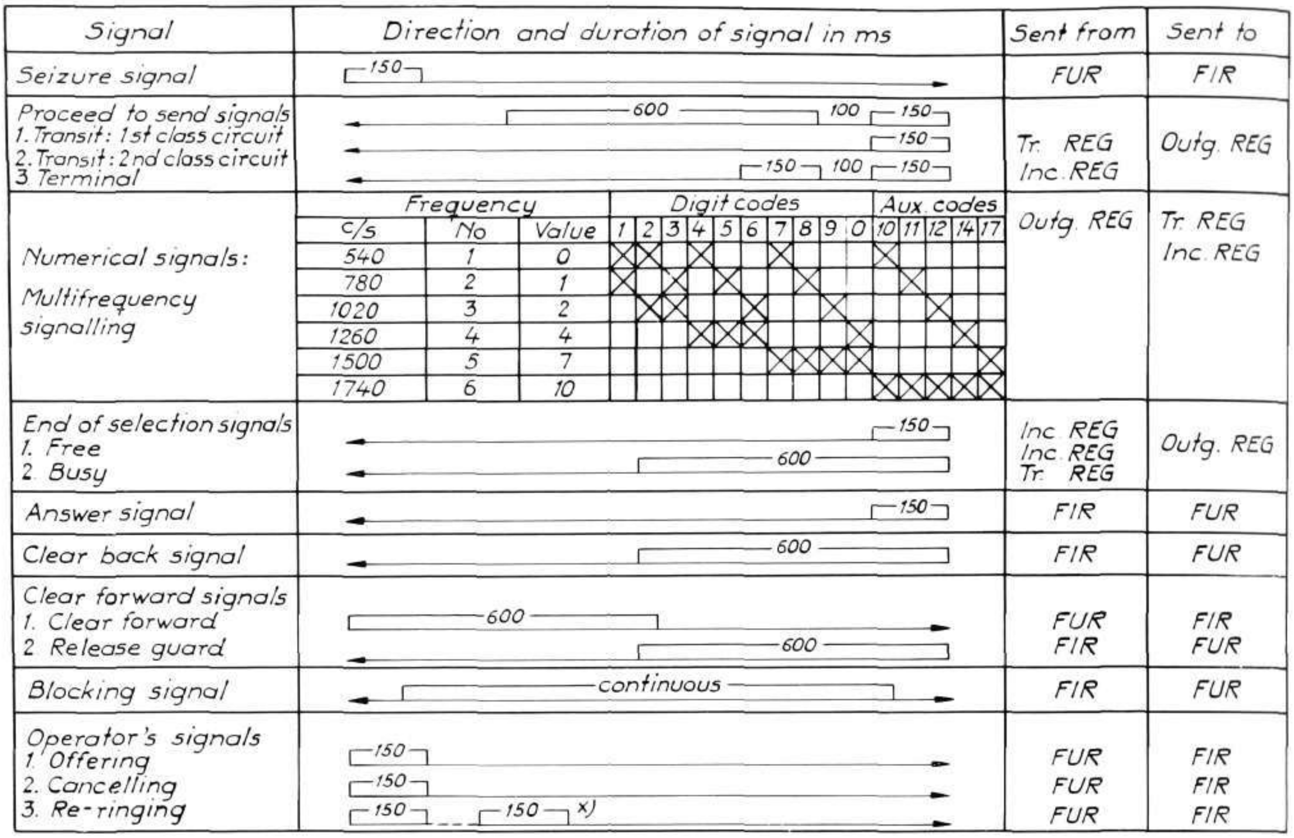
The system has facilities for automatic switching in and out of pads, which permits the long distance network to be constructed on the VNL principle.

The trunk exchanges are so designed that, with low internal congestion, they provide full availability even with a large number of circuits on a route. This ensures the highest circuit utilization attainable in practice.

The switching stages are designed for two-way traffic, which means that a two-way circuit requires only one termination in the multiple.

The system provides for individual selection of all connected circuits. This facility is used both for order wire calls between operators within the same exchange and at different trunk exchanges, and for transit connections to manual trunks tied to a particular assistance operator. Above all, the individual selection facility permits connection of automatic test units for transmission measurements on all long distance circuits in the network that are accessible from the trunk exchange.

Incoming trunk circuits are switched automatically to the terminating subscriber's line. The registers at the terminating trunk exchange are equipped for sending the numerical information on the signalling principles required by the respective local exchanges. Conversion of the local exchange line signalling to the trunk signalling scheme is done in the junction relay sets at the trunk exchange. Colombia has different local exchange systems, and the trunk exchanges are designed to interwork with, among others, step-by-step, machine-driven and MFC register signalling systems. Modifications of the local systems could thus be limited and often avoided altogether.



x) The second signal element is sent when the ringing key is restored

Fig. 5 X 7902
Signal codes for line and register signalling

The originating trunk traffic from the local exchanges is passed via record circuits connected to the trunk switching equipment. Connection of the caller to a free cord pair at a free operator's position is controlled by a queuing equipment.

The automatic trunk exchanges have equipment for service observation and traffic measurement. The service observation equipment indicates trouble in the system and locates the faults. The common control units are supervised by a Centralograph which records the identity of the faulty unit, the details of the units employed on the faulty connection, and how far the connection had advanced. The service alarm equipment indicates when the number of faults exceeds a predetermined level within a unit of time, and counters are used for counting switch occupations, switchings to alternative routes, measurement of congestion, etc. The traffic measuring equipment is used for erlang measurements in different switching groups. The measuring equipment is connected automatically during the busy hour of the exchange, as also are counters for measuring the traffic intensity and congestion. In view of the alternative routing, facilities are provided for measuring the traffic on separate routes and to the different terminating exchanges.

The conversion to subscriber-dialled long distance traffic requires that the trunk exchanges be equipped with junction circuits containing equipment for sending metering pulses to the local exchange, equipment for fee determination, and registers for receiving the numerical information from the local exchange. The local exchanges must also have equipment which can receive the metering pulses, and in some cases must be modified for sending on the pulses to the subscriber's meter.

For the subscriber-dialled traffic that is already operating, random time zone metering is employed, i.e. pulses are sent to the subscriber's meter during the conversation at a frequency corresponding to the tariff. Metering starts when the called subscriber's answer has been registered and ends when

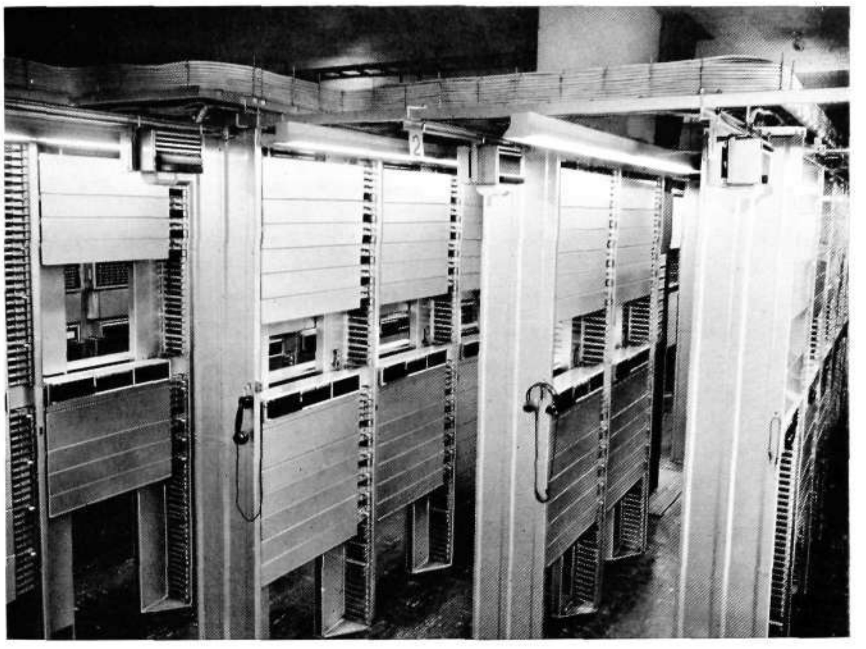


Fig. 6 X 8454
Part of the ARM 20 equipment at Bogotá

the caller replaces. Since the metering pulses are sent at random, the called subscriber's answer and the first metering pulse may not coincide.

For the semiautomatic trunk traffic two-digit codes are used for calling the trunk operator. Subscriber-dialled trunk numbers include a single-digit trunk access code, a usually three-digit group area code, and the directory number. All digits are dialled in one sequence without needing to wait for a new dial tone after obtaining a trunk line.

The operators' positions at the automatic trunk exchanges are of cordless type with keysets. The operators' position equipments and cord pairs terminate on the trunk switching equipment.

Outgoing trunk calls are usually handled at the demand position. The calls are switched automatically to a free cord pair at a free operator's position and the operator switches it to the trunk network via the same cord pair. Through-connection is not effected until the period counter has been switched into the circuit. The latter starts when the called subscriber answers and stops when the caller replaces his handset.

For demand service calls verification of the caller's number is adopted only for a limited number of connections by call-back to the subscriber. The operators' positions for non-delay working can be individually blocked against demand calls and used exclusively for delay traffic if required by the traffic conditions on certain trunks at certain times.

Some trunks, principally manual trunks, are not designed for automatic traffic. Calls on these routes are therefore handled at special delay and transit positions at the superior automatic trunk exchange. These positions have the same traffic facilities as the demand positions but are also equipped for tying of the manual circuits to specific cord pairs. This implies that the circuits are blocked against incoming automatic calls and are accessible only to the operator to whose position the circuits are tied. Connections of this kind can be established and cancelled form the operator's position, and a tied circuit can be loaned to another operator. When the tie-up is cancelled, calls on the route can be switched automatically.

The incoming traffic from the manual circuits requires an assistance operator at the automatic trunk exchange. A call on a manual trunk which is not tied to a particular operator is indicated at the delay and transit positions. Via a cord pair and the selector equipment any of these operators can connect to the line and extend the call. On a tied line a call is indicated on the cord pair to which the line is tied.

The international circuits in Bogotá, which at present are handled on a manual basis, terminate on separate positions with the same facilities as the national delay and transit positions.

All operators can enter an engaged circuit to offer a waiting trunk call. The switching system and the signalling scheme allow entry also via trunk circuits when so required and when the ordinary junction lines of the local exchange equipment possess this facility.

Order wire calls between operators within the same exchange or at different transit exchanges can be established from any cord pair at any position. Incoming operators' calls are signalled on the position equipment. The numbering of the order wire circuits is entirely independent of the subscriber numbering. Order wire calls are initiated by pressing a special key.

Traffic Routing in Trunk Exchanges ARM 20

Automatic transit exchanges *ARM 20* were described in Ericsson Review No. 2, 1960. The present account will therefore be confined mainly to the uses of these exchanges in the Colombian long distance network.

The trunking diagram of a typical *ARM 201* exchange is shown in fig. 7. The *GDA* and *GDB* stages are designed for two-way traffic and are divided into two groups. The trunk circuits terminate on one group, the upper in the diagram, and the junctions both for incoming and outgoing traffic with local exchanges terminate on the lower group. The cord pairs *SNOR* terminate on one side on the upper and on the other side on the lower switching group. Both sides of the cord pairs are designed for two-way traffic. The position equipments *OPR* terminate on the lower group; this switching path is intended chiefly for order wire calls.

All trunk circuits, one-way and two-way, are connected via junction equipments *FDR-TV* to the trunk exchange multiple. The junction equipments for automatic traffic, *FDR-TV-Y*, are connected via register finders *RS* to registers

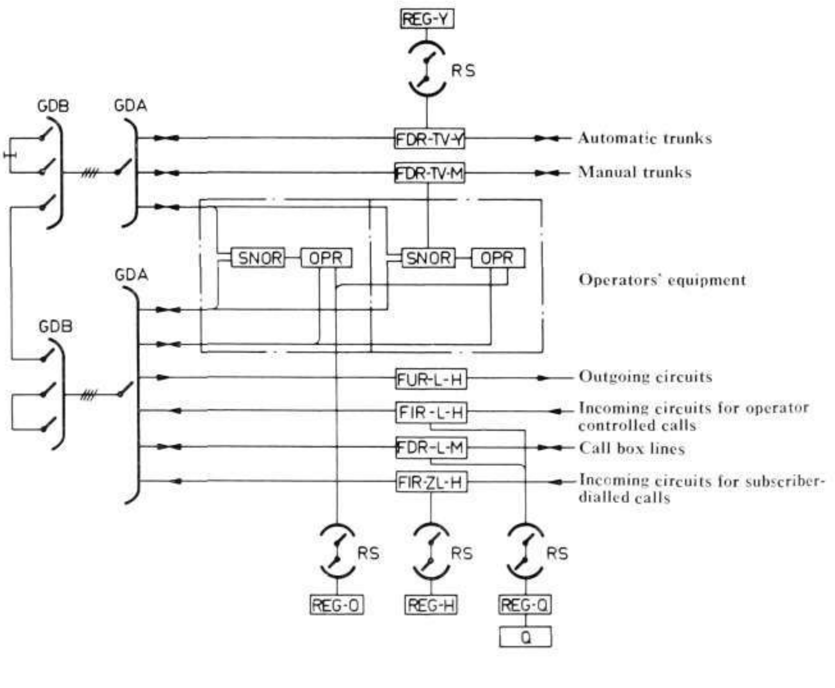


Fig. 7
Automatic trunk exchange
System ARM 201
Trunking diagram

REG-Y. On transit calls *REG-Y* controls the setting-up of the transit stage, and on incoming calls *REG-Y* also controls the operation of the switching stages in the local exchanges within the area. The junction equipments for manual trunks, *FDR-TV-M*, connect to cord pairs *SNOR* at positions for delay and transit traffic. This switching path permits tying of circuits to particular operators during peak traffic periods.

Local junction circuits for subscriber-dialled long distance calls are connected via the junction relay set *FIR-Z-H* to the transit exchange multiple. Via a register finder *RS*, *FIR-Z-H* has access to a register *REG-H*, the function of which is to receive the numerical information from the local exchanges, control the setting-up of the trunk stage and send the necessary information via the long distance network to all subsequent trunk exchanges on the route.

The record circuits from the local exchanges terminate on junction relay sets *FIR-L-H*. Via register finders *RS* the latter have access to registers *REG-Q*, which control the setting-up of the transit stage to a free cord pair *SNOR* at demand or delay positions. *REG-Q* is equipped with a queuing device which successively puts through waiting calls as operators in the desired group become free.

The junction lines *FUR-L-H* are used for all traffic to the local exchanges, i.e. subscriber-dialled, operator-controlled, operator traffic within the home trunk exchange for verification of the calling subscriber, call-back on delay calls, and incoming manual trunk calls.

Call box lines are connected to the transit centre via *FDR-L-M*. These are two-way circuits and can carry outgoing semiautomatic calls and all kinds of incoming traffic.

The trunk enquiry circuit terminates directly on the cordless enquiry positions.

The operators' equipments *OPR* connect to registers *REG-O* via register finders *RS*. The registers receive keyset pulses from the position equipment, control the setting-up of the trunk stage and send the necessary trunk information (cf. *REG-H*).

Outgoing subscriber-dialled calls pass through *FIR-Z-H*, *GD* in the lower and upper switching group and *FDR-TV-Y* to the long distance network. *REG-H* controls the entire long distance connection. Incoming automatic terminal traffic passes via *FDR-TV-Y*, *GD* in upper and lower switching group, and *FUR-L-H* to the local exchange. *REG-Y* controls the setting-up of the trunk and local switching equipment.

Transit calls between automatic trunks are passed via the upper switching group *GD*, which has special transit links with pads. The register which is connected to the incoming *FDR-TV-Y* controls only the setting-up of the trunk stage. All register information to subsequent trunk exchanges is passed through without repetition.

Transit calls from automatic to tied manual trunks are handled by an operator. A call on a tied route is signalled at the position to which the circuit is tied. If one of the desired circuits is free, the operator can operate a key to establish connection via *FDR-TV-Y*, *GV* in the upper switching group, and transit link to *FDR-TV-M*. Transit calls to manual circuits which are not tied to a particular operator can be switched automatically in the same way as between automatic trunks.

All incoming traffic from manual circuits is handled by an operator. A call from a tied circuit is signalled on the cord pair on which the circuit terminates, and connection is established without passing through the switching stages. The operator extends the call from the same cord pair via *GD* in the upper switching group to *FDR-TV*, if a transit connection, and via *GD* in the upper and lower groups to *FUR-L-H* if a terminal connection. Calls from manual circuits which are not tied to a particular operator are signalled at all free transit positions. When an operator answers the call with the key of a free cord pair, connection is established via *FDR-TV-M*, *GD* in the upper and lower switching groups to the cord pair *SNOR*. The subsequent procedure is as for tied circuits. The operator's register *REG-O* can control the connection on the long distance circuits and the setting-up of the local switching equipment.

Outgoing calls to the trunk operator are directed via *FIR-L-H*, *GD* in the upper and lower switching groups to a cord pair *SNOR* at a free position within the wanted group. The operator extends the call to the long distance network from the other side of the same *SNOR* via *GD* in the lower and upper switching groups to *FDR-TV*. The register *REG-Q* controls the setting-up of the call to the operator's position, and register *REG-O* the switching through the trunk stage and on through the remainder of the long distance circuit. Call-back to the local subscriber for verification or on a delay call is done from the same side of the cord pair as the call comes in and is extended via *GD* in the upper and lower switching groups to *FUR-L-H*.

Trunk Exchanges AFA 10

The *AFA 10* exchanges have registers *REG-Y(O)* which can receive the numerical information sent on the long distance network from other trunk exchanges and control the local exchange switching equipments. Incoming calls are extended automatically to the local subscriber without operator assistance. *REG-Y(O)* is also used for the semiautomatic outgoing trunk traffic and is therefore equipped to receive keyset pulsing from the operator's position and to control the setting-up of the trunk connections.

Register signalling and line signalling are exactly the same as for the automatic trunk exchanges and are shown in the signalling scheme in fig. 5.

Trunk exchanges *AFA 10* are not equipped with selector stages, any transit traffic that occurs being extended manually.

Subscriber-dialled traffic can be introduced under the same conditions as for the *ARM 20* exchanges with or without the addition of special switching equipment.

The operators' positions are equipped with ordinary cord pairs. Trunks, record and junction circuits to the local exchange, and internal order wires, terminate on the multiple of the manual board. Automatic trunks are also connected to incoming junctions in the local exchanges. The operators' positions have roughly the same facilities as the cordless boards at the automatic exchanges.

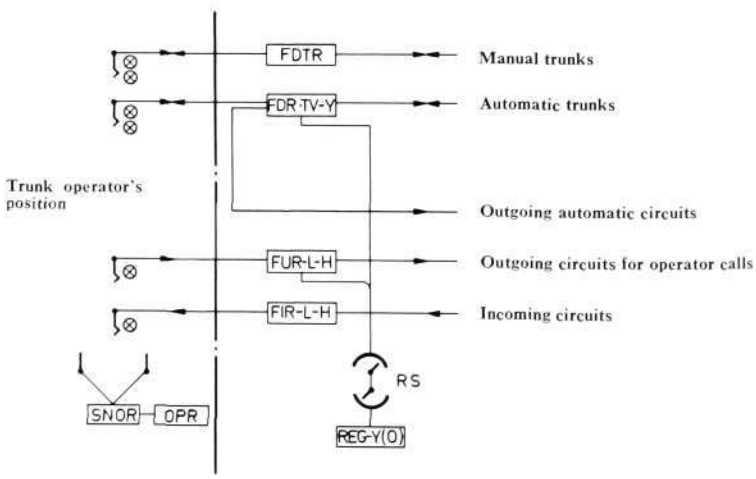


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Fig. 8
Trunk exchange
System AFA 10
Trunking diagram

The trunking diagram for an *AFA 10* transit exchange is shown in fig. 8.

All traffic to the manual trunks *FDTR* is extended entirely on a manual basis.

The junction equipments *FDR-TV-Y* are two-way and are connected to the manual switchboard multiple, to incoming junctions in the local exchange and, via register finders *RS*, to registers *REG-Y(O)*. Incoming calls are routed automatically to the local exchange or to an operator according to the received area code. Outgoing trunk calls are also passed through *FDR-TV-Y* and are controlled by the register *REG-Y(O)*.

The record circuits from the local exchange are connected to the multiple of the manual positions via junction relay sets *FIR-L-H*. Verification of the calling subscriber's number, if required, is done by calling back via the junction lines *FUR-L-H*. These lines are also used for the terminating traffic from the manual trunk network.

Resumé

The automatization of the long distance network has brought a marked improvement in the handling of the traffic. After the change from manual to semiautomatic working the same number of trunks has carried a very much larger quantity of traffic. Automatization and the large increase in number of trunk circuits have resulted in an improved service for the public through quicker setting up of connections and better quality of transmission, and for the telephone administration a continuously growing traffic intensity with the attendant increase of revenue.

This first stage in the extension of the automatic trunk network has meant that Colombia now has a very advanced national trunk service and has created a sound basis for continued expansion to full automatization of the trunk network.

A new contract was signed with Empresa Nacional de Telecomunicaciones during 1963. It covers a new automatic trunk exchange at Cartagena and extension of the already installed trunk exchanges at Bogotá, Medellín, Bucaramanga, Tunja and Pereira by altogether 1,100 lines. These extensions permit an appreciable increase in the subscriber-dialled long distance traffic.

The Telephone User and the Switching Machine

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In a previous paper[1] presented at the "First Symposium on Human Factors in Telephony" at Cambridge in 1961, the author gave some aspects on a worldwide switching machine, mainly with respect to supervision and maintenance problems. In this paper similar problems are considered from the telephone users' point of view, with special attention to the performance during conversation. Possibilities of obtaining better matching between man and machine are discussed, which may be of importance in a future worldwide automatic telecommunication network.*

The Reactions of the Telephone Users

As the aim of supervision and maintenance efforts is to give the telephone users a satisfactory service at a reasonable cost, we have to look at the problems from the users' point of view. We then find:

- As long as nothing better is available, the telephone users are satisfied with the service given.
- The better service we can offer, the more the telephone facilities will be utilized.
- Competition and the increased demands for long distance switching will bring about the development of improved new systems and equipments, but already installed equipments of old design will still be in operation.
- The users can then compare the functioning of different types of equipment, and the result will be increasing demands for a better grade of service.

The consequence of this is that supervision and maintenance people have to increase their efforts in order to meet the increased demands. As 100 per cent reliability would be much too expensive, a certain fault rate must be tolerated. From the users' point of view, the unavoidable faults will appear more or less serious, and with respect to their inconvenience to users we can divide them into two main groups:

- Faults during switching, such as
  - no connexion
  - connexions to wrong numbers
- Faults during conversation, such as
  - poor transmission caused by too low speech level or too high noise level, distortion, inconvenient echo, short breaks etc., jeopardizing intelligibility or confusing the talker
  - double connexions or intelligible crosstalk, jeopardizing secrecy of conversation
  - breakdown of connexions

Faults of the first group seldom cause complaints if they are relatively few and are not repeated too often, as a calling subscriber can never be sure of not having made a mistake himself. He is satisfied if the next trial is successful.

* Revised version of papers prepared for the L M Ericsson Maintenance Conference in Stockholm, June 1962, and Second Symposium on Human Factors in Telephony at Copenhagen, September 1963.

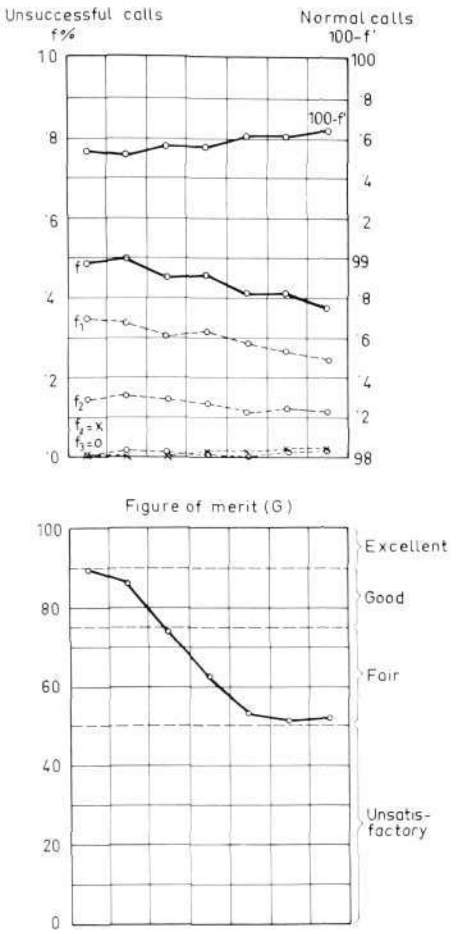


Fig. 1 X 2761

Evaluation of service reliability in automatic telephone traffic

$f' = f_1 + f_2 + f_3 + f_4$

f_1 Incomplete connection

f_2 Connection to wrong number

f_3 Speech transmission not possible

f_4 Speech cut-in on foreign connection

$G = 100 \times 1.2^{-f}$

$f = f_1 + 2f_2 + 20f_3 + 200f_4$

↑ ↑ ↑ Proposed weighing factors

(Taken from a paper written by B. Ahlstedt)

The faults are mainly of the type "no go" and are not too difficult to trace by modern supervision and maintenance methods.

Faults of the second group are much more serious and will always annoy the users as they are considered as equipment failures. They are often difficult to trace, as they may be caused by a totality of minor irregularities in a number of parts of the equipment.

It is obvious that a plain summation of all types of faults will never give a true picture of the grade of service seen from the users' point of view. A small number of irregularities during conversation is much more annoying than a larger number during switching. AHLSTEDT[2] has therefore proposed the introduction of a fault scale, whereby the irregularities are weighted with respect to the inconvenience to users. For a telephone exchange or a group of exchanges, a figure of merit can be calculated and better related to the users' opinion than a fault figure based on plain summation.

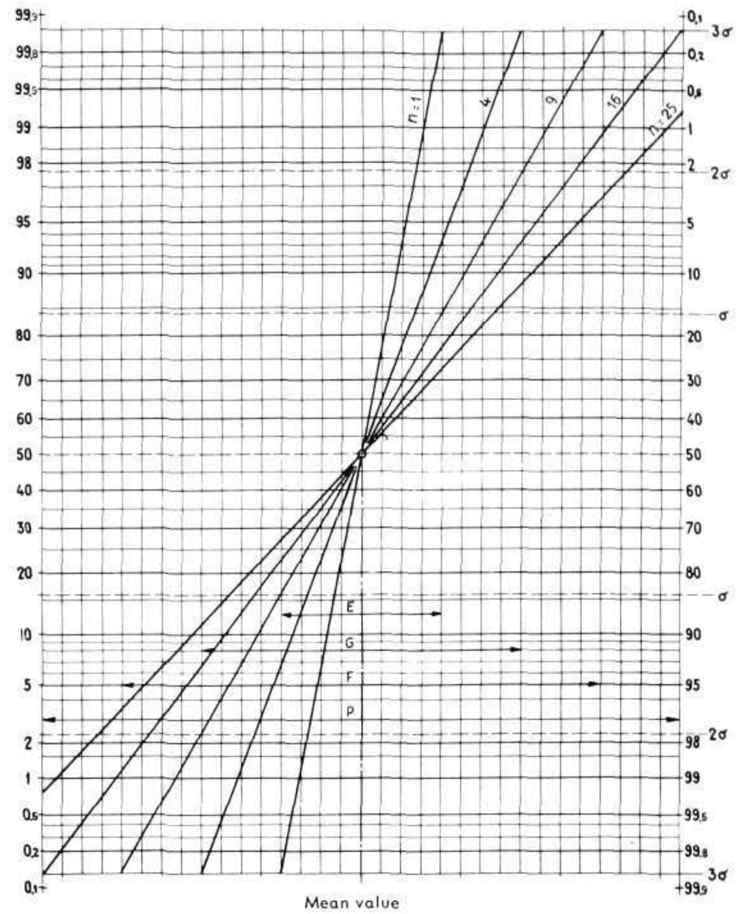
Ahlstedt's ideas may be illustrated by two diagrams from his paper–fig. 1. In the upper one we have a plain summation of four fault classes, and the grade of service seems to be increasing with time. In the diagram below the fault classes have been weighted and the figure merit is deteriorating, which means that the maintenance efforts have not been directed to the most essential points.

The Importance of Deviations from Nominal Values

The quality of a call depends on the performance and reliability of all equipment parts such as subscriber sets and lines together with interconnected switching and transmission links chosen at random. By means of measurements the supervision people can determine the fault rate or performance of certain combinations of equipment such as a telephone exchange as a whole or the exchanges in a certain area together with interlinked trunks, or of a group of carrier circuits with or without the trunk exchanges at both ends. For the maintenance parties concerned, such statistics–showing the result of the maintenance efforts or the points at which they should be put in–are of great value. But we must remember that performance figures for certain parts of the equipment can never give the whole truth about the quality of calls passing through several groups of equipment maintained by different parties, as the risk of unsuccessful calls or of calls of too poor quality will increase with the amount of equipment used. This may be illustrated by two examples:

- ☐ Faults of the type "no" instead of "yes"–such as contact faults–where the total number of contact operations in switching a call will influence the risk of an unsuccessful call. If, for a local call, we only have 1,000 contact operations, a fault rate of 10^{-7} will give a negligible fault risk, but if on a complicated long distance call we need 100,000 contact operations, the risk will increase to one per cent, which is far from negligible.

- ☐ Faults due to gradual degradation causing too great deviations from mean properties, such as variations in line leakage, relay times, transmission loss, noise level, carrier frequency etc. The distribution of such deviations can be illustrated statistically by probability diagrams, which show the risk of deviations above given levels. When a number of parts are used together, we can calculate–according to statistical laws–the standard deviation for the whole by taking the square root of the square sum of the individual standard deviations. To simplify matters we can assume that all parts have the same deviation distribution, which means that we get the total standard deviation by multiplying the individual standard deviation by the square root of the number of parts. If we further assume that the distribution can be represented by straight lines, we get a diagram as in fig. 2. We again realize that the risk of faults–in this case caused by too great deviations–will increase with the number of interconnected parts on a call.



X 8462

Fig. 2

Summation of deviations

"Opinion regions"
E = Excellent
G = Good
F = Fair
P = Poor

From the point of view of the telephone public too great deviations mean inconvenience and, in respect of public opinion, we can classify the calls as

- Excellent (E)
- Good (G)
- Fair (F)
- Poor (P)
- Bad (B)

Every class can be given a maximum deviation value which can be illustrated by vertical "opinion regions"–E, G, F, P and B–in our diagram. The more equipment is involved in a call, the bigger the risk that the quality of the call will fall in a lower class and the bigger the risk of unsatisfactory connexions.

From the diagram we can draw some general conclusions:

- When many parts are engaged on a call, unlucky combinations even of small individual deviations can cause trouble, which cannot be traced without overall testing of individual calls. There is always the risk that serious faults in some parts, causing complaints, will be explained as unlucky combinations and therefore not be traced by the maintenance people.
- The greater the distance between the subscribers, the more equipment will be engaged on a call and the bigger the risk of degraded quality.
- These calls will be the most expensive ones, and we can predict that the public demands for performance especially during conversation will increase, as poor intelligibility will prolong the conversation time and increase the cost to the calling subscriber. In reality this means that the additional equipment needed for long distance calls should be free from faults and

deviations–which, however, is impossible–or that we have to increase the performance of local switching equipment which is engaged also on long distance calls, in order to meet future subscriber demands.

Speech Level and Noise

As an example we can study the influence of speech and noise levels on the quality of a call. On the basis of investigations carried out by many administrations, CCITT has made recommendations for the total reference equivalent and its distribution over the different parts of a telephone network in order to ensure a sufficient speech level for the listener.

We have also to consider, however, that noise can jeopardize intelligibility even if the speech level in itself is sufficient. For cheap local calls this may be of less importance, but becomes more so on expensive long distance calls. Room noise the subscribers themselves can get rid of, but the reduction of circuit noise–such as noise from relay contacts or switches, intelligible or unintelligible crosstalk, intermodulation or singing in carrier circuits, echo in 2- to 4-wire switching points–must be the task of the administrations.

For maintenance and supervision people it is essential to have an idea how a combination of speech and noise levels will influence the transmission. For that purpose we can use the isopreference contours–presented by KARLIN[3] fig. 3. On the coordinate axes the relative levels of speech and noise are expressed in decibels. In the coordinate plane are drawn a number of "isopreference contours" based on opinion tests. Every contour represents a combination of speech and noise levels for which the listeners have the same preference. The figures beside the contours express relative "preference levels" in db. It is said that a relative level of about 75 db corresponds to good performance, but 50 db will be too poor. As the opinion test was carried out with a restricted number of persons under specific conditions, one has to be careful in drawing conclusions, but in spite of that we may say that:

- ☐ A high preference level corresponds to better performance.
- ☐ All isopreference contours have maximum points, indicating maximum permissible noise level for a certain performance.
- ☐ A line through the maximum points, starting at 82 db speech level, splits the plane into two regions:

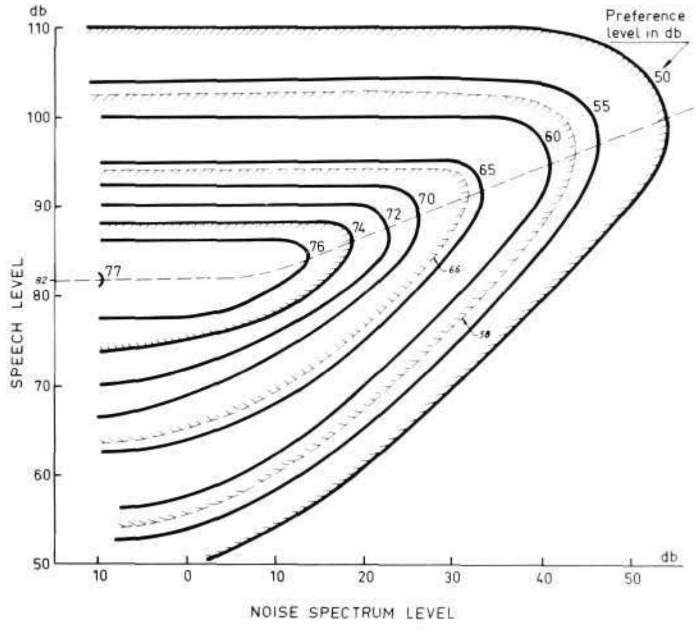


Fig. 3 X 8460

Isopreference diagram

for a 3000 c/s low pass circuit

The diagram is split in the following opinion regions:

Excellent	> 74 db
Good	74-66 db
Fair	66-58 db
Poor	58-50 db
Unsatisfactory	< 50 db

(Taken from a paper written by Munson & Karlin)

- In the upper region the performance deteriorates with increasing speech level because too high levels are painful to the listener. The horizontal shape of the contours indicates independence of noise level.

- In the lower region the opposite applies. Here performance deteriorates with decreasing speech level or increasing noise level, giving decreasing intelligibility.

- On every isopreference contour we have two points–one per region–giving the same preference, and the difference between the points shows the permissible speech level variations for a certain performance with decrease for increasing noise and increase when quality demands are reduced.

It should be noted, however, that prerecorded speech was used during the isopreference investigations, and the contours may give a wrong picture of the situation when we have natural speech between two subscribers. We can, however, compare the isopreference results with the opinion tests carried out on behalf of CCITT. MARKMAN[4], who took part in these investigations, has recalculated the CCITT results in order to get what we may call "isoopinion contours"–fig. 4–as described in the first part of Appendix 1. The contours are numbered with respect to the mean opinion score *Y*, and a table beside the diagram shows the risk of poor and bad calls for different *Y*-values, seen from the users' point of view.

As "electrical" scale parameters are used, the system reference equivalent SyRE is expressed in db and the noise level in dbmp. For purposes of comparison we have to change the "acoustical" scales re 2×10^{-4} dyne/cm^2 in fig. 3 into "electrical" scales.

- □ According to definition, an "acoustical" speech level of 65 db corresponds to SyRE of 34 db "at prescribed outgoing speech volume".
- □ Measurements at L M Ericsson show that acoustical noise level of 10 db corresponds to − 66 dbmp.

Observing that decreasing SyRE corresponds to increasing speech volume, we can introduce the acoustical scales beside the electrical ones in fig. 4 and show the isopreference contours from fig. 3 in the same diagram.

The CCITT investigations only cover the region below the splitting line, starting at 82 db in the acoustical scale corresponding to a SyRE of 17 db. The

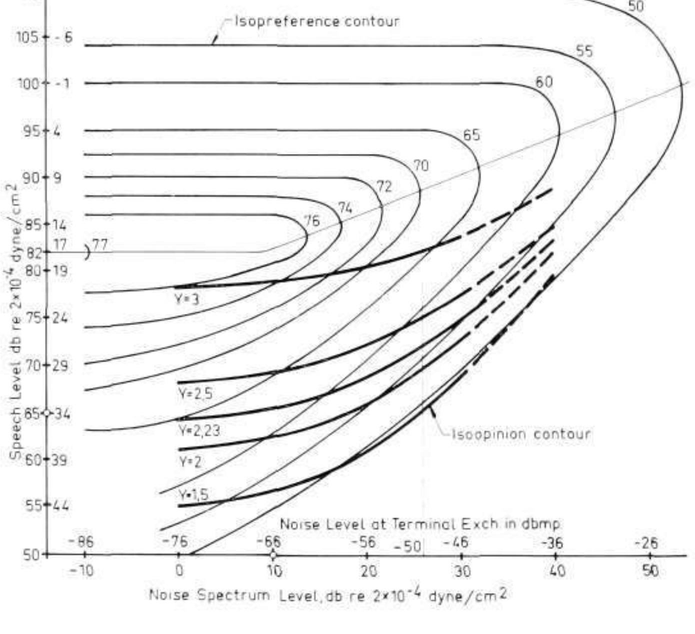


Fig. 4 X 8461

Isoopinion contours

calculated by F. Markman using CCITT opinion investigations

Y = Mean opinion score

Y	(Poor + Bad) %
3.00	0.75
2.50	7.2
2.23	15.7
2.00	25.8
1.50	52.7

trend of the isopreference and isoopinion contours is the same, but the slope of the latter is less for low noise levels. The explanation is that the talker during natural conversation adjusts his voice according to what he hears from the far end, as has been confirmed by investigations at L M Ericsson. From BOERYDS[5] investigations we have taken the diagram in fig. 5, showing the relation between SyRE and outgoing speech volume VU, when 50 db room noise but no circuit noise is present. It is interesting to note that VU has a minimum about 17 db, which is the starting point for the splitting line in fig. 4. We may therefore assume that the splitting line represents the most convenient system reference equivalents from the users' point of view. If the SyRE is too low, the users probably try to outtalk each other and raise their voices. If SyRE is higher than 17 db, the talker also raises his voice, thereby partly compensating for the SyRE increase. At a SyRE of 34 db we thus have a compensation of 4 db or about 25 % of the increase. We have here an example of a lucky interaction between man and machine. But it must be noted that the speaker does not react to his own speech but to what he hears from the far end. It is obvious that the desired adjustment of the voices will be jeopardized if the transmission conditions differ too much in the two directions, and this must be kept in mind when we later discuss long distance calls via a number of 4-wire links with repeaters.

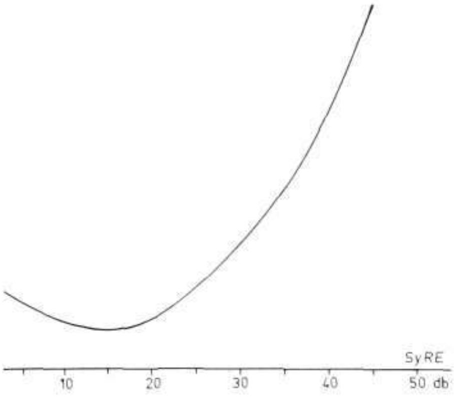


Fig. 5 X 2762

Speech volume (mean values) measured in the sending local exchange as a function of the over all reference equivalents

Participating persons: 240
(Diagram taken from a paper by A. Boeryd – fig. 1, curve 3)

From fig. 4 we may draw some conclusions from the isoopinion contours in the lower region and the isopreference contours in the upper:

- If we assume that isoopinion contour $Y = 2.23$–about 15 % risk of poor or bad calls–is the lower limit for satisfactory service, we may have SyRE = 35 db when no noise is present. On intercontinental calls CCITT permits a noise level of – 50 dbmp all the time, and we find that SyRE has to be reduced to 27 db if the same mean opinion score is to be maintained. It is obvious that supervision and maintenance people have to reduce the noise as far as possible and hunt for all noise sources, or we have to reduce the permissible SyRE, which has to be done in the 2-wire networks in order to ensure satisfactory transmission on long distance calls. A reduction of SyRE means increased investment costs in the local networks, and we have here a possibility of evaluating the inconvenience of circuit noise in terms of money.

- The isopreference contours in the upper region show that too high a level or too low a SyRE is also inconvenient to the listener. He can, however, protect himself by moving the telephone away from his ear, which one must do on a large number of calls between subscribers with short lines connected to the same exchange. If the user moves the receiver away from his ear, he moves the microphone away from his mouth and may develop unsound habits when he has to talk on long distance calls with poor transmission conditions. In fig. 3 we have approximately split the diagram into opinion regions, and if we assume that preference levels below 58 db should be considered as poor, we find that SyRE should never be better than – 4 db. Nowadays we have the technical means of attaining this, if we install modern telephone instruments with line equalizers at the subscribers' premises. It is, of course, not economical to replace all old instruments without line regulation, but a lot could be gained if this were done when subscribers complain about poor performance on long distance calls and if we teach them how to use the new instrument in the proper way and how to talk.

With respect to long propagation times and interlinked echo suppressors we have to inform our users–not being telephone experts–that they cannot intervene in each other's speech in the usual way on calls over very long distances but have to give the other party an opportunity to answer in order to avoid confusion, maybe resulting in "hallo"-calls and prolonged conversation time.

Loss Variations on Long Distance Calls

On a long distance call we have at both ends the telephone instruments connected to their 2-wire networks terminating in hybrids and between them a number of 4-wire links with repeaters. On successive calls between any two subscribers there will be rather small loss variations in the 2-wire sections, and the transmission conditions will be about the same in both directions if the transmitters and receivers of the instruments are properly maintained. Anyhow, in this part of the transmission path the variations from call to call will be negligible. In the 4-wire section we have another situation, as the transmission links are chosen at random. With alternative routing we do not know which switching points the call passes, and the number of tandem-switched links is unknown.

The links are chosen from batches for which nominal values of loss and noise can be stipulated. The individual links can, however, not be maintained exactly, but a certain deviation from the nominal batch value has to be permitted, which means loss and noise variation in the 4-wire network on different calls switched between the same distant subscribers. If we assume that all transmission links can be maintained at a standard loss variation of ± 1 db, we will have 2×1 per cent risk of a loss deviation of ± 2.33 db on one link and $\pm 2.33\sqrt{n}$ db on n tandem-switched links. For intercontinental calls, which are very expensive to the users, we may in rare cases have up to twelve 4-wire links. Using only 9 links, we shall have a total deviation of ± 7 db. In one per cent of the calls the difference between best and worst calls may be as high as 14 db, which is definitely noticeable to subscribers. If we furthermore consider that, for an intercontinental call, we have to permit a noise level of -50 dbmp, following isoopinion contour $Y = 2.23$ we find from the diagram in fig. 4 that we nominally have SyRE = 27 db, but for the best call 20 db, corresponding to a Y-value of about 2.9, and for the worst 34 db, corresponding to $Y = 1.5$. All the best calls will be considered as at least fair, but 52 % of the worst as poor or bad. Worst of all, the subscribers will note that good quality calls are possible and will therefore complain about calls with unlucky combinations of deviations.

But we must also consider that we may have different deviations in the two directions–maybe negative in one and positive in the other. The result will be that the talker with the best listening conditions has no reason to raise his voice, the more so as the other is probably shouting. This, too, will cause complaints–the reason for which is difficult to trace.

Then there is the fact that we cannot, with respect to stability and echo, switch the 4-wire paths without nominal loss. This is illustrated in fig. 6, where we have used the Bell System rules–see "Notes on Distance Dialing", section VI, according to which the nominal loss in a transmission path with n links ought to be

$$AN_0 = 2S + bn + \sum_{1}^{n} T_n \text{ db}$$

where

n is the number of tandem-switched links
S the hybrid loss
T_n a factor proportional to the propagation time of the links
b a constant

For an *actual* call we also have to take the loss deviations from the nominal values into account and introduce therefore a deviation term and get the expression

$$AN = 2S + bn \pm 2.33\,\sigma\sqrt{n} + \sum_{1}^{n} T_n \text{ db}$$

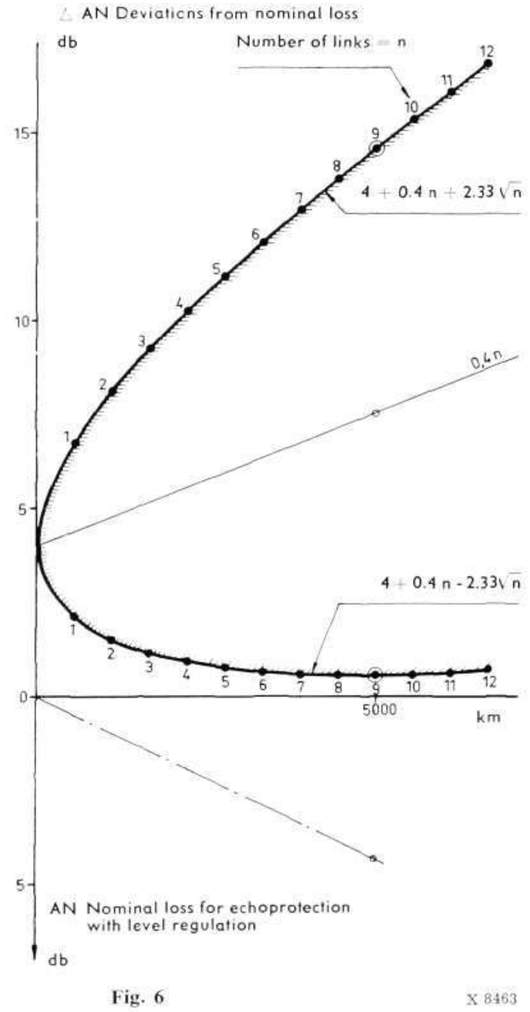


Fig. 6 X 8463

Loss variations with 1 % risk

on n tandem-switched 4-wire links each with $\pm$ 1 db standard deviation if AN with 98 % probability is to be within the deviation range $2 \times 2.33\, \sigma\, \sqrt{n}$. For the diagram in fig. 5 we have used the figures $S = 2$, $b = 0.4$ and $\sigma = 1$, giving the expression

$$AN = 4 + 0.4n \pm 2.33\sqrt{n} + \sum_{1}^{n} T_n \text{ db}$$

The last term is unknown, being dependent on the total propagation time, and therefore plotted below the zero line. The other terms are dependent solely on the number of links and are plotted above the zero line. It will be seen that the loss of $4 + 0.4\, n$ db has been inserted in order to compensate for negative loss deviations. If these loss deviations could be removed by technical means, we could maintain stability without introduction of extra loss, and all losses above the zero line could disappear. The losses below the zero line can be considered as nominal, giving echo protection when no echo suppressors are used. If the loss deviations are removed or essentially reduced, we should get:

- ☐ a reduction of nominal loss on LD calls, which means an increase in mean opinion score according to the diagram in fig. 4 and consequently in performance,
- ☐ a reduction of circuit noise influence, as the isoopinion contours for high mean opinion scores are flatter than for the lower ones, which means less dependence of circuit noise,
- ☐ the loss difference between expensive LD calls and cheap local calls will be reduced, and thereby the risk of users' complaints,
- ☐ certain users' complaints can no longer be explained unlucky combinations of deviations–so depriving the maintenance of an excuse for doing nothing.

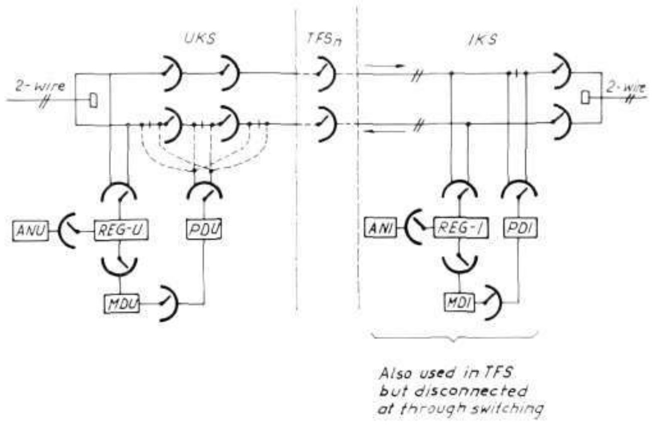
The influence of loss deviations on the overall performance is discussed more in detail in the second part of Appendix 1.

There is, however, also another reason for reducing the number of calls with unsatisfactory transmission condition. In a future worldwide switching scheme we shall mostly have no operators to build up a call and thereby lose the possibility of operator-control of the transmission quality. The users have to judge themselves. But worldwide calls will have many digits and comparatively long switching times, and the risk of congestion is not negligible. The caller will seldom reject a call when he has got through but will complain after completion of the call if too poor transmission has prolonged the conversation time.

Elimination of Loss Variations on LD Calls

As the variations in the 2-wire network on successive calls between two subscribers are relatively small, we can confine our attention to the 4-wire part of the transmission path. The idea is illustrated in fig. 7. Two 2-wire networks are connected via hybrids to a chain of 4-wire links chosen at random in a number of 4-wire switching points. The links between two switching points are statistically controlled by automatic transmission testers in order to keep them within prescribed nominal values and standard deviations. The building up of a call can be compared to the industrial assembly of parts and components. There is, however, at present an essential difference. In industry we have a final test including rejection or adjustment of the assembled product before delivery, but in telephony we deliver all calls to the users without any final test.

It has therefore been proposed and CCITT is studying the problem of introducing a transmission test with adjustment of the total loss on all expensive



X 8464

Fig. 7

Level control

on tandem-switched 4-wire circuits

UKS	Outgoing control point
TFS	Transit switching point
IKS	Incoming control point
REG	Register
AN	Analyser
MD	Level measuring device
PD	Level regulation device

calls to a prescribed nominal value before conversation starts, when the risk of unacceptable loss variations is too great. One may assume that the transmission stability of the circuits involved is such that changes during actual conversation can be neglected and one can then confine the test to a short transmission check during a suitable phase of switching of the call. The prolongation in switching time must be small.

Such a method with end-to-end control of complex 4-wire circuits using only one measuring and one level regulator per transmission direction is roughly outlined in Appendix 2. This is on the presumption that we have a uniform signalling system in the 4-wire routes with successive through switching in intermediate switching points, as they are passed by a call in progress.

For international calls the method is not feasible as the through switching in the switching points giving access to the international network does not at present take place–because of signal translation–until the called party answers. We have thus no time for an end-to-end control. Another difficulty is that we must have uniform measuring methods throughout the world.

Both complications are removed if we split the complex 4-wire circuit for international calls into three sections, the originating and terminating national networks with interlinked international network. As we ought to have uniform signalling within the sections, we can have successive through switching in all intermediate switching points and use end-to-end control in sections where it is justified. In sections where it is possible to supervise and maintain a sufficiently low standard loss deviation–of the order of 0.5 db or less–level adjustment can be omitted, as the level variations on such sections will be comparatively small.

On an international call we shall thus have a maximum of 4 control points and three measurements with level regulators per transmission direction, and the complex circuit will be reduced to three tandem-switched multilinks. For each the level adjustment can be quite precise–standard loss deviation less than 0.5 db–giving a negligible adjustment variation. The nominal loss of every section, however, should be stipulated such that sufficient stability and echo protection is maintained in a combined complex circuit.

From the loss deviation curve in figure 6 it may be seen that the deviation influence per link decreases with the number of links. If some links are left uncontrolled between the national control switching points and the hybrids, our aim of reducing the nominal 4-wire loss and its variations will be jeopardized. All the more as the additional uncontrolled links come from a large number of small routes, which are more difficult to maintain than the big main routes with the risk that standard loss deviations will not be kept sufficiently small. In introducing level adjustment on expensive LD calls in a national network, therefore, one should choose the switching points with the hybrids to the 2-wire network as control points if economically justifiable.

From the supervision and maintenance points of view essential advantages are also gained:

- ☐ As the same 4-wire links are used for cheap as well as for expensive LD calls, the individual control of the latter also gives a statistical account of the quality of uncontrolled calls, and we can avoid loading the expensive LD network with special test calls.

- ☐ The control equipment is an objective judge of the transmission quality, and too poor transmission combinations can be locked for further investigations by the parties concerned. A lot of fruitless discussions between people in different maintenance areas will then disappear.

Inconvenience to the Telephone Users Caused by Irregularities

In the foregoing we have constantly referred to the "inconvenience to telephone users" caused by different kinds of irregularities. Attempts have been made to evaluate the inconvenience in terms of users' lost time or money, and the following authors should be mentioned:

- ☐ Rapp[6] considers the inconvenience of congestion and high reference equivalents, causing lost calls or poor intelligibility and prolonged conversation times. He suggests a method of weighting the inconvenience cost to the user against plant cost in order to arrive at a minimum.

- ☐ In a similar way Christiansen and Lind[7] try to weight the inconvenience cost of technical faults against maintenance costs in order to find the most efficient maintenance methods.

Summary

- ☐ With time we have to foresee increasing performance demands from telephone users.

- ☐ All irregularities do not appear equally serious to users, and the introduction of a weighted fault scale would give supervision and maintenance people a proper picture of the inconvenience caused to users, so giving them means to direct their efforts to the most urgent points.

- ☐ The irregularities during conversation are the most serious ones, especially on expensive LD calls. On international calls we very often have language difficulties, as one or both users may not be using their own language. We can thus not count on the helpful redundance in human speech and should increase the intelligibility on international calls.

- ☐ We have therefore to reduce loss and noise as far as possible in order to give LD calls as near as possible the same quality as local calls in spite of the considerable extra equipment involved.

- ☐ It is essential to have about the same transmission conditions in both directions, so that the talkers can use their natural ability to regulate their voices in the proper way according to what they hear from the far end. This means better transmission conditions and a better interaction between man and machine.

- ☐ One way of reducing overall loss and avoiding loss variations caused by unavoidable loss deviations in tandem-switched 4-wire circuits is the introduction of a transmission check–before conversation starts–between an outgoing and incoming control switching point located as close to the hybrids as possible. The control of international calls may be split in national and international sections.

- ☐ With level regulation in the checking points the loss variations due to loss deviation combinations can be compensated for and only a loss for echo protection should remain.

- ☐ The echo protection loss in the 4-wire path can be reduced by normalizing the characteristics of the 2-wire circuits and telephone instruments to give a better matching with the 4-wire circuits.

- ☐ A transmission check on a worldwide basis, using only a relatively small number of actual LD calls as test calls, would give supervision and maintenance people in different areas and administrations a valuable help in tracing difficult transmission faults, as 4-wire connexions with too poor properties can, when desired, be automatically locked for investigation by the people concerned.

- ☐ As the control problems are worldwide, there will undoubtedly be a number of intricate problems to study and solve, which will take time. It would be advisable, however, to prepare new 4-wire switching points, so that control equipment can be introduced later on at a reasonable cost.

- ☐ The attempts to calculate and minimize the inconvenience to users from irregularities such as technical faults, congestion and too poor intelligibility are interesting, as planning, supervision and maintenance people will get a better picture of how to extend and maintain a plant economically having regard to the telephone users' demands.

- ☐ We have to teach the non-technical users to apply a certain conversation technique on very long distance calls with long propagation times and with interlinked echo suppressors, in order to prevent confusion and "hallo"-calls with the resulting prolongation of conversation time.

APPENDIX 1

Isoopinion Contours and Mean Opinion Score Deviations

In the calculation of the isoopinion contours MARKMAN[4] has used equation

$$Y = 3.35 + \beta(X + 2.5)^2 \tag{5}$$

where Y is the mean opinion score
X is the junction loss between terminal exchanges
β is a negative noise factor depending on circuit noise level as given in Markman's table 4.

In the CCITT investigations a loss of 6 db for subscribers' sets and lines was added to the junction loss. Hence we can put X = SyRE - 6 db and transform equation (5) into

$$\text{SyRE} = \sqrt{\frac{3.35 - Y}{-\beta}} + 3.5 \text{ db}$$

We get the isoopinion contours by keeping Y constant and inserting the β-values corresponding to different noise levels as given in Markman's table 4.

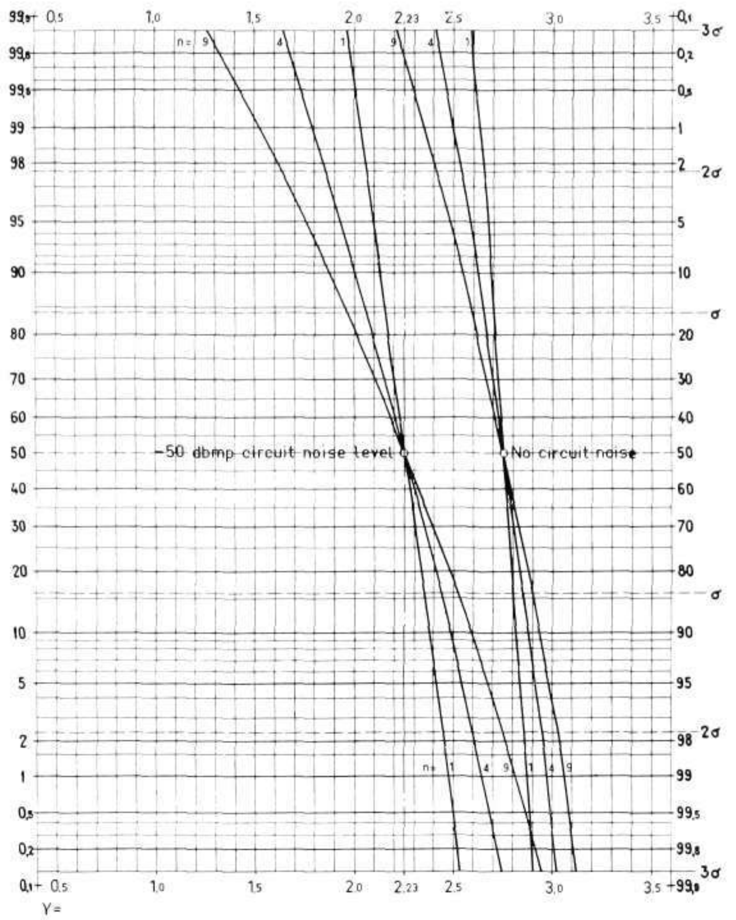


Fig. 8 X 8465

Mean opinion score distribution for *n* tandem-switched 4-wire links

Nominal SyRE = 27 db

From these curves we get only a rough picture of the trend in the mean opinion scores under various circuit conditions. We are, however, also interested in a more detailed study of the variations in mean opinion score, when we have loss variations on successive calls between two subscribers, as they will compare the worst calls with the best ones. Too big variations in mean opinion score will increase the risk of subscribers' complaints.

If we assume that the loss deviations in the 2-wire networks can be neglected on successive LD calls, we have only to consider the loss deviations in the complex 4-wire circuit. If in this circuit we have n links, each with a standard loss deviation of σ_x db with normal distribution, the loss distribution can be represented in a probability diagram by straight lines

$$X = X_0 - \lambda \cdot \sigma_x \cdot \sqrt{n}$$

where X is the nominal loss value and

λ is a linear vertical scale factor with $\lambda = \pm 1, \pm 2$ etc. for the probability levels corresponding to $\pm \sigma, \pm 2\sigma$ etc.

Hence we get

$$Y = 3.35 + \beta(X_0 + 2.5 + \lambda \cdot \sigma_x \cdot \sqrt{n})^2 \qquad (5\text{ a})$$

The diagrams in fig. 8 show the distribution curves for Y for a nominal SyRE of 27 db, i.e. X = SyRE - 6 = 21 db for 1, 4 and 9 links with a standard loss deviation of 1 db. Two curve groups are given–one for the noise level – 50 dbmp at the terminal exchange and the other when no noise is present. The curves have a slight clockwise bend but can with small error be substituted by straight lines.

This gives us a possibility to calculate a standard deviation of the mean opinion score in relation to the standard deviations of X and β. From equation (5) we get the differential mean opinion score

$$dY = (X + 2.5)^2 d\beta + 2\beta\ (X + 2.5) \cdot dX$$

By inserting the standard deviations $d\beta = \sigma_\beta$ and $dX = \sigma_x \cdot \sqrt{n}$ and observing that σ_β and σ_x are independent of each other, we get the standard deviation in the mean opinion score as the r.m.s. of the terms to the right

$$\sigma_y = (X + 2.5) \cdot \sqrt{[(X + 2.5)\sigma_\beta]^2 + (2\beta \cdot \sigma_x \cdot \sqrt{n})^2}$$

which can be transformed into

$$\sigma_y = 2\beta \cdot \sigma_x \cdot \sqrt{n}\ (X + 2.5) \cdot \sqrt{1 + \left[\frac{\sigma_\beta}{2\beta} \cdot \frac{X + 2.5}{\sigma_x \cdot \sqrt{n}}\right]^2}$$

An investigation using Markman's table 6 shows that the square term in the square root can be neglected as its influence on σ_y is only 10 to 15 % for the case we are interested in–many links and high loss values. Therefore, for further discussions we can neglect the noise variations and use the simplified equation

$$\sigma_y = 2\beta \cdot \sigma_x \cdot \sqrt{n}\ (X + 2.5)$$

or when X = SyRE – 6 db

$$\sigma_y = 2\beta \cdot \sigma_x \cdot \sqrt{n}\ (\text{SyRE} - 3.5)$$

Considering an expensive LD call we find:

- ☐ On intercontinental calls CCITT recommendations permit a noise level of – 50 dbmp all the time, giving a β about twice as high as for noise-free calls.
- ☐ By reasonable maintenance and supervision efforts we can get a σ_x of about 1 db.
- ☐ The number of links depends on the routing plan, up to 12 links being permitted on intercontinental calls.
- ☐ SyRE is mainly dependent on the present situation in the 2-wire networks.

Our possibility of reducing σ_y is thus very restricted. If, however, we introduce the proposed level control with regulation before conversation starts and use the switching points to the 2-wire networks where we have the hybrids as control points, we gain the following:

- ☐ The whole complex circuit can be considered as one link regulated from the control points for an actual call.
- ☐ The standard loss deviation on such a regulated circuit is dependent on the measuring and regulation accuracy and can be kept very low–better than for the individual links.
- ☐ As the loss deviations in a regulated complex circuit are small, we can reduce the compensation for negative loss deviations. A reduction of 3 and 5 db for connexions with 4 and 9 links respectively, seems to be possible–compare fig. 6 in the main paper.

With level regulation we thus get

- ☐ an essential reduction of the standard deviation for the mean opinion score with decreased risk for subscriber complaints.
- ☐ a reduction of SyRE without changes in existing 2-wire networks, which means an increase in mean opinion score and a desirable raise in performance on expensive LD calls.

The table below shows the gain for some cases with $\sigma_{\varepsilon} = 1$ db.

Level regulation	Noise level	None						— 50 dbmp					
	No. of links	4	9	4	9	4	9	4	9	4	9	4	9
without	SyRE db	20		27		34		20		27		34	
	M.O.S. Y	3.06		2.75		2.35		2.81		2.26		1.52	
	σ_y	0.07	0.11	0.10	0.15	0.13	0.20	0.13	0.20	0.19	0.27	0.24	0.36
	$p+$ %	0.3	0.2	1.7	1.3	7.7	6.1	1.1	0.7	8.5	6.5	38.4	32.0
	$p-$ %	0.8	1.0	4.2	5.0	16.5	18.9	3.7	4.9	22.4	26.3	64.0	69.7
with	Loss reduction db	3	5	3	5	3	5	3	5	3	5	3	5
	M.O.S. Y	3.15	3.20	2.90	2.98	2.53	2.65	2.99	3.09	2.52	2.68	1.86	2.07
	σ_y	0.03	0.03	0.04	0.04	0.06	0.06	0.06	0.05	0.08	0.07	0.11	0.10
	$p+$ %	0.2	0.2	1.1	0.7	5.2	3.3	0.6	0.3	5.0	2.8	27.3	18.1
	$p-$ %	0.4	0.3	1.6	1.1	8.0	5.2	1.5	0.6	8.8	4.8	39.0	27.3

In the table we have–using Markman's table 5–calculated the percentage poor and bad calls $p +$ and $p -$ corresponding to mean opinion scores $Y + \sigma_y$ and $Y - \sigma_y$ respectively. As σ_y is the standard deviation with respect to 4-wire loss deviations, it has to be noticed that about $2 \times 16\,\%$ of the calls will have a performance better or worse than shown in the table. Roughly the worst level regulated calls will be considered as good as the best unregulated ones by the users. The gain in performance is essential, when we have many 4-wire links, high circuit noise and high reference equivalents in existing 2-wire networks.

APPENDIX 2

End-to-end Control of Complex 4-wire Circuits

One way of introducing level control and loss adjustment of complex 4-wire circuits to prescribed nominal values is illustrated in fig. 7, where we have the following features:

- ☐ Outgoing and incoming control switching points–*UKS* and *IKS*–situated as near the hybrids as possible. Between them a number of transit switching points–*TFS*.
- ☐ In all switching points equipment–e.g. registers *REG*–which can receive sufficient numerical information in the form of code digits for country and area and, when needed, also the subscriber's local number.
- ☐ Analysers *AN* momentarily connected to the registers, which from the code digits determine:
  - In *UKS* whether an actual call needs a transmission check and whether echo suppressors need to be inserted.
  - Whether a *TFS* has to function as *IKS* or not.
- ☐ In *UKS* and *IKS* the registers must remain on the connexion until the transmission test and switching are completed. During switching automatic level regulators *PD* are connected to a suitable point in the switch train.
- ☐ No level regulation is needed in interlinked transit switching points, and the register is disconnected after through switching.
- ☐ In *UKS* and *IKS* level control units *MD* are connected between registers and level regulators *PD*.
- ☐ In *UKS* the *ANU* determines from the code digits the nominal loss value for the prospective call, which is stored in *MDU*.

The registers and analysers we already have in one or another form in modern switching systems with alternative routing, but they must have some new features added for the control. The *MD*'s and *PD*'s are new devices. In short the function will be as follows:

- ☐ *REGU* receives the code number, connects itself momentarily to an *ANU* and is informed whether level control–with or without echo suppressors–is wanted.

- ☐ If so, *MDU* is connected to the register and *ANU* transfers the nominal loss value to the *MDU*-memory.

- ☐ The call is switched through *UKS*, whereby *PDU* is connected to a suitable switching stage and also to *MDU*.

- ☐ The switching proceeds through all *TFS*, which are informed by their analysers that there is a more remote control point. With respect to alternative routing, this can be arranged dependent on the chosen route from the switching point. After through switching, the registers and analysers are disconnected.

- ☐ When the call reaches *IKS*, *ANI* directs *REGI* to switch in *MDI* and *PDI*.

In principle we can now make our measurements, as measuring and regulation outfits have been switched in at both control points, but we have to wait for a suitable moment in order not to disturb the ordinary digit transfer from *UKS* to *IKS*. If we were always able to determine from *UKS* the number of national digits in a remote area, the problem would be very simple, as we could start the measurement after the last digit and proceed with the switching in the remote area in the meantime, which would mean practically no prolongation of switching time. For areas with irregular numbering we cannot use this method, but we can always fix a minimum number of national digits, including the area code, and interrupt the sending of digits from *UKS* when these digits have been transmitted. After measuring, the remaining digits are sent. We actually save time as we can partly switch in the remote area during the measurement. Also *REGI* knows when digit sending is interrupted, and the following sequence can start:

- ☐ *REGI* sends a measuring signal in the backward direction at internationally determined level and frequency.

- ☐ The signal is received by *MDU* and the received level is compared with the loss value stored in the memory. *PDU* regulates the loss value in the backward direction to the prescribed nominal value.

- ☐ When *MDU* receives the measuring signal, it sends forward the determined reference level *increased* by the nominal loss value.

- ☐ *MDI* compares the received level with the reference level, and *PDI* regulates the loss in the forward direction to the prescribed nominal value.

- ☐ *MDI* disconnects the measuring signal, and *MDU* answers by disconnexion of its signal, whereafter both measuring devices are released and the transfer of the remaining digits can proceed.

The proposed method does not permit echo suppressors in the connexion during the transmission check, but we must be able to switch echo suppressors in or out for other reasons as well, and this can be arranged by signals from *REGU*.

On completion of switching, the two level regulators *PD* are the only additional equipment used for the call. As we have only one measurement for each talking direction of the whole 4-wire path, neither measuring nor regulation need to be too accurate, and a loss deviation of max ± 1.5 db corresponding to a standard loss deviation of 0.5 db ought to be possible with a level regulation of 1 db per step.

The nominal loss value which has to be introduced to avoid inconvenient echo when no echo suppressors are inserted should be determined with respect to the worst combination of link routes between two remote control points, giving the longest propagation time. In this way the telephone users will never note when different routes are chosen, and one reason for complaints disappears.

If the measured deviations are too large to be compensated by the level regulators, there is probably an undiscovered fault somewhere in the transmission path, but there may also be an unlucky combination of deviations. Such calls should be rejected, and as the whole digit information is stored in *REGU*, we can release the 4-wire network and build up a new path from *UKS* without disturbing the caller. In *UKS* the code numbers of all rejected calls should be registered for statistical purposes. The supervision people will then discover whether for certain code numbers there are too many rejected calls, and those numbers can be marked in *ANU*, so that the next rejected 4-wire connexion will be locked by the *PDU*-regulator. If this regulator is connected to another point in *UKS* than the incoming line from the 2-wire network, a new 4-wire path can automatically be given to the caller. The locked 4-wire path gives alarm and can be investigated by all maintenance parties concerned. In this way we give the maintenance and supervision people valuable means of discovering combination faults impossible to trace by other methods. During the transmission check we can also measure the noise level outside the narrow measuring frequency band. Calls with too high a noise level are rejected, as we cannot compensate for noise.

It is, of course, not necessary to check all LD calls. Less expensive national LD connexions not containing too many 4-wire links may be left unchecked. In this way only a relatively small number of LD calls–determined by *ANU* from the code numbers–need to be checked, which reduces the costs of the control equipment. This means, however, that in the national links we must insert sufficient loss for echo protection, which has to be compensated by the level regulators on transmission-controlled calls.

As only a small percentage of calls passing the terminating control point *IKS* has to be controlled, it is desirable to have a special forward signal from *UKS*, indicating that control is wanted in order to avoid unnecessary occupation of *MDI* and *PDI* units. Another way is to let *REGI* at a proper moment send a backward premeasuring signal, asking *REGU* for further instructions. Being dependent on the signalling possibilities in various switching systems, the problem of additional measuring signals has not been investigated in detail but should be included in a further study of level control.

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Overvoltage Protector NGC 31

B LINDGREN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.316.93
LME 7392

For the past few years L M Ericsson has been making overvoltage protectors in the form of rare gas tubes. They are primarily intended to replace the older carbon arresters. The reliability, efficacy and loading capacity of the rare gas tubes have, however, made them usable also in applications for which the carbon arresters cannot be employed. Several types have been developed, with different properties as regards striking voltage, loading capacity and mechanical design.

The technical development is briefly described and the special demands on the manufacture of the tubes are touched upon.

The Function of Overvoltage Protectors

Disturbances may be induced into telephone lines as a result of atmospheric discharges or the vicinity of power lines. The former may appear in the form of travelling waves of very great amplitude.

The function of the overvoltage protector is to protect persons speaking on the telephone as well as the subscribers' and exchange equipment against induced atmospheric overvoltages and against overvoltages caused by contact between telephone and power lines provided that the current load does not permanently exceed 20 A. Consequently it does not protect against a stroke of lightning in the telephone line at the point of the stroke. But rare gas tube protectors on the line in the neighbourhood of this point reduce its destructive effect. The protectors are generally connected between each leg of the line and earth, but some protection is gained also if the protector is connected in parallel across the line.

What a Good Overvoltage Protector should do

A rare gas tube offers a very high resistance when the voltage across it is below its striking voltage. If the striking voltage is exceeded, a glow discharge takes place in the tube. The voltage across it then falls to the maintaining voltage of about 100 V. The glow discharge changes into an arc discharge if the current through the tube is greater than about 0.1 A. In such case the voltage across the tube falls to about 25 V. The protective action of the tube lies in the fact that the overvoltage is thereby discharged to earth.

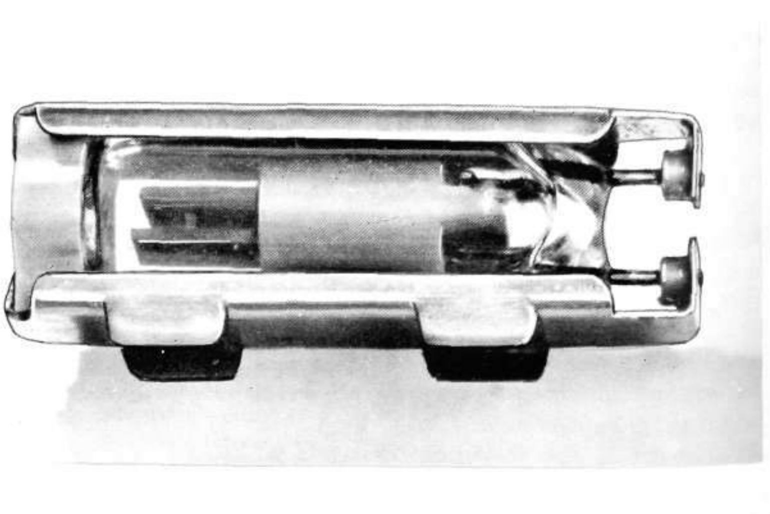


Fig. 1
Rare gas tube, NGC 313
Scale approx 2.5:1

X 8450

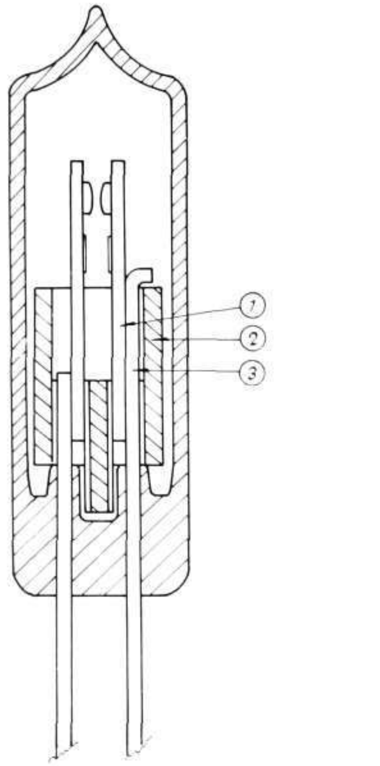


Fig. 2
Cross-section of rare gas tube type NGC 31

X 2753

It is, of course, vital that the overvoltage protector should function as rapidly as possible after the voltage has exceeded the permissible limit. In their original form rare gas tubes were not altogether ideal in this respect. They were subject to a statistically distributed time lag of between a few tenths of a microsecond and a matter of seconds. This was because the gas must be ionized to some extent for glow discharge to take place. Ionization may occur through the action of light, cosmic radiation or a strong electric field. The overvoltage protector must be so designed that the delay in striking is negligible.

The overvoltages induced by heavy atmospheric discharges may be of an order of 300 kV with a very steep wave front of 50 kV/μs. Fortunately they are very brief, generally of the order of 0.1–10 μs, but with a current intensity of thousands of amps. The overvoltage protector must therefore strike during these brief high-energy surges and discharge the energy to earth.

A good rare gas tube must therefore withstand repeated momentary currents of high amplitude without bursting of its glass envelope or destruction of its electrodes.

Construction and Properties of Overvoltage Protector NGC 31

The rare gas tube *NGC 31* is the final product in a long series. The experience of earlier designs has been utilized in the new tube. It consists of a diode in a glass envelope filled with rare gas. Its two electrodes are both cathode-activated and symmetrical, thus independent of the direction of the discharge current. The envelope has external mountings which fit into the carbon-arrester holder.

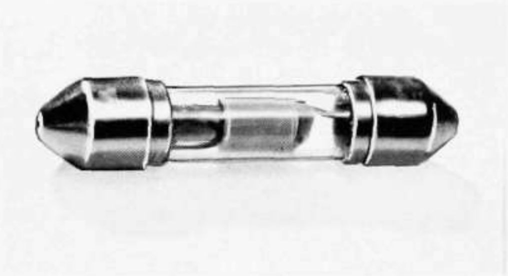
The construction will be seen from fig. 2. Two rectangular bimetallic strips (1), sized 15 × 4 × 0.65 mm, are fixed in a cylindrical ceramic body (2) with a short partition extending beyond the bottom of the cylinder. They have heavy duty contacts to avoid welding by an arc. Two fairly thick CC wires (3) through the glass stem connect the internal parts to the external mountings. CC wire is a copper-clad wire with iron core. The coefficients of expansion of the wire and of the glass into which it is fused are closely matched. This impedes leakage or too early bursting of the glass. To raise the limits for the permissible current load, the CC wire has been given a diameter as large as 0.8 mm. According to general opinion and practice in glass technique the maximum value was earlier about 0.5 mm. Through the increased diameter and special treatment of the CC wire a tight seal is obtained between copper and glass even at about three times as high a current as before.

Fig. 3
Discharge of shock wave 1/50 without and with a rare gas tube
T_1 = wave front time
T_2 = half peak value
Up = protection level
Ua = arc maintaining voltage

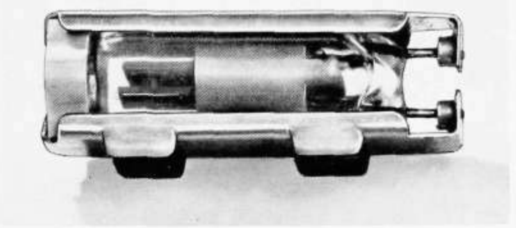
X 2754

A patented method has been used to ensure high speed of response of the protector. The method is simple and reliable. The glass-bulb is lightly powdered on the inside with a very fine-grained powder of light metal. Through the small weight of each grain the force of adhesion is sufficient to hold the powder to the glass. When a high voltage is applied to the tube, a number of micro spark discharges take place between the grains. The rare gas is then ionized and the delay in striking is reduced well below the required limit. The method is effective irrespective of the light conditions and within temperature limits of + 100 to − 78° C.

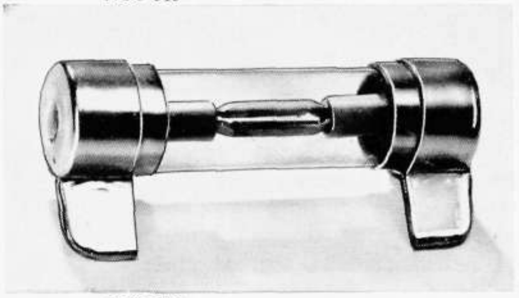
The rapidity of response of the rare gas tube is illustrated in fig. 3. For laboratory simulation of practical conditions and for testing purposes a standardized overvoltage wave has been created, known as wave form 1/50, 1 representing the wave front time and 50 the half peak value in μs. The high voltage to be impressed is optional. The *dashed* curve in fig. 3 shows the process without overvoltage protector, at an *arbitrarily* chosen peak voltage of 15 kV. The *continuous* curve shows the process when a rare gas tube is connected. The front voltage is cut off at a level slightly below 1 kV and in less than 0.1 μs. At the start there is a small tendency to oscillation which is followed by a rapid drop to arc maintaining voltage. During the first micro-



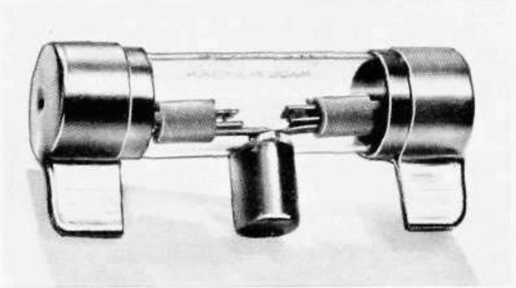
NGC 303



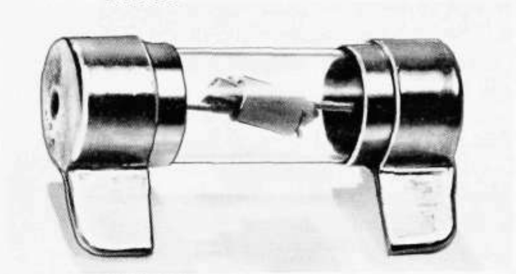
NGC 313



NGC 323



NGC 333



NGC 343

Fig. 4 X 2755—2759
Different types of rare gas tube

seconds the average residual voltage affords a level of protection of some 500 V, at which no damage can be incurred during so short a time. This result has been measured both with an oscillograph and with a specially constructed electronic, highly rapid peak-voltage meter which gives an indication of longer duration.

The electrodes, as noted, are bimetallic strips. During relatively lengthy discharges, which occur on permanent contact with power lines, the bimetallic strips are heated and come together to produce a short-circuit. On a powerful arc discharge through the tube the short-circuit is effected after about 0.5 second. It persists during the period of the disturbance and for a few seconds thereafter. The short-circuit also protects the cathode layers against gasification and greatly increases their life.

Data

Static striking voltage: Standard values are 250, 300, 350 and 400 V DC.

Shock striking voltages with wave form 1/50: (on tubes for up to 600 V DC static striking voltages) $<$ 1,000 V.

Maintaining voltage on glow discharge: 75–150 V DC.

Maintaining voltage on arc discharge: 15–30 V DC (at $>$ 100 mA).

Insulation: $>$ 5,000 Mohms.

Time of arc before electrodes are short-circuited: 2–4 seconds at 5 A, 0.5–1.5 second at 20 A.

Electrode breaking time: after 5–10 seconds.

Rupture limit of glass base after 1-minute continuous current: $>$ 20 A.

Rupture limit of glass base at 1.5 Coulomb: $>$ 2,000 A.

Continuous current load (unlimited time): 15 A.

Cathode activation: Withstands current loads up to rupture limit of glass base.

The electrode system in *NGC 31* is used in several other types of tubes for 2-pole and 3-pole termination as shown in fig. 4. All these tubes are valuable and robust components in telephone networks.

Further information concerning the various types of tubes, their dimensions, electrical data, holders, etc. will be found in "*News from the Network Department" No. N 16e: Rare Gas Tubes.*

Ericsson LM NEWS *from* *All Quarters of the World*

New Brazilian Contract: Extension of Fortaleza Network

L M Ericsson has recently signed a contract with the Brazilian Municipality of Fortaleza for extension of its telephone installations. Fortaleza is capital city and an important administrative and commercial centre in the province of Ceará. It has at present four urban exchanges with a total capacity of 14 600 lines in operation – 10 000 of the 500-line selector system AGF and 4 600 crossbar ARF. The first of these exchanges was opened in 1937 and is still rendering admirable service. The new order involves an addition of 8 000 ARF lines.

The photograph above shows the signing of the contract by the chairman of the board of Ericsson do Brasil, General Juracy Magalhães, in the presence of (from left) the head of the Fortaleza telephone administration, Gerardo Maia, the president of Ericsson do Brasil, Ragnar Hellberg, the governor of Ceará, Colonel Virgílio Távora, and the mayor of Fortaleza, General Murillo Borges.

Another Large Order from Colombia

L M Ericsson has received orders from Colombia for telephone equipment to an amount of over 10 million kronor. They comprise mostly carrier and automatic switching equipment for extension of the long distance network, which was constructed by L M Ericsson.

Colombia is a large market for L M Ericsson, which has supplied a considerable part of the telephone installations in the country. The first Ericsson automatic exchanges were delivered in the early thirties.

Extension of the automatic exchanges of Bogotá and Medellín by some 40 000 lines was contracted last year.

First Automatic Exchange in Sumatra

The first automatic exchange in Sumatra, Indonesia, was opened recently. It is an Ericsson ARF 101 exchange with a capacity of 1 000 lines and is located at Tandjungkarang. In the photograph below the Resident of Lampung, Zainal Abidin, cuts the symbolical tape.

New Ericsson Factory near Dieppe

A new factory of Société des Téléphones Ericsson (STE) was recently opened at Saint-Nicolas outside Dieppe in the presence of high-ranking personages in French telephony. The photograph below was taken during a tour of the factory. The head of Société des Ateliers Vaucanson, M. Muel (left), demonstrates the plant to the P.T.T. Minister, M. Jacques Marette (right). In the centre is the president of STE, M. André Duprez.

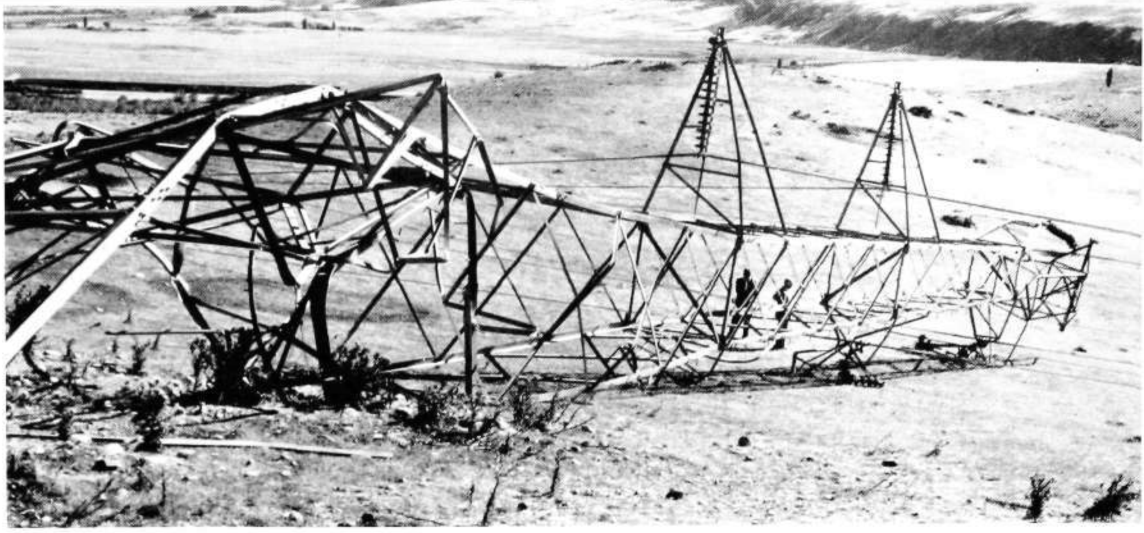
World's Largest Series Capacitor

On October 19, 1963, the Swedish Power Board put into operation the world's largest series capacitor. The bank is rated at 300 MVAr and consists of 6,000 units of Sieverts Kabelverk's type CRS 50. It is located at Djurmo in Dalecarlia on one of the 400 kV lines from Norrland. The capacitor raises the transmission capacity, by over 75 per cent, from 450 to 800 MW. The photo above shows (from right) Messrs. Gottschalk von Geijer and Gunnar Jancke of the Power Board and Mr. Kjell Hägglund of Sieverts Kabelverk in front of the new bank at the opening ceremony.

In October 1963 L M Ericsson's Dutch subsidiary opened its new sales offices at Voorburg near The Hague. During the official inauguration president Sven T. Åberg rang up the mayor of Voorburg, Mr. A. Feith (left in picture above), and asked him to officiate at the ceremony. The president of Ericsson Telefoon-Maatschappij, J. Badon Ghijben (centre), and the Director General of the Dutch P. T. T., Professor G. H. Bast (right) listened to the conversation which was relayed by loudspeakers throughout the building.

At the end of last year a study trip was arranged by the Swedish Agency for International Assistance for 21 African administrators, in the course of which they visited L M Ericsson at Midsommarkransen. Some of the group are seen in the photograph (left) in the Exhibition Room.

Ten large power line towers collapsed in a tempest in South Island, New Zealand, when the force of the gale was estimated at nearly 170 m. p. h. Although the poles were destroyed and several miles of the wires lay on the ground, this did not prevent the Ericsson carrier equipment from functioning satisfactorily. (Photo right)



(Photo left) The Jugoslavian ambassador Dušan Popović (left), with counsellor Vojislav Pekić on visit to Midsommarkransen.

The photo above shows a display window at Ericsson Telephone Sales Corporation AB, New Delhi, in which Ericsson time control equipment is effectively displayed.

The Thailand Ambassador to Sweden, Visutr Arthayukti, visited Midsommarkransen in December. (From left) The Ambassador, the Second Secretary Kanit Sricharoen, and L M Ericsson engineers L. Mjöberg and C. O. Morander.

Georg Olsson †

Georg Olsson, former president of Sieverts Kabelverk, has died at the age of 77.

After graduating from the Stockholm Technical College in 1905 he joined AEG as draughtsman and designer but soon transferred to Stockholms Allmänna Telefon AB and became head of its Installation Department in 1909. In 1915 he was appointed superintendent of its Maintenance Department and one year later head of the company's cable works at Älvsjö. There he remained until the cable works was taken over by Telefon AB L M Ericsson in 1921. In 1928 he became president of Sieverts Kabelverk, Sundbyberg, from which he retired on pension twelve years ago.

Ericsson Technics

Ericsson Technics No. 2, 1963, came out at the year end, so completing its nineteenth year of issue.

No. 1, 1963, issued last summer, opened with a paper by A. Dattner, "Experiments on Plasma Resonance". The author describes studies of resonance phenomena in plasma enclosed in a cylindrical waveguide under the influence of electromagnetic fields.

Thereafter follows "Magnetic Eddy Current Fields Calculated by Complex Successive Overrelaxation", in which J. Ehrenborg and J. E. Sigdell describe how vector fields which vary with time can be calculated by means of a complex overrelaxation factor. The method is employed for determining the field distribution in a magnetic conductor in the neighbourhood of an air gap.

In "Optimal DTL Circuits" Ø. Gjessvåg presents the general requirements for logic circuits in large logic systems and some points to be considered for their optimal design. A new type of diagram – the P-N diagram – is recommended as permitting better assessment of the properties of the digital circuit. A figure of merit for the DTL circuit is defined with reference to this diagram.

In "Cavity Method for Measuring Dielectric Constants at Microwave Frequencies" by P. Hedvall and J. Hägglund a circularly cylindrical cavity is used to measure the relative dielectric constant, ε, and the dissipation factor, tan δ, for a test rod placed axially in the resonator. Graphs and tables are presented for determination of ε and tan δ from measurements of the resonant frequency and Q value of the cavity. These are based on an exact calculation of the resonant frequency behaviour of the TM_{010} mode as a function of ε. The results hold good up to high values of ε, which is impossible with the commonly used perturbation methods.

In the concluding paper in No. 1, "Cavity Method for Measuring Plasma Properties", P. Hedvall has calculated the resonant frequency and Q value for a circularly cylindrical TM_{010} cavity containing an axially located plasma rod surrounded by a glass tube. In measurements of plasma properties by the microwave cavity method, the influence of the glass tube surrounding the plasma is often disregarded. The object of this study was to improve the cavity method by taking the glass tube into account. This improvement is of especial value when calculating the collision frequency of the plasma.

The main contents of Ericsson Technics No. 2, 1963, consist of a series of articles under the common heading "A Four-Wire Solid-State Switching System". They are concerned with a number of electronic switchboards supplied to the U.S. Air Force during 1962 by North Electric Co., L M Ericsson subsidiary, of Galion, Ohio. The switchboards form part of the 412-L air weapon control system for which General Electric was main contractor. The telephone system was designed in intimate co-operation with the Development Department of the parent company in Stockholm and is based on work on time division systems on which the Department has been engaged since the fifties. A laboratory model, EMAX I, was built on the time division principle in 1954. The series of papers on 412-L bears the following headings: "Application, Concept and Configuration", "Subscriber Instruments", "Common Control Equipment", "Numbering Plan and Signalling System", and "Time Division Switching Network". The following authors have contributed: C. Curran, C. G. Svala, A. A. Unseren, J. R. Siconolfi, C. B. Nennerfelt, A. Svensson, A. K. Bergmann, F. H. Haferd, E. Aro and S. L. Junker. The papers were previously published in conjunction with the Winter Session of I.E.E.E., New York, January 27–February 1, 1963.

This series is followed by "A Comparison between the Sensitivities of Radar Monopulse and Conical-Scan Systems" by T. Fjällbrant. With reflectors of the same diameter the systems can be made to have similar signal-to-noise ratios in the surveillance mode. In the tracking mode the monopulse system then has a 6 db better signal-to-noise ratio in the range channel and 3–6 db better in the angular error channel.

In "Excitation of Plasma Waveguides with Backward Wave Modes", finally, B. Agdur and B. Enander have studied the excitation of electromagnetic waves in a waveguide containing a cool isotropic plasma. Special attention is paid to cases in which backward waves exist. The influence of drift velocity of the plasma is investigated.

In November last year Ericsson Telefoon-Maatschappij N. V., Rijen, took part in "Europort", a large exhibition for ship's equipment in Rotterdam. Among other Ericsson exhibits were an entire range of equipment for ship's internal communications. (Photo left)

UDC 621.395.74
LME 808

ANDERSEN, E, BOHLIN, T, ERIKSSON, J & SAULEDA, E: *Long Distance Network in Colombia.* Ericsson Rev. *41*(1964): 1, pp. 2—17.

The first part of this article describes the comprehensive long distance telephone network of Colombia, that has been built by the L M Ericsson Telephone Company for the Empresa Nacional de Telecomunicaciones. The second part deals with the automatization of a large number of the long distance exchanges carried out at the same time using L M Ericsson's crossbar systems. The country's telecommunications facilities have thereby been significantly improved, a factor which actively contributes to rapid economic development.

UDC 621.3953
LME 830

ERICSSON, E A: *The Telephone User and the Switching Machine.* Ericsson Rev. *41*(1964): 1, pp. 18—33.

This article is a revised version of papers prepared for the L M Ericsson Maintenance Conference in Stockholm, June 1962, and the Second Symposium on Human Factors in Telephony at Copenhagen, September 1963. In a previous paper presented at the "First Symposium on Human Factors in Telephony" at Cambridge in 1961, the author gave some aspects on a worldwide switching machine, mainly with respect to supervision and maintenance problems. In this paper similar problems are considered from the telephone users' point of view, with special attention to the performance during conversation. Possibilities of obtaining better matching between man and machine are discussed, which may be of importance in a future worldwide automatic telecommunication network.

UDC 621.316.93
LME 7392

LINDGREN, B: *Overvoltage Protector NGC 31.* Ericsson Rev. *41*(1964): 1, pp. 34—36.

For the past few years L M Ericsson has been making overvoltage protectors in the form of rare gas tubes. They are primarily intended to replace the older carbon arresters. The reliability, efficacy and loading capacity of the rare gas tubes have, however, made them usable also in applications for which the carbon arresters cannot be employed. Several types have been developed, with different properties as regards striking voltage, loading capacity and mechanical design. The technical development is briefly described and the special demands on the manufacture of the tubes are touched upon.

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State Labs. Inc. *New York 3, N. Y.*, 215 Park Avenue South, tel: Oregon 7-8400, tgm: statelabs (For electron tubes)

• AUSTRALIA & OCEANIA •

New Zealand

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ERICSSON Review

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On cover: Finishing of parts of telephone relay sets in zinc-plating machine at L M Ericsson's main factory, Stockholm.

The Swedish Trunk Network: a Survey of Transmission Techniques

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In this article, which is also published in the Royal Board of Telecommunications Journal Tele No. 2, 1963, a survey is given of the composition and development of the Swedish trunk network. A number of technical and economic points of view are given and finally a prognosis is given for the future development.

This survey aims at showing how our trunk network is composed and how it has progressively grown and developed. The inter-zone and intra-zone networks have been counted as a single unit as there is no sharply defined technical boundary between the circuits of these networks. It is true that the intra-zone circuits are in general appreciably shorter than the inter-zone circuits, which in turn affects the normal technical specification of the two types of circuit, but there are large individual deviations as far as their lengths are concerned. The longest intra-zone circuits are thus appreciably longer than the shortest inter-zone circuits. The occurrence of cross connecting (non-backbone) routes, e.g. between a zone centre and a minor exchange in a different zone also contributes to eradication of the border line between these two types of circuit.

Statistics Concerning the Composition of the Trunk Network

A rough rule for estimation purposes says that all telephone administrations have about 1.5 km of local line and likewise about 1.5 km of trunk line per subscriber (main subscriber). This rule also applied for Sweden until the beginning of the 1950's. It still applies for the estimation of the local network, but the trunk network and particularly the inter-zone network have since then increased sharply, so that we now have more than 2.6 km of trunk line per main subscriber (fig. 1). The trunk network now has a much greater total circuit length than the local network, which should be the normal state of affairs for well developed telephone countries. Of the three dominating items in the telephone administration's investments—subscriber plant, telephone exchanges and trunk networks—the last has also been the greatest in recent years.

* Now at Telefonaktiebolaget L M Ericsson.

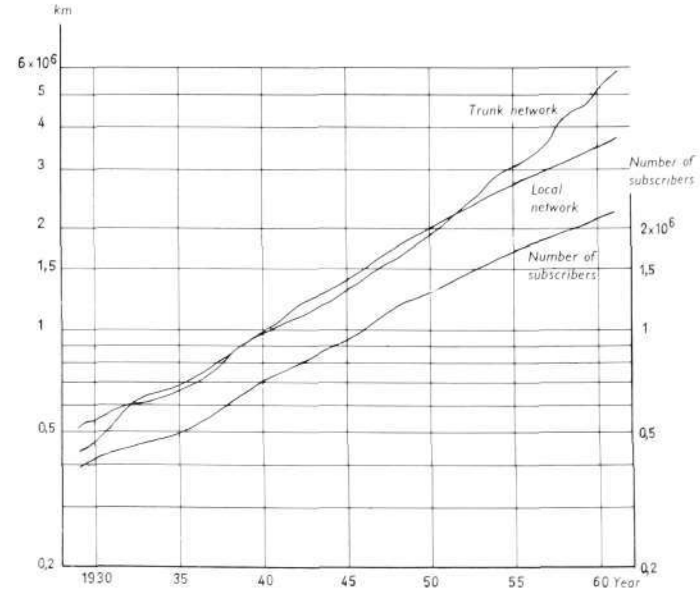

Fig. 1 X 8482

Total circuit length in local network and trunk network and number of main subscribers in the years 1929—1961

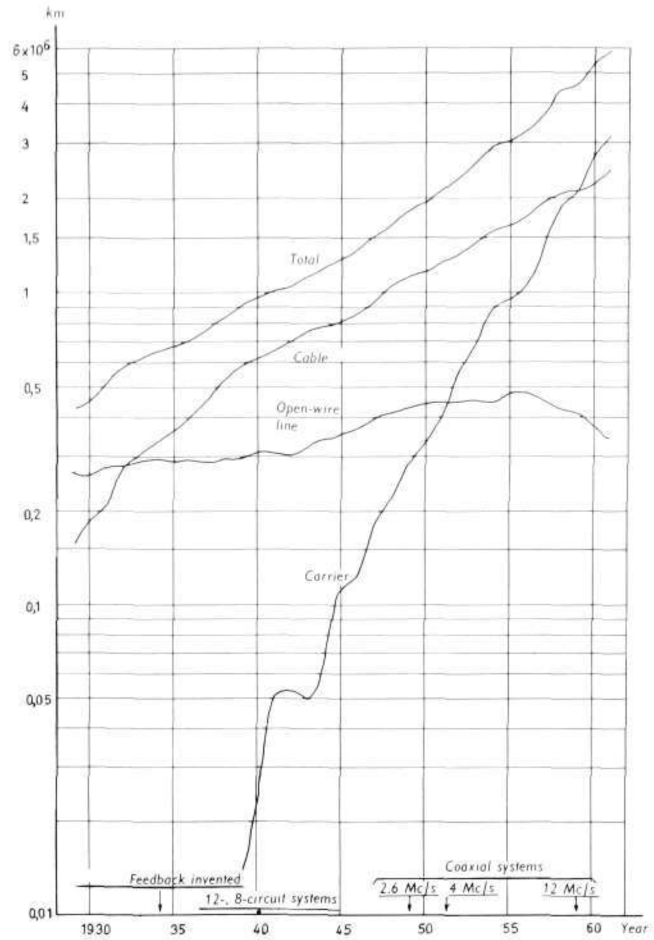

Fig. 2 X 8483

The Trunk network expansion divided up into more important circuit categories and certain milestones in carrier technique

The development of the trunk network is illustrated in fig. 2: this shows the growth of the trunk network since 1929, given as the grand total and also sub-totals of the three categories: open-wire lines, physical cable circuits and carrier circuits.

The coaxial circuits dominate in this latter category, but 8- and 12-circuit systems, radio link circuits (at present about 1 %) and carrier circuits on open-wire lines (at present about 2 %) are also included in this category. It is of interest to see that the three categories in fig. 2 have dominated in turn in the development. Thus the open-wire lines were the general rule, but were out-distanced in 1931 by physical cable circuits. Carrier circuits whose real growth first started about 1940 have quite recently taken the leading position. The graph of the total circuit length of the trunk line network shows an average increase of just over 8 % per year, the last 10 years, however, showing an annual increase of about 10 %. The carrier circuit category has during the last 20 years shown an average increase of about 25 % per year. This clearly cannot continue and the graph for this category of circuit will gradually merge with the total curve. Such a protracted and strong growth has of course meant very great efforts on the part of the personnel concerned.

A peculiar observation in fig. 2 is that despite all cable projects etc., the open-wire lines have increased in total length until about the year 1955 when a gradual decline set in.

The diagrams in figs. 1 and 2 show the total length of the trunk network in circuit kilometres. Fig. 3 shows a distribution graph of the circuit lengths in the trunk network. Peculiarly enough, this graph in the region 10–400 km is almost exactly a hyperbola (product of percentage and line length is a constant)

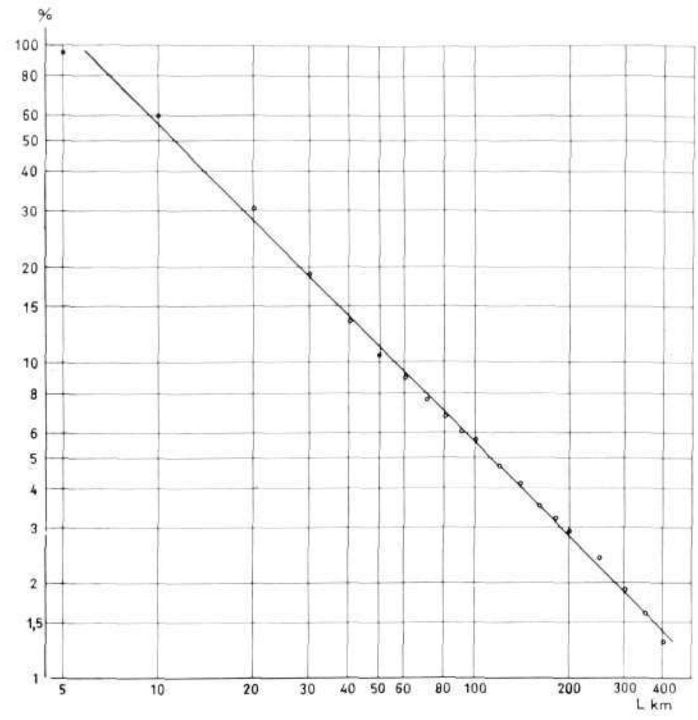

Fig. 3 X 8458

Distribution graph of circuit lengths in the trunk network

corresponding to a 45° line on the log-log scale of the figure. This means that the number of circuits of a given length is inversely proportional to the square of the length, or more accurately expressed, that the number of circuits having lengths between L and $L + dL$ is $= k \cdot \frac{dL}{L^2}$ where k is a constant. The same empirical relation appears otherwise to apply too for the trunk network in USA, judging from available information.

The number of trunk circuits was approximately 132 000 at the beginning of 1961 and their average length was about 45 km.

A Few Particulars about the Historical Development

In the comments to fig. 2, it was mentioned that the three categories in turn: open-wire lines, physical cable circuits and carrier circuits have dominated in the trunk network. This is of course a perfectly natural historical development and this change of type still goes on and can be followed in less well developed telephone countries and also in our own country where certain parts of the country are still underdeveloped as far as circuits are concerned.

Our first loaded long distance cable Stockholm–Gothenburg I was laid down in the years 1921–23. It contained only two-wire circuits and the quality was low according to present-day requirements. The network has not only grown quantitatively, but qualitatively it has also successively improved very greatly. Four-wire circuits which were then the best type of circuit for long distance circuits from the point of view of quality were introduced in subsequent loaded cables. As they were rather expensive, they had to be reserved for really long distance traffic. This epoch however did not last so long and ended with the breakthrough of the carrier technique at the end of the 1930's. Already before this the single-circuit carrier system for cables had been introduced to a small extent on certain four-wire circuits. These systems did not, however, become widespread as they introduced all the problems peculiar to carrier technique such as crosstalk difficulties and problems of intermodulation (the first amplifiers had no negative feedback!) without bringing with them their advantages as only one extra circuit was obtained. The real breakthrough for carrier technique came with the invention of negative feedback for telephone amplifiers in the year 1934 *(H. S. Black)*. As usual in the technique, it was several years before the invention was applied in practice so that common amplifiers for many simultaneous telephone circuits were obtained. Today, the record is 2 700 telephone circuits for a single amplifier. The development has not finished there, however.

The loaded 4-wire lines had relatively low propagation velocity and so the problem of echo was troublesome. We had many echo suppressors in operation at the end of the 1930's, some for international circuits and some for long national 4-wire circuits. Nowadays there are no echo suppressors in Sweden for European circuits and it is clearly due to negative feedback that we have avoided all these difficult problems.

Certain important mileposts in carrier technique such as the dates for the introduction of coaxial systems etc. into Sweden have also been marked in fig. 2. Coaxial cables were relatively late in their arrival in Sweden–namely after the Second World War. It can be said that with their arrival we stepped from handicraft to large-scale industry in the field of long distance telephony. The individual balancing of crosstalk etc., for example, was hereby no longer necessary and very large numbers of circuits could be transmitted with good quality. Coaxial cables could not be manufactured during the blockade period of the war years, but the large installation, the West Coast Cable which was inaugurated just before the outbreak of the war, ought to have been designed using coaxial cable as the cheapest and best solution. During the war years the need for long distance circuits in large quantities was satisfied by de-loading certain quads in existing loaded cables and introducing 8-circuit carrier systems. These systems are otherwise soon ready for redesign as the terminal equipment does not fulfil modern transmission requirements. It is probable that they will be converted to 6-circuit systems when the supply position in the long distance network permits. The reduction of traffic capacity arising from this is about 0.1 million circuit kilometres which relatively is very insignificant.

After the war came our coaxial cable network which was rapidly expanded and in recent years also supplemented by radio links. It was not so damaging that we first began with coaxial technique relatively late. We could thereby at once introduce relatively modern equipment and also take what was then the daring step of doing away with through connexion of basic groups and only dealing with supergroups as the smallest blocks, thereby making possible great savings, obtaining better quality and providing a clearer picture. In the most recent installations the larger blocks of mastergroups and supermastergroups are of course used as far as possible. It is possible that the number of supergroup through connexions will successively decrease. Many administrations which have introduced coaxial systems earlier than we will consequently have basic group through connexion, which approximately corresponds to changing one's whole salary into 10 crown notes on each pay day. For reasons which would take us too far if we went into them now, through connexion using too small a block is a habit which, like smoking, is easier to start than to stop.

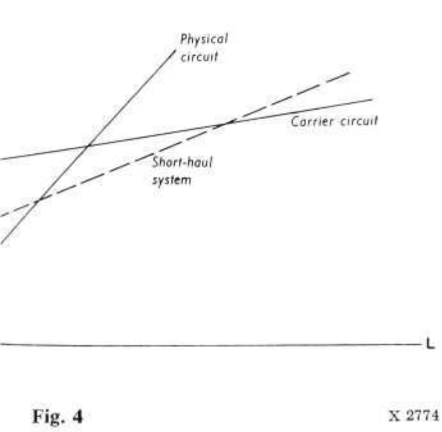

Fig. 4 X 2774

Approximate relationship between circuit cost (K) and circuit length (L)

Technical and Economic Points of View

Fig. 4 shows schematically the well-known relationship between the cost and length of line for physical circuits and carrier circuits (the graphs drawn in full). The terminal exchange cost is low and the kilometre cost (slope) is high for physical circuits, but for carrier circuits, the conditions are reversed. It can otherwise be noted that the relationship between group delay and line length for both types of circuit can be illustrated by the same figure (*K* is thus equal to the group delay) and that the point of intersection is obtained

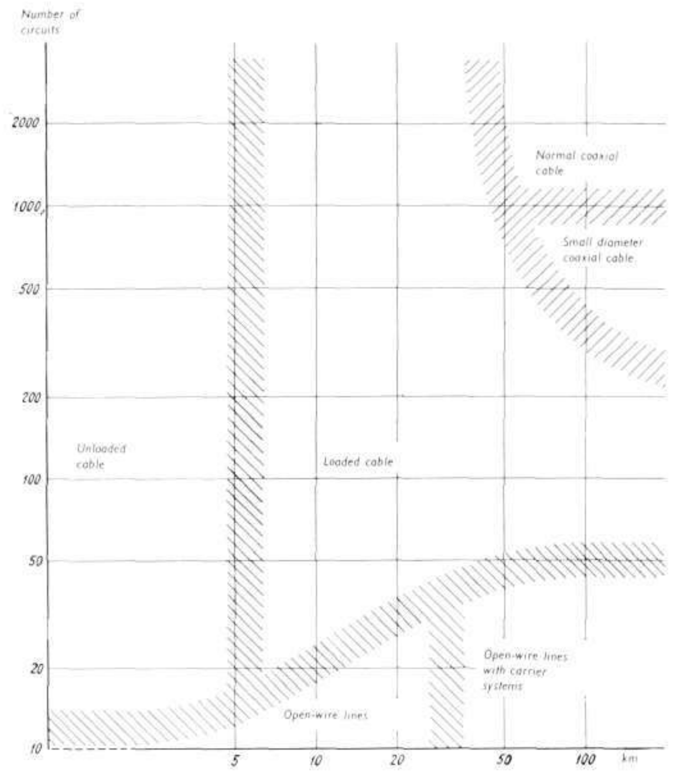

Fig. 5 X 8484

Most economic forms of plant design in the trunk network

at approximately the same line length. In a way it can be said that it is the group delay that one has to pay for. The cost diagram shows that physical circuits are cheapest for lines below a certain length but that above this length the carrier alternative is more economic.

A unique limiting length cannot be given, however, as this is dependent on the number of circuits in the route and also on fluctuating material and labour costs. It should be mentioned in this connexion that when comparing cost calculations of this type, the Swedish Administration usually works with annual costs, i.e. interest, depreciation and maintenance. Certain other Administrations base their comparisons on purchase cost and thereby differing results can be obtained.

Fig. 5 shows in more detail the forms of technical design which are at present most economic for varying circuit lengths and number of circuits when fully built-out. The boundary lines between different alternatives in fig. 5 are denoted by hatched lines, as installations coming in the vicinity of these must be investigated in relatively great detail with regard to local conditions as well.

In addition, the conditions are in practice never so clear-cut as shown here as certain circuits continue in other installations and certain circuits are branched off to exchanges on the way etc. In the figure, coaxial cable has been shown as the only alternative for longer installations having large numbers of circuits. In certain cases, the radio link alternative can come into the picture, but radio links in Sweden have not as a rule shown themselves to be more economic than coaxial cables for telephony. Naturally, it is advantageous to have different paths and transmission media on the larger routes as the risk for complete interruption is hereby eliminated. Radio links are not as sensitive to, for example, excavators as cables are! Further, radio links are specially suitable for installation to satisfy temporary requirements. Otherwise, as far as quality is concerned it can be stated that it is very much easier to satisfy the CCITT requirements of noise and interference (3 pW/km) with coaxial cables than with radio links. Curiously enough, phase distortion is a problem for telephony on radio links but not on coaxial cables, while conditions are the opposite when sending television. The reason is of course due to radio links employing frequency modulation.

In addition, a boundary line is drawn in fig. 5 between coaxial systems using normal coaxial tubes (9.55 mm tube diameter) and those using small diameter coaxial cables (4.4 mm tube diameter). The boundary goes at about 1 000 circuits for new installations but may be increased. The difference is determined by the highest frequency band which can be economically sent over the different types of coaxial line. The conditions can be illustrated by the following simplified presentation. The marginal costs of a coaxial tube are mainly proportional to its cross-sectional area and can be put equal to $a \cdot D^2$, where D is the diameter and a is a constant. The attenuation and consequently the number of repeaters of a given type, i.e. the repeater cost, are mainly inversely proportional to the diameter (due to the skin effect) and this cost is thus equal to $\frac{b}{D}$ where b is a constant. The total cost $aD^2 + \frac{b}{D}$ has a minimum when $2aD - \frac{b}{D^2} = 0$. This means that for optimum design the repeater cost, $\frac{b}{D}$ is approximately twice as great as the tube cost aD^2. The optimum frequency band therefore increases very rapidly with the tube diameter.

The dashed line drawn in fig. 4 shows the cost relationship for so-called short-haul systems i.e. systems which are more competitive than normal carrier systems at short distances. This line is more an expression of a desire than of reality as there are no short-haul systems giving cause for the name. On the other hand certain special cases arise when, for example, to cover a temporary demand for circuits, carrier systems are used over distances which normally are not economic. As indicated in fig. 4, it is basically essential for a true short-haul system, a so-called "tulip rose", that the cost of the terminal equipment is appreciably lower than for normal carrier systems. Great efforts have been made to devise some such suitable system as it could have great applications, according to the line length distribution graph shown in fig. 3, and different methods of modulation such as AM with single and double sideband, FM, pulse modulation of different types etc., have been studied for a long time. More or less luxurious solutions have been produced but the final impression is that the flora of short-haul systems denotes itself by its multiplicity rather than by its long life.

The only so-called short-haul system which has been widely used overseas is so far unique in that its terminal equipment is more expensive than the normal carrier equipment made in the corresponding year. This has later had to change its name from short haul to medium haul. The system most closely corresponds to our 8-circuit system but has double sidebands and is used on de-loaded cables.

As mentioned above, the gist is that none of the functionally suitable short-haul systems produced so far has terminal equipment which is appreciably cheaper than normal terminal equipment, and unfortunately future solutions of this problem can hardly be expected. On the other hand, the boundary length for use of carrier systems has successively decreased owing to their costs having decreased. During the last 20 years, large price fluctuations with mainly a decreasing tendency have occurred due to competition between different manufacturers, design improvements, larger production series and more rationalized manufacture. On an average, the cost of terminal equipment during this time has fallen by about 5 % per year without taking account of the decrease in purchasing power of money. If account is taken of this factor as well the real price decrease would have been about 10 % per year. The prices in recent years, however, have stabilized somewhat.

Design improvements, new components, etc., have also caused a reduction in space requirements at the same time as the price reductions occurred. The volume reduction, however, has been even greater–on an average about 15 % per year. This has of course occurred in stages as new designs were introduced.

This type change has at times occurred at rather short intervals. The limit for compression of volume has been set by the available components and also by heat dissipation. As the election tubes have been replaced by transistors having appreciably smaller power consumption, a great reduction has been possible, but even in this case the heat dissipation limit will soon be reached. It should lie at a size of the order of 600 channel terminals per bay side which can be compared with 1 bay per channel about 30 years ago (carrier system on open-wire lines). The corresponding reduction in volume otherwise applies for practically all transmission material such as loading coils, telephone repeaters, etc. This reduction of volume has to a certain extent gone against the rapid development of the trunk line network and particularly the carrier network, as far as the question of accommodation is concerned in the repeater stations, but according to the above, it is uncertain as to how long this development can continue.

The cost graph of physical circuits has been denoted schematically in fig. 4 by a straight line. This is, of course, an approximation as the conductor diameter is dependent on the line length and the 2-wire repeater can be included as a terminal and intermediate repeater. The number of 2-wire repeaters per circuit is nowadays never greater than 1 or 2 in practice. Twenty years ago, certain 2-wire circuit could contain 10 or more intermediate repeaters. According to the transmission plan which has been in use in Sweden for a long time, a maximum of five 2-wire repeaters is permitted in a complete connexion between two subscribers, where the carrier and 4-wire circuits used reckoned as a 2-wire repeater. This number appears to be fairly modest in comparison with what was permitted in the past. That the number must be restricted is a matter of the problem of stability i.e. the risk of self oscillation (singing) due to mismatch between in balances and lines. Unfortunately this risk is unavoidable but in this field there has been lively activity by inventors with more or less fantastic suggestions to replace the hybrids of the 2-wire repeater with something else and in general with something appreciably more complicated, while the risk of self oscillation remains or has been made worse. As one cannot lift oneself by one's own shoelaces, these solutions have shown themselves to be worse and more complicated, i.e. more expensive, than a common 2-wire repeater. The only exceptions are so-called negistors (negative impedance repeaters) where one has a certain choice as far as their disadvantages are concerned. Negistors have not been used in our network. About half the number of our 2-wire repeaters are terminal repeaters at transit exchanges for 4-wire transmission. These repeaters, of course, have only one hybrid. In these cases negistors cannot be considered.

It is well-known that transistors are used instead of election tubes in recent designs of 2-wire repeaters and carrier equipment. The number of electron tubes in our junction line network is at present of the order of 200 000, but the number should decrease successively as the earlier transmission equipment is gradually replaced by more modern types using transistors.

Probable Future Development

It is always a delicate matter to express oneself about the future, and it is well known that fact usually surpasses fiction (the prognoses).

For the immediate future, however, one is on fairly safe ground. Loaded cables will still be installed and more modern loading systems will be introduced for the shorter circuits in the junction line network, whereas carrier systems will dominate the longer circuits. The boundary length should continue to decrease but at an ever-decreasing rate so that carrier systems gradually penetrate further into the network, but special short-haul systems for more general applications will probably not see the light of day.

The expansion in the immediate years of the long distance network proper will be mainly in accordance with the so-called PM 9 plan. According to this plan, radio links will be used on certain routes whereas the majority of the coaxial cables will be modified for use up to 12 Mc/s by replacing the coaxial repeaters. According to the relevant prognoses, this network will transmit about 9 million km of carrier circuits, 25 percent of which will be on radio links and the rest mainly on 12 Mc/s coaxial cable systems. This should cover requirements for a long time ahead, but if the trunk network even in the future continues to grow as fast as shown in fig. 2, the network will be operating at full capacity already at the end of the 1960's, i.e. just when it has been completed.

The next stage of expansion should include certain increases in the number of radio link systems, but also a further widening of the coaxial systems is expected, this time to 50 Mc/s corresponding to about 10 000 carrier circuits per tube pair. The coaxial repeaters will probably be transistorized and the repeater spacing will be short–1.5 to 2 km. These systems will not appear until about 1970 which, in accordance with the above, means that they will just coincide with their need. Even in the circuit provision field, it appears to be difficult to fill the gap. It can be said in this connexion that in the carrier field it has never been practically possible for us to have any trial plant on a small scale, but due to continual scarcity of circuits we have been forced to install right from the beginning to the full extent all new systems which have also arrived close on each other. Very often the new systems have also had their debut in Sweden. The new installations have in addition often been loaded to capacity very early on due to limitations of circuit demands on different routes. Of course this means good economics but the conditions have meant great strains and great risks of making incorrect judgements and mistakes. The coaxial system for about 50 Mc/s should be the last stage of development for coaxial tubes of 9.5 mm diameter as very strong technical reasons point against a further expansion.

On carrier routes with a smaller number of circuits, small diameter coaxial cables should come into use to a greater extent than predicted earlier and their frequency band should be increased to at least 4 Mc/s corresponding to about 900 circuits per tube pair.

Waveguides can come into the picture in the future for long distance purposes in addition to the above-mentioned transmission media. The waveguides now being worked on in several development laboratories are circular tubes of about 50 mm diameter. One tube is required for each direction of transmission but possibly a single tube can be used for the two directions of transmission on different frequency bands and separated at the repeaters by filters. The inside of the tube is specially prepared. Very high frequencies can be transmitted with relatively low attenuation. A frequency band of about 35–1 000 Gc/s is planned to be transmitted and the repeater spacing is of the order 20 km. The repeaters are expected to be rather complicated with possibly 20 amplifiers in parallel, each amplifier for its part of the band. Pulse code modulation will be used for complete carrier groups of circuits, the present supermastergroup probably being the most suitable unit. The maximum number of circuits should be of the order of 200 000. It is peculiar that in several different places, work has been going on for a long time on waveguides, but it is only relatively recently on Swedish initiative that work has started on a more closely lying coaxial system for 50 Mc/s. The step from 12 Mc/s to waveguides appeared to us to be all too wide to be taken directly and a further widening of the coaxial cable frequency band to 50 Mc/s appears to be a suitable transition stage.

It can be of interest to compare these two future transmission systems with each other. The comparison must be made very generally as none of these systems is fully developed. In the waveguide alternative according to the above a maximum of 200 000 circuits is transmitted. For the same traffic capacity in the coaxial cable alternative, 20 tube pairs of normal coaxial cable would be required, this giving 10 000 circuits being transmitted per tube pair. The total cross-sectional area for "the cables" is approximately the same in both cases and the cost can therefore be expected to be roughly the same but probably with a slight preponderance for the coaxial cable alternative. This is, however, long from being optimum design and another alternative with, for example, 6 coaxial tube pairs of larger diameter is probably more economic. Both types of cable are very awkward. The waveguides must be laid out practically straight and only very large bending radii can be permitted. They can therefore not be brought into large cities (in blocks) but must terminate outside and entrance made with, for example, 50 Mc/s coaxial cables. In addition, in both alternatives 20 amplifiers each for 10 000 circuits would be required per repeater station but the distance between repeaters would be about ten times greater in the waveguide alternative. On the average, these amplifiers would be more complicated. The total cost is estimated to be higher for the coaxial alternative when fully built out but the costs can be expected to be of the same order of magnitude. However, the coaxial alternative has certain advantages. Branching and inclusion of pairs in the same cable can be more easily arranged in this alternative and the entrance arrangements to cities as mentioned above are easier. Probably too, 200 000 circuits will be too great a capacity in the future and the costs of the coaxial alternative fall appreciably with a smaller number of tubes. For example Stockholm requires three high-capacity routes for long distance traffic namely to Gävle, to Örebro and to Norrköping. If each of these is provided with 200 000 circuits, Stockholm will then have 600 000 long distance circuits which undeniably seems rather large for a city of about 1 million inhabitants.

Thus if the demand for circuits including new future demands for wideband circuits e.g. for data, TV + speech connexions etc., do not continue to increase as rapidly as at present but gradually stabilize at a fair level, it appears that waveguide installations will not be probable as far as Sweden is concerned. On the other hand, possibly the waveguides and particularly the intermediate repeater costs will not be so great and then, despite everything, this alternative will become more favourable than new coaxial installations even with appreciably lower traffic capacity. Under all conditions, however, a widening of existing installations is a necessary first stage measure.

Some Reactions of Telephone Users during Conversation

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This article deals with some results obtained at L M Ericsson in opinion tests of telephone circuits. The main object of the experiments was to determine the optimal attenuation conditions for a telephone connection. They were carried out between 1958 and 1962.*

The problem of determining the quality of transmission on a telephone circuit is as old as the telephone itself. This study, extending over several years, was made in order to determine the increased amount of attenuation which could be inserted in a circuit when the quality or level had been improved on any part of the circuit. The technique of quality evaluation, however, has undergone great changes in the last five to ten years. Quality improvements in different parts of the equipment on a telephone circuit need no longer necessarily be compensated by an equivalent attenuation. Improvements already introduced, and many others which may follow in future, will reduce both the attenuation and circuit noise, and will thus result in a better quality of transmission for the subscriber.

With these facts in mind it would appear to be important to chart the optimal transmission conditions for the subscriber. The only "old" method still in general use for evaluating transmission quality is the determination of reference equivalents relative to a given reference system such as SFERT (Système Fondamental Européen de Référence pour la Transmission téléphonique), or NOSFER (Nouveau Système Fondamental pour la détermination des Equivalents de Référence),[1] or relative to 1 metre air path.[2] These reference equivalents, based on volume tests, constitute the parameter against which the quality of transmission is assessed.

Sophisticated articulation tests with well trained groups of experimental subjects can only be used to assess differences between poor circuits, circuits which need no longer or should not be offered to a telephone user. The aim in the methods used today must therefore be to measure users' reactions to different types of circuits and, on the basis of the results, to ensure that the greatest number of users enjoy transmission conditions to which they do not react at all. In other words, the user's attention should be concentrated on the transmission and reception of information and not on the condition of the circuit.

To meet these goals the assessment of circuit quality must be concentrated on finding the lower limit for the optimal transmission conditions. The fundamental principles for this treatment of the speech transmission problem were developed by RICHARDS & SWAFFIELD of the B.P.O.[2, 3] The results presented in this article were obtained in studies based on the methods of Richards and Swaffield.

* Based on paper presented at Second Symposium on Human Factors in Telephony, Copenhagen, September 1963.

Experimental Conditions

The telephone connections used in the various series have been established between modern telephone instruments connected to a local exchange by a line consisting either of a 3 km 0.6 mm cable or of a 5 km 0.5 mm cable. The sidetone attenuation, which is of course of great importance, has been kept constant in all tests at 20 db measured acoustically from transmitter to receiver. The tests were made in the form of conversation tests, consisting of the description of figures produced by joining randomly plotted points on a polar diagram. The speaker had three of these figures and the listener twelve. The speaker described his three figures in his own words until the listener could identify them among the twelve presented to him. This procedure generally took from three to six minutes. After the conversation the participants were asked to assess the quality of transmission in terms of the following five categories:

Excellent	4
Good	3
Fair	2
Poor	1
Bad	0

The categories were allotted weighting numbers as above to permit calculation of a mean opinon score for each circuit.

The participants in the tests were L M Ericsson employees, some white collar and other factory personnel. None of the participants had been directly concerned with transmission questions in his normal work. They may therefore be assumed to represent ordinary telephone users.

In some of the tests the speaker was given a list consisting of 25 phonetically balanced Swedish words. After solution of the figure problem the speaker read out the list of words and the listener wrote down the words he or she had heard.

In these articulation tests the speaker chose his own volume of speech. The volumes in the conversation and articulation tests were measured at the local exchange with a *VU* meter.

Results

In opinon tests of this type the telephone user's reactions can be described in different ways. They may be classified in at least two forms, namely as conscious and unconscious reactions. The conscious reaction is expressed by the score the user allots to a particular circuit. But his judgment may be affected by different factors. Every participant in the test is, of course, biased by the quality of transmission he is accustomed to when using his own telephone. This might lead to a higher or lower score being awarded than the circuit deserves. An opinion score can therefore never be regarded as an absolute but solely as a relative measure of quality. A transmission condition which is today adjudged to be "Excellent" may in a few years, when the user has become used to a better quality, be considered only "Fair".

Unconscious reactions, on the other hand, must be regarded as of extreme significance. One such unconscious reaction is the speech volume, or rather the change of volume that takes place during a conversation or during conversation on different circuits.

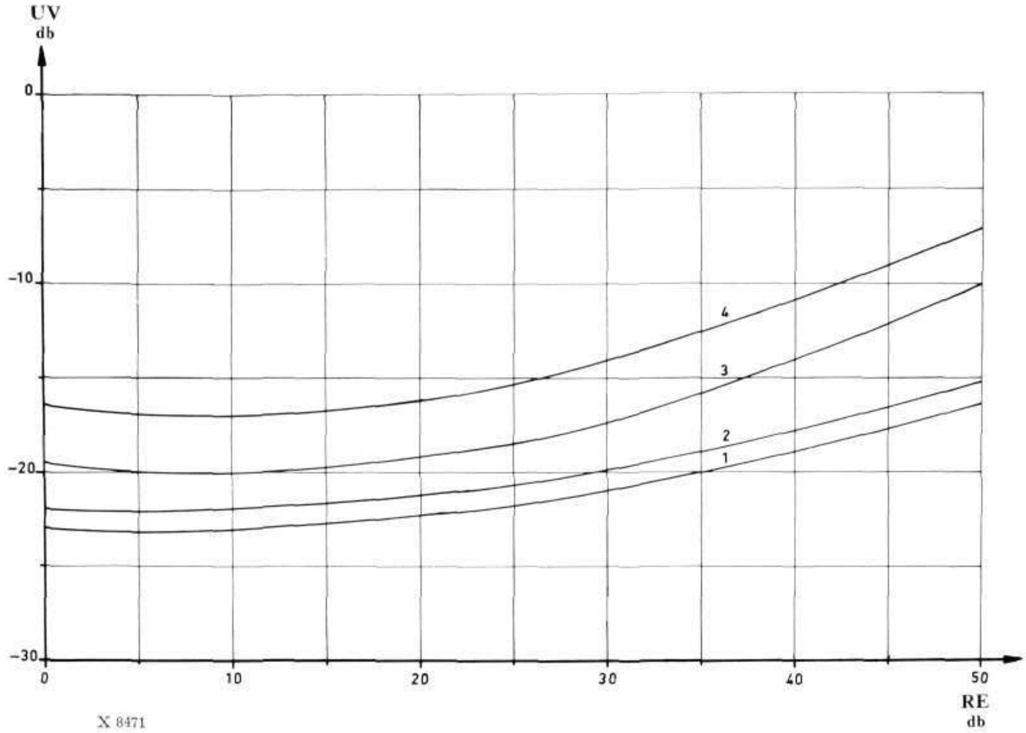


Fig. 1

X 8471

Transmitted volume measured in the local exchange as function of the overall reference equivalent (RE)

1. No room noise
2. Room noise 40 db
3. » » 50 db
4. » » 60 db

Fig. 2

X 8472

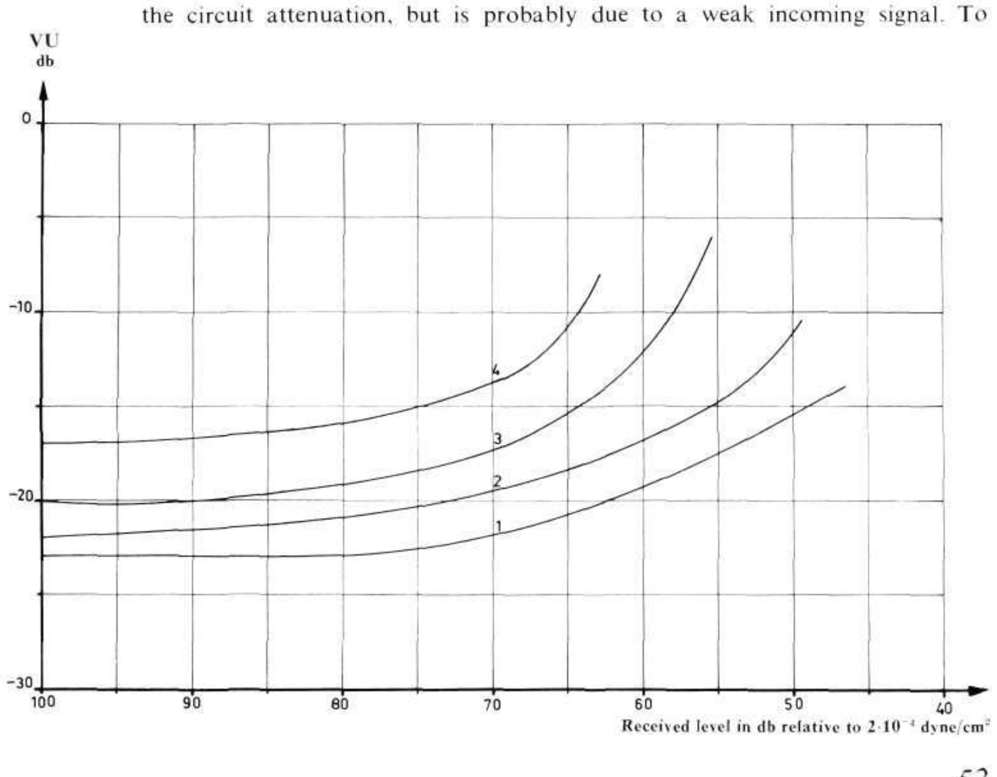
Transmitted volume measured in the local exchange as function of received speech level

1. No room noise
2. Room noise 40 db
3. » » 50 db
4. » » 60 db

Fig. 1 shows the variation in mean transmitted volume measured in the local exchange as function of the overall reference equivalent relative to SFERT or NOSFER at different levels of room noise. The results may be summarized in the following equations:

$VU = -23 + 0.0033\ (X-5)^2$	No room noise		(1)
$VU = -22 + 0.0033\ (X-5)^2$	Room noise	40 db	(2)
$VU = -20 + 0.0060\ (X-9)^2$	» »	50 db	(3)
$VU = -17 + 0.0060\ (X-9)^2$	» »	60 db	(4)

The relations illustrated in fig. 1 and in eq. 1–4 show that the user attempts to compensate for part of the increased circuit attenuation and room noise by raising his voice. This reaction is naturally not a direct consequence of the circuit attenuation, but is probably due to a weak incoming signal. To



verify this assumption, a study has been made of the transmitted volume as function of the received acoustic speech level in db relative to $2 \cdot 10^{-4}$ dyne/cm^2.

Fig. 2 shows that at moderate room noise up to 40 db the transmitted volume increases by about 0.2 db for a drop in received level of 1 db. For room noise between 50 and 60 db the increase of volume is more marked, especially for a decrease in ratio between received level and room noise. This marked increase of volume comes when the ratio decreases by more than 20 db. The ratio between received acoustic level and room noise may therefore be regarded as the point at which "talking effort" starts.

The result shown in fig. 2 can also be studied in regard to the optimal received level. According to an investigation by Munson & Karlin[4] of the preference level for different received acoustic levels at varying noise levels, the optimal received level lies within the range 80–90 db relative to $2 \cdot 10^{-4}$ dyne/cm^2. This result has been analysed by Ericsson[5] as regards the relation between received level and overall reference equivalent. This optimal received level is verified by the results in fig. 2. Based on the criterion of "incipient talking effort" the lower limit for optimal volume would appear to be about 75 db relative to $2 \cdot 10^{-4}$ dyne/cm^2. The corresponding increase of volume starts, according to fig. 1, at an overall reference equivalent relative to SFERT of about 25–30 db depending on the level of the room noise.

In the foregoing the user's volume has been studied in relation to the change in received level, generally on account of increased circuit attenuation or impaired reference equivalent. Unfortunately there may also be circuit noise on the connection, differing in frequency and level. It may therefore be of interest to see how the volume is affected by varying circuit noise. The type of circuit noise studied has been continuous white noise. Our investigations have shown that the volume employed is not noticeably affected by received noise levels below about 45 db relative to $2 \cdot 10^{-4}$ dyne/cm^2, corresponding to a circuit noise level of about -63 dbm measured in the receiving local exchange. The transmitted volume starts to be affected when the ratio of received speech level to noise level falls below 25 db. The results have shown that the change in transmitted volume, ΔVU, at received noise levels above

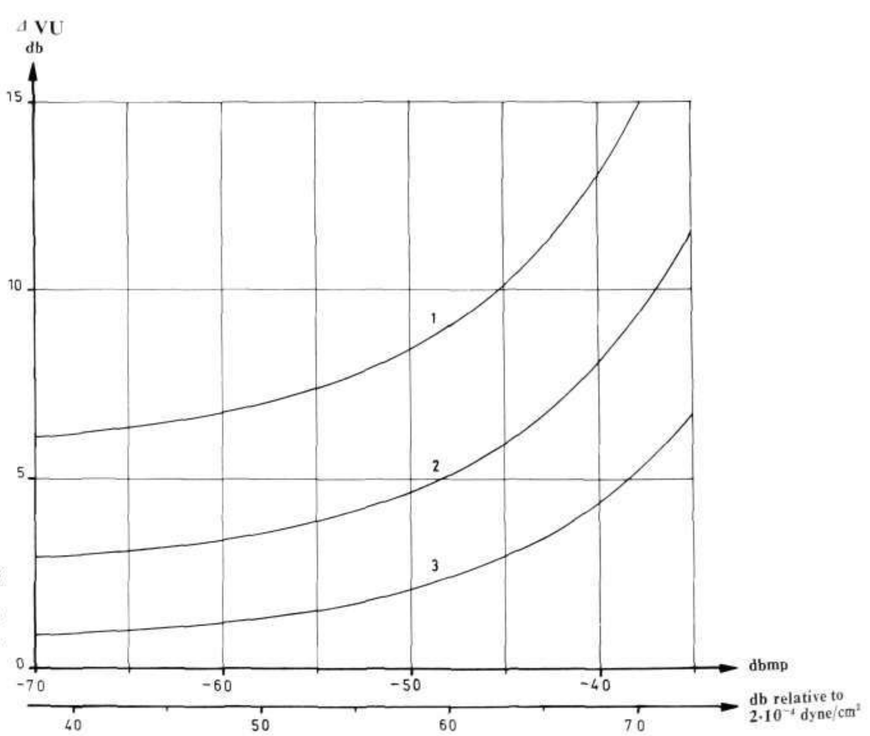


Fig. 3 X 8473

Increase of speech volume as function of noise level measured in the local exchange and in the receiver.

1. Overall reference equivalent = 40 db
2. » » » = 30 db
3. » » » = 20 db

45 db relative to $2 \cdot 10^{-4}$ dyne/cm^2 takes place exponentially according to the equation.

$$\Delta VU = 10 \cdot X \cdot e^{\frac{N}{10}} \tag{5}$$

where X is the overall reference equivalent relative to SFERT and N is the circuit noise in dbm measured in the local exchange. Eq. 5 can also be expressed by

$$\Delta VU = 10 \cdot X \cdot e^{\left(\frac{L-108}{10}\right)} \tag{6}$$

where L is the acoustically received noise level in db relative to $2 \cdot 10^{-4}$ dyne/cm^2. Fig. 3 shows the change of speech volume as function of the noise level at different reference equivalents.

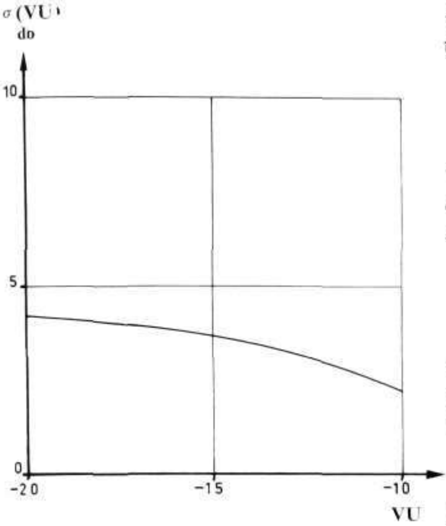


Fig. 4 X 2764

Change of mean deviation (σ) of speech volume as function of the speech volume employed

The result as shown in figs. 1 and 2 reveals, as previously mentioned, a lower limit for relatively optimal transmission conditions at overall reference equivalents of 25–30 db, depending on the room noise. As fig. 3 shows, the same condition is fulfilled at a reference equivalent of 20 db and noise level of – 50 dbm, corresponding to a received acoustic noise level of about 60 db relative to $2 \cdot 10^{-4}$ dyne/cm^2. The combined result, which indicates the change in volume, ΔVU, for simultaneous change of the overall reference equivalent (X) and of the noise level (N) measured in the local exchange, can thus be summarized as shown in eq. (7) relating to 50 db room noise:

$$\Delta VU = 0.006\,(X-9)^2 + X \cdot 10 \cdot e^{\frac{N}{10}} \tag{7}$$

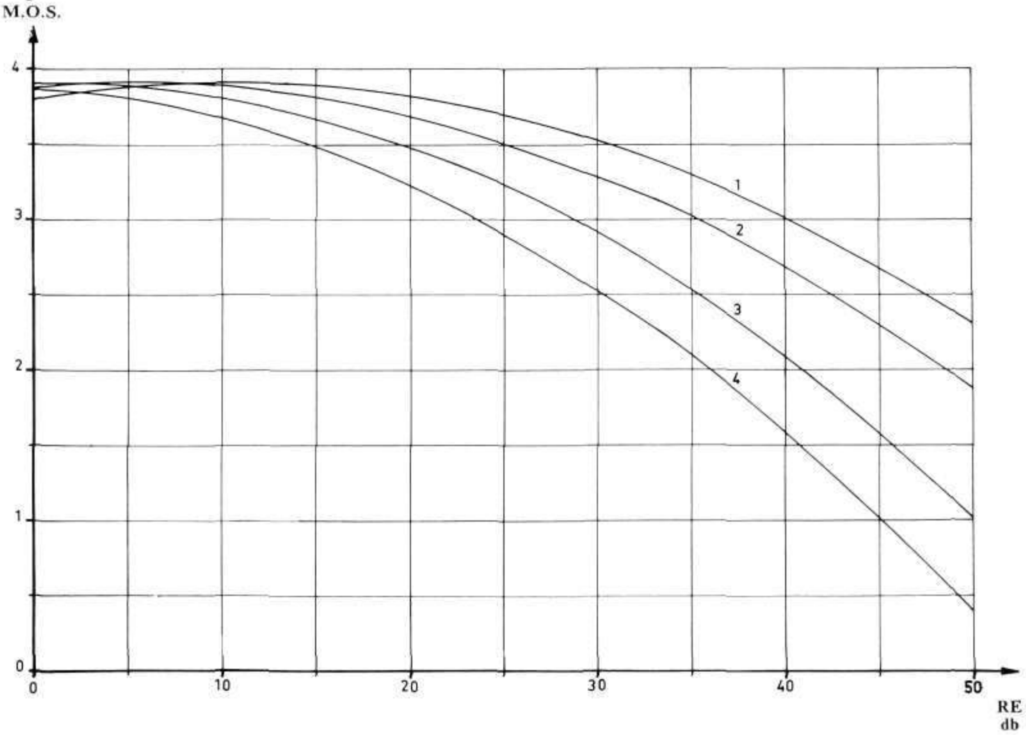
In a comparison between the present results and the iso-opinion contours reported by Ericsson[5] at different reference equivalents, the following points should be noted.

For the relevant types of receiver a noise spectrum level of 0 db corresponds to an acoustic noise level of about 30 db, both relative to $2 \cdot 10^{-4}$ dyne/cm^2. Furthermore the ratio of received acoustic noise level to circuit noise level measured in the receiving local exchange may vary by a few db depending on the efficiency of the receiver.

Fig. 5 X 8474

Mean opinion score (M.O.S.) as function of the overall reference equivalent (RE)

1. No room noise
2. Room noise 40 db
3. » » 50 db
4. » » 60 db



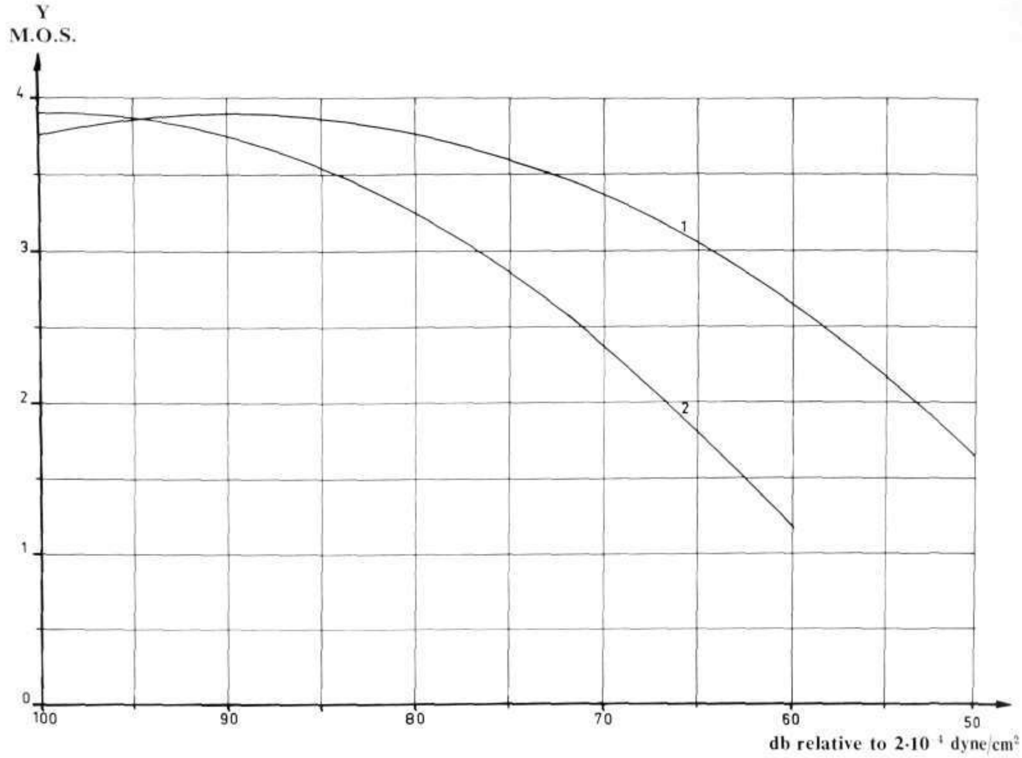


Fig. 6 X 8475

Mean opinion score as function of received speech level

1. Room noise 40 db
2. » » 50-60 db

A telephone call is not usually made solely in order to convey information in the form of words or sentences. Quite a lot of information can be communicated if the conversing parties can make felt some of their mood or temper at the moment. One way of conveying such information is to raise or lower the voice. The ability of the speech link to serve this purpose is reflected in the variations of volume during the conversation. Fig. 4 shows the mean deviation (σ) of the volume as function of the volume employed. This shows that if the quality of the link has forced the speaker to increase his volume by more than 3–4 db, the standard deviation of the volume successively decreases the greater the increase of volume. The reduction of the mean deviation of the volume seems to start when the overall reference equivalent exceeds about 30 db or when the received level is below 70–75 db relative to $2 \cdot 10^{-4}$ dyne/cm^2 (fig. 4).

As already noted, the subjects were asked to express their opinion on the circuit after completion of the conversation test by placing it in one of five quality classes. From the individual opinion scores a mean opinion score Y was calculated. The results are shown in figs. 5 and 6. Fig. 5 shows the mean opinion score (Y) as function of the overall reference equivalent (X). To these results has been fitted a function of the form

$$Y = \alpha + \beta\,(X + \gamma)^2 \qquad (8)$$

The equations for the various transmission conditions are as follows:

$Y = 3.9 - 0.0010\ (X-10)^2$	No room noise	
$Y = 3.9 - 0.0010\ (X-5)^2$	Room noise	40 db
$Y = 3.9 - 0.0012\ (X-1)^2$	» »	50 db
$Y = 3.9 - 0.0012\ (X+4)^2$	» »	60 db

It was found earlier in studies of the transmitted volume that the reaction was dependent on the level received. One may expect the same to apply to the mean opinion score. To verify this, the listeners' opinion scores have been analysed separately and compared with the received levels measured on each occasion. In this analysis room noise levels ≤ 40 db and within the range 50–60 db are considered separately. The results are shown in fig. 6.

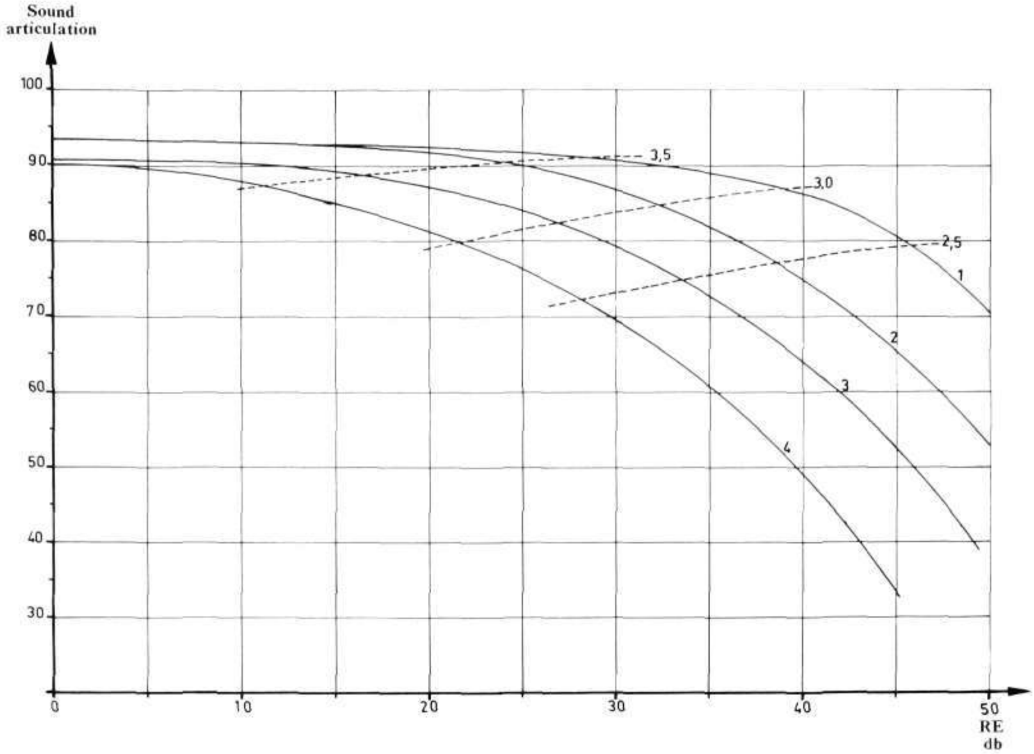


Fig. 7

X 8476

Sound articulation as function of the overall reference equivalent (RE)

1. No room noise
2. Room noise 40 db
3. » » 50 db
4. » » 60 db

The equations fitted to these measured results were found to be of the form

$$Y = 3.9 - 0.0014\ (90-L) \quad \text{Room noise} \leq 40 \text{ db}$$
$$Y = 3.9 - 0.0017\ (100-L) \quad \text{»} \quad \text{»} \quad = 50\text{–}60 \text{ db}$$

where L is the received level in db relative to $2 \cdot 10^{-4}$ dyne/cm^2.

As already mentioned, after some of the conversation tests the subjects carried out an articulation test. The results of these tests are shown in fig. 7 with sound articulation as function of the overall reference equivalent.

In analysing these results attention must be paid to the rather unusual method employed for the tests. The participants were completely untrained in the test procedure and the speaker spoke only a single word without explanatory phrase. The speaker was free to use the volume of his choice but was naturally influenced by the conditions prevailing during the prior conversation on the circuit. The object of this special method was to obtain limit values for the optimal transmission conditions and not to prove that a high circuit attenuation can also provide acceptable articulation values.

To confirm that a given relation exists between articulation sound and mean opinion score (Y), lines representing the same mean opinion scores are drawn in fig. 7. It is clearly evident that a given mean opinon score is associated with a given sound articulation, and this can therefore be taken as criterion for describing a particular transmission condition.

But it is remarkable, too, that even at so relatively high a mean opinion score as 3—a "good" circuit—some deterioration of the intelligibility starts to become noticeable.

The results reported above are summarized in the table on the next page, which is an attempt to describe the transmission conditions for a modern telephony link. The criteria in the table for listening effort and talking effort are defined as follows.

A slight listening effort is required when the sound articulation has fallen by 5–10 % which, according to the present results, occurs at a mean opinion score of $Y = 3.0$.

A considerable listening effort is required when the sound articulation has dropped by 10–20 % which, according to the present results, occurs at a mean opinion score of $Y = 2.5$. For a mean opinion score < 2.5 a very considerable listening effort was required.

A slight talking effort is required if the mean speech volume has risen by 4–7 db relative to the optimal conditions employed.

A considerable talking effort is required if the mean speech volume has risen by more than 7 db or when the mean deviation of the speech volume has decreased by more than 1 db.

Mean opinion score Y	Overall reference equivalent RE db	Room noise db rel. $2 \cdot 10^{-4}$ dyne/cm²	Received speech volume db rel. $2 \cdot 10^{-4}$ dyne/cm²	Listening effort	Talking effort
3.5	0—25	≤ 40	90—80	None	None
3.0	25—33	≤ 40	80—65	Slight	None
2.5	33—40	≤ 40	65—58	Considerable	Slight
3.5	0—19	50	100—85	None	None
3.0	20—28	50	85—75	Slight	None
2.5	29—35	50	75—65	Considerable	Slight
3.5	0—10	60	100—90	None	None
3.0	11—22	60	90—80	Slight	None
2.5	23—30	60	80—70	Considerable	Slight
2.0	36	60	< 70	Very Considerable	Considerable

The tabulated transmission conditions afford clear indications of the attenuation range that can be regarded as optimal for telephony. Based on the conditions at 50 db room noise, overall reference equivalents of 0–20 db, corresponding to a received speech level of 100–80 db relative to $2 \cdot 10^{-4}$ dyne/cm², represent the conditions which can in no case give rise to subscribers' complaints. In the future planning of networks, therefore, it should be a desideratum that this overall reference equivalent be maintained for the greatest possible number of circuits. Having regard to existing networks and equipments, it will certainly be difficult within the foreseeable future to attain this optimal range for all circuits. But any measure that can guarantee a maximal reference equivalent of 30 db would seem to be extremely desirable if there is to be a certain safeguard against subscriber complaints. The measures that may be required to attain these conditions will in the long run undoubtedly bring an appreciable financial yield. Experience shows that an improved quality of transmission, especially over large geographical distances, increases the frequency of calls.

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The mini-BX, a Miniature PABX

O SIEWERT & E SUNDT, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.25
LME 8372

L M Ericsson's new series of small PABX covers a range comprising 2–6 extensions and 1–2 exchange lines. Since the exchanges are designed for the very smallest private telephone installations and are themselves of small dimensions, they have been called mini-BX (mini-Branch Exchange).

There are innumerable small offices and shops as well as large private houses which need more than one telephoning point, with one or possibly two lines to the public exchange.

The primary requirements in such cases are that it shall be possible to initiate and receive external calls at any extension instrument, to transfer these calls to another extension when desired, and to make internal calls between the extensions.

All these requirements are fully met by the mini-BX series.

Characteristic Features

Since a telephone system of this capacity will normally not have an operator to deal with incoming calls, in the mini-BX system these calls are signalled on one or more bells which are connected to a separate "ringing circuit" and can be answered from any extension. If, after office hours or for a special reason, it is desired that incoming calls shall be directed to a particular extension, this can be arranged. In such case the incoming call rings the extension's ordinary bell.

Outgoing calls via the public exchange are set up by brief depression of an "earth button" on the extension instrument. This method of calling the exchange lines is utilized to ensure full accessibility both for outgoing and incoming calls even when the internal connecting circuit is engaged.

During conversation with an outside subscriber, the line can be held while an enquiry call is made to another extension, or the subscriber may be transferred to that extension. An enquiry call is initiated by brief depression of the earth button followed by dialling of the wanted number. An enquiry call has priority and the enquiring extension can thus enter a circuit that is already engaged. When the called party has answered, the call can be transferred simply by replacement of the enquiring extension's handset.

Internal calls are dialled in the ordinary way. With all types of mini-BX an internal call can be established even when the public exchange lines are engaged (except in the 2-line unit in which, of course, only one conversation can be in progress at a time).

The mini-BX systems can be used either as independent *PABX* with direct connection to a public exchange or as sub-exchanges to other *PABX* or *PAX*. In the latter case the mini-BX constitutes a switching unit for a department or group of people who can communicate with the remainder of the internal telephone system via "exchange lines".

Certain extensions may, if desired, be debarred from making outward calls. Alternatively a subscriber's meter can be provided for each extension for metering of trunk calls, or a simple trunk discrimination equipment can be installed which denies extensions the use of trunk lines.

An indispensable requirement in the design of the mini-BX series has been the elimination of all need for preventive maintenance. For this reason the switching elements consist solely of relays, and these have been given such ample margins that they function reliably even under conditions of widely fluctuating mains voltage. Since the exchanges are designed to be supplied via a battery eliminator, no batteries are required which would demand attention. In case of power failure, supervisory relays automatically through-connect the public exchange lines to specific extensions. Other important factors which ensure reliable operation of the mini-BX is that the resistance of the extension lines may vary between 0 and 1 000 ohms, excluding the extension instrument, and that the earth circuit resistance may be as high as 200 ohms.

A telephone installation of mini-BX type has normal telephone instruments with earth button and a simple "star-pattern" reticulation. Should the system need to be altered or extended at some future time, the existing wiring and telephones can be retained and additional equipment added as required.

In this respect the mini-BX differs greatly from systems with individual switching in each instrument, which have hitherto been used to a great extent for private telephone installations of this size and which require special telephones with a number of lamps and complicated push-button systems as well as expensive multiwire cabling.

Thanks to these various measures and the high reliability of the mini-BX systems, it may be expected that they will require practically no maintenance.

Types

The mini-BX series comprises the following types:

AMD 516,	6	extensions	and	2	exchanges	lines
AMD 512,	5	,,	,,	1	,,	line
AMD 503,	3	,,	,,	1	,,	,,
AMD 501,	2	,,	,,	1	,,	,,

6-line type AMD 516

The trunking diagram is shown in fig. 1. Of special interest is that the register and the enquiry relay set have been made as a single unit since the utilization time for these is extremely short in an installation of this size.

When an extension raises his handset, he is connected to the register *REG* via the connecting circuit *SR*. On an internal call periodic ringing signals are extended via the register and connection is established on receipt of an answer. To make a call to a public exchange subscriber, the extension presses the earth button whereupon the connecting circuit and register are released and the extension is through-connected to a free exchange line.

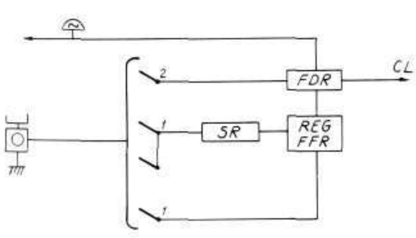
If the internal connecting circuit or the register is engaged when an extension raises his handset but there is a free exchange line, the extension hears a ticking tone and can obtain access to an exchange line by pressing the button.

Outgoing calls are thus not prevented by the engagement of a connecting circuit or register. If all exchange lines are engaged when the extension presses his earth button, normal busy tone is returned.

Incoming calls are signalled, as already stated, on one or more separate bells and can be answered from any extension by pressing the earth button. These calls as well are therefore unaffected by the condition of the internal connecting circuit.

If one wishes—for example after office hours—that an incoming call shall be answered from a particular extension which may be at a distance from the exchange, this can be arranged by means of alternative switching facilities. Incoming calls are then signalled on the extension's own bell. If the extension is engaged, a warning tone is sent to the conversing parties and the call is put through as soon as the conversation is concluded. The change-over between the alternative facilities is done with a simple switch.

If an incoming call is to be switched to another extension, this is done by the enquiry and transfer procedure. When the key for this purpose is momentarily pressed, an enquiry call is set up via the *REG-FF* link and is therefore unaffected by the state of the connecting circuit. Transfer is effected when the wanted extension has answered and the calling extension has replaced his handset. If the wanted extension is engaged, the caller hears busy tone but can enter the circuit by dialling a digit. Warning tone is then heard by the conversing parties. If the called extension replaces his handset, he is automatically rerung and the enquiry call is put through as soon as he raises his handset again.



X 2766

Fig. 1
Trunking diagram for AMD 516

CL exchange line
FDR exchange line equipment
SR internal connecting circuit
REG register
FFR enquiry relay set

In the rare cases when the *REG-FFR* link is engaged by another enquiry call, the enquiring extension is connected into the circuit concurrently with the issue of warning tone and can request that the conversation be expedited.

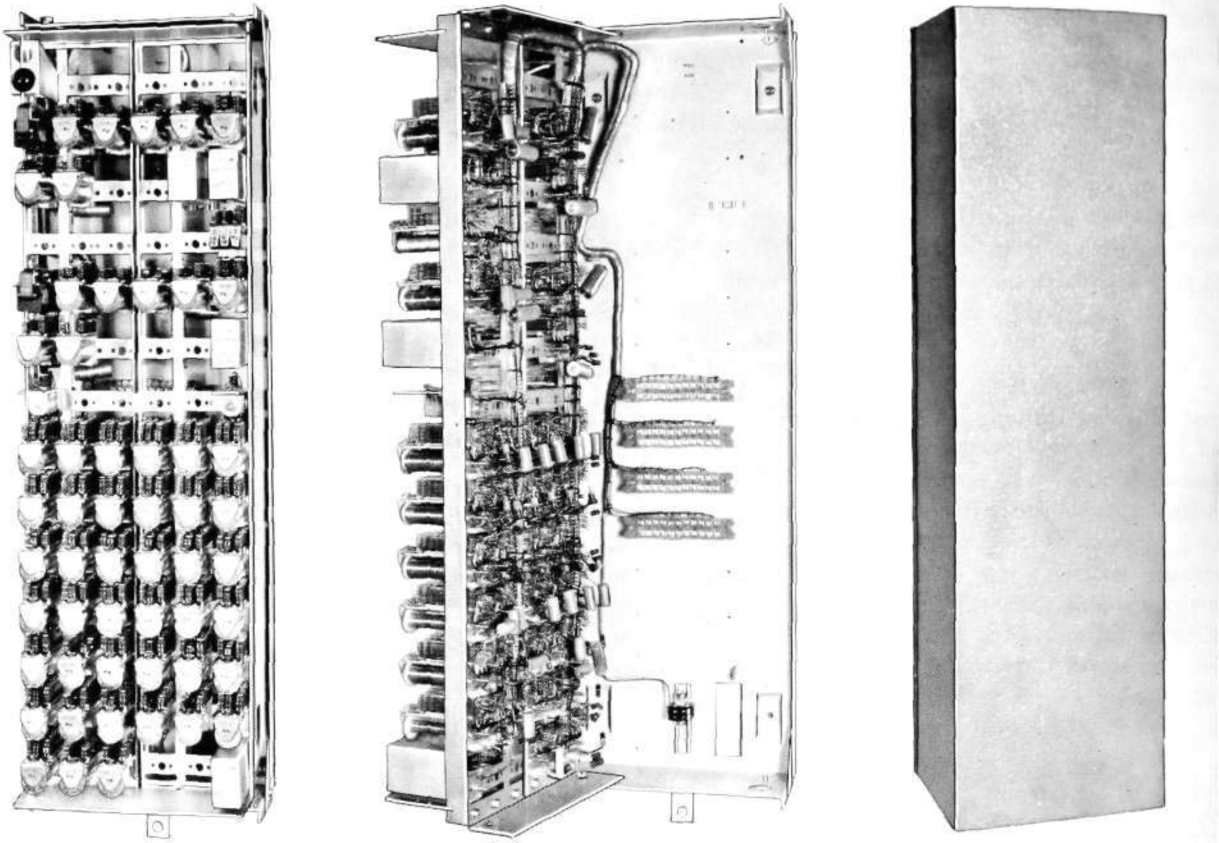


Fig. 2 X 7905

AMD 516

left, front view
centre, with front swung out
right, with cover in position

As will be seen from fig. 2, the relays and other switching elements are fitted on and permanently wired to a frame which is hinged to a sheet iron back-plate for wall mounting. The back-plate has connecting strips for termination and jumpering of the lines. The entire switchboard is protected by an aluminium-enamelled sheet metal cover.

The battery eliminator unit is designed for location separately from the switchboard. A suitable unit is *BMN 2424* which has tappings for 100–240 V, 50/60 c/s, and—in addition to 48 V operating voltage—supplies ringing current and tones.

5-line and 3-line types AMD 512 and AMD 503

These two types have largely the same traffic facilities as the 6-line *AMD 516*.

Their trunking diagram is shown in fig. 3.

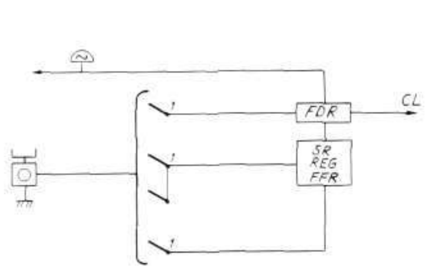


Fig. 3 X 2767

Trunking diagram for AMD 512 and AMD 503

CL exchange line
FDR exchange line equipment
SR internal connecting circuit
REG register
FFR enquiry relay set

Internal and external calls are connected in exactly the same way as in *AMD 516*. The accessibility of the various switching paths is therefore as good as in the latter type.

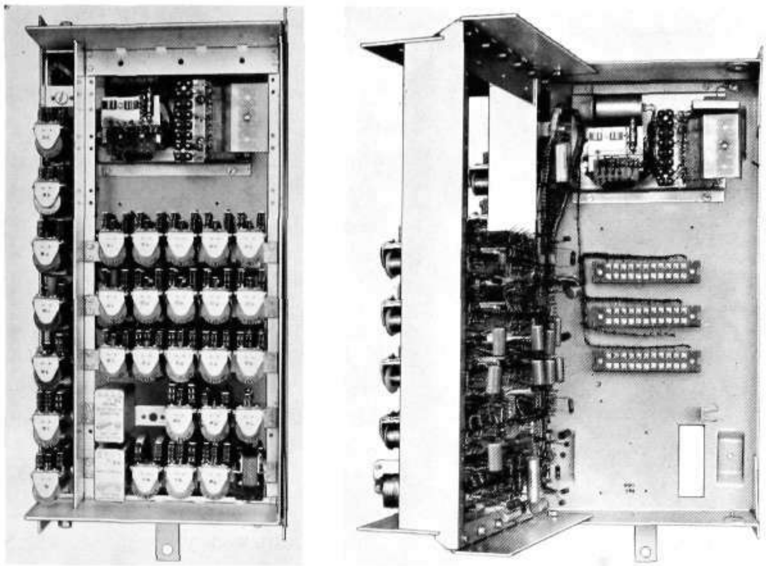


Fig. 4
AMD 512
left, front view
right, with front swung out

X 8477
X 8478

It is only in respect of enquiry and transfer calls that—on grounds of economy—a certain combination of different functions has been adopted. In *AMD 512* and *AMD 503* both the connecting circuit and the register-and-enquiry equipment are combined as one unit. This may be considered a completely warranted measure in view of the small number of extensions (3–5) and small traffic (1 exchange line and 1 internal connecting circuit), and since there would probably be very few occasions when an enquiry is made or a call is transferred while an internal call is in progress. In the 5-line exchange there is a theoretical possibility of disturbing an internal conversation when an enquiry is made to a third extension. In the 3-line exchange, however, an enquiry must obviously relate to one of the two conversing parties.

On the rare occasions when the internal connecting circuit is engaged when an enquiry call is made, the enquiring extension is connected to the circuit concurrently with the issue of warning tone and can request that the conversation be concluded or can break it down by dialling a digit and then completing the enquiry and transfer.

Like *AMD 516*, the 5- and 3-line systems have facilities for directing incoming calls to a particular extension instead of signalling them on separate bells. But, unlike *AMD 516*, the latter systems require an auxiliary equipment for this purpose.

AMD 512 is equipped for 5 extensions, 1 exchange line and 1 internal circuit. *AMD 503* is designed for 3 extensions, but has otherwise the same traffic equipment.

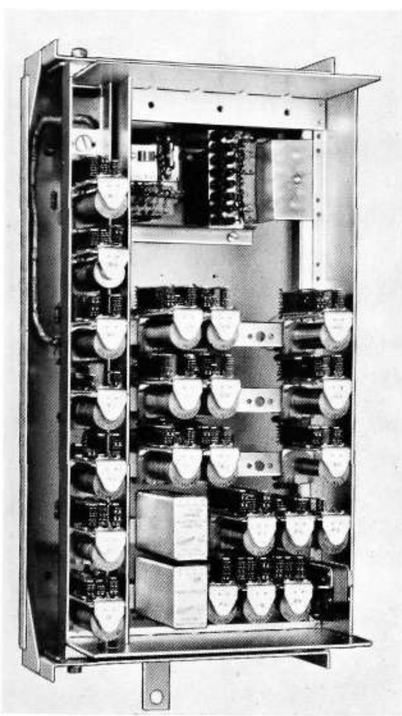


Fig. 5
AMD 503, *front view*

X 2769

The mechanical structure of the switchboards will be seen from figs. 4 and 5. All relays and other switching elements are fitted to a frame which is hinged to a sheet iron back-plate for wall mounting. On the back-plate are a battery eliminator and connecting strips for termination and jumpering of the lines. The battery eliminator has tappings for mains voltages of 110–240 V, 50/60 c/s, and—in addition to the nominal operating voltage of 48 V—supplies the ringing current and tones.

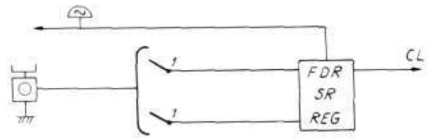


Fig. 6 X 2768
Trunking diagram for AMD 501

CL exchange line
FDR exchange line equipment
SR internal connecting circuit
REG register

2-line type AMD 501

Since this type is designed for only 2 extensions and 1 exchange line, more than one conversation can never be conducted simultaneously. All traffic functions are therefore combined in a single relay set as seen from the trunking diagram in fig. 6. The relay set is accordingly used not only for internal and external calls, but also for enquiry and for transfer of an external call to the other extension.

Internal calls are set up by dialling digit 1, whereupon a ringing signal is sent to the other extension. If the other extension is engaged, no tone is returned. Outgoing calls are initiated by momentary depression of the earth button. Incoming calls are signalled on one or more separate bells and can be answered from either telephone by pressing the earth button. By means of an auxiliary equipment, incoming calls can be directed to a given extension in this system as well.

If an external call arrives while an internal conversation is in progress, it is signalled on the separate bell. The internal call must be terminated and the external call can then be answered from either extension.

Enquiry calls and the transfer of an external call to the other extension are initiated by momentary depression of the earth button and dialling one digit. Transfer is effected when the extension answers and the caller replaces his handset.

The relay set and battery eliminator are mounted on a sheet iron frame mounted perpendicular to a wall plate. The battery eliminator is of the same type as in exchange types *AMD 512* and *AMD 503*. The entire switchboard is enclosed under a plastic cover.

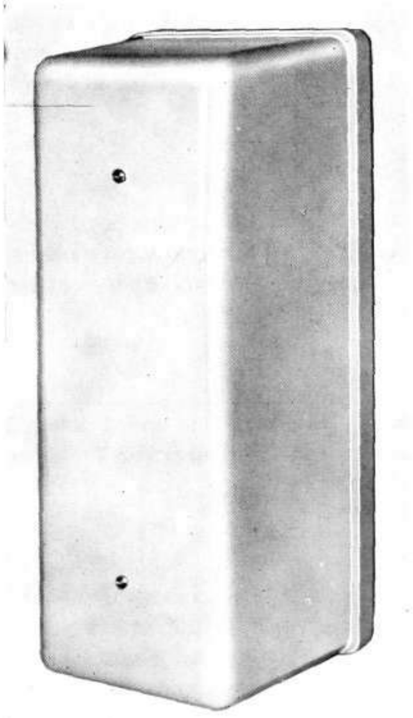


Fig. 7 X 2770
AMD 501 with cover in position

Technical Data for all types of mini-BX

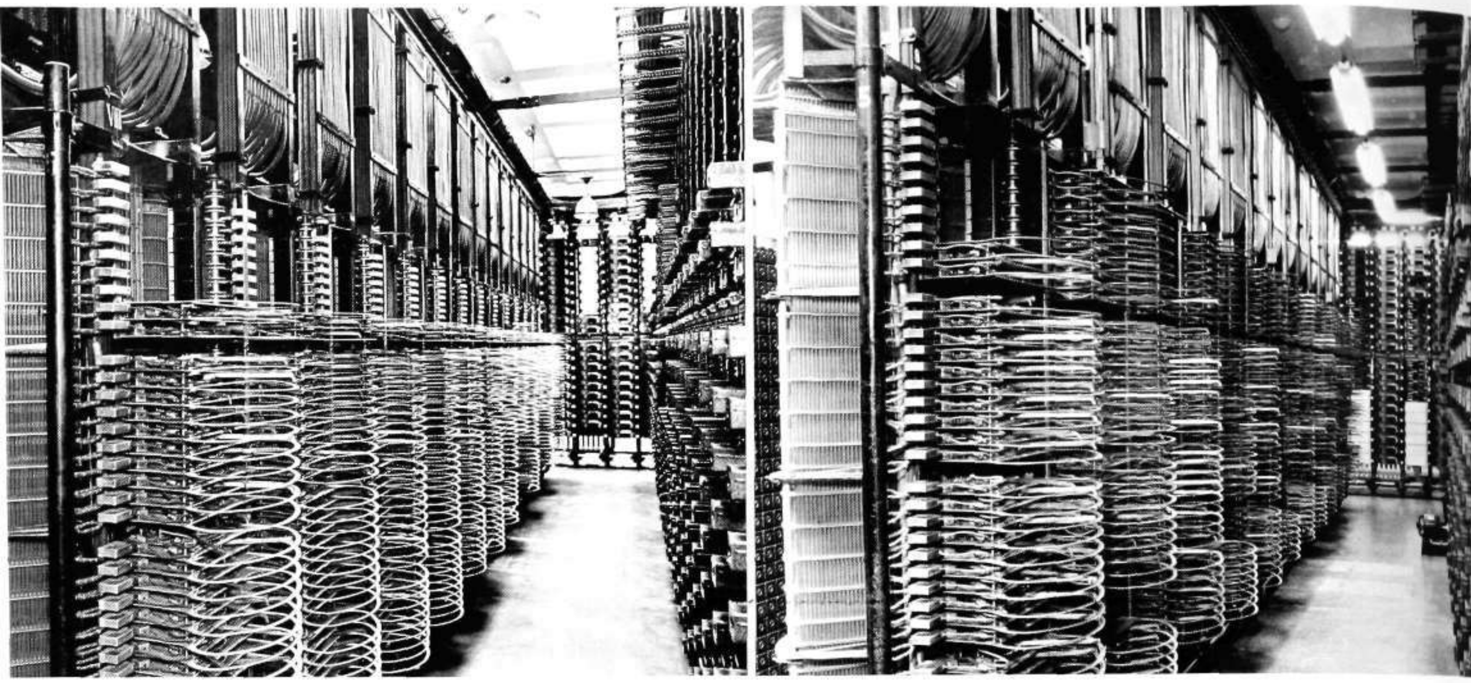
1. Operating voltage 48 V, tolerances 40–56 V with permissible mains voltage variation of ± 10 %
2. Feed 2 × 400 ohms, adjustable to 2 × 250 ohms
3. Max. extension line resistance 1 000 ohms
4. Min. extension leakage resistance 30 000 ohms
5. Max. earth circuit resistance 200 ohms
6. Dial speed 8–12 I.P.S.
7. Dial ratio 33/67–50/50.

L M Ericsson Exchanges Cut into Service 1963

CITY EXCHANGES

Public exchanges with 500-line selectors

Town	Exchange		Number of lines
Bolivia			
Oruro			1150
Brazil			
Pelotas		(extension)	500
Uberlandia		(extension)	1000
Colombia			
Bogotá DE	Teusaquillo	(extension)	2000
Calarcá		(extension)	1000
Cartagena	Bosque	(extension)	500
»	Centro	(extension)	1000
Pasto		(extension)	500
Santa Rosa de C.		(extension)	200
Ecuador			
Guayaquil	Centro	(extension)	1500
Quito	Centro	(extension)	1000
»	Iñaquito	(extension)	500
»	Villa Flora	(extension)	500
Ethiopia			
Addis Ababa	Central	(extension)	1000
Finland			
Hamina/Fredrikshamn		(extension)	500
Jyväskylä		(extension)	1000
Pori/Björneborg		(extension)	500
Italy			
North Italy			
Chioggia		(extension)	200
Mogliano		(extension)	100
Monselice		(extension)	200
Venezia/Venice	Lido	(extension)	500
»	Murano	(extension)	100
Verona	Borgo Trento	(extension)	1000
Vicenza		(extension)	500
South Italy			
Alcamo		(extension)	500
Avellino		(extension)	1000
Bari	Carrassi	(extension)	3500
Battipaglia		(extension)	200
Caserta		(extension)	1000
Cassino		(extension)	500
Castellammare di Stabia		(extension)	1000
Catania	Nesima		4000
Catanzaro		(extension)	1500
Cava dei Tirreni		(extension)	300
Crotone		(extension)	500
Giarre Riposto		(extension)	500
Isola Liri		(extension)	100
Lecce		(extension)	1000
Messina			3000
Milazzo		(extension)	100
Molfetta		(extension)	1000
Napoli/Naples	Amedeo	(extension)	500
»	Centro	(extension)	500
»	Chiaia	(extension)	1000
Palermo	Calatafimi	(extension)	1000
»	Polacchi	(extension)	1000
Piano di Sorrento		(extension)	300
Pompei		(extension)	200
Reggio Calabria		(extension)	2500
Sciacca		(extension)	500
Siracusa		(extension)	3500
Sora		(extension)	300
Termini Imerese		(extension)	500
Torre Annunziata		(extension)	1500
Lebanon			
Beyrouth	Centre	(extension)	3000
Zahlé			2000
Mexico			
Cuernavaca		(extension)	1000
Durango		(extension)	500
Mazatlán		(extension)	500
Mérida		(extension)	500
México DF	Chapultepec	(extension)	1000
»	Churubusco	(extension)	1500
»	Morales	(extension)	1500
»	Peralvillo	(extension)	2500
»	Piedad	(extension)	2500
»	Portales	(extension)	2000
»	Roma	(extension)	1000
»	Sabino	(extension)	3000
»	San Angel	(extension)	1000
»	Tacuba	(extension)	1000
»	Tacubaya	(extension)	1000
»	Valle	(extension)	2000
Tapachula			1000
Toluca		(extension)	500
Netherlands' West Indies			
Curaçao	Punda	(extension)	500
Norway			
Bodö		(extension)	500
Fiskå		(extension)	1000
Lund			1000
Madla			1000



X 7908

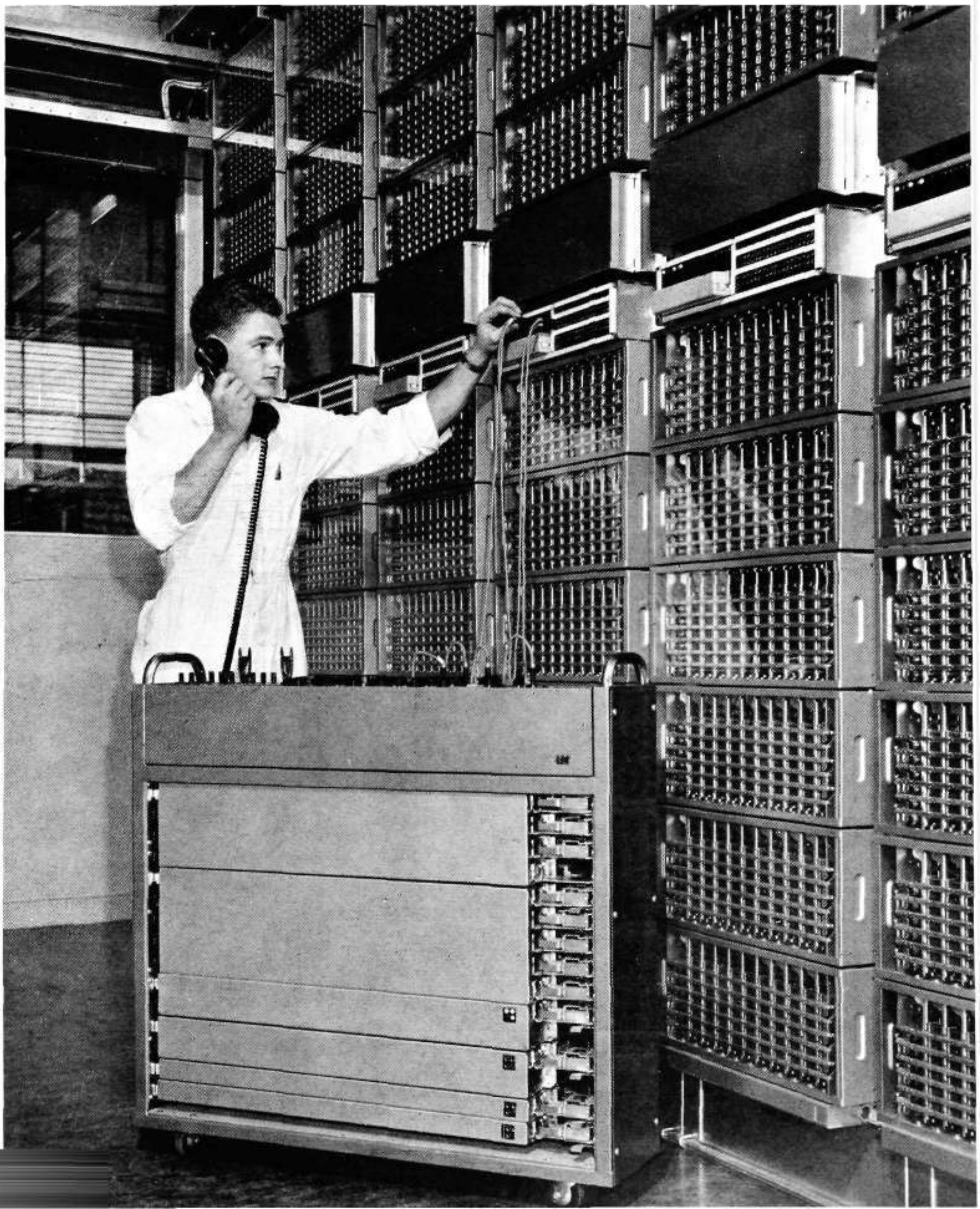
L M Ericsson's first automatic telephone exchange in Sweden, based on the 500-line switch, was opened on January 13, 1924 — the Norra Vasa exchange in Stockholm (left). Today, more than 40 years later, it is still working excellently. This exchange, which was actually put into trial operation in 1923, was initially built for 5 000 subscribers. Norra Vasa of today (right) serves twice as many subscribers, but otherwise, as is seen, no particular changes have been made.

Town	Exchange	Number of lines
Panama		
David	(extension)	400
Panama City	Panama 2 (extension)	1000
»	Panama 3 (extension)	1000
Spain		
San Sebastián	(extension)	2000
Sweden		
Borås	(extension)	2000
Göteborg/ Gothenburg		
Centre area	Drottningtorget (extension)	1000
»	Hisingen (extension)	2500
»	Vasa (extension)	500
Suburban area	Askim (extension)	1000
»	Frölunda (extension)	3500
»	Mölndal (extension)	1500
Huskvarna	(extension)	1500
Jönköping	(extension)	2500
Karlstad	(extension)	1000
Katrineholm	(extension)	1500
Kristianstad	(extension)	1000
Kristinehamn	(extension)	1000
Lidköping	(extension)	2000
Lund	(extension)	2000
Nässjö	(extension)	1000
Skara	(extension)	500
Skellefteå	(extension)	2000
Stockholm		
Suburban area	Aspudden (extension)	1000
»	Hanviken (extension)	500
»	Lidingö-Villastad (extension)	2500
»	Mälarhöjden (extension)	500
»	Norrviken (extension)	500
»	Roslags Näsby (extension)	2000
»	Råsunda (extension)	5000
»	Tyresö (extension)	500
»	Årsta (extension)	500
Södertälje	(extension)	3000
Uddevalla	(extension)	500
Uppsala	(extension)	5000
Värnamo	(extension)	1000
Ängelholm	(extension)	500
Östersund	(extension)	2000
Turkey		
Ankara	Bahçelievler (extension)	500
»	Yenimahalle (extension)	500
»	Yenişehir (extension)	1000
Venezuela		
Ciudad Bolívar	(extension)	1000
Mérida	(extension)	300
	Total	**143650**

Public exchanges with crossbar switches

Town	Exchange		Number of lines
Australia[1]			
Adelaide	Paradise		1000
Brisbane	Chapel Hill		2000
»	Cleveland		600
Melbourne	East Doncaster		1600
»	West Essendon		1000
Perth	Scarborough		1600
Sydney	Haymarket		3000
»	Petersham		2800
Whyala			2000
Brazil			
Araraquara		(extension)	600
Leopoldina			800
Recife area	Areias		600
»	Boa Viagem	(extension)	1000
»	Madalena		2000
»	Olinda		1000
»	Tamarineira		2000
Santo André area	Rudge Ramos	(extension)	200
»	Santa Terezinha		1400
»	São Bernardo	(extension)	400
Taubaté			2000
Cameroons[2]			
Yaoundé			600
Colombia			
Ibagué			5000
Medellín area	Bello		2000
»	Itagüí		2000
Denmark			
Aarhus	Brabrand	(extension)	1000
»	Nord	(extension)	1000
»	Syd	(extension)	1000
»	Vest	(extension)	1000
Espergærde			1600

[1] The equipment for these exchanges has been manufactured on L M Ericsson-license.
[2] This exchange, system CP 400, was delivered by Société des Téléphones Ericsson, Colombes.



X 7906
The new 2 800 line crossbar exchange at Petersham, Australia.

Town	Exchange		Number of lines
Fredericia			5000
Horsens		(extension)	1000
København/ Copenhagen	Bagsværd	(extension)	1000
»	Ballerup	(extension)	1000
»	Borups Allé	(extension)	4000
»	Glostrup	(extension)	1000
»	Herlev	(extension)	1000
»	Hørsholm		6000
»	Nora	(extension)	2000
»	Ryvang	(extension)	1000
»	Store Magleby		4000
»	Trørød	(extension)	1000
»	Virum	(extension)	1000
Odder		(extension)	200
Odense		(extension)	2000
Randers			10000
Roskilde			10000
Rudkøbing		(extension)	1000
Finland			
Helsinki/ Helsingfors	Gräsa	(extension)	600
»	Kaarela/Kårböle	(extension)	400
»	Oulunkylä/Åggelby	(extension)	400
»	Pakila/Baggböle	(extension)	600
»	Pihlajamäki/Rönnbacka	(extension)	600
»	Puotila/Botby		2000
»	Sörnäinen/Sörnäs	(extension)	1000
Rauma/Raumo		(extension)	500
Turku/Åbo	Martinmäki	(extension)	1000
France[1]			
Angoulême			4800
Audincourt			1000
Bischwiller			600
Briey			600
Compiègne			3200
Épernay			2400
Forbach			2800
Le Péage			1000
Lourdes			3200
Montbéliard			2000
Montluçon			4000
Pézenas			600
Sarreguemines			1600
Saumur			2400
Sedan			2000
Sète			3000
Tarbes			4000
Wissembourg			400
Iceland			
Kópavogur			2000
Vestmannaeyjar			1400

Town	Exchange		Number of lines
Indonesia			
Tandjungkarang			1000
Italy			
North Italy			
Padova		(extension)	1800
Treviso		(extension)	2600
Venezia/Venice	Centro		1400
»	Mestre	(extension)	3800
Verona	Borgo Roma		3200
South Italy			
Adrano			1000
Angri			500
Ariano Irpino			600
Bisceglie		(extension)	400
Fasano		(extension)	100
Francofonte			800
Gela			2600
Gioia del Colle		(extension)	100
Gravina di Puglia			800
Ischia		(extension)	200
Martina Franca		(extension)	200
Minturno			500
Monopoli			800
Napoli/Naples	Capodimonte		3600
»	Nolana IV		6000
»	Poggioreale		1000
»	San Giovanni		4000
Palermo	Monreale		1000
»	Romagnolo		2000
Piedimonte d'Alife			500
Porto Empedocle			700
Putignano			800
Salemi			800
San Cataldo			800
Sarno			500
Trapani		(extension)	2000
Vittoria			2200
Ivory Coast[1]			
Bouaké			800
Libya			
El Beida		(extension)	400
Islamic Republic of Mauritania[1]			
Port-Etienne			400
Netherlands			
Barendrecht		(extension)	200
Capelle		(extension)	600
Maassluis		(extension)	200
Ridderkerk		(extension)	600
Ijsselmonde		(extension)	4000
Overschie			6000

[1] These exchanges, system CP 400, were delivered by Société des Téléphones Ericsson, Colombes and their licencees.

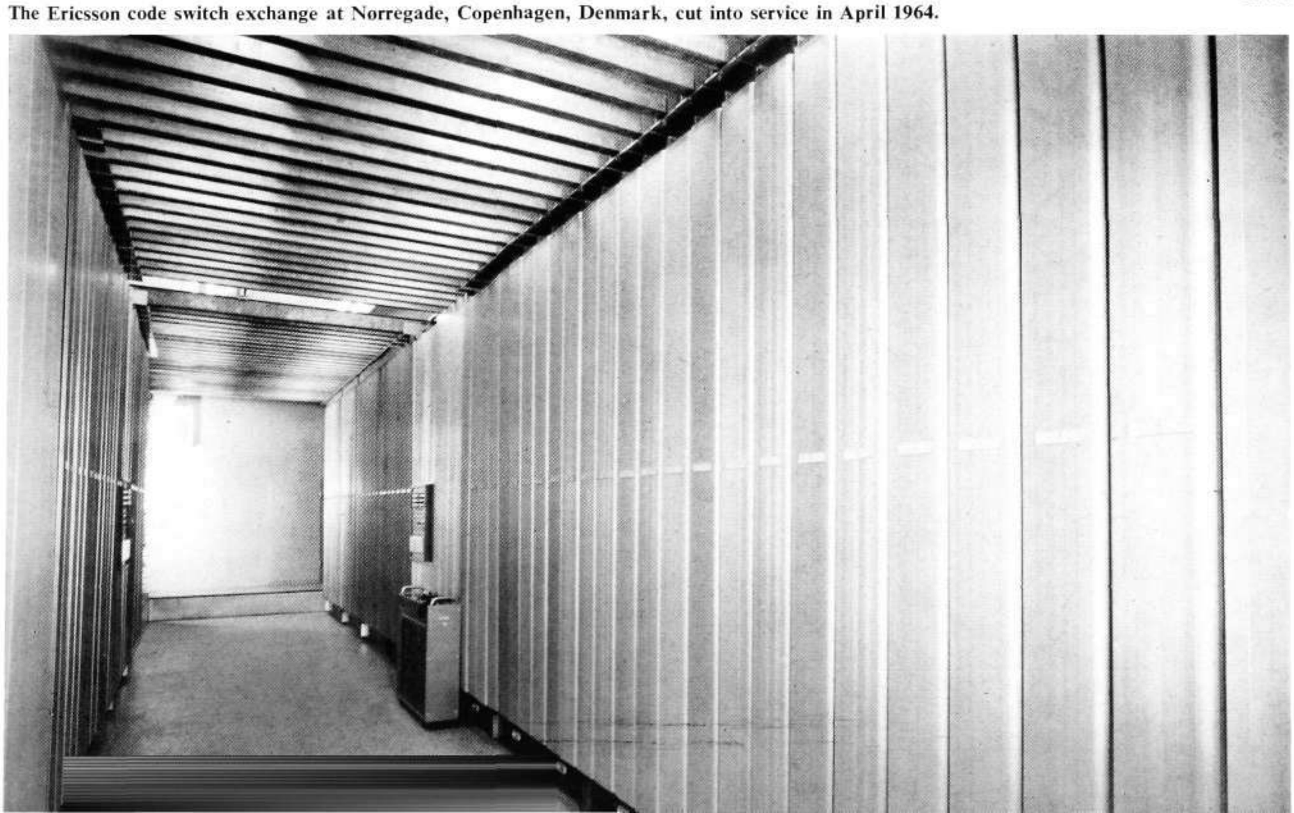
Town	Exchange	Number de lines
Sweden		
Alingsås	(extension)	900
Karlskrona	(extension)	500
Landskrona	(extension)	1400
Lysekil	(extension)	300
Motala	(extension)	1000
Nyköping	(extension)	1100
Ronneby	(extension)	400
Skövde	(extension)	500
Thailand		
Chiengmai		1000
Haadyai		1000
Tunisia		
Tunis	Hammam Lif	1000
»	Megrine	1000
United Arab Republic		
Cairo	Opera	10000
USA[1]		
Ashtabula, Ohio		2000
Canandaigua, New York		4000
Dalton, Georgia	(extension)	1000
Durham, North Carolina	(extension)	600
Elkin, North Carolina	(extension)	500
Elm Road, Ohio		1000
Galion, Ohio	(extension)	700

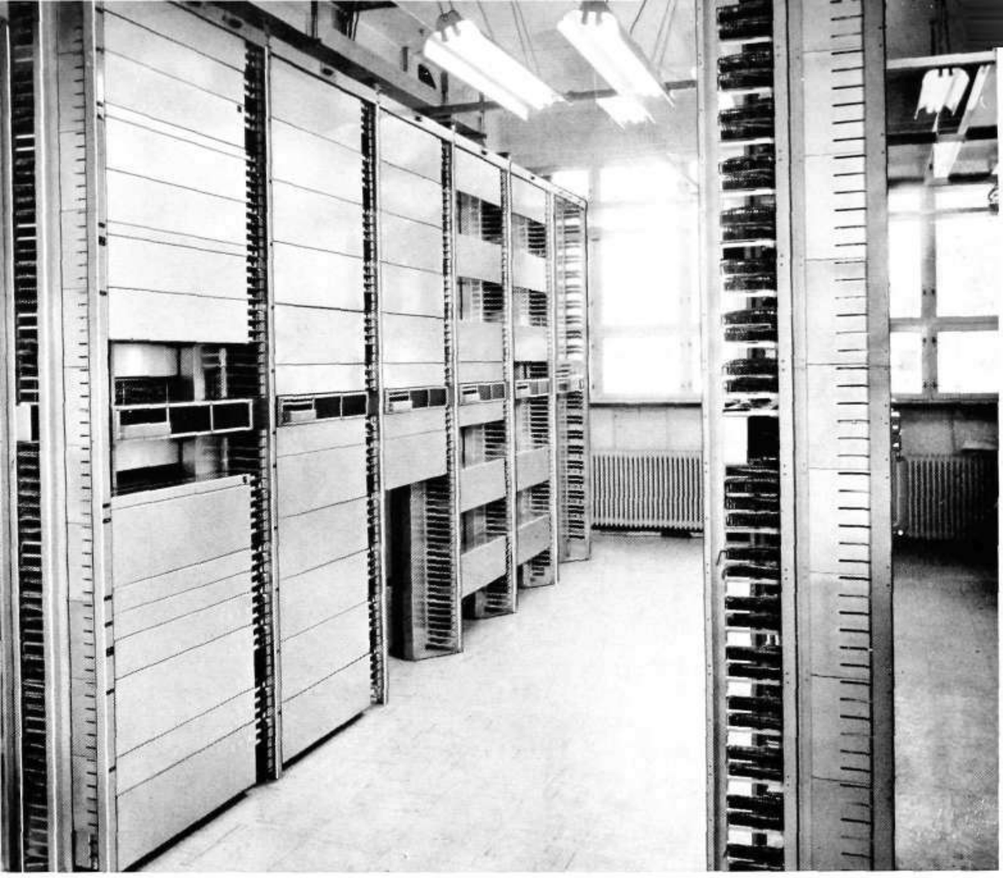
Town	Exchange	Number of lines
Leesburg, Florida	(extension)	500
Live Oak, Florida	(extension)	100
Manor Way, Washington		2200
Mansfield, Ohio	(extension)	1000
Moultrie, Georgia	(extension)	500
Redmond, Washington		2200
Rolla, Missouri	(extension)	200
Sunnyside, Washington		1500
Winter Park, Florida	(extension)	2000
Yugo-Slavia[2]		
Banja Luka	(extension)	1000
Beograd	Akademija (extension)	4000
»	Tošin Bunar (extension)	1000
Karlovac	(extension)	400
Kraljevo	(extension)	400
Nikšić	(extension)	500
Novi Sad	Novi Sad APV (extension)	600
Osijek	(extension)	1000
Pirot		600
Pula	(extension)	600
Split	(extension)	1000
Sremska Mitrovica		1000
Štip		600
Zagreb	Črnomerec (extension)	1000
»	Pešćenica (extension)	1000
»	Trnje (extension)	2000
	Total	**262900**

[1] These exchanges, system NX-1, were delivered by North Electric Co., Galion, Ohio.
[2] The equipment for these exchanges has been manufactured on L M Ericsson-license by the Yugo-Slavian factory Nikola Tesla, Zagreb.

X 7909

The Ericsson code switch exchange at Nørregade, Copenhagen, Denmark, cut into service in April 1964.





X 7907
L M Ericsson's first telex exchange was opened in 1963 in Trondheim, Norway, for combined telex and telephone service. Its capacity is 400 lines.

RURAL EXCHANGES

	Number	Number of lines[1]
Public rural exchanges with crossbar switches, system ARK, ART		
Australia[2]	3	460
Canada	8	4500
Denmark	2	900
Ecuador	2	600
Finland	93	7510
Ireland	8	1530
Italy	7	2500
Lebanon	2	800
Netherlands	—	1300
Norway	20	3035
Panama	—	150
Sweden	—	1700
USA[3]	30	9030
Yugo-Slavia[4]	38	9620
Total	**213**	**43635**
Rural exchanges with 12-, 25- or 100-line selectors, system OL, XY		
Norway	21	3810

TRANSIT EXCHANGES

	Number of junctions
Transit exchanges with crossbar switches, system ARK, ARM, ART, or with 500-line selectors, system AGF	
Canada	200
Colombia	1800
Denmark	6780
Finland	1160
Iceland	280
Italy	3200
Netherlands	3900
Norway	500
Sweden	4910
Total	**22730**

[1] The number of lines includes both new exchanges and extensions of existing exchanges.
[2] The equipment for these exchanges has been manufactured on L M Ericsson-license.
[3] The equipment for these exchanges has been manufactured on L M Ericsson-license by the Yugo-Slavian factory Nikola Tesla, Zagreb.
[4] These exchanges, system NX-2, were delivered by North Electric Co., Galion, Ohio.

Ericsson LM NEWS *from* *All Quarters of the World*

(Above) The managing director of L M Ericsson Pty. Ltd., Mr. L. G. Rowe, bids the Australian Postmaster-General, Mr. C. W. Davidson, welcome to the new factory.

L M Ericsson Factory Opened in Australia

The Telephone factory built by L M Ericsson Pty. Ltd. at Broadmeadows near Melbourne is now complete. It was opened at the beginning of December last year by the Australian Postmaster-General, Mr. C. W. Davidson, in the presence of Messrs. Malte Patricks and Hans Werthén, as representatives of the Ericsson group management, and a large number of guests headed by the Director-General of the A.P.O., Mr. Frank P. O'Grady, and the Swedish ambassador, Mr. Gösta af Petersens.

In its first stage the factory will comprise some 130 000 sq.ft. of production and office space. The number of employees is expected to rise during the first six months to above 600.

The work will comprise winding of coils, adjustment, assembly, cabling and testing. The aim is that piecepart manufacture shall be started as soon as possible.

It was in early 1951 that L M Ericsson Telephone Co. Pty. Ltd. was formed as a small sales company. In 1957 L M Ericsson delivered to the Australian Post Office two small trial exchanges with crossbar equipment, one at Templestowe, Victoria, and one at Sefton, New South Wales. In February 1959 L M Ericsson received an order for crossbar switching equipment for the 6 000-line Toowoomba exchange in Queensland, which was cut-over in September 1960.

1959 was a red-letter year for L M Ericsson in Australia. In that year the A.P.O. chose the Ericsson crossbar switching system as the basis for the future mechanization of the Australian telephone network. In the same year agreements were made with Standard Telephone and Cables and with Telephone and Electrical Industries, Sydney, under which these two companies were to manufacture Ericsson equipment on licence for delivery to the A.P.O.

In early 1961 L M Ericsson acquired its first factory in Australia by entering as main partner in Trimax Transformers Pty. Ltd., the name of which was then changed to L M Ericsson-Trimax Pty. Ltd. This company undertook the assembly primarily of PABX of crossbar type.

After L M Ericsson Telephone Co. Pty. Ltd. had been granted a contract by the A.P.O. for crossbar equipment both for city and rural exchanges, as well as trunk and telex exchanges, it became necessary to increase the factory's capacity since the contract stipulated that the bulk of the equipment should be manufactured in Australia. At the end of 1962 the groundwork was started on the new factory that has now been opened.

At the same time the name L M Ericsson-Trimax Pty. Ltd. was changed to L M Ericsson Pty. Ltd. The company is responsible for the manufacture, sale and installation of the group's equipment on the Australian market, while L M Ericsson Telephone Co. Pty. Ltd., under its new name Teleric Pty. Ltd., is reponsible as holding company for the entire interests of the group on this market.

(Below) The Broadmeadows factory.

At midnight on November 29 General Phachirn Nimibutr made the first call through the new exchange to the governor of Chiengmai, Mr. Nirandon Chayanama (photo left).

A colourful display of Thailand dances was a feature of the inauguration ceremonies.

L M Ericsson Exchange opened in Thailand

As a step in L M Ericsson's automatization of the Thailand telephone service an ARF exchange was opened at the end of November at Chiengmai, second largest city in Thailand. The present capacity of the exchange is 1 000 lines. The Telephone Organization of Thailand expects a rapid rise in the telephone demand, however, and by the beginning of 1965 the number of lines will have increased to 2 000.

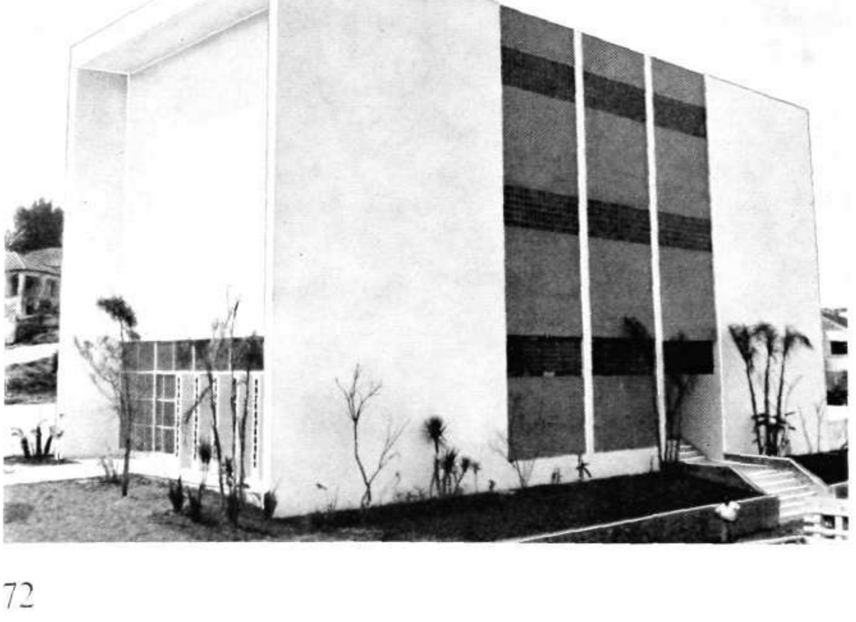
Host at the impressive inaugurating ceremony was General Phachirn Nimibutr, head of the Telephone Organization of Thailand, and among those present were representatives of the municipality and L M Ericsson, as well as the Swedish ambassador.

Large PABX in operation in Melbourne

One of the largest PABX delivered by L M Ericsson, Erga Division, was taken into use by Myer Emporium in Melbourne, Australia, at the end of 1963.

The present capacity of the PABX is 2 000 extensions, 24 operators' cord positions, and 200 incoming and 73 outgoing lines to the public network. In its mechanical features and circuit design the PABX is based on the Ericsson crossbar system ARF 10 that has been modified and supplemented by new traffic facilities for use as PABX. Among the special facilities are enquiry calls to operators and in-dialling to certain extensions used for booking of orders.

The PABX was cut-over shortly before Christmas and, according to Myer Emporium, has stood up well to the intense Christmas traffic.



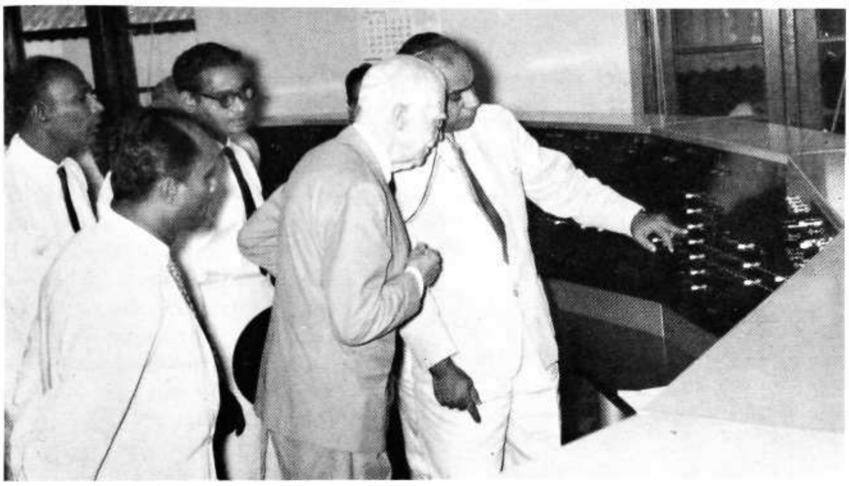
New Automatic Exchange in Brazil

On February 28, 1964, the administration of the Santo André district, Telefonica da Borda do Campo, opened a new crossbar exchange at Santa Terezinha. The new exchange has an initial capacity of 1 400 lines and is housed in a modern building as seen in the photograph on the left.

It may be recalled that the first major installation of Ericsson crossbar equipment in South America was in the Santo André district, a few miles outside Sao Paulo, where the first ARF exchanges were cut-over in 1958. The total capacity of ARF crossbar exchanges in this area is today 16 200 lines.

The two Russian cosmonauts, Gagarin and Bykovski, in the course of their goodwill visit to Sweden, spent a week in Stockholm at the beginning of March. Gagarin paid a call at L M Ericsson, Midsommarkransen. The photo (left) was taken during a tour of the factory, where he demonstrated his ability in handling a lathe. Gagarin was trained as a metalworker before he became an aviator and cosmonaut.

In Ecuador the photographer found this Indian woman who makes the acquaintance of the Ericofon.



Ceylon's former Governor General, Viscount Soulbury, visited the C.T.C. installation at Maradana, Colombo, at the beginning of January. The General Manager of the Ceylon Railway, Mr. B. D. M. Rampala (far right) demonstrates the control of signals and points on the track diagram, assisted by T. W. U. Seneviratna, Chief Signal Engineer (on left of Viscount Soulbury). The C.T.C. equipment, covering the double-track line Panadura—Colombo—Veyangoda, a distance of over 40 miles, was delivered by L M Ericsson.

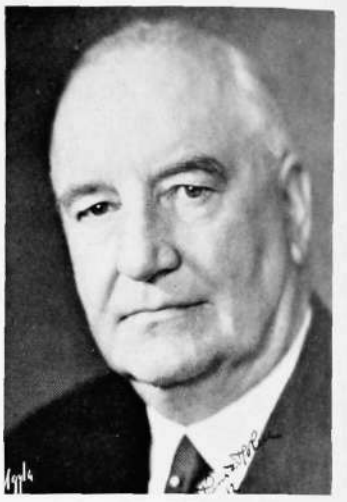
Ericsson pays tribute to 85 Gold Medallists

More than 300 persons were assembled at the Ericsson Gold Medal Celebration 1963 in the Stockholm Town Hall on a December evening just before Christmas. It was the twentieth year in which awards of gold medals were made to old-timers of the company, and the number of gold medallists on this occasion was 85. The chairman of the board, Dr. Marcus Wallenberg, and president Sven T. Åberg made the presentations, at the conclusion of which each presented a gold medal to the other. Mr. Åberg and Dr. Wallenberg are seen in the photograph with the senior male and female gold medallists, Mr. Einar Andersson (43 years of service) and Mrs. Eivor Roos (40 years of service).

In Memoriam

Jens Oscar Nielsen

Tore Ericsson



Hans Th. Holm

Professor Jens Oscar Nielsen, head of the Copenhagen Telephone Co., died suddenly on December 18, 1963.

Danish telephony has lost in Professor Nielsen one of its foremost figures. His talents and capacity for hard work were drawn upon within a wide field both in Denmark and throughout Scandinavia.

Oscar Nielsen was appointed Professor of Telecommunications Electrotechnology in 1941 at the age of only 33. He built up and led a number of research laboratories in Denmark, such as the Posts and Telegraphs Laboratory, the Microwave Laboratory, and the Telecommunications Research Laboratory. He was also one of the leading figures in the Danish Institute for Calculating Machines. He was appointed head of the Copenhagen Telephone Co. in 1961.

During his professorship Oscar Nielsen was anxious to establish intimate relations with telecommunication interests in the other Scandinavian countries. Through his kindly manner and genuine character he acquired many friends in the Swedish world of technology. He was respected and admired for his penetrating knowledge and technical perspicuity. During his years as head of the Copenhagen Telephone Co. he still found time to keep up his interest in technological matters.

Within L M Ericsson we have had the advantage of cooperating with Oscar Nielsen both in his capacity of scientist and as leader of Denmark's largest telephone administration. Most of the Danish engineers in our service acquired their basic training in telecommunications from J. O. Nielsen. Those who knew him personally will remember him with a feeling of loss and respect, whether they met him as scientist or in the sphere of telephone operation.

Christian Jacobæus

Tore Ericsson, president of L M Ericsson Swedish Sales Co., has died at the age of 59 years. He joined L M Ericsson in 1930 as newly graduated engineer, and his career in the company was mainly associated with the development of the Swedish market. He became head of the Swedish Sales Co. in 1947 and thus held this post for nearly 17 years.

Tore Ericsson was a very able technician who combined technical ability with an administrative capacity, sound judgement, industry and tact, all of which are essential attributes in a position such as that he held. The measure of his achievement may be seen also in the profits of the Swedish Sales Co.

During his long career within L M Ericsson he acquired a large number of friends both among customers and employees of the Ericsson group.

The loss of Tore Ericsson is deeply felt not only by the Ericsson management, which has been deprived of a colleague who is difficult to replace, but also by his large circle of friends.

Sven T. Åberg

Hans Th. Holm, former president of Telefon AB L M Ericsson, has died at the age of 86 years.

Born in Kristiania, as it was then called, in Norway, he graduated as engineer after technological studies, including a period in the United States. In 1904 he was taken on as head designer at Karlstads Mekaniska Werkstad. Two years later he was appointed factory manager and from 1915 to 1919 was the company's president. In 1919 he became head of the Bofors group.

After the Kreuger crash Hans Th. Holm was called on to take over the leadership of Telefon AB L M Ericsson, which he piloted through all difficulties with a firm hand—a giant undertaking which resulted in the reorganization of all companies of the group, especially the foreign interests. He also carried through a vast programme of new construction, including the building of the highly modern telephone factory at Midsommarkransen. Even after leaving the company on pension in 1942 he was for several years on the boards of a number of industrial enterprises in allied fields and for a time was chairman of the board of Sveriges Radio AB.

On many of the younger members of the staff Hans Th. Holm made an impression of dourness, but to those who had the favour of working in close intimacy with him he stood out as a great leader with an understanding for staff problems.

Sven T. Åberg

UDC 621.395.74(485)
LME 808 8400

JANSON, S: *The Swedish Trunk Network: a Survey of Transmission Techniques.* Ericsson Rev. *41*(1964):2, pp. 42—50.

This article, which is also published in the Royal Board of Telecommunications Journal Tele No. 2, 1963, gives a survey of the composition and development of the Swedish trunk network. A number of technical and economic points of view are given and finally a prognosis is given for the future development.

UDC 621.391.8
621.395
LME 8402

BOERYD, A: *Some Reactions of Telephone Users during Conversation.* Ericsson Rev. *41*(1964):2, pp. 51—58.

This article based on paper presented at Second Symposium on Human Factors in Telephony, Copenhagen, September 1963, deals with some results obtained at L M Ericsson in opinion tests of telephone circuits. The main object of the experiments was to determine the optimal attenuation conditions for a telephone connection. They were carried out between 1958 and 1962.

UDC 621.395.25
LME 8372

SIEWERT, O & SUNDT, E: *The mini-BX, a Miniature PABX.* Ericsson Rev. *41*(1964):2, pp. 59—64.

L M Ericsson's new series of small PABX covers a range comprising 2–6 extensions and 1–2 exchange lines. Since the exchanges are designed for the very smallest private telephone installations and are themselves of small dimensions, they have been called mini-BX (mini-Branch Exchange).

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons, telex: 12546

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: 242 35 00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: 227 95 30, tgm: eric

Great Britain

Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: HOLborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: HOLborn 1092, tgm: productrol holb

Italy

SETEMER, Soc. per Az. *Roma*, Via G. Paisiello 43, tel: 868.854, 868.855, tgm: setemer

SIELTE, Soc. per Az. *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

FATME, Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 780021, tgm: fatme

Netherlands

Ericsson Telefoon-Maatschappij N.V. *Rijen (N.Br.)*, tel: 01692-555, tgm: erictel, telex: 44-14354

Voorburg-Den Haag, 227 Koningin Julianalaan, tel: 81 45 01, tgm: erictel-haag, telex: 31109

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 56-1723

A/S Industrikontroll *Oslo 1*, Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, Bygdø allé 12, tel: Centralbord 56 54 94, tgm: signalindustri

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Sociedade Ericsson de Portugal, Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 57193, tgm: ericsson

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CONTENTS

On cover: Part of Rack in an Automatic Code Switch Exchange.

The Development of Code Switch Systems

E A ERICSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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The purpose of the development in exchange technology that has been conducted at L M Ericsson has been to produce a selector design substantially reducing the space requirement and capital cost of the telephone exchange equipment. The new selector should have larger multiple capacity, which affords material saving group arrangements, but smaller front face than that of the conventional crossbar switch. Due regard should be taken to modern materials and manufacturing methods. The price should be low and the multiple should be capable of being multipled by machinery. The result was the code switch and systems based on this switch. With suitably grouped selector stages a saving in space is obtained of 25 to 30 % which is increased to about 50 % if the conventional bay arrangement is replaced by suspended movable racks. In the code switch systems some facilities have been introduced which can be made use of to reduce the total cost in a telephone network.

This article gives a summary of essential system properties which are further dealt with in other articles in this issue of the Ericsson Review.

Mechanical Construction

The Code Switch

In a conventional crossbar switch the selecting members determine one dimension of the front face and no substantial reduction of this is possible while retaining the conventional selecting and contact arrangements. A radical solution was only possible by a combination of two design features which so far had not been utilized in crossbar switches:

- ☐ The introduction of V-contacts, which implies that the multiple is built up of single wire springs provided with sleeves of contact material which with twin action make contact with V-shaped contact strips. The wire springs provide compact multiple banks with small dimensions but nevertheless with adequate observation facilities.
- ☐ The introduction of binary code bar selecting similar to that used in teleprinters. The multiples are placed in a row one after the other with the code bars below the multiples instead of the conventional arrangement with vertical units and traversing selecting bars which obstruct observation and accessibility.

In this way the basis was created for the new design which is described in detail in the article "The L M Ericsson Code Switch—a new Connection Device". The attention will, however, be called below to a few important features:

- ☐ The vertical magnets receive only a short current impulse, when the selected multiple position is connected, and they are consequently dead during a call. This results in some reduction in the power consumption and is of importance in certain system applications.
- ☐ The multiple contacts are efficiently self-cleaning and are locked against the V-contact in connected position. This gives good contact reliability and through the design of the vertical unit the switch is shockproof and vibrationproof.
- ☐ With the same basic design the switch can with different number of levels be arranged for 12, 6, 4 or 3 poles with full utilization of the multiple capacity.
- ☐ Compared with the crossbar switch the height of the code switch has been reduced to one-half. There is, therefore, room for twice the number of switches per rack, which is an advantage from grouping point of view.

"Suspended Racks"

In view of the increased ground costs and the difficulties to obtain suitable sites in expanding large towns a further reduction in required exchange space is of considerable importance to the telephone administrations. This led to the development of the suspended movable racks, which are described in the following article. These racks are placed laterally close to each other on both sides of a wide aisle with all test points arranged readily accessible in the rack side facing the aisle. These test facilities are utilized in testing and fault tracing and it is possible to locate the rack that contains a faulty unit. To obtain access to this unit the rack is pulled out in the aisle. Both rack sides become accessible under good lighting conditions. The racks have to be pulled out only when something is to be replaced or adjusted. This is normally not necessary more than once or twice per rack and year. By the introduction of suspended racks the wide aisle takes the place of a great number of inspection gangways between the rows of racks, often very narrow but requiring a considerable amount of space. A code switch exchange with suspended racks can be built in one third of the space required for a conventional crossbar exchange with the same traffic handling capacity. In actual practice the saving is about 50 %, in view of the fact that code switch exchanges are provided with new facilities which require additional space but which in return can be used for a reduction of such items as the costs of the line network.

Distribution Frame

The reduced space requirement for code switch exchanges makes the size of the conventional frames out of proportion. In networks with cables only, the line protectors in the distribution frames are more and more being omitted and in modern automatic exchanges the test desk is connected to the required line over the regular selector equipment. The distribution functions then remaining are the connection of the line side to the exchange side and the cutting of this connection in case of network faults. In the distribution frame described on page 87 the line side as well as the exchange side are connected over connectors by jumper wires stripped at each end so as to present a twin plug arrangement. In the jumpering no soldering, screwing or twisting is, therefore, necessary. The new distribution frame requires a floor space of 12 m² for the first 10 000-group and about 6 m² for each subsequent 10 000-group.

System Engineering

As already intimated above, the principle features of the code switch are largely the same as those of the crossbar switch. They conform closely to the link system technology which has been developed by L M Ericsson around the crossbar switch. The code bar selection and the absence of current during the calls involve, however, certain modifications in the selector operation. The increased multiple capacity effects the link grouping as follows:

- ☐ With the same number of sub-stages a larger system capacity is obtained.
- ☐ With the same system capacity the number of sub-stages may be reduced.

The following examples may be mentioned:

- With the conventional crossbar switch with 20-line verticals a group selector stage with two sub-stages has $20 \times 20 = 400$ outlets. With a 4-pole code switch access can be had to $40 \times 42 = 1\,680$ outlets. This grouping is too large for manageable handling but an increase from 400 to 840 outlets is advantageous as the number of outgoing routes can be increased without increasing the congestion in the stage. The additional routes can be utilized as junction routes and a saving can then be made in the selector equipment in the exchange or in other exchanges. As in the case of long distance service a high degree of congestion can be tolerated on the junction routes, as refused traffic can be transferred to tandem routes with low congestion through alternative routing. In this way there is not only a saving in group selectors but the need for tandem traffic is reduced, which is important in large networks where the tandem exchanges otherwise can become unmanageable giants.

- In the subscriber stage the 1 000 grouping is retained. This grouping requires with conventional crossbar switches four sub-stages for incoming traffic whereas in code switch exchanges only two sub-stages are needed with conditional selection from the last group selector.

The articles "Automatic telephone exchanges with code switches" and "50-line P.A.B.X., *AKD 741*" describe how the code switch is used for large and small telephone systems. As already intimated some new facilities have been introduced of which the following may be mentioned:

The Line Allotter

The introduction of the line allotter means that an exchange line can be assigned one or more arbitrary directory numbers within the number series of the line allotter. This can in operation be utilized in several ways:

- ☐ If a subscriber terminates his subscription or changes directory number, the old number should for a certain time be kept vacant. If line allotters are available, this need not affect the exchange line but this can immediately be allocated to a new directory number. Vacant directory numbers are marked specially in the line allotter so that calls to these are connected to operators or announcing machines. As a rule there are about 10 % vacant directory numbers, and for 10 000 directory numbers the number of exchange lines may, therefore, be reduced to 9 000 or the surplus of exchange lines may be used for subscribers that do not require directory numbers such as for outgoing one-way exchange lines from private branch exchanges or for incoming exchange lines to such exchanges that are not individually connected out of office hours.
- ☐ Heavily loaded subscriber groups can be relieved without changes in the directory numbers by rearrangements in the distribution frame as well as in the allotter.
- ☐ Arbitrary lines in the 10 000-group can in the line alotter be collected into *PBX* groups with a common reserve for extensions. The lines within a *PBX* group are allocated a common group number and individual directory numbers for out of office hours. The lines for ordinary subscribers and *PBX* groups can be arbitrarily intermixed in the subscriber stages for the purpose of traffic equalization.
- ☐ In private branch exchanges several persons often share the same instrument. If line allotters are available, the instrument can have several directory numbers—for instance one number common to the office and an individual one for each person. When an employee is transferred from one office to another, the personal number is connected to another instrument. In this way out-of-date information in the internal directory can be avoided, which otherwise not infrequently occurs before the printing of a directory is completed.

Detached Exchanges

A detached exchange contains one up to four 50-groups, which have been separated from the subscriber stage of the parent exchange and are placed in a suitable position in the local network. In this way the line requirements between the parent exchange and the position where the detached exchange has been placed may be reduced by up to 75 %. Subscribers connected to detached exchanges have exactly the same facilities as those directly connected. By utilizing the line allotter subscribers may be connected directly or over detached exchanges without noticing anything. The detached exchanges operate as subsidiaries under the parent exchange and have simple connection functions. As the code switch does not require current during a call, the power consumption is low and the detached exchange requires only a small battery, which is charged from the parent exchange over free junction lines. Capital and maintenance costs will, therefore be low.

As regards the limit of profitability this depends on local conditions and only a few examples will therefore be outlined below of how the build-up of a local network can be facilitated with the aid of detached exchanges:

- ☐ The capital investment for an extension of the subscribers' network can be postponed to a convenient time by connecting a number of directly connected subscribers to a detached exchange. In this way the required junction lines are made available for the detached exchange. After the enlargement of the local network the subscribers are again connected directly to the parent exchange and the detached exchange can be used in other positions of the network.
- ☐ It is rarely possible to extend the exchange equipment at the same rate as the subscriber growth. In certain exchange areas there may be waiting subscribers whereas in others there is an excess of exchange equipment. By means of temporary detached exchanges the waiting subscribers in a deficiency area may be connected to another exchange area.
- ☐ In the development of a new district it may be difficult to assess the trend of the subscriber growth and where in the district an exchange ought to be built. The investment for the new exchange can be postponed, if the subscribers are temporarily connected over detached exchanges to an existing exchange with free capacity. If this exchange is alotted two series of directory numbers no change of number is necessary, when the new exchange has been completed.
- ☐ In some cases it is very expensive to extend the primary cable network for an exchange. The streets are narrow and the canalization must be enlarged. It can then be profitable to connect even short subscribers lines over detached exchanges.

As follows from the above, detached exchanges open a number of possibilities for economic network planning with an optimum utilization of available resources in exchange equipment and subscriber's line network.

Decentralization of Exchange Units

When planning a local network the costs for the building site, exchange premises, exchange equipment and exchange maintenance have to be balanced against the actual network cost. Modern telephone exchanges are so reliable that the operational supervision can be safely centralized. A decentralization of exchange units will then bring about small increases in exchange maintenance and not appreciably affect the costs for the exchange equipment. The costs for building sites and exchange premises weigh heavier. The considerably reduced space requirements for code switch exchanges should, however, increase the possibilities for an economic decentralisation of 10 000-units. With centralized supervision, exchange premises without windows may be acceptable and in many cases it should not be impossible to obtain the right to use required space in suitable buildings at a reasonable price.

Summary

In the foregoing certain potential properties of the code switch systems have been described as well as their utilization, such as:

- ☐ Small space requirements
- ☐ Line allotter with free number allocation
- ☐ Detached exchanges for an optimum balancing of network costs and investments
- ☐ Decentralization of exchange units with centralized supervision

How these possibilities can be made use of depends on local conditions. In the article "The automatic exchanges in central Copenhagen" it is stated that the line capacity for an already erected building has been doubled by the change to code switch system instead of continuing the crossbar system previously installed in Copenhagen. It also appears that the line allotter solved the problem of intermixing heavy callers with new ordinary subscribers without the need for the 10 000-groups to be fully extended from the beginning.

The LM Ericsson Code Switch — a New Connection Device

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UDC 621.316.544
621.395.344
LME 7363 83385

The article below describes a new selector, the code switch. This can be applied to all types of exchanges and allows the construction of exchanges that offer considerable advantages through reduced space requirements, improved power economy and savings in maintenance cost. Within the framework of its total number of contact points it permits a considerable variation in capacity and pole number making it adaptable to all existing requirements.

The 1950's represented the definite break-through for the crossbar system. In this process L M Ericsson has played a leading part through the development and production of exchange types for all requirements. The basic component in these exchanges, the crossbar switch, came into existence during the first twenty years of this century. It is natural to ask whether modern technology in manufacturing methods and raw materials has not created prerequisites for a new design which could offer advantages over the crossbar switch. Research in this direction were actually commenced before the ascendency of the crossbar switch but it was not until the late fifties that the outlines of a concrete development object could be discerned, fig. 1. The framework for the development was provided by general system technology, where considerations regarding selector sizes, selector controls and selector operation were particularly important. The construction of the multiple with wire contacts was a prominent feature. New modern materials were used. Special machines were developed for the switch providing application of mass production methods in spite of the fact that a number of different variants of the switch necessarily had to be supplied.

General Considerations

The general construction of the switch must allow the use of the marker system. The experiences made on crossbar switches were decidedly such that the marker principle must be considered as indispensible. Some of the traffic facilities that a modern telephone system must offer could only be met by the use of this principle. The complexity of the marker systems has not reduced its reliability but on the contrary created essential conditions for this. The markers have put better tools in the hands of the maintenance staff than those provided by other exchange types. A possible future electronic selector control can only be made on the basis of the marker principle.

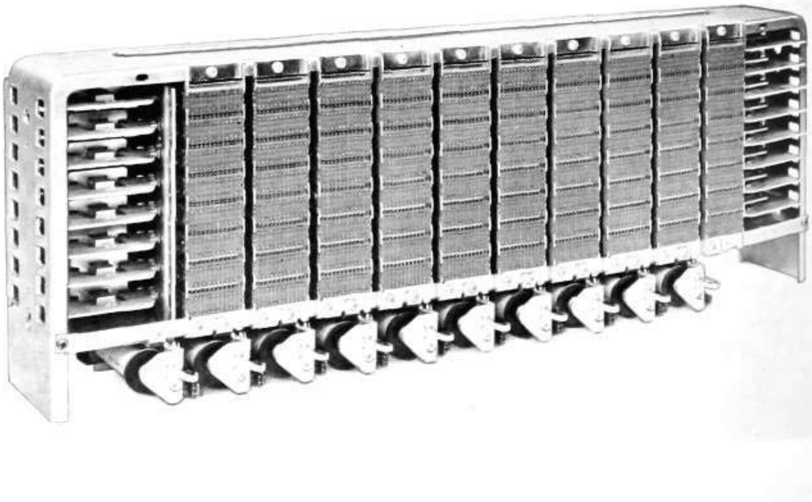

Fig. 1 x 7926
Crossbar switch with wire spring multiple

One effect of the marker principle is that link systems can be used in the selector grouping. This provides a great amount of latitude in exchange construction. The bunches of junction lines can be well utilized. The link systems make comparatively small selectors economical as their number can be limited. The number of selectors will however, be larger with smaller selector capacities as the total number of contacts is reduced.

In the development of selectors experience proves that for small selectors the relative cost of the operating devices will be almost prohibitive. It is, therefore, necessary to arrange some form of common utilization of these devices for several selectors. Research soon indicated a structure similar to the crossbar switch, i.e. with a unit consisting of several part selectors with a common operating device. A decision then had to be made as to the capacity of the part selectors and the number of such selectors in a unit.

The capacity of the part selectors is economically determined by the design of the components. As a general rule the price of the selector can be considered as composed of a basic cost plus the costs for the contact points. With cheap contact points in relation to the basic costs it is correct to have a comparatively large capacity for the part selectors. The increased number of contact points is then balanced by the comparatively reduced number of selectors. The detailed investigations that have been made at L M Ericsson in these matters show, however, that the cost varies very little over a fairly wide range around the minimum value. A certain importance can, therefore, be attached to other factors than those determining the cost.

As a suitable compromise the capacity 50 has been chosen for a three-pole multiple. With this number it will be possible to extend the capacity of exchanges having one selector stage comparatively far, which is desirable, at the same time as larger units can be made at lower cost.

With reference to the number of part selectors in the unit, ten such units proved to be a satisfactory solution from design point of view as well as from economical considerations. The complete unit, the code switch, was then conveniently manageable for handling and rack mounting at the same time as grouping and circuit requirements were adequately satisfied.

The Multiple

As mentioned above wire springs in the multiple were one of the fundamental ideas in the development work. The reason for this was primarily that it proved possible to make the multiple with a spacing of only 3 mm in both directions. This meant a considerable reduction in the space requirement assuming that only one wire spring was needed in each point. As twin contacts were considered essential, two contact points were arranged by the use of a tubular contact pressed on the wire. This contact mated a fixed contact wire press formed so as to obtain a V-formed contact surface. The principle of the design is shown in fig. 2.

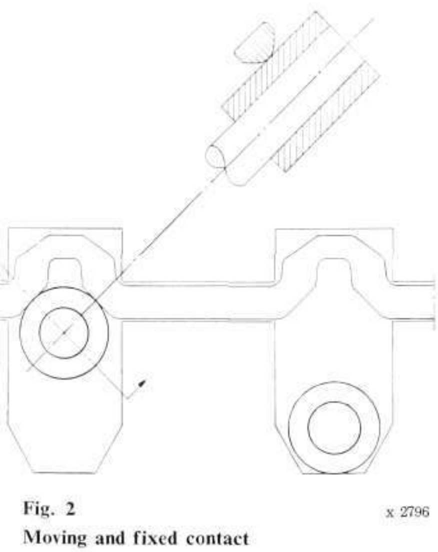

Fig. 2
Moving and fixed contact

x 2796

The contact properties in a selector are of vital importance for its use, and very extensive investigations were, therefore, made to establish the properties of the proposed design. The mechanical wear proved to be negligible. Electrical erosion is for selector contacts very seldom of importance as these contacts do not break or make live circuits. Even in the few cases where this is necessary the apprehensions with regard to abnormal wear proved to be exaggerated. The most important of the selector contact properties, viz. reliability, the insusceptibility to dirt and dust, was investigated particularly. Absolute measurements of such properties are difficult to apply. The best method seems to be to make a comparison test relative to known designs, i.e. to test new contacts and known contacts under identical conditions. In this

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case normal relay contacts and crossbar contacts were compared with wire contacts in such a way that all contacts had to operate in the same closed chamber. Dust was injected in the chamber and the number of faulty functions were recorded. This test showed that no faults occurred in the case of the wire contact until the amount of dust injected was so large that the comparison contacts ceased to operate altogether.

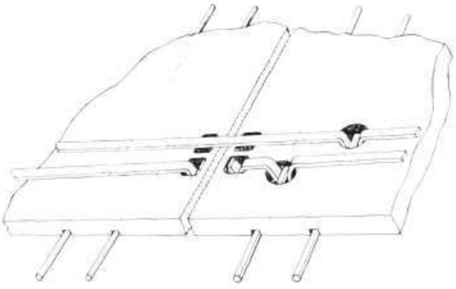


Fig. 3 x 2797
Design of the multiple strip

One of the development postulates was naturally that the production as far as possible should be carried out by automatic methods. Especially the internal connection in the multiple should be born in mind. This was solved in such a way that the multiple was built up of contact spring strips placed on top of each other to form a complete multiple. It was decided that the multiple should consist of ten units, vertical unit multiples as in a crossbar switch. The contact spring strips could be manufactured in an automatic machine in endless lengths, which were cut into pieces of ten units. The strips were built up of rectangular moulded plates with grooves on both sides. One side of the plate accommodated the multiple wires running lengthways to the strip whereas the other side held the contact springs perpendicularly to the multiple wires. The moulded plates were provided with holes in the intersection points and through these holes the multiple wires were pressed down so as to form a loop. The contact springs were pushed through the loops, a small piece of solder was placed in each hole and all intersection points could then be soldered simultaneously by high frequency heating. The soldering time could be kept as low as 1.5 sec. and the mouldings were, therefore, not affected. The construction is shown in fig. 3 and a complete strip in fig. 4.

It was decided to build up the complete multiple with twelve strips on top of each others, providing twelve contact points vertically. That the figure twelve was chosen was due to the fact that the multiple could be readily divided vertically with the contact number 2, 3, 4, 6 or 12 on each level depending on the use.

As it was desirable to obtain at least fifty outlets per unit in the three-pole variant, it was decided to provide each unit with seventeen contact wires. As four contact wires must be used for the inlet in the three-pole variant, it remains $17 - 4 = 13$ for the outlets which results in $4 \times 13 = 52$ outlets. In the same way a four-pole multiple will have $3 \times 14 = 42$ outlets, a six-pole multiple $2 \times 15 = 30$ and a twelve-pole multiple $1 \times 16 = 16$ outlets. The contact spring strips must of course be cut up so that they match the multiple in question. This is carried out by cutting away superfluous free ends of the contact springs and cutting off the multiple wires in suitable position.

The multiple is assembled with a bottom plate and a top plate held together with a number of screws. The lifting combs are then mounted in position.

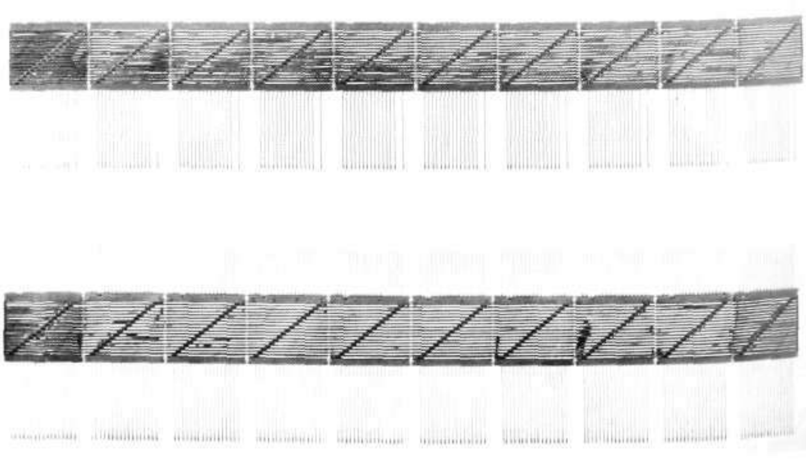


Fig. 4 x 7927
Complete multiple strip

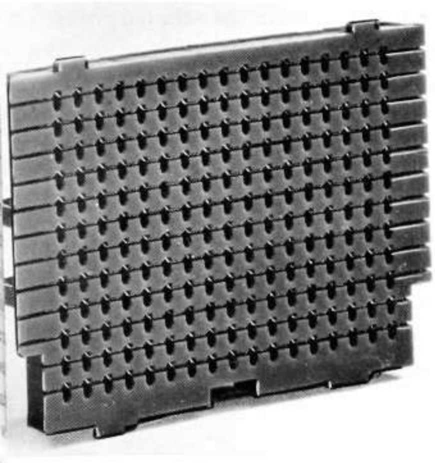


Fig. 5
Contact frame

x 2798

Owing to the small spacing—3 mm.—the combs are placed at an angle and they can, therefore, be made sufficiently wide to provide adequate rigidity. In this way another advantage was achieved, viz. that the contact wires could be guided in all directions of the lifting combs although the holes for the contact wires must be large enough to allow the contacts to pass through in the assembly. Finally the multiple was completed by a fixed contact frame consisting of a moulded plate for each multiple unit. In this plate the fixed contacts in the form of indented wires are secured in slots, fig. 5.

The multiple, fig. 6, built up in this way is robust and rigid and can be produced quite independently of the selector otherwise, which is not the case with the conventional crossbar switch.

The Mechanism

In a multiple constructed in this manner the same selecting system cannot be used as that in the crossbar switch. Instead of this a "binary code system" was chosen for the selection. Such a system has a capacity of 2^n where n stands for the number of code elements. With $n = 6$ the number of combinations amounts to $2^6 = 64$. With five code elements the number is $2^5 = 32$, which is not sufficient to cover the requirement which is at least 52 for the three-pole multiple and six code elements must, therefore, be used.

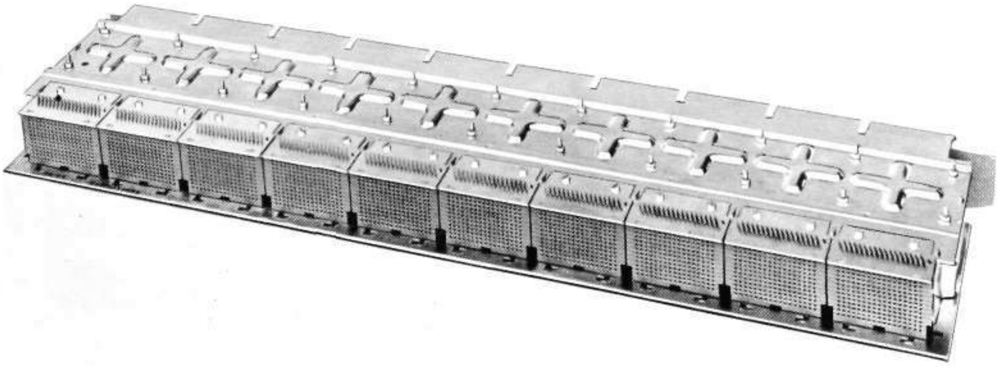
In view of the selecting system the complete unit is termed "code switch".

The code elements consist of long bars which are provided with teeth and spaces in one of the edges. The teeth for six bars are cut in different combinations in such a way that the bars placed on top of each others constitute the selecting feature in the unit. The bars can be displaced lengthways a small amount equalling half the spacing in the multiple i.e. 1.5 mm. The operation of the bars takes place by means of six electromagnets with armatures engaging holes in the code bars. The holes are shaped in such a way that one bar only is displaced by the movement of each armature.

The code bars are divided into two groups. One group consists of two bars and determines the level that is to be connected. The selection is accomplished by a space being formed which traverses the edges of all bars. The mechanism must, therefore, be capable of finding these negative selections, the open spaces. The procedure is as follows: Each connecting magnet—vertical—can operate seventeen selecting elements—one for each spring set in the multiple—consisting of L-shaped rockers pivoted on a common shaft and being individually spring loaded so as to move down against the teeth of the code bars. The rockers are, however, normally held out of engagement with the code bars by a lifting bar operated by the connection magnet. When this magnet is operated the rockers are released and one of the arms is pressed down against the code bars. Most of the rockers come to a halt against one or more teeth on the code bars but two of the rockers, one level rocker and one outlet rocker, are free to move into open spaces. These will take up positions different to the rest of the rockers and engage the upper edge of the lifting bar. When

Fig. 6
Complete multiple

x 7928



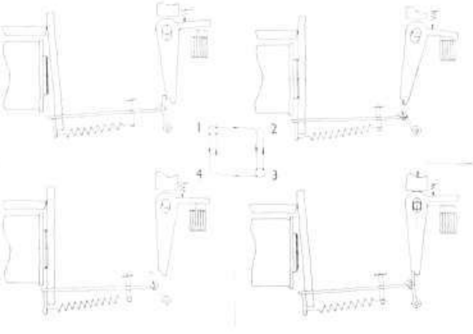


Fig. 7 x 2793
Operation of the selecting system
1 Rest position
2 Selection position
3 Connection position
4 Locked position

the connection magnet releases, the lifting bar will actuate the selected rocker in such a way that they are lifted up operating in their turn the lifting combs in the multiple immediately above. The other rockers are returned to the original position. The code bars can now return to home position and a new selection can immediately take place. It follows that a change-over from one position to another can take place without homing the selector. The method of operation is illustrated in fig. 7 which shows the different positions that the selector mechanism and the rockers can take up. It also follows that the switch requires power only at the moment of change-over. The switch is thus dead in home position as well as in operated position and this means naturally a saving in power. This is particularly important in case of such functions as concentration. Also with reference to a future electronic control of the switch this property is valuable.

Although a particular home position is not required, such a position may in certain cases be desirable and it should also be possible to indicate this in a special way. Among the positional combinations which the code bars can take up, the non-operated position of all bars is one. This position can preferably be utilized as home position. With a suitable arrangement of the teeth on the code bars it is possible in this case to operate two adjacent lifting combs simultaneously. An additional contact spring set can be placed on top of the multiple which is operated only when these two lifting combs are actuated. This is accomplished in such a way that a metal stud fixed on a wire spring is resting on the two lifting combs, being displaced if one lifting comb only is actuated but lifting the spring set if both combs are actuated simultaneously. The method is shown in fig. 8.

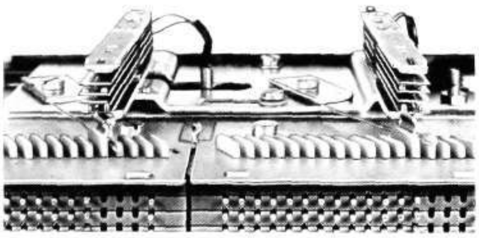


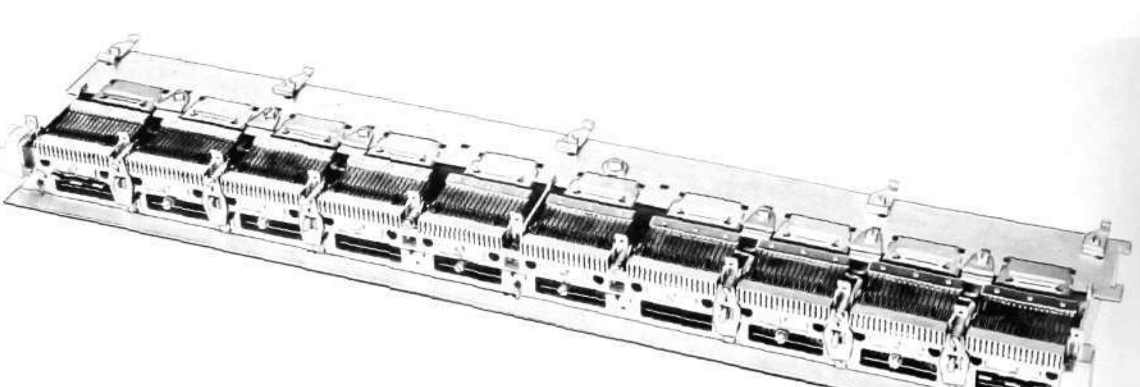
Fig. 8 x 2800
Home position spring set

The mechanism is assembled on a relay bracket common to all ten connection magnets. The code magnets are placed in six of the spaces between the connection magnets and do not, therefore, require any extra space.

The rockers belonging to each connection magnet are collected into a rocker unit which is mounted on an L-chaped steel rail running along the front of the switch which also carries the code bars. This subassembly of the switch mechanism is secured to the relay bracket and the magnet by means of three steel pieces which also serve as feet for the entire mechanism. The switch mechanism is now complete and constitutes a separate unit in the same way as the multiple. (Fig. 9.) These two units are then assembled by means of screws between the contact frames. Under the screw heads expanding washers are inserted which press the multiple and the mechanism together with great accuracy. It is only at the front that an accurate fit is required between the mechanism and the multiple. The assembly of the two units at the rear can, therefore, be made by pushing the bottom plate of the multiple under lugs fixed on the relay bracket. A complete switch is shown in fig. 10.

To prevent displacement of the mechanism relative to the multiple a stud is placed in a hole in the relay bracket. The stud fits into a corresponding

Fig. 9 x 7929
Selector mechanism



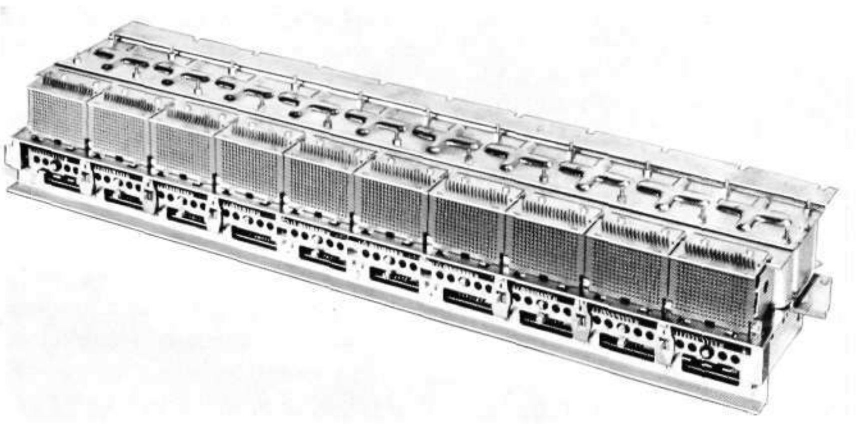


Fig. 10 x 7930
Complete switch

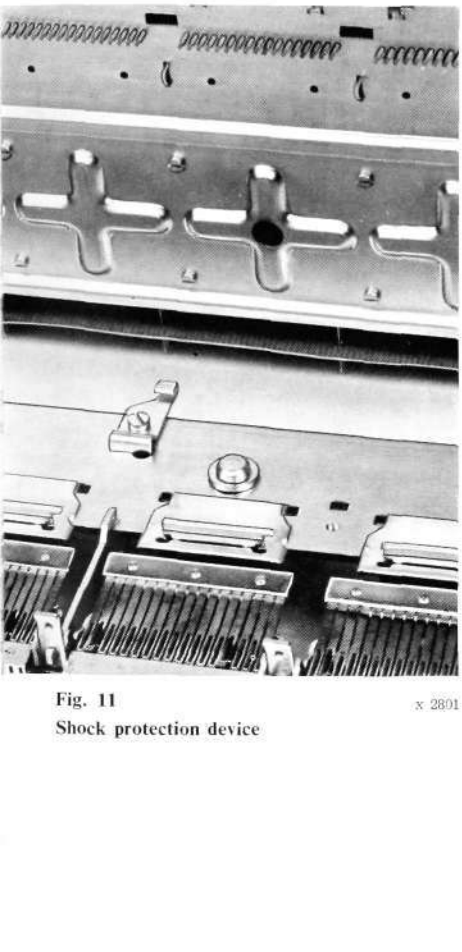


Fig. 11 x 2801
Shock protection device

hole in the bottom plate of the multiple and secures in this way the mechanism positionally to the multiple. (Fig. 11.) It should be observed that this arrangement serves to take up exceptional stresses only, for instance in transit. In normal operation it is quite unnecessary.

A switch built up in this way has the following data:

Height	Width	Depth	Front face	Weight
mm 112	mm 656	mm 158	dm^2 7.35	kg 9.85

For a four-pole switch this means 24.7 g and 1.83 cm^2 per outlet. As a comparison it can be mentioned that the corresponding values for a normal crossbar switch is 72.5 g and 6.4 cm^2 per four-pole outlet.

Wiring of the Multiple

Owing to the compact construction of the multiple it is difficult to carry out wiring direct on the multiple wires, for instance by soldering. Instead of this a plug and jack method is used where the multiple wires themselves constitute the male members. The female side of the connection consists of U-shaped channels where the legs have been provided with four indents which force the multiple wire to take up a slightly curved path. As finally dimensioned the pressure on the four indents is 80, 240, 240 and 80 g respectively which provides a very reliable and shockproof contact.

Twelve such channels are mounted in a flat frame with a thickness slightly less than the spacing of the multiple (3 mm.). The connection of the cable is carried out at the rear part of the channels. As the frame is made in a flexible plastic material—polypropylene—the channels can after soldering be inserted in holes in the rear of the frame with the wires held securely in place. The wired complete unit is a thin, flat plate with the wires extending from one edge of the frame. (Fig. 12.) It is also possible to connect several such connectors by a traversing bunch of wires. A wire bunch with connectors can be used to connect an arbitrary number of selector multiples in parallel.

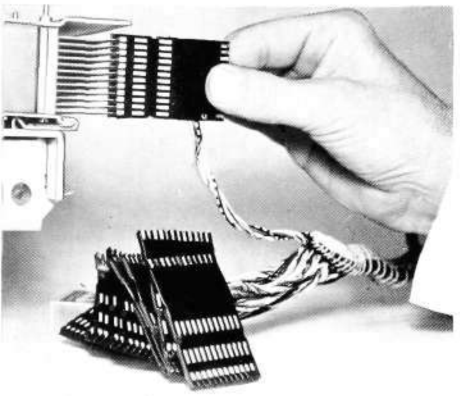


Fig. 12 X 2802
Connector

Connection Relay

In conventional crossbar systems the connection of a certain selector to the common control device, such as the marker, is achieved with special connection relays common to a number of selectors. This results in a great con-

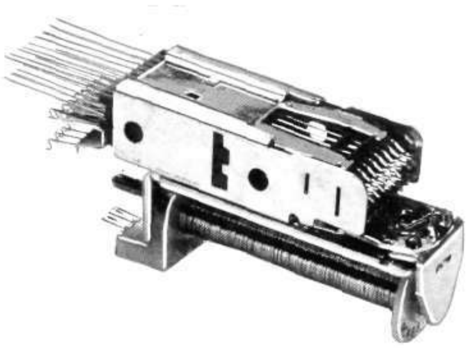


Fig. 13 x 2893
Connection relay

centration of wires in the racks, as all magnet windings in the selectors must be connected right up to the connection relay. This is advisable when the selectors have fixed cabling in their rack. As the code switch is connected with the connectors described above and consequently does not require fixed cabling in the rack, it is desirable to provide each switch with an individual connection relay. When the selector equipment in a rack is increased, there will be a corresponding addition in the number of connection relays.

Such a relay must have one male contact for each magnet winding i.e. 16. As a standard LME relay has a maximum of 12 makes a new design was desirable. A relay with 18 make contacts is shown in fig. 13. As in the code switch round wires are used as relay springs and the contact is essentially constructed in the same manner in the two designs. The V-shaped contact is obtained as follows: The tube of contact material that is pressed on the front end of the relay spring is long enough to extend in front of the spring end. This front part of the tube can be formed to required V-shape. The other member of a contact pair is cylindrical in the same way as in the code switch.

Rack Constructions

L M Ericsson has for a long time used relay sets connected over plug and jack to the rack wiring. As the selector now is similarly connected, the lay out of the rack construction will be more flexible. Particularly for large exchanges it is desirable to reduce the space requirement for the connection devices. In order to reduce this as far as possible it was decided for system *AKF 10* to make the racks so that they could be placed side by side as books in a bookshelf. To make both sides accessible for repairs and maintenance they were arranged so that they could be pulled out one by one. The racks were suspended in trolleys running in girders above the racks. The cabling required for the exchange was placed in the floor below the racks and there is, therefore, no cabling above the racks. The space required for the cabling can normally not be used for other purposes, as connection devices cannot be placed at this level for maintenance reasons. With movable racks the cabling to the indi-

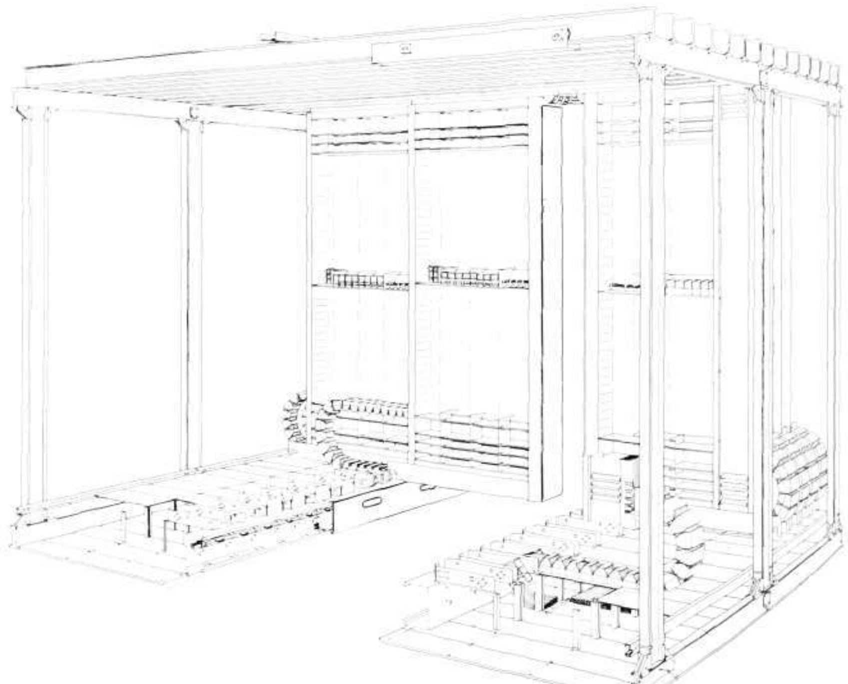


Fig. 14 x 7931
Construction of telephone exchange with code switch

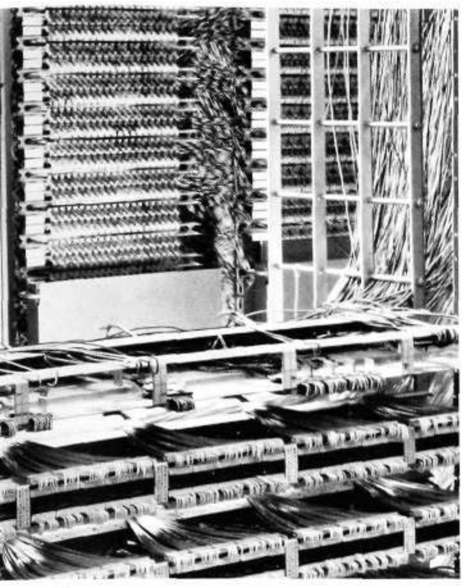


Fig. 15 x 2804
Part of distribution frame

vidual racks must be flexible. This problem was solved by running the cables through a flexible link chain, which starts at the rear end of the rack and then in a 180° bend runs down and forwards underneath the rack. The construction is shown in fig. 14. With this arrangement the space requirement for the connection devices was reduced to about one third of that for a corresponding exchange with a conventional crossbar system. The saving in space is due roughly to 50 % to the selector design and otherwise to the rack design.

The racks are constructed with a front spacing of 210 mm and are provided with a hinged lid covering fuses, blocking keys and jacks for the connection of power supply for the equipment as well as jacks for tests of different kinds.

Power Distributions between the Racks

Underneath the front of the racks there is a space used for power supply and signal current supply. The spacing between the racks is very small and the voltage drops, therefore, low. From the power supply equipment insulated cables are run and these are stripped at each rack and provided with an individual fuse. From this fuse a flexible cable is run through the flexible cable chain and to the front of the rack. The cable is connected to the fuse holder in the front upright, which contains individual fuses for the equipment in the rack. Required signal currents are distributed similarly. In front of the cables running underneath the racks a horizonal cover is arranged common to a number of racks. This cover can be readily removed for test and inspection as well as for replacement of blown fuses.

Distribution Frame

The very much reduced space required for the apparatus hall was drawing the attention to the distribution frame (fig. 15), which by conventional methods tended to require almost as much space. In view of the fact that the fuses in the distribution frames more and more were omitted by administrations all over the world owing to the increased use of cables in the local networks, it was decided to develope a distribution frame without fuses. The female connector described above could then with advantage be used as connection point without screw or solder connection of the jumper wire. The latter was produced as an insulated cable with conductors made of the same material as that in the code switch multiple. By stripping this cable at both ends to a convenient length each end can be used as plug in the connector. Connectors for 10 lines were collected in holders mounted in shelves accommodating 500 lines. The shelves are mounted horizontally in racks for 25 shelves, i.e. 12 500 lines.

Two such racks are placed side by side with a small space between. This space is used for the vertical distribution of the jumper wires. One of the racks is connected to the line side and the other to the exchange side. The two racks constitute a distribution frame for 10 000 exchange lines and 12 500 outgoing lines. In addition there are 2 500 lines in reserve for various purposes such as for the connection of lines requiring fuses.

A distribution frame of this type requires a floor space of 12 m² only. It is also possible to build larger distribution frames with several units of 10 000 lines. These units are then joined with horizontal shelves to hold the jumper wires between the units. Each additional 10 000-group then requires about 6 m² only in floor space.

Automatic Telephone Exchanges with Code Switches

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L M Ericsson has developed new automatic telephone exchange systems with code switches. The first large public telephone installation using code switches has been put into operation in Copenhagen and a presentation of the system design and its essential characteristics is made in the following article.

The development of the code switch which has been described in the previous article, has also involved the development of new telephone exchange systems using code switches.

The design of the code switch exchanges is based on the same technique and grouping methods used in L M Ericsson's crossbar exchanges, but the switching characteristics of the code switch with selection of multiple positions by a binary coding method and the greater multiple capacity of the code switch vertical can be said to be the main reasons for making the new designs.

In the planning and design of the new automatic telephone exchange systems using code switches, L M Ericsson has made a detailed inventory of the current and future needs and desires concerning the facilities which a fully modern telephone exchange plant should offer or could be adapted to give. This has resulted in the code switch system being provided with new and improved technical facilities which for telephone Administrations mean more rational usage of the different units of the system and give improved service to the subscribers.

One of the factors which has influenced the development of the code switch is the possibility of having an improved economic arrangement of the local exchange network by decentralizing simpler exchange units in the subscriber networks to a greater extent. A greatly increased usage of the lines in the subscriber cables is thereby obtained with consequent great economic advantages.

A deployment of exchange equipment from the main exchange assumes that this equipment requires little space, uses a small amount of power, i.e. permits the use of simple power supply equipment, has components which are insensitive to external conditions, and of course requires a minimum of maintenance. These requirements are fulfilled by the code switch which has the well-known advantages of the crossbar switch and also offers new characteristics, among which can be mentioned:

it requires less space,
has greater multiple capacity,
has improved contact properties,
uses less power.

Decentralized exchange equipment has to have a simple schematic design, and more qualified equipment for switching and supervision functions has to be centralized at the superior exchange system. It is also desirable that subscribers connected to decentralized units or to superior exchange are offered the same facilities.

The rapid development in the field of long distance telephony places special requirements on a modern telephone exchange system. The transition from manually operated long distance telephony to fully automatic operation means more rapid and simpler establishment of long distance circuits and often at very much less cost. As a consequence, the long distance traffic rapidly increases at the same time as it changes character i.e. it has shorter conversation time and increased call frequency. One of the consequences of this development is a progressively increasing need of telephone systems which can be built out to large exchange units, have large traffic handling capacity and which satisfy the increasing requirements of technical facilities and traffic routing possibilities.

The increasing automatization of long distance traffic to and from small local towns has brought about demands for smaller, well exploited and economic exchange equipment which satisfies demands for technical facilities in the same way as the main exchanges of the large exchange areas and which furthermore offers possibilities of expansion in economically well balanced stages.

The design of code switch systems has also been made having regard to the greater flexibility when interworking with telephone systems of other manufacture and to the possibilities of modifying and supplementing existing signalling methods and a possible future change over to more rapid signalling systems.

General Characteristics

A similar schematic design is used for the code switch system *AKF* as that for L M Ericsson's crossbar systems. Both systems are register controlled and consist of subscriber stages and group selector stages. The subscriber stages are combined line finder and final selector stages and handle both outgoing and incoming traffic. The group selector stages are individual units and the systems can be provided with one or more stages depending on traffic conditions in the exchange area.

The individual selector stages consist of two or more partial stages which are connected together according of the link connection principle. The setting of the switches is controlled by markers.

New functional possibilities have been introduced into the code switch system *AKF 10*, which means that the system in certain aspects has a design which departs from the crossbar system.

The *AKF 10* system has a line allotter which is common to a 10 000-line group thereby enabling the subscriber directory number to be completely independent of the position of the subscriber line in the exchange system. This means that there are no restrictions in the whole 10 000-line group concerning locations of *PBX* lines, choice of *PBX* calling and individual numbers, rearrangement of all types of subscriber lines for smoothing out of traffic and the introduction of subsidiary exchanges without having to change the subscriber's directory number. The line allotter also enables a saving in the exchange equipment as the reserve numbers which should exist to cater for the turnover of subscribers, removals etc., need not occupy multiple capacity.

The register functions are divided up so that the register proper contains equipment for reception and storage of digital information from telephone sets with dials or keysets. All traffic routing and analysing functions are concentrated to separate, highly qualified, common groups of devices, coordinators and code senders. In this way the functions are concentrated to a few devices, thereby leading to simplifications when the junction line network has to be rearranged.

Internal connections are controlled by coordinators which can reach all interworking markers in switch stages and line allotters via a bypath which is completely separate from the speech path. The internal transfer of information between coordinators and markers occurs over bypaths using high-speed, self checking d.c. code signalling.

The subscriber stage *SL* in the *AKF 10* system consists of two partial stages for both outgoing and incoming traffic. This has been made possible due to the greater multiple capacity of the code switch and by the switching from the input of the last group selector stage to the calling multiple position in the subscriber stage being made by conditional selection. The conditional selection is made by establishing interworking between the markers in the different switching stages via the bypath network. An appreciable saving in the subscriber stage selector equipment has been obtained using this procedure.

System Design

The system design for *AKF 10* applied to the requirements for medium-sized and large public city networks is seen in the block schematic fig. 1.

The system consists of the following units:

Subscriber stages
Line allotters
Group selector stages
Registers
Coordinators
Bypath networks
Code senders
Code receivers

The subscriber stage, SL, is grouped for 1 000 subscriber lines and consists of two partial stages *SLA* and *SLB*. The *SLA* stage is divided into units of 200 multiple positions, each consisting of four primary groups of 50 lines corresponding to the code switch vertical capacity in the selected grouping. The 50 lines are connected to a number of verticals in parallel i.e. 10, 15 or 20 depending on the desired traffic capacity. Each 200-line group in the *SLA* stage is provided with an individual subscriber identifier *ID*.

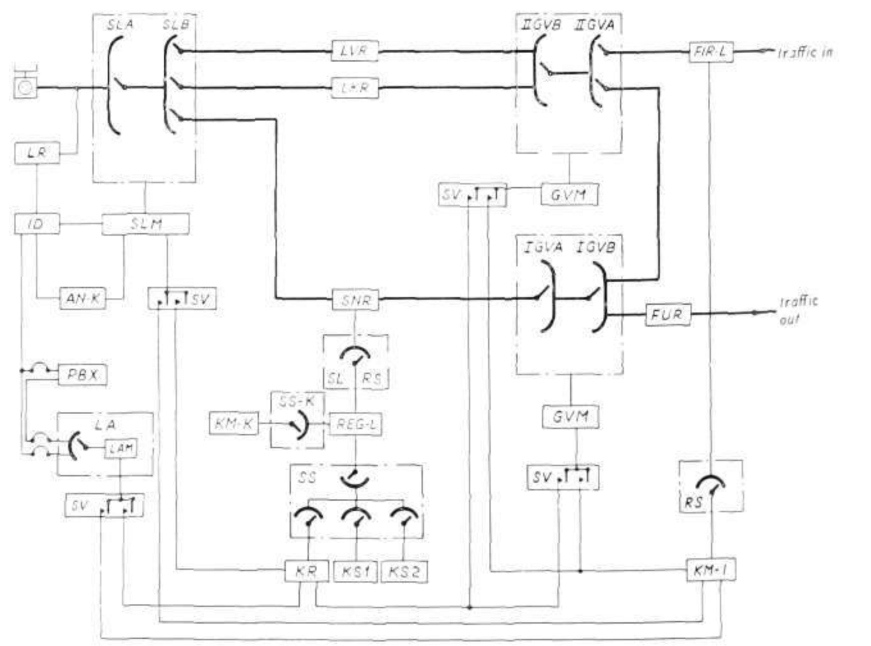

Fig. 1 X 7932
System AKF 10. Block schematic

LR	Subscriber line relay equipment
SLA, SLB	Subscriber stage
SLM	Marker for subscriber stage
ID	Subscriber identifier
GVA, GVB	Group selector stage
GVM	Group selector marker
SNR	Link circuit relay set
LVR, LKR	Final selector relay set
FUR	Line relay set for outgoing traffic
FIR-L	Line relay set for incoming traffic
SLRS, RS	Register finder
REG-L	Register
SS-K	Finder for push button code signalling receiver
KM-K	Push button code signalling receiver
SS	Sender finder
KR	Coordinator
KS1, KS2	Code signalling sender
KM-I	Code signalling receiver
LA, LAM	Line allotter
PBX	PBX equipment
AN-K	Analyser for subscriber classes
SV	Bypath relays

The verticals in the *SLB* stage are divided for incoming and outgoing traffic and the number of verticals varies with the traffic handling capacity of the *SLA* stage.

The 1 000-line group is served by two markers *SLM* operating in parallel and each marker can simultaneously handle two calls displaced in time. The main function of the *SL* markers is to carry out the connection through the *SL* stage. In the case of an outgoing call the marker controls the switching from the subscriber's line equipment through the *SL* stage via a free link circuit *SNR*, register finder *SLRS* to a free register *REG-L* in one selection.

In the case of an incoming call, the marker investigates the state of the subscriber and selects the inlets in the *SLB* stage that can be used by the group selector so that a connection can be established to the desired subscriber, and carries out the switching.

The line allotter LA is an equipment that enables any subscriber to have any arbitrary directory number irrespective of the position of the subscriber line in the whole 10 000-line group exchange multiple. The 10 000 directory numbers are each represented by a position in a distribution frame and selection of the individual positions is made from the line allotter which receives information concerning the dialled directory number from the register via the coordinator or from the incoming code receiver.

In the same distribution frame there are calling wires to the subscriber identifiers *ID* corresponding to the 10 000 multiple positions of the exchange unit in the subscriber stages. By jumpering in the distribution frame any directory number can be associated with any multiple position. The function of the line allotter is to select the multiple position of the subscriber's line, and at the same time to make a call to the subscriber identifier and to a marker in the 1 000-line group *SL* to which the line is connected.

The distribution frame for associating the directory number with the position number is a miniaturised distribution frame of the type described in the previous article. Jumpering is made using twin wire, one wire of which is used for selecting the subscriber position and call to the identifier. One of the functions of the other wire is to connect the call meter to the subscriber multiple, so that the call meter is always associated with the directory number.

The group selector GV has 200 inlets and 840 outlets in the multiple. The stage is served by two markers *GVM* operating parallel.

The disposition of the 840 outlets of the group selector multiple can be simply adapted to the traffic requirements of the exchange plant. The multiple outlets can be divided into a maximum of 100 different routes and the availability in each route can be varied between 5 and 80.

The group selector marker controls the switching in the stage and carries out alternative routing using the number of alternative choices that are required in different fields of use. The alternative routing is concentrated to separate plug-in type relay sets which can be plugged into the marker as required.

The register REG-L contains equipment for receiving digital information from the telephone set. As no translation and traffic routing functions occur in the register, storage of the digital information is made on simple relay stores and in coded form, permitting reading off and transfer to interworking devices without translation of signals.

The coordinator KR controls the internal switching in the system. It analyzes the received directory number so as to decide the called exchange, translates the exchange number to a routing code and transfers this to the first group selector marker.

In the case of internal switching, the coordinator arranges the transfer of directory numbers from the register to the line allotter, receives information from the called *SL* marker concerning the identity of the subscriber stage in which the subscriber line is connected as marker and passes on this information to the marker in the last group selector stage. The coordinator also passes on the flow of information between interworking devices and in the correct sequence. As soon as the subscriber's position has been selected, the coordinator requests information from *SLM* on the state of the subscriber. If the subscriber is free, the switching is carried out. If the subscriber is busy or barred, the switching is interrupted and the calling subscriber can be put on line lock-out.

In the case of external switching, the coordinator is connected for switching the first group selector stage. Guided by information from the group selector marker concerning the selected line, the coordinator determines the type of code sender to be called and then sends to this unit all information required for further switching.

The coordinator holding time is very short compared with that of the register. In general, the number of coordinators required to the number of registers is roughly in the ratio of 1 to 10. Like other groups of devices in the register system, the group of coordinators is designed in accordance with traffic requirements.

Signal transfer between coordinators and interworking devices, i.e. markers and line allotters, occurs over an 18-wire bypath network separate from the speech paths using self-checking d.c. code signalling.

The bypaths are individual to each coordinator, i.e. there are as many bypaths as coordinators. The bypath network permits signal transfer and switching to be carried out very rapidly in several stages simultaneously. The last-mentioned functional possibility is used for internal switching when switching of the first group selector stage occurs at the same time as transfer of the directory number to the line allotter, selection of the subscriber position and call of the identifiers and markers in the subscriber stage.

The code sender KS is used for transfer of information to other exchange units. The code sender is provided with all equipment dependent on external signalling conditions, and when interworking with different telephone systems, the exchange can be provided with different types of code sender without having to make any changes to the rest of the system. This means a simplification when interworking with exchanges in existing networks and makes easier the successive change over to more modern, and possibly more rapid, signalling methods in the future.

Compelled sequence multifrequency code (*MFC*) signalling is used when interworking with other *AKF 10* exchanges and with certain crossbar systems of L M Ericsson's design.

The code receiver KM-I for incoming traffic is connected to the input of the last group selector stage. It is provided with a simplified coordinator for interworking with markers and line allotters via the bypath network.

The system can be provided with the various types of code receiver or register necessary for interworking with different exchange systems.

Technical Facilities

In addition to the specific functional possibilities mentioned in the previous section, the *AKF 10* system possesses many other technical facilities, of which the most important will be seen in the following.

Telephone sets. Both telephone sets with dial speeds of 10 or 20 i.p.s. and push button telephone sets can be connected to the system simultaneously and both types can be used at the same time on the same subscriber line. The code receivers for receipt of digital information from push button telephones are connected when the subscriber is given a special class in case only some of the subscribers are provided with this type of telephone.

PBX subscribers. The line allotter allows the subscriber line connections to the exchange system to be completely independent of the subscriber directory number. For *PBX* subscribers, this means that the lines belonging to the same *PBX* group can be spread in any manner over all the 10 000-line group without having regard to the selected group number or individual number for night lines. It is not necessary either to reserve multiple positions or directory numbers in sequence in the system for future expansion of the *PBX* group size. New lines can be put into free multiple positions anywhere in the system and be reached with the original group number.

The *PBX* equipment is a completely independent equipment which can be expanded in small units and can be connected to the system via the line allotter distribution frame. Within the line and traffic capacity of the exchange system, the *PBX* groupings can be made without limit to the number of *PBX* groups, their size, or the choice of group or individual number.

Coin boxes. Both single coin boxes and three slot coin boxes, unrestricted or barred to trunk traffic can be connected to the system.

Party lines. The *AKF 10* system can be provided with equipment for connection of party lines.

Subscriber classes. To satisfy a continually increasing need for subscriber classes, for example different types of blocking for national and international traffic, traffic routing depending on the calling subscriber's class, charging dependent on the called subscriber's class etc., the system is provided with a class analyser permitting any subscriber to be class marked for both outgoing and incoming calls.

The standard design of class analyser permits expansion in steps from 24 to about 64 different classes and this number can be increased further by the addition of supplementary equipment, if required.

Class marking of the subscribers is carried out in a distribution frame of the same type used for connecting the subscriber's directory and position numbers together.

The class analyser is connected to the subscriber stage marker which determines the classes and forwards these to the registers or other interworking devices.

Line lock-out. If a connection cannot be established e.g. due to congestion in switching stages or outgoing routes, or if the called subscriber is busy, the calling subscriber is put on individual line lock-out and all switching devices are restored. The subscriber then receives busy tone from the line equipment.

If the register is seized for longer than a given time, the calling line is put on line lock-out and the register is released.

Priority marked traffic. The *AKF 10* system is designed so that certain subscribers can be priority marked. During periods of heavy traffic and when the priority facility is connected, traffic from priority marked subscribers will be handled before ordinary traffic.

The system permits the use of different degrees of priority. For example, the system can be equipped so that priority marked traffic meeting congestion in a route blocks this route for ordinary traffic for a given time and repeated switching attempts are made automatically by the register. This degree of priority thus allows ordinary traffic to be handled during periods of low traffic.

A higher degree of priority means total blocking of traffic from non-priority marked subscribers.

Call metering. Each subscriber is provided with an individual call counter which is associated with a given directory number. Metering of local calls can be made with one metering pulse for each answered call or by using random call metering, i.e. the number of metering pulses corresponds to the conversation time.

Metering of national trunk calls or international calls is made using time-zone metering i.e. the interval between metering pulses is dependent on the circuit length. In general the rate is determined at the superior exchange and the metering pulses are sent over the speech wires to the local exchange which forwards the pulses to the call counter.

Identification of calling subscriber. It is necessary to have this facility when toll-ticketing is required and a card printed for each call made. The system is prepared for the addition of equipment which identifies the calling subscriber directory number and sends this to the toll-ticketing equipment of the superior exchange.

Subscriber-dialled trunk traffic. In addition to the different types of metering methods used for trunk traffic—time-zone metering or toll-ticketing, the subscriber-dialled national and international traffic places special demands on the storage and sending of a large number of digits. The register group in the standard design of the *AKF 10* system can store 12 digits simultaneously, which in general is sufficient for the national traffic and probably also for the international one.

If a greater number of digits is required, so-called cyclic operation of the digital store is used i.e. as soon as groups of digits have been sent to the superior national and international registers, the store can be used for further digits. This method means that the register group can receive and forward an unlimited number of digits.

In-dialling to *PABX* extensions is a natural facility for the centralized *PABX* system, but the standard design of the *AKF 10* system also permits in-dialling to extensions in decentralized *PABX* exchanges.

Interception service (absent subscriber service). The system is designed for centralized interception service. The subscriber's lines can be marked for this service and be reset to normal operation with the assistance of the telephone operator answering the call. The equipment provides the possibility of having different markings and includes incoming calls to a subscriber marked for this service being answered by a telephone operator who can provide individual information or being connected to an answering machine. The subscriber marked for interception service can make outgoing calls without the assistance of the telephone operator.

When a call is made to a vacant number it can be redirected to the telephone interception service or to a special outlet in the group selector multiple which sends out a special tone.

The detached exchange and *the line concentrator* are used to reduce the number of lines in the subscriber network. The detached exchange is characterized by it being part of the parent exchange subscriber stage which can be geographically removed and placed in the subscriber area which it serves.

The detached exchange requires the least possible addition to the exchange equipment as the normal common equipment of the parent exchange is used to control the part which has been moved out. The only addition required at the parent exchange is equipment for sending and receiving of signalling.

Subscribers connected to detached exchanges have the same technical facilities as subscribers connected to the parent exchange. Detached exchanges are designed in units of 50 to 200 subscriber lines. Power supply is obtained from a local battery which is charged from the parent exchange via disengaged trunks.

The detached exchange permits appreciable savings to be made in many types of subscriber network both when it is included as a definite unit in the exchange area and also in the cases when it is used as merely a temporary solution to defer the extension of the cable network.

As the code switch detached exchange is a part of the parent exchange, it is to a certain extent dependent on the system but it can equally well be connected to either code switch systems or crossbar switch systems of L M Ericsson's design.

The line concentrator on the other hand is completely independent of the parent exchange system. This type of exchange can be expanded to the same size as the detached exchange, i.e. for 50 to 200 subscribers lines.

The line concentrator has the same economic advantages in the subscribers network as the detached exchange but requires more material.

Supervision of Operation and Traffic Recording

The *AKF 10* system is provided with equipment for checking traffic handling and fault finding. Supervision of operation is made to a great extent by using information given by the common equipment. This contains circuits which when a fault develops, seize registration equipment and give information as to which devices have taken part in the unsuccessful switching and in which switching phase the fault occurred.

Occasional disturbances should not in general require intervention in the equipment. This should first occur when the number of disturbances exceeds a certain predetermined value. The common devices are provided with counters for this purpose which count the number of calls and also the number of faults. If the fault percentage exceeds the permissible value, the registration equipment is seized, in the case of larger installations this consists of a card punch, which registers the identity of the faulty device, time, interworking devices and switching stage.

The subscriber-dependent part of the switching is supervised by check register which besides automatically measuring the subscriber line, checks the result of the switching attempt. Faults are recorded on punched cards. Central observation equipment can be connected to the check register permitting supervision operators to follow the switching and intervene in case of a fault.

The system also contains many other maintenance aids. These include automatic supervision of outgoing routes, automatic identification of interworking equipment in the speech paths, automatic blocking of faulty devices when there is high fault frequency, etc.

Occupation counters and congestion meters for measuring the availability of common devices are also used for supervision.

Traffic measuring equipment is used for measuring traffic flow in the different groups of devices and congestion counters for measuring call intensity and call distribution. Having regard to alternative routing, it is possible to measure traffic on different routes and to different destinations. For larger and more important routes, e.g. routes for overflow traffic to local tandem exchanges, continuous congestion supervision is used.

The *AKF 10* system is equipped for connection of test equipment for both checking of quality and checking of individual devices and traffic routes.

The Automatic Exchanges in Central Copenhagen

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With the cut-over of the first fully automatic exchange at Nörregade on April 21, 1964, the automatization of the central Copenhagen telephone system had started and an epoch in the history of the Copenhagen Telephone Company (KTAS) is thereby nearing its completion. The Central Exchange, which has been the centre of the Copenhagen telephone system, will be closed down in the course of the coming four years; those of its subscribers who live in the city of Copenhagen will be transferred to the new automatic exchanges at Norregade and the remainder to district exchanges in the area where they live.

"The Copenhagen System"

Before the First World War

The telephone system peculiar to Copenhagen was designed in the years 1905–10 on the initiative of the Director General of the Telephone Company at that time, Frits Johannsen. On the basis of extensive statistical analyses of telephone utilization and of studies of the technique and profitability of the various exchange systems, it was decided to build a large central exchange for the whole of Copenhagen including the outer suburbs, comprising altogether about 450 000 inhabitants and 34 000 telephone subscribers, supported by a system of small district exchanges. Subscribers with an annual calling rate of 3 000 and above were to be connected to the Central Exchange and other subscribers to the district exchanges.

Since the frequent callers—banks, large firms, public institutions etc.—at that time communicated mostly with other subscribers of the same category, a large part of the traffic was "local traffic" within the Central Exchange. A local call was completed by an operator, while a call to and from other exchanges required the assistance of two operators. In view of the large local traffic of the Central Exchange—in 1910 about 70 % of all calls—this meant that a large quantity of traffic was handled for a comparatively moderate operating effort, and therefore both quickly and cheaply.

The large Central Exchange building was erected in the years 1908–09, and the new manual C. B. exchange was cut-over on the night between June 18 and 19, 1910, simultaneously with the closing down of the old magneto exchange (at Jorcks Passage).

The equipment for the new Central Exchange was supplied by Telefonaktiebolaget L M Ericsson, Stockholm. At the cut-over it comprised equipment for 14 000 lines with a multiple capacity of 18 000 in four suites on two floors, and about 9 500 high-usage business telephones were connected.

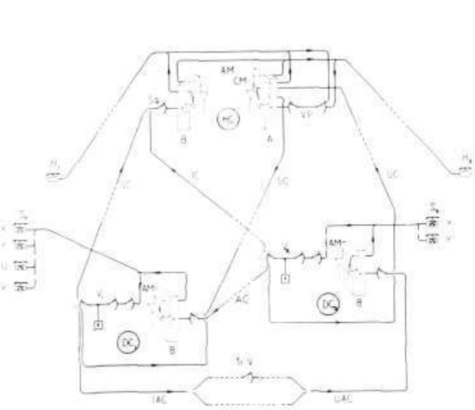


Fig. 1 X 2805

"The Copenhagen system"

A simplified trunking diagram of "The Copenhagen system" after modernization of the manual Central Exchange with, among other features, automatic distribution of calls to single-cord operators' positions. HC denotes Central Exchange, DC_1 and DC_2 semiautomatic district exchanges.

After the First World War

At the end of the first world war in 1918 the Central Exchange was in need of expansion. After a detailed study of the technical and economical possibilities it was decided to retain the Copenhagen system with manual central exchange extended by a new group of operators' positions, and at the same time to carry out a thorough revision of the system so as to incorporate, for instance, an effective system for semi-position operation, automatic distribution of calls among operators, an advanced system of keyless single-

Fig. 2 X 7933
A view of the manual switchroom of the Central Exchange as it looks to-day. One sees part of the four suites on the "floor" and in the "gallery"

cord working, lamp signals for assistance in testing, the use of machines for announcing the name of the Central Exchange, lighter cord weights, better switchboard profile etc.

After the Second World War

By 1947 the number of subscribers connected to the Central Exchange had reached its maximum of 21 000. These subscribers made about 165 million calls a year, and the outgoing and incoming traffic was handled at 326 operators' positions.

Thanks to the improvements that had been effected, these positions could handle about 400 calls an hour with an average time-to-answer of only 1.7 second and a setting-up time between two Central Exchange subscribers (from the moment of raising the handset until the called subscriber was rung) of 8 seconds.

A few years ago Dr. Karlsson's principle of call metering was introduced. This enabled Central Exchange subscribers to obtain trunk calls on a demand basis; at the same time this facility was adopted at the district exchanges in Copenhagen.

All this meant that the Central Exchange functioned excellently for many years. Until very recently it has been the preferred exchange for business telephones since, in addition to its technical and service advantages, it was considered "smart" and good for publicity to have a "Central Exchange" number.

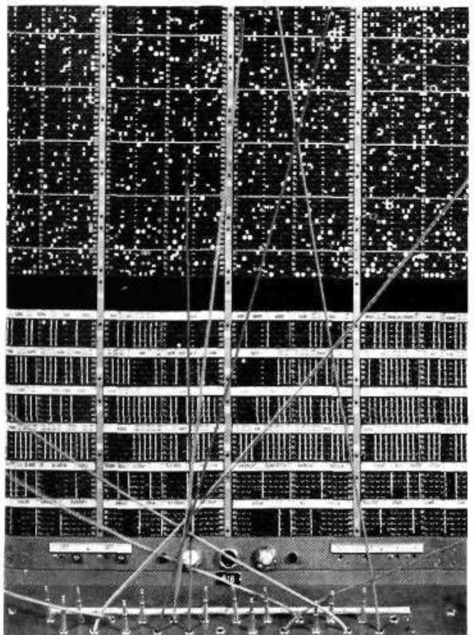


Fig. 3 X 2806
The multiple field of an operator's position at the Central Exchange. At the top are the subscriber multiples with indicator plugs and PBX jacks, further down the large subscriber multiple for subscribers with more than 5 lines, and at the bottom the junction multiple with lines to district exchanges etc. On the keyshelf are seen single cords with call and clearing signal lamps.

Automatization Comes up for Consideration

Even if these advantages for the Central Exchange subscribers could be maintained over a period of many years of intense technical development, it was nevertheless clear—from the time when fully automatic exchanges and subscriber dialling in Copenhagen were planned—that it would be necessary to replace the manual exchange by an automatic system.

With the relation that has existed between prices of materials and wages, especially since the war, it was clear that the time of the manual exchanges was past. The operating expenditure for the main exchange had risen to nearly four times the 1939 level, and on economic grounds alone the automatization of the Central Exchange was considered necessary.

Developments in other respects—in particular the growth of the city and the consequent removal of many business firms from the centre—had meant that the percentage of local traffic, which had originally been about 70, had fallen already by 1944 to around 50 per cent and in 1957 had reached the level at which only about 35 per cent of calls from a Central Exchange subscriber went to other Central Exchange subscribers.

This meant that the original motives for establishing and retaining the Central Exchange had disappeared, and the reasons for special treatment of the Central Exchange subscribers had been invalidated by the extremely sharp rise in trunk traffic that has taken place in the last ten years.

Planning for Automatization

Plans for an automatic exchange to replace the manual Central Exchange were started in 1957.

Location of Exchanges

The first question to be settled was whether the new automatic exchanges which were to replace the Central and the three district exchanges—Byen, Palæ and Minerva—should be located as close as possible to the old exchanges or whether the opportunity should be taken of distributing them more evenly through the area.

After detailed investigations it was decided that new exchanges should be placed as close to the old Central Exchange as possible. An important factor in this decision was the routing of the cables for the future subscriber distribution. On the basis of a preliminary plan for Copenhagen drawn up by the Municipal Town Planning office it was found that the distribution of cables in different directions would be roughly unchanged provided that the new automatic exchanges were placed in Nørregade. This meant, too, that the existing conduit network would cover the requirements of subscriber cables in the area for very many years ahead, and since the cost of conduits is very high this was the determinative factor in the location of the exchanges.

Type of Exchange

The next question was what type of exchange to adopt since it was desired to continue to employ L M Ericsson crossbar switching equipment.

Whereas the local traffic through the Central Exchange had in due course been reduced, this did not apply to the absolute traffic quantity—measured in erlangs. Here the Central Exchange subscribers remained in a class of their own—among other things because of the many and highly rationalized private installations, P.A.B.X. and the like, the traffic from which is highly concentrated on a comparatively small number of exchange lines.

As will be seen from the table below, the average traffic for Central Exchange subscribers is about three times as great as the average traffic for subscribers on the remaining exchanges in the district and about twice as high as the average for the City area (HC, By/Pa/Mi) as a whole.

	Number of lines	Total traffic			Traffic per 1 000 subscribers		
		out-going	in-coming	total	out-going	in-coming	total
HC	10 000	1 235	1 490	2 725	134	149	273
By/Pa/Mi	28 000	1 450	1 250	2 700	52	45	97
Total	38 000	2 685	2 740	5 425	71	72	143

Two essentially different solutions were therefore considered:

1) a separate automatic exchange for high-traffic Central Exchange subscribers, and ordinary automatic exchanges for subscribers from the Byen, Palæ and Minerva exchanges with more normal average traffic, or

2) automatic exchanges designed for the average traffic for the City area including subscribers from the Central and the three district exchanges.

During the extensive discussions of these problems which took place in 1957 between L M Ericsson and KTAS, it was decided that, using crossbar equipment type *ARF 10*, there would be only a very slight difference between the costs for the two solutions, but that the provision of exchanges for the average traffic in the district would nevertheless be the cheapest solution. This solution was preferable, moreover, both on technical and administrative grounds. No type of exchange had been developed which could cover the traffic requirements of the Central Exchange subscribers, whereas the average traffic for the area could be handled by a "standard type" of exchange of traditional structure, which would lead to a number simplifications in future administration, operation and maintenance.

Furthermore this solution would avoid the administrative difficulties which would arise in the evaluation of the correct locating of subscribers and their transfer to or from a high-traffic exchange.

The answer to this question was, therefore, that exchanges should be installed for the average traffic of the area, and thereby the final fate of "the Copenhagen system" was decided.

Since limitations of finances and of manpower precluded the otherwise desirable conversion of all four exchanges of the area simultaneously, it was decided that the Central Exchange should be converted first owing to the expense of manual operation. On the other hand the average traffic for the Central Exchange subscribers was, as noted, about three times as high as the average traffic for district exchange subscribers. And in order to achieve a uniform distribution of the traffic without needing to change the directory numbers of the transferred subscribers, it was decided that—using crossbar system *ARF 101, 10A*—the Central Exchange subscribers should be distributed from the start over four 10 000-line exchanges corresponding to the roughly 40 000 subscribers in the area.

During the subsequent deliberations L M Ericsson put forward a proposal under which this large expansion at the beginning of the period of conversion could be reduced to about half by modifications of the markers and later internal transfer of subscribers (without change of numbers). But apart from the alteration of the markers, this solution implied that very strict rules must be followed in the allotting of directory numbers in order to ensure a sufficiently even distribution of the traffic over the individual 200-line groups. It was nevertheless considered advantageous and was therefore accepted as basis for the preparations for the necessary crossbar equipment.

The Code Switch System Enters the Picture

Simultaneously with these discussions concerning the detailed equipping and building of new exchanges, L M Ericsson was working on the development of a new switch—the code switch—and of a new exchange system based on it. Work on this switch had started in 1955 and had now reached the stage at which the possibilty of its use in Copenhagen could be seriously discussed.

The new system appeared to have many features which would be advantageous in large automatic exchanges of the type considered, but it was so new that one could hardly count on the final design of the system being completed at a sufficiently early stage.

The new building which was to house the new automatic exchanges, and which was to be erected on a site behind the Telephone Administration Building in Nørregade, was therefore planned for the installation of crossbar equipment. In the first stage a building was to be constructed which, in addition to the necessary common equipment such as M.D.F., power plant and the like, would house equipment for 40 000 lines. A further building was to be added later which would bring the capacity up to 80 000 lines, which was thought to be maximum for the number of subscribers in the area. Work on the first stage started in May 1960 and comprises a built-up area of about 730 m² and a gross floor area of about 5 000 m².

Tender for the Code Switch System

The development of the new code switch system proceeded quicker than expected, however, and by the beginning of 1961 meetings were arranged in Stockholm at which various details concerning the structure and design of the system were discussed. It became evident that the system possesses important advantages compared with the previous crossbar. And as it was found possible to adapt the already started central exchange building for the new system, it was agreed that L M Ericsson should work out tenders for delivery of the automatic exchanges for Nørregade based on the code switch system.

The Code Switch System

The code switch system *AKF 10* is characterized especially by the entirely new design of switch, the entirely new racking arrangements, and by a circuitry which, in addition to a number of new operating facilities, permits easy adaption of the system to future requirements.

The mechanical structure of the system had already been thorougly studied, and the results of the extensive laboratory tests of the mechanical and electrical functions of the switch were known. The examination of the offer was therefore concentrated to floor plans and circuit functions, since the price of the new system differed so little from that for crossbar equipment as to be of no significance.

With the code switch racks suspended on rails under the ceiling and placed closed together, it is theoretically possible to install three times as much equipment in a given space as with the previously used equipment. But as regards the Nørregade exchanges, KTAS, for reasons of caution, had requested that arrangements should be made for the racks to be drawn out so far that two neighbouring racks or two racks one above the other could be inspected at one time so as to ensure access to any two points in the central equipment simultaneously. This arrangement resulted in a roughly 50 per cent saving of space for the switching equipment and permitted the installation of equipment for 80 000 lines in the first stage of construction. It also meant that the second stage could be eliminated or could be used for other purposes. This was a weighty argument in the acceptance of the tender.

In the working out of the code switch system the previously used circuit diagrams were critically examined and revised and the opportunity was taken of introducing a number of finesses of technical, economical and operational character.

The most important of these new features is without doubt—especially for the present assignment—the so called line allotter. This combined relay equipment and I.D.F. permits the locations of the subscribers in the exchange system to be changed by means of simple reconnections without changing their directory numbers, which permits equalization of the traffic in the individual 200-line groups. The line allotter also makes it possible to concentrate terminals which are arbitrarily distributed over a 10 000 line unit of the exchange into a *PBX* group with one directory number. Finally the line allotter makes it possible to use any number within the 10 000 range even if switching equipment is installed only for a smaller capacity, provided that the line allotter is installed to full capacity from the start. This last feature is of particular advantage for conversions of existing exchanges.

Among other features of the new system which had a great influence on the decision to accept it, may be mentioned that it is arranged for connection of detached exchanges while—owing to the line indicator—maintaining full freedom in respect of the allocation of directory numbers. It also permits the use of a large number of calling and called subscriber categories. Apart from providing the normal services such as coin box telephones, trunk barring, keyset instruments and the like, this feature can be utilized for saving of switching equipment in that subscriber numbers which owing to removal, change of number or the like are to be intercepted, need only be marked in the line allotter and therefore do not occupy other equipment.

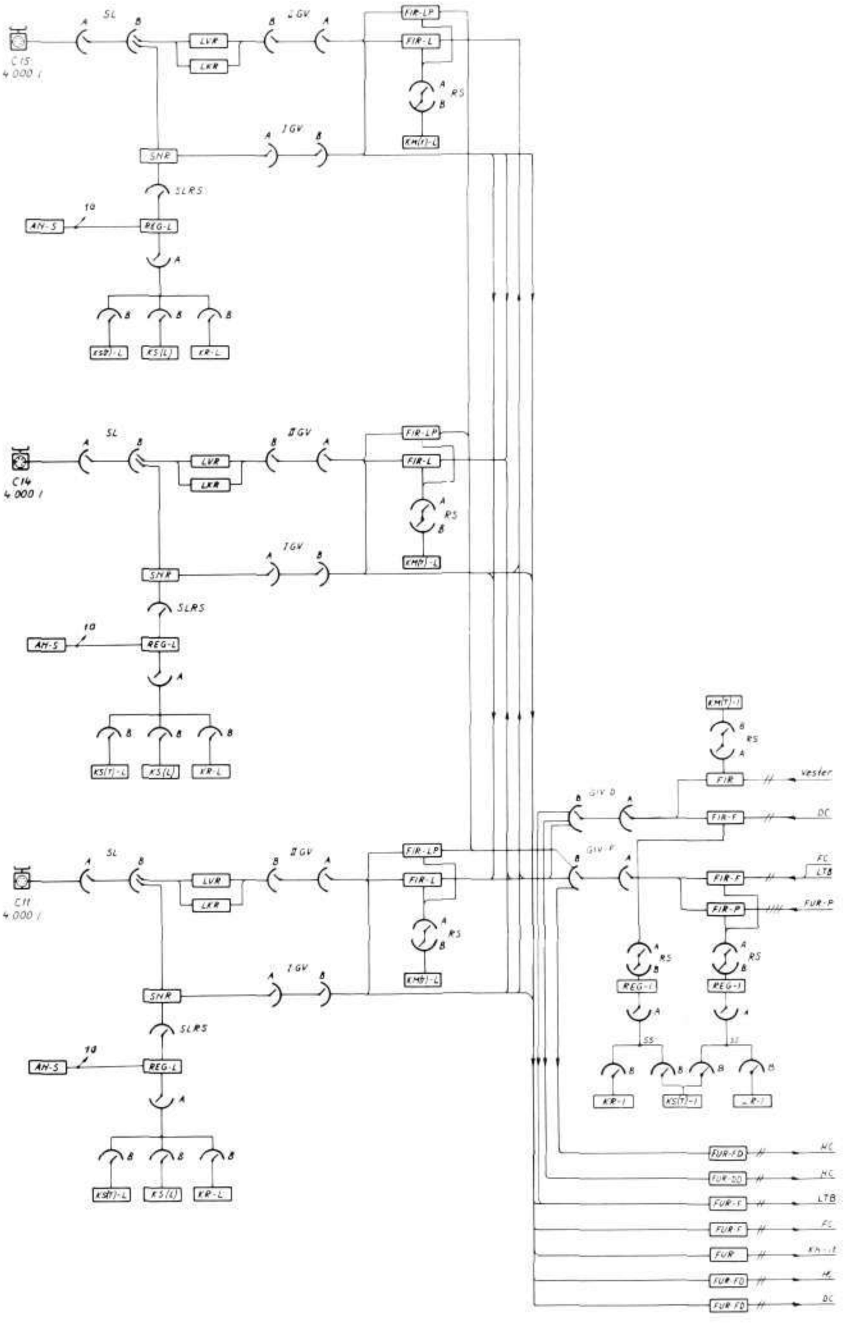


Fig. 4 X 7934

Trunking diagram for code switch exchanges at Nørregade

The equipment for 12 000 subscriber numbers is divided into 3 units with area codes 15, 14 and 11, each serving 4 000 lines. The common group selector stage, GIV, at the right, was brought into operation in December 1963 and distributes the incoming traffic both to the old exchanges at Nørregade (HC, Byen, Palæ and Minerva) and to the code switch exchanges.

Acceptance of Code Switch System

Apart from these functions and properties the code switch system possesses a number of advantages in respect of constructional details and traffic handling, which will not be related here but were taken into account in the evaluation of the tender and, with those already referred to, resulted in KTAS' decision to adopt the code switch system and accept the tender on November 3, 1961.

The order comprised equipment for altogether 12 000 subscriber lines distributed among 3 exchanges with area codes 15, 14 and 11, and calculated to include roughly half of the 10 000 or so Central Exchange subscribers who were left in the area. The transfer of the subscribers is easy to perform and will be done in two stages spread over about three years, since it is calculated that the equipment for the further 14 000 lines will be installed in the already commenced exchange units and at a new unit with area code 12 during the course of 1965.

The switching equipment is placed in the basement of the new building and on the 1st, 2nd and 3rd floors, while the ground floor consists of an open structure and is expected to be used for a car parking. In the basement there are the cable entries and M.D.F. with space for altogether 150 000 lines on the line side and about 88 000 on the exchange side.

The 1st floor accomodates equipment for the first three 10 000-line units comprising *SL* stage, *I-GV*, *II-GV* and *FIR-L* relay sets, *REG* etc., whereas the corresponding equipment for the next three 10 000-line units will be placed on the 3rd floor.

In between—on the 2nd floor—is the equipment for line allotters, *PBX* equipment and subscriber's meters with space for altogether 8 × 10 000 lines, *FIR* and *FUR* relay sets and the common group selector equipment *GIV*.

The Maintenance Control Room

On the 2nd floor is also the maintenance control room for the exchange complex. Here all important information comes in concerning the operating

Fig. 5
Layout of equipment on 1st floor

X 7935

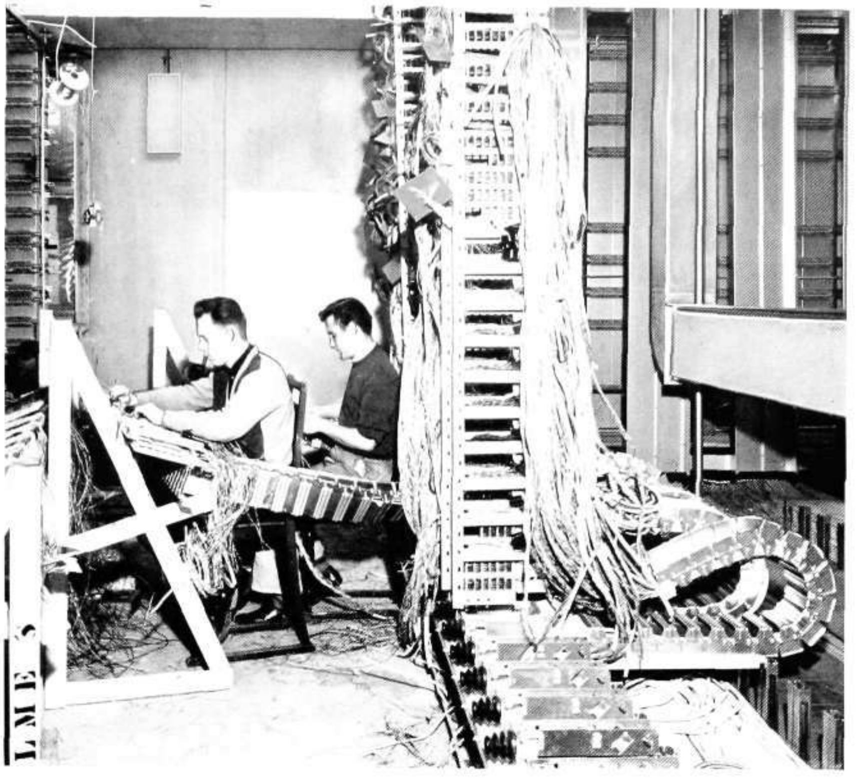


Fig. 6 X 7936
From installation of code switch equipment

conditions of the exchanges, and from here the operation of the exchanges is checked and faults are traced. This is done both by supervision of actual traffic and by automatic setting-up of test calls.

The handling of traffic in the individual switching groups is supervised in special metering equipment and the meters issue an alarm if the fault rate for the group exceeds a preset value. The faulty unit in the group can thereafter be located by connecting other meters.

Instead of meters a punch card machine can be connected automatically or manually for recording the date, time and number of the unit in which the faults exists or, in the event of more complicated units, a note of the nature of the fault.

Finally the maintenance control room has traffic measuring equipment, call and congestion meters and equipment with which a connection can be traced back through the switching stages in order directly to identify the units implicated on a lamp panel, so avoiding the necessity for pulling out racks.

Whether such an extensive control equipment will always be necessary for maintenance of so advanced a system as the code switch system with its "sealed" racks is difficult to decide. But there can be no doubt that it is justified in so extensive and concentrated an exchange complex as in the Nørregade building, where the maintenance control room has already proved of extreme value for fault tracing and traffic control despite the relatively short time it has been in operation.

Power Plant

In order to keep the necessary cross-section of power supply cables and bus bars to a convenient size, it was decided from the outset that the power plant including rectifiers, batteries and distribution panels should be placed on the same floors as the switching equipment. In order that the power

Fig. 7
Testing of code switch equipment

X 7937

equipment might be located as centrally as possible, space was allocated for it in a short transverse wing connecting with the future building.

After a careful evaluation of the advantages and disadvantages of a common power supply compared with several supply points, one per floor or per two floors—taking into consideration the location of switching equipment, rate of expansion, operating conditions, stand-by capacity of batteries etc.—it was decided to arrange a common plant with the batteries on the 1st floor, the distribution panels on the 2nd floor, and the rectifiers on the 3rd floor, located vertically one above the other.

The distribution panels were built from the outset for full capacity corresponding to switching equipment for 80 000 lines.

The rectifier equipment, which can be easily supplemented as the need arises, comprises in the first stage four 300 amp. silicon rectifiers, which it is thought will cover the requirements until the exchange has been built to a capacity of about 20 000 lines. The room has space for altogether 15 rectifiers.

The battery, like the rectifiers, is made up of several small units. This has a number of advantages, among which may be mentioned the possibilty of sucessive expansion in pace with the switching equipment, more easily handled cells and a smaller cross-section of battery cable, which permits the use of twisted cables, so ensuring a very low noise level: also convenient access for battery inspection, charging and discharging, and repair, without lowering the plant capacity to a hazardous level. The first stage consists of three batteries in parallel, each having 22 + 3 cells. Each of these batteries has a capacity of 1 000 Ah with 1 hour's discharging and is connected via a common cell switch which automatically connects the three cells if the rectifiers fail and the batteries alone are to cover the power supply. This leads to a lower normal operating voltage and permits better utilization of the battery capacity, both of which are significant for operating economy. With a battery unit out of operation, this capacity will cover the requirements of about one busy hour with about 40 000 lines in use.

The power plant also includes an emergency unit in the basement. In the first stage this will consist of a 215 kVA diesel set which automatically starts on failure of the mains supply and in the course of about six seconds supplies 3 × 380 V, 50 c/s, to rectifiers and emergency lighting. This plant can later be expanded by another unit of the same size.

The Cut-over

The transfer of the subscribers from the manual Central Exchange to the code switch exchanges started on April 21, 1964, and in the course of the summer some 1 800 subscriber lines were transferred. Owing to the short period of operation there are still no statistics for a detailed evaluation of the operation of the exchanges, but experience of the code switch group selector equipment for the distribution of the incoming traffic to the old and new exchanges at Nørregade, *GIV*, which were opened in December 1963, gives reason to expect that the results will not be inferior to the excellent results obtained with the previous crossbar system.

50-Line P.A.B.X., AKD 741

W ADENSTEDT & S ULLTIN, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.2
LME 8372

L M Ericsson's new 50-line P.A.B.X., AKD 741, is characterized by its high traffic capacity and reliability. Based on the code switch, it is highly adaptable, silent operating, and has a large multiple capacity. Owing to the small mechanical motions there is very little wear. The P.A.B.X. therefore has a long life and costs very little in maintenance.

The P.A.B.X. *AKD 741* is a register-controlled code switching system working on the bypath principle. It has a maximum capacity of

50 extension lines
14 exchange lines
6 internal connecting circuits
2 enquiry circuits

AKD 741 permits very high traffic. When equipped to maximum capacity, up to 28 extensions can converse simultaneously. It also incorporates all facilities required by a modern business organization.

The components of *AKD 741* consist principally of relays and code switches. The code switch possesses all the advantages of the well-known crossbar switch. It has also a larger multiple capacity and occupies less space. The small dimensions of the code switch enable the *P.A.B.X.* to be accommodated on racks of a size which fit conveniently into ordinary office premises (fig. 1).

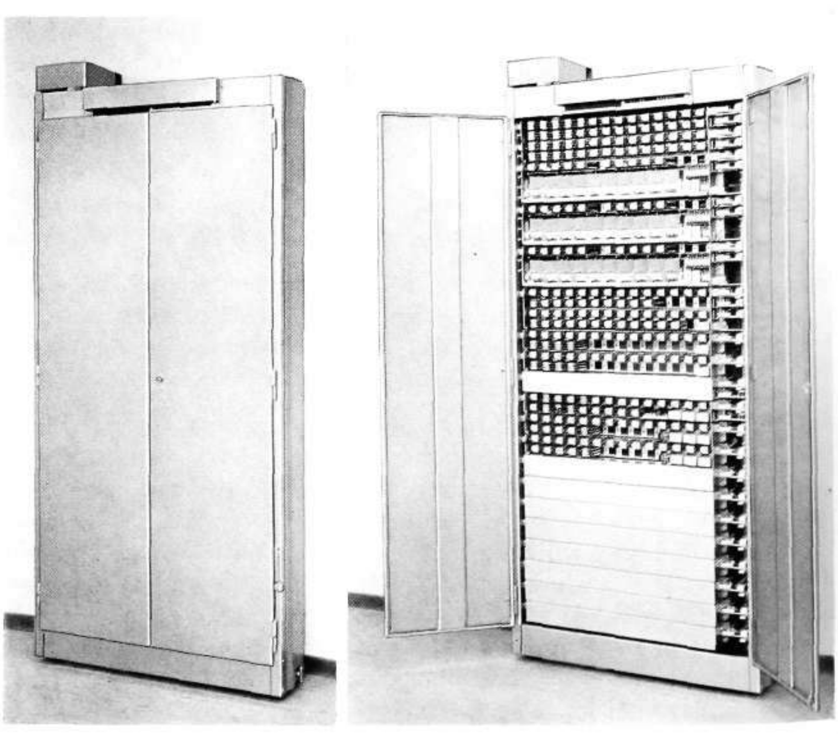


Fig. 1 X 8488
Code switch P.A.B.X. AKD 741
(right) with doors open

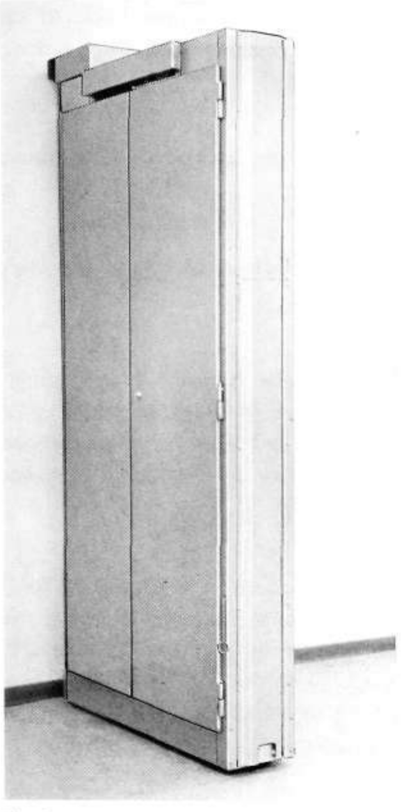


Fig. 2 X 2776

AKD 741 swung out from wall

The racks can be placed directly against a wall and are easily swung out when required (fig. 2). Doors on the front of the racks and panels on the back can both be locked. Behind a panel on the left-hand end of the rack are terminal blocks for extensions and exchange lines and an M.D.F.

All relay and switching equipment is assembled in small units and connected to the rack by multipole plugs. This enables the *P.A.B.X.* to be adapted to the initial capacity desired, and additional units can thereafter be installed as and when required up to the maximum capacity.

One rack accommodates all equipment for 50 extension lines, 10 exchange lines and 6 connecting circuits. If more than 10 exchanges lines are required, a second rack must be added.

The operator's console (fig. 3) is of modern and attractive design with grey plastic casing. In each key are two signal lamps. The upper side of the keys is of transparent plastic, under which the desired symbols are engraved. Apart from various signal lamps there are lamps for indication of faults and a lamp panel showing which extensions are engaged.

Traffic Facilities

The various traffic facilities include:

Enquiry calls, which can be made to other extensions, the operator, or to public exchange subscribers.

Transfer of external calls to other extensions without the operator's assistance. Calls can be transferred any number of times and, if desired, can be put back to the operator.

Extension categories. The extensions can be divided into four categories, viz.

a) Unrestricted extensions with full traffic facilities.

b) Trunk-barred extensions with facilities for all kinds of traffic except dialled trunk calls.

c) Semi-restricted extensions with full internal traffic facilities. These can receive incoming calls but external calls can be set up only with the assistance of an operator.

d) Fully restricted extensions, to whom all but internal traffic is barred.

Every extension can be individually strapped for the desired category.

Priority facility for selected extensions. If a called extension is engaged, a priority connection can be set up after receipt of busy tone. A faint busy tone is issued to the conversing parties as a warning that a third party is on the line.

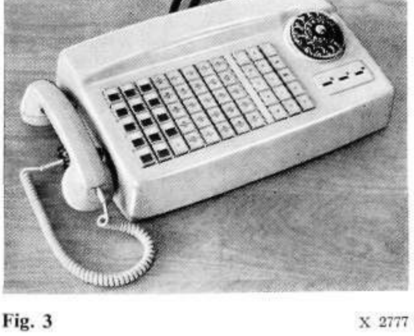


Fig. 3 X 2777

Operator's console

Two types of night service under control of operator's console. With individual night service incoming calls are switched to predetermined extensions connected to the respective exchange lines. With common night service a separate bell rings on all incoming calls, which then can be answered from any extension.

Serial calls, implying that an outside caller is always put back to the operator after each completed conversation. The operator can thus connect the caller to a number of extensions in succession.

The operator's console permits efficient telephone service and maximum utilization of the operator's time.

Each exchange line is represented by a push-button key, a calling lamp and a supervisory lamp.

The console contains a number of keys with built-in lamps, among which splitting keys which permit the operator to speak to the external or internal party without the other hearing, and keys for night service, serial calls, paging, operator's line, cancellation, extending of calls, and for connection of audible ringing signal.

For putting through calls to the extensions there is a set of 25 keys. Every key corresponds to two extension numbers. Each key contains two lamps indicating whether the respective extension is free. The first 25 extension numbers are called by depressing the line key once. Calls to the second 25 extensions are preceded by depression of a group button. This ensures very quick switching of incoming calls.

If the wanted extension is engaged, an incoming call can be placed on an automatic waiting circuit (camp-on busy) and is then put through automatically when the extension becomes free.

The operator can offer a call to an engaged extension, and a faint warning tone is sent to the conversing parties as long as the operator is on the line.

An incoming call that has been switched to an extension can be visually supervised until the extension has answered. There is also an automatic timing device which informs the operator that a waiting period has elapsed, so that there is no risk of the caller being forgotten.

The *P.A.B.X.* may also be equipped with the following extra facilities:

Group calls to a group of extensions dealing with the same sort of business. These extensions can also be called on their individual numbers.

Visual paging. Paging calls can be made direct from the extensions or by the operator. The operator can switch an incoming call to the paging equipment; when the wanted party answers, he is connected direct to the exchange line without the operator's assistance.

Automatic tie lines to other private exchanges.

Subscribers' meters for metering dialled trunk calls when the public exchange can transmit metering pulses.

Trunk discriminator equipment which prevents unauthorized extensions from dialling trunk calls.

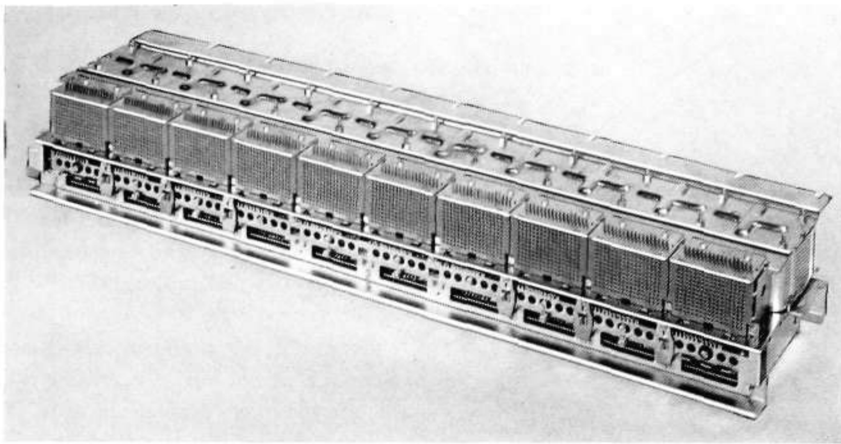


Fig. 4
Code switch

X 8489

Equipment

Code Switches and Relays

The code switch (fig. 4) has a capacity of 10 inlets and 52 outlets. The small dimensions of the switch are due largely to the introduction of a new type of contact and to a new method of multipling between the verticals.

The moving contact consists of a wire spring with a cylindrical contact tip. The fixed contact is V-shaped. This arrangement provides a twin contact function which, in conjunction with the high contact pressure, ensures very good contact performance. In the operated position the moving contact is locked in the vee, so that the contacts are insensitive to impact or vibration. The contact action ensures very efficient self-cleaning of the active contact points and, among other things, renders them insusceptible to dust.

The relays (fig. 5) are the well-known *RAF* and *RAH* relays which are used also in public exchanges.

Racks

AKD 741, when equipped to maximum capacity, requires two racks. The first rack accommodates all equipment for 50 extensions and 10 exchange lines. Only when this number of exchange lines is exceeded is a second rack necessary. The three exchange line positions—at the bottom of the first rack—will accommodate relay sets for paging and group calls instead of exchange line relay sets if desired.

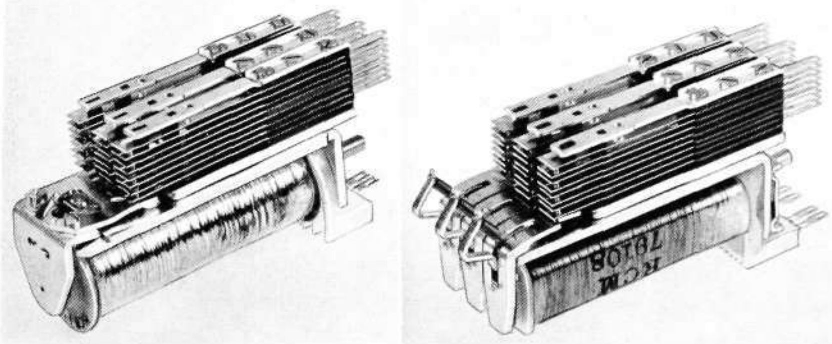


Fig. 5
RAF relay (left) and RAH relay

X 2778
X 2779

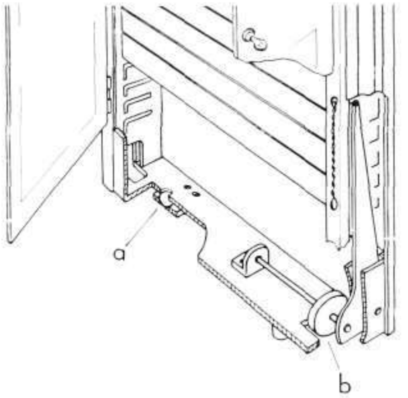


Fig. 6 X 2780
a steel ball
b wheel

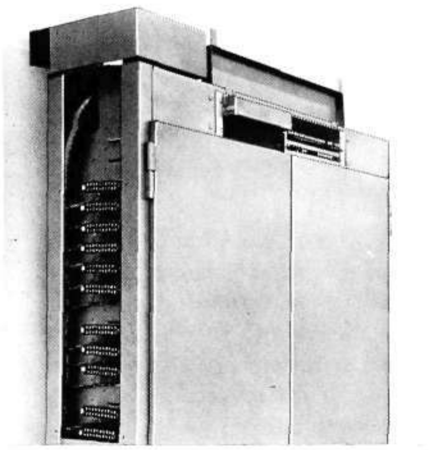


Fig. 7 X 2781
M.D.F.

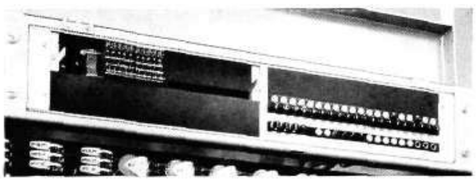


Fig. 8 X 2782
Fuse and lamp panel

The dimensions of the racks are:

height 2 200 mm
width 1 025 mm
depth 250 mm

The left-hand side of the rack rests on a steel ball; on the right-hand side is a wheel which is retracted when the rack is against the wall. By means of a simple mechanism the wheel can be pressed down (fig. 6) to allow the rack to be swung-out from the wall.

The racks are supplied cabled for their maximum capacity. The cabling terminates on multipole jacks into which the necessary relay sets and switches are plugged. This principle greatly facilitates installation and maintenance, as well as future extension of the system. The cable to the operator's console and the inter-rack cable also terminate in multipole plugs.

The incoming cable enters the rack at the top left-hand corner and terminates on the M.D.F. which is located under a panel (fig. 7) on the left-hand end of the first rack.

The upper part of the first rack (fig. 8) accommodates fuses, blocking buttons for the exchange lines, and supervisory lamps for all the traffic-carrying equipment. To eliminate the risk of accidental pressing of the blocking buttons, the buttons with fuses are protected by a cover which is locked simultaneously with the doors.

Operator's Console

All switching operations are done with push-button keys. In each key are two lamps which facilitate supervision of established connections. Five such keys are mounted as a separate unit. The push-button contact springs and lamps are wired to a multipole plug. The key units plug into the console as shown in fig. 9. The casing is of grey plastic. The plastic tops of the buttons are easily removable for change of lamp or engraving.

The handset is connected to the console by plug and jack.

The dial, which is used only for external calls, is placed on the right of the console as dialling is normally done with the right hand.

Fig. 9 X 8490
Operator's console with dust cover removed

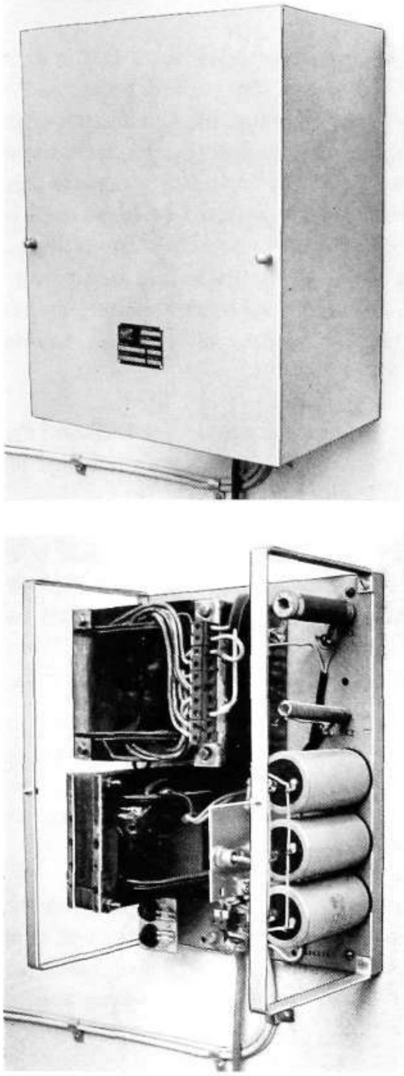


Fig. 10 X 2783 X 2784

Battery eliminator BMN 2425

(below) with cover removed

Power Equipment

The *P. A. B. X.* is designed for an operating voltage of 48 V but will operate between 44 and 56 V without loss of reliability.

At places where power failures are comparatively rare, a battery eliminator is recommended as it requires no maintenance. The battery eliminator should be rated 48 V, 8 A, and have an extra tapping for 90 V, 5 VA AC for ringing current. On a power failure the exchange lines are automatically connected direct to certain predetermined extensions. A suitable battery eliminator for these exchanges is *BMN 2425* (fig. 10).

Where batteries and chargers are required, 48 V/48 Ah lead acid batteries should be employed. The new sealed batteries have several advantages over previous types—they take up less space and do not require a separate battery room.

The charger should be rated 48 V, 4 A. It should have an extra tapping for 90 V ringing current.

On a power failure in a battery/charger plant a pole changer is automatically switched on and generates the necessary ringing current.

The tones are produced by a transistor unit placed on one of the *P.A.B.X.* relay sets. The frequency of the tones is 425 c/s. The periods of the tones and ringing signals are controlled by relays in the *P.A.B.X.*

Switching Procedure

The trunking diagram of the *P.A.B.X.* is shown in fig. 11.

Internal Calls

When an extension raises his handset, his line is identified by *ID*, which seizes the marker *M*. The marker connects to a free register *REG* and the marker and identifier then release. Dial tone is returned from *REG* and the two-digit number of the wanted extension can be dialled.

On receipt of the called number, *REG* seizes the marker *M*. The calling and called lines are now connected to a free connecting circuit. *M* and *REG* release simultaneously with the transmission of the first ringing signal. Intermittent ringing continues concurrently with the transmission of ringing tone to the caller. When the called party answers, connection is established.

If the called extension is engaged, busy tone is returned to the caller from *SNR*. The caller, if a priority extension, can enter the engaged circuit by dialling one digit. A faint warning tone is sent to the conversing parties as a sign that there is a third party on the line.

As soon as any extension replaces the handset, his line is cleared.

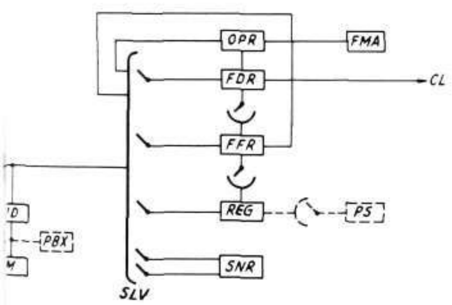


Fig. 11 X 2785

Trunking diagram

ID Cut-off relays and line relays combined with identification
SLV Line finder-finder selector
M Marker
OPR Operator's relay set
FMA Operator's console
DRF Exchange line units
FFR Enquiry units
REG Register
SNR Internal link circuits
PBX Equipment for PBX hunting
PS Paging system

Outgoing Calls

When an extension raises his handset and has received dial tone from *REG*, he can dial the code digit to the public exchange. This digit may be 0, 1 or 9. When *REG* has received this digit the extension is connected to a free *FDR* and *REG* releases. The extension now receives dial tone from the public exchange and can dial the wanted subscriber's number.

Incoming Calls

Incoming calls are registered by an exchange line relay set *FDR*, and a calling lamp on the operator's console *FMA* lights. The call is answered by the operator pressing the button in which the lamp has lit. Connection with the operator is now established. She completes the connection to the wanted extension by pressing the extension's line key. The operator's console has three lamps—a green, a yellow and a red—which indicate whether the extension is free, engaged or restricted. If either of the first two lamps lights, the operator can leave the connection by pressing the extending call button. If the extension is engaged, the call is placed on an automatic waiting circuit until the extension becomes free. If the red lamp lights, the operator has no possibility of extending the call.

If an important call is to be put through to an engaged extension, the operator can enter the engaged circuit and offer the call. A tone is heard by the conversing parties as a warning that the operator is on the line.

As long as an external call is connected to an extension but has not been answered, the supervisory lamp for that exchange line remains alight. If the call is not answered within 30 seconds, the operator's attention is called by flashing of the exchange line lamp.

Enquiry Calls

An enquiry call can be initiated by an extension in the course of an external call. There are three types of enquiry call.

An *enquiry to an operator* is made by dialling 2. The calling lamp in the exchange line button on the operator's console lights. The exchange line is at the same time connected to a holding circuit in *FDR*. After the operator has answered, the extension can either return to the exchange line connection or hand it over to the operator.

An *enquiry to another extension* is initiated by dialling 1. *FDR* then seizes *FFR*, which connects to a free *REG*. The extension hears dial tone from *REG* and dials the wanted extension's number. On receipt of the two digits by *REG*, the extensions are interconnected via *FDR*, *FFR* and *SLV*.

On completion of the enquiry the extension redials 1 to return to the external subscriber. *FFR* releases as soon as the consulted extension has hung up. If the latter does not hang up, the original extension can reconnect to him by dialling 1 again.

An *enquiry call on another exchange line* is made by dialling 1 and, after receipt of dial tone from *REG*, the code digit of the public exchange. The extension is thereby connected via the established *FDR-FFR-SLV* circuit and a new *FDR* to the public exchange. On receipt of dial tone from the public exchange, he dials the subscriber's number. After the enquiry call he returns to the original connection, and *FFR* and the last used *FDR* are restored.

Transfer

An external call can be transferred to another extension authorized to receive external calls, the procedure being the same as for enquiries. After establishing an enquiry connection the extension replaces his handset. *FFR* seizes *M*, which identifies the called extension. *FDR*'s position in the code switch multiple is switched to the latter extension, who takes over the connection. *FFR* and *M* are restored.

If the call cannot be established, either because the called extension is restricted, because the call is unanswered, or because dialling is not completed, *FFR* releases and the extension making the enquiry is rerung. This provides a good assurance that the external connection is not lost.

Night Service

Two types of night service can be set up from the operator's console.

Individual night service. When the operator leaves her position, she presses a button marked *N1*. The lamp in this button lights.

On an incoming call *FDR* seizes the marker *M*. The marker connects a code switch *SLV* to the extension allotted to that exchange line. Intermittent ringing signals are sent from *FDR*. When the extension answers, connection is established.

If the extension does not answer, *FDR* releases within a given time after the caller has replaced.

An engaged extension hears a brief tone as a sign that an external call is waiting. The waiting call is put through automatically as soon as the previous conversation is terminated.

The night service extensions can be connected individually to the exchange lines, or a group of exchange lines may be connected to a single extension.

Common night connection. The operator presses button *N2* on her console before going off duty.

When *FDR* registers an incoming call, one or more bells placed at strategic positions in the offices ring. The call can be answered from any extension by raising the handset and dialling 0.

If the call is not answered, it is cleared in the same way as on individual night service.

Automatic night service is established if the operator forgets to press either of the night service buttons. The type of night service to be adopted under these circumstances is determined by strapping in *OPR*.

Serial Calls

If a subscriber wishes to speak to several persons within an organization, as often happens on trunk calls, the operator presses the serial call button. She puts the call through to the first extension in the ordinary way. At the end of this conversation *FDR* recalls the operator, who can connect to the next extension. After the last conversation the operator presses a restoring button and *FDR* is released.

Paging

If an external or internal call is unanswered, the visual paging system can be used to trace the wanted party either by the operator or by the calling extension. If an external caller wishes to wait for the called party to be traced, the operator presses button *P* and then keys the extension's number.

The number is registered by *PS* and the extension's code is displayed on all lamp panels. The operator can now leave the connection by pressing the extending call button.

When the party sees his code on a lamp panel, he goes to the nearest extension telephone and dials a single-digit answering number. *REG* then seizes the marker *M*, which ascertains in which *FDR* the call is parked and connects that *FDR* to the extension from which the wanted party has answered. *PS*, *REG* and *M* release.

If the extension does not answer the paging call within 2 minutes, the operator is recalled and *PS* releases.

Installation and Maintenance

These *P.A.B.X.*, occupying little space and being silent in operation, can be placed in any office accommodation. Racks, relay sets and switches are wired to multipole plugs and jacks. This makes the units easy to handle and simplifies installation, testing and maintenance. When the rack has been fitted in its intended positon, the extenson and exchange line cables and the cable from the power plant are connected to easily accessible terminal blocks on the left-hand end of the rack. When the jumpering and category strapping arrangements have been completed in accordance with the customer's wishes, the relay sets are plugged-in. The rack accommodates multipole jacks for plugging-in of the operator's console.

Mechanical selectors require regular preventive maintenance. For code switch systems this maintenance is entirely unnecessary and the maintenance costs are greatly reduced.

Two-wire cables are used between the extensions and the *P.A.B.X.*

Technical Data

Operating voltage

AKD 741 operates on 48 V, but the voltage may vary between 44 and 56 V without affecting the reliability of operation.

Line data

The resistance of extension lines, including the telephone instrument, may be up to 1 000 ohms.

The insulation resistance between the two branches of a line or between one branch and earth may be as low as 25 000 ohms.

The line and insulation resistances of the exchange lines are dependent on the performance of the public exchange.

Feed

The resistance of the feed coils is 2×400 ohms, which can be adjusted to 2×250 ohms.

Dial

The dial speed may vary between 8 and 13 I.P.S. and the impulse ratio (make/break) between 30/70 and 50/50.

Attenuation

The transmission loss is max. 1.3 db on internal as well as external calls, measured between 300 and 3 400 c/s. The crosstalk attenuation, also measured between 300 and 3 400 c/s, is above 78 db.

Psophometric noise

Noise due to hum from the battery eliminator or crosstalk from the tone and signal circuits does not exceed 0.5 mV on internal or external calls.

Tones

The frequency of the tones is 425 c/s.

1. Dial tone is a continuous tone.
2. Busy tone: approx. 0.3 sec. on
   approx. 0.35 sec. off
3. Ringing tone: approx. 1 sec. on
   approx: 4 sec. off
4. The warning tone on a priority connection is a faint busy tone.

Ringing signals

The ringing signal frequency is 50 c/s and ringing voltage 90 V.

The first ringing signal is sent as soon as a connection is completed. The subsequent signals come at intervals of approx. 1 sec. on, 4 sec. off.

Main Features

1. High traffic capacity
2. Low maintenance cost
3. Silent operation
4. Automatic enquiry and transfer
5. Automatic camp-on busy
6. Priority for selected extensions
7. Serial call facility
8. Two alternative night service facilities
9. Facilities for paging, group number calls, and automatic tie lines to other private exchanges
10. The *P.A.B.X.* can be equipped to the desired initial capacity and thereafter extended simply by plugging-in additional units
11. The *P.A.B.X.* can be placed against a wall and therefore takes up little space
12. Tropical finish
13. The doors of the *P.A.B.X.* can be locked
14. Operator's console of attractive appearance and easy to operate

Transistorized 12- and 24-circuit Carrier Terminals for Radio Links

G JOHANSEN, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.453/.454
621.395.463
621.396.65
LME 8425

It is usual to provide telephone circuits between small towns by means of radio links using a frequency band sufficient for 12 to 24 telephone channels.

L M Ericsson's terminal equipment for 12 and 24 circuits with a baseband of 6–108 kc/s for four-wire connexion to radio links is described in this article.

The terminal equipment which is completely transistorized is mounted in a bay of either of two sizes:

a tall bay type *ZCC 812* providing space for one 24-circuit system or two 12-circuit systems or a short bay type *ZCC 803* providing space for one 12-circuit system or one half of a 24-circuit system.

The terminal equipment consists of:

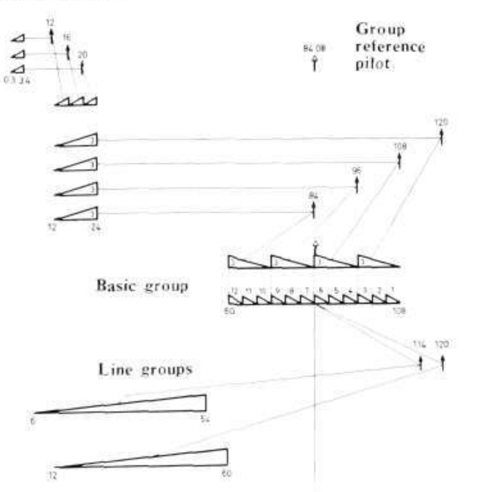
modulation equipment which carries out the frequency translation between the VF bands and the above-mentioned baseband by modulation and demodulation respectively,

equipment for matching the modulation equipment to the HF line feeding a remotely located radio link equipment,

four-wire terminations and compandors,

carrier generating equipment generating the carriers necessary for modulation and demodulation of one or more signalling frequencies and 84.08 kc/s group reference pilot frequency,

power supply equipment, alarm equipment, service telephone and level meter.



x 2771

Fig. 1
Modulation plan

I. System Arrangement

In the modulation plan, fig. 1, it will be seen that the 12 voice frequency speech bands are modulated via channel- and subgroup-modulation to the 60–108 kc/s basic group band which corresponds to CCITT's basic group B. The basic group band can be used as baseband, which is from now on called line group, either in the unchanged frequency range or modulated with 114 and 120 kc/s to give the 6–54 kc/s or 12–60 kc/s frequency range respectively. The 12–60 kc/s band corresponds to the basic group A. A 24-circuit system is formed by combining the bands 6–54 and 60–108 kc/s or 12–60 and 60–108 kc/s which gives the 24-circuit band 6–108 kc/s or 12–108 kc/s.

The 6–108 kc/s system variant has arisen because here the relatively complex filter equipment necessary to separate groups A and B in the 12–108 kc/s variant is avoided. The frequency interstice between groups A and B is only 350 c/s when there is out-band signalling, the highest frequency of group A being then 59.825 kc/s and the lowest frequency of group B 60.175 kc/s. The corresponding interstice for the 6–108 kc/s frequency band is 6.35 kc/s.

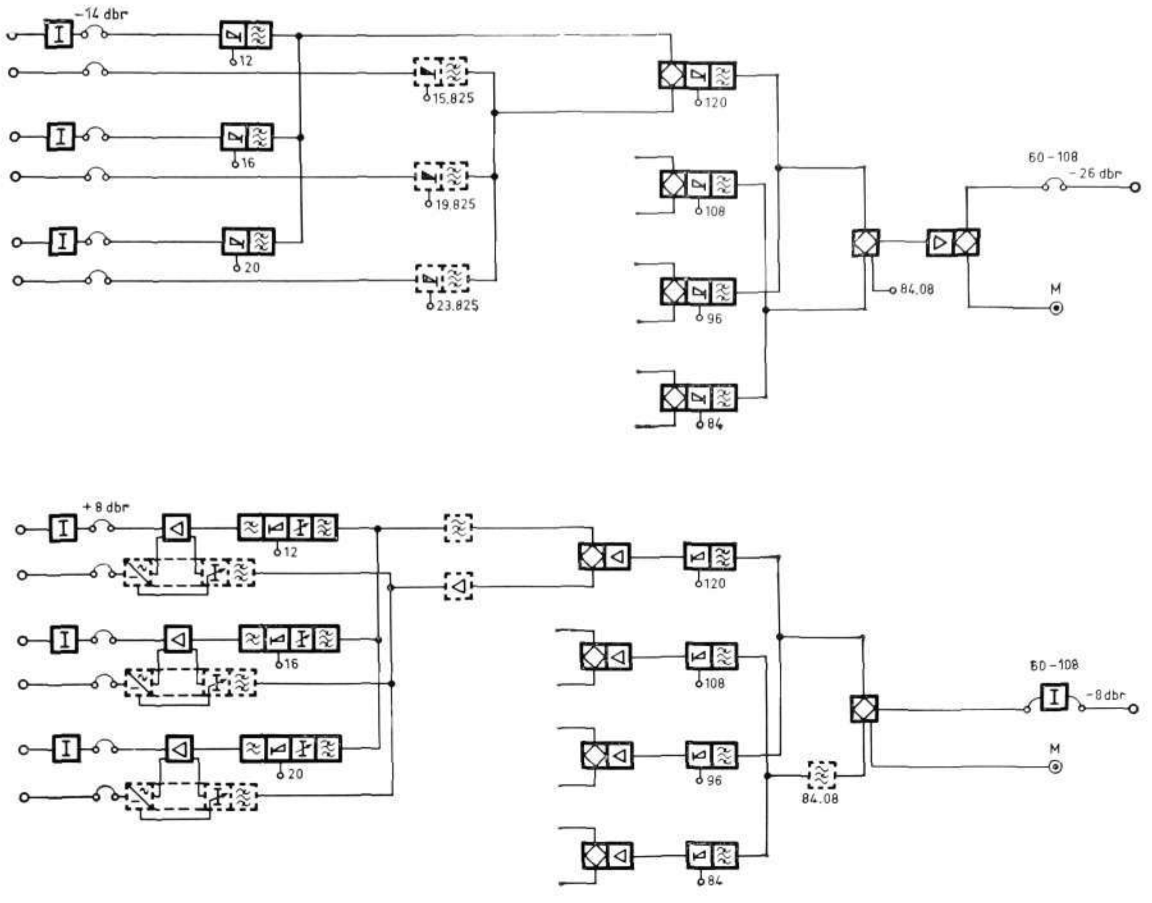


Fig. 2 x 7813

Block schematic for the formation of a basic group

The blocks drawn with dashed lines denote equipment for low-level out-band signalling. All frequencies are in kc/s.

Where the carrier terminal equipment and the radio terminal station are connected together by long cables, the advantage of having simple directional filters in the system variant for 6–108 kc/s may, in fact, be outweighed. This is because such cables often have an irregular attenuation response for frequencies below 12 kc/s and therefore may require relatively expensive equalizing networks.

In the choice of frequency band 6–54, 12–60 or 60–108 kc/s for a 12-circuit system, attention must be paid to matching to the radio link and also to whether there is a probability of extension to a 24-circuit system.

II. Modulation Equipment

Channel and Subgroup Modulation

See the block schematic, fig. 2.

The 60–108 kc/s basic group is formed by channel and subgroup modulation of 12 speech channels.

Channel and subgroup modulation has been described earlier in Ericsson Review No. 2, 1961 pp. 30–40.

The process of modulation using channel and subgroup modulation is used in all our carrier systems. This means a standardization, i.e. the same units are always included in the equipment forming the 60–108 kc/s basic group, irrespective of the system in which the equipment is included.

The sending and receiving directions of the 60–108 kc/s basic group so formed are brought out to the bay terminal strip panel. This permits through connexion of basic groups to other systems and also through connexion to the line group equipment in the same bay.

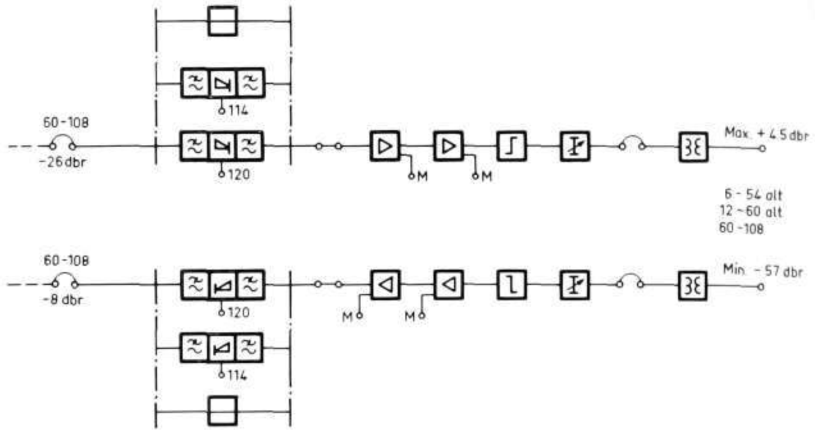


Fig. 3 x 8479

Block schematic for line group equipment with basic group modulation for 12-circuit system

Group Translating and Line Group Equipment

See the block schematics figs. 3 and 4.

The group translating unit consists of a modulator and a low-pass filter which is placed on either side of the modulator. The modulator units for sending and receiving directions (modulator and demodulator) are identical.

There are three types of group translating unit which differ from each other in the characteristics of one of the two low-pass filters.

The low-pass filters on the basic group side for the sending and receiving directions i.e. the equipment which sends and receives the 60–108 kc/s basic group are identical in all three types of unit.

The low-pass filter has a cut-off frequency of 108 kc/s and in the receiving direction acts as a suppressor of the unwanted upper sideband group when demodulating. This upper sideband causes unnecessary loading of subsequent amplifiers. The stop band attenuation is approximately 30 db.

The first type of modulator is only used in 12-circuit systems with a 12–60 kc/s line group, the modulating frequency (carrier) being 120 kc/s. The 12–60 kc/s line group is thus formed from the 60–108 kc/s basic group.

The low-pass filter which characterizes this type of modulator suppresses frequencies above the 60 kc/s cut-off frequency by more than 30 db. The

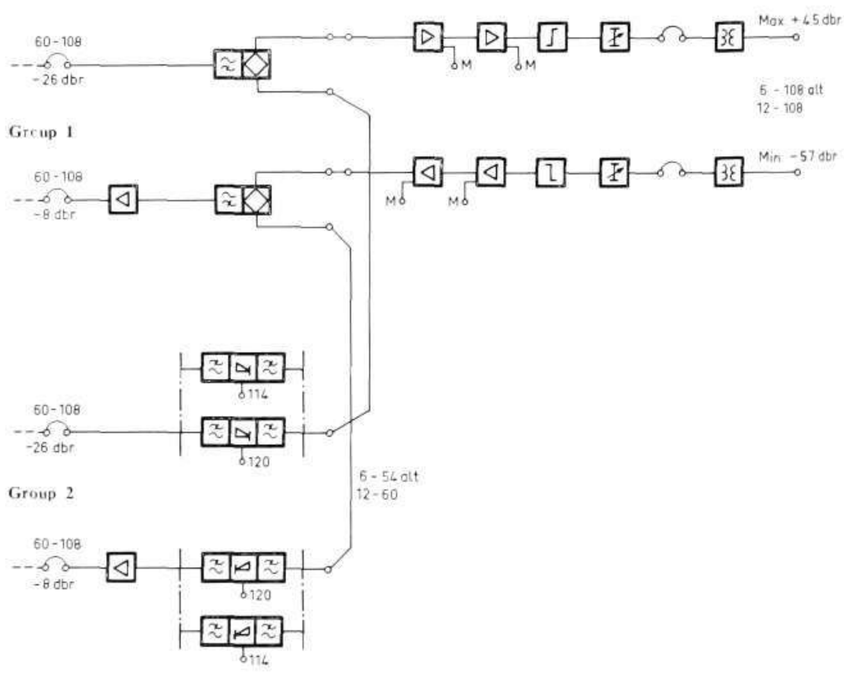


Fig. 4 x 8480

Block schematic for line group equipment with basic group modulation for 24-circuit system

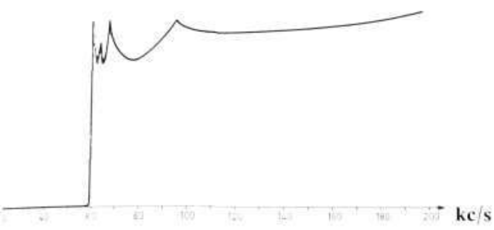


Fig. 5 x 2772
Attenuation graph for the low-pass filter in the basic group modulator 60—108 to 12—60 kc/s

main duty of the filter is to stop the unwanted upper sideband formed in the modulator, thereby avoiding additional loading of the subsequent equipment. The stop attenuation for the 60–108 kc/s direct leak is not sufficient to prevent disturbances when connecting with another 60–108 kc/s basic group when the formation of a 24-circuit system is required.

The second type of modulator is used in 24-circuit systems having 12–60 and 60–108 kc/s line groups. Like the previous modulator, this is also intended for the modulating frequency of 120 kc/s and this translates the 60–108 kc/s basic group to the 12–60 kc/s frequency band which constitutes the lower-half of the 24-circuit system line group. The low-pass filter here provides a large stop attenuation for frequencies above the 60 kc/s cut-off frequency. Fig. 5 shows the attenuation characteristic of the filter. The stop attenuation of 60–108 kc/s direct leak is sufficiently high so as not to interfere with the other 60–108 kc/s group i.e. the upper half of the 24-circuit system line group.

The high filter attenuation of the 120 kc/s carrier leak and the upper sideband also enables the 12–60 kc/s group to be included as an extra group in for example, 60- or 120-circuit systems, whereby these are increased to 72- and 132-circuit systems respectively.

The third type of modulator is used in 12-circuit systems having a 6–54 kc/s line group or in 24-circuit systems having 6–54 and 60–108 kc/s as line group. The 6–54 kc/s line group is formed by modulation with 114 kc/s.

In a 24-circuit system with 6–54 and 60–108 kc/s line group, the large gap between the two groups places moderate requirements on the low-pass filter as far as the steepness of the flank of the attenuation response is concerned.

A comparatively simple low-pass filter is thus quite sufficient to suppress the 60–108 kc/s direct leak even if this modulator is included in a 24-circuit or larger system.

In a 12-circuit system with 60–108 kc/s line group, it is not necessary to have extra modulation of the basic group which already has the frequency allocation of the line group. The group modulator is therefore replaced by a dummy unit. The necessary filtration of the group is therefore carried out in the sub-group modulator.

When two 12-circuit equipments are to be connected together to form a 24-circuit system, the group modulator is replaced by a group hybrid (differential transformer) in one of the group equipments whose unmodulated group is then connected to one input of the hybrid. The other input is connected to the modulated group of the other group equipment. The hybrid output is connected to the amplifier which is common to the two group equipments and to the subsequent matching equipment. The above applies, of course, for the sending direction, and in reverse for the receiving direction where 24 channels are split in its hybrid into two groups.

As mentioned in the introduction the above two group equipments can be mounted in two short bays or in one tall bay. As far as the group modulators and the following line group equipment are concerned, these can be equipped so that either one 24-circuit system or two separate 12-circuit systems are obtained.

The line group equipment through which the line group passes before it is fed to a radio link consists of:

a) Two amplifiers and manually adjusted pads with which the line group sending and receiving levels can be matched to those of the radio link. Level adjustment in small steps and level variation to compensate for temporary variations can be carried out by using the manually adjusted pads. A larger adjustment step is obtained by replacing one of the amplifiers with a dummy unit.

b) Cable equalizer which can be inserted when the radio link equipment is at such a distance away that a long cable is necessary to transmit the line group. An equalizer is available for each of the three frequency bands

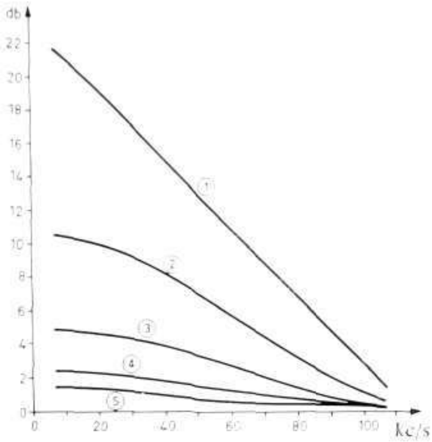


Fig. 6 x 2773
Attenuation response for networks 1—5 in cable equalizing network for 6—108 kc/s

6–54 kc/s, 12–60 kc/s and 6–108 kc/s. Each equalizer is built up of five networks in series which can be connected into circuit by means of straps. The networks have an attenuation response as shown in the example in fig. 6. A slope of the cable attenuation response corresponding to 40 db max. at the highest frequency can be corrected by the networks with an error of ± 1 db. Individual irregularities in the attenuation response of the cable are corrected by mop-up networks, space for these being reserved in the manually adjusted pad.

c) Line transformers which match the impedance of the line equipment and the HF line to the radio link equipment. Matching to different cable impedances is obtained by rearranging the connections on the transformer terminals. The different outputs have been chosen so that the return loss recommended by CCITT is obtained for all the usual cable impedances.

III. Voice Frequency and Signalling Equipment

See the block schematic, fig. 7.

The voice frequency and signalling equipment matches the terminal equipment to the exchange equipment as far as the speech circuits are concerned. Two-wire or four-wire operation can be used and as far as the signalling is concerned, according to the alternatives given in the table below. This table also shows the way in which the signals are then sent over the carrier equipment.

VF and signalling equipment		Carrier equipment
Type of operation	Method of signalling	Method of signalling
2-wire 2-wire 4-wire	d.c. a.c. d.c.	1-VF in-band
4-wire	2-VF in-band	2-VF in-band
2-wire 2-wire 4-wire	d.c. a.c. d.c.	High or low level out-band

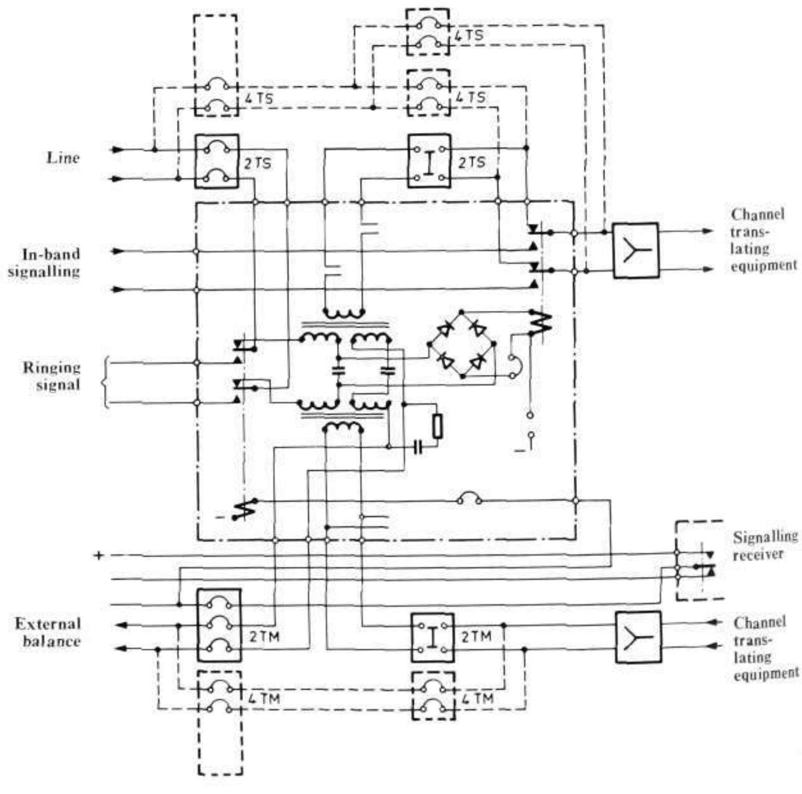


Fig. 7 x 8481
Block schematic for VF equipment with 2-wire a.c. signalling to 4-wire in-band signalling
The blocks drawn with dashed lines denote parallel connected U-links for changing over to 4-wire operation to exchange.

The hybrid necessary for two-wire operation is located in the four-wire terminating unit which also contains a signalling relay (for feeding in the in-band signal) and balance network for the cable to the exchange.

Changing from two-wire to four-wire operation and from d.c. to a.c. signalling is carried out by means of U-links at the side of the bay front. The level to the exchange can be adjusted to a suitable value by replacing the U-links with pads.

If the prevailing operating conditions are such that the noise level is considered to be too high relative to the speech level, they can be improved by introducing compandors, space for which has been reserved in the VF equipment.

The terminal bay can be equipped for either in-band or out-band signalling. One or the other method of signalling is selected by providing the channel translating equipment with units for the required alternative. The principles for in-band and out-band signalling have been described earlier in Ericsson Review No. 2, 1961 pp. 35–40.

Sending of 1-VF in-band signalling is effected in this bay by injection prior to the channel translation. The same is the case for 2-VF in-band signalling. In the latter case, the four-wire termination is removed and replaced by a signalling receiver for one of the two signalling frequencies.

IV. Carrier Generating Equipment

See the block schematic, fig. 8.

Generation of Carriers and Pilot

All carriers are derived from a crystal-controlled master oscillator with thermostatically controlled crystal. The oscillator is of the same type that is

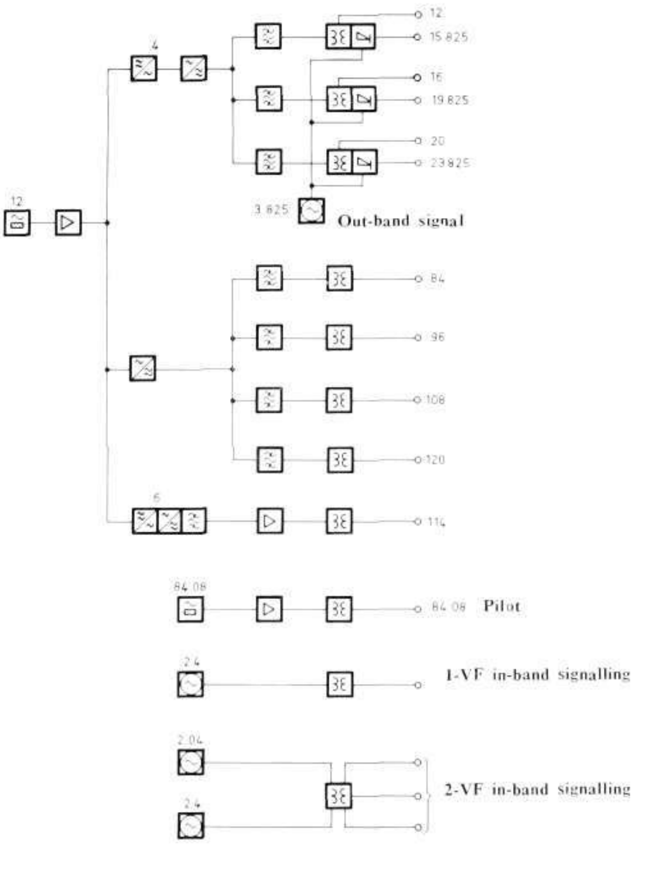


Fig. 8 x 8482

Block schematic for carrier generating equipment

used for L M Ericsson's large carrier systems. The frequency stability is therefore so high that group or line group through connexions to larger systems can be made while fulfilling CCITT's recommendations concerning the maximum frequency displacement of a transmitted speech band.

The carriers are generated by extraction of harmonics of the fundamentals 4, 6 and 12 kc/s. 4 and 6 kc/s are obtained by frequency division of the 12 kc/s master oscillator frequency. Each of three basic frequencies is fed to its harmonic generator which in turn feeds the filters connected in parallel. Each filter extracts the appropriate carrier. The carriers 12, 16 and 20 kc/s are formed as harmonics of 4 kc/s whereas 84, 96, 108 and 120 kc/s are obtained as harmonics of 12 kc/s. Finally, the 114 kc/s carrier is obtained as a harmonic of 6 kc/s. The three functions of frequency divider, harmonic generator and filter have been combined into one unit for the last-mentioned frequency. With the exception of the carrier equipment for 114 kc/s, all units are of the same type as in the carrier equipment in large carrier systems.

The 84.08 kc/s group reference pilot is generated in a separate thermostically controlled pilot oscillator. The crystal determining this frequency is placed in the same oven as that for the master oscillator.

The carrier generating equipment provides sufficient power to feed up to five 12-circuit systems with carriers and pilot.

Generation of Signalling Frequencies

The 3.825 kc/s out-band signalling frequency is obtained from a signalling generator. This frequency is modulated in signalling modulators with the carriers 12, 16 and 20 kc/s, from which are obtained the frequencies 15.825, 19.825 and 23.825 kc/s which are then fed into the subgroup.

The in-band signalling frequencies for 1-VF and 2-VF signalling are obtained from separate signalling oscillators. The respective frequency is brought to a suitable level in a signalling distribution unit before being injected into the channel band.

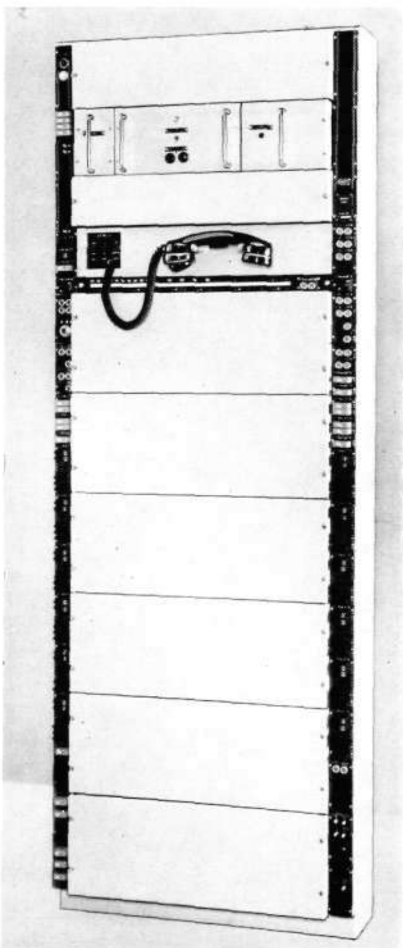


Fig. 9 x 2585

Carrier terminal bay ZCC 803 for a 12-circuit radio link

V. Technical Data for the Line Group

(Technical data for the group translating equipment including signalling is given in Ericsson Review No. 2, 1961.)

Mechanical data

ZCC 812, height 2 743 mm (9'), width 670 mm (2'2³/₈"), depth 236 mm (9¹/₂")
ZCC 803, height 1 830 mm (6'), width 670 mm (2'2³/₈"), depth 236 mm (9¹/₂")

Frequency range

12-circuit system	Alternative 1	6– 54 kc/s
	Alternative 2	12– 60 kc/s
	Alternative 3	60–108 kc/s
24-circuit system	Alternative 1	6–108 kc/s
	Alternative 2	12–108 kc/s

Sending level max. + 4.5 dbr

Receiving level min. − 57 dbr

Impedance

Sending and receiving 125–175 ohms balanced

Variation of attenuation

Variation of attenuation relative to that at 84.08 kc/s over the band 60–108 kc/s for sending and receiving equipment looped on the line group side is less than	± 1.2 db

Intelligible crosstalk

For all combinations of near-end and far-end crosstalk the crosstalk ratio is greater than	80 db

Unintelligible crosstalk

Crosstalk ratio via inverted frequency band when connected to other systems is greater than	85 db

Noise in unloaded system

With no load in the speech and signalling channel the psophometrically measured noise in a point of zero relative level is less than	75 pW

Noise in a loaded system

Total mean noise per channel when all other channels are loaded with white noise having a level of − 7.5 dbm0 per channel and measured psophometrically in a point of zero relative level is less than	230 pW

Power supply

Voltage	110–220 V a.c. or 24 V d.c.

Power consumption

12-circuit system	100 W
24-circuit system	130 W

Miniaturized Cable Cabinet

J P LUTZ & G ÅBERG, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.316.344
LME 1375

There is a need in telephone plant for cross-connecting points at which a given pair in an incoming group of conductors can be connected to any pair in an outgoing group. The main distribution frame between exchange and lines is one example of such a point—the distribution cabinet in the line network is another.

The equipment at present employed at these cross-connecting points often takes up unduly much space, which has proved an increasing inconvenience as the number of subscribers grows. L M Ericsson has therefore developed a miniaturized equipment which radically reduces the space requirements for the cross-connecting points.

Introduction

The distribution system recommended by L M Ericsson for urban networks incorporates a number of cross-connecting points, for example at places where the main cables from the exchange (the primary network) join the smaller cables which feed the distribution points (the secondary network). This has the following advantages:

- flexibility and greater percentage of cable fill,
- minimum investment, since any part of the network can be extended independently of the others and can therefore be dimensioned in the most economical manner for that part of the network,
- simple means of testing a line for fault tracing and similar purposes,
- simple, clear numbering and recording, which simplifies operation and maintenance.

The new features that have been introduced in urban cable networks in the last few years, and others which may be expected in the future, have further accentuated the importance of cross-connecting points in the network.

Examples:

- Plastic cable has been introduced in secondary networks while paper-core lead-covered cable has been retained in primary networks. If a cross-connecting point is provided between the primary and secondary networks, the two types of cable can be kept separate without troublesome joints between plastic and lead cables.
- Pressurization is now standard practice in primary networks but is only exceptionally employed in secondary networks. The cross-connecting points simplify pressurization and fault location.
- Line concentrators are now being used to an increasing extent. The best positions for them are at the connecting points between primary and secondary networks. If the network as a whole has been constructed from the outset in accordance with L M Ericsson's distribution system, the introduction of line concentrators is simplified.

All these advantages, which together result in a reduction of the installation and operating costs of the network, require appropriate equipment at the cross-connecting points. The equipment described below fulfils high requirements in this respect.

The Cable Terminal Box*

The basic feature in miniaturization is that the screw connection is replaced by a plug-and-jack connection. The stripped end of the jumper serves as plug. The jack is designed as a 5-pair jack strip with 3 mm spacing, known as the sleeve contact unit (fig. 1) which has been used for some years in various LME equipments. Two such 5-pair sleeve contact units form the 10-pair unit in the C.T. box.

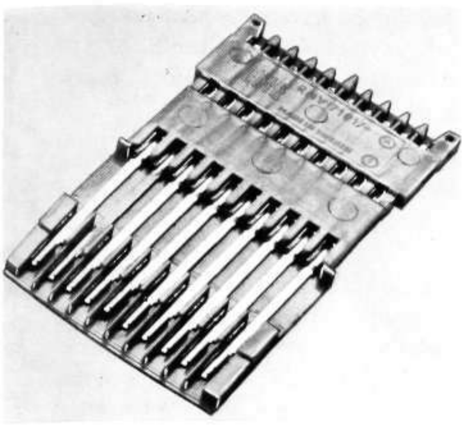


Fig. 1 X 2806

Sleeve contact unit, natural size

The ten terminals of the sleeve contact unit are formed as channels with four indentations in a zigzag arrangement, two on each side. When plugged-in, the wire, which must be rigid, is forced into a slightly sinusoidal, resilient position inside the jack. The result is two contacts with 80 p** and two with 240 p** nominal contact pressure (fig. 2). Extensive experiments and operating experience have shown that this plug-and-jack connection has a low transition resistance with good and stable contacts, and that, owing to the high-quality insulating material in the sleeve contact unit, the leakage is very small. At the bottom of the unit the terminals are formed as soldering tags.

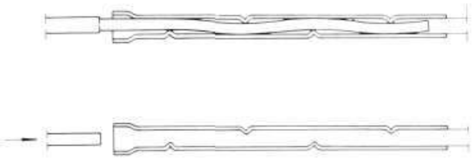


Fig. 2 X 2807

Four contacts of plug-and-jack connection

When these sleeve contact units are assembled to form C.T. boxes, the jumpers must not obscure the main top surface of the box at which the jacks emerge. For this reason wire guides have been introduced between the 10-pair units (fig. 3). The wire guides have channels in which the jumpers run from the jack openings to a plane at right angles to the main top surface (fig. 4). Each opening in the front face is associated with particular pairs in the main jack field. The wire guides gather the jumpers into a bundle which does not obstruct or delay the wiring-up of the box, and the wiring can therefore be kept neat and orderly.

* Swedish patent no 187987

** 1 p = 1 gramme force

Fig. 3

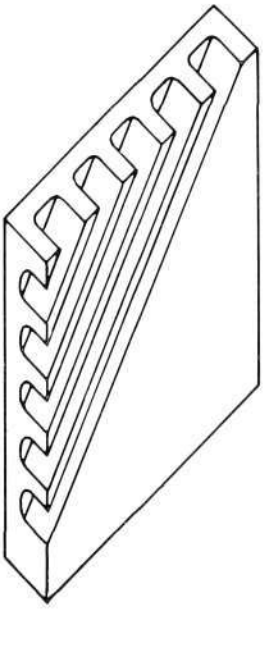


Fig. 4

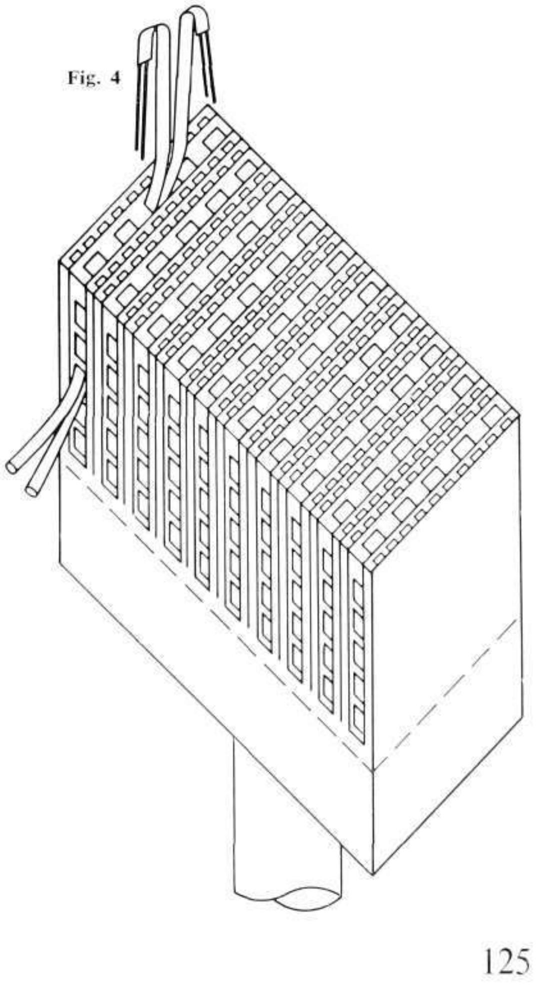


Fig. 3 X 7939

Schematic sketch of wire guide

Fig. 4 X 7940

Schematic sketch of minibox

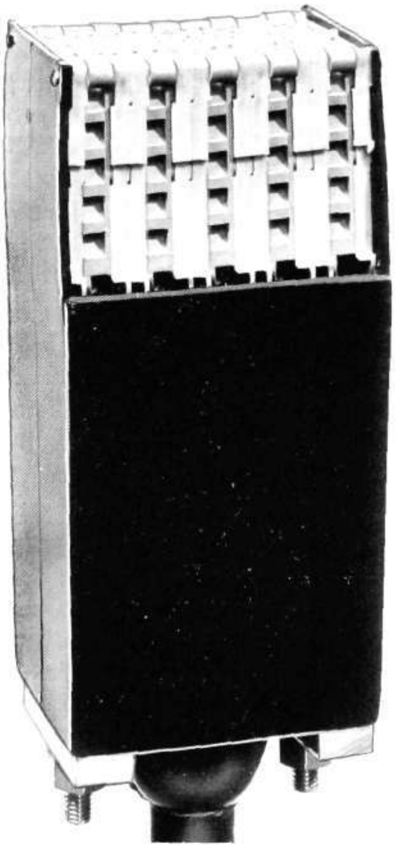


Fig. 5 X 2308

Minibox, 50-pair

Dimensions: height 110 mm, width 55 mm, depth 40 mm

C.T. boxes for 50 and 100 pairs, called miniboxes, have now been standardized (fig. 5). A stub of polythene-insulated polythene-covered cable *(ELLY)* or of paper-core lead-covered cable *(EPB)* with 0.5 mm conductors is connected and hermetically sealed to the box in the factory.

The average length of these stub cables is 6 metres. Instead of connecting a 6-metre stub cable to each box, two miniboxes are connected to a 12-metre cable, one at each end. At the time of installation the cable is cut as required. The reason for this is as follows.

These cable coils, with two boxes connected, offer manifest advantages in manufacture and control, as well as for transport and stockholding. Supplied in an inexpensive packing they form an easily handled unit (fig. 6) with minimum risk of breakage of the cable at the entry to the box. Cable waste is at the same time reduced to a minimum. Provided that the average length is correctly estimated and the distribution curve for the lengths of stub cable needed in practice is symmetrical in relation to the average length, the waste will be zero. The latter condition should be virtually fulfilled in practice. The former is dependent on the accuracy of planning of the network and should be fulfilled after some experience.

The connection of the cable should be done in the factory, i.e. the minibox should be supplied with stub cable connected. The carrying out of this operation as bench-work permits rational manufacture and efficient control. The advantages in terms of price and quality are so great that manufacture on site should be done only when the demand is so large as to warrant a local workshop with special equipment.

The miniboxes are designed for installation side by side in a single row with the main top surface roughly horizontal and inclined slightly forward. The side at which the jumpers are introduced into the wire guides, and in front of which the bunch of wires is placed, then forms the easily accessible front of the row of boxes (fig. 8).

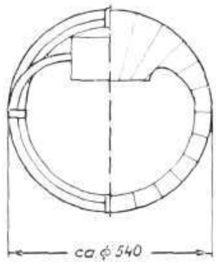


Fig. 6 X 2809

Schematic sketch of NCL 50102, half packed

The Cable Cabinet

Owing to the small dimensions of the miniboxes and the space-saving arrangement of the wiring, the volume of the cable cabinet could be reduced to about $^1/_{20}$ of that of an ordinary cable cabinet (fig. 7). It is made of a light alloy and is therefore rust-proof. It consists of a frame on which the

Fig. 7 X 7941

Cable cabinet NBD 60102

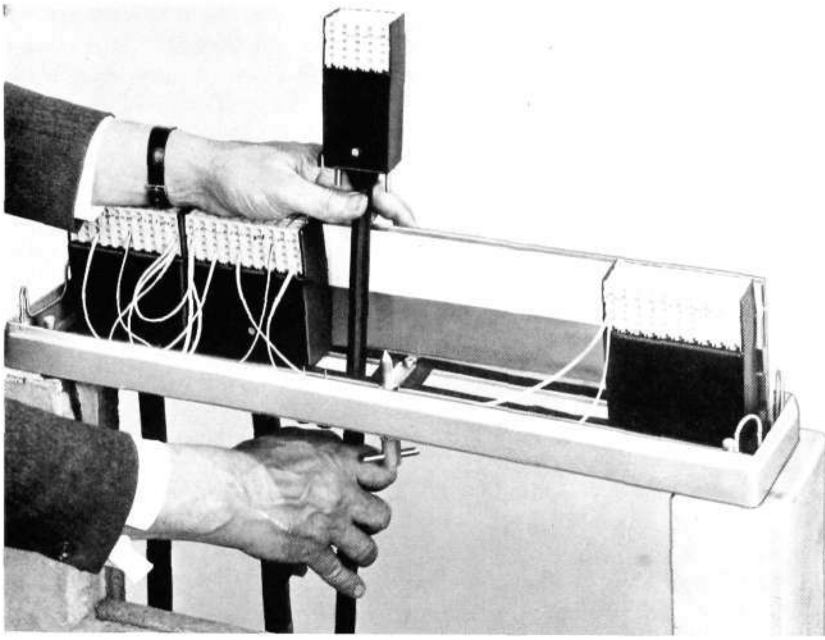


Fig. 8 X 7942

Insertion of 50-pair minibox in NBD 60102

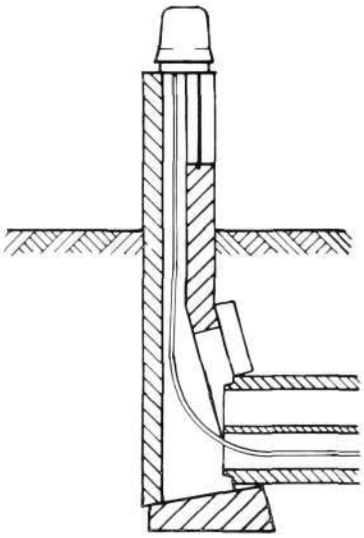


Fig. 9 X 2310

Connection of cable cabinet NBD 60102 on independent concrete base for conduit cable

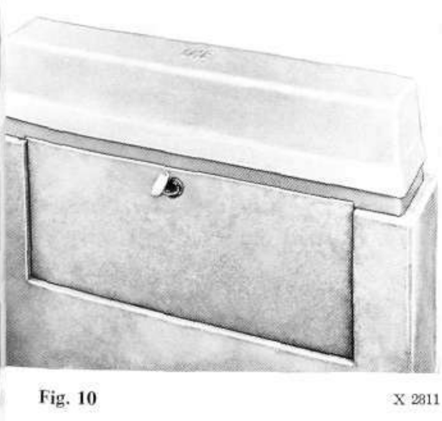


Fig. 10 X 2811

NBD 60102 on concrete base with unlocked door

boxes are attached and the bunch of wires placed, and of a cover running in guides with packing strip. The cover is tightened to the frame with a robust handle placed under the frame. The boxes are mounted in a 30 mm wide slot (fig. 8) through which the stub cable is passed. The minibox is secured by plates and two bolts M 5. If the cabinet is not filled with boxes, dummy plates *684071* are placed in the slot. A sponge rubber tape on the slot provides a seal.

If the cabinet is to be used for cable in conduit or armoured buried cable, it is placed on a concrete base made on site (fig. 9). A duct fits into the hole in the base. The base has a lockable door on the front (fig. 10) which gives access to the handle for locking the cover and to the cables under the cabinet. This makes a separate cabinet manhole unnecessary, at least if the distance between cabinet and manhole is less than 10 metres. On a wall the cabinet is attached to two brackets (fig. 11) and on a pole to another form of bracket.

Miniaturization has reduced the price both of cabinets and boxes, as well as of transport and installation. As a rule the cost of a cabinet manhole is also eliminated. Nor should it be difficult to obtain permission from private persons or authorities to set up these cabinets, which take up a minimum of space. All these points of view necessitate revision of the previous norms for the most economical size of cabinet districts. It will be apparent from the above that the fixed cost per cabinet, i.e. the part of the cost that is independent of the capacity of the cabinet, will be lower than for previous types. Consequently the economically optimum size will also be smaller. For the present, therefore, the maximum size has been limited to 500 pairs and two standard sizes are made, 300 and 500 pair cabinets. The smaller type is intended for fitting to a wall or pole, the larger on a concrete base or wall.

The smaller size of cabinet necessitates a larger number of cabinets and of more groups of primary pairs with inferior utilization of the latter. This can be counteracted by connecting a given number of pairs, e.g. a 50-pair unit, in parallel to two cabinets. From the utilization point of view these two cabinets can be regarded as a single unit and the utilization factor is very good. The additional cost for an extra minibox is very slight and the cable record entails no problem.

Should cross-connecting points with larger capacity be required in special cases, miniboxes can naturally be used, the necessary number being fitted on a rack indoors or in cable cabinet out-of-doors.

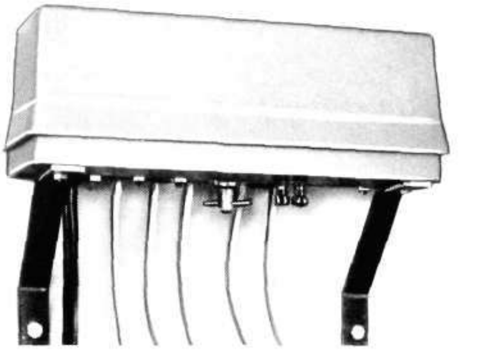


Fig. 11 X 2812

Cable cabinet mounted on wall indoors with brackets

The cabinets for miniboxes are well suited also for location indoors. Their robust construction and minimum space requirement permit their location even in premises to which other persons than telephone personnel have access, such as corridors, cleaners' cupboards, basements, factories etc.

In a sufficiently dry climate the secondary cables can be connected indoors directly to open 10-pair terminal units (fig. 12). This is especially recommended when only 10-pair cables are used in the secondary network. These units take up more space per pair than the normal miniboxes. A 300 or 500 pair mini-cabinet has space for 50 and 100 pairs respectively of primary cable in mini-boxes, and 80 and 130 pairs respectively of secondary cable in open sleeve contact units.

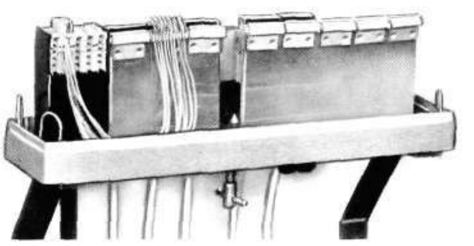


Fig. 12 X 2813

NBD 60101 with a 50-pair minibox and eight 10-pair terminal units

Air Conditioning

The high degree of miniaturization results in comparatively short surface leakage current paths. Laboratory tests, however, have shown that the leakage is nevertheless very low and well comparable with that in our present terminal blocks of mica-filled thermosetting resin. This is because of the excellent insulating properties, of the body of the sleeve contact unit even in a humid atmosphere. In order to guarantee fully adequate insulation under extreme conditions, however, the cable cabinet can be air-conditioned.

This is done by injecting dry air into the cabinet from a compressor in the exchange via the primary cable. The primary cable must be pressurized. The injection takes place via a pneumatic resistor of such size that about 2 g/h of air is injected into the cabinet, in which an overpressure is thus built up which prevents the ambient air from entering. Owing to the extremely small internal dimensions of the cabinet, it takes only a few hours to develop the necessary overpressure.

This type of air conditioning will be necessary, for example, in tropical coastal climates where salt-laden particles during the dry season, and salt-bearing humid air in the rainy season, produce a coating on the insulation surfaces which greatly increases the leakage. In the vicinity of some chemical plants it may also be advisable to prevent corrosive gases from entering the cable cabinets with the atmosphere. Since the additional cost of air conditioning is very slight, is should be the rule and not the exception. All cable cabinets are equipped for this purpose.

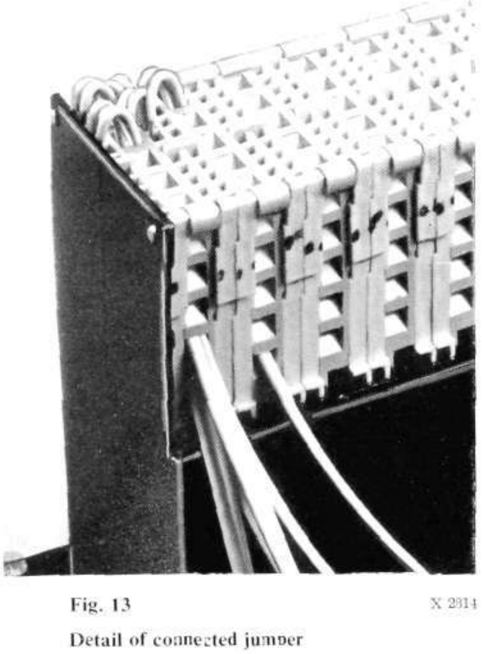


Fig. 13 X 2814

Detail of connected jumper

Jumper Wire, Connecting-up

As already mentioned, the stripped wire acts as a plug. The wire must therefore be sufficiently rigid. A nylon-coated 1-pair cable with 0.6 mm parallel PVC-insulated bronze conductors is suitable for the purpose. The conductors are cut and stripped with a special pair of pliers.

The termination of the 1-pair cable is effected by passing the wires into the wire-guide hole corresponding to the primary jacks in the main top surface. They are stripped with the pliers over a length of about 30 mm. The bare wires are plugged fully down into their respective jacks. The wire is then pulled back to a distance such that a short loop remains (fig. 13). The free ends are passed into the bunch of wires at the bottom of the cabinet to the hole in the front face corresponding to the secondary-pair jacks and are there terminated in the same way.

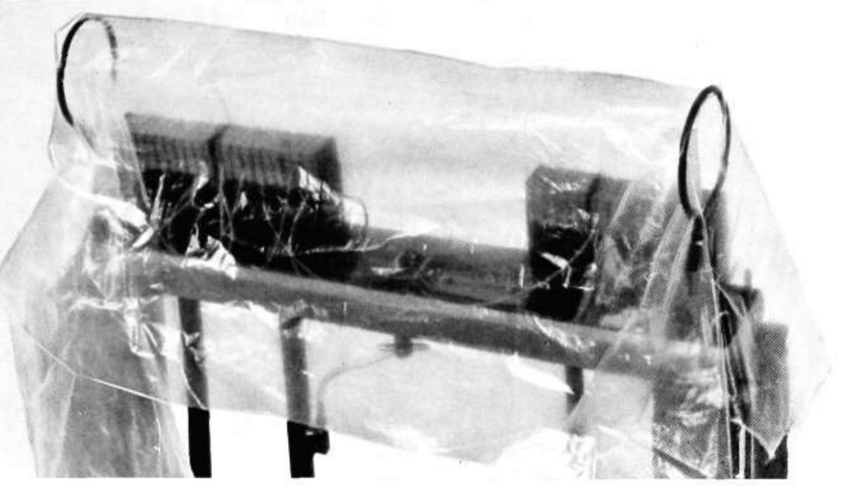


Fig. 14 X 7943

500-pair minicabinet NBD 60102 with tent 684091 on concrete base

Even at the maximum cable fill there is adequate space for the bunch of wires, and the wiring arrangement is neat. Disconnection is effected in a similar manner by pulling the plugs out of the jacks, cutting-off the bare wire and pulling out the remainder.

A very simple but efficient tent of transparent plastic permits wiring work to be done in bad weather (fig. 14).

Marking, Testing

The cabinet contains a label holder behind the boxes. It contains a label strip of transparent plastic with a paper backing, both of which are replaceable. The holder can be fixed with hooks into the two outside boxes just under the main top surface so that every jack can be marked and read on the label without risk of confusion (fig. 15). Entries can also be made by hand on the paper backing. After work in the cable cabinet has been completed, the preliminary entries can later be replaced by typed designations on the transparent plastic strips.

The cable cabinet contains a test plug which is connected to two terminals that are accessible from outside the cabinet. This permits termination of the test equipment to any pair in the boxes.

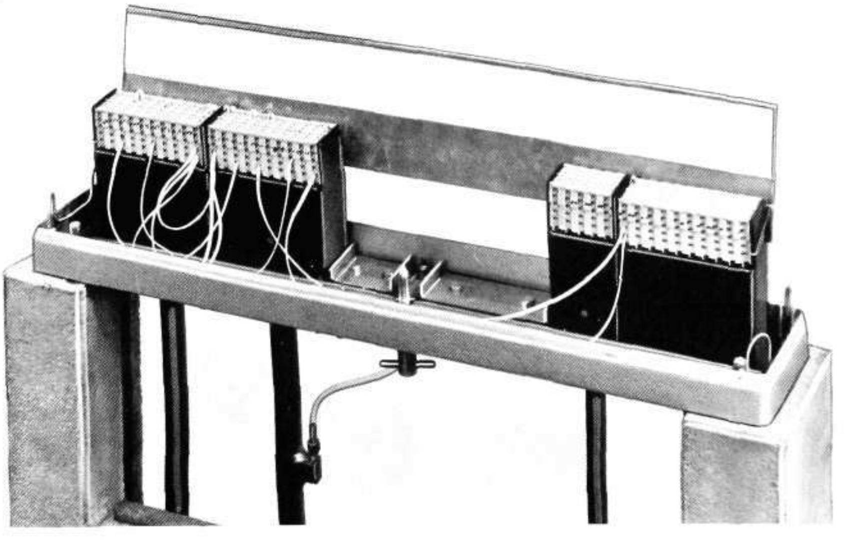


Fig. 15 X 7944

NBD 60102 with three 100-pair and one 50-pair miniboxes. Label holder raised

Designations

Stub cable with boxes. The unit consists of 12 m cable with a minibox at each end. The cable is packed in a coil of about 540 mm diameter, the boxes being well protected inside the coil.

designation	with cable	net weight
		kg
NCL 50102	ELLY 50 × 2 × 0.5 mm	5
NCL 50104	ELLY 101 × 2 × 0.5 "	10
NCL 50112	EPB 50 × 2 × 0.5 "	13
NCL 50114	EPB 101 × 2 × 0.5 "	22

Units with other type of cable (e. g. armoured paper-core lead-covered cable *EPJ*, armoured plastic cable *ELLY-R*), or with other length of cable, can be supplied on request.

Cable cabinets. In addition to frame and cover with locking device, the unit contains a test plug, label, and equipment for connection of air conditioning.

designation	capacity in pairs for installation of:		length	width	height
	miniboxes	minibox + 10-pair terminal units*			
			mm	mm	mm
NBD 60101	300	50 + 80	408	130	165
NBD 60102	500	100 + 130	632	130	165

* The terminal unit is designated 684099 and consists of two 5-pair sleeve contact units assembled with wire guide in a holder.

Optional Accessories

Drawing of mould for casting concrete base	*684057*
Front door with lock for concrete base	*684063*
Dummy plate	*684071*
Plastic tent	*684091*
Fixing bracket for *NBD 60101* on pole	*684095*
Bracket for mounting cable cabinet on wall (2 brackets per cabinet)	*684098*
Pneumatic resistor, 250 Lohms	*NVB 1507*
Jumper wire for plug connection	*BR-EKNA* 2 × 0.6 mm
Pliers for stripping and cutting of ditto	*LSD 2178*

Summary

The equipment at present used at the cross-connecting points of a telephone network takes up considerable space, which in some cases may cause troubles and problems. To overcome this disamenity a miniaturized cable terminal box—called a minibox—has been developed. The previous standard screw connection has been replaced by a plug-and-jack connection in which the jumper itself serves as plug. The boxes are fitted in miniaturized cabinets which can be set up on a concrete base, wall or pole. The cabinet is air-conditioned from the telephone exchange via the primary cable. The price is about the half, and the volume of the cabinet some 20 times less than that of ordinary cable cabinets.

NEWS *from* *All Quarters of the World*

Change of President at LM Ericsson

Mr. Sven Ture Aberg—President of the Ericsson Group for the past 11 years—had notified the Board at its 1964 meeting of his desire to retire from his appointment. The Board had no other course than regretfully to take note that the successful Abergian era in the company's history had come to an end and to extend to Mr. Åberg their warm thanks for his great achievements during these many years.

In the presence of the assembled Board I formulated our vote of thanks roughly as follows.

The great loss felt by the company to-day is due not only to Mr. Åberg's exceptional qualifications and the stimulating teamwork he has created around him, but also to his sterling personal attributes. I may even say—without in any may wishing to belittle his predecessors during the company's illustrious but sometimes chequered history—that Mr. Aberg is the most prominent president that the company has ever had. During the period of his management the company has solved its capital problems, for instance, in a very satisfactory way. L M Ericsson is the first Swedish company to gain the support of the international capital market in the form of a loan—I am thinking of the Swiss loan. Its shares have been introduced on a number of international stock exchanges in conjunction with the release of the shares earlier tied up in the United States. This would not have been possible without a solid international reputation which—I can state positively—was to a great extent built up through Mr. Aberg's personal efforts.

There can be few companies in the world which have expanded in the same way during this 10-year period. Most of the company's activities such as sales, invoicing etc. have trebled in magnitude. One—the number of employees—has only doubled. Behind these facts I discern one of Åberg's many admirable attributes as a leader, namely his ability to choose a capable team and to stimulate them to wholehearted efforts.

The company's profits have likewise been satisfactory. It is significant that the net profits of the group for 1963 were equal to the company's capital of class A shares ten years ago, which was around 50 million kronor.

Even if Mr. Aberg is now retiring from the presidency, he will remain on the board of the parent company and on the boards of some of its subsidiaries, so that we can still draw upon his great experience especially in the international field—for which we are very grateful.

I believe that I have the entire 40 000-strong staff of L M Ericsson behind me when I now extend to Mr. Aberg our hearty thanks and express our admiration for his great achievements, especially during the eleven years he has been the company's president.

Marcus Wallenberg

The board has appointed Mr. Björn Lundvall president in succession to Mr. Aberg.

Mr. Lundvall was born in 1920. In 1943 he graduated as M. Sc. from the Stockholm Institute of Technology and in the same year joined L M Ericsson where he was placed in charge of the development and design of carrier equipment in the Long Distance Division.

In 1954 he was appointed Chief Engineer and three years later Sales Manager of the Long Distance Division. In 1961 he became Head of the Division and Vice President of the company. Last year he was appointed Senior Executive Vice President and Deputy to the President.

Mr. Hans Werthén, Executive Vice President in charge of Production, is taking over Mr. Lundvall's post as Deputy to the President and Head of Military Electronics. Mr. Knut Styrén has been appointed Executive Vice President and member of the Board of Directors.

New President of LM Ericsson, Denmark

Mr. Lars Christian Nørrelund retired on April 10, 1964, from the presidency of our Danish sales company, L M Ericsson A/S (LMD), after 35 years in its service. The board of LMD appointed as his successor Mr. Frantz Liisberg, previously Vice President of the company. From the same date Mr. Nørrelund became chairman of the board of LMD in succession to Mr. S. T. Åberg.

Mr. Nørrelund graduated as building engineer at the Polytechnical College of Copenhagen in 1926 but, while

Cont. on p. 134

Egyptian Orders for 62 Million Kronor

L M Ericsson has signed agreements with the United Arab Republic for the delivery of telephone components, tools and instruments amounting to 50 million kronor to the state-operated telephone factory outside Cairo, which makes telephone equipment for Egypt on Ericsson licence.

At the same time L M Ericsson has received orders from the Telecommunications Administration of the United Arab Republic (UARTO) for the delivery of carrier equipment for coaxial cables amounting to 12 million kronor. This equipment will be used for automatic long distance traffic in the north of Egypt.

The photograph above shows Mr. Arne Stein with Minister Abdel Wahab El Bishry after signing the factory contract for 50 million kronor. Organizationally the Egyptian telephone factory comes under the War Ministry.

Opening of New Ericsson Exchanges

Two automatic exchanges were recently opened in Mexico, an ARF exchange at Ciudad Satélite with 2 000 lines and an AGF at Churubusco with 5 000 lines. Both exchanges have an ultimate capacity of 30 000 lines.

The largest cutover of crossbar exchanges in Australia has taken place. The operation covered ten exchanges including three tandem centres situated in eight Melbourne suburbs.

A new 4 000-line crossbar exchange was opened in the spring at Sfax, second city of Tunisia, which thus went over to all-automatic local traffic.

At the same time a new manual trunk exchange was put into operation. The conversion comprised about 2 500 subscribers.

Our second ARM exchange for intercontinental telephone traffic was cut over on June 15. It belongs to the Canadian Overseas Telecommunications Corp. and is situated at Vancouver. A similar exchange was earlier opened at Montreal.

Three new ARM exchanges have been opened in Egypt. These are trunk exchanges for 1 400 lines in Cairo, 800 lines at Alexandria and 600 lines at Tanta. The photograph below shows the inauguration of the Tanta exchange by the Egyptian Minister of Communications, Dr. M. Riad.

Dr. Ricardo Baquero González, chairman o, the board of C. A. Centro Médico, Caracas makes the first call through the new ARD 151 P. A. B. X. recently opened at Centro Médico. The exchange has 300 extensions and 40 exchange lines and is equipped with several special facilities. On the left of the photograph is Sr. José L. Garcia de Ceca of our subsidiary company, Teléfonos Ericsson C. A., Caracas.

Large Orders from El Salvador and Costa Rica

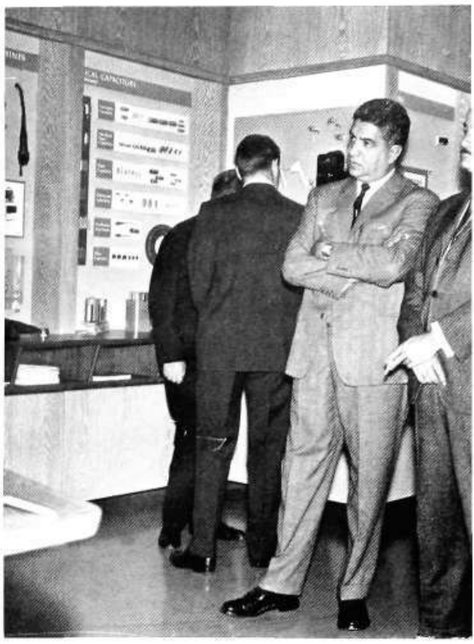
L M Ericsson has recieved orders for telephone equipment from Central America amounting to some 30 million kronor. The equipment will be used for extension and modernization of telephone exchanges in El Salvador and Costa Rica, both projects being financed chiefly by long-term loans granted by the World Bank.

The telecommunications of El Salvador, where L M Ericsson equipments have been known for many years, are to be developed on the basis of the crossbar system. The order comprises equipment for public local exchanges, trunk exchanges and a quantity of telephone instruments.

To Costa Rica are to be supplied five automatic crossbar exchanges for the capital, San José, with surroundings, and also an exchange for automatic and semi-automatic trunk connections. In the San José area the traffic is at present being handled exclusively by manual exchanges, which are now to be successively replaced by Ericsson automatic crossbar exchanges.

Tenders were submitted by the main telephone manufacturers of the world and were scrutinized by international technical experts in accordance with the rules of the World Bank. These orders are among the first for telephone development projects financed by loans from the World Bank.

The new Dialog telephone is demonstrated to the Portuguese Minister of Finance, Professor Texeira Pinto Dr. André Gonçalves Pereira and (standing) Mr. A. Bergenstjerna of the Johnsson group by Mr. E. Lundqvist of L M Ericsson.



The Mexican Minister of Commerce, Dr. Salinas Lozano, and (left) Sr. Bernardo Quintana Arrioja, chairman of ICA (Ingenieros Civiles Asociados) in the Exhibition Room.

SOME DISTINGUISHED VISITORS TO L M ERICSSON, STOCKHOLM

The Irish Minister of Communications, Mr. M Hilliard (left) and the President of L M Ericsson, Mr. B. Lundvall, try out some early Ericsson telephones.

The Governor of Cairo, Mr. Salah Dessouki, was also an interested visitor to the exhibition.

From Costa Rica there came Minister Mario Quiroz with wife, and in June the Colombian Minister of Communications, Miguel Escobar. (From left) Sr. M. Escobar, Mr. G. Magnusson, First Secretary of the Swedish Foreign Office, and Mr. S. Friberg of L M Ericsson studying a step in the assembly of the code switch.

Dr. Ramón Martinez Vallejo, Director General of ENTC (Empresa Nacional de Telecomunicaciones, Bogota, Colombia) is shown a model of the main factory. On the far left is Mr. G. Fernstedt of L M Ericsson.

New President . . . *Cont. from p. 131*

Mr. Lars Christian Norrelund

still an undergraduate, began to develop an interest in telephony as draughtsman at the Copenhagen Telephone Company. After a brief appointment with the Fyn Municipal Telephone Company he was taken on by LMD in 1929 and in 1942 was appointed its president.

Under Mr. Nørrelund's leadership LMD grew into the perhaps most successful sales company of the Ericsson group, with a constantly growing business on the private, and in particular on the public, market. His main achievement as head of LMD was the introduction of our crossbar system in Denmark. The first crossbar orders were placed by the Jutland Telephone Company, but the great breakthrough for crossbar switching came with the contract for a new system for the Copenhagen area in 1951. Through his business acuity, his ability to foresee the future development of switching technique at an early stage, and his keen ear for the desires of the administrations, Mr. Nørrelund made an invaluable contribution to the realization of these important first transactions. During the last ten years Denmark has been the largest market for crossbar equipment. The completion of the first code switch exchange at Nørregade in Copenhagen a short time ago was a worthy conclusion to Mr. Nørrelund's period as head of LMD.

He also played an important part in the co-operation with Telephone Fabrik Automatic in the management of Dansk Signal Industry A/S.

Mr. Nørrelund's solid character and winning manner made him a respected and popular head of LMD. He made many friends within the Group and among telephone technicians from the whole world who visited Copenhagen to study our crossbar switching technique and who there had the advantage of meeting "Lars Crossbar" and his never failing helpfulness and hospitality. *Sven T. Åberg*

New L M Ericsson Factories

At the end of last year AB Alpha opened a new factory at Kristianstad.

Built by Kristianstad Industribyggnads AB on a 6 250 m² site, the single-storey building measures 50 × 60 metres and includes a basement floor.

The factory at present employs some 40 persons. This number will in due course be increased to around 250, of whom half women.

The production comprises thermoplastic components, but the design of the factory allows for a change to other products without any great difficulty. A machine tool department is planned to be in operation this year.

In September this year the factory built by AB Rifa at Kalmar was opened by the Provincial Governor, Ivar Persson.

The gross area of the factory is around 11 000 m², production and storage space amounting to 6 900 m², office space 600 m², and dining hall 300 m². The remaining space has not yet been allocated.

A special feature of the Kalmar factory is the large fan system. This was necessitated by the especially high requirements of cleanliness in the manufacture of many of Rifa's products, and also of regulated humidity which is needed because of the great variation in strength of capacitor paper at different degrees of humidity. Thorough cleanliness is also a condition for the high quality Rifa must maintain as supplier of capacitors to the telephone industry. The life of telephone equipment is calculated at a minimum of 40 years and the capacitors must last at least that period.

The L M Ericsson stand at the World Exhibition in New York 1964.

The Kalmar factory at present employs some 100 persons. Assembly and running-in of machinery, and training of personnel, are in full swing. By the year end it is expected that the working force will be around 125 persons.

With the equipment at present installed there is employment for around 300 persons. It is hoped that this number may be increased within the next few years. Further extensions can thereafter be made, if required, by drawing upon the reserve accommodation.

The production of the Kalmar factory consists at present of polystyrene capacitors used principally in equipments for long distance telephony, spark quenchers for the protection of contacts in automatic telephone switching equipment, and finally MP (metallized paper) capacitors for fluorescent lighting. The manufacture of Miniprint capacitors will start during the autumn. This type of MP capacitor is impregnated with epoxy resin and is principally used within the radio and TV industry.

Entrance to Rifa's new factory at Kalmar.

UDC 621.395.344.001.6
LME 83021

ERICSSON, E A: *The Development of Code Switch Systems.* Ericsson Rev. *41*(1964): 3, pp. 76—79.

The purpose of the development in exchange technology that has been conducted at L M Ericsson has been to produce a selector design substantially reducing the space requirement and capital cost of the telephone exchange equipment. The new selector should have larger multiple capacity, which affords material saving group arrangements, but smaller front face than that of the conventional crossbar switch. Due regard should be taken to modern materials and manufacturing methods. The price should be low and the multiple should be capable of being multipled by machinery. The result was the code switch and systems based on this switch. With suitably grouped selector stages a saving in space is obtained of 25 to 30 % which is increased to about 50 % if the conventional bay arrangement is replaced by suspended movable racks. In the code switch systems some facilities have been introduced which can be made use of to reduce the total cost in a telephone network.

This article gives a summary of essential system properties which are further dealt with in other articles in this issue of the Ericsson Review.

UDC 621.316.544
621.395.344
LME 7363 83385

ALEXANDERSSON, H V: *The LM Ericsson Code Switch — a New Connection Device.* Ericsson Rev. *41*(1964): 3, pp. 80—87.

The article below describes a new selector, the code switch. This can be applied to all types of exchanges and allows the construction of exchanges that offer considerable advantages through reduced space requirements, improved power economy and savings in maintenance cost. Within the framework of its total number of contact points it permits a considerable variation in capacity and pole number making it adaptable to all existing requirements.

UDC 621.395.722
621.395.344
LME 8344 8354

ANDERSEN, E: *Automatic Telephone Exchanges with Code Switches.* Ericsson Rev. *41* (1964): 3, pp 88—95.

L M Ericsson has developed new automatic telephone exchange systems with code switches. The first large public telephone installation using code switches has been put into operation in Copenhagen and a presentation of the system design and its essential characteristics is made in the this article.

UDC 621.395.722
621.395.344
LME 834 835

CARLSEN, I: *The Automatic Exchanges in Central Copenhagen.* Ericsson Rev. *41*(1964): 3, pp. 96—105.

With the cut-over of the first fully automatic exchange at Nørregade on April 21, 1964, the automatization of the central Copenhagen telephone system had started and an epoch in the history of the Copenhagen Telephone Company (KTAS) is thereby nearing its completion. The Central Exchange, which has been the centre of the Copenhagen telephone system, will be closed down in the course of the coming four years; those of its subscribers who live in the city of Copenhagen will be transferred to the new automatic exchanges at Nørregade and the remainder to district exchanges in the area where they live.

UDC 621.395.2
LME 8372

ADENSTEDT, W & Ulltin, S: *50-Line P. A. B. X., AKD 741.* Ericsson Rev. *41*(1964): 3, pp. 106—115.

L M Ericsson's new 50-line P.A.B.X., AKD 741, is characterized by its high traffic capacity and reliability. Based on the code switch, it is highly adaptable, silent operating, and has a large multiple capacity. Owing to the small mechanical motions there is very little wear. The P.A.B.X. therefore has a long life and costs very little in maintenance.

UDC 621.395.453/.454
621.395.463
621.396.65
LME 8425

JOHANSEN, G: *Transistorized 12-and 24-circuit Carrier Terminals for Radio Links.* Ericsson Rev. *41*(1964): 3, pp. 116—123.

It is usual to provide telephone circuits between small towns by means of radio links using a frequency band sufficient for 12 to 24 telephone channels.

L M Ericsson's terminal equipment for 12 and 24 circuits with a baseband of 6–108 kc/s for four-wire connexion to radio links is described in this article.

UDC 621.316.344
LME 1375

LUTZ, J P & Åberg, G: *Miniaturized Cable Cabinet.* Ericsson Rev. *41*(1964): 3, pp. 124—130.

There is a need in telephone plant for cross-connecting points at which a given pair in an incoming group of conductors can be connected to any pair in an outgoing group. The main distribution frame between exchange and lines is one example of such a point—the distribution cabinet in the line network is another.

The equipment at present employed at these cross-connecting points often takes up unduly much space, which has proved an increasing inconvenience as the number of subscribers grows. L M Ericsson has therefore developed a miniaturized equipment which radically reduces the space requirements for the cross-connecting points.

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CONTENTS

DIALOG — the New Telephone

Å KÅELL, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

Fig. 1 X 2816
The DIALOG is easy to carry

UDC 621.395.72
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*When L M Ericsson brought out its telephone with plastic handset and casing in 1931, an external form was created for the telephone instrument which, in its main outline, has been accepted and retained by all large telephone manufacturers of traditional subscriber instruments with handset, dial and bell. Its characteristic features were the sloping front with the dial, and the form of the casing which provided a sturdy seating for the handset. When there have been special purposes in view, or the design has been based on a new telephone instrument philosophy, new types have of course arisen with a shape and functional character of their own, such as the **ERICOFON** introduced in 1956 and the loudspeaking **ERICOVOX** in 1958. The world market needs some variation, and different types can be successfully produced side by side. But quite obviously the large telephone administrations wish for the most part to supply their subscribers with a modern instrument of traditional type. A new telephone, called the **DIALOG**, has therefore been designed in intimate co-operation with the Swedish Telecommunications Administration.*

Design Considerations

The general spirit of rationalization, mechanization and functional design which now permeate our society and set their mark on the modern home have extended also to the telephone, in that subscribers now make certain practical demands which the older telephone instruments could not fulfil. These demands relate to the handling and functioning of the instrument and to its fitness for its environment.

Nowadays the telephone is not hidden in a dark corridor or lobby. It is an important everyday appliance in the running of the home and needs a central and convenient location. Hence follow the requirements of *attractive appearance* and of a choice of *different colours*.

It has become increasingly common to use a plug-and-jack termination in order that the telephone may be moved from one room to the other. This requires that the instrument is *easy to carry*.

A *light handset* is a natural desire since the telephone has become as usual an object in the hand as a pencil, pipe or newspaper.

A loud ringing signal is often not only unnecessary but even disturbing. The subscriber therefore wishes to have an easily *adjustable ringing signal*.

Another reasonable demand is that all subscribers—in that they pay the same charge for their calls—shall as far as possible enjoy the same quality of transmission. An important step in this direction has been achieved through *automatic regulation of the transmission level* according to the length of the line. This is dealt with in a separate article.

It is naturally in the interest of telephone administrations to have subscribers satisfied, by making telephoning simple and attractive. But the administrations have another important and more direct requirement, namely that telephones can be *rationally maintained*.

It was with these desires and requirements in mind that the DIALOG was designed.

Fig. 2 X 2817
The ringing signal can be easily adjusted

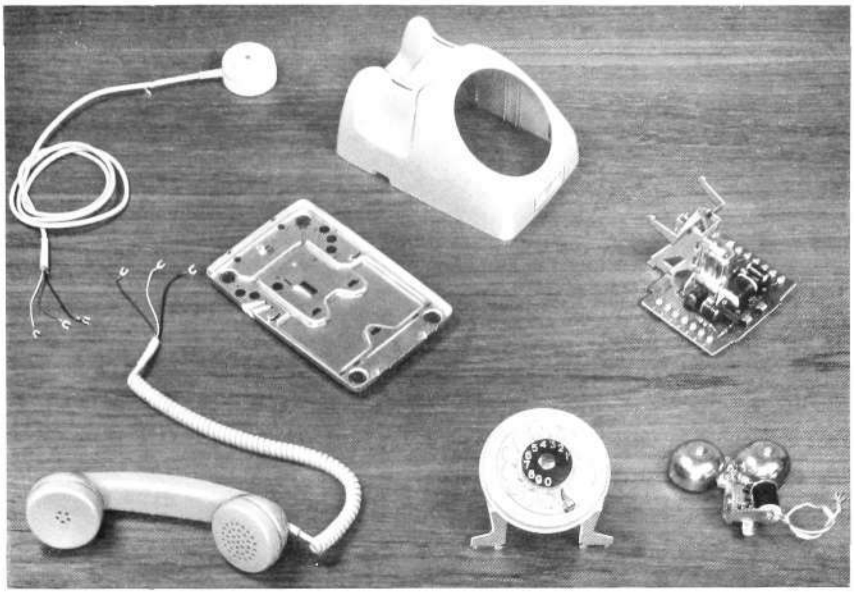


Fig. 3 X 7945
The DIALOG is organically divided into seven main components

Structural Features

The main principle in the design of the DIALOG has been to collect mechanically and electrically associated parts into groups of main components which can be easily replaced. This simplifies maintenance and spare part stockkeeping as well as the production of variant types. If a telephone is made up of a few organic, standard units, the replacement of a component in the event of a fault can easily be done at the subscriber's premises by semi-skilled staff and the faulty component thereafter repaired at a central workshop by specially trained personnel. The work at the subscriber's premises can in such case be limited to a few simple operations with a screwdriver. This has been the reason why the DIALOG has been given a mechanical structure based on a radically new principle, namely a kind of building-block assembly without screw connections.

The DIALOG is organically divided into seven main units, viz.

- ☐ Base
- ☐ Bell
- ☐ Transmission unit
- ☐ Dial
- ☐ Casing
- ☐ Handset
- ☐ Cords

The bell, transmission and dial units have mounting plates with tabs which fit into openings in the adjacent mounting or base plate. The bell unit, and thereafter the transmission unit, are slid into the base plate. The dial is then

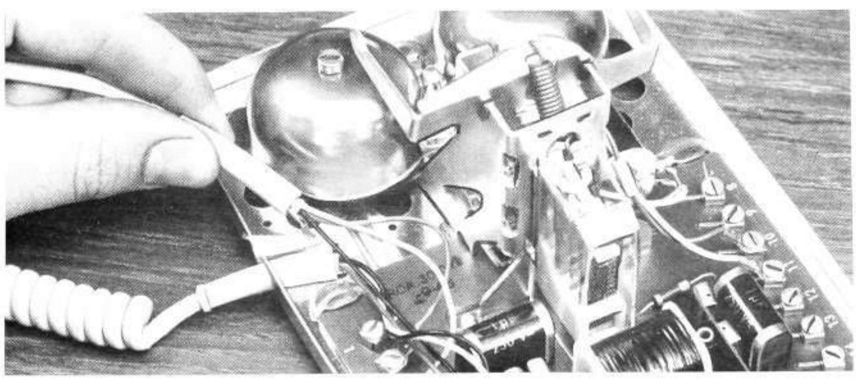


Fig. 4 X 7946
After the bell and transmission units have been assembled, the cords are hooked to the base plate

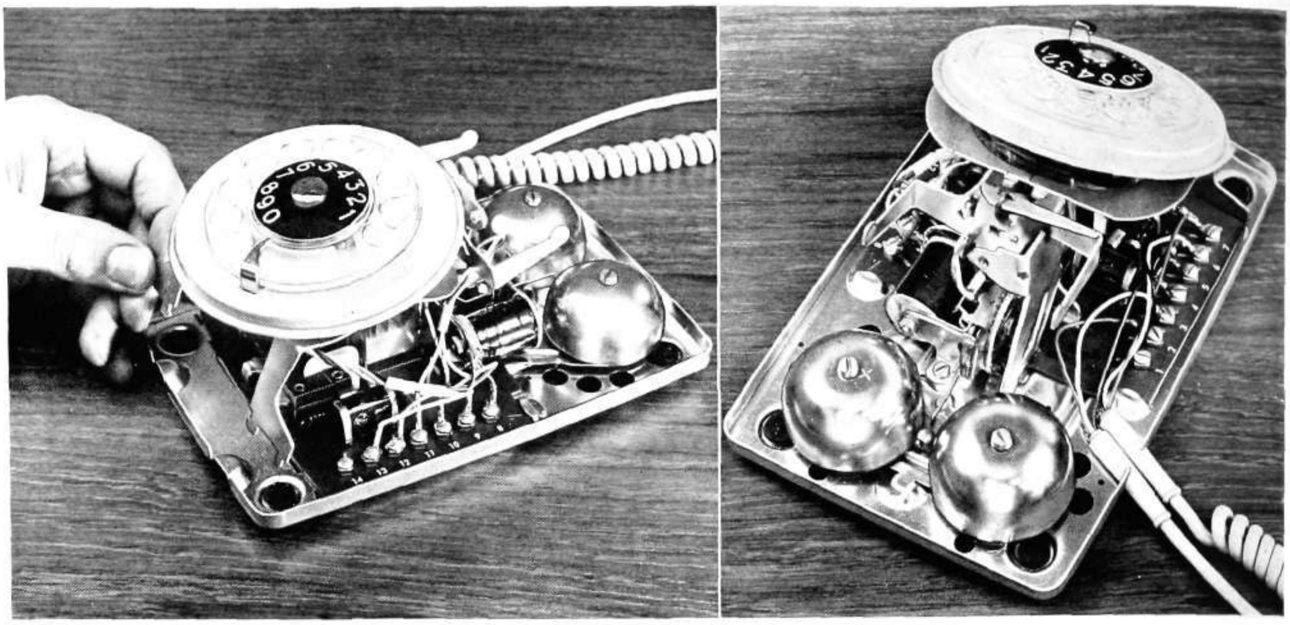


Fig. 5 X 7947
The dial, which keys into a frame on the transmission unit, snaps into position in the base and so locks the internal mechanism

keyed to a frame on the transmission unit and snapped into position in the base, whereby these three functional units are mechanically locked at that point. The two cords, the straight wall terminal cord and the spiral cord of the handset, are then hooked to the base plate. The casing can now be put on and attached to the frame of the transmission unit by a single screw in the hand-grip in the rear.

Fig. 6 X 2818
The casing is secured by a screw in the hand-grip

Base Unit

This consists of 0.8 mm sheet steel with reinforcements, holes and recesses which make it a stable foundation for the telephone. Like other steel parts in the instrument the base plate is galvanized and chromate-coated. It is also coated with a transparent lacquer on both sides. This preserves the fresh appearance on the outside and adds to the insulation of the printed wiring board above it.

The edge of the base plate is bent up all round. In addition to the added stability this provides, it ensures a firm attachment to the thin thermoplastic casing. Ribs on the inside of the casing engage with the bent-up edge, so guaranteeing a close fit vertically and horizontally.

A notch has been made in the base plate for the two cords, and the edge is cut away there to facilitate assembly. Each cord has a strain-relieving device which hooks into a slot in the base plate. The casing holds the cords in position but the entire tensile stress on the conductors due to pulling on the cords is taken up by the robust attachment of the cord covering to the base plate.

Apart from these slots and recesses required for assembly, the base plate has acoustic perforations for the bell and a slot which permits easy access at the bottom of the instrument to a device for regulating the sound of the bell.

In the four corners are round holes for the non-slip pedestals which consist of studs of neoprene. These retain their properties very well with time and do not damage lacquered and polished table surfaces.

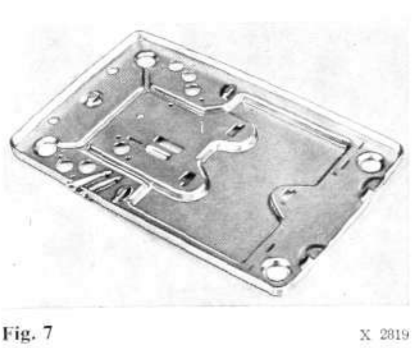


Fig. 7 X 2819
Inside of base plate

Bell Unit

The relatively new bell mechanism, *KLA 160*, which has already been employed in certain types of the *DBH* telephone sets, is used in the DIALOG.

The mechanism is characterized particularly by a new magnetic circuit with a single coil and a small AlNiCo magnet. The permanent flux and the alternating flux are forced into separate paths in a large part of the circuit. The fluxes join again close to the air gap and pass through the armature

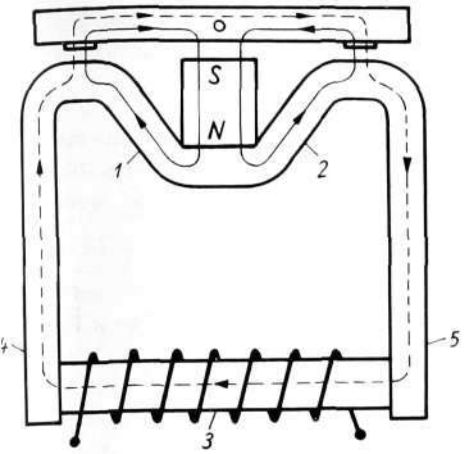


Fig. 8 X 2820
The magnetic circuit of the bell

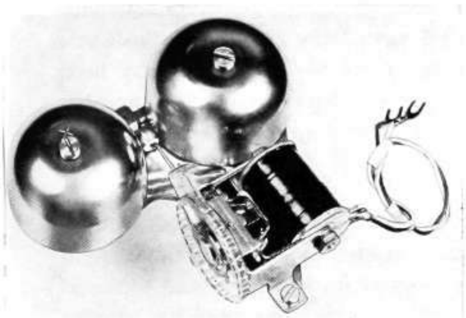


Fig. 9 X 2821
Bell unit

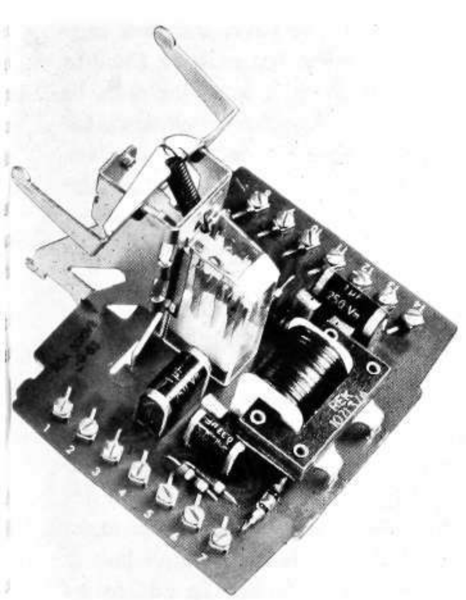


Fig. 10 X 2822
Transmission unit

together. This ensures high efficiency with a small quantity of material. The schematic of the magnetic circuit (fig. 8), to which the numerals in the subsequent text refer, shows how this has been achieved. Portions 1 and 2 have large slots which reduce the cross-section. The flux from the magnet saturates these parts of the circuit and the alternating flux is forced across the air gap into the armature. The permanent flux takes the shorter route through the armature and only the alternating flux from the coil passes through portions 3, 4 and 5, which can therefore have small cross-sections.

The hammer rod is clamped to the armature in parallel with it. At the point of attachment the hammer rod is extended into a U-section so that a free end projects in the direction of the hammer. The free end is used for limiting the armature stroke. This is done by turning a disc with a cam edge.

The bell mechanism and the gongs are attached to a common mounting. Under each gong is a dome of polyamide. These domes contain a specific air volume. In the lower edge of the dome is an opening sufficiently large to form with this air volume an oscillating circuit with resonant frequency of 1 000–1 500 c/s. The effect of these resonators is very marked compared with gongs in which they are lacking. The gongs themselves are too small to produce a sufficiently audible sound within the most sensitive region of the ear. The resonators increase the harmonic components within this region, which is of considerable assistance especially to old people with poor hearing.

The bell coil has several tappings for different purposes. By varying the winding data different impedances can be obtained for matching to the ringing system and to the rest of the circuitry. Apart from this traditional type with 3 000–5 000 ohms impedance at ringing frequency, there are high impedance bells up to 25 000–30 000 ohms. These high values permit permanent connection of the bell between the two legs of the line and the bells are then supplied with their own capacitor (approx. 0.3 μF) fitted to the bell mechanism, for which the extra tappings on the coil come into use. Normally, however, a fairly low impedance bell is still used with the same capacitor as for spark quenching of the dial (1 or 2 μF), the capacitor being switched when the handset is raised.

Transmission Unit

The switching function and the transmission circuit are concentrated to a transmission unit which consists of a printed wiring board on which the cradle-switch springset with its associated mechanism is mounted. The board carries all transmission elements and has screw terminals along its edge for the bell, dial, handset and wall terminal cords, which are connected by means of cable clips. This makes for an orderly arrangement of the main components with easy connections for maintenance or replacement of a unit by an alternative type.

To hold the printed wiring board securely to the base plate and to protect it against heavy mechanical stresses, the cradle-switch frame and a bracket for the transformer are so shaped that, in addition to their attachment to the printed wiring board, they are also secured to the base plate. The principle of steel-to-steel engagement is thus consistently followed in the mechanical structure. The elastic printed wiring board fits smoothly into its points of attachment and easily carries the other transmission elements, which are "self-supporting", i.e. are soldered to the underside of the printed wiring board.

In the cradle-switch springset one should notice the assembly of the contact springs in a box of acetal resin. The mechanical design and the choice of material ensure good insulation and shape permanence. The springs are inserted into small slots in the upper and lower sides of the box. In this way

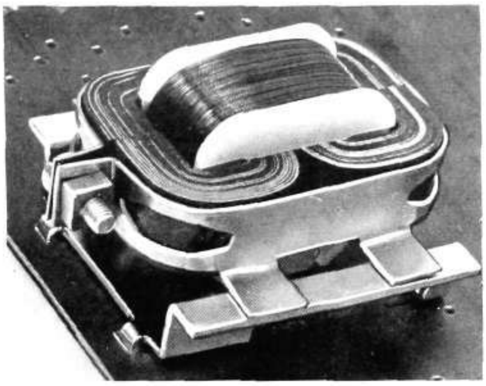


Fig. 11 X 2823
Induction coil with laminated core

Fig. 12 X 2824
Keyset unit

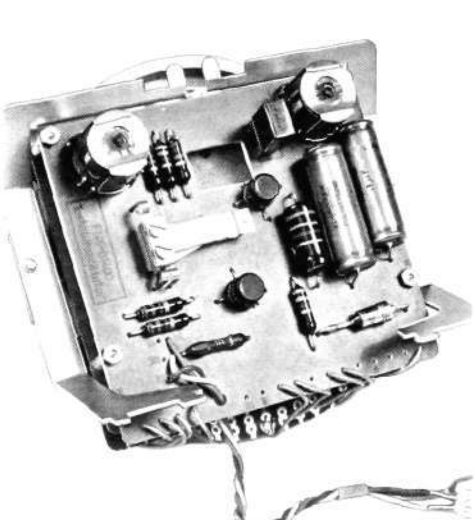


Fig. 13 X 2825
Keyset unit, underside

the elastic properties of the springs are utilized along their entire length. The springset is protected against dust and human contact by a cover of transparent styrene-acrylonitrile copolymer.

Another important detail is the mounting of the cradle which transmits the movement of the switch. Polyamide bearings guarantee an unchangeable cradle-switch function without wear of the steel surfaces which would result in detached metal particles and the attendant risk of faults.

The circuit elements—transformer, resistors, varistors and capacitors—have a tropical finish. The capacitors are of metallized paper (MP) and specially designed for printed wiring. This "self-healing" type of capacitor provides good protection against most overvoltages to which the telephone may be exposed. Being connected to the line in series with the bell when the telephone is not in use, the capacitor takes the first shock. The conventional paper capacitor has its definite voltage limit (in telephone instruments usually at 500 V). Increasing the dielectric strength of the capacitor means in this case simply that an incoming overvoltage may produce a flashover at some other point, usually the cradle-switch. The MP capacitor allows the overvoltage to break through, but quickly returns to its normal state. In this way the capacitor can absorb a very large number of shocks above its voltage rating. Even very high voltages (kilovolts) can break through the capacitor innumerable times before the metallization gives way and the capacitance falls below the tolerance limits. It is the quantity of electricity that decides the effect of the flashover. Experience in operation has been very satisfactory. MP capacitors have been used, for instance, in the ERICOFON since it was first produced in the mid-fifties. The MP capacitors now in use fulfil the requirements of humidity class 56 in IEC Publication 68.

In the DIALOG a new type of induction coil has been introduced, with C-core of grain-oriented silicon steel. This has resulted in high permeability and an important saving of material. High inductance values have been obtained with moderate copper losses, and the very good coupling between the winding sections results in high sidetone attenuation. For practical reasons an ordinary induction coil was used in the DIALOG during the first year.

Dial Unit

The dial is of a type that has long been used in earlier Ericsson telephones. It was described in Ericsson Review No. 3, 1947. The cover disc has been specially designed for the DIALOG, however, since the dial must be fitted to the base before the case is positioned. The hole in the case must therefore be larger than the diameter of the fingerplate and, in contradistinction to earlier types of telephone, the cover disc has a larger diameter than the fingerplate. The cover disc must seal tightly to the case, which is facilitated by an annular packing between them. For other reasons the diameter of the cover disc has been made extra large, which gives the dial its new characteristic appearance.

One of the reasons for this "new look" is that the rim of the cover ring outside the fingerplate is an excellent place for extra digits or letters which are necessary on certain markets. Another reason for the large hole in the case is to enable the DIALOG to be easily adapted to other kinds of pulsing device. There is a special model for v.f. or d.c. keysending. The dial is in such case replaced by a keyset with brackets for attachment to the cradle-switch frame and base plate in the same way as the dial. One model for magneto systems, with hand generator in the position of the dial, is also under development. For all these models it is an advantage to have an ample hole in the front of the case to allow freedom in component design. To add to the attraction of the centrally located dial, it has a fingerplate of transparent acrylic.

Fig. 14 X 2826
Dial with extra contact (earth button)

In certain PABX the extensions must be able to reach the operator through the connection of one leg of the line to a third conductor (which may be earth). For this purpose there is an alternative design of dial in which simple contact can be effected with a small non-locking button placed on the cover ring at the fingerstop.

Casing

This consists of a single envelope which in itself carries no circuit elements but presents a natural cradle for the handset. It is, of course, the casing that gives the telephone its characteristic appearance, but its association with the handset also gives it an important dynamic function. For the cradle is so formed that the handset, however carelessly replaced, always falls into position or, in the event of extreme carelessness, slides down onto the desk. The critical case of an apparently replaced handset not actuating the cradle switch might possibly occur, but only if the handset is intentionally replaced awry. The characteristic rear horns of the Ericsson telephones since 1931 have been retained and they still serve the purpose of taking the impact if the handset is banged down.

At the rear of the casing is a recess which provides a convenient grip for carrying the telephone. In this recess is the single screw with which the casing is attached to the base. The screw passes through a resilient plastic insert in the recess to the cradle-switch frame. This flexible joint has several advantages. The effect of normal manufacturing tolerances of the components is eliminated and compensation is allowed for the cold flow of the thermoplastic, which admittedly should be small but must nevertheless be foreseen. Another advantage is the shock-absorbing effect of the elastic mounting which greatly reduces the heavy impact to which the telephone is exposed if it falls, for instance, on a hard floor. The entire building-block assembly of the DIALOG components contributes to good mechanical resistance.

The casing, like the handset, is made of thermoplastic of ABS type (acrylonitrile-butadiene-styrene polymer). At present this type of material appears best to fulfil the natural requirements of good impact strength, shape permanence

Fig. 15 X 7943
The casing

and colour stability in combination with adequate surface gloss, chemical resistance and scratch resistance. Thermoplastics have to an increasing extent superseded thermosetting resins in telephone casings, handsets and the like. The main technical reason is the quicker manufacturing process and the virtually free option of colour. The development in this field has been very intensive in many quarters, and one must naturally expect future changes of materials which improve still further the sum of the properties one can reasonably demand.

The insert in the recess, which takes up heavy forces when the telephone is exposed to impact, is made of an extremely strong polycarbonate resin. And, being transparent, it admits sufficient light to make the interior of the instrument unattractive as a home for insects, a not uncommon complaint in the tropics.

The plungers of the cradle-switch, which are actuated by the handset, are made in the form of plates instead of the usual round plungers. This ensures efficient operation of the cradle-switch springset by the handset. The plates are of transparent acrylic but have polyamide soles on the underside with which the levers of the cradle-switch engage.

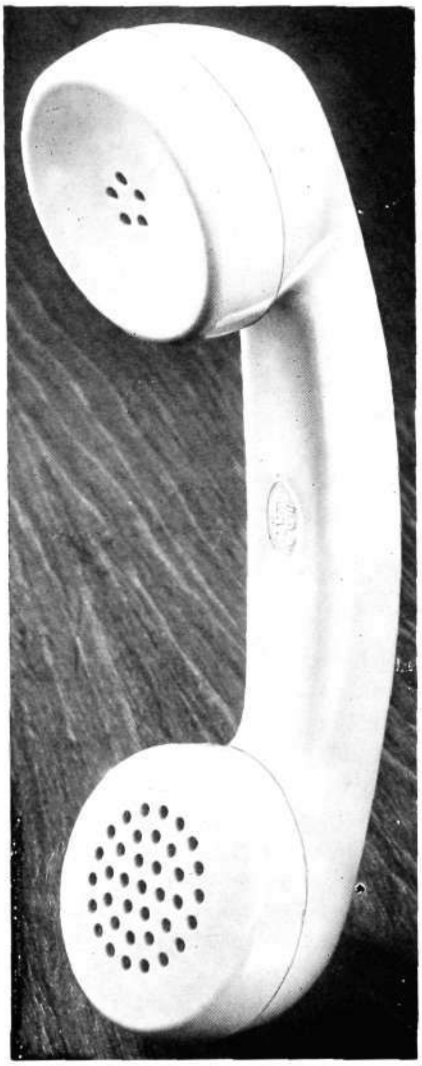


Fig. 16 X 2827
The handset

Handset

The new handset represents a big step towards greater telephone comfort, being very light and so shaped that good transmission properties are attained without the classical transmitter mouthpiece. The handset thus has a fairly symmetrical profile with similar but non-interchangeable caps for the transmitter and receiver insets.

The transmitter cap has slightly convex sides, akin to the ERICOFON. This shape of cap has the important advantage that the transmitter output is less dependent on whether the transmitter is positioned exactly in front of the mouth.

The shape of the handset gives it a well defined position in the hand and makes it easy to grip and to hold. This design follows the recommendations of industrial physiology that handles should widen towards the hand at an angle of about 20°.

Fig. 17 X 7949
Handset parts

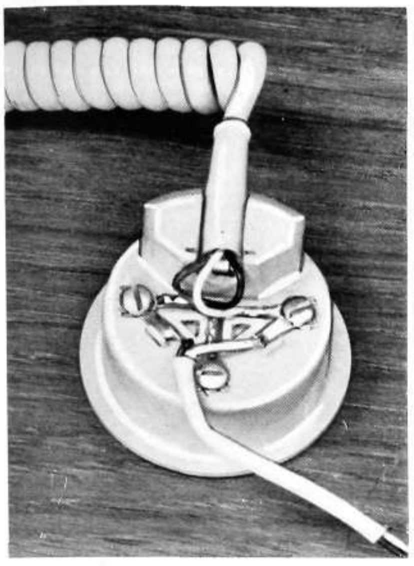


Fig. 18 X 2828
Transmitter cup with handset cord fitted

Since thermoplastic must of necessity be in the form of a thin shell, it has been arranged that the inner core of the moulding tool forms a large hole below the transmitter. This hole is covered by a transmitter "cup" which has the threefold function of covering the hole, of limiting the volume behind the transmitter inset, and of providing a secure attachment for the handset cord. The cord carries a metal clip which fits into a slot in the transmitter cup. When the cup is in position and covering the large hole, the cord cannot be moved in either direction.

The transmitter inset is placed above the cup, the whole being locked when the transmitter cap is screwed on. The cup contains screw terminals for the conductors of the handset cord. From two of these terminals multiwire conductors run up to the receiver cavity where they terminate on screw terminals in the receiver inset.

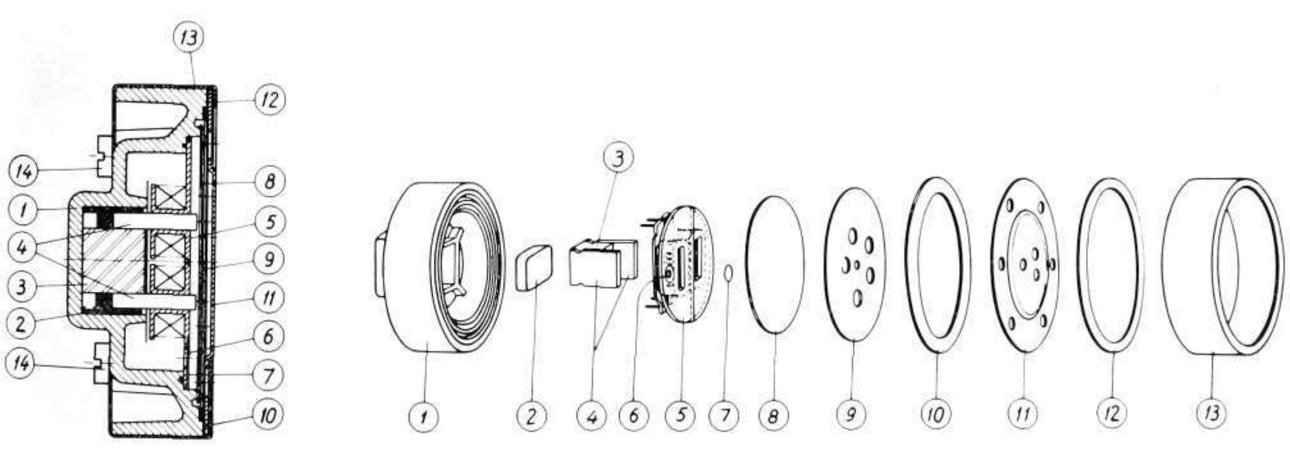
The transmitter inset is the *RLA 201* model which has been made for many years and has won appreciation for its uniform frequency response, relative independence of position and good stability. It was described in Ericsson Review No. 4, 1956. An even better design of inset, *RLA 301*, is now nearing completion and will soon replace *RLA 201*. The achievement of a higher sending level combined with highest possible stability and corrosion resistance has been the goal in the design of the new transmitter, which will be described in a coming number of Ericsson Review.

The receiver inset is type *RLD 529*, an improved version of an earlier series of which one type was described in Ericsson Review No. 4, 1956. The phenolic body has been redesigned to a shape which for certain reasons it was found advisable to standardize. The magnetic system has a magnetic shunt outside the diaphragm. The shunt is formed as an extra diaphragm but has several large holes in order that the mechanically active diaphragm may freely act upon the external acoustic circuit terminating in the listener's ear. The shunt permits a higher permanent flux in the air gap between the pole-pieces and the diaphragm without unfavourable effect on the reversible permeability at the centre of the diaphragm. The shunt has increased the sensitivity of the receiver by about 3 db. The classical type of receiver has thus been given a remarkably high output level without loss of its reputedly good mechanical rigidity and stable transmission properties, which are reinforced by the high quality magnet and ferrocobalt diaphragm.

Cords

A PVC insulation is now the standard covering for telephone instrument cords. The DIALOG has a straight cord with tinsel strands between the telephone and the wall terminal. The handset cord has the same make-up but is spiralized to comply with the general market requirements. Special attention has been paid to the attachment of the cords. They have metal clips at

Fig. 19 X 7950
Receiver inset



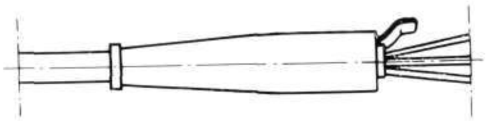


Fig. 20 X 2329
Stay clips and protective sleeve for removing strain on conductors and increasing wear resistance of cord

both ends which hook into their respective terminations. In this way the cords cannot be shifted in any direction at their point of attachment, and there is no strain on the electrical conductors. The clips have a PVC sleeve which increases the wear resistance of the cord at the points where abrasion may be expected against hard edges.

Extra Tropical Finish

Some markets require extra precautions against extremes of humidity and temperature and against insects. For such applications the assembled transmission unit is given an extra treatment. It is first cleaned in an ultrasonic bath which removes the normal resin coating. The underside of the unit is then treated with a tropicproof varnish which preserves the critical printed wiring side.

A high relative humidity also requires good air circulation. In such case a group of small perforations is made at the top of the casing in front of the handset. These perforations at the top in conjunction with all openings in the bottom provide an air circulation which counteracts condensation due to daily fluctuations of temperature.

Insects have a preference for dark enclosed cavities. In countries with insect problems one must protect telephone sets by sealing-off holes and slots. Ventilation is still necessary, however, and all openings are therefore covered with wire gauze of suitable mesh. The junction between the casing and base is sealed by placing a frame of polypropylene round the bottom edge. A loosely fitted bushing of acetal resin surrounds the disc which regulates the sound of the bell.

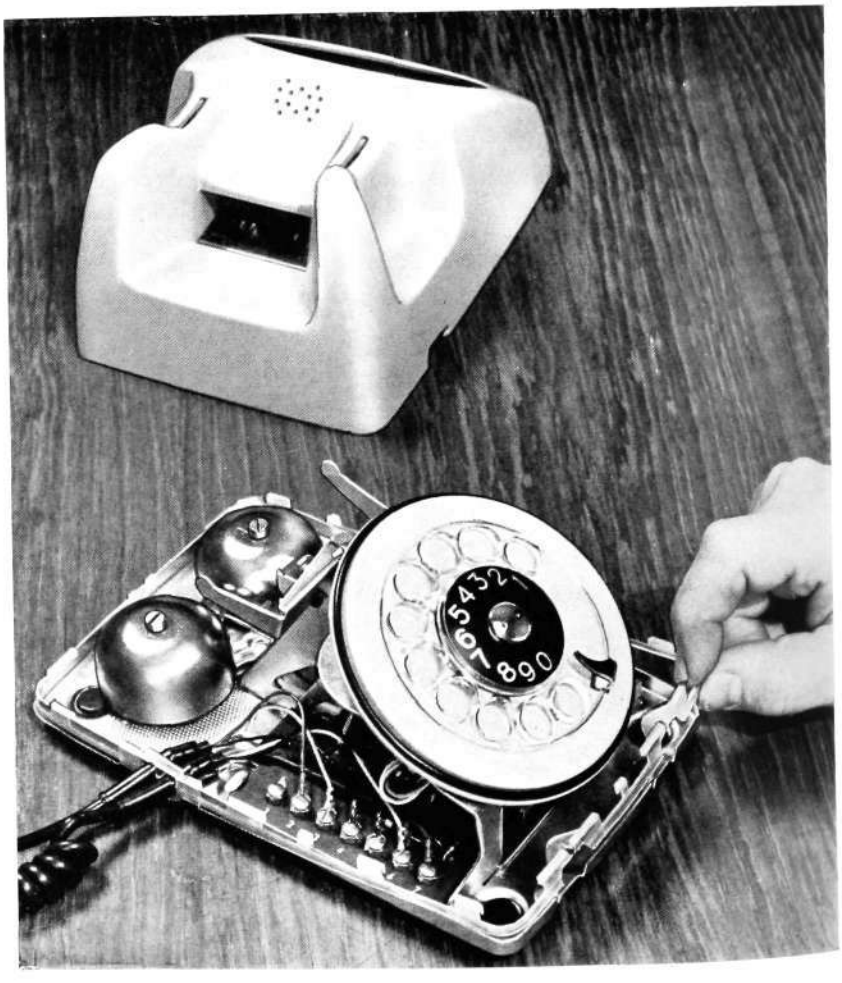


Fig. 21 X 7951
Extra tropical finish

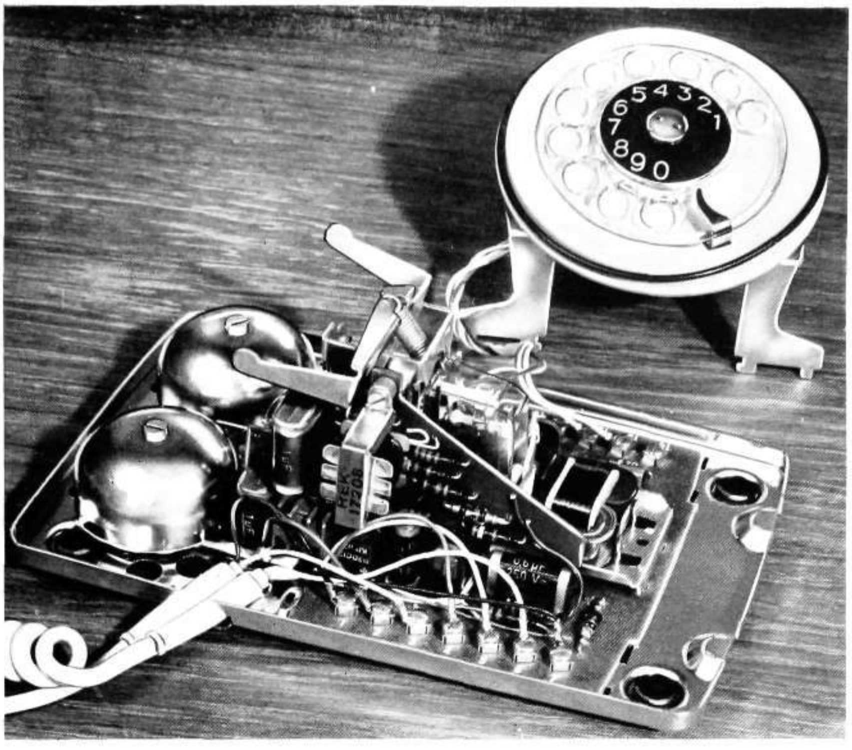


Fig. 22 X 7952
DIALOG with built-in transmitter amplifier

Alternative Models

The structure of the DIALOG permits variations of the basic model to meet different market requirements. Reference has already been made to how different desires as regards the bell and pulsing device can be easily met through the organic sectioning of the instrument. This applies very particularly to the circuitry which, of course, must be matched to different supply systems and customer requirements. For the normal types the same printed wiring board can be used, and the modification then consists of a choice of different circuit elements (resistors, capacitors etc.). The present account will be concerned with some special models.

Our noisy age sometimes requires extra amplification of incoming speech, and in standardized telephone networks amplified reception is usually allowed for the hard-of-hearing. This requirement is met by a handset with built-in receiver amplifier with a key for switching it on and off.

Telephone networks are being increasingly automatized. The number of manual *C.B.* telephones is quickly falling to zero. For the requirements that still exist, there is a DIALOG model in which the dial is replaced by a flat cover plate. Magneto telephones with signal generator are disappearing more slowly. A DIALOG model with electronic signal generator will come into production next year, and work has started also on a model with conventional hand generator.

The time now seems ripe for serious trials with a higher quality transmitter with amplification. The deficiencies of the carbon granule transmitter have hitherto weighed light in the balance compared with its high output level and very low cost. Having regard to quality and maintenance considerations, however, there has been some speculation concerning an electrodynamic or electromagnetic transmitter. A small batch of DIALOG instruments has been made with the receiver *RLD 529* used also as transmitter and with a transistor amplifier added to the ordinary transmission circuit. This exclusive experiment has aroused much interest, and it is likely that circuitry will develop in the direction of a more economical solution of the electronic problems in telephone instruments. A combination of different circuit functions seems a likely approach. Transistor circuits are used, for example, for v.f. keysending and ringing, and an extension of their applications will undoubtedly open the way to a still more modern and more functional DIALOG in which the classical mechanism of hand generator, electromagnetic bell and clockwork dial is replaced by electronics, with the aim of attaining higher quality and better economy in design and maintenance.

Concluding Remarks

With the DIALOG comes a family of telephone instruments built on radically new principles. Modern materials have been used, each according to its special properties: ABS thermoplastic as an envelope for structural elements, acetal resin in a couple of small internal parts with high shape permanence requirement, polyamide in bearings and sole for the cradle-switch plunger, and the strong polycarbonate resin in the resilient part of the hand-grip that is exposed to heavy mechanical stresses. PVC is used for all insulation and as protection for conductors and cords. Acrylics and styrene-acrylonitrile copolymer is used for parts requiring a hard surface in combination with transparency.

The DIALOG weighs only 1.5 kg. Remarkably low is the weight of the handset, less than 250 g, which adds to conversational comfort.

A large step forward has been taken in respect of transmission properties. Around a new design of induction coil a transmission circuit has been built up which, with varistors, resistors and capacitors, forms a balancing network with d.c. regulation characterized by low deviation of the transmission data on different lengths of local line. The transmission properties will be dealt with in a separate article.

Transmission Characteristics of the DIALOG

Background and Results

A BOERYD, TELEONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.721.3
LME 822 8402

Efforts to improve the quality of the telephone have been made ever since the first instrument was brought out at the end of last century. The guiding and driving factor in these strivings has been not only the demands of subscribers for better telephone connections but, still more, the necessity of compensating for the increasing attenuation resulting from the intercontinental spread of telephone networks. The advent of the electron tube in the twenties, and the rapid development of semiconductor, especially transistor, techniques in the fifties, have been important factors in reducing line losses, with improved transmission conditions as a result. However complicated and perfected the transmission and switching equipments may be, it is nevertheless the telephone set itself which ultimately determines the quality of transmission attainable between any two subscribers. This implies a great responsibility but is at the same time a source of inspiration in the design of telephone sets.

The attenuation on a telephone link is illustrated in fig. 1.

Between the two local exchanges is a link which may be composed of junction circuits, tandem centres, carrier systems, radio links, satellite connections etc. Irrespective of the type of transmission system, all equipments have one property in common, that they introduce some loss on the connection. The magnitude and distribution of these losses vary in different telephone administration areas. A realistic maximum figure might be around 20 db, to which is added the loss in the local network. An analysis of the telephone networks constructed by L M Ericsson in different countries in the course of the years shows that the length of subscriber lines is seldom more than 5 km except for a few isolated subscribers. On economical grounds it is, of course, desirable to use a single type of cable in local networks. The best cable technically and economically is at present 0.4 mm ($r = 280$ ohms/km, $c = 40$ nF/km). The maximum length of local cable of this type introduces an a. c. loss of about 10 db, disregarding the transmission loss due to reduced feeding. The attenuation between any two subscribers may thus vary between 0 and 40 db.

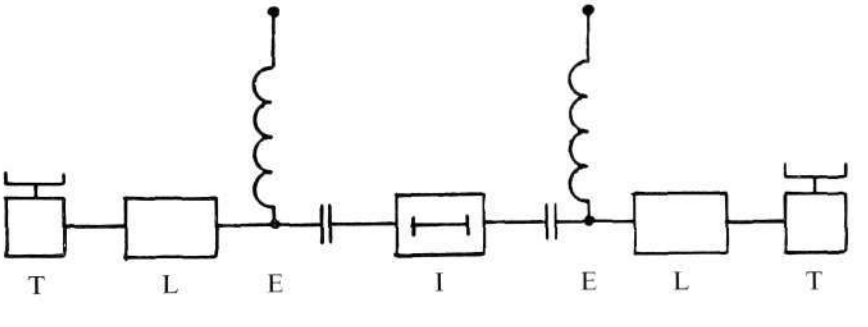


Fig. 1 X 8497
The attenuation conditions in a telephone network

T Telephone
L Local line
E Local exchange
I Transmission link

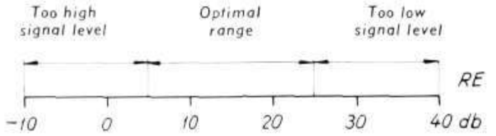


Fig. 2 X 2788

Preference for different values of overall reference equivalent

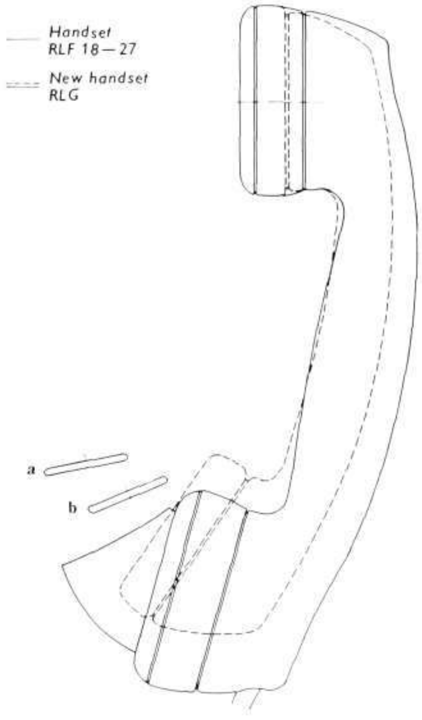


Fig. 3 X 2789

Comparison between DIALOG and earlier Ericsson handsets

a location of guard ring in AEN measurements

b location of guard ring for determination of reference equivalents

Different reference systems are used by different administrations to define the transmission conditions on a telephone circuit. The quality of a circuit is expressed as the loss or gain inserted in the circuit relative to the particular reference system. The systems that have hitherto enjoyed the widest international use and are recommended by the International Telecommunication Union (UIT) are SFERT (Système Fondamental Européen de Référence pour la Transmission téléphonique) or the newer system NOSFER (NOuveau Système Fondamental pour la détermination des Equivalents de Référence).[1]

In recent years extensive investigations have been made by different telephone administrations to determine the optimal reference equivalent between two subscribers. The results of these investigations may be summarized as shown in fig. 2.[2, 3]

The optimal conditions are provided by a relatively well delimited attenuation range for the reference equivalent of + 5 to + 25 db.[2, 3]

When designing the transmission circuit for a new telephone set, therefore, one should strive to ensure that the overall reference equivalent for as many subscribers as possible comes within the range desirable for telephony irrespective both of the feed system and of the length of local line.

The Handset

Older types of handset have often been fitted with a funnel-shaped mouthpiece. This was desirable form the transmission point of view on several grounds. Provided that the mouthpiece was held in front of the speaker's lips, the transmitted speech volume was increased and room noise was to some extent screened out. But if the position of the microphone relative to the mouth was changed, the mouthpiece caused a fairly large variation in the transmitted speech volume. In the design of the new handset it was considered desirable to eliminate the funnel. The resulting transmission loss had then to be regained by other means. This could be done by reducing the length of the handset and by changing the angle of the microphone relative to the mouth. The new handset compared with the earlier type *RLF 18–27* is shown in fig. 3, and the variation of outgoing speech volume due to change of the position of the microphone relative to the mouth in fig. 4.

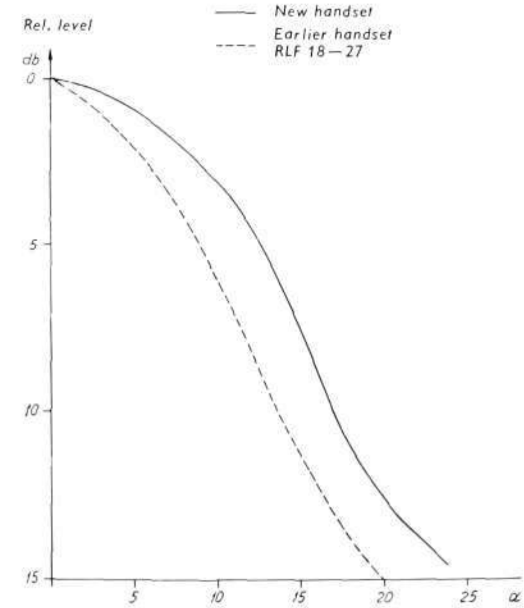


Fig. 4 X 8498

Variation of speech level with change of position of handset relative to the mouth

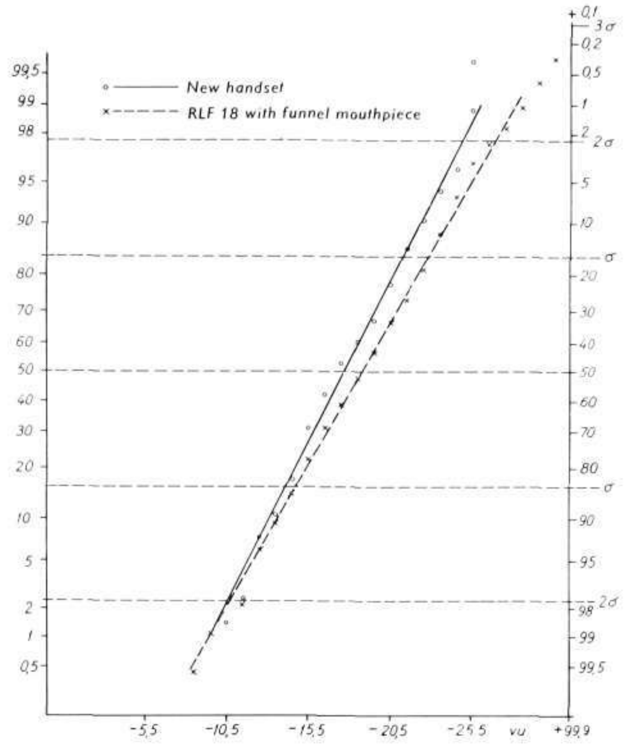


Fig. 5 X 8499

Statistical difference between speech volume measured in the local exchange using the old and the new handset

The favourable results recorded in fig. 4 have been confirmed in comparative conversation tests with different types of handset. These tests, which were carried out under identical conditions and with the same transmitter (fig. 5), show the difference in the percentual distribution of outgoing speech volume when using the old and the new handset. As is seen, the mean speech volume has increased by about 1.5 db and the standard deviation (σ) has decreased by the same amount. The increase of speech volume, moreover, is greatest at the lower levels and unchanged at the higher levels. This shows that the true gain in transmission provided by the new handset is greater than that from measurements under strictly defined conditions, e. g. for the determination of reference equivalents.

The Transmission Circuit

In designing the transmission circuit for a two-wire telephone set the following factors must be taken into account:

1. Supply systems
2. Maximum permissible loop resistance in the local line
3. Line impedance and its variation with length of line
4. Efficiency of the available types of microphone and receiver
5. Desired sensitivity control on short local lines

The supply systems used by different telephone administrations may be divided into three main groups:

50 V, 2 × 200 ohms to 48 V, 2 × 250 ohms

60 V, 2 × 500 ohms to 48 V, 2 × 400 ohms

36 V, 2 × 500 ohms to 24 V, 2 × 400 ohms

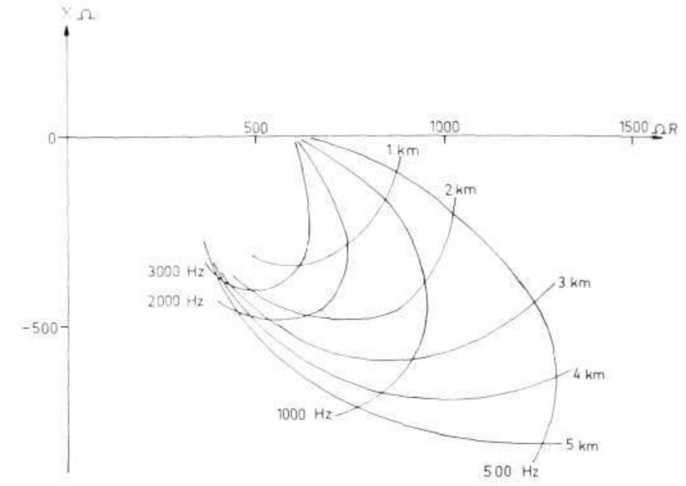


Fig. 6 X 7911
Input impedance for 0.4 mm cable with 600-ohm termination

On the assumption that modern switching equipments can operate at up to about 1 500-ohm loop resistance in the local line, the lowest line currents for the various supply systems are 24, 21 and 10.5 mA respectively. At these line currents it is desirable that the sending efficiency of the telephone ensures satisfactory transmission for subscribers with a correspondingly long local line. In the case of the carbon microphone the a. c. power output is dependent on the d. c. input. For a given type of microphone, owing to the high internal resistance of the d. c. source, the a. c. efficiency can be increased by increasing the microphone resistance. An increase of the microphone resistance from 100 to 150 ohms thus increases the d. c. input to the microphone by 50 per cent, which increases the efficiency of the microphone within the d. c. range of interest by 1.5 db. By a suitable choice of d. c. regulation the microphone can then be protected against the higher d. c. input on short local lines.

As already mentioned, it is technically desirable to use 0.4 mm cable to the greatest possible extent in future networks. For this type of cable the input impedance of the line with 600-ohm termination varies as shown in fig. 6. On the basis of these values and the corresponding data for 0.5 and 0.6 mm cable, the input impedance of the transmission circuit has been put at 1 000 ohms in the calculations.

Studies of the recent development of electroacoustic components show that the increase of efficiency has been considerably greater for the receiver than for the microphone. This fact has also been taken into account in drawing up the CCITT recommendations as regards the distribution of the national sending and receiving reference equivalents relative to NOSFER. These were finally decided at the plenary meeting of CCITT at Geneva in June 1964[4] and are:

Sending 20.8 db (2.4 N)

Receiving 12.2 db (1.4 N)

In designing the transmission circuit for a new telephone set, account should be taken of the numerical value of the sending and receiving reference equivalents to permit the use of the smallest possible diameter of cable in the local line. And for economic use of the telephone the limit values for sending and receiving should be attained simultaneously, which means that the difference between sending and receiving for the long line should be about 8.6 db (1 N).

The microphone *RLA 301* and receiver *RLD 529* that were available when designing the DIALOG have the following reference equivalents relative to NOSFER matched on a no loss basis to a load impedance of 600 ohms at a line d. c. of 30–15 mA.

Sending − 2.5 db to − 0.5 db

Receiving − 10 db

In view of the desired difference of 8.6 db between sending and receiving on the long line, the circuit was designed for equal sending and receiving loss for supply systems of 48 V, 2 × 250 ohms and 48 V, 2 × 400 ohms, and for a lower sending loss for supply systems of 36 V, 2 × 500 ohms and 24 V, 2 × 400 ohms.

The compensation network for the transmission circuit is as shown in fig. 7.

Z_L = line impedance $\qquad \frac{N_1}{N_3} = r$

Z_M = microphone impedance
Z_B = balancing network impedance $\qquad \frac{N_2}{N_3} = n$

Z_R = receiver impedance
Z_F = bias impedance for the automatic sensitivity control $\qquad \frac{N_4}{N_3} = t$

The magnitudes which should be considered as given in the calculation of the transmission circuit for the long line when the sensitivity control is no longer active are the line impedance Z_L (fig. 7) and the microphone impedance Z_M. Having regard to the difference between the efficiency of the microphone and receiver, the Y ratio of the circuit – the composite sending or receiving loss – should also be given.

As appears from fig. 7, the microphone output during sending is divided between the line impedance and the balancing network impedance. In the same way a power from the line will be divided between the microphone impedance and the receiver impedance. The following relations can be proved to be equal:

$$\frac{\text{Received power consumed in the microphone}}{\text{Received power consumed in the receiver}}$$

and

$$\frac{\text{Sending power to the line}}{\text{Power consumption in the line balancing network during sending}}$$

This ratio, called the Y ratio of the circuit,[5] regulates the ratio between sending and receiving loss. By introducing the composite sending attenuation (a_s) and composite receiving attenuation (a_m), it can be shown that

$$a_s = 10 \cdot log\left(1 + \frac{1}{Y}\right) \qquad (1)$$

$$a_m = 10 \cdot log\,(1 + Y) \qquad (2)$$

As will be seen from these equations, an increase of the Y ratio implies a decreased composite sending attenuation and at the same time an increased composite receiving attenuation.

The basic equations for the circuit in fig. 7 give the following relations for the optimal sending and receiving conditions:

$$e^{2a_s} = \frac{Z_M}{Z_L} \cdot \left(\frac{1+n}{n}\right)^2$$

$$e^{2a_m} = \frac{Z_R}{Z_L} \cdot \left(\frac{1+n}{r}\right)^2$$

a_s = composite sending attenuation in nepers
a_m = composite receiving attenuation in nepers

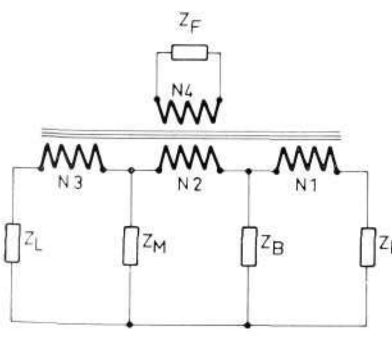


Fig. 7 X 2790

The general transmission circuit of the DIALOG

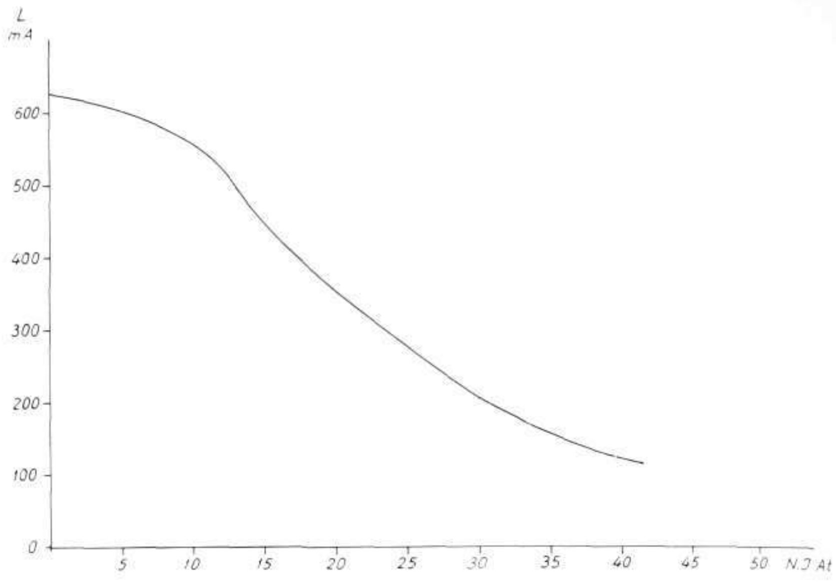


Fig. 8 X 7912
Inductance *(L)* of the induction coil as function of the d.c. ampere-turns

For supply systems of 50 V, 2 × 200 ohms, 48 V, 2 × 250 ohms, and 48 V, 2 × 400 ohms, the circuit has been designed for a *Y* ratio of 1.0, and for 36 V, 2 × 500-ohm, and 24 V, 2 × 400-ohm systems for a *Y* ratio of 1.6.

The desired balancing network impedance Z_B for maximum sidetone attenuation is obtained from

$$Z_B = \frac{1}{\frac{r}{j\omega L \cdot n} + \frac{1}{Z_L} \cdot \frac{n + r + 1}{n \cdot r} + \frac{1}{Z_F} \cdot \frac{t^2}{n \cdot r}} \qquad (5)$$

It will be seen from eq. 5 that the desired balancing network impedance consists of three impedances in parallel: an inductance $L \cdot \frac{n}{r}$, the overreduced line impedance $Z_L \cdot \frac{n \cdot r}{n + r + 1}$ and the overreduced bias impedance $Z_F \cdot \frac{n \cdot r}{t^2}$. If the inductance of the induction coil is low, the desired balancing network impedance will be inductive or capacitive depending on the frequency. By striving for the highest possible inductance, however, the ideal balancing network impedance will be chiefly capacitive, which makes it possible to reproduce its imaginary component by means of a relatively simple RC network.

These have been the prime considerations governing the choice of core material for the induction coil. The final choice of material for induction coil *REK 121* is grain-oriented silicon steel. In the cold rolling and heat treatment of the silicon steel sheet, the grains of the elementary magnets in the crystal lattice are oriented, which greatly increases the permeability while maintaining the iron losses at a low level. The maximum permeability is obtained when the direction of the flux is parallel with the direction of rolling. To make full use of this property, the choice fell on a 6 × 10 mm² C core. The most favourable distribution between copper and iron is obtained with a double C core. The resulting inductance *L* of eq. 5 as function of the ampere-turns is shown in fig. 8.

For production reasons the DIALOG models made during 1963 and 1964 have a microphone inset *RLA 201*, the efficiency of which is about 2 db below that of the later type *RLA 301*. During this period the induction coil was type *REK 107*, which is made of normal silicon steel with a much lower permeability.

Regulation of the Transmission Level

Sending and receiving

As already noted, the *RLA 301* microphone, matched to a 600-ohm load at 1 000-ohm line resistance on a no loss basis, has a reference equivalent relative to NOSFER of — 2.5 db. Taking into account the *Y* ratio of the circuit and the resistance losses in the induction coil, this reference equivalent is reduced to + 1.5 db. The transmission loss due to reduced feeding is $4.5 \cdot 10^{-3}$ db per ohm line resistance. The sending reference equivalent for a zero-ohm local line is thus – 3 db. The efficiency of the receiver implies for this circuit a receiving reference equivalent relative to NOSFER of – 7 db. The overall reference equivalent for two subscribers interconnected without line attenuation would then be – 10 db, corresponding to a received speech level at normal speech volume of about 104 db relative to $2 \cdot 10^{-4}$ dynes/cm^2. This low reference equivalent is far outside the optimal range in fig. 2. The efforts to achieve satisfactory transmission on medium and long subscriber lines should therefore be reinforced by measures to reduce the efficiency of the microphone and receiver on short lines.

To attain this attenuation on short subcriber lines, different measures have been employed by different administrations.[6] Some administrations have solved the problem by classification of microphones and receivers according to their efficiency. Microphones and receivers of low efficiency are given to subcribers with short lines, and of greater efficiency to those with long lines. These measures have also been combined with an attenuation network corresponding to 1–2 kilometres of local cable, placed either close to or inside the actual telephone set.

These measures might place high requirements on the technical ability of the maintenance staff if a correct classification is to be retained after replacement and repair of telephone sets or their electroacoustic components.

Some other major administrations, however, among which Bell System,[7] British Post Office[2] and Australian Post Office,[8] have chosen other methods of automatic sensitivity control. All these systems operate on the principle that an attenuation, the magnitude of which is determined by the active line current in the local circuit, is connected into the subscriber's apparatus circuit. Since the line current is a direct function of the resistance of the local line, and at the same time also of the attenuation of the line, the efficiency of the telephone set can be adjusted so that the reference equivalent for the local system, line and telephone set is as far as possible constant and independent of the length of the local line.

As shown by fig. 2, the overall reference equivalent should not appreciably exceed 0 db. Thus, in the present case, the sum of the attenuations caused by the sending and receiving sensitivity control should be about 10 db. The distribution of this sensivity control between the sending and receiving channels can be viewed from different aspects. It is generally desirable that the sending and receiving transmission level should be constant. For the sending direction this means that both the d. c. power loss, about 4.5 db per 1 000 ohms, and the a. c. loss of the line would be compensated, whereas in the receiving direction the a. c. loss alone would be compensated. From several points of view, however, it may be inadvisable to attenuate the outgoing speech signal more than necessary.

Telephone networks nowadays contain telephone sets of new as well as old types. It has already been stated that the increase of efficiency during the last ten years has been very much greater for receivers (about 5–7 db) than for

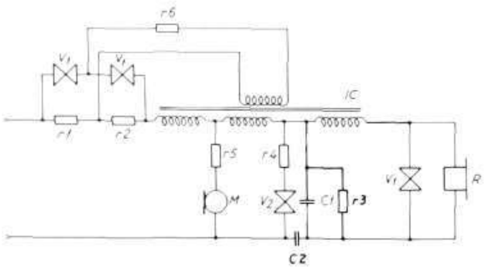


Fig. 9 X 2791
Transmission circuit of the DIALOG

microphones (about 2 db). This means that a larger number of telephones with a receiving reference equivalent of about 0 db are still in use. A high attenuation on the sending channel for a telephone with automatic sensivity control would, therefore, not give the desired improvement in transmission on most connections between new and old telephones. It would also be desirable to guarantee the best possible signal-to-noise ratio, which is best attained by a moderate attenuation on the sending channel. Automatic sensivity control should also be achieved with a minimum of components, and the components should be usable with equivalent result in telephones designed for different supply systems. Particular attention must be paid also to the effect of automatic sensivity control on the impedance of the telphone. As a compromise between these various requirements the automatic sensitivity control has been designed for max. 5 db attenuation both for sending and receiving.

The transmission circuit (fig. 9) contains two types of varistor, V_1 and V_2, the current and voltage characteristics of which can be expressed by the relation

$$I = k \cdot V^n$$

where I is the direct current and V the impressed d. c. voltage. The a. c. conditions are obtained by differentiation of this equation, which gives

$$\frac{dv}{di} = \left(\frac{1}{k}\right)^{\frac{1}{n}} \cdot \frac{1}{n} \cdot I^{\left(\frac{1}{n}-1\right)} = \frac{V}{I} \cdot \frac{1}{n} \cdot \frac{R_{=}}{n} = R_{\sim}$$

The a. c. resistance of the varistor $R_{\sim}$ is thus equal to the d. c. resistance divided by the exponent n.

Fig. 10 shows the characteristics of the two varistor types *REY 13101* (V_1) and *REY 20101* (V_2). The former consists of two opposing selenium rectifiers and the latter of a specially developed pnp varistor on a silicon base.

The automatic sensitivity control consists of d. c. regulation of the microphone current and of a. c. attenuation which varies with the line current and is operative both during sending and receiving. The varistor V_2, which from the a. c. point of view is part of the balancing network impedance, is in the d. c.

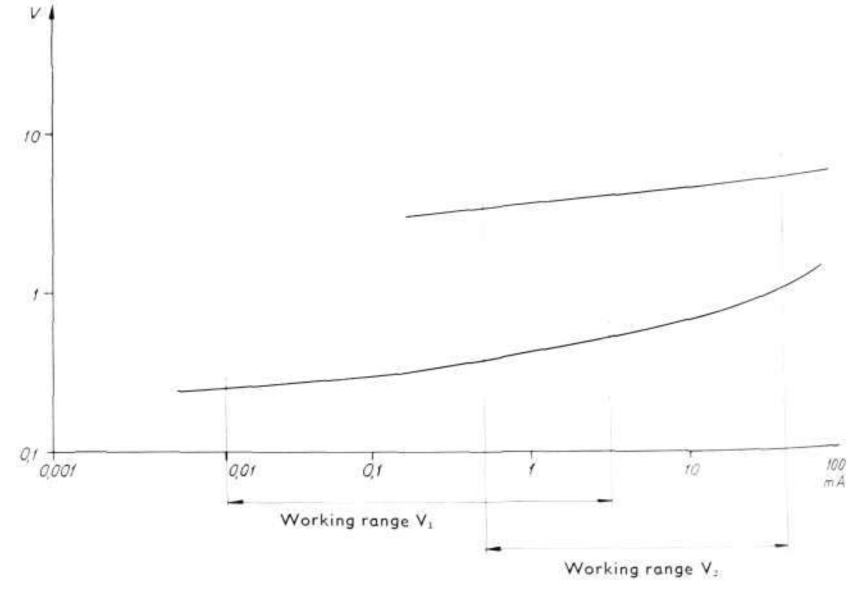


Fig. 10 X 7913
The d.c. characteristics of varistors V_1 and V_2

circuit in parallel with the microphone and so limits the microphone current on short lines. On a zero-ohm line the varistor consumes about 30 per cent of the line current, but on a 1 000-ohm line only about 5 per cent. The resulting limitation of the efficiency of the microphone owing to this d. c. regulation of the microphone current is 2.5 db on a zero-ohm line. Every carbon microphone has some tendency to increase its d. c. resistance with time as a result of ageing of the carbon granules. This increases the d. c. voltage drop across the microphone and under unfavourable conditions may accelerate the rise of resistance. The varistor V_2, however, eliminates the risk of increase of the d. c. voltage, which greatly diminishes the tendency to ageing of the microphone. The line current is also stabilized and becomes practically independent of the variation of resistance of the microphone. Disturbance caused by too high a microphone resistance is thereby eliminated.

A varying a. c. loss has been accomplished by giving the induction coil an extra winding, the bias impedance of which varies with the line current. The load on this extra winding consists of two varistors V_1 which are connected in parallel in the a. c. circuit in series with a resistor r_6. The impedance of the varistors, and so the magnitude of the a. c. loss, is determined by the d. c. voltage across the two resistors r_1, r_2. The a. c. loss can be matched to different supply systems by changing the resistors r_1, r_2 and r_6. The resulting a. c. loss on a zero-ohm line has been designed for a receiving loss of 4.5 db and a sending loss of 2.5 db.

Sidetone Regulation

As earlier shown in eq. 5, the balancing network impedance needed for optimal sidetone attenuation should be equal to the line impedance multiplied by a factor $n \cdot r/(n + r + 1)$. For the present induction coils, the ratios n and r of which are 0.4 and 0.55, the balancing network impedance should be $0.1 \cdot Z_L$. This means that the balancing network must have a low impedance. To ensure an acceptable sidetone attenuation for all types of local cable, its magnitude and phase angle should vary with the length of line. The varistor V_2, the d. c. regulating properties of which have been mentioned above, is a significant element in realizing this aim. The equation for this varistor can be approximately expressed by the relation.

$$I = 10^{-9} \cdot V^{11}$$

or

$$R = 10^{9} \cdot V^{-10}$$

where V = the d. c. voltage across varistor V_2

I = the direct current through varistor V_2

R = the d. c. resistance of varistor V_2

At line resistances above about 1 000 ohms the resistance of the varistor is about 3 000 ohms, and at zero-ohm line resistance about 300 ohms. The corresponding a. c. resistance is, respectively, 270 and 27 ohms. To obtain the maximum degree of freedom in the design of the balancing network impedance and its automatic matching with the line impedance, it was decided in the final circuit solution for the DIALOG to form the balancing network impedance as a π network. This coupling of the balancing network impedance requires a four-wire handset cord, a disamenity which is outweighed by the improved transmission characteristics. The capacitor C_2, the value of which is 1 or 2 μF, can at the same time be used in the spark-quenching circuit of the dial during pulsing.

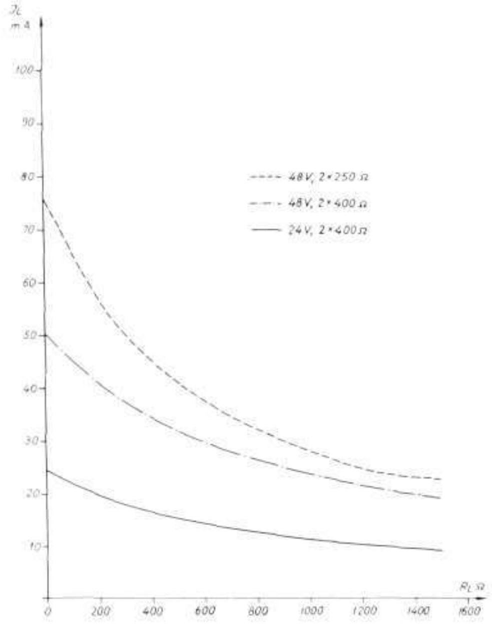


Fig. 11 X 2792

The d.c. consumption of the DIALOG as function of the line resistance

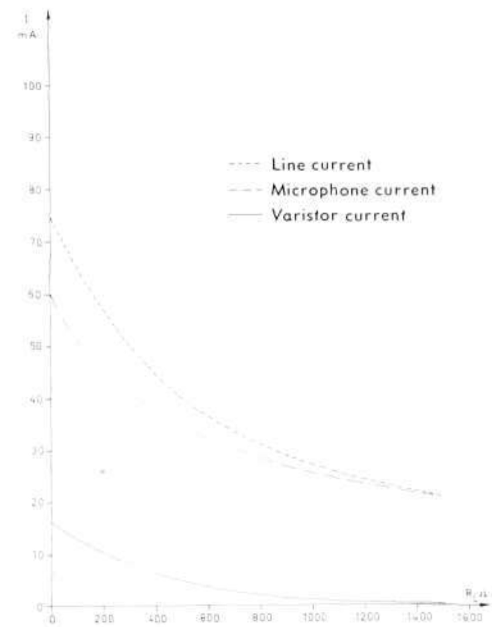


Fig. 12 X 2793

Distribution of direct current in the telephone instrument circuit at different line resistances for a 48 V, 2 × 250-ohm system

Fig. 13 X 7914

Image attenuation of the local line as function of the frequency

Transmisson Data

The design of local cable networks is often based on the d. c. properties and transmission data of the subscribers' apparatus. A knowledge of the d. c. properties is necessary in order to decide on the permissible line resistance from the characteristics of the switching equipment, while the transmission data determine the quality of the connection.

Fig. 11 shows the line current as function of the resistance of the local line for the three supply systems 48 V, 2 × 250 ohms, 48 V, 2 × 400 ohms, and 24 V, 2 × 400 ohms. Fig. 12 shows the distribution of the direct current between microphone, varistor V_2 and line for the 48 V, 2 × 250-ohm system.

As already mentioned, the quality of a telephone circuit is defined in most cases by the overall reference equivalent. Other factors of significance are the frequency response of the microphone, receiver and local line.

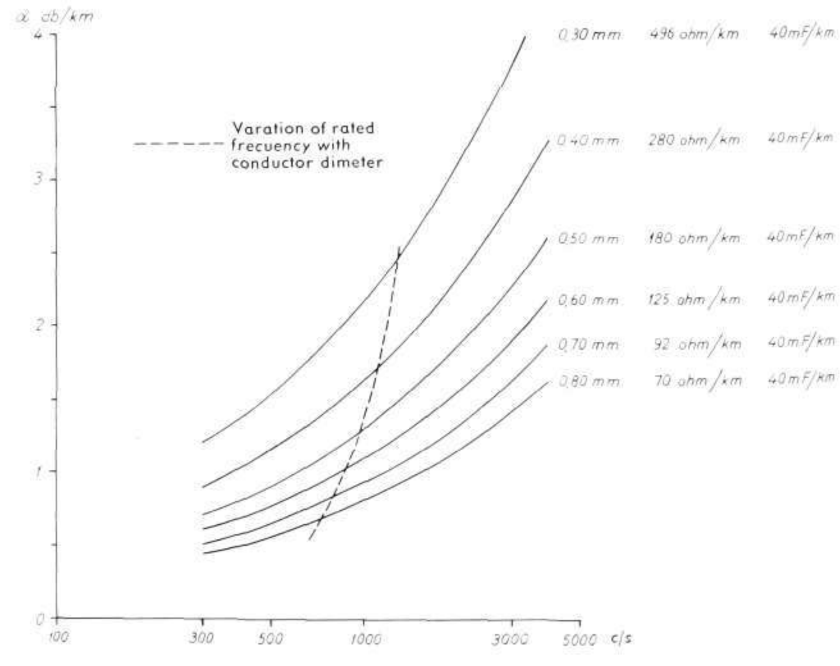
Reference Equivalents

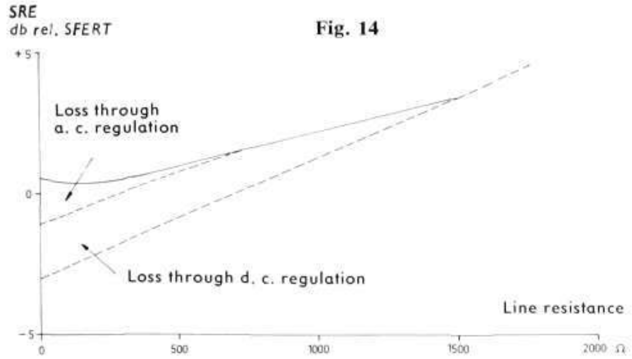
To assist in the compution of local systems the reference equivalent of the subscriber's apparatus relative to SFERT or NOSFER is indicated as function of the line resistance. The reference equivalent of the local system is then obtained by adding to it the attenuation constant α for the local cable in use. According to CCITT's recommendation P 11, this can be calculated by adding the attenuation constant for the type of cable at 800 c/s. This recommendation, however, was issued before 0.5–0.4 mm conductor cables came into general use.

The attenuation constant of the cable is obtained from

$$\alpha = \sqrt{\frac{\omega r c}{2}}$$

where r is the resistance and c the capacitance of the cable per unit length. At high values of r and c the frequency distortion of the cable increases (fig. 13), which should result in an increase of the frequency at which the attenuation constant (reference equivalent) of the cable is to be calculated. To verify this, and to determine the increase of frequency, extensive tests have been made to decide on the reference equivalent for different types of cable. On





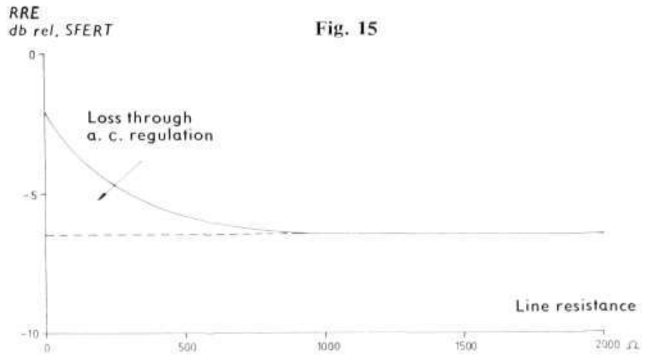


Fig. 14 X 7915

The sending reference equivalent as function of the line resistance excluding the line attenuation

Fig. 15 X 9716

The receiving reference equivalent as function of the line resistance excluding the line attenuation

the basis of the results the frequency was determined at which the attenuation constant of the local cable should be calculated in order to be directly addable to the reference equivalent of the telephone set at the line resistance concerned. The results may be summarized in the empirical relation

$$f\alpha = 25c \cdot [1.9 - 2.5\,d + 1.3\,d^2]$$

$f\alpha$ = the frequency for calculation of the attenuation constant

c = the capacitance of the cable in nF/km

d = the conductor diameter of the cable in mm

The relation for calculation of the frequency is usable for conductor diameters between 0.8 and 0.3 mm. Fig. 13 shows the attenuation constant as function of frequency and the change of the rated frequency for different local cables. The cable capacitance in this diagram has been assumed to be 40 nF/km.

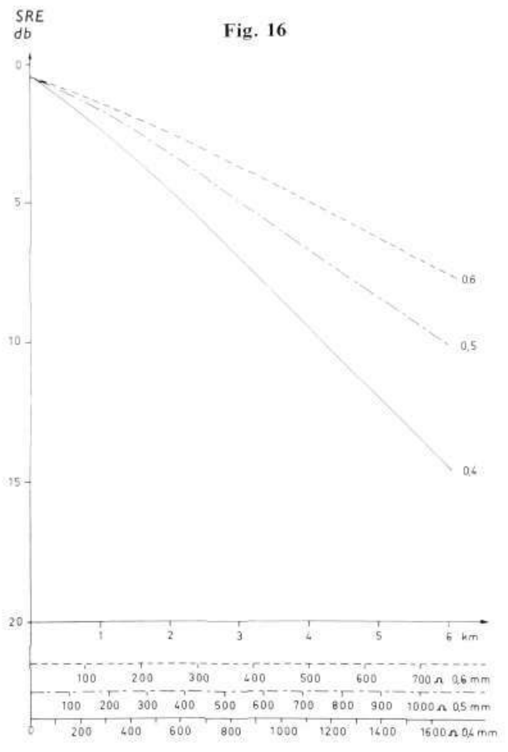
The reference equivalent relative to SFERT is shown in figs. 14–17. Fig. 14 shows the sending, fig. 15 the receiving reference equivalent as function of the line resistance (excluding the a. c. loss of the line). The diagrams also indicate how the sensitivity control is divided between d. c. loss and a. c. loss. The reference equivalent for telephone set and local line is then obtained by addition of the attenuation constant for the cable as in fig. 13. The sending and receiving reference equivalents for different local cables are illustrated in figs. 16 and 17.

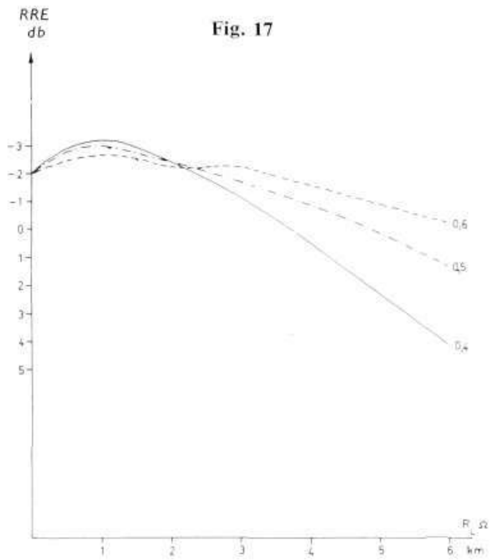
Fig. 16 X 7917

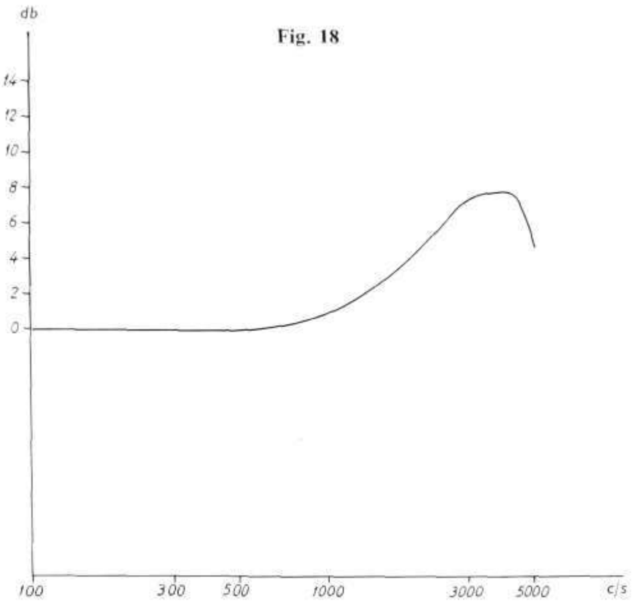
The sending reference equivalent as function of the length of local cable

Fig. 17 X 7918

The receiving reference equivalent as function of the length of local cable







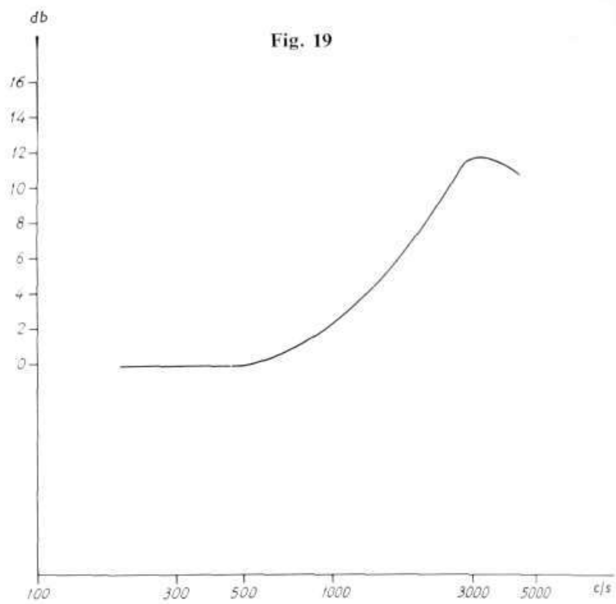


Fig. 18 X 7919
The increase of sound pressure at the entrance to the auditory canal when listening in free air

Fig. 19 X 7920
Desired frequency response in a telephone system

Sending and Receiving Frequency Responses

When computing the frequency response for a telephone set one should, of course, aim to achieve the desired response within the frequency range of interest. When listening in free air from a sound source at a given distance from the listener, there is an increase of sound pressure at the entrance to the auditory canal within the range 1 000–4 000 c/s.[9] This rise of pressure is illustrated in fig. 18. When listening with a receiver pressed against the ear there will, of course, be no rise of pressure and a compensation for this should be introduced. As already shown in fig. 13, the attenuation in the local cable increases with rise of frequency. If we consider a local line of 2×1.5 km, 0.4 mm conductor, the desired frequency response for a complete telephone system will be as shown in fig. 19. This frequency distortion should lie chiefly in the sending channel of the telephone set. An increase of level of the low-energy consonant sound is then obtained before the speech signal is injected into the line, so ensuring the maximum ratio between these weak consonant sounds and any noise on the line. For the sending and receiving frequency responses of the DIALOG, shown in figs. 20 and 21, these targets are well achieved. The sending response shows an increase of about 15 db between 400 and 3 000 c/s, whereas the receiving response is virtually linear with the frequency.

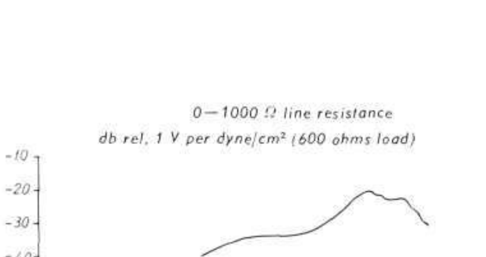


Fig. 20 X 2794
Sending frequency response

Sidetone Characteristics

The importance of efficient sidetone attenuation may be viewed in different lights. In the first place the subscriber should not be troubled by too high a volume of reproduction of his own speech via the receiver. If this happens he unconsciously lowers his voice, which has a detrimental effect on the speech level entering the line. Subjective tests for optimal sidetone attenuation from this point of view have indicated that a sidetone reference equivalent relative to SFERT or NOSFER below 8 db is disturbing to about 25 per cent of subscribers, while a figure above 12 db is considered disturbing only by some 2–3 per cent of the observers.

A telephone should also be usable without inconvenience in premises with a fairly high room noise level. An unsatisfactory sidetone attenuation, how-

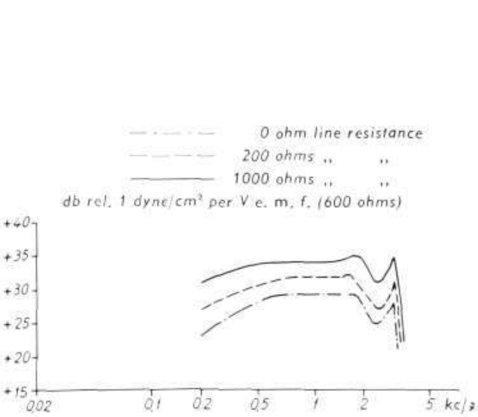


Fig. 21 X 2795
Receiving frequency responses

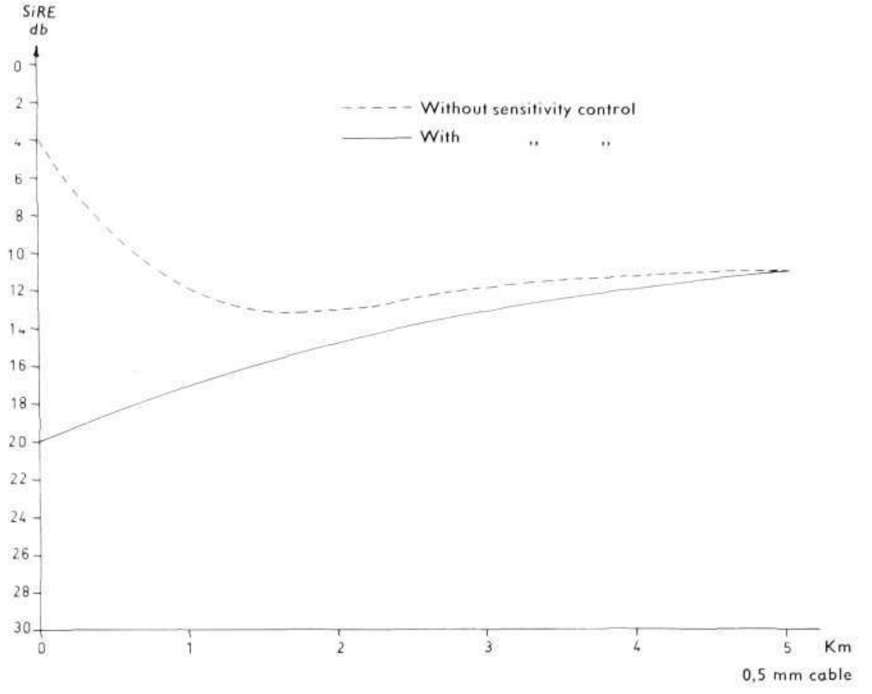


Fig. 22 X 7921
Sidetone reference equivalent as function of the length of local cable

ever, limits its use under these conditions since the room noise is picked up by the microphone and the sidetone masks a weak incoming speech signal.

To illustrate the sidetone attenuation of the DIALOG, fig. 22 shows the sidetone reference equivalent relative to SFERT or NOSFER and fig. 23 the acoustic attenuation measured as the ratio between the sound pressure delivered by the receiver and the sound pressure at the microphone. The automatic sensitivity control from the sidetone point of view is clearly evident from fig. 22 in which the sidetone reference equivalent is indicated for the same transmission circuit but with the sensitivity control disconnected.

Telephone Instrument Impedances

The transmission circuit of the DIALOG, as already noted, is designed for an input impedance of about 1 000 ohms to ensure the best possible match with the local cable on long lines. The automatic sensitivity control functions as a varying resistive load on the speech circuit, which lowers the impedance of the telephone instrument at high line currents.

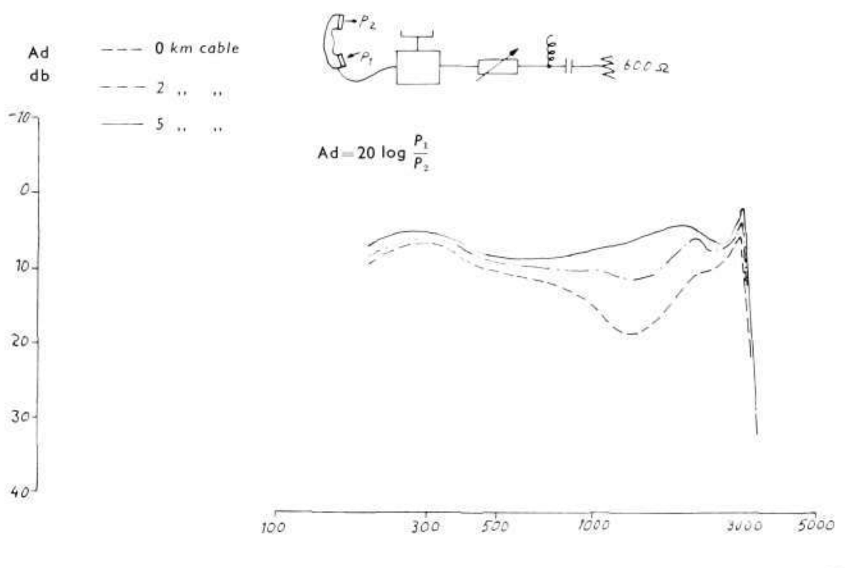


Fig. 23 X 7922
Sidetone attenuation from mouth to ear as function of the frequency

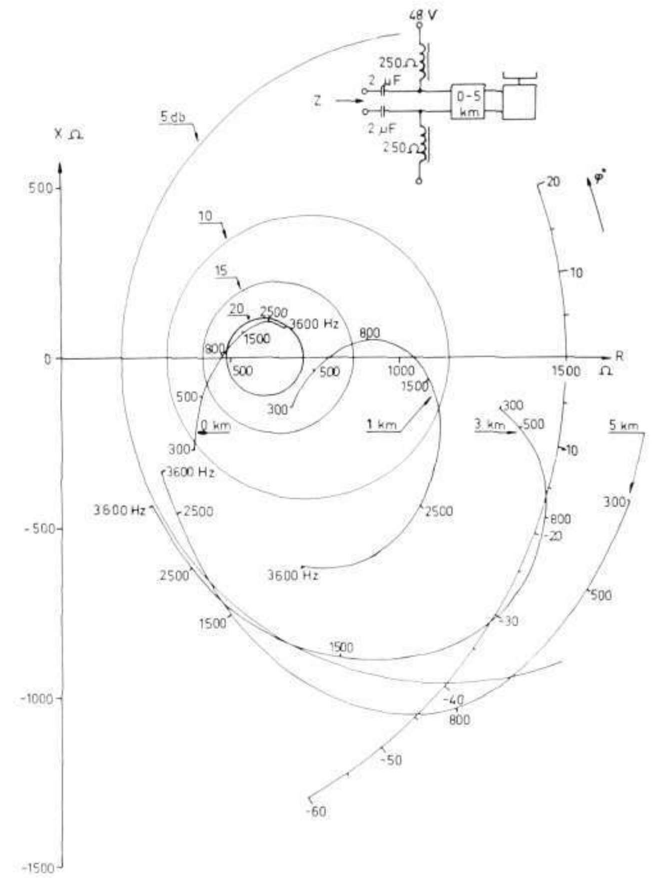


Fig. 24 X 7923
Input impedance of the local system for varying lengths of 0.5 mm cable

Owing to the increasing tendency to four-wire circuits over an extended area of the network the impedance of the subscriber's apparatus plays an increasingly important role in the statistical distribution of the return loss at the terminating set. Of interest in this context is the impedance of the local line including the telephone set. This is shown in fig. 24 in which the boundary lines for a number of equal return losses measured against a balancing network impedance of 600 ohms in the hybrid are also indicated. Fig. 25 shows the impedance of the telephone instrument itself as function of the resistance of the local line.

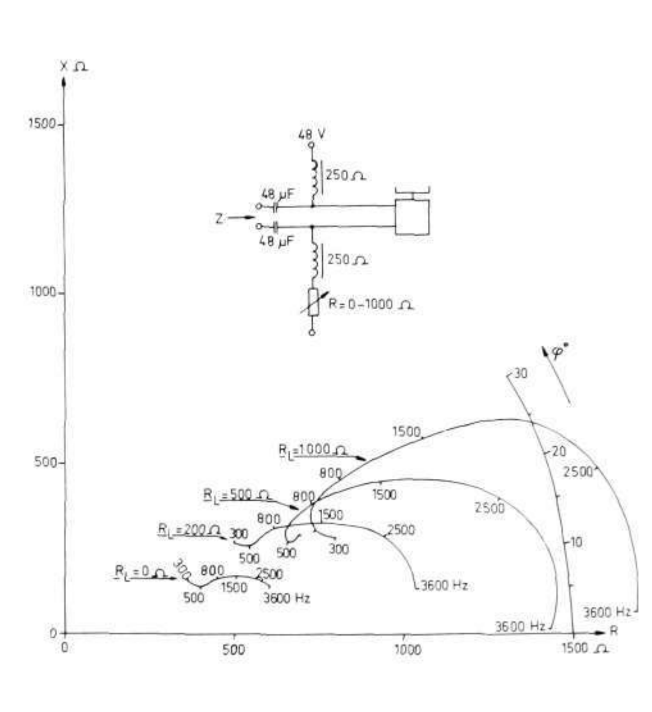


Fig. 25 X 7924
Input impedance of the DIALOG for varying line resistance

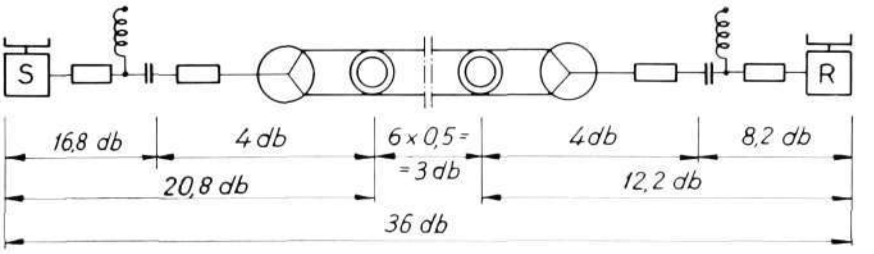


Fig. 26 X 7925
Possible distribution of the reference equivalent in a transmission plan

Concluding Remarks

In conclusion it may be of interest to examine how the transmission conditions would appear if the DIALOG were to be used in an altogether up-to-date telephone network.

The new transmission plan accepted at the plenary meeting of CCITT at Geneva in June 1964 is based on the reference equivalent distributions shown in fig. 26. The maximum overall reference equivalent is 36 db. A loss of 3 db is allotted to the international intercontinental section of the connection. According to CCITT recommendation G 121 the loss between the international switching centre and the local exchange can be limited to 4 db. For the local system there then remains a reference equivalent of 16.8 db for sending and 8.2 db for receiving.

According to the aforementioned statistics of the distribution of length of local lines, the local line seldom exceeds 5 km. Assuming 0.4 mm conductor the subscriber with the longest local line will have a nominal reference equivalent of + 12 db for sending and + 2 db for receiving. The overall reference equivalent including the long distance network will then be 25 db, and within the same local exchange + 14 db. With a zero-ohm local line the corresponding reference equivalent will be + 1 db for sending and — 2 db for receiving. Including the long distance network the overall reference equivalent will be + 10 and — 1 db, respectively, within the same local exchange. The nominal reference equivalent will thus vary in total between — 1 and + 25 db. With larger diameters of conductor, of course, this variation will be still smaller. As will be seen, the maximum nominal variation of — 1 to + 25 db is fairly close to the optimal range of + 5 to + 25 db for the overall reference equivalent stated in the introduction.

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DIALOG—External Design and Colouring

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The telephone made by L M Ericsson since the early thirties has undergone great development in its technical features. But, apart from minor modifications, its outer shape has remained unchanged.

Many of the inventions and new conceptions in telephone instrument technique have been described in previous articles in this journal, and likewise the new facilities offered in the form of casing and handset materials and the requirements placed by rising wages on the rationalization both of manufacture and maintenance. The new features demanded by the telephoning public and the telephone administrations have also been described.

The earlier model admittedly fulfilled very high demands from the external design aspect, but did not meet the technical and functional requirements which were specified for the DIALOG. These were to a large extent entirely new and were very rigorously formulated. In the development of the DIALOG, therefore, the casing and handset were reshaped to meet the new requirements.

Design

Some of the requirements placed on the new model were:

- that the distance between transmitter and receiver insets should be shorter than in previous models.
- that the casing should be easy to remove by a repairman,
- that the telephone should be easily portable,
- that the dial should be the same model as introduced in the Ericovox,
- that the lodgement of the handset in the cradle should be further improved,
- that its weight should be considerably lower than that of earlier telephones,
- that the casing and handset should be made of thermoplastic and not of thermosetting resin,
- that its interior should not be entirely dark having regard to the insect problem in the tropics.

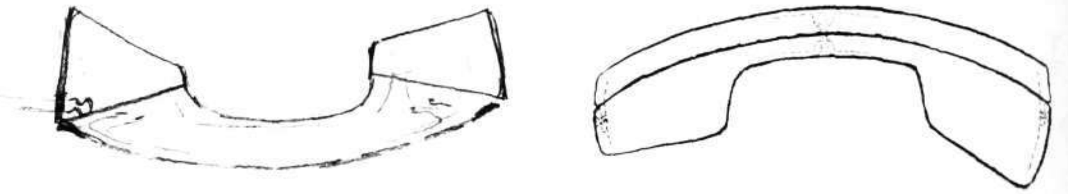
Many other points of view could be added. In general it was demanded that the casing and the handset parts should be further simplified for purposes of manufacture, and that the appearance should match up to the standards set by the Ericofon and Ericovox. Despite these new or accentuated demands, however, it must be said that the essential design requirements were the same. The instrument still consists of two main parts, a handset for listening and talking, and a casing with dial which encloses the telephone mechanism and on which the handset rests. The need to search for an entirely new form as in the design of the one-piece telephone—the Ericofon—or of the loudspeaking telephone—the Ericovox—has therefore not existed. Instead it was necessary, by relatively small means, to adapt a given type of telephone to new requirements. The task was of the same kind as the development of a classical object or implement such as a spoon or fork, or a type of boat. This situation characterized the entire work. The new casing and handset are thus a direct development of L M Ericsson's earlier models of 1931 and 1947, but complying with the new functional and manufacturing requirements. Characteristic elements such as the Ericsson horns at the rear of the cradle for trapping the handset have been retained. The positions of the parts handled by the subscriber—the dial and handset—are essentially unchanged.

The form of the DIALOG developed successively as a result of the interplay between different factors. Material and production technique, internal build-up, assembly and maintenance, function, shipping weight and volume and handling by the subscriber, have all determined its form. The scope for purely aesthetic features from the design point of view has been limited. This does not mean, however, that the work did not have a characteristic rhythm in the interaction between the purely logical, empirical analysis of the problems and intuitive creation. Nor is there any doubt that the intuitive, purely artistic elements have marked a decisive step on the road to the final solution.

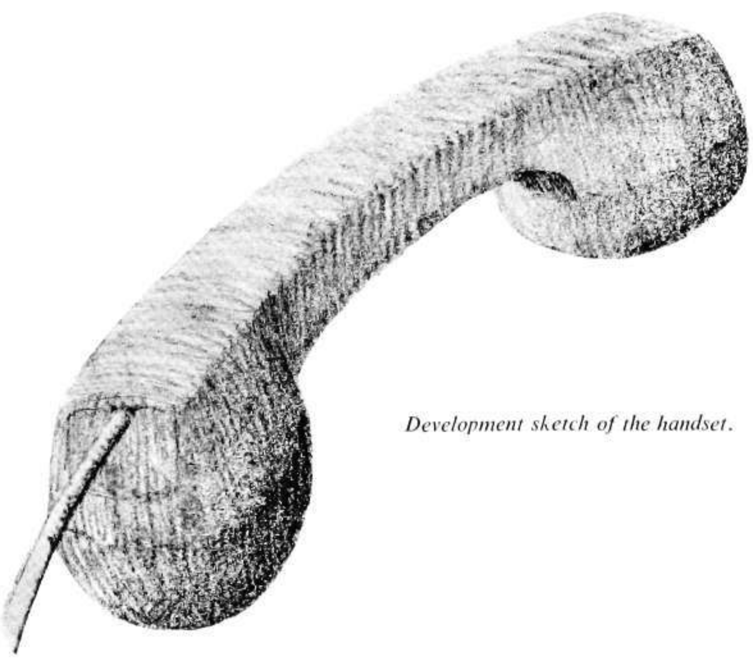
The first part of the work was devoted almost entirely to studies of the handset. In the programme for the handset there was of necessity less room for manoeuvre than in that for the casing. In the introductory phase, therefore, the handset was given priority, and a preliminary handset thus existed as basis for drawing up the programme for the casing. Thereafter the planning of the casing started, and finally a study was made of the relations between casing and handset and of the modifications these would necessitate. This work resulted in a provisional model which was subjected to extensive tests. Experience from these tests led to a further study of certain problems, such as the carrying grip at the rear, the actuation of the plungers by the handset, and the grip around the handset handle.

This description of the planning process is naturally a simplification of the actual course of events. As the work proceeded, new points of view came to light. The programme underwent constant development. It was therefore natural to return to earlier stages of planning, to reconsider the preliminary results, and to correct dimensions and shapes to fit new or changed requirements.

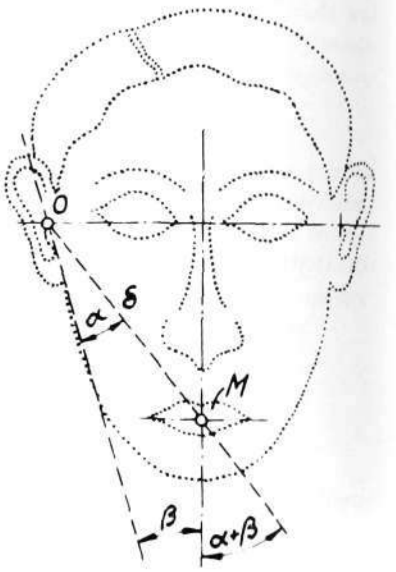
The relative positions of the receiver and transmitter insets were based on studies made of facial dimensions in different countries. According to how the design of the transmitter cap could be imagined in principle—with strongly concave, funnel-like cap, plane or slightly convex cap, or slightly concave cap, etc.—three possible relations were selected between the receiver and transmitter. Models were tested from the transmission aspect and in respect of the position of the transmitter relative to the mouth in different speaking positions. The model was chosen which showed the greatest conformity with different shapes of head, test specifications and, last but not least, comfort. A requirement which had a marked effect on the detailed design was the change from thermosetting resin to thermoplastic. To a large extent this implied a simplification of the external form. The necessity for a uniform and small wall thickness limited the opportunities for free sculptural design of the handset contrary to that of the older model. The problem was then how to achieve, by small means, a handset which was easier in the hand and, of course, as light as possible. For this purpose extensive model studies were made with different sections of handle. It was found that the easiest grip was obtained with a handle having a broad back narrowing off towards the ends. This is because the pressure of the fingers required to hold the handset against the palm of the hand is thereby diminished and at the same time distributed over a larger area of the palm, so that the handset feels lighter and easier in the hand. With the broad-backed handle less force is required to hold the handset in a constant position than when it balances on an edge. A handset with broad



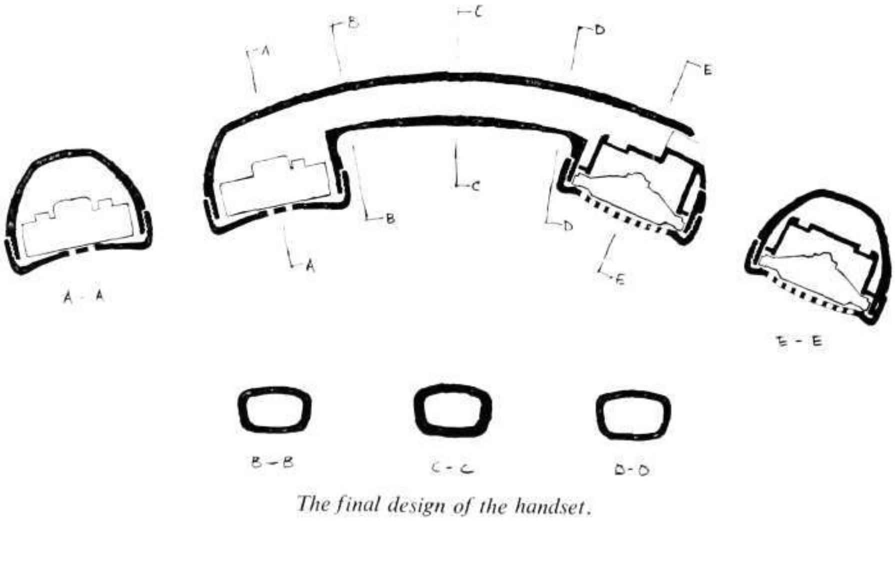
Reduction of the number of components in the handset. The sketch on the left shows three parts—the handle and two caps; That on the right shows only two—upper section and lower section.



Development sketch of the handset.



The principal dimensions of the handset have been based on the average facial measurements of a large number of people.



The final design of the handset.

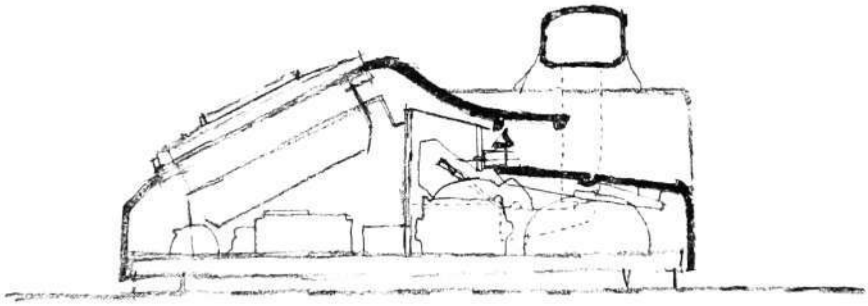
The change to thermoplastic makes it possible to meet differentiated desires concerning colouring.

back and rather inward-sloping sides also offers a favourable form for lifting from the cradle and for actuation of the cradle plungers. The relatively pronounced shuttle shape of the handle is intended to favour a vertical stability of the grip.

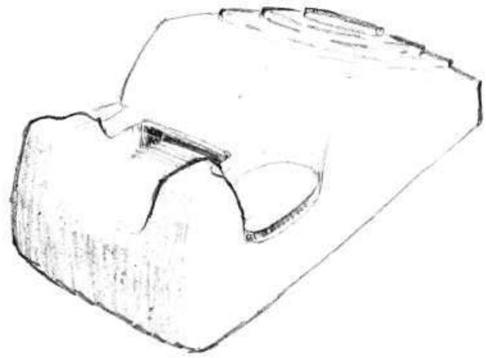
Concurrently with the development of the handset, acoustic tests were made with different designs of transmitter cap. The final form with a slightly convex surface was chosen because of the optimal air volume between transmitter inset and cap and because of the desire to avoid screening of the speaker's voice in different positions of the handset. This means that one obtains the optimal output in practical use and not only the maximum output in the specified tests.

Once the form of the transmitter cap had been decided, a definite choice could be made between the alternative shapes of handle referred to above. Extreme care was taken in the choice of optimal dimensions for the handset, taking into account all known technical requirements presented in studies throughout the world.

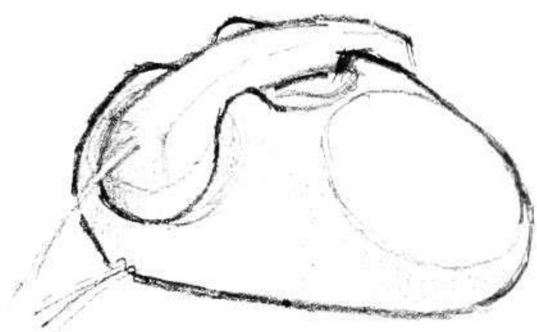
With the main dimensions of the handset now fixed, the programme for the casing could be formulated. The following additional requirements had to be met. The cover ring under the fingerhole plate must allow not only for an outer circle of letters or digits but also for the future fitting of a keyset, probably of rectangular shape. The dial slopes at 30° to the horizontal plane, which is a comfortable angle for dialling. The height of the lower edge of the dial above the baseplate, which is determined by the underlying components,



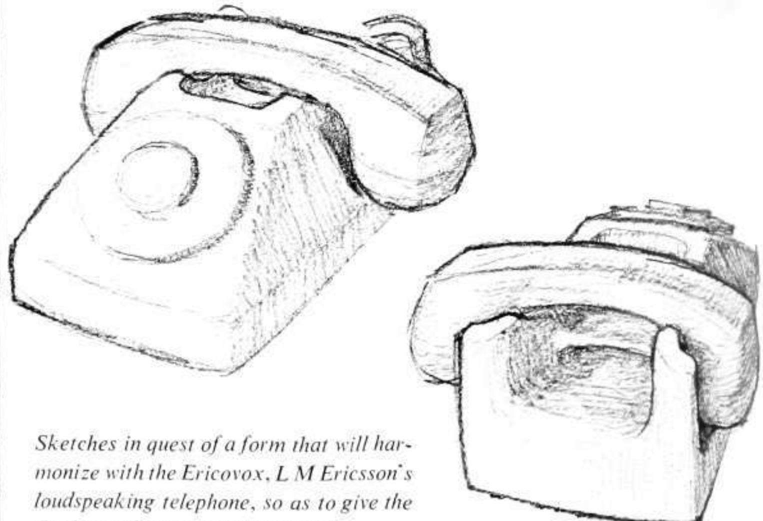
Section of the instrument case.



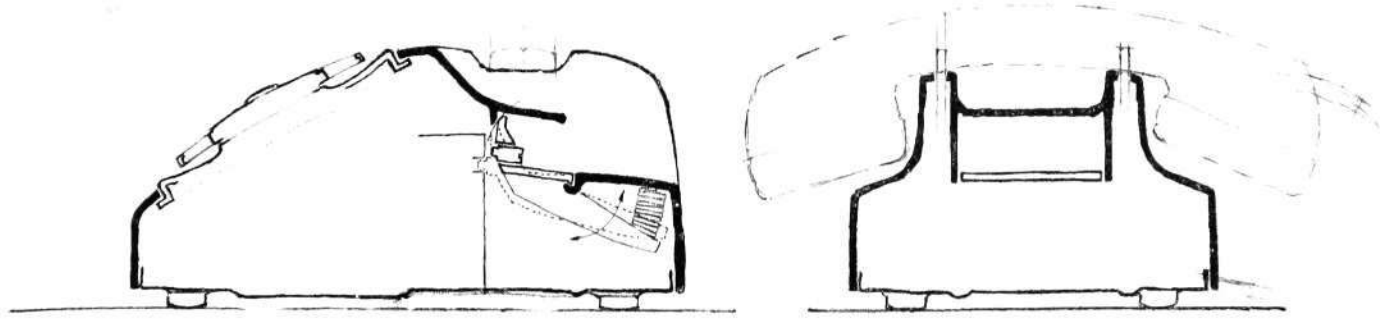
Sketch and clay model of the telephone in which the plungers are replaced by "pillows" on which the receiver and transmitter rest. The case is designed to fit snugly over the internal mechanism.



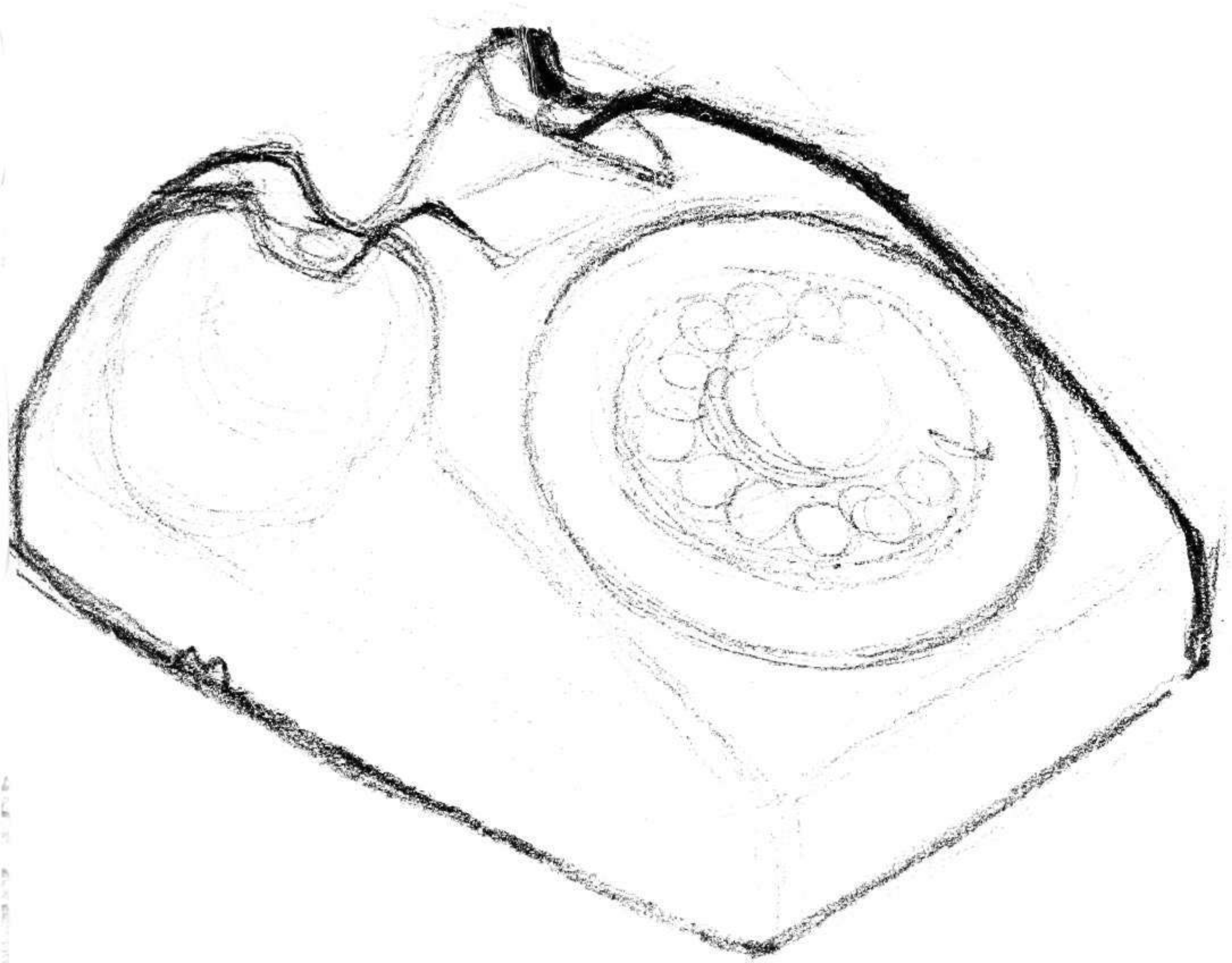
Working towards a unified overall design. The case is pretty well triangular in plan.



Sketches in quest of a form that will harmonize with the Ericovox, L M Ericsson's loudspeaking telephone, so as to give the firm's products a family likeness.



The final shape begins to emerge. The longitudinal section shows the carrying grip with its "window" and the signale screw for removing and replacing the case. The cross-section shows how the handset, which is asymmetrical, is given a balanced appearance when it lies in the instrument cradle. The perspective sketch shows the surfaces whose shapes cause the handset to slide into position.



is about 40 mm. A very considerable part of the surface of the casing is thereby determined. The carrying grip should be about 50 mm wide for the insertion of three fingers. This dimension on the one hand and the length of handset handle on the other determines the position and the main dimensions of the rear horns in their new form. In this context reference may be made to the difficulties of achieving an attractive design of the carrying grip. Problems were encountered in the corners and in the boundaries between the casing and the transparent partition of the grip. The demand for definite trapping of the handset even when replaced from the rear requires similar surfaces at the front and rear of the cradle. This is an innovation which from the design point of view involves a greater width of the front portion of the casing. Receiver and transmitter will thus be recessed in the sides of the casing. The height needed to force down the plungers fixes the minimum height of the rear and front horns. Numerous other factors could, of course, be mentioned which place definite requirements on the various sections of the casing. It is this entire functional complex that decides its main form. The aim in the design was to find the optimal detailed form for each particular function and at the same time to arrive at an attractive whole.

The new model should have some permanence on account of the reserve space inside the casing and the flexibility in location of the components which this allows. The long life of L M Ericsson's earlier models from 1931 and 1947 shows the importance of a far-sighted design policy.

Some of the standard DIALOG colours.

Colouring

If the *form* of the DIALOG—despite a number of fairly radical changes and innovations—is a direct development of the older L M Ericsson telephone, its *colouring* involves an entirely new concept. Whereas the Ericofons had already been produced in a polychrome series, the usual two-piece telephone had generally been made in two standard colours, black and white. The change to thermoplastic, however, opened the way to the more differentiated colour range desired by the customers. The number of possible colours and shades is, in fact, unlimited. But both from manufacturing and maintenance points of view too large a number of colours would involve problems and therefore an extra cost. A reasonable choice of colours is an advantage also for the telephone administrations. In the colour programme for the DIALOG, therefore, the desire was to provide as meaningful variations as possible with a limited number of colours. The selected colours, moreover, should have a reasonable life.

Various systems and principles exist for the analysis of colour problems. They provide a certain framework but do not, as such, indicate a solution of the problem. Colour preference studies should give some guidance but in reality have proved to be of extremely limited value. In the first place they merely provide information of the preference at a given moment, unless repeated for example every third year under constant conditions. A series of such studies would be needed to reveal the more stable changes of preference as opposed to passing whims. The varying symbolical significance of colours in different cultural circles is a further complication. In general colour is a strictly subjective matter. It is therefore difficult to arrive at a result of any general validity.

By studying the colouring of different groups of objects, however, certain discoveries were made which in due course narrowed the choice. It was found that the majority of the "fashion colours"—i.e. short-lived colours—were not the primary colours but were on the outer zone of each colour cycle, i.e. yellowish green, blue green, yellowish red, violet, etc. Notable exceptions are black and pink, which are striking colours or rather hues. They also have a life unusual to fashion colours, extending over thirty or so years. On the other hand the colours with the longest life—the heraldic—were found to be the pure primary colours and black and white.

It seems, therefore, as though colours close to the primaries could be expected to have a longer life than those further off in the colour cycle. As is known, a colour changes its character to the eye according to the colour of the environment or illumination. A colour which in a yellowish environment appears bluish may appear red in another environment. A colour which in white daylight is clearly green may appear brown in evening light. The more saturated a colour is, the more resistant it is to these external factors.

The form of an environment is appreciated through the effects of light and shade. The plastic character of an object is viewed through its own shadows, and its relation to other objects is viewed through the shadows it throws on surrounding surfaces and objects. An absolutely black object has no shadows of its own and its form is difficult to appreciate unless shown up by its silhouette and reflections. In a purely white object the light and shade effect may readily be so weakened by its strong reflection that its form is also difficult to appreciate. The shadows, however, are always more or less filled with reflexes. A common colour characteristic of the shadows makes the environment appear uniform. An object which in its shading has too deviating internal reflexes is readily appreciated as freely floating and broken out of the environment. This is the case with objects whose colour has no black component.

Finally, an analysis of the colour environments in which telephones are used showed that practically all contained a certain yellow component. To be striking, stable, and at the same time well matched to the environment, therefore, it was found that the colours should be selected as follows. In tone they should lie close to their respective primary colours. They should be relatively saturated. They should be faintly shaded with black. They should have a slight tendency to yellow. This applies both to white, grey and black, and to red, green and blue. In the final choice of standard colours, moreover, attention was paid not only to the colour but also to its brilliance. The series black, grey, white in itself covers the requirement in this respect. The other standard colours, however, have also a certain dispersion in respect of brilliance.

A number of practical problems associated with colours can only be intimated here, e.g. the ageing of different plastics, their stability—so that new parts match earlier supplied parts, for example when a dial is replaced by a keyset, etc. Large buyers of telephone instruments, moreover, have often expressed clear demands for special colours which, of course, must be met. In conclusion it may be said that the wide investigation of suitable colours for the DIALOG has enabled L M Ericsson to quickly introduce new shades within the desired colour cycles over and above its existing standard colours.

As will appear from the above, the design problems of a conventional telephone have been extremely thoroughly studied by L M Ericsson. The same applies to the problems of colouring. The result has been primarily the DIALOG, but the possibility has also been created for an entire family of telephones with the form of the DIALOG as pattern.

Ericsson LM NEWS from All Quarters of the World

Order for 50 Million Kronor from Saudi Arabia

In conjunction with a radical modernization and extension of the telephone communications in Saudi Arabia, L M Ericsson is to supply telephone equipment for about 50 million kronor.

The project comprises the delivery of automatic telephone exchanges for more than 40,000 lines for the twelve largest towns in Saudi Arabia: Riyadh, Jeddah, Mecca, Medina, Taif, Dammam, Hofuf, Quatif, Dharan, Al Khobar, Mobaraz and Saihat. The order also includes about 51,100 telephones and considerable quantities of line equipment. The installations are to be completed within five years.

L M Ericsson obtained the order in stiff competition with other large international telephone manufacturers. Saudi Arabia is the fourth Arabian state to choose L M Ericsson telephone systems for conversion of their networks to automatic operation. The three others have been the United Arab Republic, Lebanon and Tunisia.

This project forms an important part of the extensive plans for development and modernization of the country which are being carried through under the new regent King Feisal.

The photograph (left) shows the fine building in the capital, Riyadh, which houses the Ministry of Communications and the highest planning authority in the country.

Below, seated in foreground (from left) Mr. B Thisell, Regional Director for Africa & Middle East, LM Ericsson, Stockholm, Sheikh Ahmad Juffali, General Manager, EPPCO (Engineering Projects & Products Co., LM Ericsson's agent and main contractor for the project), H. E. Omar Towfiq, Minister of Communications of the Kingdom of Saudi Arabia and Mr. S-O. Tonnaeus, Regional Director for Middle East, LM Ericsson, Stockholm.

Opening of Ireland's First Telex Exchange

In the middle of October the first telex exchanges in Ireland were opened in the presence of the Minister of Communications, Mr. H. Hilliard, and the Swedish Ambassador, Mr. N.-E. Ekblad. L M Ericsson has supplied the three exchanges situated in Dublin, Shannon and Cork. The Dublin exchange is the largest and is equipped also for international automatic telex traffic. The traffic was opened by a telegram of thanks sent by Mr. Hilliard to the Right Honourable Reginald Bevins, Postmaster General, London, for the assistance received in the linking up of Ireland's telex network with that of the United Kingdom and the continent.

Just previously Mr. Hilliard had opened a new 800-line ARK exchange at Navan in Ireland. In his inaugural address Mr. Hilliard stated that 300 new automatic exchanges have already been ordered and in part delivered from L M Ericsson but that there were still nearly 1000 manual exchanges in Ireland which were to be converted to automatic operation.

Mr. Hilliard (left) and Ambassador Ekblad at the opening of the telex exchange in Dublin.

Carrier Equipment for Scandinavian Telesatellite Station at Råö

The new 25.6 metre radio telescope of the Chalmers Institute of Technology and the installations of the Scandinavian Telesatellite Committee (STSK) at Råö were recently inaugurated in the presence of representatives of financing and scientific institutions and of the Scandinavian Telecommunication Administrations. The inaugural ceremony marked the successful première for direct TV transmission from the United States to Sweden. The transmission came from a station in the Mojave desert in California via the Relay I telesatellite to Råö.

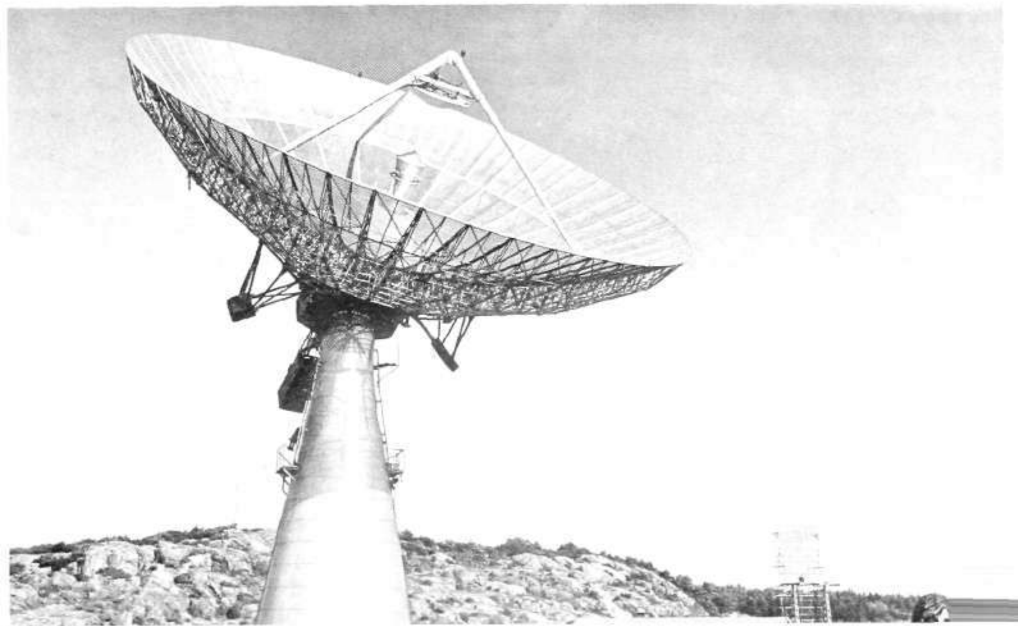
STSK will have the use of the Råö telescope for three years for experiments in reception of different signals transmitted via telesatellites. The major part of this experimental work will form part of the programme organized by NASA (National Aeronautics and Space Administration, USA).

The bulk of the apparatus needed by STSK for its reception experiments is housed in the building seen on the right of the photograph. The equipment includes the complicated programme control apparatus with which the antenna is caused to follow the movements of the satellites with great precision.

The stations taking part in the experiment will use for sending and receiving a base band corresponding to the basic groups A for the frequency range 12–60 kc/s and B for 60–108 kc/s standardized by CCITT. Of special interest in this connection is that L M Ericsson supplied the equipment for frequency division of the base band. It consists of a normal transistorized carrier terminal for transmission of 12 telephony channels on radio links. By means of a switching device which can be remote controlled, it is possible to change between the two basic group positions A and B in the base band. This is of value since reception from different ground stations, with transmission on different channels within the entire frequency range 12–108 kc/s, may be desirable at different times of the day and at short intervals.

Expansion of L M Ericsson Factory in Visby

The expansion of the Visby factory has started and is expected to be completed within one year. The factory will then have obtained a much needed addition of nearly 120,000 sq. ft., which doubles the total factory area to some 216,000 sq. ft. The reason for the extension is principally the increased manufacture of relay sets, and that standard relays are to be both manufactured and adjusted at Visby. The number of employees will increase at the same time from 600 to about 1000.



The new radio telescope at Råö.

Organizational Changes

In conjunction with certain organizational changes the Board of L M Ericsson has appointed the following vice-presidents: Sten Engström, Head of the Long Distance Division, Arne Mohlin, Works Manager at the Head Factory, Sten Ake Nilsson, Head of Erga Division, and Fred Sundkvist, Head of the Telephone Exchange Division.

Large Orders for Sieverts Kabelverk

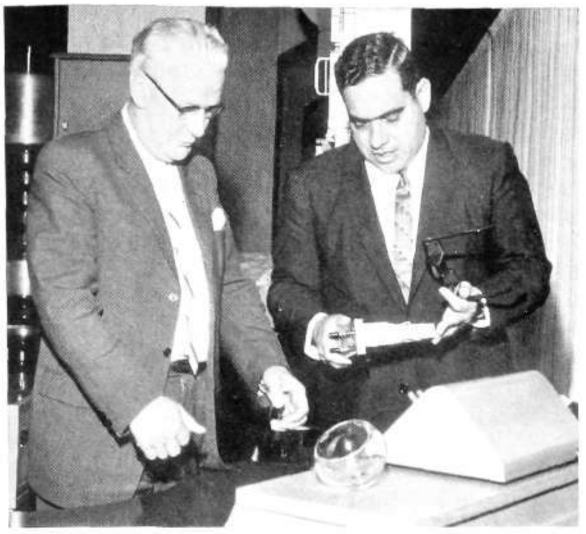
Sieverts Kabelverk has received from the Swedish Power Board an order for the largest series capacitor in the world. Rated at 525 MVAr, this capacitor bank is to be connected to the 400 kV Hjälta–Enköping circuit. Sieverts also delivered the 300 MVAr bank installed at Djurmo in 1963, also a record at that time.

Although the output of the new bank will be 75 per cent higher than that at Djurmo, it will take up less space. This has been achieved by the use of a new capacitor paper with lower losses and higher dielectric strength. The output of the capacitor units has thus been increased within the same volume from 50 to 90 kVAr. The transmitting capacity of the line has thereby risen from 500 to 1100 MW.

From India Sieverts Kabelverk has received an order for seven shunt capacitor banks including breaker equipment for voltages between 11 and 132 kV. The total output will be about 180 MVAr and the order is worth about 4 million kronor.

The British Central Electricity Generating Board (CEGB) has ordered two shunt capacitor banks for 145 kV with output of 60 MVAr each. Earlier in the year contracts for altogether 50 MVAr had been signed with Britain. As from the beginning of 1964 Fuller Electric have been Sieverts' agents in the United Kingdom.

Export sales of capacitance voltage transformers have greatly increased. Among large orders on hand are 85 units of 300 kV for Norges Vassdragsvesen and the Oslo Electricity Works, 63 of 275 kV for the Electricity Supply Commission in South Africa, 63 of 150 kV for Denmark, and 60 of 123 kV for the Electricity Supply Board, Ireland.



The Director General of Telecommunications, Nicaragua, Col. F. Medal, recently visited L M Ericsson. He is seen in the photograph (right) studying a trunk board with Mr. G. Fernstedt, L M Ericsson.

This way of treating L M Ericsson's new DIALOG telephone is not exactly recommended, even if the DIALOG can well carry the weight of a Volkswagen. A testimony as good as any other to the quality of L M Ericsson products.

The start of automatic traffic in Jugoslavia was recently inaugurated in Belgrade by the Vice-President, Aleksandor Ranković. The Jugoslavian PTT has ordered from L M Ericsson 15 crossbar trunk exchanges, the installation of which has now started. Within the near future a large part of the long distance calls in the country will be subscriber-dialled. In the photograph Vice-President Ranković is seen conducting the first conversation with Zagreb. On the left is Prvoslav Vasiljević, Director General of the PTT.

L M Ericsson recently received a visit from Thailand. (From left) Dr. Prapat Chakrarak, National Economic Development Board, Mr. Piew Phusavat, Technical and Economic Cooperation, and Mr. Kayoon Limtong, Budget Bureau.

L M Ericsson's Mölndal factory was visited in the autumn by the Swedish Commander-in-Chief, General Torsten Rapp, accompanied by Major General C-E. Almgren, Chief of Defence Staff, Col. S-O. Olson, Chief of Planning Division, and Lieut. Col. Hj. Mårtensson, Adjutant to the Commander-in-Chief. The Commander-in-Chief was informed of the present situation as regards work being conducted by LME on radar and other electronic equipment for the Swedish defence forces. (From left) K. Styrén, L M Ericsson, Lieut. Col. S-O. Olson, P. Lindegren, L M Ericsson, Major General C-E. Almgren, Torsten Lange, L M Ericsson, General T. Rapp, Lieut. Col. Hj. Mårtensson, and Major K-G. Kahnlund, L M Ericsson.

Anders Steiner In Memoriam

Anders Steiner died on November 16 after a brief illness. He was one of the last of the team of men who had built up the Älvsjö Cableworks from its foundations. After the death of Georg Olsson in 1951, and until his own retirement on pension three years ago, Anders Steiner was the leader of the Cableworks and the guiding spirit in everything which took place within its walls. Though not himself a technician, he knew most things about its technique and production. Sales and finances were his main occupation, and these he dealt with in detail in the best interests both of customers and of the company. He knew all his employees personally and took care of them individually.

This he could do because the Cableworks and everything concerned with it were his life's interest. For Anders Steiner the Cableworks was not only a duty, it was his hobby, the thing that lay nearest his heart.

It was therefore not surprising that his enthusiasm spread to all above and below him in the company. He had the stubborn will of the Dalecarlian to drive through what he had given his mind to, yet without giving offence, since with it went a natural and spontaneous kindliness and considerateness.

He made many friends. We grieve at his departure but remember him with happiness.

Anders Steiner was born in 1896. He joined the AB Stockholmstelefon Cableworks in 1917, became Sales Manager of the Älvsjö Cableworks in 1928 and Works Manager in 1952. He retired on December 1, 1961, but remained available for special consultations until April 8, 1963.

A Westling

Ericsson Technics

No. 1/1964 starts with an article by M Björklund and A Elldin, "A Practical Method of Calculation for Certain Types of Complex Common Control System". The article describes how the traffic capacity of composite marker complexes can be calculated in practice. The method has been tried out with simulations for a computer and with real traffic measurements and was presented at the Fourth International Teletraffic Congress in London in July 1964, as also was the following article by Y Rapp, entitled "Planning of Junction Network in a Multi-exchange Area. I. General Principles". The methods developed for this purpose greatly facilitate the expensive and time-consuming work required for the planning of large exchange areas and trunk networks.

The third article,[1] "A Discontinuity Problem in a Circular Waveguide Containing Two Dielectrics", by B Enander, presents studies made in recent years on inhomogeneous waveguides, i.e. waveguides filled with two or more dielectrics. An essential problem is how to transfer energy between inhomogeneous and conventional waveguides. A special problem of this kind is studied in the article, namely the transfer of circular symmetrical waves between a coaxial circuit and a circular waveguide with a central dielectric rod.

In the final article in No. 1, "A System of Single Sampling Inspection Based on Economic Optimization", S Westerberg describes the method used at L M Ericsson's Production Control Department. The method aims at achieving an economic distribution between control costs and actual costs of faulty parts.

No. 2/1964 starts with Y Rapp's "The General Plan for a Multi-exchange Area". This paper is designed to facilitate the planning of multi-exchange areas by presenting the principles for treatment in a computer of the most laborious processes such as the determination of exchange locations and the boundaries of the exchange areas.

The second article, "A Distribution Model for Telephone Traffic with Varying Call Intensity, Including Overflow Traffic" by B Wallström describes a theoretical model for telephone traffic which allows a more general description, inter alia, of overflow traffic. As a special case the usability of the negative binomial distribution is studied in conjunction with overflow problems. The precision of the method has been tested by simulations in a computer.

In "Some Numerical Methods Used for Telephone Traffic Theory Applications" E Szybicki presents some numerical methods used in the calculation of traffic expressions in computers. Among other things he describes the method used for calculation and supplementation of the third edition of Palm's "Table of the Erlang Loss Formula".

In "Linear Active Network Theory" T Fjällbrant presents a survey of the most used basic elements in active circuit theory and of different methods of synthesis developed by means of them. Special studies are made of the relations between the various active elements; also of which elements are necessary and sufficient for the representation of all activity, and how they can be used in the analysis and synthesis of active networks.

The last article in No. 2, "Waves in Hot Anisotropic Electron-Plasmas" by B Agdur and P Weissglas describes the occurrence of different types of electromagnetic waves in an electron plasma in a static magnetic field. If the plasma is of finite dimensions it acts as a waveguide capable of transmitting several groups of modes. An attempt is made to systematize the various modes which can be propagated along a plasma slab parallel to a static magnetic field. Apart from the ordinary waveguide modes with phase velocities greater than the speed of light, there are, for instance, surface waves and electroacoustic waves. Some typical cases are presented.

[1] This paper is the thesis on which the author was awarded the degree of Doctor of Technology in the spring of 1964.

New L M Ericsson Representative in Austria

At the end of May Telecom HG. m. b. H., Vienna, became L M Ericsson's representative in Austria.

An inaugural lunch was held to which had been invited, among others, the Chief of the Air Force, General Lube, the Chief of the Army Administration, General Tanata, Ministerialrat Schmid, PTT, the Commercial Attaché at the Swedish Embassy in Vienna, G Palmstierna, and a number of representatives of the Austrian ministries of Communications and Defence.

In the evening some thirty representatives of the daily and trade press were invited to an informational meeting at which a selection of our products was demonstrated.

UDC 621.395.72
LME 8220

KÅELL, Å.: *DIALOG — the New Telephone*. Eriksson Rev. *41*(1964): 4, pp. 136—146.

When L M Ericsson brought out its telephone with plastic handset and casing in 1931, an external form was created for the telephone instrument which, in its main outline, has been accepted and retained by all large telephone manufacturers of traditional subscriber instruments with handset, dial and bell. Its characteristic features were the sloping front with the dial, and the form of the casing which provided a sturdy seating for the handset. When there have been special purposes in view, or the design has been based on a new telephone instrument philosophy, new types have of course arisen with a shape and functional character of their own, such as the ERICOFON introduced in 1956 and the loudspeaking ERICOVOX in 1958. The world market needs some variation, and different types can be successfully produced side by side. But quite obviously the large telephone administrations wish for the most part to supply their subscribers with a modern instrument of traditional type. A new telephone, called the DIALOG, has therefore been designed in intimate co-operation with the Swedish Telecommunications Administration.

UDC 621.395.721.3
LME 822 8402

BOERYD, A.: *Transmission Characteristics of the DIALOG. Background and Results*. Eriksson Rev. *41*(1964): 4, pp. 147—161.

Efforts to improve the quality of the telephone have been made ever since the first instrument was brought out at the end of last century. The guiding and driving factor in these strivings has been not only the demands of subscribers for better telephone connections but, still more, the necessity of compensating for the increasing attenuation resulting from the intercontinental spread of telephone networks. The advent of the electron tube in the twenties, and the rapid development of semiconductor, especially transistor, techniques in the fifties, have been important factors in reducing line losses, with improved transmission conditions as a result. However complicated and perfected the transmission and switching equipments may be, it is nevertheless the telephone set itself which ultimately determines the quality of transmission attainable between any two subscribers. This implies a great responsibility but is at the same time a source of inspiration in the design of telephone sets.

UDC 621.395.721:7.05
LME 822 1023

OLSSON, T & SILOW, S.: *DIALOG — External Design ond Colouring*. Ericsson Rev. *41*(1964): 4, pp. 162—170.

The telephone made by L M Ericsson since the early thirties has undergone great development in its technical features. But, apart from minor modifications, its outer shape has remained unchanged.

Many of the inventions and new conceptions in telephone instrument technique have been described in previous articles in this journal, and likewise the new facilities offered in the form of casing and handset materials and the requirements placed by rising wages on the rationalization both of manufacture and maintenance. The new features demanded by the telephoning public and the telephone administrations have also been described.

The earlier model admittedly fulfilled very high demands from the external design aspect, but did not meet the technical and functional requirements which were specified for the DIALOG. These were to a large extent entirely new and were very rigorously formulated. In the development of the DIALOG, therefore, the casing and handset were reshaped to meet the new requirements.

The Ericsson Group

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AB Ermi, *Karlskrona 1*, tel: 23010, tgm: ermibolag
AB Rifa *Bromma 11*, tel: 08/262610, tgm: elrifa
AB Svenska Elektronrör *Stockholm-Tyresö 1*, tel: 08/712 01 20, tgm: electronics, telex: SER/1275
Instruktionsteknik AB, *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec
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L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 08/68 07 00 tgm: signalbolaget
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Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 30 50 11, tgm: catel
Industrias Eléctricas de Quilmes S. A. *Quilmes, FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

Brazil
Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson, telex: rio 310

Canada
LM Ericsson Ltd. *Montreal 9, P.Q.*, 2300 Laurentian Boulevard, City of St. Laurent, tel: 331—3310, tgm: caneric, telex: 1-2307

Chile
Cía Ericsson de Chile, S. A. *Santiago de Chile*, Casilla 101 43, tel: 825 55, tgm: ericsson

d, Apartado Aereo 4052, tel: 41 11 00, tgm: ericsson

Ecuador
Teléfonos Ericsson C. A. *Quito*, Casilla 2138, tel: 16100, tgm: ericsson
Guayaquil, Casilla 376, tel: 16892, tgm: ericsson

Mexico
Teléfonos Ericsson S. A. *México D.F.*, Apartado 9958, tel: 464640, tgm: ericsson

Peru
Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson
Soc. Telefónica del Perú, S. A. *Arequipa*, Apartado 112, tel: 6060, tgm: telefonica

El Salvador
Telefonaktiebolaget LM Ericsson, Technical Office *San Salvador*, Apartado 188, tel: 4989, tgm: ericsson

Uruguay
Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

USA
The Ericsson Corporation *New York, N. Y.*, 100 17, 100 Park Avenue, tel: MUrray hill 5-4030 tgm: erictel, telex etelsac 22 41 35
North Electric Co. *Galion, Ohio*, P. O. B. 417, tel 468-24 20, tgm: northphone-galionohio, telex: 586-u

Venezuela
Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson
Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia
L M Ericsson Pty. Ltd. *Broadmeadows (Victoria)*, P. O. B. 41 tel: 307-2341, tgm: ericmel
North Sydney (NSW), 182 Blue's Point Road, tel: 92 11 47, tgm: ericsyd
Teleric Pty. Ltd. *Broadmeadows (Victoria)*, P. O. B. 41, tel: 307-2341, tgm: teleric
North Sydney (NSW), 182 Blue's Point Road, tel: 92 11 47, tgm: teleric

Representatives

• EUROPE •

Austria
Telecom G. m. b. H. *Wien XI*, Geiereckstrasse 6, tel: 73 55 81, 73 55 91 tgm: teleric, telex: electrodiesel wn 2436

Belgium
Electricité et Mécanique Suédoises *Bruxelles 5*, 56 rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece
"ETEP" S. A. Commerciale & Technique *Athens 143*, 57, Akadimias Street, tel: 62 99 71 tgm: aeter-athinai

Iceland
Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 10632 tgm: rönning

Yugoslavia
Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinać 23, tel: 36941, tgm: merkantile, telex: 02-139

• ASIA •

Burma
Burma Asiatic Co. Ltd., Ericsson Department *Rangoon*, P.O.B. 1008, tel: 10999, tgm: ericsson

Cambodia
The East Asiatic Company Ltd. *Phnom-penh*, P.O.B. 129, tel: 762-1070, tgm: pyramide

Ceylon
Vulcan Trading Co. (Private) Ltd. *Colombo 1*, New Caffoor Building, 40, Church Street, tel: 36-36, tgm: vultra

Cyprus
Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

Hong Kong & Macao
The Swedish Trading Co. Ltd. *Hongkong*, P. O. B. 108, tel: 35521, tgm: swedetrade

Iran
Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 28, tel: 376 66, tgm: iranoswed

Iraq
Usam Sharif Company W.L.L. *Baghdad*, Sinak-Rashid Street, tel: 870 31, tgm: alhamra

Japan
Gadelius & Co. Ltd. *Tokyo C*, P. O. B. 259 81, tel: 403-2141, tgm: goticus, telex: 22-675

Jordan
The Arab Trading & Development Co., Ltd. *Amman*, P. O. B. 1, tel: 259 81, tgm: aradeve

Korea
Gadelius & Co. Ltd. *Seoul*, I. P. O. Box 1421, tel: 2—9866, tgm: gadeliusco

Kuwait
Morad Yousuf Behbehani *Kuwait*, P. O. B. 146, tel: 2251, tgm: barakat

Lebanon
Swedish Levant Trading (Elie B. Hélou) *Beyrouth*, P. O. B. 931, tel: 231624, tgm: skefko

Malaysia
The Swedish Trading Co. Ltd. *Kuala Lumpur*, P. O. B. 2298, tel: 68112, tgm: swedetrade
Singapore, 42, Chartered Bank Chambers Battery Road, tel: 94362, tgm: swedetrade

Pakistan
Vulcan Industries Ltd. *Karachi City*, West Pakistan, P. O. B. 4776, tel: 325 06, tgm: vulcan

Philippines
U.S. Industries Philippines Inc. *Manila* P. O. B. 125 tel: 88 93 51, tgm: usiphil, telex: 344

Saudi Arabia
Engineering Projects & Products Co. *Jeddah*, P. O. B. 1502

Syria
Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Thailand
Trading Office, Telephone Organization of Thailand *Bangkok*, Ploenchit Road, tel: 57036-8 tgm: telthai

Vietnam
Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, P.O.B. 10 49, tel: 22 660, tgm: telerad

• AFRICA •

Congo
I.P.C.T. Congo *Leopoldville*, Ave. Ministre Rubbens, Building "Le Leggia", P. O. B. 679, tel: 5345, tgm: induexpan

Ethiopia
Mosvold Company (Ethiopia) Ltd. *Addis Abeba*, P.O.B 1371, tel: 47070, tgm: mosvold

Ghana
The Standard Electric Company *Accra*, P.O.B. 17, tel: 646 15, tgm: standard

Kenya, Tanzania, Uganda
Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel: 271 03, tgm: transcanda

Libya
The Gulf Trading Co. *Tripoli*, P.O.B. 417, tel: 5715, tgm: gultraco
Nadim S. Dajani Co. *Tripoli*, P.O.B. 577, tel: 455 51, 421 30, tgm: nadaco

Mauritius
Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

Morocco
Elmar S. A. — SEYRE *Tetuan*, Apartado 440, tel: 3701, tgm: elmar

Mozambique
J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: tinsmarques

Nigeria
I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult

Sudan
TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: sutecoma

• AMERICA •

Bolivia
Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

Costa Rica
Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

Dominican Republic
García & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3645, tgm: gartier

Guatemala
Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira

Honduras
Quinchón León y Cía *Tegucigalpa*, Apartado 85, tel: 1229, tgm: quinchon

Netherlands Antilles
S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao*, P. O. B, 172, tel: 1200, tgm: madurosons

Nicaragua
Sonitel Centroamerica S. A. *Managua*. Apartado 1271, tel: 4476, tgm: sonitel

Panama
Sonitel, S. A. *Panama, R. P.*, Apartado 4349, tel: 5-3640, tgm: sonitel

Paraguay
S. A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

Puerto Rico
Splendid Inc. *San Juan*, P. O. B. 4568, tel: 3-4095, tgm: splendid

El Salvador
Dada-Dada & Co. *San Salvador*, Apartado 274, tel: 4860, tgm: dada

Surinam
C. Kersten & Co. N. V. *Paramaribo*, P. O. B. 1808, tel: 4444, tgm: kersten

Trinidad, W. I.
Leon j. Aché Ltd. *Port-of-Spain*, 100 Frederick Street, tel: 32357, tgm: achegram

USA
State Labs. Inc. *New York 3, N. Y.*, 215 Park Avenue South, tel: Oregon 7-8400, tgm: statelabs, telex: NY 1-1807 (For electron tubes)

• AUSTRALIA & OCEANIA •

New Zealand
Welling-
70-614,