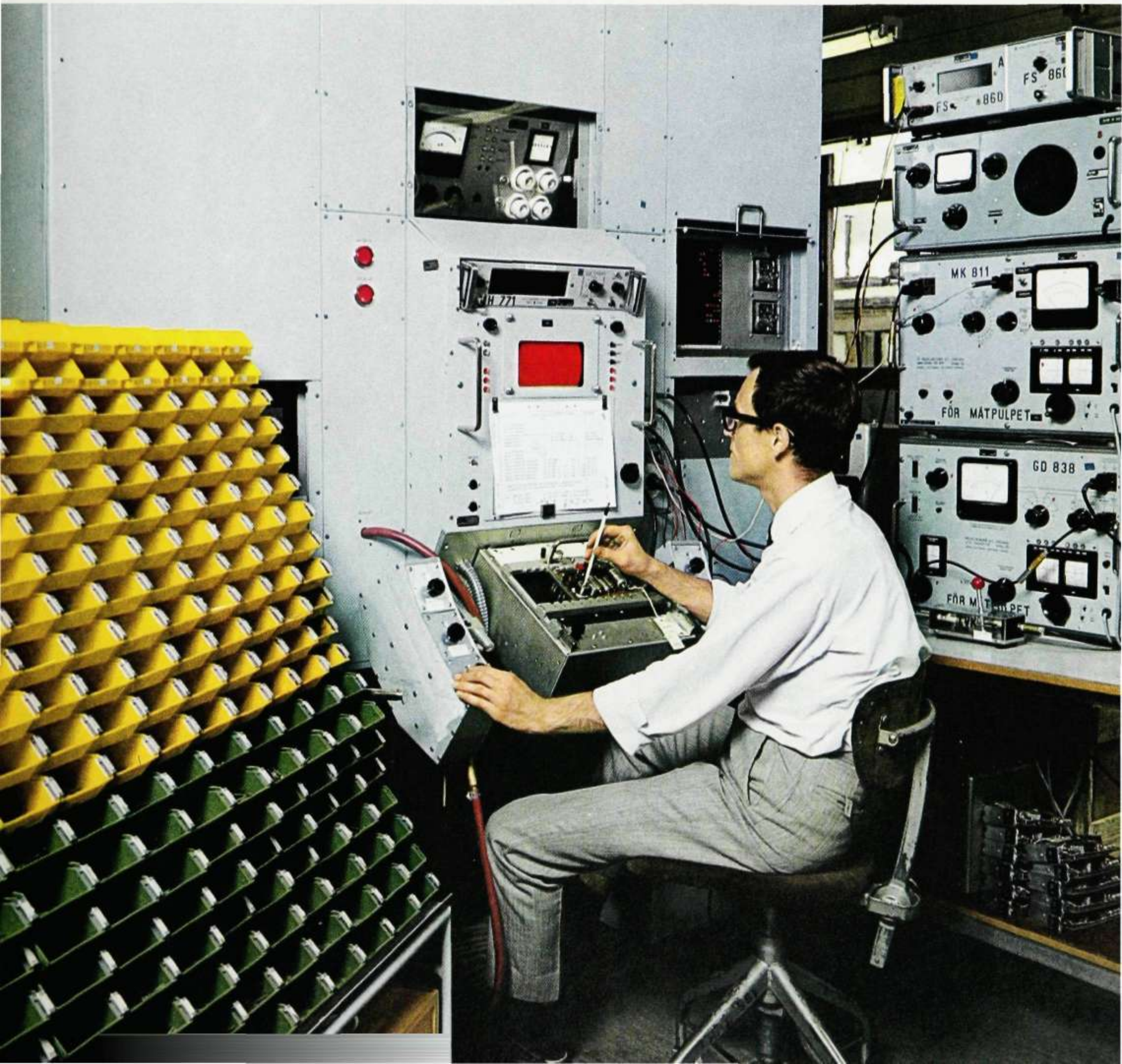
# ERICSSON *Review*

1

1967



# ERICSSON REVIEW

Vol. 44 1967

RESPONSIBLE PUBLISHER: CHR. JACOBÆUS, DR. TECHN.

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1:50; ONE COPY $ 0:50

## CONTENTS

## TELEPHONE INSTRUMENTS



## TELEPHONE EXCHANGES AND SWITCHBOARDS



## TELEPHONE TRAFFIC THEORY



## MISCELLANEOUS

# ERICSSON REVIEW

Vol. 44 No. 1 1967

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

## CONTENTS



On cover: Performance test console for automatic testing of printed-circuit units.

# The Maintenance of Local Exchanges in Helsinki, Finland

M. HARVA, EXECUTIVE VICE PRESIDENT, HELSINKI TELEPHONE COMPANY
P. PACKALÉN, CHIEF OF EXCHANGE OPERATIONAL BUREAU, HELSINKI TELEPHONE COMPANY

UDC 621.395.722.004.5
LME 835 154

*The Helsinki Telephone Company was established in 1882 and the first automatic exchange of step-by-step type was put into service in 1922. Crossbar exchanges were introduced in the area in 1950. This article deals with the maintenance organization in the Helsinki area and compares the operating results and maintenance efforts for the crossbar exchanges in relation to an average for all exchanges in the area.*

## Maintenance Philosophy

A curve depicting the correlation between time spent on the maintenance of automatic exchanges—i.e. operational costs—and operational reliability is a hyperbola: maintenance time eventually grows much faster than reliability. Towards the end of the curve any increase in reliability becomes insignificant compared with other factors, such as mistakes by subscribers. There is no sense, therefore, in blindly aiming at maximum reliability without counting the cost. The ratio between repairs and maintenance must be so fixed as to give adequate reliability at a reasonable cost.

Ideas differ regarding the proper relationship between preventive and corrective maintenance. Accentuated servicing leads to "preventive maintenance"—a constant round of adjustments, cleaning and replacement of parts performed in an effort to prevent any breakdown from occurring. The result is a relatively high and constant level of reliability, but also high expenditure. On the other hand, cutting down maintenance and concentrating on repairs reduces costs but also diminishes reliability to an undesirable degree. Eventually it may lead to major defects—possibly to a complete breakdown.

## Helsinki Practice

The present practice in Helsinki is based on a variety of supervisory measures. Generally the equipment is touched only when a defect is to be eliminated or when necessitated by the operational statistics. The extent and cause of the failure are then ascertained and action is taken. The result is a steady level of reliability and reasonable costs.

The idea of planned maintenance based on service supervision was first put forward in the Helsinki Telephone Company in 1938. Owing to the war and the difficult post-war period, it could only be put into practice at the end of the 1940's. The Company's network comprises exchanges designed on three different

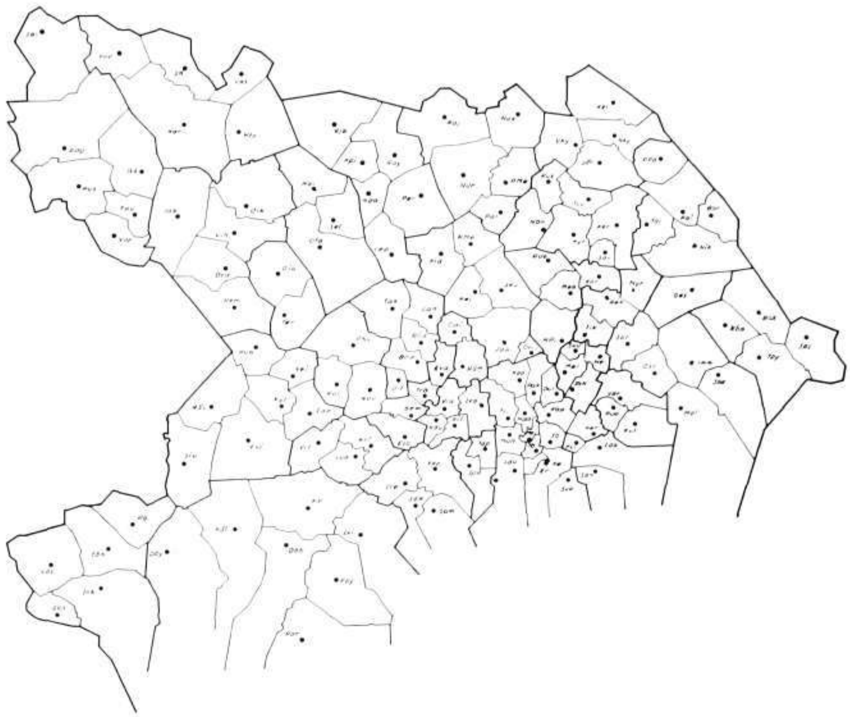


**Fig. 1**
**Helsinki Telephone Company area: exchanges and exchange areas**

principles, and maintenance has been developed accordingly. The essential features are:

- ☐ The reliability targets are set by the Board of the Company with due regard to the Company's economy and standard of service.
- ☐ Exchange equipment is subject to fixed norms which it must satisfy within the guarantee period at the latest.
- ☐ Qualitative service control is based on fault statistics, traffic observation and test calls. Automatic equipment is used.
- ☐ Maintenance is planned by a team that collects data and proposes the type, extent and priority of maintenance operations.
- ☐ Repair and maintenance personnel are directed to their jobs from a central office according to a daily plan that can be supplemented throughout the day, as required.

## Company Area

The area of the Helsinki Telephone Company (Fig. 1) comprises the town of Helsinki and part of the province of Nyland. Its population is about 740,000 and it covers approximately 3,700 sq.km. The total number of subscriber lines at the end of 1965 was 208,130, and there were altogether 296,226 telephones on them—making roughly 0.4 per inhabitant.

The area is fully automatized. The exchanges number 143, of which six in the centre of the town, 18 in the suburbs and 119 in the rural area. They vary in size between 50 and 50,000 subscribers. They are operated by a staff of 169, of

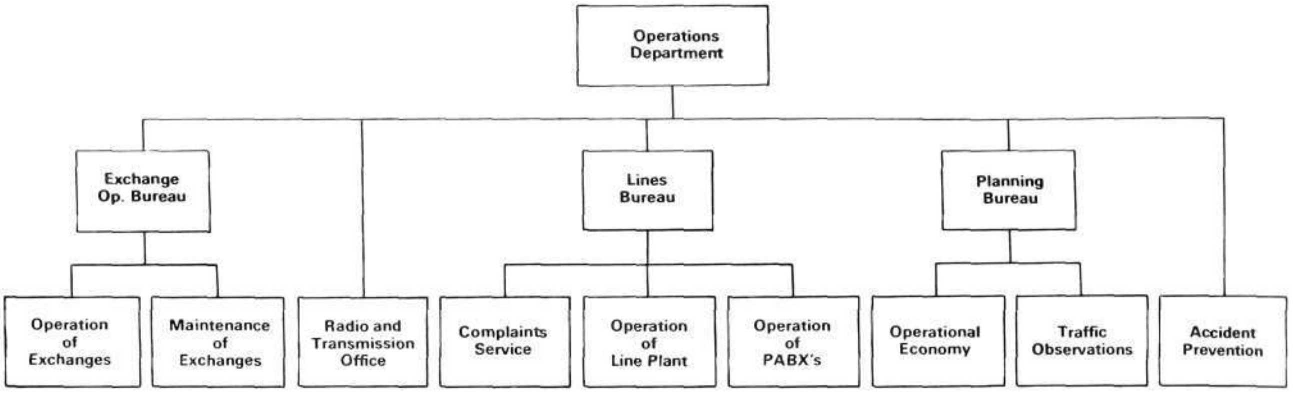



**Fig. 2**
**Organization of Operations Department**

whom 148 technical personnel. The exchange equipment includes a step-by-step design first introduced in 1922, the newer crossbar equipment dating from 1950, and a motor selector design dating from 1957.

## Maintenance Organization

The organization needed to satisfy the maintenance demand can be built up in several ways. The first thing is to consider all factors which influence the form of the organization. These factors, of course, vary within wide limits according to local conditions. The size of exchanges, their geographical location, the type and quality of the line plant and switching equipment, the quality of the maintenance personnel (degree of schooling) and their number, the character and quantity of the traffic, are examples of such factors.

The Helsinki maintenance is managed by an Operations Department, with bureaux for lines and exchanges, a carrier and radio maintenance office, a planning bureau for control of the economic utilization of routes, traffic measurements, traffic distribution and traffic quality control, and an accident prevention office for fire protection, labour safety and similar questions (see Fig. 2).

The main objects of maintenance, however, are the exchange equipments with their varying switching apparatus, auxiliary and signal devices and power supply plants. These questions are handled by the Exchange Operational Bureau, which is also responsible for PBX power plant maintenance and the planning and installation of power plants. The present number of staff of the Bureau is 160 persons (Table 1).

The main thread we have tried to follow in the organization of the Bureau (Fig. 3) is that an acute case of disturbance should be taken care of as soon as possible and that the preventive measures should be well planned. The acute disturbances are investigated and handled by the staff in the four districts, Centrum, Tölö, Sörnäs and the provincial exchange district. The large exchanges (20,000–60,000 lines) are manned during heavy-traffic hours. Motorized staff are sent to the medium and small exchanges. At low-traffic periods, e.g., in the evenings and at nighttime, some of the maintenance staff remain in their homes, prepared to turn out in an emergency.

A technical control group and the work planning staff are responsible for the planning of the test programs and preventive measures. These plans are executed by special work groups organized for this purpose. Power supply and associated questions are taken care of by the power group. The distribution of work to the maintenance staff as well as to the work groups is done from a common Job Distribution Centre to which is also concentrated the supervision

*Table 1. Personnel of Exchange Operational Bureau*

| | Head of Bureau | Operation of exchanges: 1 head of exchange operation, 1 head of work planning, 1 head of job distribution | Operation of exchanges: Exchange areas | Operation of exchanges: Technical supervision | Operation of exchanges: Work planning | Operation of exchanges: Job distribution | Maintenance of exchanges: Head of exchange maintenance | Maintenance of exchanges: Working groups | Maintenance of exchanges: Work planning | Maintenance of exchanges: Power group | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Engineers | 1 | 3 | | | | | 1 | | | | 5 |
| Masters | | | 4 | 1 | 1 | 1 | | 1 | | 1 | 9 |
| Operational technicians | | | 7 | 1 | | | | 1 | 1 | | 10 |
| Technical office staff | | | | | 2 | 12 | | | 2 | | 16 |
| Mechanics | | | 32 | 3 | | | | 9 | | 2 | 46 |
| Fitters | | | | | | | | | | | |
| male | | | 9 | | | | | 12 | | 7 | 28 |
| female | | | 20 | | | | | 22 | | 4 | 46 |
| | | | | | | | | | | Total | 160 |

of fault signals in the exchanges. This Centre is manned both day and night. Subscribers' fault reports, which have a tendency to come in with some delay, are received by the Complaints Service where a preliminary test is made from a remote control test equipment to determine whether the complaint applies to the exchange or the line side. Subscriber complaints which apply to the exchange side are transmitted to the exchange supervisory position by a pneumatic tube system. The exchange and power supply equipments have alarm contacts for indication of faults in preselected units or sections of units; other observations of disturbances are made by the staff at work, during tests, measurements, etc.

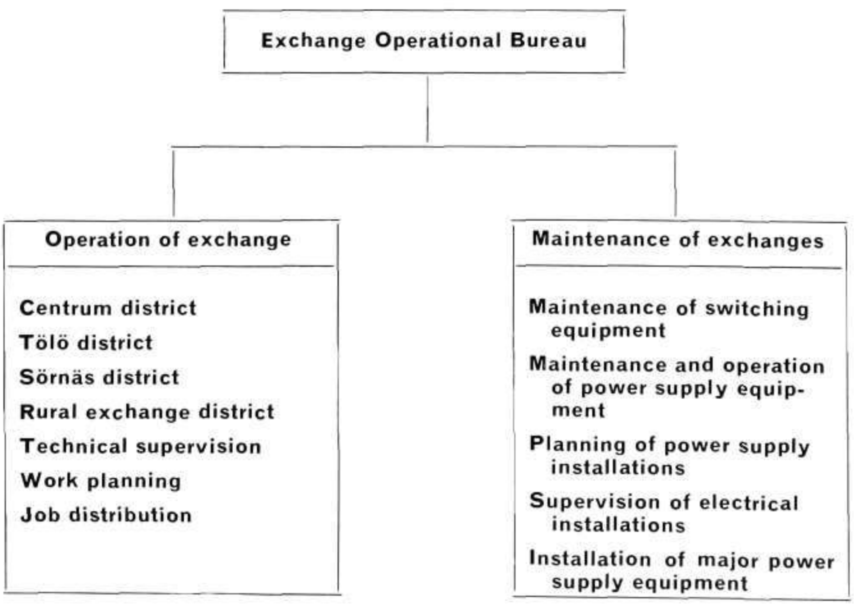



Fig. 3
Organization of Exchange Operational Bureau

## Alarm Signal Transmitters and Receivers

In order to inform the Supervisory Centre of alarms in the exchange equipment itself, each exchange is equipped with an alarm signal transmitter. The alarm signal transmitter establishes a connection for transmission of the alarm signal from the exchange in question to the Supervisory Centre on the normal traffic routes. In the Supervisory Centre the call is connected to an alarm signal receiver, consisting of a relay unit and a data recorder. When the connection is established, the alarm signal transmitter first transmits the exchange code, followed by the alarm signal code. When the reception is acknowledged the connection is automatically released. If congestion or any other hindrance occurs when establishing the connection, the alarm signal transmitter repeatedly tries to complete the connection until it succeeds. At least once every 24 hours each alarm signal transmitter is checked. A check call is made from the Supervisory Centre to the signal transmitter's check number, causing the transmitter to start and repeat any existing alarm signals or to send an OK signal.

The alarm signals are grouped according to their degree of urgency and can be co-ordinated by the Supervisory Centre staff with other reports. Personnel can then be sent to the exchange where they are most needed.

In the Supervisory Centre the fault reports and job cards are filed in pigeon-holes, one for each exchange (Fig. 4). Once a job has been allocated, the fault reports and job cards are transferred from the exchange pigeon-hole to the pigeon-hole of the man to whom the job is given.

## Control of Visitors

In connection with the alarm signal transmitter a supervisory measure of some importance may be mentioned, namely the control of visitors to the exchanges. At every exchange the door of the switchroom is kept under supervision. The procedure is that, when the door is opened by a key, a contact in the lock closes, causing the signal transmitter to transmit the exchange code together with a door code to the Supervisory Centre. A telephone set is connected to

**Fig. 4**
**Job distribution and supervisory centre**

each end of the connection and the ringing signal is sent both sets. The idea is that the visitor shall answer the call and state his name and the reason for his visit. If he has no key he can obtain connection with the Supervisory Centre by pressing a button and, after stating his errand, ask the Supervisory Centre to send a signal to open the lock. The lock is electrically operated.

## Fault Tracing

We have purposely dwelt on the subject of the transmission of alarm signals to the Supervisory Centre because an immediate report of the events in the exchange is the basic presumption for quick action for the location and repair of faults.

In order to facilitate fault tracing the number in each group of 100 numbers in which the last three digits are identical has been selected as test number, for instance xxx222. The test numbers (speech wires and meter wire) are concentrated on a test number concentration rack, or in smaller exchanges on test number strips. By this means automatic test traffic devices and other test equipments can be put into operation immediately without lengthy preparations. Some of the test numbers can be allocated to the staff as personal telephone, but with priority for test calls.

Besides technical knowledge and experience, the staff should be equipped with the necessary instruments, testing devices and tools together with means of conveyance. Fault tracing is done with exchange testers, automatic route testers, automatic number generators, pulse recorders, earthing meters, attenuation meters and/or several types of manual test devices.

The maintenance staff reports the results of the tests, the causes of disturbance and action required (which are also entered in a record at the exchange concerned), the time spent on the job, and the number of kilometres to the Supervisory Centre, where the reports are entered on special forms. Faults are treated in the same way at attended and unattended exchanges. The results of the investigations of subscriber fault reports are passed on to the Complaints Service for entry in the subscriber's file and, if necessary, for communication to the subscriber.

## Data Processing

The reports are statistically analysed, coded and transferred to punched cards for subsequent data processing. For the maintenance service the surveys showing the condition in the various exchanges and the occurrence of equipment disturbances are the most important factors. Decisions regarding preventive measures are based on these data and a subsequent technical check. Having decided upon the necessary measures—whether for overhaul of selector equipment, circuit modification, replacement of parts, etc.—the work is carried out by specially trained staff, the mobile work groups. The personnel for these groups are selected according to demand, and women are also employed on adjustment, cleaning and lubrication procedures.

## Operational Results

A scrutiny of the operational results from the last few years shows that the failure rate (failed or disturbed connections) for the different crossbar exchanges varies slightly, but with a tendency to stabilize at 1.5 failures per

*Table 2. Results of Operation 1960—1964*

| Centrum 5 and 6 crossbar exchanges | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|
| Lines (mean) | 12.807 | 13.369 | 13.841 | 13.792 | 13.274 |
| kWh/line and year* | 10.0 | 9.7 | 9.5 | 9.0 | 8.6 |
| Failure rate** technical failures/1000 connections | 1.9 | 1.5 | 0.6 | 1.5 | 2.0 |
| Failure reports/1000 lines — Total | 250 | 220 | 180 | 150 | 140 |
| Work hours/line — Total | .7 | .9 | .4 | .5 | .5 |
| Failures/100 kWh* | | 1.9 | 1.9 | 1.7 | 1.6 |
| Work hours/100 kWh* | | 11.4 | 7.1 | 5.7 | 6.4 |
| Fault tracing hours/report | 1.0 | 1.4 | 1.2 | 0.9 | 2.2 |
| Number of power plants | 1 | | | | |

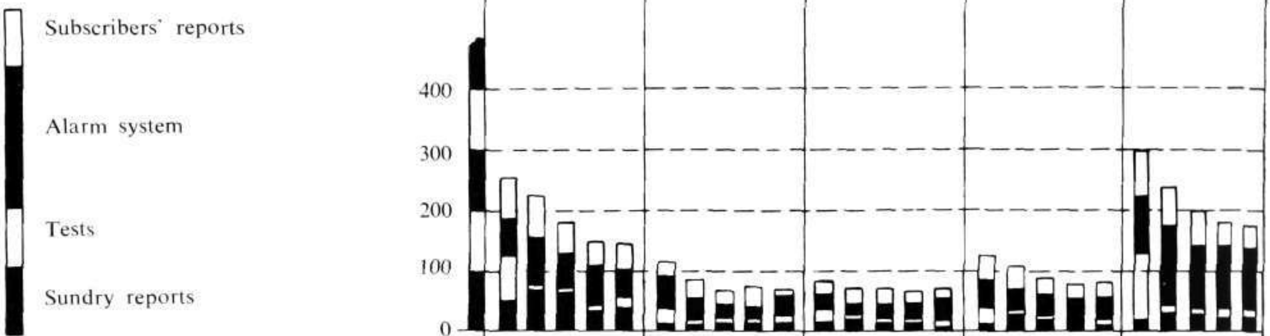
| Sörnäs crossbar exchange | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|
| Lines (mean) | 17.913 | 18.591 | 20.454 | 22.026 | 23.167 |
| kWh/line and year* | 4.7 | 5.0 | 5.1 | 5.4 | 5.3 |
| Failure rate** technical failures/1000 connections | 2.5 | 1.8 | 1.9 | 1.7 | 1.5 |
| Failure reports/1000 lines — Total | 110 | 80 | 60 | 70 | 70 |
| Work hours/line — Total | .6 | .4 | .3 | .3 | .4 |
| Failures/100 kWh* | | 1.4 | 1.2 | 1.2 | 1.3 |
| Work hours/100 kWh* | | 10.3 | 9.0 | 5.8 | 7.0 |
| Fault tracing hours/report | 2.0 | 1.6 | 1.6 | 1.4 | 2.0 |
| Number of power plants | 1 | | | | |

| Sörnäs suburban crossbar exchanges | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|
| Lines (mean) | 15.358 | 17.412 | 21.507 | 24.191 | 29.327 |
| kWh/line and year* | | 6.4 | 5.7 | 5.9 | 5.8 |
| Failure rate** technical failures/1000 connections | | | | | |
| Failure reports/1000 lines — Total | 80 | 70 | 70 | 60 | 70 |
| Work hours/line — Total | .3 | .4 | .2 | .2 | .2 |
| Failures/100 kWh* | | 1.3 | 1.2 | 1.0 | 1.2 |
| Work hours/100 kWh* | | 6.8 | 3.8 | 3.2 | 3.9 |
| Fault tracing hours/report | 2.1 | 1.6 | 1.4 | 1.4 | 1.4 |
| Number of power plants | 11 | | | | |

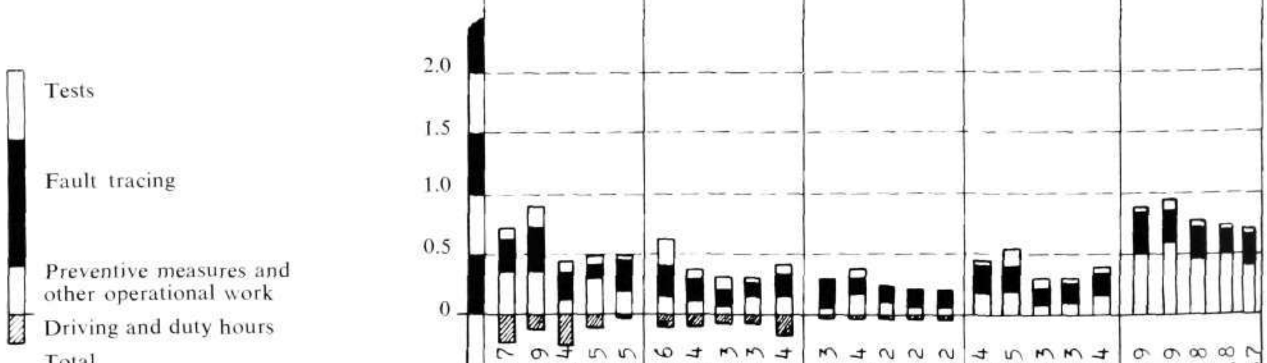
| Total for all crossbar exchanges | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|
| Lines (mean) | 56.764 | 60.604 | 68.330 | 75.247 | 81.518 |
| kWh/line and year* | | 6.7 | 6.4 | 6.5 | 6.4 |
| Failure rate** technical failures/1000 connections | | | | | |
| Failure reports/1000 lines — Total | 130 | 110 | 90 | 80 | 80 |
| Work hours/line — Total | .4 | .5 | .3 | .3 | .4 |
| Failures/100 kWh* | | 1.5 | 1.4 | 1.2 | 1.3 |
| Work hours/100 kWh* | | 8.8 | 6.2 | 4.8 | 5.9 |
| Fault tracing hours/report | 1.6 | 1.6 | 1.4 | 1.3 | 1.8 |
| Number of power plants | 23 | | | | |

| Total for HTF*** exchanges | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|
| Lines (mean) | 140.316 | 149.075 | 161.134 | 173.735 | 185.463 |
| kWh/line and year* | | 8.1 | 8.2 | 8.1 | 8.2 |
| Failure rate** technical failures/1000 connections | 3.6 | 4.3 | 4.4 | 5.0 | 4.5 |
| Failure reports/1000 lines — Total | 300 | 240 | 200 | 190 | 180 |
| Work hours/line — Total | .9 | .9 | .8 | .8 | .7 |
| Failures/100 kWh* | | 2.7 | 2.5 | 2.4 | 2.2 |
| Work hours/100 kWh* | | 12.5 | 10.3 | 9.2 | 8.9 |
| Fault tracing hours/report | .9 | 1.0 | 1.1 | 1.0 | 1.2 |
| Number of power plants | 139 | | | | |

Failure reports/1000 lines




Work hours/line




* Energy consumption in telephone exchange

** Values determined by means of test connections internally within the respective exchanges. The values for HTF were determined by means of traffic observations of subscriber controlled traffic, including inter-exchange traffic.

*** Helsinki Telephone Company

1,000 connections, and for all exchanges, irrespective of type, at about 4.5 failures per 1,000 connections (Table 2). It should be noted, however, that the rates are not directly comparable, as the crossbar exchange figure is based on internal test connections while the figure for the entire Helsinki Telephone Company is derived from traffic observations, i.e., observations of subscriber-dialled traffic, which may, of course, go to any exchange. In the latter case the result will be influenced by junction lines, repeaters and matching equipment.

The number of disturbances (fault reports related to the exchange, alarms etc.) at crossbar exchanges has stabilized at 70 to 80 per 1,000 lines and year, of which 25 per 1,000 lines are subscribers' complaints, and for all exchanges 110–180 and 35 respectively.

The average number of direct working hours per line and year is 0.3 for the crossbar exchanges and 0.6 for all Helsinki Telephone Company exchanges.

The cost for spare parts for crossbar plants has amounted to US $0.03 per line and year.

## Targets for Operational Department

In order that an Operational Department may attain the aims mentioned under the heading "Helsinki Practice", certain targets should be laid down as tabulated below.

| | |
|---|---|
| 1. Failure rate in junction network (failed connections recorded in traffic observations) | ≤ 0.5 % |
| 2. Intelligible crosstalk | ≤ 0.001 % |
| 3. Metering faults | + 0.001 %<br>− 0.05 % |
| 4. Faults reported by subscribers per annum and telephone | ≤ 0.5 |
| 5. Mean loss of subscriber-subscriber calls during heavy-traffic periods (established by test connections) | |
| a) city traffic | ≤ 1 % |
| b) entire network | ≤ 2 % |
| 6. Repair times for subscribers connected to public exchanges | |
| a) faults repaired on reporting date (1st day) | 60 % |
| b) faults repaired on 2nd day | 92 % |
| c) faults repaired on 3rd day | 99 % |

## The Future

Without attempting to guess at the future of electronic exchanges, it is obvious that the trend in the maintenance of the present electromechanical equipment is towards greater automation. Signs of this are automatic defect spotting equipment, automatic metering and controls from which the results are registered straight on punched cards, punched tape or magnetic tape. Trials with increasingly automatized defect spotting equipment are being made by telephone companies and equipment manufacturers. It is certain that automatic equipment will release much of the present operational staff. On the other hand it will call for far higher qualifications in the remaining operational and maintenance personnel.

# L M Ericsson's Crossbar Systems—Developments in Components and Mechanical Equipment

A. REJDIN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.344.6
LME 83021

*Ericsson Review No. 4, 1966, contained an article entitled "L M Ericsson's Crossbar Systems, Their Development and New Traffic Facilities". That article dealt only summarily with the developments in components and mechanical equipment. The present article therefore presents a more complete account of these developments.*

L M Ericsson's crossbar systems comprise the public local system *ARF*, rural system *ARK*, transit system *ARM*, line concentrators *ARL* and telex exchanges *ARB*.

These extremely flexible systems are based on the principle of plug-and-jack connection of relay sets, and of the switch racks and certain relay racks to the exchange cabling. They are also characterized by a uniform mechanical structure. Most components are common to all systems. This has great advantages from the points of view of operation and maintenance.

Through intimate cooperation with customers, analysis of operation results, and continuous attention to new developments and improvement of quality, L M Ericsson has increasingly perfected its existing components and introduced new and more reliable types.

Components and equipments have also been successively designed to allow a high degree of automation in production and tests.

## The Crossbar Switch

The crossbar switch is an old Swedish invention. The first patent was filed in 1919 by Betulander-Palmgren (Fig. 1). Palmgren was for many years the head of L M Ericsson's laboratory. It is interesting to note that the first crossbar switch made in accordance with this patent has essential resemblances to the crossbar switch made by L M Ericsson today.

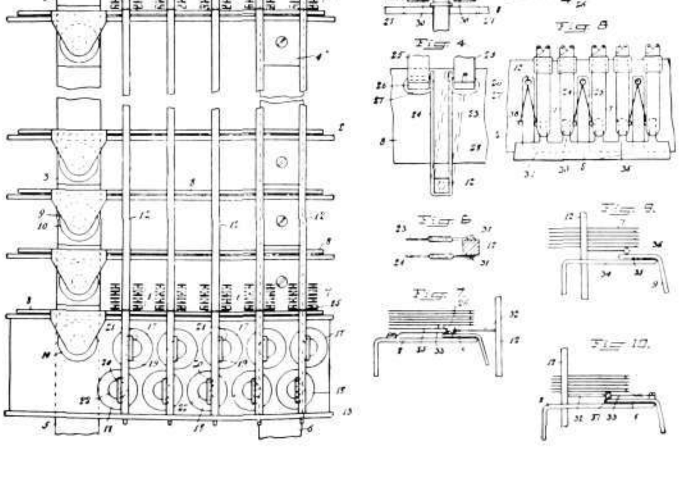


**Fig. 1**
**Betulander-Palmgren's crossbar switch according to Swedish patent 49816 from 1919**

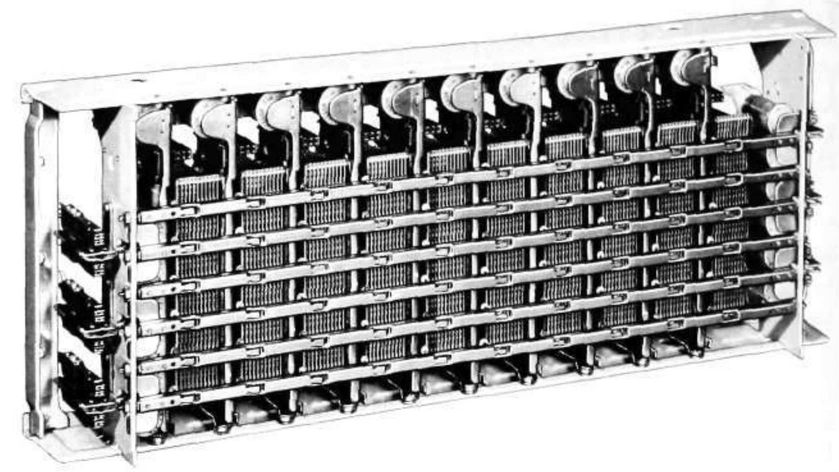


**Fig. 2**
**L M Ericsson's new crossbar switch**

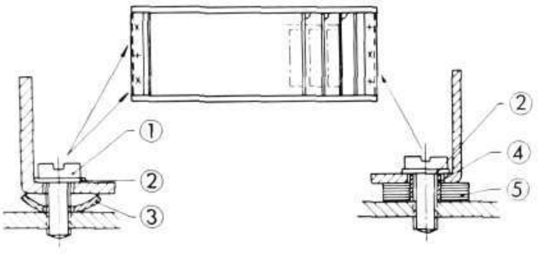


**Fig. 3**
**Attachment of the switch on the rack**
① Screw ECS 6 × 14 SO3
② Washer SCA 28 101
③ Washer 428 099
④ Tube SCS 20 301
⑤ Packing SCG 30 261

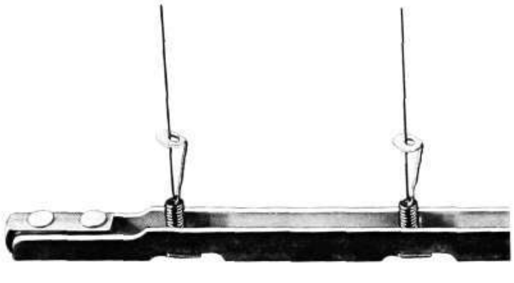


**Fig. 4**
**Part of horizontal with selecting finger damper**

Different types of crossbar switch now exist on the world market. The design of Ericsson's chief type, with 6 horizontals and 10 verticals, was preceded by extensive economic and technical investigations. Switch design is an important factor in the overall economy of an exchange; and it has been confirmed by later calculations, made both by our licensees and ourselves, that the design of switch adopted has resulted in good economy and minimum maintenance in the various kinds of crossbar exchanges in operation today.

Even if the crossbar switch resembles the original in its fundamental principles, it has been redesigned on several occasions. The latest major alterations are now being incorporated into the production (Fig. 2). The modifications have been based on a thorough analysis of operational results. The aim has been a stable product manufactured with a high degree of mechanization and in controlled processes. The main changes are briefly:

- The switch frame has been stiffened by lengthening the bent-down edges of the side pieces. The vertical is now fixed in one of the two holes in the side pieces instead of in the earlier slots. The effect of external forces on the switch is reduced by means of vertically resilient brackets. The switch is fixed to the rack by three screws. Two domed steel washers are placed between the switch frame and upright on one side of the switch. A relatively thick rubber washer is used at the third point of attachment (Fig. 3). This arrangement prevents strain on the switch in the event of deviations from the dimensional tolerances for the uprights. Accurate adjustment is therefore better maintained during installation, testing and transport.

- The introduction of an accurately dimensioned selecting finger damper ensures brief transients and more reliable function (Fig. 4).

**Fig. 5**
**Relay springsets in crossbar switch**

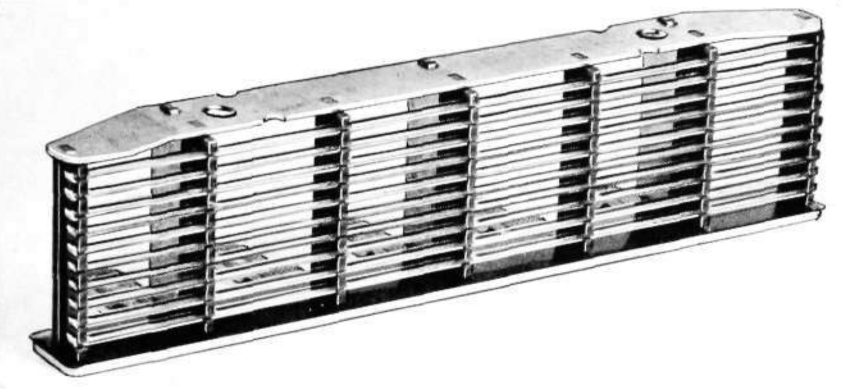


Fig. 6
Contact frame

☐ The modern relay springsets have been introduced as horizontal and vertical springsets (Fig. 5). These give the switch a favourable load characteristic and very long life and enable the same method of adjustment to be used for relays and switches.

☐ The contact strips and their frame are of entirely new design, suited for automatic production. They are stable, have very small dimensional variations, and thus ensure uniform contact forces. The materials are so stable that the function is not affected even by heavy variations of temperature and humidity (Fig. 6).

☐ New horizontal magnet circuits, new horizontal dampers and new springsets have increased the speed of the switch (Fig. 7). This advantage has usually not been utilized in existing systems in view of the desire to retain replaceability. The time gains have instead been utilized as extra safety margins.

☐ Detailed changes have been made at many other points in order to create a standard product with increased reliability for the customer. The modifications have been subjected to severe tests at every point. The modified switch constitutes a fully functional replacement of the earlier switch.

Fig. 7
Horizontal magnet circuit with horizontal damper and associated relay springset

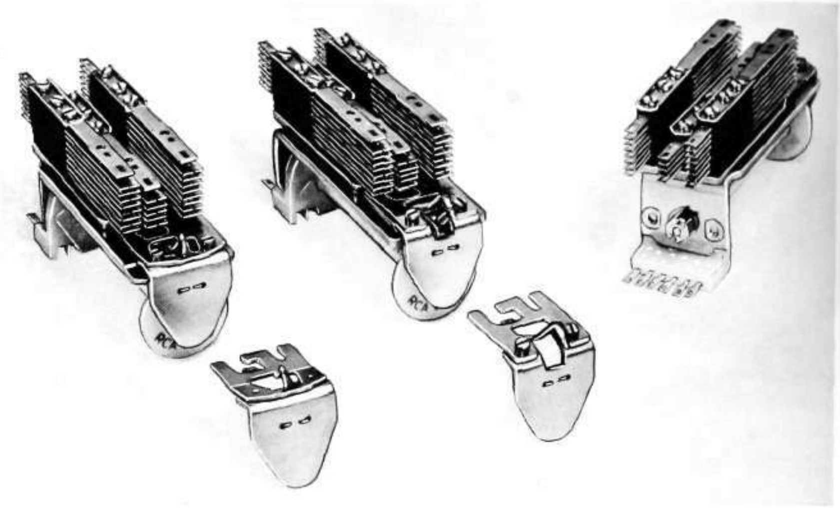


Fig. 8
Relays RAF and RAB
In the foreground the relay armatures

# Relays

## *General Telephone Relays*

The main relays in the crossbar systems are the two types *RAB* and *RAF*. They are designed on the same principles and both have an angular armature. The main difference is that the armatures have different leverage ratios. The two types supplement one another in respect of operate and release times, together providing a wide range of applications. The range of coils and springsets is common to the two types.

In recent years the relays have been modernized and improved in several respects (Fig. 8). The main aim of the modifications was to adapt the relays to modern manufacturing methods which yield a more uniform product. Reliability questions were considered at the same time. Some of the main improvements are listed below:

- High-class modern insulating material has been introduced in coils and springsets, which gives the relays a very good resistance to temperature and humidity stresses.

- The attachment of the relays in relay sets has been improved. In conjunction with the change to two-hole attachment the heel ends of the yokes have been formed so that impact and vibrational stresses arising during handling and transport do not affect the functional data or mechanical adjustment of the relays.

- The suspension of the armature on the yoke has been improved in both types. Precise coining of the fulcrum, combined with appropriate distribution of the forces, ensures a very long life even under severe operating conditions.

- The relay armature tongues, which actuate the springsets, have been modified to allow quicker and simpler adjustment.

- The springsets have been redesigned. Modification of the shape of the load-carrying parts and improvement of the form of the points of support in relation to the yoke provide increased stability and more reliable function.

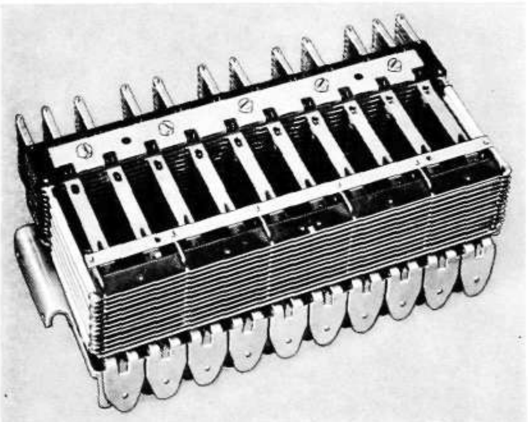


Fig. 9
Multicoil relay RAM

## *Special Relays*

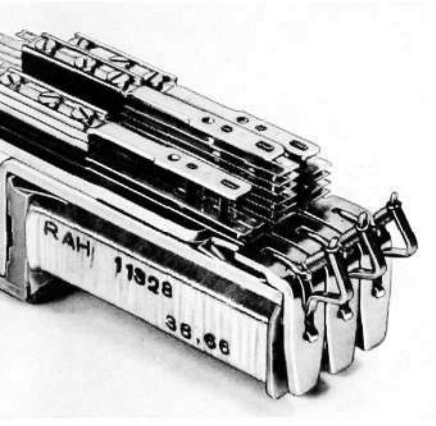



**Fig. 10**
**Three-coil relay RAH**

In some simple applications, such as switch control circuits and digit storage, two types of special relays are used. A characteristic feature of these relays is their compact structure.

The multicoil relay *RAM* with 10 armatures on a common yoke has a multiple of the same kind as that of the crossbar vertical. The moving contact members are operated groupwise by the armatures, while the fixed members are common to all functional units (Fig. 9).

The three-coil relay *RAH* (Fig. 10) is equipped with three armatures pivoted on a common yoke. Each armature operates its own springset and the relay thus contains three independent functional units. The relay occupies the same space as a *RAB* or *RAF* relay.

## *Reed Relays*

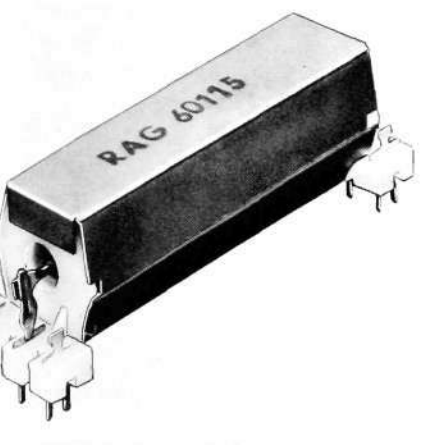



**Fig. 11**
**Dry reed relay RAG**

Reed relays have also been introduced as switching elements in modern crossbar systems. They are of two kinds, with dry or mercury-wetted contacts.

Owing to the small dimensions of their moving parts the reed relays are extremely rapid. Their normal functioning times are 0.5–2 ms.

There are two types of *dry reed relays* (Fig. 11), one with one and the other with two glass capsules each containing one make-contact. The encapsulation of the contacts protects them completely against dirt and atmospheric action.

A specially tested coating of the contact surfaces in combination with a conditioned atmosphere in the capsule gives the contact very good circuit-breaking properties and extremely reliable function.

The *mercury-wetted contacts* (Fig. 12) are also enclosed in a glass capsule containing a small quantity of mercury which wets the contact points. The circuit-breaking thus takes place in a drop of mercury and there is no contact erosion. The reliability of this contact as well is extremely good.


**Fig. 12**
**Mercury-wetted relays**

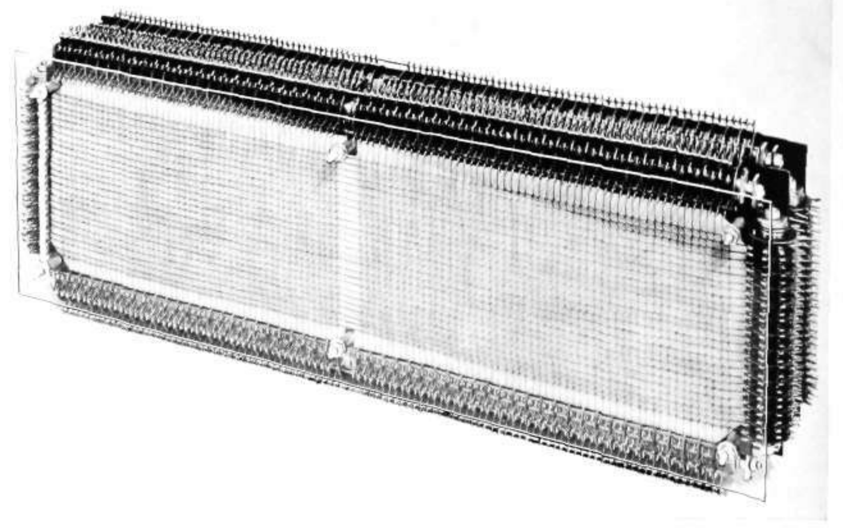


Fig. 13
Ferrite matrix in toll-ticketing equipment

## Electrical and Electronic Components

Various new electronic components have been introduced in recent years, especially semiconductors such as transistors, thyristors and diodes. The types that are now used were selected after extensive tests. The determining factor in the choice of component types has been their reliability and resistance to environmental stresses.

- RC units have replaced previous types of varistors and, being excellent contact protectors, have greatly increased the life of relays
- Cracked carbon resistors have come into use in place of earlier types of wire-wound resistors
- Heat-resistant and moisture-resistant capacitors have replaced previous types
- Copper oxide and, to some extent, selenium rectifiers have been replaced by silicon diodes of modern design
- Transformers with ferrite core have come into use
- Ferrite matrices are used as stores in toll-ticketing and other equipment (Fig. 13).

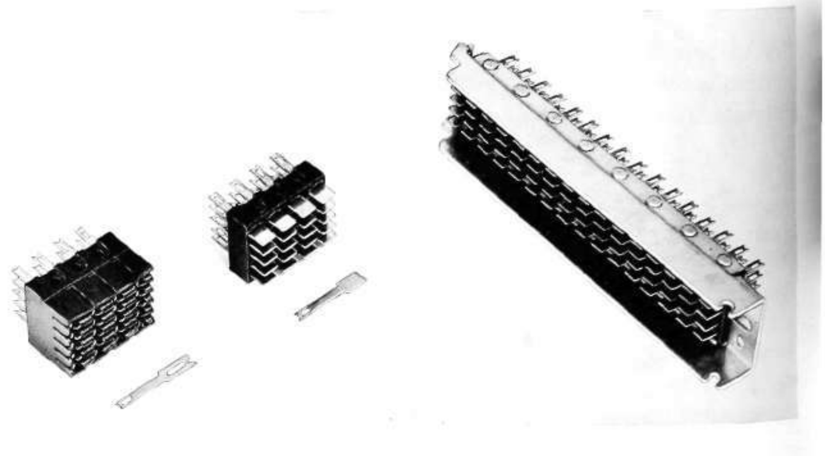


Fig. 14
Jack RNV 2051, plug RPV 2051 and an 80-point plug unit
In the foreground the terminals of the respective units

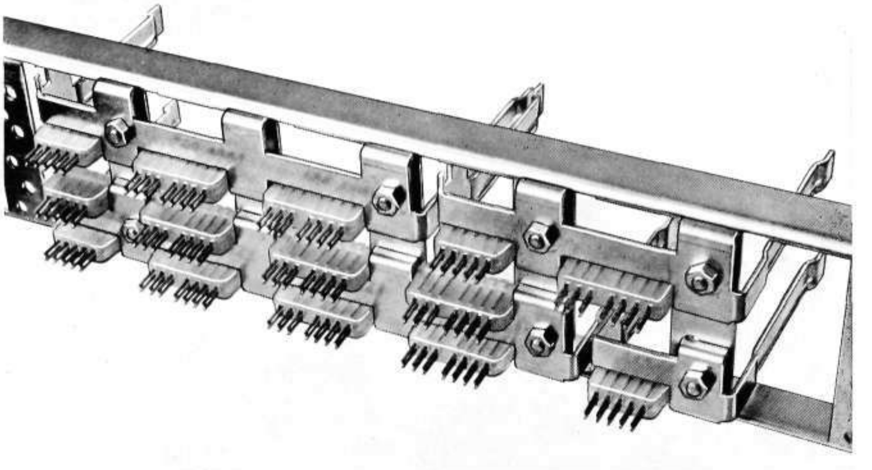


**Fig. 15**
**Jack unit RNV 212 mounted on a BCH bar**

## Other Components

Plugs and jacks are important components in telephone exchange equipments. Two of the most important types used in crossbar systems are the following:

- The 20-point jacks *RNV 2051* and plugs *RPV 2051* are the most used types. They are employed mostly for connection of relay sets to the rack cabling and of racks to the exchange cabling. They are extremely reliable and robust and have been perfected in recent years by minor modifications. These can be combined into larger units, the most usual type of which is the 80-point unit used in *BCH* relay sets.

  The terminals consist of a forked and a flat section. When a flat terminal is inserted between the two members of a forked terminal, the latter are separated and provide a high and uniform contact force without torsion (Fig. 14).

- The jack unit *RNV 212* is used for printed circuit assemblies. There is a 5-point and a 7-point model. The units consist of a row of obliquely placed terminals which are inserted in a plastic base and locked by spring action. The jack unit is designed for mounting on a relay position and is attached between the relay set frame and a screwed-on bracket which serves also as guide for the printed circuit card (Fig. 15).

Another component is the printed circuit card *ROA 120–121* which was designed in order to make use of the good functional properties of modern components intended for printed wiring (Fig. 16). The card has eight soldering tags, the positions of which coincide with those of a relay springset when the card is placed in its bracket in a relay position. Three cards can be mounted in one relay position, which permits great concentration of the components. A number of wiring patterns have been standardized, but special patterns can be supplied. The adjustment of trimming resistors, for example, can be done without needing to remove the printed circuit cards from the relay set.

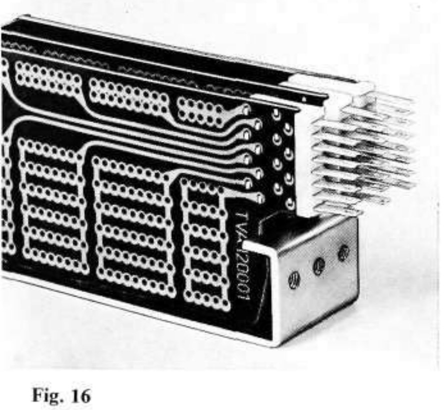


**Fig. 16**
**Printed circuit card ROA 120—121**

## Racking and Relay Bars

In conjunction with the design of the rural exchange *ARK 101*, which was introduced at the year end 1946, an entirely new mechanical system was developed.

The characteristic feature of *ARK 101* was that all multipling was done in the direction of the vertical unit, which determined the form both of racks and relay sets. A terminal block was designed with as nearly as possible the same tag pattern, and also with the same module, as a crossbar vertical. A number of these terminal blocks formed a terminal field for connection of the exchange cabling to the racks.

In the late 1940's the bypath system *ARF 10* was developed. This placed new requirements on the mechanical design, chiefly from the cabling point of view. Multipling in this system is partly in the direction of the horizontal and partly of the vertical unit. The same terminal field is used, however, for the connection of the exchange cabling to the rack. Plug-in relay sets *BCG* are used for the most part.

The relatively large quantity of cabling required both on and between racks gave rise to the development of the new method. The testing methods which were under development at the same time also had their influence. During the latter part of 1953, therefore, the construction practice was developed which is still used for permanently cabled racks in systems *ARF* and *ARM*.

The main change was that the rack uprights were made more commodious and that the incoming cabling was connected by plug and jack. The racks were equipped with 360-point jack units and the exchange cabling with 40-, 80-, 120- or in some cases 360-point plugs. This provided the means both of simple and methodical connection of test equipment and also permitted the exchange cabling to be completed before the racks arrived on the site of installation. The cabling method has been further developed in the course of the years; and the short time of installation for these types of exchanges is due to a large extent to the better facilities for rational cabling and testing that the plug-and-jack connection provides.

In the last 10 years the *BDE* racks with relay sets *BCG* have been increasingly replaced by *BDH* racks with relay set *BCH*. The latter construction practice has a greater capacity as regards plugs and jacks, and all relay sets are of plug-in type (Fig. 17). The *BDH* racks are well adapted for the use of jack units (Fig. 18).

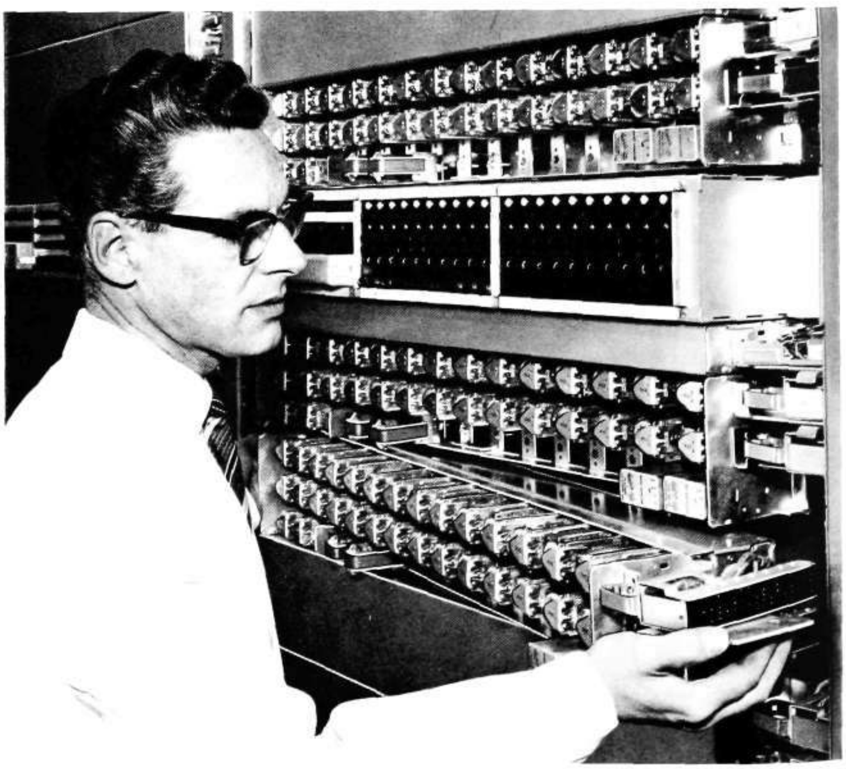


**Fig. 17**
**Relay set BCH with plug and jack**

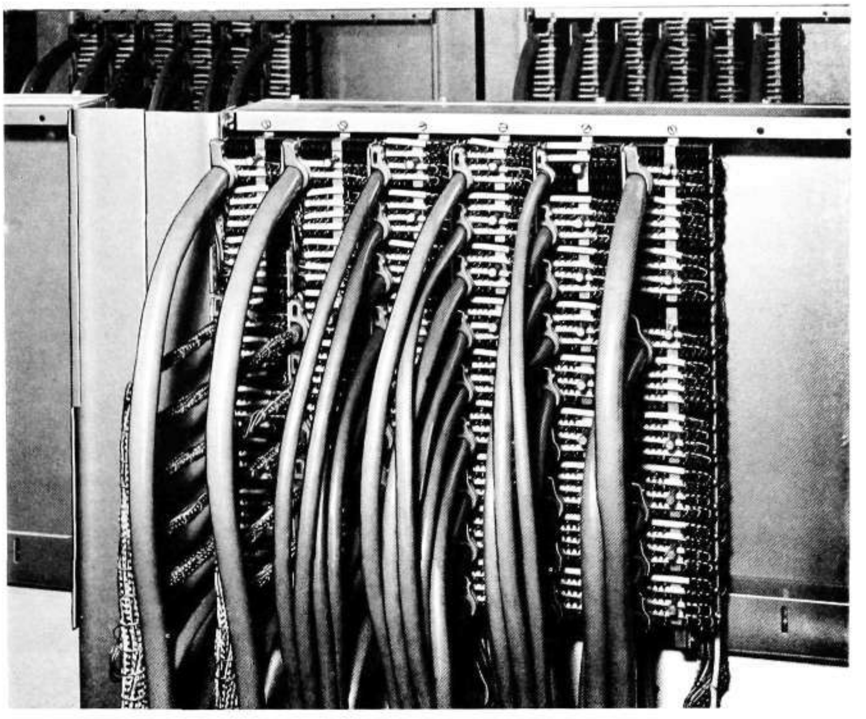


Fig. 18
Vertically mounted rack jack unit

L M Ericsson's modern crossbar systems, therefore, are today constructed on uniform principles, the use of plug and jack connection offering many advantages, among which the following may be particularly mentioned.

- Soldering is done on a uniform and standardized terminal unit which ensures a uniform and reliable result
- The jack units provide simple and reliable terminations for testing and checking of the racks, which is done in automatic equipment in the factory prior to delivery
- As an appreciable portion of the exchange cabling is made for plug-in connection, both the cabling and testing work can be done before the racks are installed on site
- Since the racks need not be in position during a large part of the cabling work, the working conditions for the installation personnel are very much improved, which results in better work
- Cabled racks can be replaced without lengthy interruption of service.

## Reliability

Reliability is naturally of extreme importance in the choice of telephone system. The telephone systems referred to in the introduction are predominantly made up of Ericsson crossbar switches and relays, which comply with very high requirements. The mean time between failures for the crossbar switch is 40–50 years and for the relays 400–500 years. These figures apply even when switches and relays are not subjected to preventive maintenance. To simplify and cheapen maintenance of L M Ericsson crossbar exchanges, it is part of our maintenance philosophy that preventive maintenance shall never be employed.

Fig. 19
Interior of an ARF 101 switchroom

To ensure correct quality of equipment, a continuous reliability assessment is made of components. This constitutes an integral part of the company's quality control system. The assessment is made in the Components Laboratory. The components are sampled directly from the production in accordance with a special program. Tests are made in accordance with fixed programs which differ according to the type of component. Apart from checking of adjustment, mounting, finish etc., the tests comprise functional, environmental and life tests.

## Installation

As already pointed out, the relay sets are of plug-in type and the racks are connected to the exchange cabling by means of jack units, which greatly facilitates installation (Fig. 19). A few other properties that have been worked into the systems in order to simplify and cut down the cost of installation work are:

- The racks are cabled and automatically tested in the factory prior to delivery
- A trough type cable runway is used which greatly simplifies the cabling and also presents a tidy appearance
- All racking and cable runways can be installed and all cabling work, including skinners to the jacks, can be done with the aid of simple forms of equipment before the cabled racks and relay sets are plugged-in.


Fig. 20
New RSA subscriber meter
In the background the type employed hitherto

## Future Plans

The development of mechanical equipment and components for L M Ericsson's crossbar systems is proceeding continuously. One example is that, before the end of 1967, production is to be started on an entirely new and improved subscriber's meter (Fig. 20). Production is also starting on C-core transformers for mounting on printed circuit cards, and on a new type of rectifier with selenium plates cast in epoxy resin. The successive developments are often based on very intimate cooperation with our customers.

# Power Supply and Alarm Arrangements in M4 Transmission Equipment

R. GUSTAFSSON & G. KROONI, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.311.4:621.395.722
LME 8475 8477

*The article describes power supply and alarm arrangements in transmission equipment engineered in the M4 construction practice. A decentralized power supply is employed, which means that each bay has been provided with its own power pack for the generation of the –21 V transistor voltage. These power supply units are regulated and designed for connection to non-stabilized mains or battery voltages.*

*Two types of alarm are provided: urgent (A) alarm for fault conditions interfering with traffic, non-urgent (B) alarm for other fault conditions. Facility is provided for disconnecting alarm functions, a reminder indication being brought up at the same time. The same power supply and alarm arrangements are used in practically all bay types.*

## Power Supply, General Principles

The transmission equipment engineered in the *M4* construction practice is fully transistorized. The only operating voltage required is the – 21 V transistor voltage, which is obtained from the power pack placed at the bottom of the bay. Normally each bay is equipped with one power supply unit, but if a standby supply unit common to a number of bays is considered necessary, this can be placed in any one of the bays concerned. Owing to the use of standardized power supply cabling, previously-supplied bays can be easily supplemented with a standby set. Also, one power supply unit can feed several bays provided that the total power consumption does not exceed 300 W.

### *Circuit Breakers*

On fuse failure considerable overvoltages of a few microseconds' duration may develop due to the cable inductance. The magnitude of the overvoltage depends on the design of the protector device, the type of cable and how the cables are run. The use of magnetic circuit breakers in the *M4* design is advantageous in this respect.

The primary voltages are normally distributed to the respective power supply units in a suite of bays via individual circuit breakers arranged in the suite end cabinets. Where no suite cabinets are provided the circuit breakers can be placed in the left-hand bay upright on a level with the power supply unit.

### *Distribution of Secondary Voltage –21 V*

The secondary voltage from the power pack is distributed to the various shelves and shelf stacks via fuses in a central shelf called service shelf. This service shelf, which can be withdrawn, provides a fuse distribution field permitting strap connections to be established between the fuses and the standardized power distribution cable in the right-hand bay upright. The various strap connections are indicated in the circuit diagram of the bay concerned. The service shelf and the shelf assemblies to be supplied with power are connected to the inter-shelf cabling by plugs and jacks.

The jacks for the connection of the transistor voltage are placed all along the right-hand bay upright. This arrangement provides a very high degree of flexibility in assembling the shelves and shelf stacks into bays.

## *Standby Power Arrangements*

The high degree of power supply reliability has made it possible to supply the power required for the apparatus accommodated in one bay from a single supply unit. Alternatively, a number of bays, e.g. a suite of bays, may be allocated one common standby unit, which can be placed above the regular supply unit in any one of the other bays where mounting space is available. The regular and standby supply unit are identical.

The arrangement with a duplicated power supply operates as follows. The regular supply unit is connected via a built-in diode to the distribution strip in the service shelf in the centre of the bay. Via an additional diode also a standby supply unit having a slightly lower output voltage can be connected to this strip. This diode protection enables one supply unit to be used as standby for several regular supply units. The secondary voltage from the standby unit is fed to the above-mentioned distribution strip via screw terminals at the top of the bay, from where it can be distributed to the required number of additional bays, no further cabling being needed in any of these bays. In fig. 1 the emergency power to bay no. 2 is supplied by the standby supply unit in bay no. 1.

## *One Power Pack Supplying more than One Bay*

If a number of bays have a total power consumption of less than 300 W, they can be supplied, if desired, from a single power supply unit, which can be provided with a standby unit as described in the previous paragraph. The requisite connections are made at the top of the bay. No additional bay cabling is required. Fig. 1 illustrates how the regular and standby power supply units in bay no. 1 supply bay no. 3.

## *Two Separate Systems in One Bay*

A bay may contain two separate systems supplied from supply units I and II via their respective distribution strips. The strapping which normally connects the two strips must be removed in this case. The connections for bay no. 4 are shown in fig. 1.

**Fig. 1**

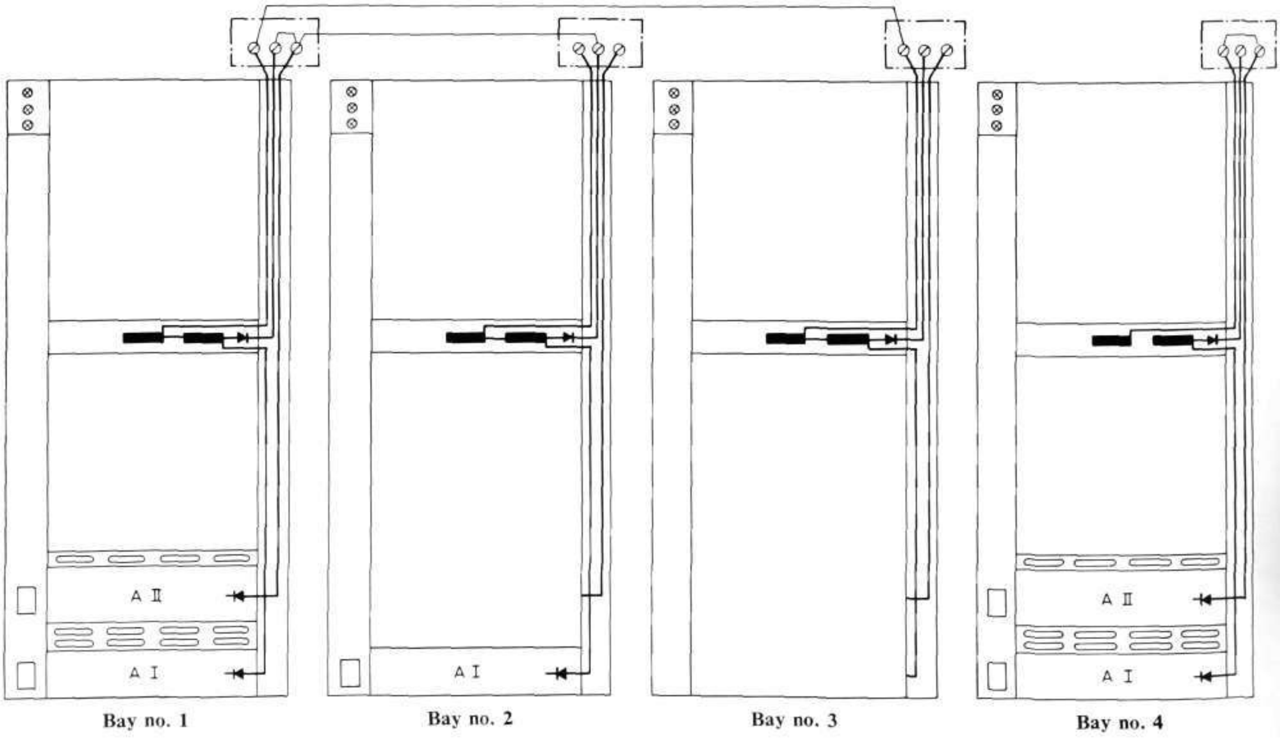
**Distribution of secondary voltage – 21 V from power supply units to distribution strips in service shelf.**

**Bay no. 1 contains one regular and one standby supply unit, the latter being used as standby for the regular supply in bay no. 2 as well.**

**Bay no. 3 receives its voltage from the duplicated power supply in bay no. 1. The total power requirement for bays no. 1 and no. 3 shall be less than 300 W.**

**Bay no. 4 contains two separate systems supplied from unit I and II respectively via corresponding distribution strips in the service shelf of the bay.**

**A I Power supply unit I, regular**
**A II Power supply unit II, standby**



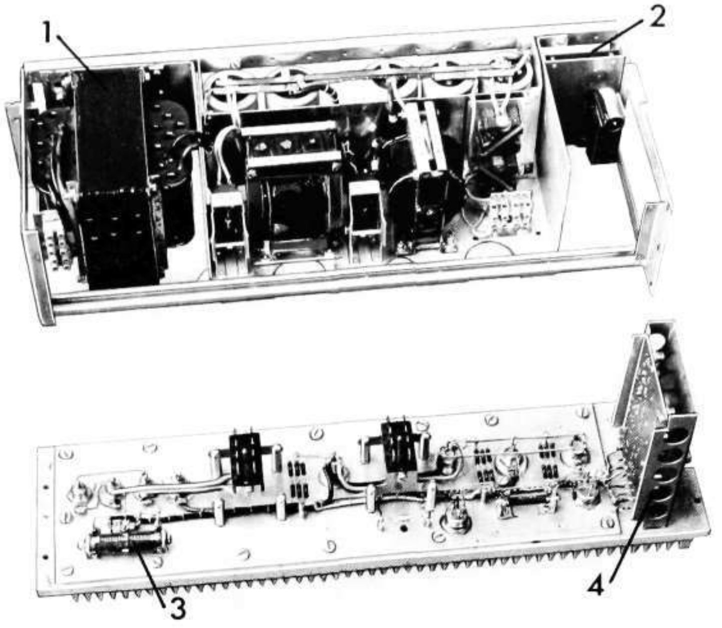



**Fig. 2**
**AC power unit with heat sink removed**
1 Mains transformer
2 Alarm circuit
3 Short-circuit and overvoltage protector
4 Trigger circuit

## *Earthing*

On the basis of experience the station earth system has been arranged to combine the earthing of all station equipment, such as h.f. equipment, power supply, bay frames, cable run irons, etc. into a uniform, closely-meshed network.

To provide the good earth connection which is so essential for transmission equipment, an earth strip has been mounted inside the shelves and shaped so that it is automatically connected to the copper earth bar of the bay when the shelf is screwed into the bay. The bay earth bar is connected to the station earth system.

## Power Supply Units

The power for the shelves and shelf stacks is provided by a common power pack in each bay.

The rated secondary voltage from this power unit is 21 volts ± 2 % for loads of 0–300 W.

The power units are available in three versions for operation from the following primary voltages
- mains voltage 48–65 Hz 110, 127 or 220 V ± 10 %
- battery voltage 36, 48 or 60 V + 20 %, − 15 %
- battery voltage 24 V + 20 %, − 15 %

## *Construction*

The three power unit variants have the same mechanical design and occupy when mounted in a bay its full width and depth as well as 3.5 height modules. Mechanically the unit consists of two main parts, as shown in fig. 2:

- ☐ chassis with mains transformer (only in mains-operated version), input and output filters as well as alarm circuit.
- ☐ heat sink, on which are mounted semiconductor devices (all silicon-type), trigger circuit, short-circuit and overvoltage protectors. The heat sink can be plugged into the chassis.

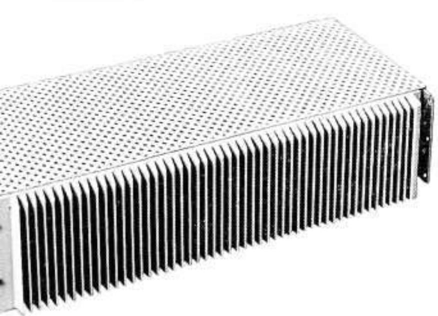


**Fig. 3**
**Assembled power unit covered with screening plate.**

## *Operation*

The simplified circuit diagram, fig. 4, shows the mains-operated version as well as the input circuits of the battery-operated versions. The 24-volt power unit is provided with a d.c. converter, which raises the input voltage, 24 volts − 10 %, to 30 volts.

The power is pulsed through a power transistor at a constant frequency but at variable pulse duration. The output voltage is then smoothed so that the superimposed alternating voltage has an arms value of less than 10 mV. Smoothing is effected by a double *LC* section. The energy stored in the inductance of the *LC* section is discharged between the pulses via a power diode. Also on the input side the power passes through an *LC* section. In the mains-operated variant the *LC* section is used for filtering the rectified alternating voltage and in the battery-operated version to eliminate interference towards the battery.

The power transistor is controlled by a trigger circuit, which is triggered by the output voltage, thereby maintaining this within ± 2 % even at such substantial changes in load as the transition from no load to full 300 W power drain.

The trigger circuit, which is assembled on an interchangeable printed-circuit board, operates as follows. A unijunction transistor acts as a sawtooth generator with a fixed frequency of 6.5 kHz. The sawtooth generator is followed by a Schmitt trigger, which is triggered at a certain sawtooth voltage level. This level is varied by an amplifier, which senses the difference between a reference voltage and the output voltage.

To achieve efficiency and power economy in bottoming and cutting off the power transistor two auxiliary voltages are provided. The saturation voltage is obtained from the secondary of one of the inductances incorporated in the output filter and the reverse bias from a capacitor which is charged across a voltage divider.

When the power unit has been started but the auxiliary voltage has not yet fully developed, the saturation current is provided by a starting transistor in series with a thermistor. After the power transistor has bottomed, the starting transistor is cut off and the thermistor is relieved.

The output voltage can be adjusted about ± 0.25 V by a simple strapping.

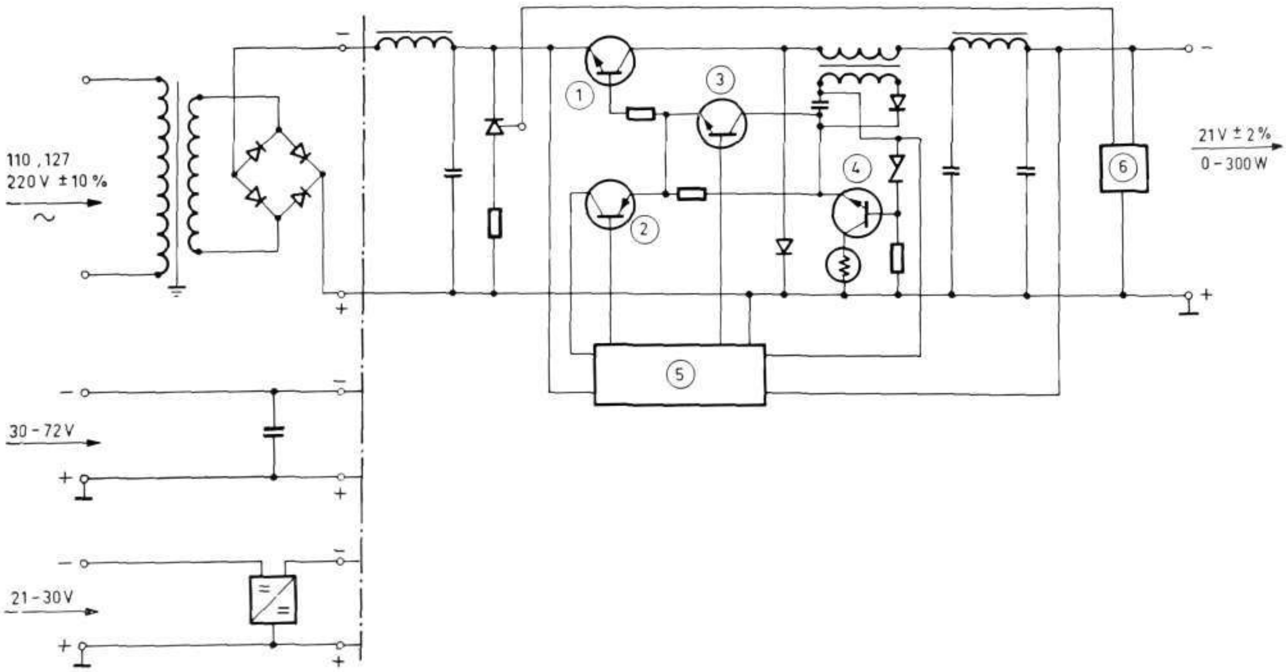



**Fig. 4**
**Simplified circuit diagram**

1. Power transistor
2. Control transistor
3. Control transistor
4. Starting transistor
5. Trigger circuit
6. Alarm circuit

## *Short-Circuit and Overvoltage Protection*

A thyristor in series with a low-impedance resistor is connected across the input of the power unit. On an overload or a short circuit occurring at the output a current sensing relay included in the alarm circuit operates. This bottoms a transistor, which, after an interval of about 10 msec fires the thyristor. The short-circuit current trips the power supply circuit breaker in the left-hand bay upright or in the common suite cabinet. At the same time an alarm signal (+) is extended from the alarm circuit to the bay service shelf.

The 10-msec time delay prevents the power unit circuit breaker being tripped in the event of short circuits after the secondary fuses placed in the service shelf.

In case of an excessive output voltage (25 volts) the above process is repeated, but the time delay before tripping is less than 1 μsec. Should the output voltage drop to 19 volts an alarm signal is extended to the service shelf.

## *Technical Data*

| | |
|---|---|
| Input voltage | |
| mains-operated version *BMN 90440* | 110, 127, 220 V ± 10 %, 48–65 Hz |
| battery-operated version *BMN 90441* | 36, 48, 60 V = + 20 %, − 15 % |
| battery-operated version *BMN 90442* | 24 V = + 20 %, − 15 % |
| Output voltage | − 21 V ± 2 %, positive to earth |
| adjustable by | approx. ± 0.25 V |
| Output power | 0–300 W |
| Efficiency | |
| depending on input voltage and load | 70–82 % |
| Interference | |
| towards battery | $<$ 1 mV |
| towards load | $<$ 100 Hz, $<$ 10 mV |
| | $>$ 500 Hz, $<$ 1 mV |

## Alarm Arrangements

Alarms are initiated by level faults, secondary voltage failures and blown fuses. Each of these fault conditions causes two lamps to glow, namely one indicator lamp to indicate the cause of the alarm, and one larger lamp at the top of the bay to show the fault type. Two types of alarms are sent out from the bay: urgent *(A)* alarm for fault conditions interfering with traffic, non-urgent *(B)* alarm for other fault conditions.

## *Level Alarms*

The level limit indicators incorporated in the carrier systems are provided with four alarm outlets. As will be seen from fig. 5, one of these outlets is connected to an individual indicator lamp for each level limit indicator or group of level limit indicators. Another outlet is connected to the common shelf alarm lamp, which is always lit when the alarm contact in any one of the level limit indicators closes. The alarm contact may consist of a relay but is in most cases a semiconductor circuit. Near the common alarm lamp, whose light is visible through a window in the cover strip along the lower edge of the shelf, is a non-locking push button which on being depressed lights the above-mentioned individual alarm lamp associated with the level limit indicator that indicates the faulty level. The individual alarm lamps are invisible when the cover strip is in its normal, i.e. closed, position.

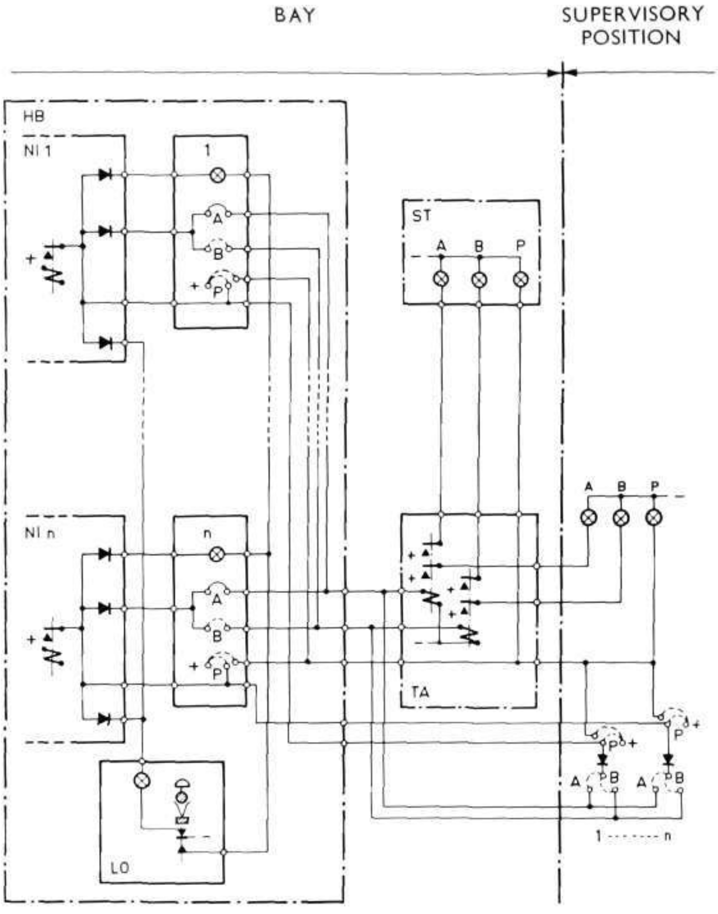



Fig. 5

**Basic circuit for adjustment and indication of level alarms.**

Adjustments between 'urgent', 'non-urgent' and 'reminder' indications are made by means of a U-link either in the bay or at the supervisory position. A U-link may be inserted at one of the two positions only.

- A Urgent alarm
- B Non-urgent alarm
- P Reminder indication
- HB Shelf stack
- LO Fault location
- NI Level limit indicator
- ST Bay top
- TA Service shelf

With the help of a small U-link in the maintenance strip of the shelf concerned the third of the diode alarm outlets can be connected to the 'urgent' or 'non-urgent' alarm relay in the bay service shelf. Adjustment to 'non-urgent' alarm indication is made when a frequency block is withdrawn from traffic. The fourth alarm outlet is intended for individual connection to the alarm circuit of the station.

When work is to be carried out on a group, supergroup, etc. link, its normal alarm indication can be changed into a 'reminder' indication by moving the respective U-link from the urgent *(A)* or non-urgent *(B)* jack to the adjacent jack designated *'P'*. Hereby the *P* lamp at the top of the bay and suite end cabinet, if provided, is lit; at the same time a positive voltage is applied to the central alarm wire and the shelf alarm lamp.

The bay alarm equipment is arranged to permit adjustments between 'urgent', 'non-urgent' and 'reminder' indications to be made at the supervisory position of the station. In the present case the U-link is not to be inserted in the maintenance strip of the shelf; the alarm impulse from the level limit indicator is passed via a loop closed on the central alarm wire and energizes the *A* or *B* alarm relay. A 'reminder' indication is obtained by applying earth to the central alarm wire at the supervisory position.

## *Voltage Supervision*

If the secondary voltage of the power unit exceeds the alarm limits −19 V and −25 V, an alarm is given which, dependent on whether a standby supply is provided or not, can be extended to the *B* or *A* alarm relay in the service shelf. In the former case a non-urgent alarm is fully adequate because the standby arrangement prevents interference with traffic.

In the rare event of failure of the regular as well as the standby power supply at the same time, an urgent alarm is given via a voltage supervisory relay. The secondary voltages from power units I and II (regular and standby) can be measured by means of an external voltmeter, which is connected to the test points (banana jacks) at the front of the service shelf.

## *Service Shelf Design*

The service shelf occupies one height module (40 mm) in a bay, is extractable and is connected by plugs and jacks to the power supply cable in the right-hand upright of the bay. On the left of the service shelf front are a number of v.f. trunks with associated lamps. By changing strap connections the v.f. trunks can be converted into service circuits with call and busy lamps. In addition to the v.f. trunks there are test leads and coaxial jacks for h.f. trunks.

The right-hand half of the shelf front is occupied by fuses for shelves and shelf stacks as well as test points for the transistor voltage. Each fuse is provided with individual alarm indication facility. All the devices located at the front have designation labels.

The service shelf contains the distribution strips, the fuse distribution field and the power diode required for connecting the standby supply unit dealt with under the heading 'Power supply'. Also the various alarm relays including the acknowledgement relays are placed in the service shelf.

# Combination Effects Observed with Out-Band Signalling

M. GRÖNBERG, ROYAL BOARD OF TELECOMMUNICATIONS, STOCKHOLM
N.O. JOHANNESSON, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.391.82:621.395.44
LME 8460

*This article describes a type of disturbance hitherto neglected and only recently observed, and a means of suppressing it. The method described*—random phasing—constitutes a simple and elegant solution of a problem which has become of importance in Sweden and elsewhere due to the full-scale use of semi-continuous out-band signalling in a network of broad-band links. The investigation has been carried out in co-operation with the Royal Swedish Board of Telecommunications, especially as concerns the planning and execution of a realistic series of measurements. The phenomena are of interest both for those concerned with long-distance transmission and with switching. (The article is being published simultaneously in "Tele", issue 1, 1967.)*

A system of signalling which has been widely used for some years in carrier systems is the semi-continuous low-level out-band method. As experience was gained with this system, certain discoveries were made which at first appeared disconcerting.

Narrow voltage pulses of unacceptably high level appeared in those parts of carrier systems where the voltages from the various channels are combined in their different frequency allocations. This was considered to constitute a risk of overloading in the line amplifiers etc.

Another undesirable effect was that intelligible crosstalk between channels with a certain frequency spacing increased considerably after transmission of the multiplex signal over a coaxial line link containing a number of intermediate repeaters.

In contrast to many other forms of interference, these effects were observed only during periods of low traffic.

The difficulties proved to be due to an unexpected cause: too regular a phase behaviour in the equipment. Modern carrier systems have in fact such stringent demands on performance and such close tolerances that the various parts of the system automatically have closely similar phase characteristics.

The problems have been solved by quite simply introducing a systematic disorganization in the carrier system! This can be done in various ways, for instance by making a carefully chosen random phase inversion of certain voltages when the out-band signalling is injected. Both theoretical calculations and exhaustive practical measurements carried out by the Swedish Telecommunications Administration have conclusively led to identical results. A short report of these is given below.

## Characteristics of the Signalling System

The form of out-band signalling in actual use implies, briefly, that all signals for dialling, indication of hook-switch conditions, metering impulses, etc. are transmitted by switching on and off a sine wave corresponding to a channel frequency (3825 Hz) lying just above the speech band (300—3400 Hz). Since the out-band signal is filtered out from the speech band, signalling can be carried on during the course of a conversation by sending short bursts of the signalling

* Patent applied for by LME in several countries.

frequency. On an idle circuit the signalling frequency is sent continuously. The level of the out-band signal has been chosen as a compromise: sufficiently high to give reliable signalling, and sufficiently low not to result in an undue (power) loading on the carrier system. The latter condition implies that the combined sine-wave voltages of the signalling have been placed on the same footing as random noise with the same mean power, which in turn involves relatively modest peak voltages. It has indeed long been known that a combination of a large number of sine waves behaves as random noise if their frequencies are not commensurable, i.e. have no common basic frequency.

Out-band signals, however, are not incommensurable in this sense—they are derived from a common 3825 Hz oscillator for a whole system, and then lie at exactly 4000 Hz intervals from each other. If we further study the present-day technique of injecting the out-band signals into the system, we find rigid phase relationships. The modulators are fed by carrier frequencies generated in a common oscillator equipment resulting in fixed relations in phase.

Many groups of out-band signals pass through identical filters and modulators in a single terminal. In this connexion it is of particular interest to note the relative phase difference between two signals with a given frequency spacing. In a system using sub-group modulation, there are especially many frequencies spaced at 48 kHz and having the same phase difference. (In a system with direct modulation to groups, the corresponding frequency spacing is 240 kHz.)

## Combination of Sine-Waves of Commensurable Frequencies

A mathematical study of a finite sum of commensurable sine waves, such as out-band signals having frequencies ($f_s + n \cdot f_0$), shows that this exhibits certain characteristics which can be summarized as follows:

The composite signal is not properly speaking periodic, either with the signalling frequency $f_s$ (3825 Hz) or with the channel spacing $f_0$ (4000 Hz). It can however be regarded as a single-sideband modulation in which two truly periodic components can be distinguished.

The first component (the modulating frequency) is a pure sine wave having the beat frequency $f_0 - f_s$ (4000 – 3825 = 175 Hz). The other component is a set of sine waves with frequencies $n \cdot f_0$. The amplitudes and phase angles of the individual terms remain unchanged from their original form.

The modulation results in the overall behaviour in the time domain always being contained within a periodic envelope of basic frequency $f_0$ (4000 Hz). The curve of the envelope, which is what is of interest for us, can be computed from a knowledge of the amplitude and phase of the individual component terms. If for example we have a sum of $N$ sine waves each of unit amplitude, the highest conceivable peak which can occur in the envelope is quite simply $R_0 = N$. However, a very special choice of phase relationships between the individual terms is required if we are to be able to find an instant when all terms reach maximum or minimum exactly simultaneously. The peak is thus correspondingly very narrow.

If the phases of the $N$ sine waves are chosen at random, we obtain a time domain behaviour which exhibits several voltage peaks, but in which with a very high degree of probability all peaks have lower amplitudes. The variations of the voltage envelope with random phasing are found to follow extremely closely a Rayleigh probability distribution. The exact form of the envelope is of course different for each particular random choice of phase relationships, but the highest peak is nevertheless always found to be given with a high probability of good accuracy by the expression $\hat{R} = \sqrt{N(\ln N + 1)}$.

For the high values of $N$ which we need to consider in the context of carrier systems, e.g. 300 to 2700, we obtain a significant reduction of the peak value $R$ by comparison with $R_0$.

The mathematical treatment of the problem also indicates that the random phasing does not necessarily have to be uniformly distributed over all values between 0 and 2 $\pi$, but that it is sufficient to use the two possible values 0 and $\pi$, with equal probabilities for both. However, there must be no appreciable skewness in the distribution, especially for large values of $N$. If the choice of either phase predominates over the other, there is an immediate increase in the expected maximum peak amplitude. (For instance, if $N = 2700$, and the possible values of phase are 0 and $\pi$, the deviation from equal distribution between them should not exceed ± 1.5 %.)

If the various sinusoidal terms have unequal amplitudes, the expression for the highest peak value with random phasing can be written as

$$R = R_e \sqrt{2(\ln N + 1)}$$

where $R_e$ is the r.m.s. value of all the $N$ sine waves together.

It is thus worth pointing out that a combination of commensurable sine waves does *not* by any law of nature necessarily lead to worse conditions with higher peak values than a combination of incommensurable sine waves or random noise. The pre-requisite is simply that the phasing is arranged to be genuinely random with sufficiently low skewness.

Mathematically similar problems have been treated in the literature, e.g. the problem of the drunkard's walk—see fig. 1.

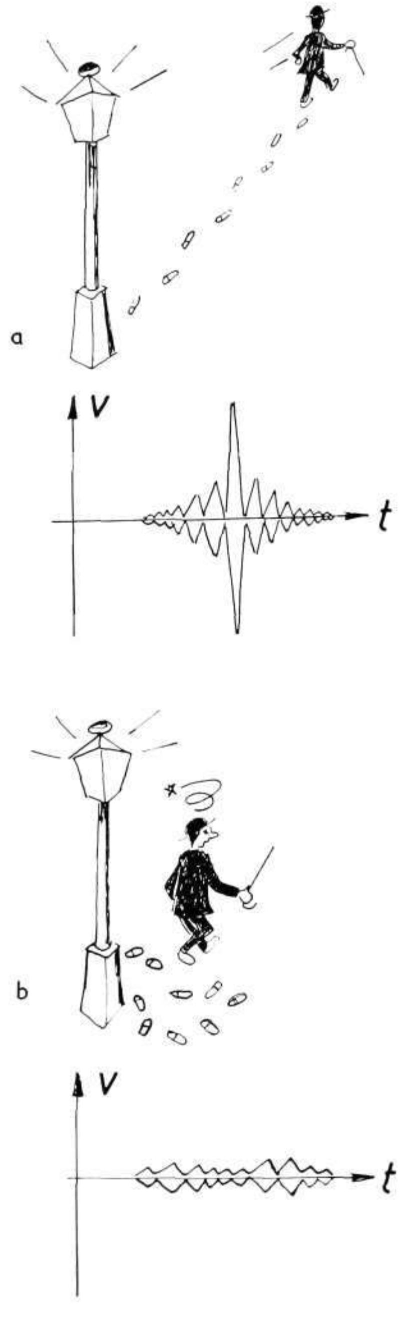



**Fig. 1**

**Combination of commensurable sine waves can be compared to a succession of paces.**

**a Walking in a fixed direction, or systematic phasing**

**b Drunkard's walk, or random phasing (smaller resultant magnitude)**

## Expected Value of Peak Amplitude

If the peaks coming from out-band signalling can be reduced down to the random-phasing level, a comfortable safety margin will remain below the CCITT recommended overload limit. With the commonly used signalling level of – 18 dBm0, the curves of fig. 2 are obtained.

## Measurement of Peak Amplitude

Fig. 3 shows the sum of the out-band signals in a basic mastergroup (frequency allocation 812—2044 kHz), in one case with systematic injection of the frequency in the same phase for all channels, and in the other case with random choice between two opposite phases for the different channels. The envelope of the composite signal has a periodicity of 4000 Hz modulated by 175 Hz.

The relative level of the measuring point corresponds to a peak amplitude for an individual out-band signal of 1.55 mV. It can be seen from fig. 3 that the maximum amplitude with systematic phasing is about 140 mV as compared with 465 mV for true voltage addition. With random phasing the maximum amplitude is about 70 mV. This value agrees well with the formula $\hat{R} = \sqrt{N(\ln N + 1)}$, which for $N = 300$ gives $R \cdot 1.55 = 69.6$ mV. As will be seen, the composite signal has a random noise character due to the random phasing.

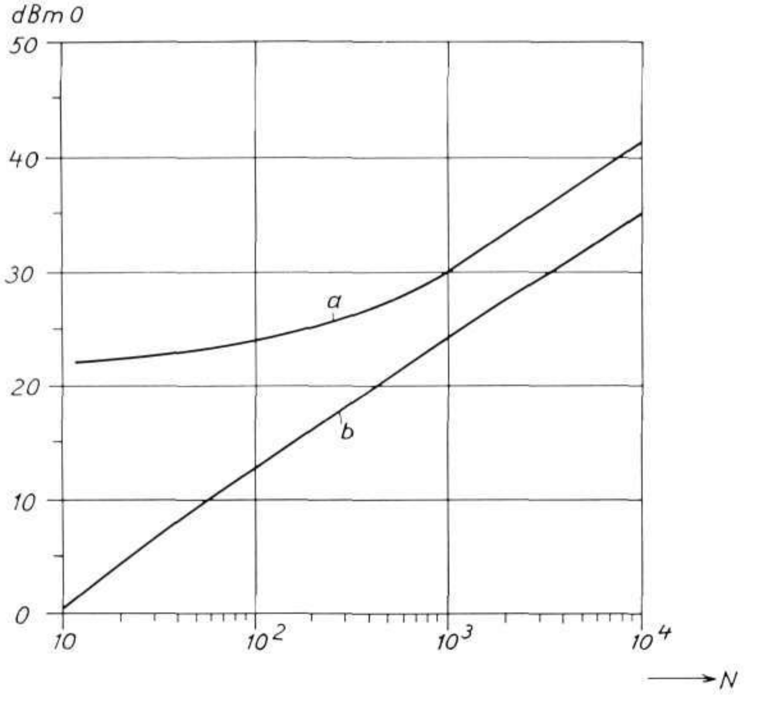



**Fig. 2**
**Comparison between (b) expected peak amplitude, and (a) CCITT's recommended overload limit, for a signal level of − 18 dBm0 per channel**

N No. of channels

## Origination of Crosstalk

Spurious frequencies known as intermodulation products can be produced in a line amplifier handling carrier signals due to its non-linearity. For instance, if there are three voltages having frequencies $f_a$, $f_b$ and $f_c$ (corresponding to channels *a*, *b* and *c* respectively), there appears amongst others a new voltage of frequency

$$f_b = f_a + f_b - f_c$$

This type of third-order intermodulation product is particularly dangerous, since such intermodulation voltages add linearly in direct proportion to the number of repeaters. (For other types of product, e.g. $f_e = f_a + f_b + f_c$ or $f_g = f_a - f_b - f_c$, the addition takes place in proportion to the square root of the number of repeaters. These facts have long been known.)

If $f_b$ and $f_c$ are two out-band signalling frequencies, their difference $f_b - f_c$ must represent an integral multiple of the channel spacing. Hence we directly obtain intelligible crosstalk from channel *a* to channel *d*.

A large number of simultaneous out-band signals results in a combination of the crosstalk voltages produced in a given repeater by all out-band signals having the same difference $f_b - f_c$. Hitherto repeaters have been designed in respect of intermodulation on the assumption that this addition always takes place on a power basis. This is true provided that all frequencies $(f_b - f_c)$ are uncorrelated. But if the carrier terminal is designed in the conventional manner, the out-band signals at certain frequency intervals will have identical phase, as mentioned earlier. For this particular frequency spacing, something more nearly like *voltage addition* will occur, resulting in poor crosstalk performance.

On the other hand with random phasing of the out-band signals the result will be more nearly a power law of addition, which even in the worst case will only produce acceptable values of crosstalk. (The addition of the intermodulation voltages will be a combination of coherent sine waves. The same laws as given earlier apply to the maximum values.)

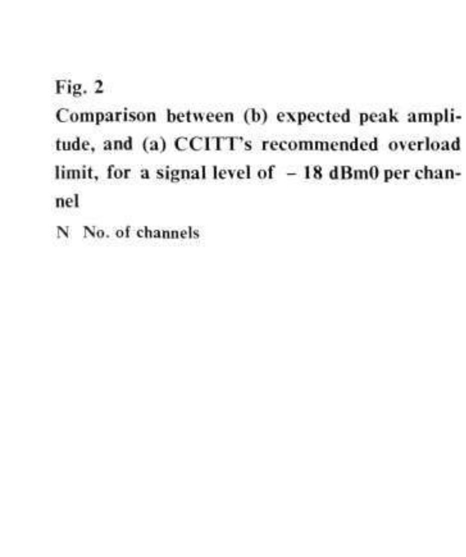



**Fig. 3**
**Example of combination of out-band signals in a basic mastergroup (300 channels)**

**a** Systematic phasing
**b** Random phasing

Frequency range: 812—2044 kHz
Level: Peak amplitude 1.55 mV per out-band signal
Vertical scale: 100 mV per division
Horizontal scale: 50 μs per division

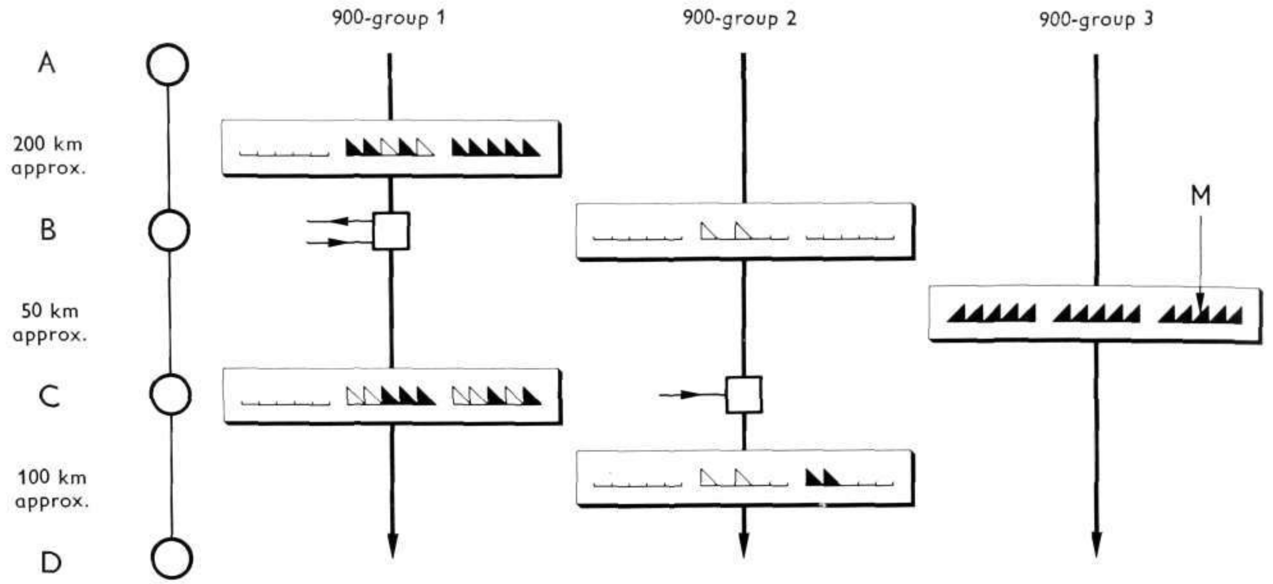



**Fig. 4**

**Frequency allocations in a 12 MHz system during crosstalk measurements**

Solid (black) triangles: supergroups with out-band signalling

Outline (white) triangles: supergroups with in-band signalling

Supermastergroup 1 is demodulated at B, where some supergroups terminate, while the others are through-connected and re-appear at new positions in the band of line frequencies. At C on the other hand the entire supermastergroup is directly through-connected unchanged. The same applies at B for supermastergroup 2, which however is demodulated at C where two more supergroups are added. The highest supermastergroup is directly through-connected unchanged at both intermediate stations.

M Mastergroup being measured

**Fig. 5**

**Variation of crosstalk during the course of a weekday**

A Systematic phasing of out-band signals

B Random phasing of out-band signals (integration time about 10 minutes)

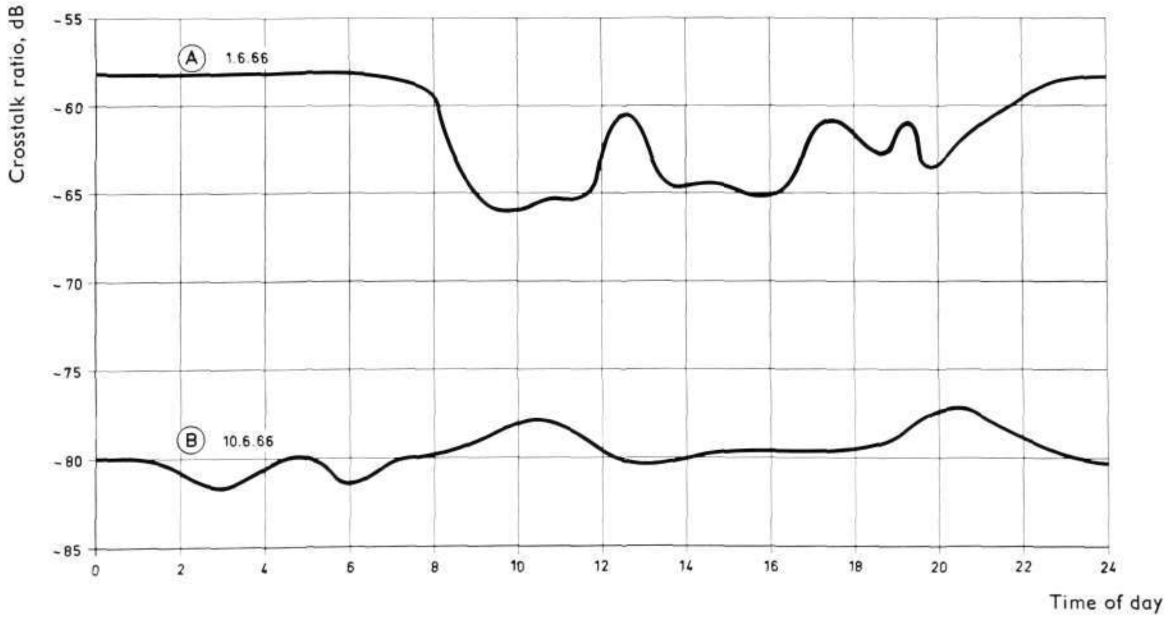
## Measurement of Crosstalk

The theoretical calculations have been confirmed by measurements on carrier systems in service. As an example, some results will be given of measurements on the 2700 channel installation indicated in fig. 4, which shows the exploitation of the various coaxial line sections when the measurements were made.

All the supergroups with out-band signalling had systematically phased signals (solid black triangles) at the start of the measurement: only a small number of supergroups used in-band signalling (white triangles).

As will be clear from the figure, the test comprised a case of actual operation with a very large amount of equipment. The results shown can therefore be regarded as representative for the network of an entire country.

The change in intelligible crosstalk due to random phasing of all the out-band signals in the system was registered with a pen recorder. Fig. 5 shows the variations in the average crosstalk in the mastergroup being measured during



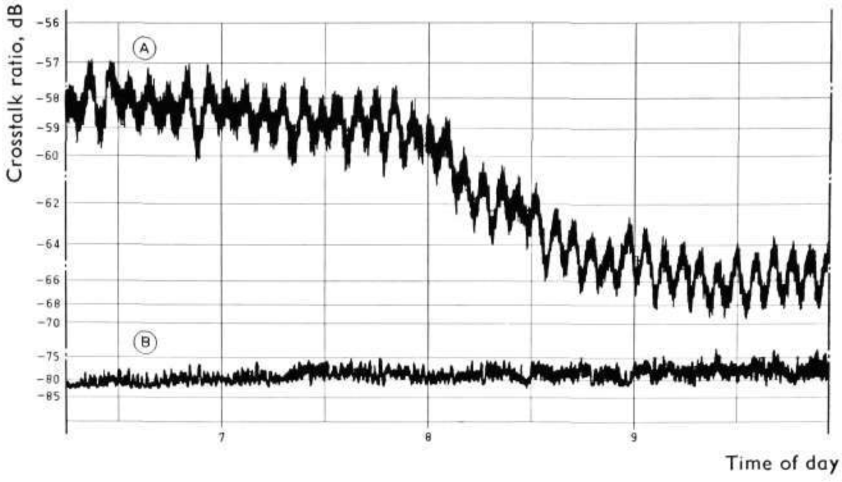



Fig. 6
**Recording of crosstalk ratio.**
A Systematic phasing of out-band signals
B Random phasing of out-band signals

the 24 hours of a weekday for one of the worst channel combinations (48 kHz frequency spacing), before and after effecting completely random phasing, respectively.

With systematic phasing, the level of crosstalk is closely correlated with the traffic intensity and reaches its highest value during the period of low traffic (11 p.m. to 7 a.m.). In addition, maxima can clearly be distinguished during the lunch hour (12 to 1) and the time of the television news program at 7 p.m.

With random phasing the crosstalk ratio is improved to 80 dB and has no longer any significant correlation with traffic intensity. After carrying out random phasing the majority of the measured crosstalk levels were below the inherent noise level of the measuring set. However, for the worst combinations of channels the average improvement was about 15 dB.

Fig. 6 reproduces two sections of the recordings on which fig. 5 has been based. With systematic phasing the crosstalk varies cyclically with a period of about 5½ minutes. This is caused by beats between intermodulation products due to supergroups from different terminal stations, each being locked to the free-running master oscillators of its own station which control the frequencies for modulation and signalling respectively. With random phasing this effect disappears.

# Centralized Fundamental and Pilot Frequency Generating Equipment for Carrier Terminals

N. TANGEN & K.-G. ZEIPEL, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.44
LME 8421
751

*The introductory section of this article gives an outline of the carrier and pilot supply for carrier terminals engineered in the M4 construction practice.*

*In the continuation of the article a description is given of the centralized fundamental and pilot frequency generating equipment and its interworking with the decentralized, local carrier supplies in the respective translating bays.*

Fully-transistorized equipment in conjunction with the M4 construction practice has created opportunities to rationalize the design and disposition of the carrier and pilot supply for carrier terminals. A long-nourished wish to be able to proportionate the capacity of the carrier and pilot generating equipment of a terminal to its immediate traffic volume, and at the same time to facilitate its further expansion, has been fulfilled.

This has been achieved by dividing the frequency generating equipment into a centralized section common to the whole terminal, and decentralized sections for local use in the various translating stages. Hereby the centralized, common section has been simplified so as to comprise the apparatus for the generation of a few fundamental and pilot frequencies occupying part of one bay side only.

*All frequencies—including the pilot frequencies—are derived from the master frequency.*

The equipment in the centralized section has been duplicated throughout, since a failure occurring in this section would affect the entire terminal.

A fault in a local section, however, will affect only the translating equipment supplied by that section but will have no effect whatever on the other local sections or the translating equipments associated with them. Also, the fault probability has been reduced, the number of series-connected units in the local sections being small.

The division of the frequency generating equipment into a centralized section and a number of local sections has resulted in a considerable reduction in the number of station cables required for carrier and pilot distribution. In comparison with a completely centralized equipment of earlier design a reduction of the order of 10 : 1 has been achieved.

Finally routine maintenance has been reduced to such an extent that it now consists in only a few checks in the centralized equipment.

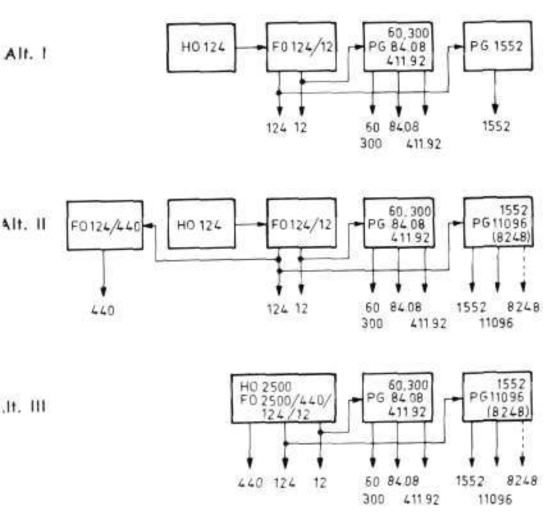



**Fig. 1**
**Centralized fundamental and pilot frequency generation**
**HO** Master oscillator
**FO** Frequency converting equipment
**PG** Pilot generating equipment
Frequencies in kHz

## Electrical Design

### *Frequency Generation*

Three alternative versions of the common frequency supply are provided according to system capacity and the master frequency desired.

Simplified block diagrams of the different alternatives are shown in fig. 1.

Alternative I is designed for 300-, 960- and 2 700-circuit systems on a supergroup basis. For these systems are generated carrier basic frequencies of 12 and 124 kHz used for the generation of carrier frequencies in the decentralized carrier generating equipments. Further frequencies generated are the reference pilots 84.08, 411.92 and 1 552 kHz as well as the frequency comparison pilots 60 and 300 kHz.

Alternatives II and III are intended for 900- and 2 700-circuit systems on a mastergroup basis. In addition to the frequencies in alternative I these two versions provide for the generation of the 440 kHz carrier basic frequency and the 11 096 kHz supermastergroup reference pilot. The 8 248 kHz sometimes used as a line group reference (or line link) pilot in 2 700-circuit systems can also be provided. Alternatives II and III generate the same frequencies but have different master oscillators.

Alternative III has a higher frequency stability and is applicable in systems providing up to 10 800 circuits (60 MHz systems).

The question may arise why the generation of reference pilots has not been incorporated in the decentralized frequency generating equipment as in the case of the generation of carriers. To this may be answered that the reference pilots have alternative injection points in the system, which complicates the accommodation of decentralized pilot generating equipments. Besides, local pilot generating equipments would involve unnecessary repetitions, the power requirements of the reference pilots being so small that several 2 700-circuit systems can be supplied by a single amplifier per frequency. Finally the reference pilots require a certain amount of maintenance of output levels, which is greatly facilitated if carried out at a central position in the station.

## *Frequency Stability*

The difference between a voice-frequency band applied to an international telephone circuit and the band received at the other end of the circuit must not exceed 2 Hz after passing all modulation and demodulation stages in transmission, through connection and reception.

To meet this requirement the CCITT recommends the following accuracies for carrier frequencies (CCITT Blue Book, Volume III, Recommendation G.225):

- For group and supergroup carrier frequencies, i.e. for systems providing up to 960 circuits, $\pm 10^{-7}$
- For mastergroup and supermastergroup carrier frequencies, i.e. for systems providing up to 2 700 circuits, $\pm 5 \cdot 10^{-8}$

To fulfil the requirements for the above-mentioned systems—and for 10 800-circuit systems as well—two master oscillators have been designed for use in the common frequency supply.

One master oscillator generates a frequency of 124 kHz and has a frequency stability of $\pm 5 \cdot 10^{-8}$ per month, the other generating the 2 500 kHz and having a stability of $\pm 10^{-8}$ per month. The former oscillator is applicable to systems of up to 2 700 circuits; the latter, however, is designed for 2 700- and 10 800-circuit systems.

The choice of the 2 500 kHz as master frequency has been made in view of the extremely severe demands for frequency stability. The 2 500 kHz lies within a particularly favourable range from the point of view of crystal techniques. Moreover, the 2 500 kHz is an internationally employed standard frequency, the stability problems of which have been given special attention.

Regarding reference pilots the CCITT recommends a frequency accuracy of ± 1 Hz for the 84.080 and 411.920 kHz, ± 2Hz for the 1 552 kHz and ± 10 Hz for the 11 096 kHz. The requirements are so stringent as to require crystal-controlled oscillators with temperature control equipment if the pilots are to be generated separately.

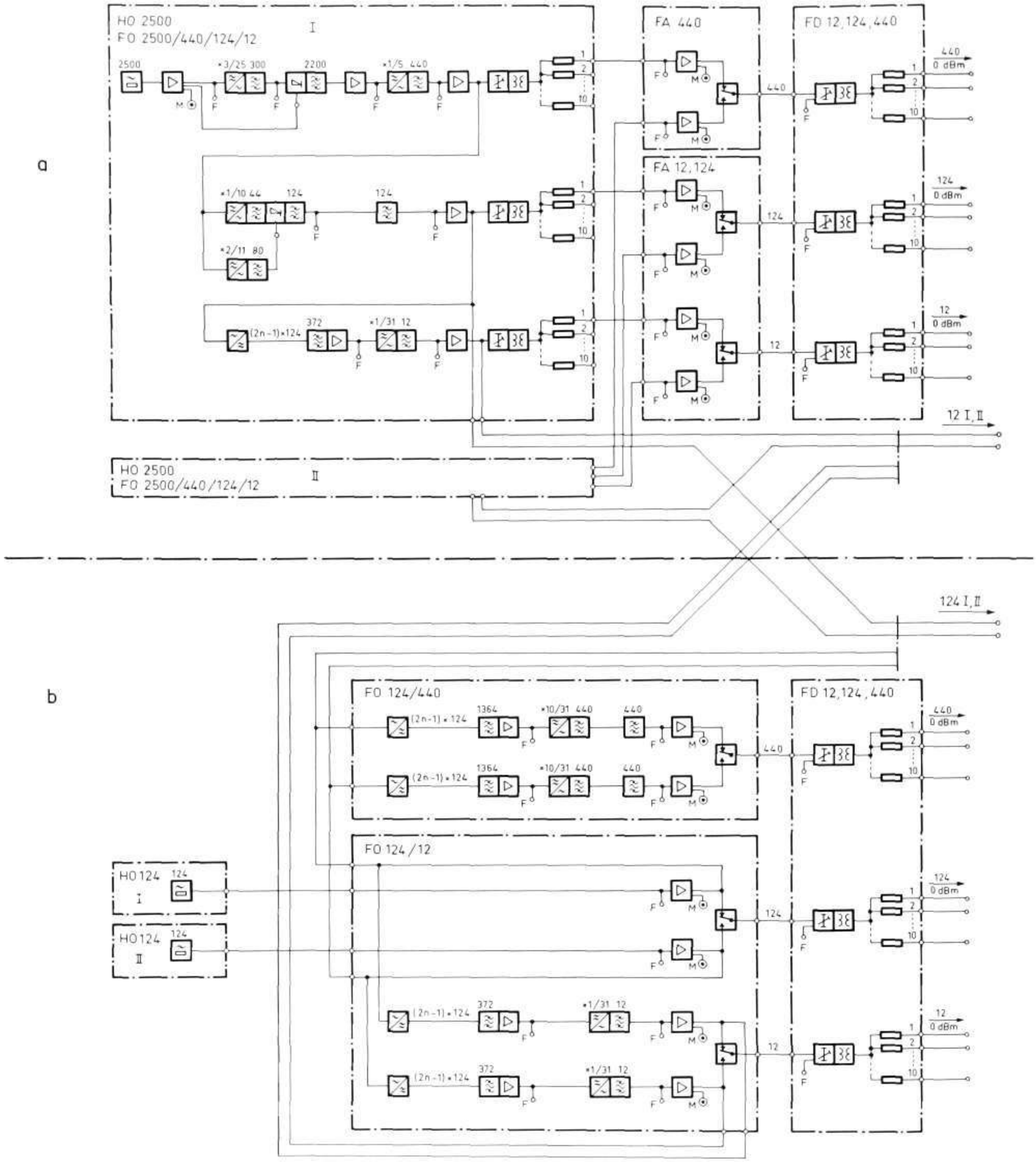



**Fig. 2**

**Centralized generation of fundamental frequencies**

- **a** With master oscillator 2 500 kHz
- **b** With master oscillator 124 kHz

**HO** Master oscillator
**FO** Frequency converting equipment
**FA** Amplifier
**FD** Distributor
**M** Maintenance test point
**F** Fault location test point

**Frequencies in kHz**

By synchronization with the master frequency, however, a considerably higher frequency accuracy is achieved for all pilots than those recommended by the CCITT. Also, this arrangement dispenses with a number of free-running oscillators and consequent maintenance work.

## *Block Diagrams*

The schematic diagram of the generation of carrier basic and pilot frequencies in a 2 700-circuit system is shown in figs. 2 and 3. Fig. 4 illustrates how from the basic frequencies the carrier, signalling and auxiliary frequencies are derived in the decentralized frequency generating equipments incorporated in the respective translating stages. The injection of reference pilots is also shown.

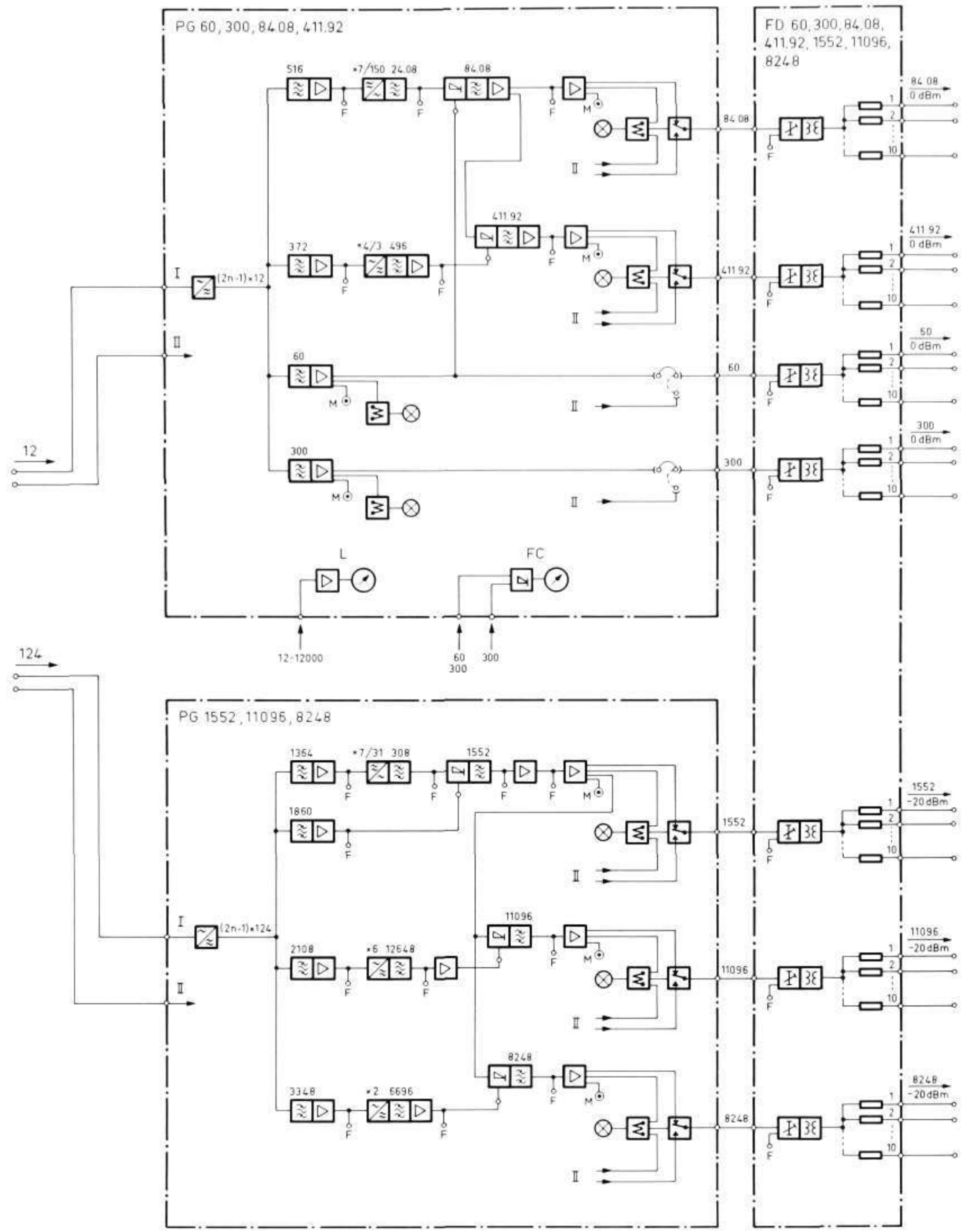



**Fig. 3**

**Centralized generation of pilot frequencies**

**PG** Pilot generating equipment
**L** Level measuring set
**FC** Frequency checking equipment
**FD** Distributor
**M** Maintenance test point
**F** Fault location test point

Frequencies in kHz

Fig. 2 a shows the generation of the carrier basic frequencies 440, 124 and 12 kHz, which are derived by frequency conversion from a 2 500 kHz master frequency. The frequency conversions comprise frequency multiplication, division and modulation.

The 2 500 kHz master frequency is divided by 25 to produce 100 kHz. The frequency divider in which division takes place, like all the frequency dividers mentioned below, provides an output signal that is rich in harmonics. In this case the 3rd harmonic, 300 kHz, is selected and caused to modulate the 2 500 kHz. The lower side frequency, 2 200 kHz, is selected and divided by 5 to produce the 440 kHz carrier basic frequency.

The 440 kHz is divided by 10 and 11, the 44 kHz and the 2nd harmonic of 40 kHz being selected from the respective frequency divider outputs. After modulation the 124 kHz carrier basic frequency is obtained from these two frequencies.

The 124 kHz is fed into a harmonic generator which, like all the harmonic generators mentioned below, produces odd harmonics. In the present case the 3rd harmonic, 372 kHz, is selected. The 372 kHz is then divided by 31 to produce the 12 kHz carrier basic frequency.

Fig. 2 b shows the generation of the same carrier basic frequencies. Here, however, the basic frequencies are derived by frequency conversion from a 124 kHz master frequency.

From the output of a 124 kHz harmonic generator the 1 364 kHz is selected as the 11th harmonic of 124 kHz. The 1 364 kHz is divided by 31 to produce 44 kHz. By selecting the 10th harmonic of this frequency the 440 kHz carrier basic frequency is obtained.

Since the 124 kHz has been chosen as master frequency, no frequency conversion equipment is needed in this case to obtain the 124 kHz carrier basic frequency.

The 12 kHz carrier basic frequency is obtained in the same manner as previously described.

All basic frequency generating equipments are duplicated and provided with changeover units, which in the event of excessive level deviations in the regular equipment (I) provide automatic changeover to the standby equipment (II). In addition, an alarm is given in case of a level fault in either set of equipment.

The carrier basic frequencies are distributed via 10 parallel outlets provided with short-circuit protection.

Fig. 3 shows the generation of the pilot frequencies 84.08, 411.92, 60, 300, 1 552, 11 096 and 8 248 kHz. The first-mentioned four pilots are derived from the 12 kHz basic frequency and the last-mentioned three from the 124 kHz basic frequency.

From the output of a 12 kHz harmonic generator the 60 and 300 kHz pilot frequencies are selected directly as the 5th and 25th harmonics respectively of the 12 kHz fundamental. From the same spectrum of harmonics of 12 kHz are selected the 43rd (516 kHz) and the 31st (372 kHz) harmonics, which are used in the generation of the 84.08 and 411.92 kHz respectively.

The 516 kHz is divided by 150 in a frequency divider. From the spectrum of harmonics of 3.44 kHz produced the 7th harmonic, 24.08 kHz, is selected. After modulation of 60 kHz with 24.08 kHz the upper side frequency provides the required 84.08 kHz pilot frequency.

The 372 kHz is divided by 3 in a frequency divider. From the output spectrum of harmonics of 124 kHz thus produced the 4th harmonic, 496 kHz, is selected. After modulation with 84.08 kHz the lower side frequency gives the 411.92 kHz pilot frequency.

From the output of a 124 kHz harmonic generator are selected the 11th (1 364 kHz), 15th (1 860 kHz), 17th (2 108 kHz) and 27th (3 348 kHz) harmonics.

The 1 364 kHz is divided by 31 to produce 44 kHz, the 7th harmonic of which, 308 kHz, is selected. Modulation of 1 860 kHz with 308 kHz then produces the 1 552 kHz pilot frequency.

The 11 096 and 8 248 kHz pilot frequencies are generated by means of 1 552 kHz, which is caused to modulate the 12 648 kHz and 6 696 kHz respectively. The latter two frequencies are derived from 2 108 and 3 348 kHz respectively by multiplication.

All the pilot frequency generating equipments are duplicated. The 84.08, 411.92, 1 552, 11 096 and 8 248 kHz are provided with the same type of automatic changeover units as mentioned previously in the case of the carrier basic frequencies. For 60 and 300 kHz changeover is carried out manually by means of U-links.

In the event of an excessive level deviation in any one of the pilot generating equipments an alarm is given. Distribution arrangements are the same as those used for the carrier basic frequencies.

Fig. 4 illustrates the employment of carrier basic frequencies and reference pilots in a 2 700-circuit system using mastergroups.

From the 12 kHz basic frequency are derived

*the carriers*

- 12, 16 and 20 kHz for channel translation
- 84, 96, 108 and 120 kHz for subgroup translation
- 420, 468, 516, 564 and 612 kHz for group translation

*the signalling frequencies*

- 3 825 Hz for out-band signalling
- 2 400 Hz for in-band signalling

From the 124 kHz basic frequency are derived

*the carriers*

- 1 364, 1 612, 1 860, 2 108 and 2 356 kHz for supergroup translation

*the auxiliary frequencies*

- 496 kHz for adaptation of the 411.92 kHz supergroup pilot to the 84.08 kHz pilot receiver
- 12 648 kHz for adaptation of the 11 096 kHz supermastergroup pilot to the 1 552 kHz pilot receiver
- 6 696 kHz for adaptation of the 8 248 kHz line link pilot to the 1 552 kHz pilot reveiver

From the 440 kHz basic frequency are derived

*the carriers*

- 10 560, 11 880 and 13 200 kHz for mastergroup translation
- 12 704 and 16 720 kHz for supermastergroup translation

For the generation of the 12 704 kHz carrier the 124 kHz basic frequency is also needed.

## *Changeover and Level Supervision*

For all carrier basic and pilot frequencies, with the exception of the 60 and 300 kHz, facilities are provided for automatic changeover between regular (I) and standby (II) sets of equipment.

Under normal operating conditions the regular equipment is connected to the distributing equipment, the standby equipment being connected to a 75-ohm dummy load included in the changeover unit. Should the output level of the working amplifier fall by more than 2 or 3 dB, the standby equipment is automatically switched into circuit and the regular equipment is connected to the dummy load. At the same time an alarm is sent out. In this condition changeover is locked. This prevents any tendencies towards unduly repeated switching between regular and standby. After fault clearance the regular set is switched back into circuit by means of a push button; at the same time the alarm disappears.

A corresponding level drop in the standby equipment will also initiate an alarm.

The changeover units employ mercury-wetted contact relays having a high degree of contact reliability and short changeover times. Furthermore the changeover unit is designed to provide substantial attenuation of any crosstalk between the regular and standby sets.

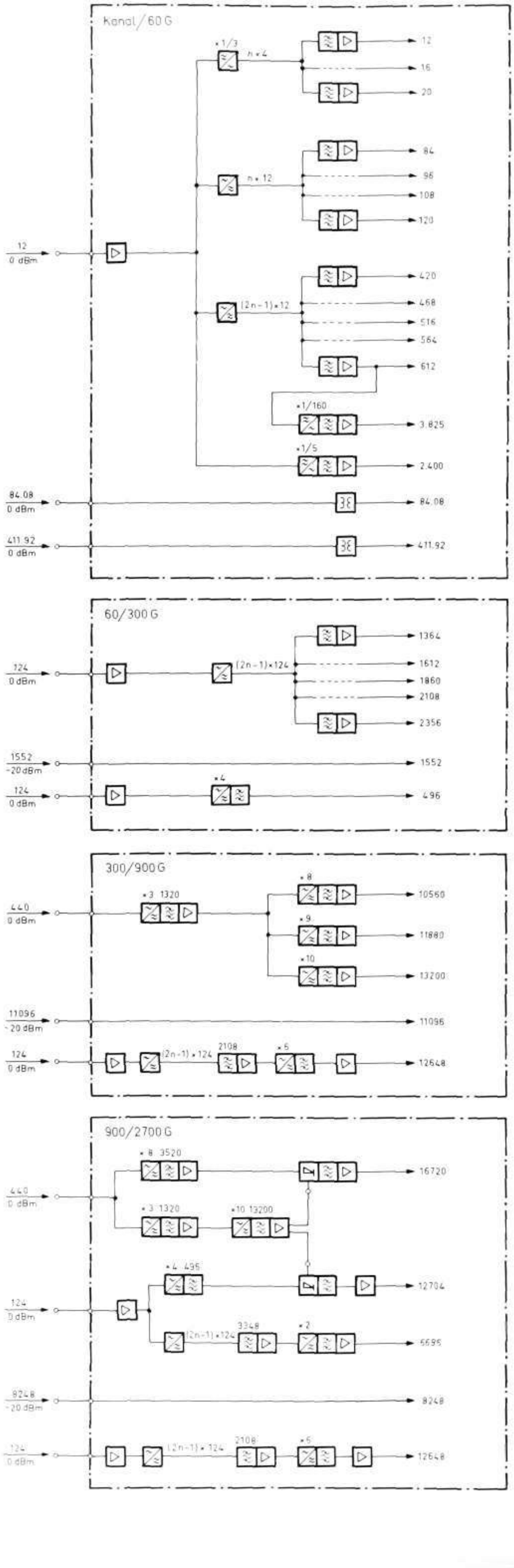



**Fig. 4**

**Decentralized generation of carrier frequencies in a 2700-circuit terminal**

| | |
|---|---|
| **Kanal/60G** | Channel and group translating equipment |
| **60/300G** | Supergroup translating equipment |
| **300/900G** | Mastergroup translating equipment |
| **900/2700G** | Supermastergroup translating equipment |

Frequencies in kHz

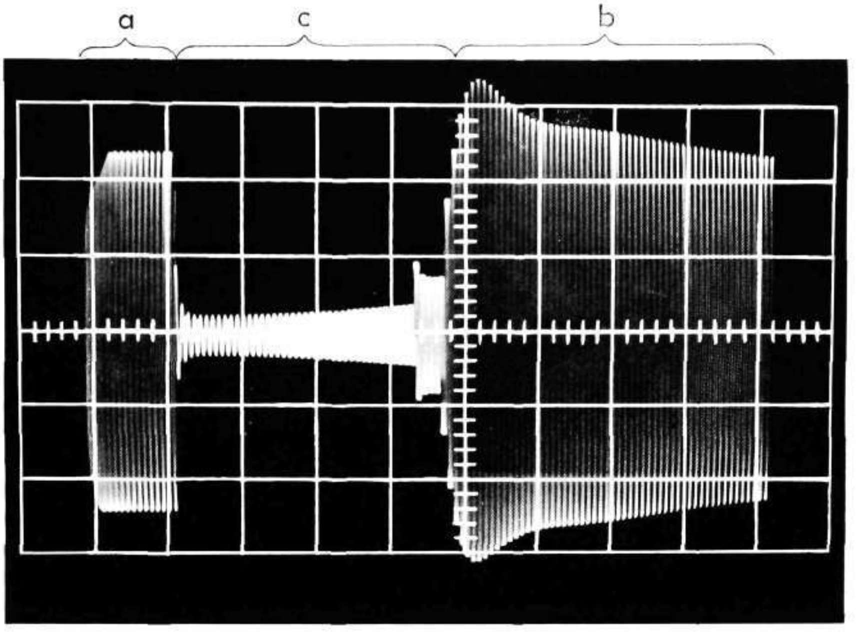



**Fig. 5**
**Changeover characteristic for carrier basic frequency 12 kHz**

a Output level from regular amplifier
b Output level from standby amplifier
c Interruption
1 square = 1 millisecond

Fig. 5 shows the changeover characteristic for the 12 kHz carrier basic frequency. With this frequency the time constant of the rectified voltage used to control the changeover unit is greater than with the other carrier basic and pilot frequencies. Consequently the total changeover time for the 12 kHz carrier basic frequency is slightly longer than those of the other basic and pilot frequencies.

In the case of the frequency comparison pilots 60 and 300 kHz automatic changeover facility is not required. Instead changeover is effected manually by means of U-links. The 60 and 300 kHz are supervised by means of level limit indicators, which provide an alarm on level drops of the same values as described above for the changeover unit.

For the reference pilots 84.08, 411.92, 1 552, 11 096 and 8 248 kHz, however, a more accurate supervision is required in addition to that provided by the changeover unit. For this reason special level limit indicators are included providing an alarm on level deviations greater than ± 0.5 dB relative to nominal level. Supervision is applied to the level of the distributed pilot.

Supervision of the reference pilots can also be carried out by means of level recorders. For this purpose a recorder outlet is provided in the respective pilot distributors.

If required, the changeover units for all carrier basic frequencies as well as for the 84.08 and 411.92 kHz pilots can be bypassed by means of U-links, as shown in fig. 6.

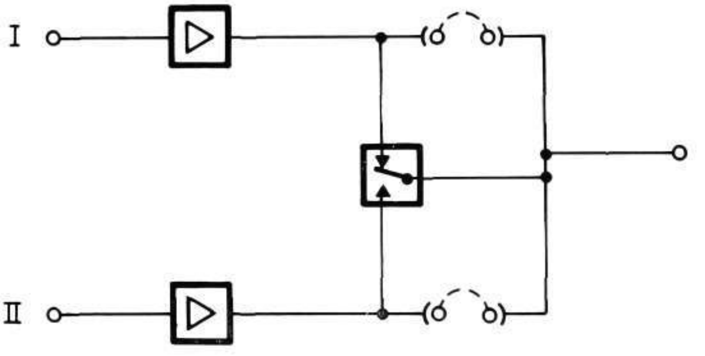



**Fig. 6**
**Bypassing a changeover unit**

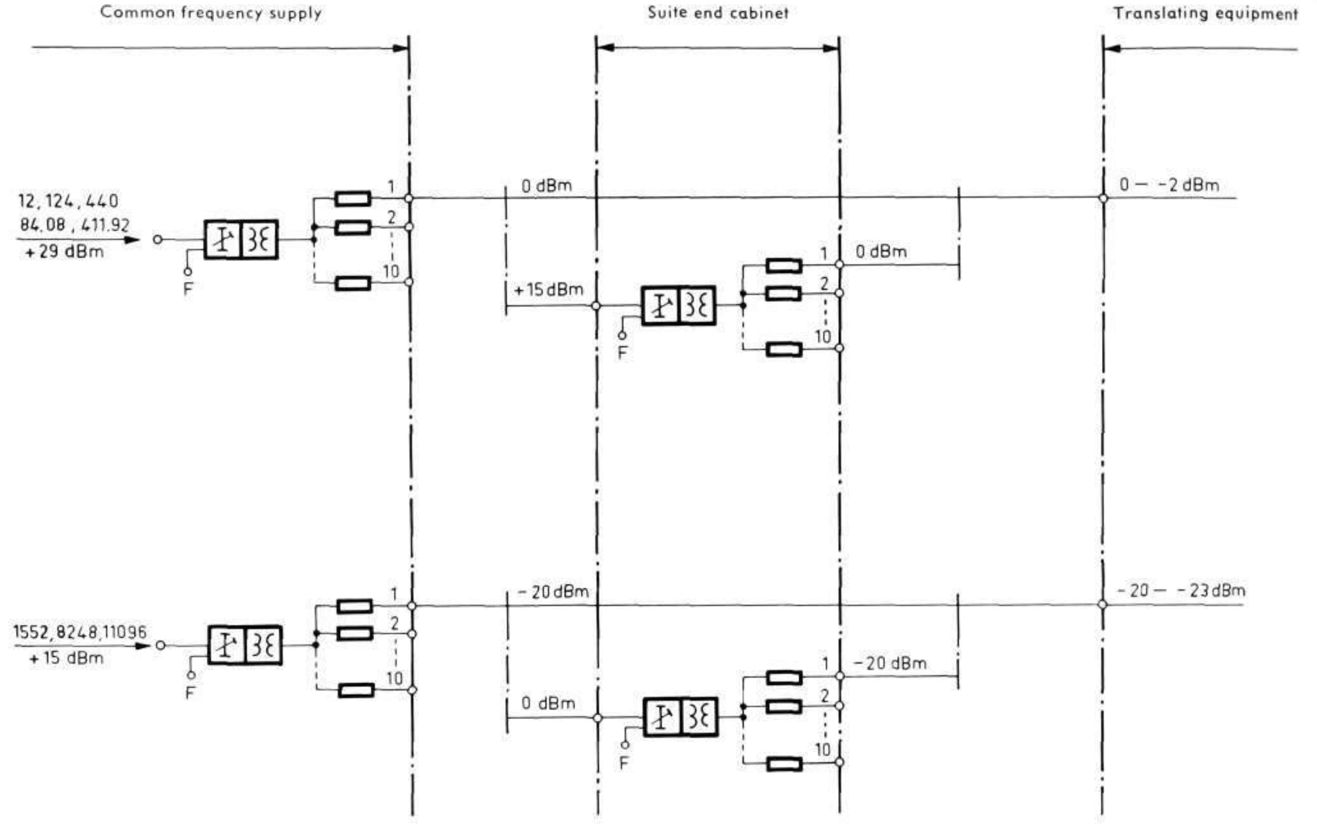



**Fig. 7**
**Distribution of carrier basic and pilot frequencies**
**Frequencies in kHz**

## *Distribution*

Fig. 7 shows a schematic diagram of the distribution of carrier basic and pilot frequencies from the common frequency supply to the various translating stages. Each outgoing frequency is distributed via a 10-outlet distributor. Distribution is arranged either direct from the common frequency supply to the translating equipments or, if the number of outlets required for one frequency is larger than 10, via further distributors accommodated in the suite end cabinets. Thus each outlet in the common frequency supply is subdivided into 10 outlets in the suite end cabinets. In this manner a maximum of 100 outlets per frequency can be obtained.

The 60 and 300 kHz frequency comparison pilots are always distributed direct from the common frequency supply, because they are injected only into the line frequency band and thus need considerably fewer injection points than other frequencies to be distributed.

Each distributor outlet is protected against short circuits by means of a series resistor. In the event of a short circuit at one of the outlets a minor level drop will occur at the other outlets. This level drop does not affect the distribution to the associated equipments.

Each distributor includes a variable attenuator permitting the output levels to be adjusted to the level requirements of each particular application. A fault location test point is provided at the input of each distributor. The distributors of reference pilots also include outlets for connection to a level recorder.

In certain cases, for instance where the equipment is used in conjunction with equipment of earlier design, the distribution of carrier basic frequencies may be required to take place from the regular and standby sets separately.

For this reason the distributors are designed for high-impedance connection to the respective amplifier outputs. Thus it is possible to distribute the carrier basic frequencies in two different ways at the same time, as shown in fig. 8.

## *Test Points*

To facilitate routine measurements and rapid location of any fault that may occur two types of level test points, namely maintenance test points and fault location test points, are provided in the equipment. In the block diagrams, figs. 2 and 3, they are denoted by M and F respectively.

The maintenance test points, which are used for routine maintenance and fault location test are short-circuit-proof, i.e. a short circuit at the point does not noticeably affect the main level. Test points of this type are provided at the outputs of all regular and standby amplifiers. They consist of coaxial jacks arranged in the maintenance strip along the lower edge of the respective shelf.

In addition to the maintenance test facilities, fault location test points are provided at convenient points, thus simplifying logical fault location. The fault location test points, except those of the distributors, are designed as bridging points and not protected against short circuits. They are located on the various apparatus units, access being obtained by removing the shelf dust cover. The fault location test points for the distributors are placed in the shelf maintenance strip and are short-circuit-proof.

## *Level Checking*

The nominal test level at all maintenance test points is −10 dBu (0 dBu = 0.775 V) measured against a 75-ohm termination. For checking this level a level measuring set is incorporated in the common frequency supply, namely in the shelf stack housing the equipment for the generation of the 60, 300, 84.08 and 411.92 kHz pilots, as shown in fig. 3. This level measuring set has a total accuracy of measurement of ± 0.2 dB and covers a frequency range of 12 kHz–12 MHz. It has a built-in level calibrator. The level measuring set has two ranges of measurement: −4 to +1 dB and ± 1 dB. 0 dB corresponds to −10 dBu.

The indicating instrument mounted on the unit front is provided with corresponding scales. The ± 1 dB scale is extended, thus permitting very accurate scale readings to be made.

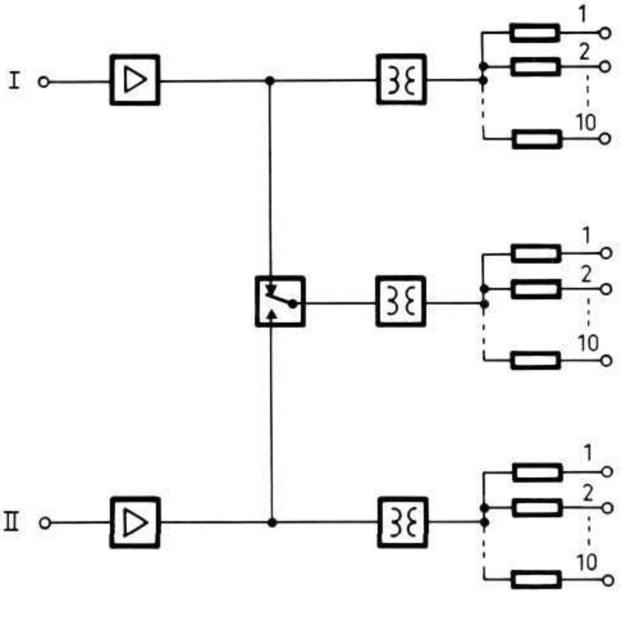



**Fig. 8**
**Extended distribution of carrier basic frequencies**

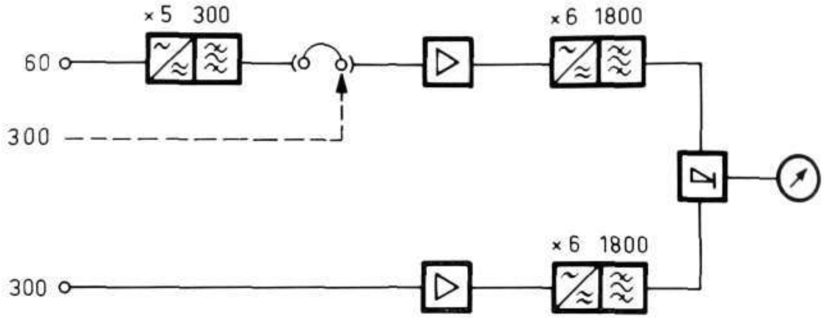



**Fig. 9**
**Frequency checking equipment**
Frequencies in kHz

All output levels are stabilized in the respective amplifiers, so that level adjustment is not normally required. For fine adjustment of the levels of the reference pilots variable attenuators are included in the amplifiers permitting the output level to be adjusted by ± 0.2 and ± 0.4 dB.

## *Frequency Checking*

For synchronization of the two duplicate master oscillators with each other or each of them against an external frequency standard, a frequency checking equipment is provided. A block diagram is shown in fig. 9.

In 960-circuit systems a frequency comparison pilot of 60 kHz is employed, in 900- and 2 700-circuit systems 300 kHz.

The frequency checking equipment can be supplied with either 60 kHz at one input and 300 kHz at the other, or 300 kHz at both inputs. In the former case a frequency multiplier 60 to 300 kHz is incorporated in the equipment. As an alternative to 300 kHz a frequency comparison pilot of 1 800 kHz can be fed into the equipment, if required.

This equipment uses the beat method, i.e. it indicates the difference frequency between the two input frequencies as a pulsating d.c. current. The duration of one beat can be read from the indicating instrument by means of a stop watch. Both frequencies are passed through a 300 to 1 800 kHz multiplier, so that comparison is effected at 1 800 kHz. This frequency can therefore also be used as an external frequency standard.

When using the 1 800 kHz as comparison frequency a convenient beat reading is produced on the indicating instrument. Thus a frequency stability of $\pm 10^{-8}$ corresponds to a beat duration of 55 seconds, $\pm 5 \cdot 10^{-8}$ producing a beat duration of 11 seconds.

The internal frequency comparison pilots 60 and 300 kHz are connected to the frequency checking equipment via special maintenance test points at the outputs of the amplifiers incorporated in the pilot filters 60 and 300 kHz respectively.

With the exception of the indicating instrument, the frequency checking equipment is accommodated in the pilot generating shelf stack 60, 300, 84.08 and 411.92 kHz. The instrument is of standard design and is located in the left-hand bay upright.

## *Master Oscillator 2 500 kHz*

The complete master oscillator comprises two parts, namely the master oscillator proper and the crystal oven with its electronic temperature control circuit. A block diagram of the oscillator is shown in fig. 10.

The oscillator is of the linear type. The oscillations are generated in an amplifier stage with positive feedback via a quartz crystal, the frequency of oscillation being determined by the series resonance of the crystal. To minimize crystal aging the crystal power is maintained at a low value, whereby a high long-term stability is achieved.

The crystal oven consists of an aluminium cylinder enclosing the oscillator section with the crystal and a temperature sensing bridge circuit. The oven temperature can be adjusted to the turnover temperature of the individual crystal, i.e. the temperature at which the temperature coefficient of the crystal is zero. Hereby the effect of variations in ambient temperature is negligible.

## *Master Oscillator 124 kHz*

The 124 kHz master oscillator comprises a bridge-stabilized Meacham-type oscillator with a temperature control circuit. Since the stability characteristics of crystals at 124 kHz are not quite as good as at 2 500 kHz, the 124 kHz master oscillator has a slightly lower frequency stability than the 2 500 kHz oscillator ($\pm 5 \cdot 10^{-8}$ per month as against $\pm 10^{-8}$ per month).

However, the use of a 124 kHz master oscillator simplifies the generation of carrier basic frequencies and, if monthly adjustments are made, its stability is adequate for systems providing up to 2 700 circuits.

## *Frequency Multipliers*

The frequency converting apparatus comprises various types of multipliers, such as magnetic harmonic generators and diode harmonic generators.

The characteristic element of the magnetic harmonic generator is an iron-core coil which is periodically saturated, causing an RC network to be nearly short-circuited each half cycle. This produces a continuous train of pulses containing a large number of harmonics having approximately equal amplitudes.

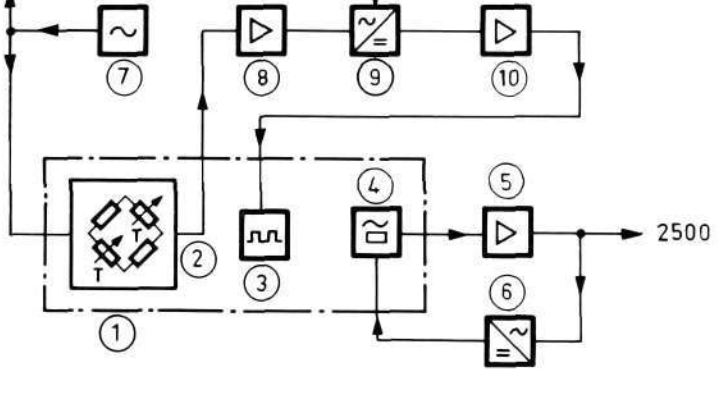
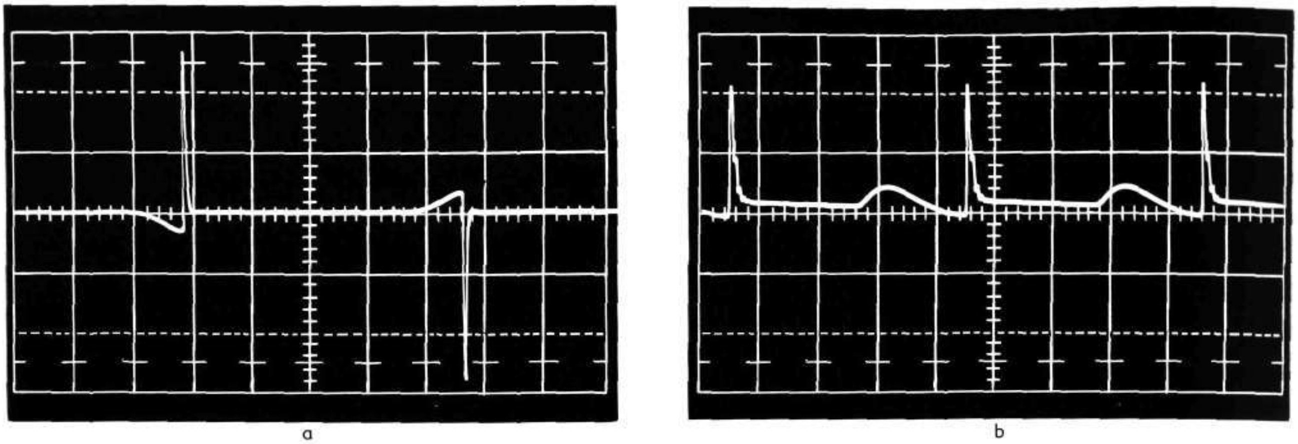



**Fig. 10**
**Master oscillator 2 500 kHz**
① Crystal oven
② Temperature sensing bridge
③ Heater winding
④ Crystal oscillator
⑤ Amplifier
⑥ Rectifier and level reference
⑦ AF oscillator
⑧ AF amplifier
⑨ Discriminator
⑩ DC amplifier



a b

Fig. 11
**Harmonic generator**

a Output voltage from magnetic harmonic generator with resistive load. Fundamental frequency 12 kHz
b Output voltage from diode harmonic generator with resistive load. Fundamental frequency 1.5 MHz

The main element in the diode harmonic generator is a semiconductor diode having an accurately-defined reverse conductivity time. The transition from reverse storage conduction to cut-off is so fast that the transition time is calculated on a nanosecond basis (1 nsec = $10^{-9}$ second). An appropriate circuit enables the diode to generate a sharp pulse for each cycle of the fundamental frequency.

The diode harmonic generator is mainly used for frequency multiplications in the MHz range.

Oscillograms of the output levels for the two harmonic generator types are shown in fig. 11.

## *Frequency Dividers*

In frequency division synchronism between the input and output frequencies is not as readily achieved as is the case with frequency multiplication. In dividers therefore consideration should be given not only to conversion properties but to a still higher degree to synchronization stability.

To provide both functions step-type counter circuits have been chosen for the design of the frequency dividers, namely toggle dividers and staircase dividers. The stability of synchronization is good. The input voltage and the power supply voltage ($U_i$) may vary by ± 30 % without synchronism being impaired, and the effect of any variations in ambient temperature is of a scarcely appreciable magnitude.

The toggle frequency divider consists of a number of cascaded bistable multivibrators, each toggle stage dividing the frequency applied to its input by 2. Thus with a number of $n$ toggle stages a division of $2^n$ is obtained, i.e. the input frequency is divided by numbers of 2, 4, 8, etc. Division by any desired whole number can be achieved by feeding back one or more pulses to preceding toggle stages.

In the staircase frequency divider a capacitor is charged by a pulse at each cycle of the input frequency. After a certain number of pulses the capacitor discharges, triggering a blocking oscillator, which produces a short-duration pulse. In the staircase divider the divisor is equal to the number of charging pulses per discharge.

The toggle divider as well as the staircase divider produces output voltages rich in harmonics and can therefore also perform frequency multiplication functions. This combination of functions allows the dividers to be used for frequency division operations with fractional numbers.

Oscillograms for both frequency divider types when using a division ratio of 5 are shown in fig. 12.

## *Crosstalk*

The carrier supply may give rise to crosstalk and noise in the signal transmission path in two different ways, namely through impurities in the carrier frequencies, and through the internal impedance of the feeding carrier source.

Impurities in carrier frequencies consist in one or more frequency-shifted disturbing bands being superimposed on the desired sideband during modulation and demodulation. If these impurities are grouped around the carrier frequency at distances which are integral multiples of the channel width, this will produce intelligible crosstalk between the channels in the frequency band concerned. Also impurities grouped at other distances may produce inconvenient interference.

A special source of interference is hum modulation, which arises when a carrier frequency is modulated by a power-supply frequency spectrum ($\pm n \cdot 50$ Hz). Hum modulation generally does not cause crosstalk, but disturbs the individual channels when busied.

The problem of supplying the modulation stages with sufficiently pure carrier frequencies has many aspects. A suitable design and advanced filter techniques are basic requirements. Careful consideration has also been given to the reduced inter-component and inter-unit spaces resulting from an extremely compact design and the consequently increased risk of direct crosstalk.

An appropriate disposition of the components in the different apparatus units and well-shielded cabling have been employed. In developing the design for the frequency generating apparatus it has been a general objective to arrange that all important levels are at approximately the same value, thus reducing crosstalk between points having different levels.

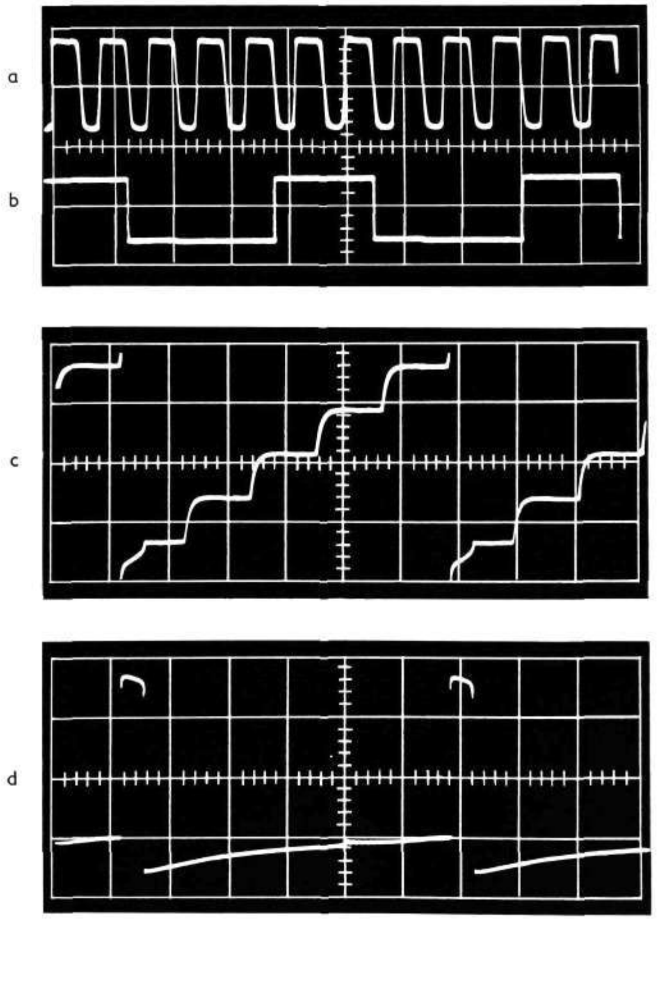


**Fig. 12**

**Frequency divider using division ratio of 5**

**Oscillograms showing, from top downward:**

- **a Toggle divider, drive voltage at fundamental frequency**
- **b Toggle divider, output voltage**
- **c Staircase divider, charging curve**
- **d Staircase divider, output voltage**

Power packs, by their internal impedances, may act as crosstalk paths between the associated units. The most effective and economic way to keep this type of crosstalk within acceptable limits has been found to be the specification of stringent thresholds for mutual interference between power supplies and associated apparatus. In addition, the maximum permissible amount of ripple produced by a power supply has been specified. These measures facilitate the dimensioning of the protective arrangements required to cope with the previously mentioned hum modulation.

The crosstalk path via the internal impedance of the carrier source is shown in the left-hand diagram of fig. 13. As will be seen, the crosstalk attenuation consists of three components, the balance return loss in a disturbing modulator, the balance return loss in a disturbed modulator and an external loss component.

Normally the two balance return losses are of such magnitude that they alone will provide almost sufficient crosstalk protection. Balance return losses being rather unstable, however, an ample margin should be provided, viz. an adequate external loss contribution. In this connection it will be found that when a low-impedance carrier source feeds several modulators and demodulators in parallel, the shunt impedance at the distribution point is so low that the value of the external loss contribution is high enough by itself and no special arrangements need be made.

The carrier supply for the lowest three modulation stages is arranged in this manner.

In the higher modulation stages, however, the carrier supply is confined to one modulator and one demodulator per carrier frequency: at the same time frequencies are higher and crosstalk attenuation requirements more stringent. Consequently in single parallel supply configurations the external loss contribution may be inadequate.

In such cases, therefore, the carrier supply may be arranged as illustrated in the right-hand diagram of fig. 13. The supply has been assigned to two amplifiers operating in parallel, one for the modulator, another for the demodulator.

Thus a substantial external loss contribution is obtained, which together with the balance return losses fully meets the crosstalk attenuation requirements involved.

Impurities in pilot frequencies can also produce interference in the transmission path. However, these impurities are easily suppressed, the attenuation requirements being moderate.

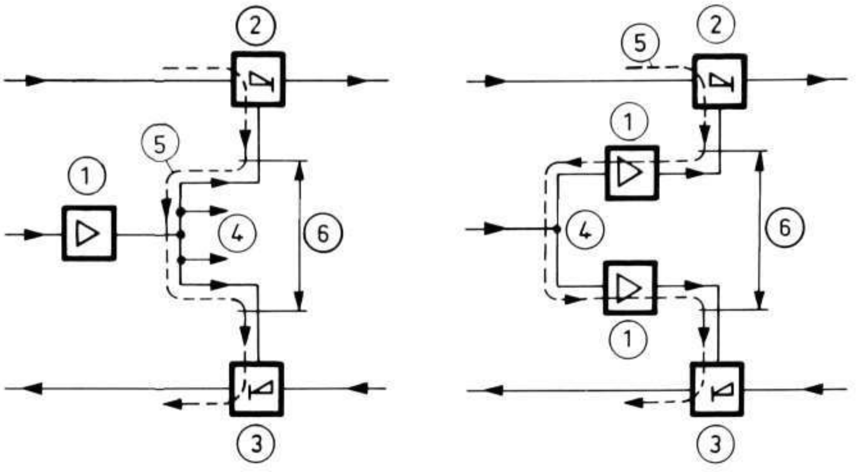
Crosstalk via the internal impedance of the pilot source does not present a problem either. Each pilot is injected separately via attenuators and unsymmetrical hybrid transformers. Hereby a fully adequate amount of crosstalk attenuation is obtained.

## Mechanical Design

Mechanically the equipment for the generation of carrier basic frequencies has been arranged in two different combinations of shelf assemblies depending on the capacity of the system and the master oscillator accordingly chosen. The two configurations are shown in a block diagram, fig. 2.

The 124 kHz master oscillator is suitable for use in systems providing up to 2 700 circuits. The carrier basic frequency generating equipment as shown in fig. 2 b has been arranged so as to facilitate incorporation in a variety of systems.

Fig. 13
**Crosstalk via carrier supply**
Left-hand diagram: carrier amplifier common to several modulators
Right-hand diagram: one carrier amplifier for each modulator
① Carrier amplifier
② Disturbing modulator, transmit
③ Disturbed modulator, receive
④ Distribution point
⑤ Crosstalk path
⑥ External loss contribution




The 124 kHz master oscillator shown in fig. 2 b occupies one shelf. Duplication of the equipment requires two such shelves. Frequency conversion from 124 kHz to 12 kHz is effected in another shelf containing two sets of converting equipment. The same shelf also accommodates two 124 kHz amplifiers with changeover facility. Together with two master frequency generating shelves the frequency converting shelf forms a duplicated supply of carrier basic frequencies 12 and 124 kHz.

Where a carrier basic frequency of 440 kHz is desired, an additional shelf is required in which duplicated sets of 124 to 440 kHz converting equipment are housed.

The 2 500 kHz master oscillator is designed for systems providing 2 700 or more circuits. Accordingly, the carrier basic frequency generating equipment has in this case been given a different mechanical arrangement from that described in the previous case.

The 2 500 kHz master oscillator and the equipment for the frequency conversion from 2 500 kHz to the 12, 124 and 440 kHz carrier basic frequencies have been combined into one shelf stack comprising two shelves housing a single set of equipment as illustrated by fig. 2 a. Amplifiers and changeover facilities have been placed in separate amplifier shelves, those for the 12 and 124 kHz being housed in one shelf, those for the 440 kHz in another. As shown in fig. 2 a it is possible to feed several amplifier shelves in parallel in those cases where the carrier basic frequency capacity is to be shared among several duplicated sets of amplifiers. In addition, an increase in capacity can be achieved with this parallel arrangement.

The pilot frequencies 60, 300, 84.08 and 411.92 kHz are generated in two identical sets of equipment accommodated in a shelf stack consisting of two shelves, as shown in fig. 3. The same shelf stack also contains a level measuring set and frequency checking equipment. An indicating instrument associated with the latter equipment is located in the left-hand bay upright.

Duplicated sets of 1 552, 11 096 and 8 248 kHz pilot generating equipment as shown in fig. 3 have been assembled into a shelf stack comprising three shelves.

The distributors required for the distribution of all carrier basic and pilot frequencies are mounted in a separate shelf. This shelf is placed at the top of the bay concerned, as the station cabling is connected directly to coaxial jacks at the front of the distributors and leaves the bay vertically upward.

The mechanical arrangement of the common frequency supply in shelves and shelf stacks as described above provides a high degree of flexibility and makes it suitable for application in a variety of systems from 300 circuits upwards.

An example of how the different shelves and shelf stacks can be combined into a centralized frequency generating bay on a 124 kHz master frequency basis for use in carrier systems on coaxial cables is shown in fig. 14. It contains two master frequency generating shelves 124 kHz, one frequency converting shelf 124 to 12 kHz, ditto 124 to 440 kHz, one pilot generating shelf stack 60, 300, 84.08 and 411.92 kHz, ditto 1 552, 11 096 and 8 248 kHz and one frequency distributing shelf. In addition one service shelf and two power packs for mains or battery operation are included. The power packs feed one set of equipment (I or II) each.

This bay is suitable for application in systems providing up to 2 700 circuits. When fully equipped and provided with additional distribution equipment in the suite end cabinets, the bay can supply a terminal with a capacity of 10 000–20 000 circuits.

As previously mentioned, the station cabling for outgoing frequencies is connected directly to coaxial jacks arranged at the front of the distributors in the frequency distributing shelf at the top of the bay.

Where the distribution of carrier basic frequencies is required to be arranged from the regular and standby sets separately, the corresponding station cabling is connected to coaxial jacks at the front of distributors placed at the left-hand end of the shelf in which the carrier basic frequencies concerned are generated. These station cables are housed in the space in the left-hand bay upright.

In so far as the required carrier basic frequencies are already available elsewhere in existing supplies, the corresponding equipment in the centralized frequency generating bay can be omitted. The other equipment in the bay can then be driven by these external carrier basic frequencies supplied via station cabling in the left-hand bay upright.

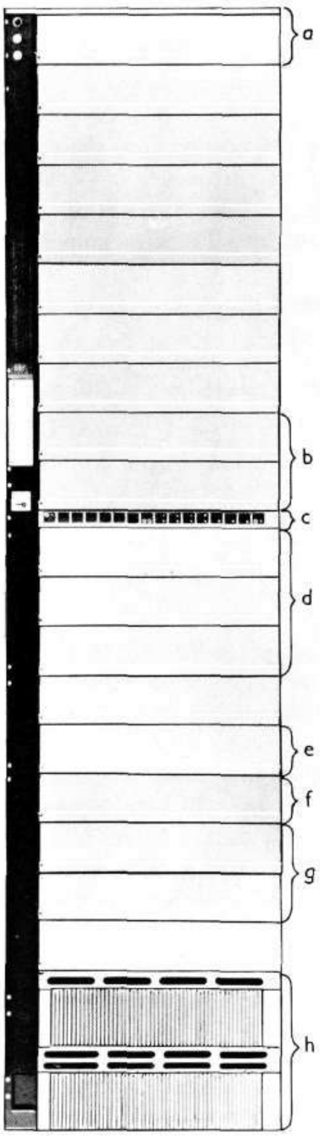



**Fig. 14**

**Centralized frequency generating bay using master frequency 124 kHz**

- a Frequency distributing shelf 12—11 096 kHz
- b Pilot generating shelf stack 60—411.92 kHz
- c Service shelf
- d Pilot generating shelf stack 1552—11 096 kHz
- e Frequency converting shelf 124 to 440 kHz
- f Frequency converting shelf 124 to 12 kHz
- g Master frequency generating shelves 124 kHz
- h Power packs

## Technical data

*Frequencies*

| | |
|---|---|
| Master frequencies | 124 alt. 2 500 kHz |
| Carrier basic frequencies | 12, 124, 440 kHz |
| Pilot frequencies | |
| reference pilots | 84.08, 411.92, 1 552, 11 096, 8 248 kHz |
| frequency comparison pilots | 60, 300 kHz |

*Number of outlets per frequency*

| | |
|---|---|
| With distributors in one stage | 10 |
| With distributors in two stages | 100 |

*Capacity*

| | |
|---|---|
| With distributors in one stage | 2 400 circuits |
| With distributors in two stages | 10 000–20 000 circuits |

| | |
|---|---|
| *Frequency stability after 6 months' continuous operation* | |
| With master oscillator 124 kHz | $\pm 5 \cdot 10^{-8}$ per month |
| With master oscillator 2 500 kHz | $\pm 10^{-8}$ per month |
| *Nominal output levels* | |
| 12, 124, 440, 84.08, 411.92, 60, 300 kHz | 0 dBm |
| 1 552, 11 096, 8 248 kHz | −20 dBm |
| *Nominal test level* | |
| At all maintenance (M) test points | −10 dBu/75 ohms (0 dBu = 0.775 V) |
| *Level measuring set* | |
| Frequency range | 12 kHz–12 MHz |
| Nominal input level for 0 dB deflection | −10 dBu |
| Input impedance | 75 ohms |
| Range of measurement | −4 dB to +1 dB and ±1 dB |
| Accuracy of measurement | ±0.2 dB |
| *Level stability* | |
| Carrier basic frequencies and frequency comparison pilots | ±1 dB per 3 months |
| Reference pilots | ±0.3 dB per 3 months |
| *Nominal impedances* | |
| Output impedance per distributor outlet | 75 ohms unbal. |
| Load impedance | 75 ohms unbal. |
| *Changeover data for carrier basic frequencies and reference pilots* | |
| Level drop at which automatic changeover from regular to standby is effected | $\geqq$ 2–3 dB |
| Time of interruption when automatic changeover to standby or manual reconnection of regular is effected | $\leqq$ 4 ms |
| *Alarm data for carrier basic frequencies and frequency comparison pilots* | |
| Alarm is given when level in regular or standby set drops by | $\geqq$ 2–3 dB |
| *Alarm data for reference pilots* | |
| Alarm is given when level of distributed pilot (regular or standby) deviates from nominal by | $\geqq \pm 0.5$ dB |
| Alarm is given when level of pilot not being distributed (standby or regular) drops by | $\geqq$ 2–3 dB |

*Power consumption*

Shelves and shelf stacks
(operated from 21 V d.c.)

| | |
|---|---|
| Master frequency generating shelf 124 kHz | 17 W |
| Frequency converting shelf 124 to 12 kHz | 27 W |
| Frequency converting shelf 124 to 440 kHz | 26 W |
| Basic frequency generating shelf stack 12, 124, 440 kHz | 40 W |
| Amplifier shelf 12, 124 kHz | 16 W |
| Amplifier shelf 440 kHz | 8 W |
| Pilot generating shelf stack 60–411.92 kHz | 54 W |
| Pilot generating shelf stack 1 552–11 096 kHz | 60 W |

Bays

| | Operated from | | |
|---|---|---|---|
| | d.c. supply | | a.c. supply |
| | 24 V | 36, 48 or 60 V | 110, 127 or 220 V |
| frequency generating bay (124 kHz master) equipped with:<br>2 master frequency generating shelves 124 kHz<br>1 frequency converting shelf 124 to 12 kHz<br>1 frequency converting shelf 124 to 440 kHz<br>1 pilot generating shelf stack 60—411.92 kHz<br>1 pilot generating shelf stack 1 552—11 096 kHz | 290 W | 245 W | 280 W |
| frequency generating bay (2 500 kHz master) equipped with:<br>2 basic frequency generating shelf stacks 12, 124, 440 kHz<br>1 amplifier shelf 12, 124 kHz<br>1 amplifier shelf 440 kHz<br>1 pilot generating shelf stack 60—411.92 kHz<br>1 pilot generating shelf stack 1 552—11 096 kHz | 310 W | 265 W | 300 W |

# ERICSSON News from All Quarters of the World

The signing of the 175 million kronor contract between Companhia Telefônica Brasileira (CTB) and Ericsson do Brasil (EDB). Seated (from left) Sr. Geraldo Nóbrega, EDB, Sr. Portugal Gouvêia, President of CTB, São Paulo, Mr. Ragnar Hellberg, President of EDB, and Sr. Oswaldo Baldi, CTB. Standing (from left) Sr. José Diniz, EDB, Mr. Robert Grierson, CTB, and Sr. Frederico Falcão, EDB.

## Large New Orders for LME Companies in South America

BRAZIL

Ericsson do Brasil, L M Ericsson's Brazilian subsidiary, has signed a contract with the São Paulo Telephone Administration for the delivery of L M Ericsson crossbar exchanges to a total value of some 175 million kronor. The equipment is intended exclusively for the city of São Paulo where it will be installed in 10 new and 12 existing exchanges.

With this order Ericsson do Brasil has in rather more than one year received orders for more than 400 million kronor. About a year ago L M Ericsson obtained its first large contract in São Paulo comprising 13 automatic telephone exchanges. A large order followed in November 1966 for extension of existing exchanges and for equipment providing for automatic interworking between São Paulo and nearby cities. São Paulo is the largest and most rapidly expanding industrial city in Latin America, with around 6 million inhabitants. In the last ten years the population has more than doubled.

Including the large order about one year ago from Brazil's third city, Belo Horizonte, and successive orders for several other cities in the country, Ericsson do Brasil has delivered and received orders for telephone exchanges and associated equipment for about 500,000 subscriber lines in more than 300 localities.

L M Ericsson has been established in Brazil through subsidiary companies since 1924 and has had its own factory at São José dos Campos since 1955. The factory is expanding vigorously and at present employs some 1,000 persons. The bulk of the aforementioned orders will be delivered from this factory.

VENEZUELA

L M Ericsson's Venezuelan subsidiary, Compañía Anónima Ericsson, has been awarded a very large order for telephone exchange equipment from the Venezuelan Central Telephone Administration. The project covers the delivery and installation of 12 Ericsson automatic crossbar exchanges for altogether 69,000 lines.

The order was obtained in the face of very stiff competition from American, German, Japanese, Canadian and Dutch telephone manufacturers and amounts to more than 42 million kronor. The order is being financed by loans from the World Bank.

The project covers the extension of the telephone network of the capital, Caracas, by altogether 42,000 lines, and extension and automatization of the telephone networks of six provincial cities.

L M Ericsson has been established in Venezuela since 1948 and has already achieved considerable successes in that country. There are today Ericsson telephone exchanges serving more than 40,000 Venezuelan subscribers. An order for equipment for automatization of the trunk traffic, comprising an international and 26 national transit centres, is at present under delivery.

The signing of the contract between L M Ericsson's Venezuelan subsidiary (CEV) and the Venezuelan Central Telephone Administration (CANTV) by (from left) Mr. Sven Wenhammar, President of CEV, Dr. Jorge Armand, President of CANTV, and Dr. Luis Hernandez Rovati, Legal Consultant of the Administration.

## Kuwait Again in the News

A large contract was signed on January 27 this year with the Kuwait Telephone Administration. The contract comprises 19,000 ARF lines at five new exchanges and extensions of five earlier exchanges. In less than one year L M Ericsson has received orders from Kuwait amounting to 35,000 lines.

The first five exchanges are at present being installed at a rapid rate, and four of them are expected to be in operation by November this year. They will total 8,000 lines including interworking equipment with existing step-by-step exchanges.

Kuwait has at present the largest national income per capita in the world and is quickly developing technically and socially. L M Ericsson's successful establishment in Kuwait creates an appreciable good will for the group also within the rest of the Arab world.

## Carrier Telephony in Central America

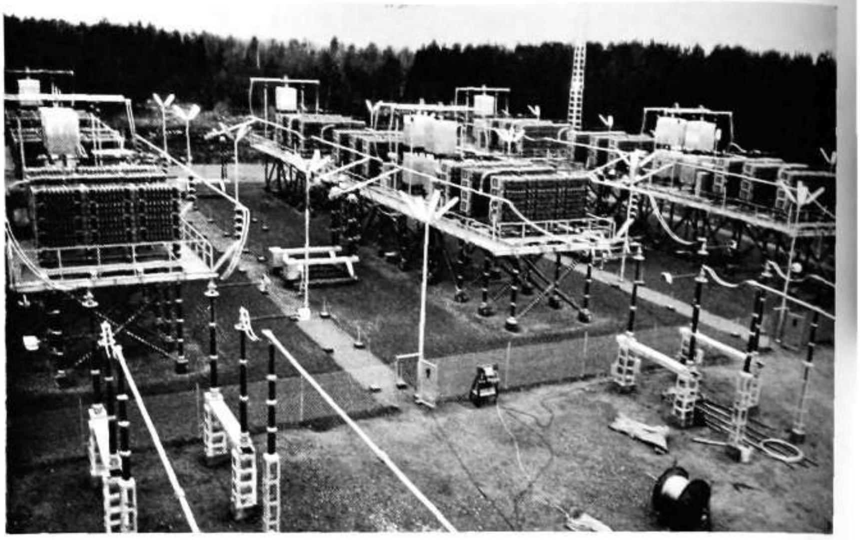
The first international carrier telephone system between Guatemala and Mexico was put into operation during the first half of 1966 at the initiative of the Mexican Telephone Company TELMEX, which also installed the equipment.

An agreement was made with the National Telephone Company of Guatemala, GUATEL, that an overhead line system should be installed, and L M Ericsson's 12-channel system supplemented by a 4-channel system was selected.

The telephone companies of Guatemala and its neighbour, El Salvador, have decided to extend the system southwards and intend to build an overhead line between the capitals of the two countries, Guatemala City and San Salvador.

At the beginning of the year the Long Distance Division received an order for the terminal bay for Guatemala City, and an order is expected shortly from San Salvador for its carrier equipment.

This order, the first received by the Long Distance Division from these countries, must be considered especially satisfactory.



The new capacitor bank at Vittersjö — with the largest output in the world.

## The World's Largest Series Capacitor

Sieverts Kabelverk have delivered a new capacitor bank to Vittersjö in Gästrikland. This is the seventh series capacitor in Sweden on a grid system and has the largest output in the world.

The current was switched on at the end of last year. The capacitor consists of 5,832 units and is connected to a 400 kV line.

At the tests made before the plant was put into operation at Vittersjö there were representatives from the Caracas Power Company, Venezuela. Four series capacitors on the Swedish pattern are to be installed there in 1969 on the 230 kV network.

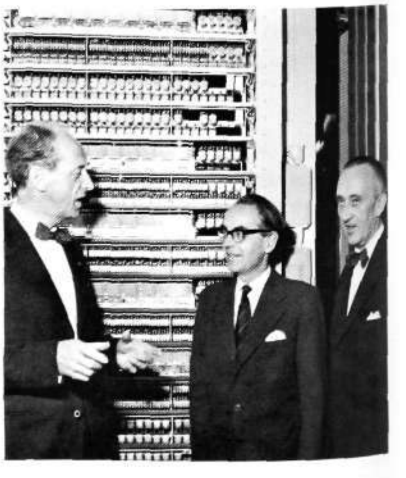
In view of the heavy voltages the testing apparatus had to be placed on insulated stands on the 400 kV platforms and be switched on electrically from the ground with photocells.

The line on which the new series capacitor is placed is 250 miles long but has shrunk, figuratively speaking, to 110 miles. The transmission costs are thereby reduced by 15 %, which in monetary terms represents a gain of $2\frac{1}{2}$–3 million kronor per annum. The total cost of the plant is 11.5 million kronor.

In 1950 Sieverts Kabelverk were first in the world to supply capacitors for grid systems. The first installation was on a 300 mile long 220 kV line. The first 400 kV capacitor came four years later and six similar equipments have since been installed at regular intervals.

### New Code Switch Exchange in Gothenburg

The large code switch exchange, Änggården, in Gothenburg was cut over in December 1966. This exchange, with a present capacity of 14,000 lines, serves as a local suburban exchange within the Gothenburg zone, which is otherwise served entirely by 500-line switch exchanges. The photograph shows (from left) Mr. Gustav Toshach, District Manager of the Telecommunications Administration, Mr. Sture Lauhrén of the Board of Telecommunications, and Mr. Eric Ledin, L M Ericsson, in front of one of the sliding "bookshelf racks" which characterize code switch exchanges.

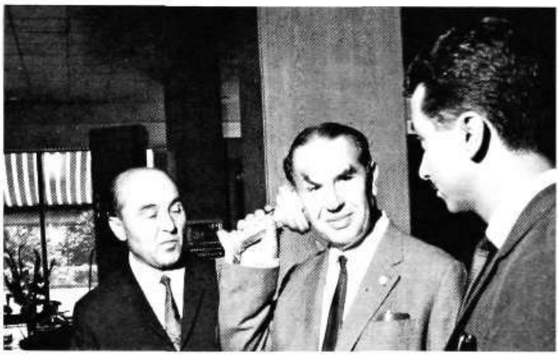


The new construction practice M4 has been introduced at a high level within the Swedish Telecommunications Administration. Mr. Tellus Erik Eriksen's work with the screwdriver is followed with interest by Director General Bertil Bjurel (foreground), Deputy Director General Torsten Larsson, and LME President Björn Lundvall.

On February 20 and 21 the Board of L M Ericsson visited the Karlskrona factory. The event was immortalized in this group photograph showing (from left) Mr. Gunnar Svalling, LME, Mr. Torsten Skytt, AB Rifa, President Björn Lundvall, LME, Vice-Admiral Erik Anderberg, Mr. Hans Werthén, LME, Mr. Wilhelm Söderman, Dr. Marcus Wallenberg, Mr. Erik Boheman, Mr. Erik Olsson, LME, Karlskrona, and Mr. Rune Höglund.

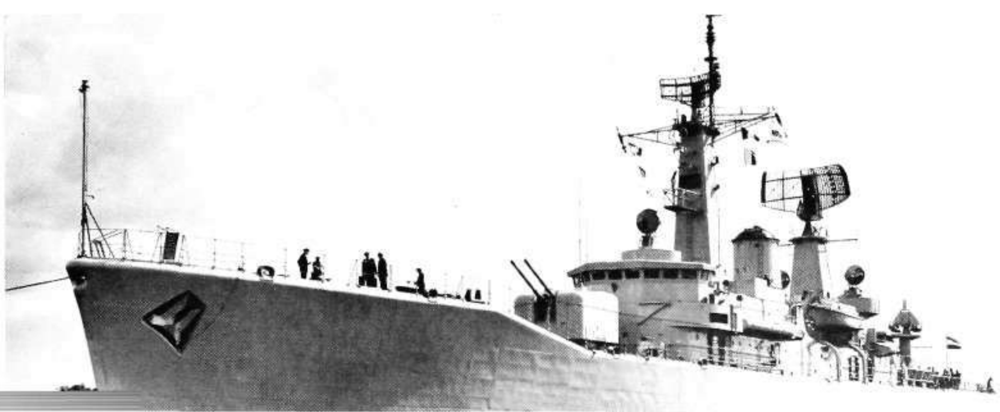
The first public crossbar exchange in Mauritania was opened at the end of last year at Port-Étienne. The exchange was delivered by L M Ericsson's French subsidiary, Société Française des Téléphones Ericsson (STE), and is of type CP 400.
M. Ould Abdellahi, Director of the Ministry of Supplies, dials the opening call with, on his right, M. Ould Ba, Government Delegate, M. Assane Diallo, Manager of the Exchange, and M. Mustapha N'Diaye, Head of Telecommunications, and on his left M. Jacques Rosselin (partly hidden), STE, M. Ould Sidya and M. Guisset, Director of P & T.

Ericsson do Brasil's (EDB) plant at São José dos Campos is being extended stage by stage and within the next year to eighteen months will have doubled its floor space to some 320,000 sq.ft.
A new building was opened at the end of 1966. It was originally intended to serve chiefly as warehouse but to an increasing extent has been used for production. The "ceremonial knot" was untied in the presence of a delegation from the São Paulo Telephone Syndicate (CTB): (from left) Marshal Nelson de Mello, EDB, Sr. Portugal Gouvêia, CTB, Mr. Ragnar Hellberg, President of EDB, Sr. Luiz Cabral de Menezes, EDB, Consul General Erik Svedelius, Sr. Carlos Reis Filho, President of CTB, São Paulo, and Sr. Geraldo Nóbrega, EDB.



Mr. Moazezz Tulga, Assistant Director of the Turkish Civil Defence, tries out an 1878 LME telephone in the exhibition room. On his left is Mr. Galit Baidar, Secretary of the Turkish PTT, and on his right his interpreter Mr. Chentinbay Kent. The Turkish Civil Defence is at present looking over its alarm system and L M Ericsson's pneumatic sirens are of interest in this context.

The Dutch destroyer Van Speyk—the first of a series of six—left dock in December last year. The vessel is equipped with a PABX ALD 24. All telecommunication equipment was supplied by Ericsson Telefoonmaatschappij, Rijen, Holland.



Mr. Hans Werthén

## Mr. Hans Werthén Leaves L M Ericsson

In May 1967 Mr. Hans Werthén, Senior Executive Vice President, will leave the company to become President of AB Electrolux.

The board has appointed Mr. Arne Mohlin to succeed him as Director of Production and Senior Executive Vice President.

## 500,000th Crossbar Switch Made in Sweden

The crossbar switch has become a great success for the Ericsson group, tangible evidence of which was the demonstration at the Karlskrona factory of the 500,000th switch to leave the production line in January this year. Of these 500,000 switches made in Sweden the Karlskrona factory has made 425,000.

The demand for crossbar necessitates a heavy increase of production this year. During the first quarter an increase of 35 per cent is counted on compared with the same period for 1966. This amounts to 2,000 crossbar switches per week. An increase of 50 per cent is expected in the second quarter.

By no means all switches find buyers in Sweden, most of them—60 per cent—being exported. The switches are made on licence in Egypt, among other countries, and several of the group's foreign factories have the crossbar switch on their production programme.

In conjunction with the showing of the jubilee switch the Karlskrona Factory Manager Mr. Erik Olsson, had calculated how much copper wire had been used for the 500,000 switches. He found that the wire would extend round the earth 180 times or complete the return journey from the earth to the moon 19 times.


In silent meditation on the 500,000th crossbar switch—made in Karlskrona—are seen (from left) Tester Erling Carlsson, Foreman Nils Strömberg and Factory Manager Erik Olsson.

# L M Ericsson Takes over Gylling's Telecommunications Activities

The L M Ericsson Telephone Company has concluded an agreement with the owners of AB Gylling & Co., Stockholm, to take over the latter company's telecommunications activities from February 13, 1967. The take-over comprises essentially the development, production and sale of intercom systems, but not of the activities concerned with radio, TV and industrial electronics.

The take-over concerns the factory at Norrköping and the activities at Oskarshamn where, however, the manufacture of printed circuits will still be conducted by Gylling & Co. The activities at these two production units will continue as hitherto. The sales companies in Sweden, Norway, Denmark, Britain, France, West Germany, U.S.A., Canada and Peru are also covered by the agreement.

The development and design activities will be united under L M Ericsson Telemateriel AB, Bollmora.

The name of Gylling will be retained within the Gylling group. The trademarks "Centrum" and "Sinus" will be taken over by L M Ericsson for the intercom systems and sound distribution equipment, while Gylling will retain the name "Centrum" for its radio and television sets.

The reason for the agreement is the desire, in a stiffening market, to enable the Swedish telecommunication industry and Swedish exports to develop more rapidly. As a result of the transfer the activities and resources of the Gylling Companies will be concentrated to the domestic electronics and industrial electronics sectors, while L M Ericsson, with its world-wide resources within the telecommunications field, will take over the activities within the telecommunications sector.

(Left) President Bertil Gylling and his son, B. Gylling Jr., and (right) President Björn Lundvall, L M Ericsson, signing the contract which confirms the take-over of AB Gylling & Co's telecommunications activies by L M Ericsson.

UDC 621.395.722.004.5
LME 835 154

HARVA, M. & PACKALÉN, P.: *The Maintenance of Local Exchanges in Helsinki, Finland.* Ericsson Rev. *44*(1967): 1, pp. 2—10.

The Helsinki Telephone Company was established in 1882 and the first automatic exchange of step-by-step type was put into service in 1922. Crossbar exchanges were introduced in the area in 1950. The article deals with the maintenance organization in the Helsinki area and compares the operating results and maintenance efforts for the crossbar exchanges in relation to an average for all exchanges in the area.

UDC 621.395.344.6
LME 83021

REJDIN, A.: *L M Ericsson's Crossbar Systems — Developments in Components and Mechanical Equipment.* Ericsson Rev. *44*(1967): 1, pp. 11—20.

Ericsson Review No. 4, 1966, contained an article entitled "L M Ericsson's Crossbar Systems, Their Development and New Traffic Facilities". That article dealt only summarily with the developments in components and mechanical equipment. The present article therefore presents a more complete account of these developments.

UDC 621.311.4:621.395.722
LME 8475 8477

GUSTAFSSON, R. & KROONI, G.: *Power Supply and Alarm Arrangements in M4 Transmission Equipment.* Ericsson Rev. *44*(1967): 1, pp. 21—27.

The article describes power supply and alarm arrangements in transmission equipment engineered in the M4 construction practice. A decentralized power supply is employed, which means that each bay has been provided with its own power pack for the generation of the −21 V transistor voltage. These power supply units are regulated and designed for connection to non-stabilized mains or battery voltages.

Two types of alarm are provided: urgent (A) alarm for fault conditions interfering with traffic, non-urgent (B) alarm for other fault conditions. Facility is provided for disconnecting alarm functions, a reminder indication being brought up at the same time. The same power supply and alarm arrangements are used in practically all bay types.

UDC 621.391.82:621.395.44
LME 8460

GRÖNBERG, M. & JOHANNESSON, N.-O.: *Combination Effects Observed with Out-Band Signalling.* Ericsson Rev. *44*(1967): 1, pp. 28—33.

The article describes a type of disturbance hitherto neglected and only recently observed, and a means of suppressing it. The method described–random phasing–constitutes a simple and elegant solution of a problem which has become of importance in Sweden and elsewhere due to the full-scale use of semi-continuous out-band signalling in a network of broad-band links. The investigation has been carried out in co-operation with the Royal Swedish Board of Telecommunications, especially as concerns the planning and execution of a realistic series of measurements. The phenomena are of interest both for those concerned with long-distance transmission and with switching.

UDC 621.395.44
LME 8421
751

TANGEN, N. & ZEIPEL, K.-G.: *Centralized Fundamental and Pilot Frequency Generating Equipment for Carrier Terminals.* Ericsson Rev. *44*(1967): 1, pp. 34—52.

The introductory section of the article gives an outline of the carrier and pilot supply for carrier terminals engineered in the M4 construction practice.

In the continuation of the article a description is given of the centralized fundamental and pilot frequency generating equipment and its interworking with the decentralized, local carrier supplies in the respective translating bays.

# The Ericsson Group

## *Associated and co-operating enterprises and technical offices*

· EUROPE ·

**Denmark**

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson, telex: 9020 ericsson kh

Telefon Fabrik Automatic A/S *Søborg*, Telefonvej 6, tel: 69 51 88 tgm: automatic, telex: 5264

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: A 8282, tgm: ericssons, telex: 12-546

**France**

Société Française des Téléphones Ericsson *F-92-Colombes* 36, Boulevard de la Finlande, tel: Paris (1)242 35 00, tgm: ericsson colombes, telex: 62179
*F-75-Paris* 147, rue de Courcelles, tel: Paris (1)227 95 30, tgm: eric paris

**Great Britain**

Swedish Ericsson Company Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric
Production Control (Ericsson) Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

**Ireland**

L M Ericsson Ltd. *Dublin* 2, 32, Upper Mount Street, tel: 61931, tgm: ericsson, telex: 5310

**Italy**

FATME, Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 4694, tgm: fatme, telex: 61327

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

SIELTE, Soc. per Az. *Roma*, Viale Campo Boario, tel: 577 80 41, tgm: sielte

**Netherlands**

Ericsson Telefoonmaatschappij, N.V. *Rijen (N.Br.)*. tel: 01692-3131, tgm: erictel, telex: 54114
*Voorburg-Den Haag*, P.O.B. 3060, tel: 81 45 01, tgm: erictel-haag, telex: 31109

**Norway**

A/S Elektrisk Bureau *Oslo 3*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 1723
A/S Industrikontroll *Oslo 6*, Grensevejen 86/88, tel: Centralbord 68 34 64, tgm: indtroll
A/S Norsk Kabelfabrik *Drammen*, P.B. 500, tel: 83 76 50, tgm: kabel
A/S Norsk Signalindustri *Oslo 3*, P.B. 5055, tel: 46 18 20, tgm: signalindustri

**Portugal**

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

**Spain**

Cía Española Ericsson, S. A. *Madrid 13*, Torre de Madrid, Plaza de España, tel: 241 14 00, tgm: ericsson, telex: 7369

**Sweden**

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 08/19 00 00, tgm: telefonbolaget, telex: 19910
AB Alpha *Sundbyberg*, tel: 08/28 26 00, tgm: aktiealpha, telex: 10082
Casa Konsult AB *Älvsjö*, Huddingevägen 417, tel: 08/47 25 65 tgm: casaconsult
AB Ermi *Karlskrona 1*, tel: 0455/23010, tgm: ermibolag
AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308
AB Svenska Elektronrör *Stockholm-Tyresö 1*, tel: 08/712 01 20, tgm: electronics, telex: 1275
Instruktionsteknik AB *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec
L M Ericsson Data AB *Solna*, tel: 08/83 07 00, tgm: ericdata, telex: 10793
L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 08/68 07 00, tgm: signalbolaget
*Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00, tgm: ellem, telex: 1275
Sieverts Kabelverk AB *Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676
Svenska Radioaktiebolaget *Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio, telex: 10094

**Switzerland**

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *8032 Zürich*, Postfach, tel: 32 51 84, tgm: telericsson, telex: 52 669

**Turkey**

Ericsson Turk Ticaret Ltd. Sirketi *Ankara*, Rumeli Han, Ziya Gökalp Cad., tel: 12 31 70, tgm: ellem
*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahoekapi, tel: 22 81 02, tgm: ellemist
*Izmir*, Izmir Bürosu, Kisilkaya Han, Kat 3, No. 13, Halif Ziya Bulvari, tel: 37832, tgm: ellemir

**West Germany**

Deutsche Ericsson G.m.b.H. Telematerial *4 Düsseldorf-Rath*, Postfack 136, tel: (0211)63 30 31, tgm: erictel, telex: DSSD 8 58 6871

· ASIA ·

**India**

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: 45 44 94, tgm: inderic
*New Delhi 16*, L 25, South Extension Part II, tel: 765 05 tgm: inderic

**Indonesia**

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151—153, tel: 8294, tgm: javeric
*Djakarta*, Djalan Gunung Sahari 26, tel: OG 48531, tgm: javeric

**Iraq**

Telefonaktiebolaget LM Ericsson, Technical office *Baghdad*, P. O. B. 493, tel: 91454, tgm: ellemco

**Kuwait**

Telefonaktiebolaget LM Ericsson, Technical office, *Kuwait, State of Kuwait*, P.O.B. 5997, tgm: erictel

**Lebanon**

Telefonaktiebolaget LM Ericsson, Technical office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 25 26 27, tgm: ellem

**Thailand**

Ericsson Telephone Corp. Far East AB *Bangkok*, P.O.B. 824, tel: 55511-2 *tgm: ericsson*

**Egypt**

Telefonaktiebolaget LM Ericsson, Technical office Egypt Branch *Cairo*, P.O.B. 2084, tel: 46 581, tgm: elleme

**Morocco**

Société Marocaine des Téléphones Ericsson *Casablanca*, 38, rue Mohamed Sedki, tel: 788-75, tgm: ericsson

**Rhodesia, Botswana and Malawi**

Ericsson Telephone Sales Corporation Ltd. *Salisbury, Rhodesia*, P.O.B. 2891, tel: 25737, tgm: ericofon

**Tunisia**

Telefonaktiebolaget LM Ericsson, Technical office *Tunis*, Boîte Postale 780, tel: 2405 20, tgm: ericsson

**Zambia**

Ericsson Telephone Sales Corp. AB. *Ndola*, P.O.B. 2256, tel: 3885, tgm: ericofon

· AMERICA ·

**Argentine**

Cía Ericsson S. A. C. I. *Buenos Aires*, Casilla de Correo 3550, tel: 33 20 71, tgm: ericsson
Cía Argentina de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 33 20 76, tgm: catel
Cía Entrerriana de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 33 20 76, tgm: catel
Industrias Eléctricas de Quilmes S.A. *Quilmes, FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

**Brazil**

Ericsson do Brasil Comérico e Indústria S.A. *Rio de Janeiro*, C.P. 3601-ZC-00, 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*, Casilla 101 43, tel: 825 55, tgm: ericsson

**Colombia**

Cía Ericsson Ltda, *Bogotá*, Apartado Aéreo 4052, tel: 41 11 00, tgm: ericsson

**Costa Rica**

Telefonaktiebolaget LM Ericsson, Technical office *San José*, Apartado

Teléfonos Ericsson C.A. *Qui*
Casilla 2138, tel: 16100, tg
ericsson
*Guayaquil*, Casilla 376, tel: 1689
tgm: ericsson

**Mexico**

Teléfonos Ericsson S.A. *Méxi*
*D.F.*, Apartado M-9958, te
46 46 40, tgm: coeric
Latinoamericana de Cables S.
de C.V. *Mexico 12, D.F.*, Apart
do Postal 25737, tel. 493650, tg
latincasa
Teleindustria, S.A. de C.
*Mexico 1, D.F.*, Apartado 106
tel: 46 46 40, tgm: ericsson, tele
017:7485

**Peru**

Cía Ericsson S. A. *Lima*, Apartad
2982, tel: 34941, tgm: ericsso
telex: 3540202
Soc. Telefónica del Perú, S.
*Arequipa*, Apartado 112-1012, te
60 60, tgm: telefonica

**El Salvador**

Telefonaktiebolaget LM Ericsso
Technical office *San Salvado*
Apartado 188, tel: 21-7640, tgm
ericsson

**Uruguay**

Cía Ericsson S.A. *Montevide*
Casilla de Correo 575, tel: 9261
tgm: ericsson

**USA**

The Ericsson Corporation *Ne*
*York, N.Y.*, 10017, 100 Par
Avenue, tel: MUrrayhill 5-403
tgm: erictel, telex: etelsac 62014
North Electric Co, *Galion, Ohio*
44833, P.O.B. 688, tel: (419
468-24 20, tgm, northphone-ga
lionohio, telex: 098-728

**Venezuela**

Cía Anónima Ericsson *Caraca*
Apartado 3548, tel: 543121, tgm
ericsson, telex: 734

· AUSTRALIA & OCEANIA

**Australia**

L M Ericsson Pty. Ltd. *Broadmea*
*dows (Victoria)*, P.O.B. 41, tel
3092244, tgm: ericmel, telex: AA
30555
*Sydney N.S.W.*, 134 Barcom
Avenue, Rushcutters Bay, tel
31 09 41, tgm: ericsyd
Teleric Pty. Ltd. *Broadmeadow*
*(Victoria)*, P.O.B. 41, tel: 30
2244, tgm: teleric, telex: AA 3055
*Sydney N.S.W.*, 134 Barcom
Avenue, Rushcutters Bay, tel
31 09 41, tgm: teleric

## *Representatives*

· EUROPE ·

**Austria**

Telecom Handelsgesellschaft m. b. H. *1140 Wien*, Schanzstrasse 33, tel: 72 26 21, tgm: teleric, telex: 11638.

**Belgium**

Allumage Lumière *Bruxelles 7*, 128-130, chaussée de Mons, tel: 22 98 70, tgm: allumalux, telex: 21582

**Greece**

Angelos Cotzias *Athens*, 39, Odas Acadimias, tel: 626-031, tgm: cotziasan, telex: 252

**Iceland**

Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

**Yugoslavia**

Merkantile Inozemna zastupstva *Zagreb*, Pošt pretinac 23, tel: 36941, tgm: merkantile, telex: 21139

· ASIA ·

**Burma**

Myanma Export Import Corp. Import Division (Electrical Stores) *Rangoon*, P.O.B. 403, tel: 14618, tgm: myanimport

**Cambodia**

Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 233 34, tgm: comink

**Cyprus**

Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

**Hong Kong & Macao**

Swedish Trading Co Ltd. *Hongkong*, P.O.B. 108, tel: 23 10 91, tgm: swedetrade

**Iran**

Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

**Iraq**

Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 870 31, tgm: alhamra

**Japan**

Gadelius & Co. Ltd. *Tokyo C*, P.O.B. 1284, tel: 403-2141, tgm: goticus, telex: 242-2075

**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. B. 1421, tel: 22—9866, tgm: gadeliusco

**Kuwait**

Morad Yousuf Behbehan *iKuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat

**Lebanon**

Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 23 16 24, tgm: skefko

**Malaysia and Brunei**

Swedish Trading Co. (M) Ltd. *Kuala Lumpur*, P.O.B. 2298, tel: 253 16, tgm: swedetrade

**Pakistan**

TELEC Electronics & Machinery Ltd. *Karachi 2*, 415, Mehboob Chambers, Victoria Road, tel: 231723, tgm: elco

**Philippines**

U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: 344

**Saudi Arabia**

Engineering Projects & Products Co. Ltd, Eppco, *Riyadh*, P.O.B. 987, tel: Jamhur 271, tgm: eppcol

**Singapore**

Swedish Trading Co. (M) Ltd. *Singapore 1*, 3rd floor, 31 Bank of China Bldg, Battery Road, tel: 94362, tgm: swedetrade

**Syria**

Constantin Georgiades *Damas*, Rue Fardos (Balkis), Immeuble Kosseihati, P.O.B. 2398, tel: 26673, tgm: georgiades

**Vietnam**

Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, P.O.B. 10 49, tel: 22 660, tgm: telerad

· AFRICA ·

**Congo**

I.P.T.C. (Congo) Ltd. *Kinshasa*, P.O.B. 8922, tel: 5345, tgm: induexpan

**Ethiopia**

Mosvold Company (Ethiopia) Ltd. *Addis Abeba*, P.O.B. 1371, tel: 14567, tgm: mosvold

**Ghana**

R.T. Briscoe Ltd., *Accra*, P.O.B. 1635, tel: 66903, tgm: briscoe, telex: 29

**Kenya, Tanzania, Uganda**

Transcandia Ltd. Telecommunication Division *Nairobi, Kenya*, P.O.B. 5933, tel: 271 03, tgm: transcanda

**Liberia**

Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Street, tel: 22222, tgm: radiolibe

**Libya**

ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 33906, tgm: adeco

**Mauritius**

Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

**Mozambique**

J. Martins Marques & Co Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

**Nigeria**

I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531 tgm: consult, telex: shell bp 35

**South Africa, South-West Africa**

Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

**Tunisia**

Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

· AMERICA ·

**Bahama Islands**

Anglo American Electrical Company Ltd., *Freeport, Grand Bahama*, P.O.B. 104

**Bolivia**

Johansson & Cía, S.A. *La Paz*, Casilla 678, tel: 25923, tgm: johansson

**Guiana**

General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwlks

**Costa Rica**

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 22 55 11 tgm: troco, telex: CR-126

**Dominican Republic**

Carcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3645, tgm: gartier

**Guatemala**

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62257, tgm: nilspira

**Honduras**

Q
*ga*
tg

**Jamaica and Brit. Hondura**

Morris E. Parkin *Kingston*, P.O.B.
354, tel: 24077, tgm: morrispark

**Netherlands Antilles**

S.E.L. Maduro & Sons. Inc.
*Willemstad, Curacao*, P.O.B. 304,
tel: 11200, tgm: madurosons

**Nicaragua**

Sonitel Centroamerica S.A. *Ma-*
*nagua*, Apartado 1271, tel: 4476,
tgm: sonitel

**Panama**

Sonitel, S. A. *Panama, R. P.* Apar-
tado 4349, tel: 5-3640, tgm:
sonitel, telex: PA 134

**Paraguay**

S.A. Comercial e Industrial H.
Petersen *Asunción*, Casilla 592,
tel: 9868, tgm: pargtrade

**El Salvador**

Dada-Dada & Co. *San Salvador*,
Apartado 274, tel: 214860, tgm:
dada

**Surinam**

C. Kersten & Co. N.V. *Para-*
*maribo*, 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, N.Y.*,
*10003*, 215 Park Avenue South,
tel: (212) 677-8400, tgm: state-
labs, telex: (212) 867-6996 (For
electron tubes)

· AUSTRALIA & OCEANIA

**New Zealand**

Ltd. *Wellin*
614

# ERICSSON Review

2
1967

# ERICSSON REVIEW

Vol. 44 No. 2 1967

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

## CONTENTS



On cover: L M Ericsson's crossbar system has been chosen for automatization of Australia's telex network. Interior of the intercontinental telex exchange in Sydney.

# Automatic Test Equipment for the »37 Viggen» Aircraft

S. LARSSON, TELEFONAKTIEBOLAGET LM ERICSSON, MÖLNDAL

UDC 621.317.799
621.389
LME 1548

*This article gives a general outline of an automatic test equipment developed by the MI Division of Telefonaktiebolaget L M Ericsson. The equipment has been ordered by the Royal Swedish Air Force and will be used for performance checking and fault detection in the electronic system of the 37 Viggen aircraft.*

*The article describes the working of the equipment and its electrical and mechanical construction. The programming is illustrated by examples and technical data are summarized.*

In recent years electronic equipment has become so complex that its users have discovered that manual checking and trouble-shooting have begun to be difficult and time-consuming. This has entailed larger maintenance sections, and in particular an increase in the number of highly qualified personnel. In many cases the best solution to this problem has been to introduce automatic test equipment, i.e. various stimuli and measuring units, automatic control and evaluation circuits, which reduce the time spent on tests as well as the personnel requirements.

In October 1965 the MI Division started work on the development of an automatic test equipment for checking and fault location in the electronic system of the 37 Viggen aircraft. The equipment has been designed to meet demands for great flexibility, and this makes it possible to use it, with the same units, in other applications.

## Operation

The automatic test equipment is computer-controlled and, in addition to the computer with its input-output units, includes stimuli and measuring units, loads, test point multiplexer and patchboard. The computer can also control other units, e.g. adaptation circuits for microwave measurements, and will work in conjunction with any computer incorporated in the tested system.

A block diagram of the equipment is shown in Figure 1.

The internal monitoring and calculation subroutines are stored in the computer memory, whereas the programme for the object under test is stored on magnetic tape (or punched tape) which is fed into the reader when the test is due to begin. The computer takes the test programme from the reader in blocks, i.e. one test at a time. Each block is fed into the computer memory and the instructions are then carried out in the order prescribed by the programme. Via the multiplexer and patchboard (Fig. 8) the computer connects the signal channels between the tested object and the stimuli and measuring circuits, and sets the stimuli circuits to the values required to be fed out to the tested object. The measured value is first put into digital form by the measuring circuits, then fed into the computer, where it is compared with the corresponding tolerance limits predetermined in the programme. The measured value is also fed into a magnetic tape recorder and registered for subsequent processing. If the value lies within its tolerance limits, the computer moves on to the next test, positioning the circuits accordingly. If the value is wrong, the computer runs a self-checking programme to test whether the error is in the test equipment or not. If the error is in the system

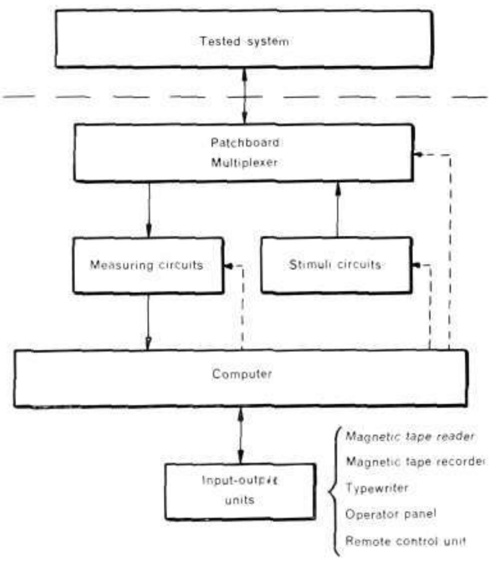



**Fig 1**
**Block diagram**
Continuous lines between blocks indicate signal channels
Dotted lines between blocks indicate control signals

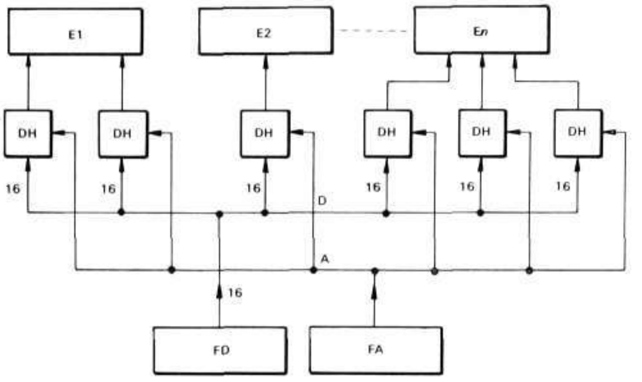



**Fig. 2**
**Principle for control of units.**

| | |
|---|---|
| E1—En | Stimuli and measuring units |
| DH | Drive and hold circuits |
| FD | Data register |
| FA | Address register |
| D | Databus |
| A | Addressbus |

being tested, the measured value is printed out on a typewriter, together with the corresponding upper and lower limits and the identification number of the faulty unit. The typewriter is also used for printing instructions to the operator whenever manual operations are to be performed, as is sometimes necessary for individual tests. If, however, the self-checking programme indicates that the error is in the test equipment, the operator feeds in a special monitor programme. This carries out a large number of tests for detailed internal performance checking and fault detection, and checks whether or not the equipment complies with the specified data; if not, it traces the fault to a replaceable unit in the equipment.

Various types of signals can be received from the stimuli circuits, e.g. d.c. voltage, 400 cycles a.c. voltage, different kinds of ramp signals, low frequency sinusoidal voltage and sawtooth voltage. The measuring circuits can evaluate a.c. or d.c. voltages, pulse amplitude, peak-to-peak values, phase, frequency, time and resistance. The equipment also contains resistances for loading the measured and stimuli signals.

The test equipment can be operated either from an operator's panel unit or from the remote-control unit. These units activate various parts of the computer and are also used for feeding values read off the instruments in the aircraft cabin into the test equipment.

The different units in the automatic tester are controlled from the computer's interface unit, *FE*. This consists of a data register, *FD*, which transmits control words to and receives information from the various units, and an address register, *FA*, indicating which unit is to be selected. All control signals from the interface unit go out in the form of short duration pulses (about 200 $\mu s$). To control the units in the test equipment, however, continuous signals which are present throughout the measuring period are required. A memory element, called the drive and hold circuits, *DH*, is therefore interposed between the computer and the controlled units. When one of these circuits receives a pulse, a contact is closed and remains closed until the arrival of a reset pulse. Via the drive and hold circuits the units thus receive continuous control voltages which can be connected and disconnected by the computer as required.

In general, different units require different numbers of command signals, depending on how many functions the units have. The computer has a word length of 17 bits, of which 16 are used for control words and data. In certain cases, because of the limited number of bits in each word, the command signals have to be sent to a unit in several groups of at most 16 bits each. For this reason the drive and hold circuits have also been divided into groups of 16 bits. The different bits are supplied by the data register in the interface unit, and each group is given an address which is supplied by the address register in the interface unit.

The principle of this system is shown in Figure 2.

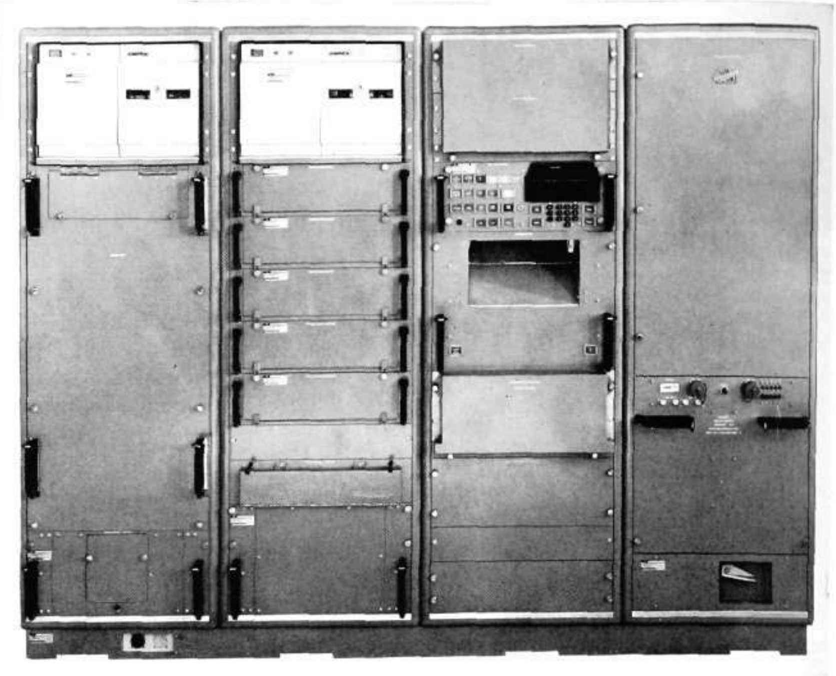


**Fig. 3**
**Automatic test equipment for 37 Viggen aircraft**

## Construction

The test equipment is built of four blocks mounted on a base containing the inter-block wiring. The units belonging to these blocks are of plug-in type, 19" wide. The majority of the electrical circuits are on printed cards.

Counting from the left in Figure 3, the principal contents of the blocks are the computer, stimuli units, measuring units and operator's panel unit, multiplexer and patchboard. At the top of blocks 1 and 2 are the magnetic tape reader and recorder. At the bottom of block 1 is a power supply for the digital circuits, and at the bottom of block 2 is a power supply for the remaining circuits.

The cables coming from the object under test–about 1200 wires–are connected to the back of the right-hand block, block 4 in Fig. 3.

Since the equipment is designed to be placed in a van and may be subject to shock and vibration, it is mounted on rubber pads.

Some examples of the structural principles are shown in Figs. 4–8.

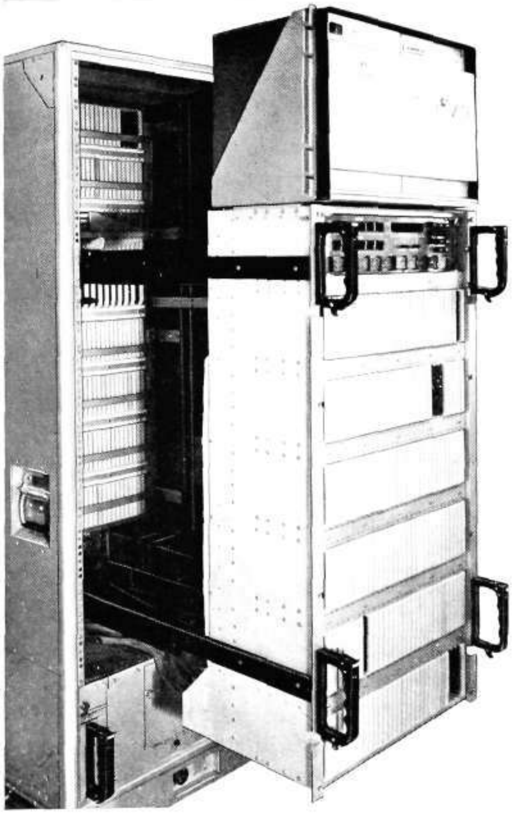


**Fig. 4**
**Computer**
It will be seen how the rack is used for card assemblies in depth.

## Reliability and Serviceability

A great deal of effort has been devoted in the design of the equipment to fulfilling the high demands for reliability and serviceability. The equipment has a predicted mean time between faults (MTBF) of 500 hours and a mean time to repair (MTTR) of 1 hour. The high reliability figure has been achieved by a careful choice of components, most of them satisfying military specifications. Good serviceability has been achieved by constructing the equipment of easily accessible units which can be changed without necessitating any trimming of the system. To minimize the total cost of the equipment, an extensive analysis has been made of all maintenance parameters, taking into account the size, weight and price of each replaceable unit, the test instrument and personnel requirements, etc.

Fig. 5

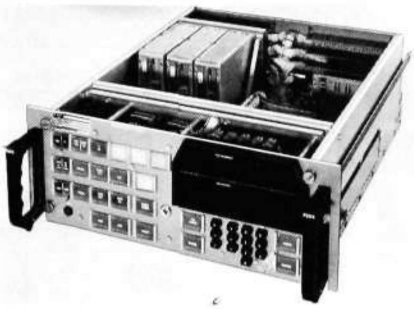


Fig. 6

Fig. 7

**Fig. 5**
**Low frequency unit**
Note how the design of the unit makes it simple to service.

**Fig. 6**
**Operator's panel**
The front portion with controls and indicators is detachable. It can be placed outside the test equipment and connected to it by a cable.

**Fig. 7**
**Multiplexer unit, cover removed**
The relays are mercury-wetted.

## Programming

As mentioned above, the programmes which directly control the test equipment in operation are first fed into its memory. The test programme, the application programme, is read, one test at a time, from the magnetic tape reader into a memory area reserved for that purpose. A test block consists chiefly of a block number, test number, patchboard identification number, and then, in principle, an identification word and a list of parameter words for each test operation. Finally the block ends with the block number inverted, to allow reverse direction searching on the magnetic tape. Due to this block numbering system the tests can be stored in any order on the tape.

To simplify the preparation and modification of the programme for the test object an extensive programming system has been developed which makes it possible to programme the equipment in a straightforward way using easily understood abbreviations for different test operations. Transcription into the test equipment's machine language and checks that the test is written correctly are performed by an off-line computer with the help of an assembler programme. The advantage of this method is made clear by the following two examples, which demonstrate that application programming can be done without any great programming experience. The method used in the examples is called macroprogramming.

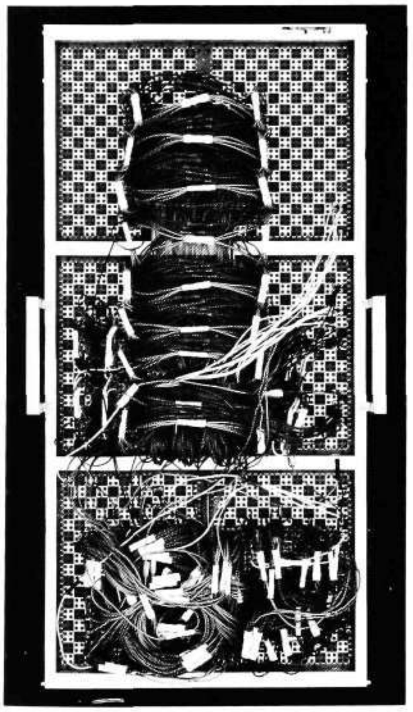


**Fig. 8**
**Patchboard**
Connection to the test equipment is via terminals on the back of the patchboard. This permits quick replacement of the patchboard.

### *Programming example 1*

Fig. 9 shows a completed programme blank, a test blank, for a test in which an a.c. voltage of 10 V is generated and sent to test points A 10060 and K 10060 (the return wire) in the object under test; a voltage of 120 V d.c. is sent to A 20312 and K 20310, after which two wires coming from the tested object on points A 10051 and K 10612 are connected together. The signal between K 10406 and K 10706 is then measured. To be accepted, the measured value must lie between the limits + 102 V and + 98 V. If the value is correct, the equipment continues to test number 18550. If the value is wrong, the next test will be number 20200, which in this case is the first test of a fault-detection loop. A test of this kind is carried out by the test equipment in about 1 second.

### *Programming example 2*

Fig. 10 shows a completed test blank for a test in which a 5.5 V, 2 Hz sinusoidal voltage is generated and sent to test points A 10070 and K 10070 in the object under test, after which the computer waits for two seconds and then authorizes the peak-to-peak value measurement between K 10410 and K 10411. To be accepted, this value must lie between 4.6 V and 4.4 V. If correct, the test equipment proceeds to test number 18560; if wrong, to test number 27160.

TEST BLANK

Ericsson LM

| Programmer: | Date (six figures) day month year | | Mod |
|---|---|---|---|
| 00 00 | 02 03 66 | | |

| Test system: | Name of test: | Test no. | Test object: / Code: / AT: |
|---|---|---|---|
| Radar | Performance check of amplifier 1 | | AT: 18540 |

| Function | | Type | Stimulus value | Measured value HL | Measured value LL | Test point Signal | Test point Return | Remarks |
|---|---|---|---|---|---|---|---|---|
| | 01 00 | SAC | 10 V | | | A 10060 | K 10060 | |
| | 02 00 | SDC | +120 V | | | A 20312 | K 20310 | |
| | 03 00 | KØPPL | | | | A 10051 | K 10612 | |
| | 04 00 | MDC | | +102 V | +98 V | K 10406 | K 10706 | |

| | | Reg | | |
|---|---|---|---|---|
| 05 | Right GØ | | 2 | 18550 |
| 06 | Wrong NØGØ | | 2 | 20200 |

| mod. | copy for | no. | page |
|---|---|---|---|
| | | | |

**Fig. 9**
**Programming example 1**

For further processing of the tests a card is punched for each line of the test blank, the numbers at the left indicating the card number, and the card is then passed to the assembler. In addition to macroprogramming, the assembler can deal with symbolic machine code which is employed when

**Fig. 10**
**Programming example 2**

TEST BLANK

Ericsson LM

| Programmer: | Date (six figures) day month year | | Mod |
|---|---|---|---|
| 00 00 | 02 03 66 | | |

| Test system: | Name of test: | Test no. | Test object: / Code: / AT: |
|---|---|---|---|
| Radar | Performance check of servo amplifier 3 | | AT: 18550 |

| Function | | Type | Stimulus value | Measured value HL | Measured value LL | Test point Signal | Test point Return | Remarks |
|---|---|---|---|---|---|---|---|---|
| | 01 00 | SSIN | 5,5 V | 2 HZ | | A 10070 | K 10070 | |
| | 02 00 | VÄNTA | 2 S | | | | | |
| | 03 00 | MTT | 2 HZ | 4,6 V | 4,4 V | K 10410 | K 10411 | |

| | | Reg | | |
|---|---|---|---|---|
| 04 | Right GØ | | 2 | 18560 |
| 05 | Wrong NØGØ | | 2 | 27160 |

| mod. | copy for | no. | page |
|---|---|---|---|
| | | | |

the equipment is to be used in a special way. The symbolic machine code employs easily remembered letter groups instead of the machine language number groups. Symbolic machine code requires a greater programming knowledge than demanded in the examples given above, but is seldom necessary. For example, in the test programme for the 37 Viggen aircraft, out of approximately some 5000 tests all but 5 % can be macroprogrammed. The same test blank is used for symbolic machine code programming as for macroprogramming, and the two methods can be employed jointly in a test. Tests can also be written in machine language of course.

Other programmes have been written in addition to the assembler programme mentioned above. For example there is a programme for compiling the equipment's cross-connections using an off-line computer. Other programmes check that there are no wrong connections in the multiplexer and patchboard wiring system, thus preventing any possible damage to the tested object due to erroneous connections. Finally, there is a programme which makes it possible to try out complex test problems without using the test equipment. This programme simulates the working of the automatic tester on another computer.

The first of the automatic testers described above was delivered to the Royal Swedish Air Force in August 1966.

## Selected Technical Data

### *Computer*

| | |
|---|---|
| Type | Synchronous series machine |
| Memory | Core memory with a capacity of 4096 18-bit words<br>One bit for internal parity check |

### *Measuring Circuits*

All measurements are carried out with inputs floating in reference to the equipment's chassis and circuits, with the exception of the measuring circuit being used. The following data relate to the test equipment's terminals.

*D.C. Voltages*

| | |
|---|---|
| Range | 0–500 V |
| Accuracy | ± 0.05 % |
| Input resistance | 10 MΩ |
| Number of measurements per second | Max. 50 |

*A.C. Voltages*

| | |
|---|---|
| Range | 0–250 V r.m.s. |
| Accuracy | ± 0.5 % |

*Peak-to-Peak Values*

The peak-to-peak value of an a.c. voltage can be measured in the presence of a d.c. voltage.

| | |
|---|---|
| Range | 0.1–100 V |
| Accuracy | ± 5 % |
| Frequency range | 0.01–2000 Hz |

*Phase*

| | |
|---|---|
| Range | − 180° to + 180° (0.01–800 Hz) |
| Accuracy | ± 1° at 400 Hz |

*Pulse Amplitude*

| | |
|---|---|
| Range | 0.1–20 V |
| Accuracy | ± 3 % |
| Frequency | 200–2000 Hz |
| Pulse width | 0.05–5 ms |

*Frequency*

| | |
|---|---|
| Range | 0–50 MHz |
| Accuracy | ± 1 part in $10^9$ of measured value |

*Time*

| | |
|---|---|
| Min. separation interval | 1 ms |
| Accuracy of clock signal | ± 1 part in $10^6$ |

*Resistance*

| | |
|---|---|
| Range | 0–10 MΩ |
| Accuracy | ± 0.2 % for 0–1 MΩ<br>± 0.5 % for 1–10 MΩ |

## *Stimuli Circuits*

All stimulations are carried out with inputs floating in reference to the equipment's chassis and circuits, with the exception of the stimulus circuit being used. The following data relate to the test equipment's terminals.

*D.C. Voltage*

Two mutually independent sources

| | |
|---|---|
| Range | 0–200 V in steps of 1 mV |
| Accuracy | 0.1 % |
| Output impedance | < 1.5 Ω |
| Ripple | 1–40 mV r.m.s. depending on output voltage |

*A.C. Voltage 400 Hz*

Two mutually independent sources. Both sources can be used self-oscillating or controlled from outside, and their signals can be made to have a phase difference of 90°.

| | |
|---|---|
| Range | 0–100 V r.m.s. in steps of 10 mV |
| Accuracy | ± 0.2 % |

*Ramp Signals*

Two mutually independent sources. It is possible to programme start level − 100 to + 100 V, sweep slope − 10 V/sec to + 10 V/sec, and pulse time 0 to 5 sec.

*Sinusoidal and Sawtooth Signals*

Two mutually independent sources. Frequencies of 0.01 to 10 Hz and amplitudes of 0–200 V can be programmed.

The equipment also includes programmable loading units offering resistance in the range 10 Ω to 100 k Ω.

## *Environment (test specifications)*

| | |
|---|---|
| Temperature range | 0° C–40° C for operation, − 55° C – + 70° C for storage |
| Relative humidity | 95 % for at least 24 hours |
| Vibration | An induced acceleration of 2 *g* ($g = 9.81$ $m/s^2$) in a frequency range of 5–500 Hz |
| Shock | 1000 shocks at 25 *g* in three directions |

## *Warming-up Time*

With ambient temperature of 0° C the maximum warming-up time is 5 minutes. After this time the equipment works within the above specifications.

# Telex—a General Survey

E. STRINDLUND, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.394.34
LME 814
80777

*Since the second world war the world-wide telex network has been the branch of telecommunications which has grown most rapidly. In 1960 there were around 100,000 subscribers in the whole world. Now there are more than 260,000 in over 100 countries. It is therefore natural that L M Ericsson has included telex exchanges, based on the crossbar switch, on its production schedule. Crossbar switching has made it possible to increase the reliability of telex networks, reduce maintenance and add a number of new and extremely valuable traffic facilities.*

*An account is given below of the characteristics and traffic facilities offered by L M Ericsson's telex system with a brief description of the system design.*

In the early days telegraphy was a means of communication by which a person who had a message to send delivered it in written form to the nearest telegraph office, from which it was transmitted to the nearest telegraph office at the other end and thence delivered by messenger to the addressee.

In the first decades of this century teleprinters were designed which could be handled in the same simple way as an ordinary typewriter. This made it possible for the subscribers themselves to send and receive telegraph messages.

The organizations responsible for telegraph service started to procure equipment which, first manually and later automatically, could set up connections between teleprinters located at the national and private organizations which wished to utilize the new service. This service became known as telex (*Tel*eprinter *Ex*change).

The teleprinters were equipped with a device which, on incoming calls, could be automatically made to send its own identity (tripping of answer-back). This was an important step in the development, for it permitted transmission to unattended subscriber equipments and the telex messages could be received at any hour by teleprinter. If, for example, a message is sent from Stockholm at 4 p.m. and is addressed to a subscriber in Melbourne, the time there is one o'clock at night. The addressee's teleprinter is probably unattended at that time. It presents the automatic answer-back signal, however, and the message is received and has been typed by the machine when the staff arrive at the office next morning.

Teleprinters are being increasingly equipped with apparatus for tape punching and automatic transmission of messages. Thereby, when a connection has been established, transmission can take place continuously at the maximum speed, i.e. 400 characters per minute. The cost will also be minimum since the charge is based on the duration of the connection. This facility thus has a considerable economic significance.

The usual practice is that the *A* subscriber merely transmits the message and waits for the answer at a later time. Immediately after the transmission he receives an acknowledgement of receipt from the addressee through the fact that the *A* subscriber, in accordance with CCITT's recommendation, ends his message by tripping the *B* subscriber's answer-back. A telex connection, however, allows "conversation" between the subscribers, and this facility is sometimes used in practice. A connection of this kind, which permits transmission alternately from the *A* and *B* subscribers' teleprinters, is called semi-duplex.

The result is that telex traffic exhibits a number of characteristic features, e.g.:

- high total traffic per subscriber
- mostly commercial traffic
- heavy concentration of initiated traffic to office hours
- predominantly international and automatic traffic
- few local connections (within the same exchange)
- unattended subscriber's apparatus possible in principle and common in practice.

## L M Ericsson's Crossbar Switching System for Telex

The aforementioned features and other characteristics of telex traffic led to the design of L M Ericsson's telex crossbar switching system.

In the first place a new terminal exchange *ARB 111* was designed. In its schematic structure it resembles L M Ericsson's rural exchange system *ARK 50*; but as the traffic intensity per subscriber is much greater than in telephony, *ARB 111* has a higher traffic capacity. The initial size of the exchange is 40 subscriber lines, and it can be extended in steps of 40 lines to an ultimate capacity of 400 lines.

Telex signalling principles differ entirely from those of telephony, and *ARB 111* is of course designed for modern telex signalling.

Since the traffic per trunk circuit is equally great in telephony and telex, the same crossbar exchanges can be used as national and international transit centres, viz. *ARM 201* and *ARM 503*. The terminal exchanges *ARB 111* are connected via telex repeaters and associated register to the *ARM* exchanges. The only points in which the telex transit exchanges differ from those of telephony are in the repeaters and registers and, in certain cases, operator relay sets, since these are entirely adapted for telex signalling. Telex signalling will be dealt with in a coming number of Ericsson Review.

L M Ericsson's telex system comprises the following types of exchange:

- National terminal exchanges, *ARB 111*
- National transit exchanges, *ARM 201* and *ARM 503*
- International transit exchanges, *ARM 201*
- Intercontinental transit exchanges, *ARM 201*.

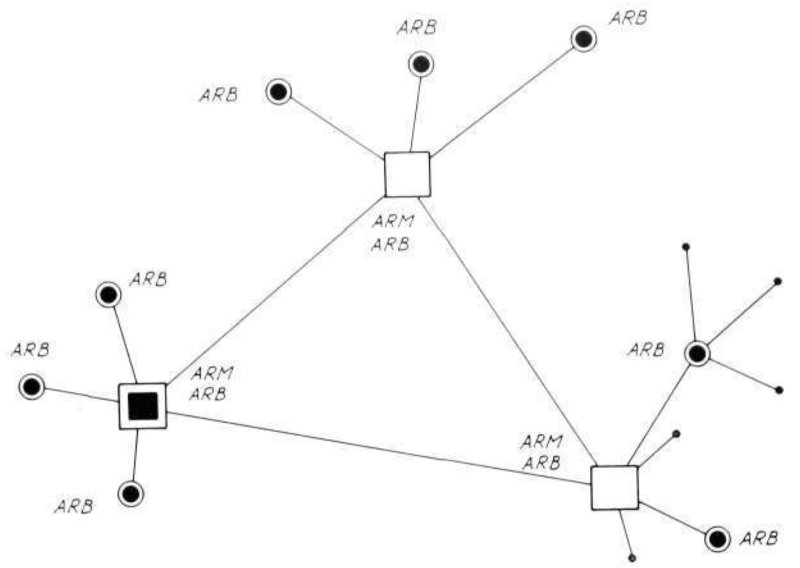



**Fig. 1**
**Telex network**

■ International transit exchange ARM 201 + ARB 111

□ National transit exchange ARM 201, ARM 503 + ARB 111

◉ Terminal exchange ARB 111

• Remote or local subscriber

## National Networks

Fig. 1 shows how a national network can be built up with these types of exchanges.

The skeleton of the network consists of transit centres *ARM*, with which one or more terminal exchanges *ARB 111* are always directly integrated. The remaining terminal exchanges, in the number required, can be connected to the transit centres on VF telegraph channels.

Subscribers situated so far from the terminal exchange that they cannot be connected via a DC circuit are connected to *ARB 111* on their own VF telegraph channels, being then known as "remote" subscribers. Each of these subscribers can from the outset be allotted a number which remains unchanged even if the subscriber is later connected to a new and closer terminal exchange.

A country can be divided into a large number of tariff zones. To any one terminal exchange *ARB 111*, moreover, it is possible to connect remote subscribers situated in up to 20 zones and base the tariffs on the geographical distance between the communicating *A* and *B* subscribers. On the same analogy it is possible, for instance, to charge for a connection between two remote subscribers in the same tariff zone at the local rate although the connection is set up via an *ARB 111* exchange situated, for example, at a distance of 100–200 miles from the subscribers.

## System Characteristics and Traffic Facilities

Through the introduction of L M Ericsson's telex system the worldwide teleprinter network has been provided with crossbar switching centres having the following valuable characteristics and traffic facilities, many of which are entirely new in the telex field:

☐ *The crossbar switch is used as switching element* because of its great rapidity and reliability. As regards mechanical movement and wear it corresponds to relays and thus requires a minimum of maintenance. The twin contacts in Ericsson crossbar switches, which are made of a special contact material, guarantee excellent contact performance and eliminate selector noise. This is of especially great significance on a telex connection, since brief interruptions in the "speaking circuits" may result in wrong characters, instead of the "clicks" on a telephone connection.

☐ *A new type of telegraph relay* needing no mechanical adjustment is used in the units which have to repeat telegraph signals with as low distortion as possible.

The contacts are of reed type and mercury-wetted, and are enclosed in a glass bulb under high pressure. The absence of oxygen eliminates the problem of burnt contacts.

The use of mercury as contact material eliminates all bounce in contacts. This is because the mercury adheres to both surfaces of the contacts so that the bridge between them is retained after closure. The mercury also damps any mechanical vibration. Other information on mercury relays will be found in Ericsson Review No. 4, 1966.

☐ *The same crossbar switching technique* can be used in the telex and telephone network, which is an important factor in reducing costs on personnel training and maintenance. Transit centres for telex and telephony can also be integrated into a single unit with common control devices such as markers, test blocks etc.

☐ *Full availability* exists in the *ARM* exchanges, even on the largest routes. This leads to optimum utilization of circuits and to large savings in the LD network. The gain on this score is especially important in the intercontinental and international transit centres, which set up connections over very expensive transmission channels, e.g. ocean cables, radio links and satellites.

☐ *Alternative routing* can be arranged to the extent required, as, for each direction of traffic, *ARM 201* offers a direct route and up to four alternative routes.

The advantages of this are especially great for telex purposes, as so large a proportion of the traffic is international and is thus carried over large distances. As international transit centres, moreover, are often situated on widely different longitudes, the peak traffic at different centres comes at entirely different times. If, for example, an international centre is to set up a connection which can be routed via alternative international transit centres and is rejected from the first-choice route, a route can be selected via another transit centre situated on a longitude where for the moment there is little traffic.

☐ *Up to 15 categories of subscribers* can be connected to *ARB 111*. This permits maximal utilization of the telex network. Examples of such categories are ordinary telex subscribers, police, banks, news agencies, embassies, subscribers with the Roman alphabet, subscribers with Arabic alphabet.

The old morse telegraphy hardly exists any longer, since telegraph offices all over the world have been equipped with teleprinters which are connected either to a separate network or to a public telex network. The traffic initiated by these teleprinters for international telegrams was originally called gentex traffic. The name has since been transferred in popular use to apply to teleprinters at telegraph offices, and so one speaks of gentex subscribers though, of course, they also employ the national network.

In L M Ericsson's telex system the gentex subscribers can be allotted a separate category. This has great advantages since gentex subscribers can then be connected to the national teleprinter network. In this way direct communication can take place between an ordinary telex and gentex subscriber. Telegrams between telex subscribers and telegraph offices can be transmitted in both directions in the same way as telex messages, so eliminating expensive and time-consuming delivery by messenger.

Traffic can be optionally barred in one or the other direction between subscribers of different categories, e.g. police and other telex subscribers. Thus it may be permissible for the police to send messages to all other subscribers in the network while ordinary telex subscribers may be barred from communicating with the police teleprinters.

Traffic between subscribers having teleprinters with different alphabets is naturally impossible.

When a call is made, the subscriber's category is transmitted to a register at the transit centre before the proceed-to-select signal is issued. The centre thus knows which category of subscriber is calling. If it is a subscriber with keyboard selection, the register adapts itself for reception of telegraph characters. If the caller is a dial subscriber, on the other hand, the register prepares to receive dial pulses.

A subscriber equipped for transmission at, for example, a speed of 75 Bauds—owing to his category indication—receives a channel which can transmit at this higher speed.

It is also possible to introduce differentiated charging for different categories of subscribers. A connection of the same duration between the same places can thereby be made to cost different amounts for a news agency, for example, and an ordinary telex subscriber.

☐ *The PBX connection equipment* has been very amply designed, as facilities must exist for the connection to *ARB* of large numbers of gentex teleprinters, for example, which must be accessible on a common number.

Any subscriber can be placed in the *PBX* group and the individual numbers need not be in sequence. Consequently spare levels need not be reserved for extension of a *PBX* group. In a fully installed 400-line *ARB* exchange, up to 180 subscribers may be *PBX*-connected. The size of *PBX* groups may vary within very wide limits, from a few subscribers in several small groups to all 180 subscribers in the same group.

☐ *Printed service signals are transmitted to the A subscriber* in accordance with the CCITT recommendations. The sound of the starting of the teleprinter motor has often been the criterion which indicated to the subscriber that he should start to transmit. Within the not too distant future, however, there are likely to be silent electronic teleprinters on the market. A printed proceed-to-select signal *GA* is therefore sent to the *A* subscriber. The complete list of service signals for call supervision is as follows:

| | |
|---|---|
| *GA* | Proceed-to-select |
| *OCC* | Subscriber engaged |
| *NC* | No circuits, e.g. all trunks busy |
| *NA* | Connection not admitted |
| *NP* | Not a working line |
| *ABS* | Subscriber absent or office closed |
| *DER* | Out of order |
| *MOM* | Wait |

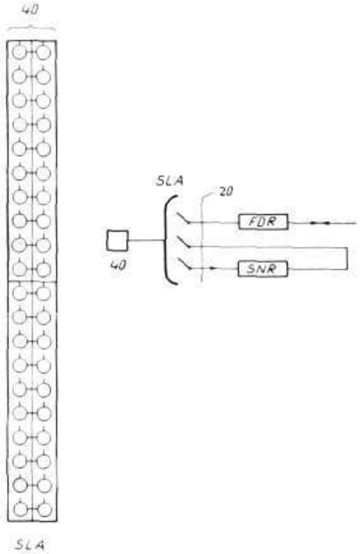



**Fig. 2**
**ARB 111 grouping plan, 40 subscribers**

□ *Keyboard selection* is the normal procedure—another advantage of the speed of crossbar switching. A 5-digit number transmitted from a normal dial takes 6–7.5 seconds, while the same number of digits from a keyboard takes 0.75 second. A telex operator also finds it more natural to use the teleprinter keyboard than a dial.

□ *Telegraph signalling* is used for all digital transmission between the exchanges of a network. This makes for great economic savings since connections are set up extremely quickly and circuits and exchanges can be dimensioned accordingly.

□ *Interworking with other systems* is possible since the registers can receive and transmit both telegraph code and dial code and translate between them.

□ *Automatic tripping of the B subscriber's answer-back* takes place after the call connect signal has been received.

□ *Single current subscriber lines are connected to ARB 111 on a balanced basis*, so that the disturbing effect of the telex network on the telephone network is reduced to a minimum when these networks are integrated.

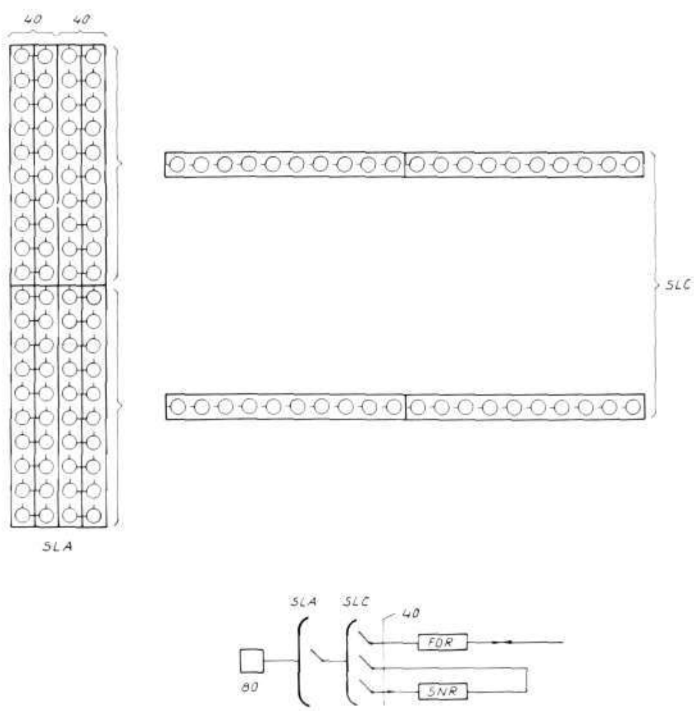



**Fig. 3**
**ARB 111 grouping plan, 80 subscribers**

# Terminal Exchanges ARB 111

*ARB 111* may be denoted as a combined linefinder and final selector stage for connection of telex subscribers. The initial capacity is 40 subscribers, in which case a crossbar selector stage is used consisting of four 10-vertical crossbar switches called *SLA* as shown in fig. 2. Every crossbar switch vertical has 20 outlets and the outlets are multipled over 20 verticals. The stage has 20 inlets to which are connected repeaters *FDR* and, when required, internal cord circuit relay sets *SNR*. Every *FDR* occupies one inlet and every *SNR* two inlets.

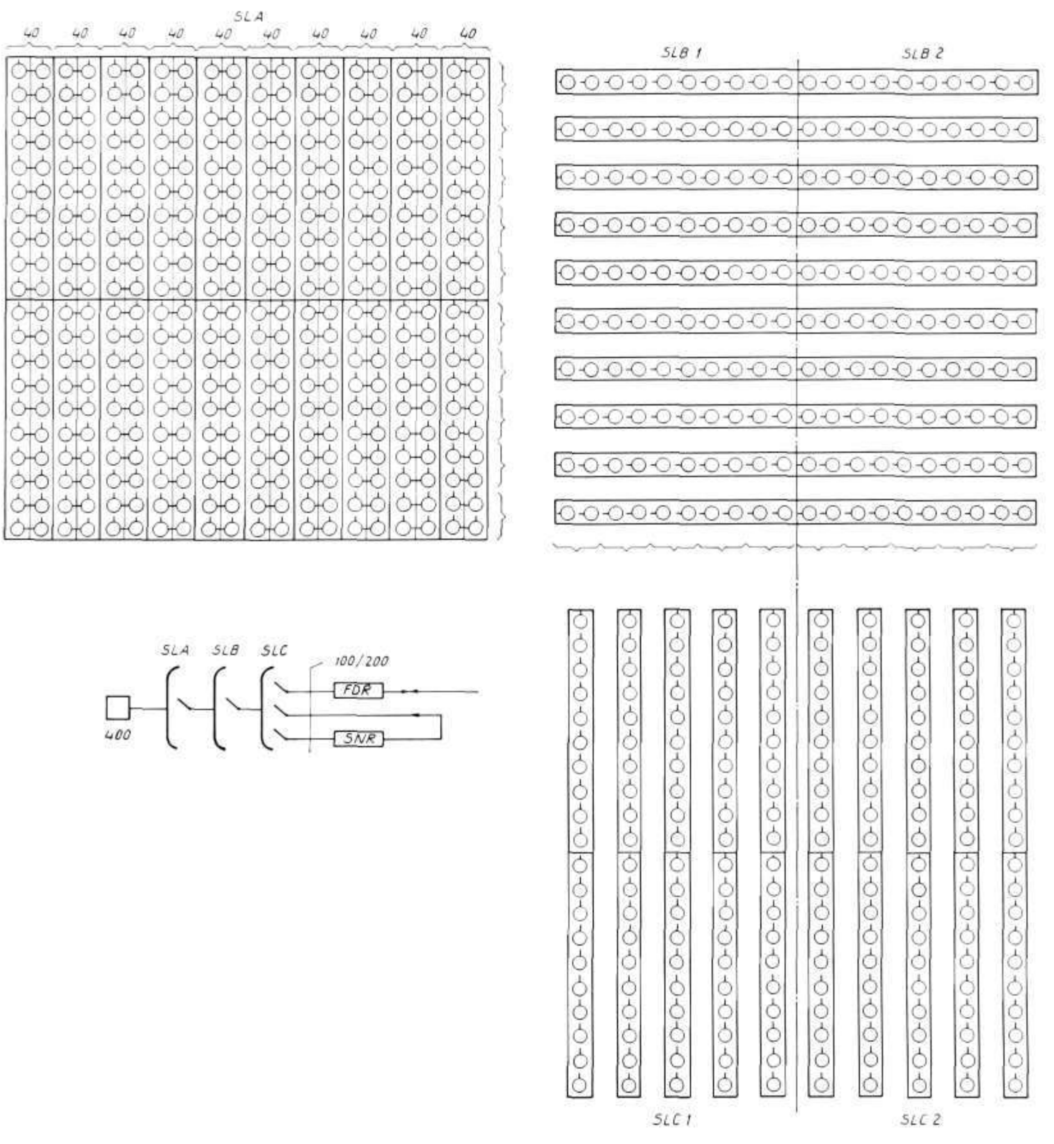
Fig. 3 shows the grouping applying to capacities between 41 and 80 subscribers. It is made up of two 40-line groups in a *SLA* stage and of a *SLC* stage for connection of repeaters and internal cord circuit relay sets.

For capacities between 81 and 400 subscribers three switching stages are used as in fig. 4. The *SLA* stage is extended by the addition of plug-in crossbar switches, each also containing line relay equipment for 10 subscribers.

With 400 subscribers, therefore, there are 40 *SLA* switches. The *SLB* and *SLC* stages may be of two sizes depending on the required traffic capacity.

**Fig. 4**

**ARB 111 grouping plan, 400 subscribers.**



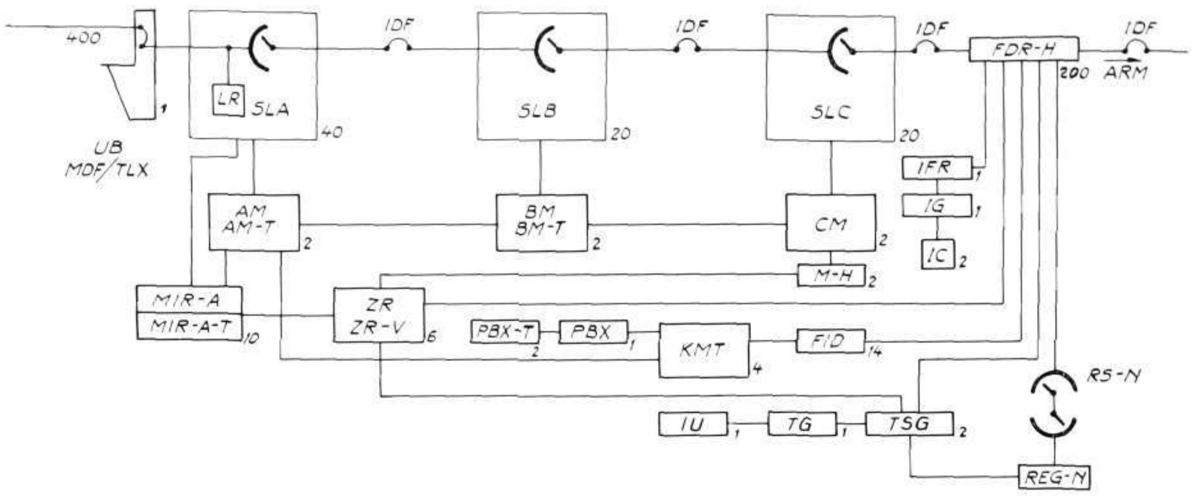



Fig. 5

**ARB 111 block schematic**

| | |
|---|---|
| SLA, SLB, SLC | Switching stages |
| UB | Line test desk |
| MDF/TLX | Main distribution frame, telex |
| MIR-A, MIR-A-T | Marker connecting relay set with strapping facilities for the category and tariff zone of every subscriber |
| AM, AM-T | Marker, A stage |
| BM, BM-T | Marker, B stage |
| CM | Marker, C stage |
| ZR, ZR-V, M-H | Relay sets for transmission of proceed-to-select signal to subscriber and category and tariff zone information to REG-N. |
| FDR-H | Two-way repeater |
| IC | Master clock |
| IG | Pulse relay set for generation of tariff pulses |
| IFR | Pulse distribution relays |
| FID | Connecting relays |
| KMT | Code receiver: functions as register for terminating traffic |
| TSG | Telegraph signal generator (OOC, NC etc.) |
| TG | Time announcer relay set |
| IU | Master clock for TG |
| PBX, PBX-T | Relay sets for testing of PBX series |
| RS-N | Register finder |
| REG-N | National register |
| LR | Line relay |
| IDF | Intermediate distribution frame |

The figures indicate the maximum number of units

The grouping with 10 *SLB*/10 *SLC* (*SLB 1* and *SLC 1*) provides a total traffic of 0.17 E per subscriber at full capacity. Using, instead, 20 *SLB* and 20 *SLC* the figure is 0.28 E per subscriber for 5 ‰ loss in the exchange.

A terminal exchange *ARB 111* can be connected to a transit centre in two ways:

- Integrated with the transit centre, the repeaters of the *ARB* unit being directly connected to the transit exchange registers and switches. A transit centre may have a large number of integrated *ARB* units.

- Separately located terminal exchange connected to the superior transit centre by two-way VF telegraph channels. Local traffic between subscribers connected to the same exchange can be passed either via the transit centre or on special internal cord circuits with associated register in the terminal exchange.

Fig. 5 shows a block schematic of a terminal exchange installed to full capacity and connected to *ARM 201*. The main functions of the relay sets are indicated.

## Mechanical Structure

The construction practice for the telex system is the same as for our crossbar telephone systems. All racks in terminal exchange *ARB 111*, as in rural exchange *ARK 522*, are fitted with jack units. This greatly simplifies installation of racks and relay sets.

The placing of the relay sets on the respective racks will be seen from fig. 6. Figs. 7 and 8 show how these racks can be placed to form a 400-line group *ARB 111*. The photograph (fig. 8) is from Zagreb (Jugoslavia), all relay set dust covers being removed. From the left are seen four *SLA* racks for 80 subscribers each, a *SLA* rack equipped for 30 subscribers, a *M/KMT* rack, a *SLB* rack, a free position for a further rack, and at the end of the suite a *SLC* rack. Repeaters etc. for the 400-line group are placed at the rear of the suite.

In order that the maintenance personnel may as far as possible remain outside the switchroom, subscriber line jacks with line adjusting resistors and M.D.F. are placed in a line test desk which, with instruments, teleprinters and automatic exchange testers, is placed in a control room.

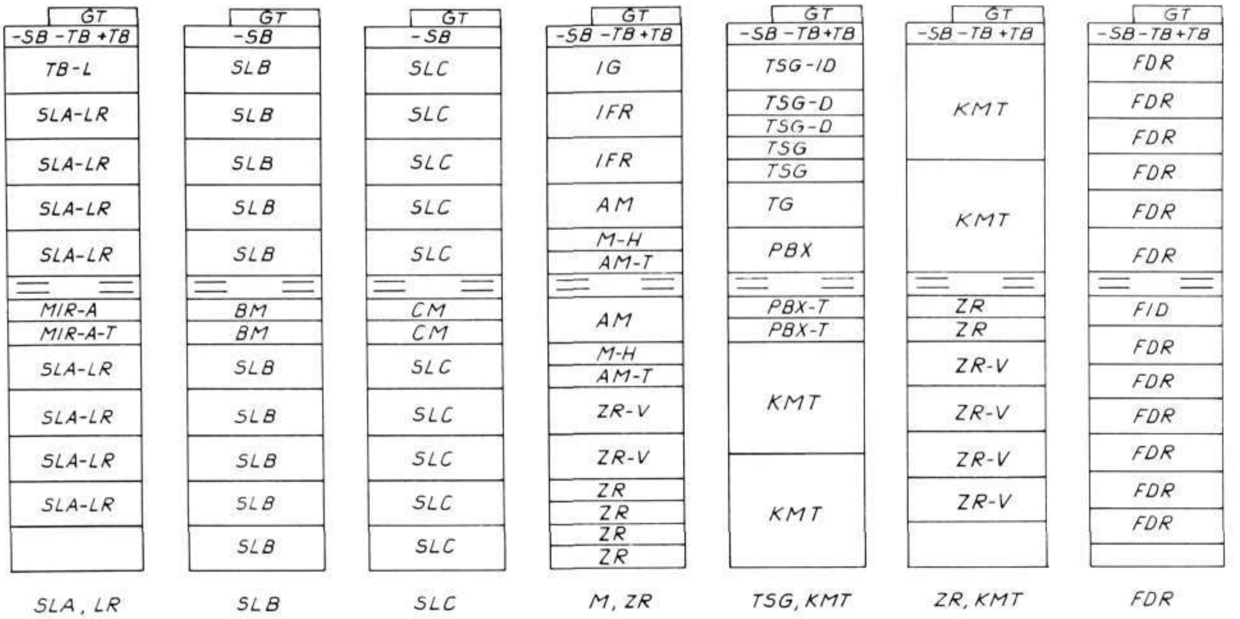



Fig. 6

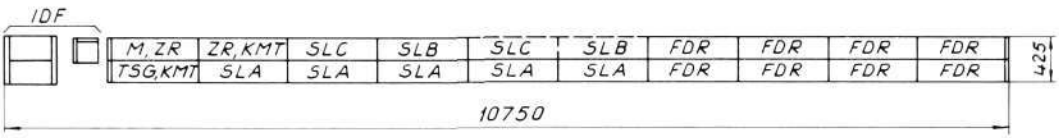



Fig. 7

Fig. 6

Rack equipment layout, ARB 111

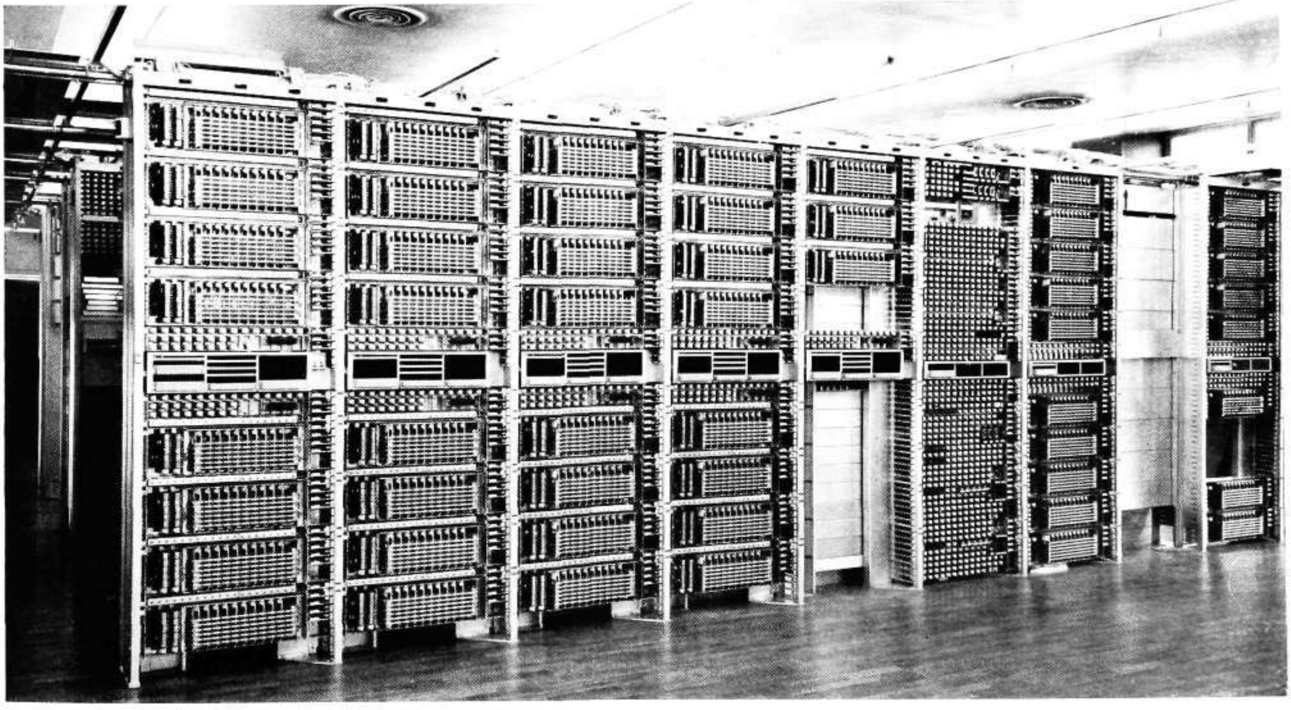
Fig. 7

ARB 111, 400 subscribers, floor layout

Fig. 8

ARB 111 terminal exchange at Zagreb, Jugoslavia

(In front) ARB 111 equipment with protective covers removed



# Transit Exchanges ARM 201 and 503

The very valuable properties and traffic facilities which characterise these types of exchange, and which have been earlier described in Ericsson Review, come to their full use for telex traffic as well. Transit centres may be national, international or intercontinental.

These centres can be used for connection of long distance circuits working on the telex signalling methods recommended in the CCITT Blue Book No. VII under *U 1*, *U 11* (table II) and *U 20*. Type *A* signalling is used for automatic and semiautomatic traffic with keyboard selection, and type *B* signalling for the same classes of traffic but with either keyboard or dial selection.

Type *C* signalling according to Table II in recommendation *U 11* can be used for two-way traffic on the route from an international to an intercontinental transit centre which also has circuits with the complete type *C* signalling according to Table I in *U 11*. The ability of the intercontinental centre to translate between Tables I and II and vice versa can thereby be fully utilized by the international transit centre.

In telex networks radio channels are often used over large distances. In order that these channels may operate reliably, a 7-unit alphabet is employed, which provides 35 combinations, all of which have the ratio 3 : 4 between stop and start polarity pulses. Thirty-two combinations are used to correspond to the characters of the 5-unit alphabet and the remaining three have special significations. At the receiving end of the connection the signals are analysed and those not having the ratio 3 : 4 give rise to a request for signal repetition, whereupon a *RQ* signal is sent. This repetition continues until signals with the correct ratio are received. Since the request for repetition takes place automatically, the equipment is called *ARQ*. Other names are *TOR* (Teleprinting over Radio) and *MUX* (Time Multiplex).

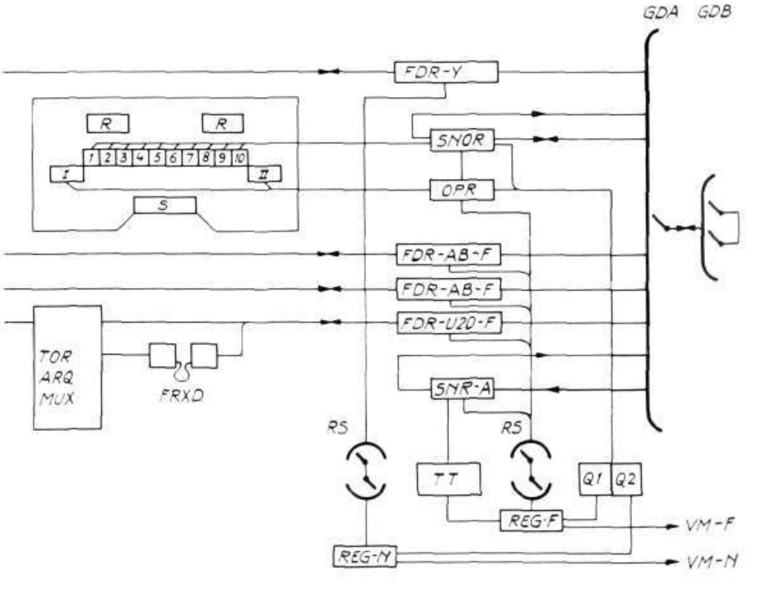
Since the subscriber equipment uses a 5-unit alphabet, a translation to 7-unit alphabet is used at the sending end of an *ARQ* circuit, and at the receiving end a retranslation to the 5-unit alphabet. This translation is done in the *ARQ* equipment. The sending subscriber's characters are passed via a buffer memory to *ARQ*, in which they are stored when repetition is taking place on the radio channels. This store is called *FRXD* (Fully Automatic Reperforator Transmitter Distributor).

**Fig. 9**

**Trunking diagram ARM 201**

**International transit exchange**

| | |
|---|---|
| FDR-Y | Two-way repeater, national network |
| FDR-AB-F | Two-way repeater, international network, type A or B signalling |
| FDR-U20-F | Ditto but with U20 signalling |
| SNOR | Cord circuit relays for operator-supervised traffic |
| SNR-A | Cord circuit for automatic outgoing international traffic |
| OPR | Operators' position relays |
| R | Receiving teleprinter |
| S | Detached keyboard |
| 1—10 | Cord circuit sets |
| I, II | Operators' position sets |
| RS | Register finder |
| REG-N | National register |
| REG-F | International register |
| Q1, Q2 | Queue equipments in which Q1 has priority over Q2 |
| VM-F | Route marker for international traffic |
| VM-N | Ditto for national traffic |
| TT | Toll ticketing equipment |
| GDA, GDB | Two-way group selector stages |



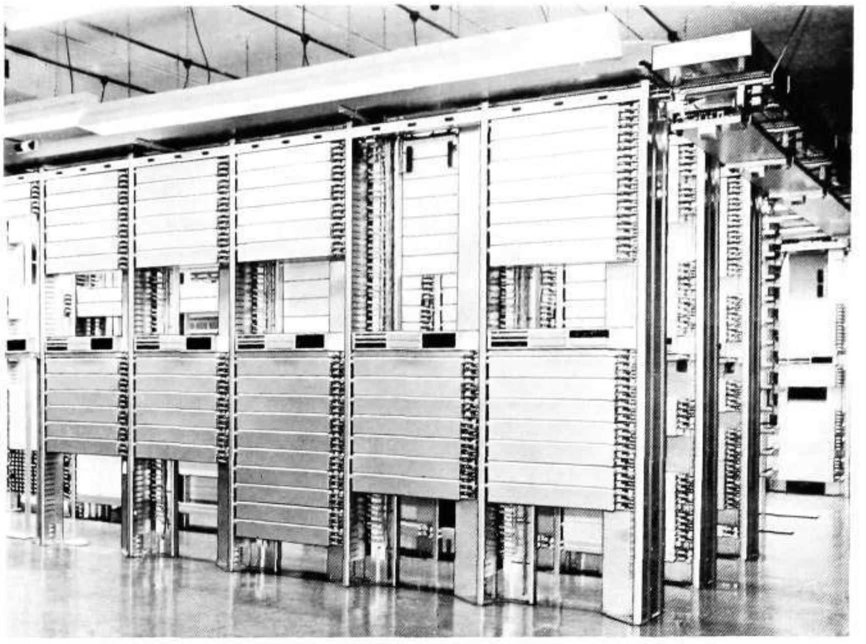


Fig. 10

Intercontinental transit centre ARM 201 at Sydney, Australia

According to present international practice a subscriber pays only for effective sending time. Time used by the radio channels for repetition of characters must therefore not be charged. The result of this practice is that such calls are placed under the supervision of an operator. The operator has for each circuit a period counter which is stepped from the *ARQ/FRXD* equipment only when effective transmission is taking place.

L M Ericsson transit exchanges are designed for connection of repeaters, registers and operator equipments also for *ARQ* traffic.

Fig. 9 shows a trunking diagram for an international transit centre with repeaters connected from lines with the aforementioned types of signalling. The group selector stage multiple can be extended to an ultimate capacity of 4000 terminations.

*All connections are set up automatically.* If the telex traffic to the destination country is automatic, charging takes place in the international exchange automatically by means of toll ticketing. In the case of semiautomatic traffic to the destination country the connection is also set up automatically, and from the *A* subscriber's point of view the call is fully automatic. An operator, however, is connected in parallel for charging purposes. Owing to the extremely limited duties every operator can supervise up to 10 simultaneous connections. Modern and efficient cordless switchboards have been designed for this purpose.

Every switchboard has two operators' equipments, two teleprinter receivers and a keyboard with a transmitter which enables the operator to supervise the establishment of two connections simultaneously.

A call to an operator is directed via a queuing equipment, which sends exchange identity and the *MOM* signal to the calling subscriber.

The illustration on the cover of this number shows the cordless operators' positions in the intercontinental transit centre of the Australian Overseas Telecommunications Commission at Sydney, and fig. 10 the corresponding switching equipment.

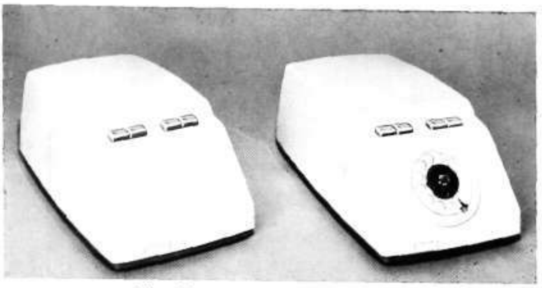


**Fig. 11**
**Subscriber's control units**

## Test Equipments

A very extensive program has been developed for automatic testing. Procedures such as the generation of test calls, tariff tests, distortion measurements on repeaters and subscriber apparatus, and register tests, are performed automatically under the control of an automatic tester. Both the *ARM* and *ARB* exchanges have facilities for individual selection of every circuit on a route, also under the control of the automatic tester. The facilities provided by the automatic tester will be described in a coming issue.

## Subscriber Control Units

Fig. 11 shows L M Ericsson's control units, which are of modern design and can be used with any type of system.

They are made in four types:

- for single current with keyboard selection
- for single current with dial selection
- for double current with keyboard selection
- for double current with dial selection.

They can be connected to the normal types of teleprinter and automatic tape transmitter.

## Examples of Installed Systems

The first *ARM 201* exchange with integrated terminal exchange *ARB 111* for telex and gentex was opened at Trondheim, Norway, in 1963. Type *A* signalling is used, with ± 60 V TB voltages, and *ARM 201* is simultaneously a transit centre for telephony. Similar equipments have since been installed at Bodö and Stavanger in Norway.

In 1964 three *ARB* exchanges were installed in Ireland. They use type *B* signalling, keyboard selection and ± 80 V TB voltages. The Dublin exchange also carries automatic international traffic.

In the following year three intercontinental exchanges were installed at Montreal and Vancouver in Canada and at Sydney in Australia. The first two of these also carry telephone traffic. All three exchanges cater for *A*, *B* and *U 20* signalling.

The telex and gentex network in Jugoslavia is based on *ARM 201* and *ARB 111* exchanges, and at present there are altogether 15 exchanges in operation, of which Belgrade and Zagreb are international. They use *B* signalling with keyboard selection.

In June 1966 the Australian telex network was converted to automatic operation through the installation of five *ARM 201*, one *ARM 503* and a large number of *ARB* exchanges, with *B* signalling and keyboard selection.

# Planning of Junction Networks with the Aid of a Computer

Y. RAPP & B. ERIKSSON, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 681.3
621.395.74
LME 8077
0009

*Like most public utilities, a telephone network involves considerable long-term investments. It is of very great importance, therefore, to make an economic comparison between alternative means of supplying the telephone need before coming to a decision. The numerical calculations required for a comparison of this kind, however, are so laborous that they can hardly be carried out manually, at least for multiexchange areas. For this reason L M Ericsson have developed methods which permit programming of the most laborous operations for a computer.*[1,2,3] *In the last few years these methods have come into wide use and L M Ericsson have assisted administrations in several countries in drawing up the guiding lines for planning of local and trunk networks.*

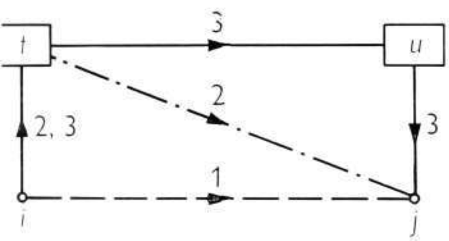



**Fig. 1**
**Three-choice traffic routing**

$i$ = an originating exchange in tandem area $t$
$j$ = a terminating exchange in tandem area $u$
$i-j$ = first choice, high-usage route
$i-t-j$ = second choice, high-usage route
$i-t-u-j$ = third choice, final route

*Ericsson Review No. 4, 1962, contained an article describing how the locations of exchanges and their area boundaries are determined. The present article will describe how, with the aid of a computer, an optimal solution for traffic routing in an alternative routing network can be quickly and effectively arrived at. The solution includes an indication of the number of tandem points required, where they should be located, and which exchanges shall be subordinated to different tandem points.*

The planning of a junction network entails decisions concerning cable runs, the number and locations of tandem points, what exchanges shall be subordinated to the various tandem points, and the methods of routing-direct, tandem or alternative routing. It is also necessary to study the effect which the future growth of traffic may have on the network structure. A series of configurations is thereby obtained which enable the various stages of expansion to be incorporated in the plans as economically as possibly.

Questions of security and protection of cables also enter into the picture. These can be provided for by alternative routing with a number of suitably selected tandem points and by geographical dispersion of the circuits concerned among different cable runs.

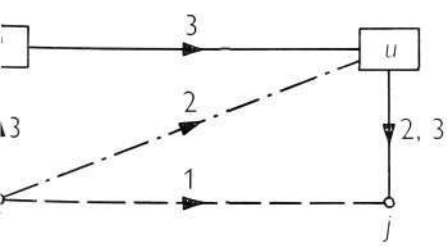



**Fig. 2**
**Three-choice traffic routing**

$i$ = an origiaating exchange in tandem area $t$
$j$ = a terminating exchange in tandem area $u$
$i-j$ = first choice, high-usage route
$i-t-j$ = second choice, high-usage route
$i-t-u-j$ = third choice, final route

Data processing makes it easy to obtain information concerning the size and growth of the tandem points with future increase of traffic. It provides an indication of new cable runs which should be introduced in the network, and of suitable means of routing the traffic.

## Main Principles of Network Structure

It is as well to start by considering the two main principles for traffic routing, as shown in Fig. 1 och 2, which may occur with alternative routing in large networks. In these figures $i$ denotes an exchange with outgoing traffic, $j$ an exchange with incoming traffic, and $t$ and $u$ the tandem points corresponding to exchanges $i$ and $j$. A network as shown, for example, in Fig. 1 can be calculated by the abovementioned programming method. A network of the kind in Fig. 2 can also be dealt with. In the latter case the calculations are made

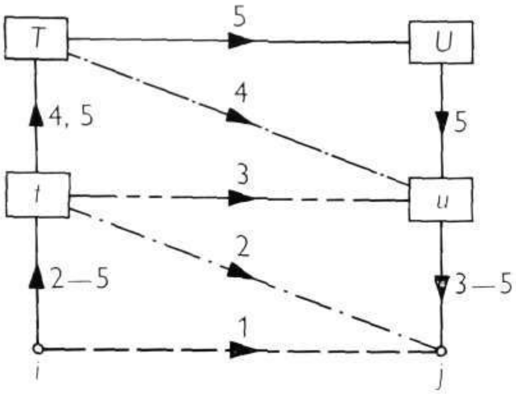



**Fig. 3**
**Traffic routing with up to five choices**

$i$ = an originating exchange in tandem area $t$
$j$ = a terminating exchange in tandem area $u$
$i-j$ = first choice
$i-t-j$ = second choice
$i-t-u-j$ = third choice
$i-t-T-u-j$ = fourth choice
$-t-T-U-u-j$ = fifth choice

in steps. One calculation is made for each tandem point with the quantities of traffic offered from exchanges $i$ to tandem area $u$. The network between the tandem points is thereafter determined in order to arrive at the final configuration. The various routing principles may be dependent on the grouping of the exchanges, the community of interest, and on earlier constructed cable runs, as well as on the need for a particular form of routing, as a result of the introduction of automatic telephone systems in the network. Assuming, for example, that the number of exchanges $i$ is greater than $j$, the number of routes $t$–$j$ in accordance with Fig. 1 will be smaller than the number of routes $i$–$u$ in Fig. 2. In such case the routing principle of Fig. 1 will usually be more advantageous owing to the better circuit economy. A combination of the two routing methods may also lead to a saving in overall capital expenditure.

These principles, which apply to traffic routing with up to three choices, can also be applied to networks with up to five choices (Fig. 3). In this case as well the calculations are carried out in steps.

## Input Data

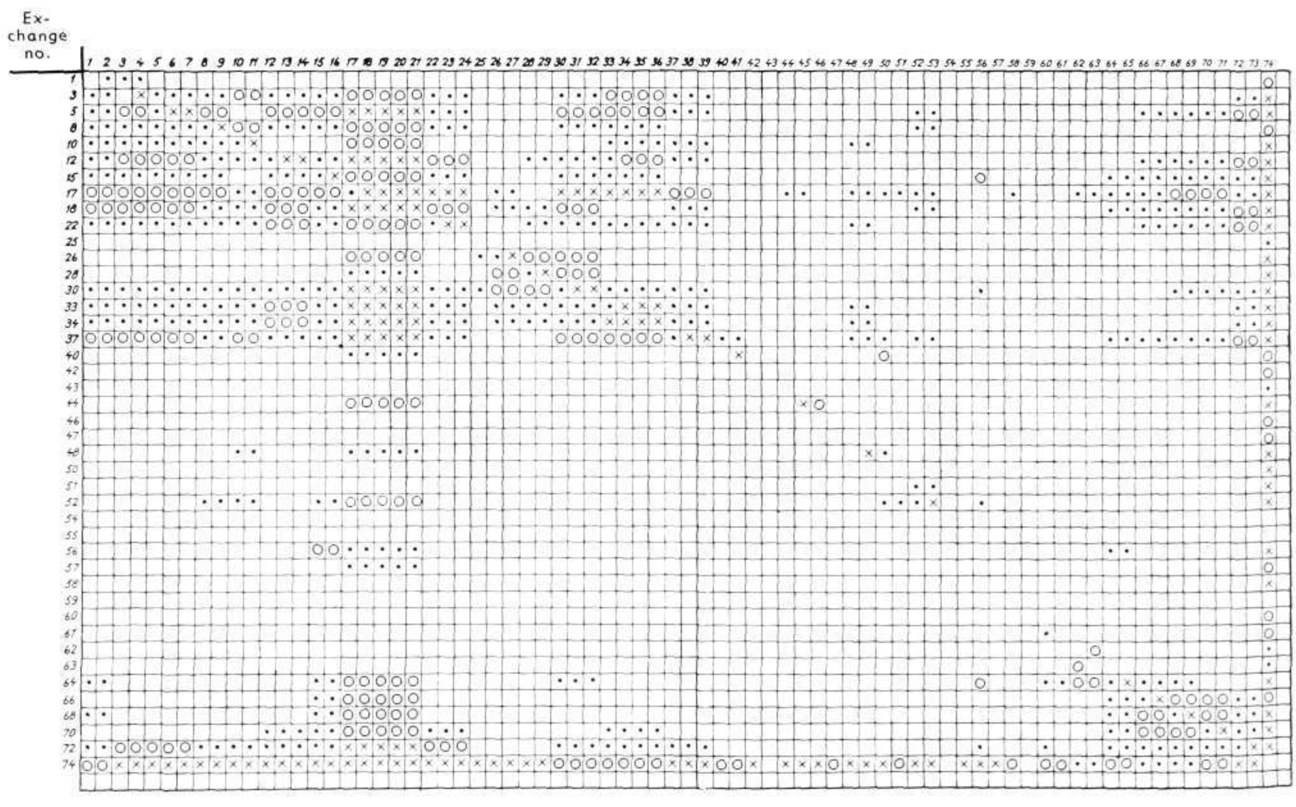
The following input data to the computer are used:

- *Traffic matrix* indicating the predicted traffic between the exchanges in the network.
- *Cost matrix* indicating the cost of relay and switching equipment and junction circuits both for direct junctions between the exchanges and for the junctions between the exchanges and their respective tandem points.
- *Junction matrix* with the notation $t$ (tandem), $d$ (direct) for predetermined traffic routing and $h$ for cases when the routing ($t$, $d$ or $h$) is to be established by the computer.

**Fig. 4**
**Traffic distribution between the exchanges**

☐ A < 5
⊡ 10 > A ≥ 5
◎ 20 > A ≥ 10
☒ A ≥ 20

A Traffic in Erlangs



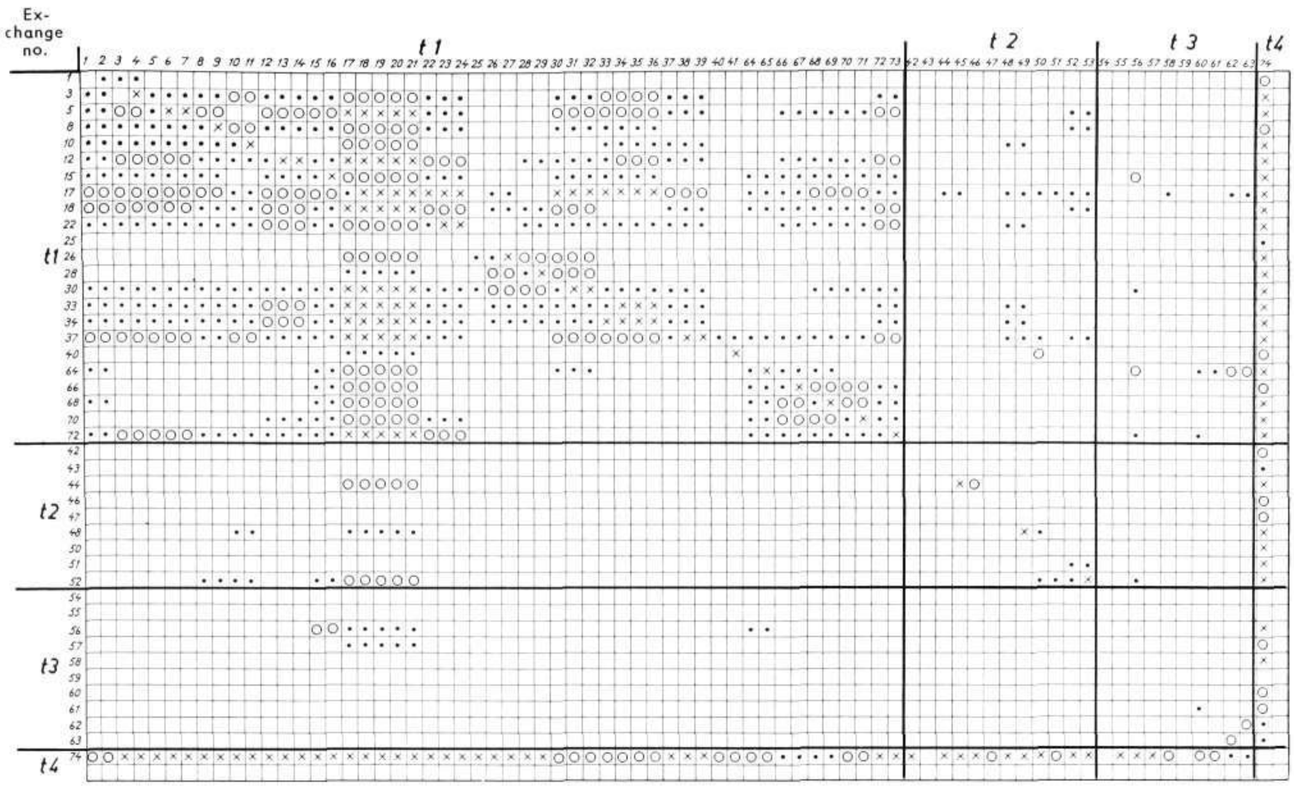



**Fig. 5**

**Traffic distribution after division into tandem areas**

□ A < 5

⊡ 10 > A ≥ 5

◎ 20 > A ≥ 10

⊠ A > 20

A Traffic in Erlangs

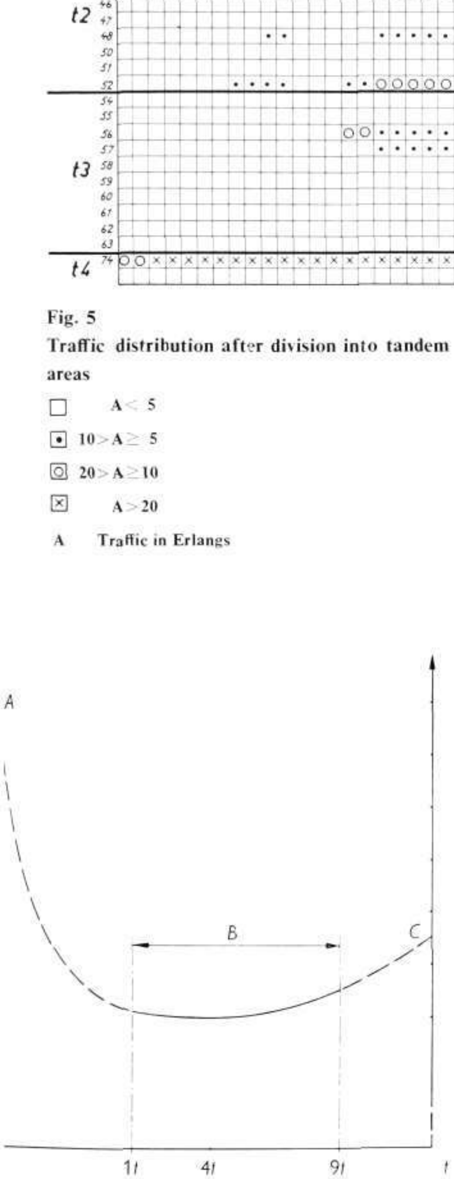



**Fig. 6**

**Comparison between the network costs per cent of minimum cost for different numbers of tandem points and solely direct or solely tandem routing.**

*A* **Direct routes only**

*B* **Alternative routing**

*C* **Tandem routes only**

*t* **Tandem exchanges**

# Investigation and Results

In the handling of a problem a traffic matrix and cost matrix are fed into the computer. The junction matrix is then changed in accordance with the various cases to be studied in respect of the main principles for the network structure, number of tandem points and exchanges to be associated with each tandem point. The result of a study comprising 74 exchanges and maximum 9 tandem points is presented below. Some assistance in the division into tandem areas can be obtained by indicating the traffic intensity between different exchanges on a grid. Fig. 4 shows an example of a grid of this kind. Every exchange has been allotted a number, and the different traffic intensities are indicated by the symbols shown in the figure. The positions of the exchanges are then changed on the basis of the community of interest between them (Fig. 5). Having these communities of interest and the geographical location of the exchanges in mind one can form tandem areas which are suitable for further study. To decide what network structure is preferable from the economic and security aspects, calculations are then made under different assumptions as regards the number and location of the tandem points, and as regards the exchanges to be associated with a given tandem point. To get an idea of the profitability of alternative routing a calculation is also made with direct junctions alone compared with routing solely via the tandem exchanges.

The computer delivers cost and circuit data, as well as several other valuable items of information. An extract is shown in tables 1, 2 and 3, the symbols in which are explained below.

For the aforementioned cases an example is shown in Fig. 6 of the resulting cost relation in percent of the minimum value (100 %).

## Computer Output

In the junction matrix originally fed into the computer the symbols *h*, *d* and *t* are used, where

*h* = alternative routing to be investigated

*d* = direct (low-usage) route

*t* = tandem route

The symbols *d* and *t* lock the program, whereas the symbol *h* implies that a program investigates whether alternative routing for the route in question is profitable or not according to the methods described in earlier articles.[2, 3] If, in the calculation, the computer finds that a direct route is more economical, the symbol changes from *h* to *b*. If tandem is more profitable, the symbol changes from *h* to *l*. An *h* in the data output implies alternative routing.

The example of a junction matrix in table 1 shows in the first row that an *h* in the input matrix has changed to *l*. This means that the traffic in question should only be routed in tandem. The first and second rows of the table indicate the traffic routing from exchange 1 to exchange 1 (denoted by a dash since the internal traffic need not be investigated), 2, 3, 4 etc. up to exchange 74. The subsequent rows show the traffic routing from the remaining exchanges investigated.

*Table 1. Junction Matrix. Extract from Computer Output*

| Exchange | | |
|---|---|---|
| 1 | -lllllllll llllllllll llllllllll llllllllll llllllllll llllllllll<br>llllllllll lllh | Exchanges |
| 2 | t-tttttttt tttttttttt tttttttttt tttttttttt tttttttttt tttttttttt<br>tttttttttt tttt | |
| 3 | lh-hllllh hhhhhhhhhh hhhhlhhllh hhhhhhhhhh hllhhllhhh hhhllhlhll<br>lllhhhhhhh hhhh | |
| 4 | ttt-tttttt tttttttttt tttttttttt tttttttttt tttttttttt tttttttttt<br>tttttttttt tttt | |
| 5 | lhhh-hhhhh hhhhhhhhhh hhhhlhhhhh hhhhhhhhhh hllhhlllll lhhllhllll<br>lllhhhhhhh hhhh | |
| 6 | ttttt-tttt tttttttttt tttttttttt tttttttttt tttttttttt tttttttttt<br>tttttttttt tttt | |
| 7 | tttttt-ttt tttttttttt tttttttttt tttttttttt tttttttttt tttttttttt<br>tttttttttt tttt | |
| 8 | lhhhhhh-hh hhhhhhhhhh hhhhllllh hhhhhhhhhl lllllllhhh hhhllhllll<br>lllllhhhhh hhhh | |
| | \| \| \| \| \| \| | |
| 72 | lhhhhhhhhh hhhhhhhhhh hhhhlhhhhh hhhhhhhhhl llllllllll lhhhlhhlhh<br>lhhhhhhhhh h-bh | |
| 73 | tttttttttt tttttttttt tttttttttt tttttttttt tttttttttt tttttttttt<br>tttttttttt tt-t | |
| 74 | hhhhhhhhhh hhhhhhhhhh hhhhhhhhhh hhhhhhhhhh hhlhhhhhhh hhhlhhhlll<br>hllhhllllh hhh- | |
| t1 | ddddddddd ddddddddd ddddddddd ddddddddd dhhlhhhddd hddhhhlhhh<br>hhhlhddddd dddl | Tandem |
| t2 | lhhhhhhhhh hhhhhhhhhh hhhhlhhhhh hhhhhhhhhh hddddddhhh dhhllhllll<br>lhhllhhhhh hhhl | |
| t3 | lhhhhhhhhh hhhhhhhhhh hhhhlhhhhh hhhhhhhhhh hllllhlhhh hhhddddddd<br>dddddhhhhh hhhl | |
| t4 | lhhhhhhhhh hhhhhhhhhh hhhhhhhhhh hhhhhhhhhh hhllhhhhhh hhhlhhllll<br>hhhlhhhhhh hhhd | |

*Table 2. Data of the Outgoing Circuits from the Exchanges. Extract of Computer Output.*

```
from  exch  1= 22             max
 t    ait   nit  eit   v/a   nit     ai.      bit
 1 127.33  148  .019  1.74   159   495.10    2150

 j    aij   nij  eij    cij       bij
 1    6.70   0    1  1.000       2150
 2    6.70   5  .407 0.775       2150
 3    7.60   8  .213 0.623       2275
 4    7.60   8  .213 0.623       2275
 5    7.80   8  .224 0.608       2175
 6    7.80   8  .224 0.608       2175
 7    7.80   8  .224 0.608       2175
 8    6.10   5  .367 0.709       2925
 9    6.10   5  .367 0.709       2925
10    6.70   6  .312 0.721       3100
11    6.70   6  .312 0.721       3100
12   11.00  14  .085 0.447       1700
 |     |     |    |    |          |
 |     |     |    |    |          |
 |     |     |    |    |          |
 |     |     |    |    |          |
65    3.90   3  .442 0.726       4250
66    6.40   7  .211 0.583       3075
67    6.40   7  .211 0.583       3075
68    6.90   8  .173 0.587       3300
69    6.90   8  .173 0.587       3300
70    8.50  11  .101 0.438       2225
71    8.50  11  .101 0.438       2225
72   18.60  23  .059 0.392       1675
73   18.60  23  .059 0.392       1675
74   43.20  35  .247 0.866       5500
```

The result for exchange $i = 22$ is shown in table 2, where

- *ait* is the traffic in Erlangs rejected from direct circuits to the tandem exchange $t = 1$
- *nit* the number of circuits corresponding to *ait* calculated for the mean congestion
- *eit* the resulting congestion
- *v/a* the degeneration factor (the ratio of variance to mean value of the traffic on the tandem circuit)
- *max nit* the number of circuits corresponding to a fixed congestion on the tandem route
- *ai.* the traffic originated from exchange $i$ to other exchanges with the exception of traffic on routes on which direct routing alone is employed
- *bit* the input cost per circuit between exchange $i$ and its tandem exchange $t = 1$

Thereafter the table indicates

- *aij*, the outgoing traffic from exchange $i$ to other exchanges $j$ ($j = 1, 2, 3, 4$ etc.)
- *nij*, the number of direct circuits corresponding to the traffic calculated on the basis of the cost ratio *cij*
- *eij*, congestion on the direct route between $i$ and $j$
- *cij*, the ratio between the costs for direct and alternative routing (in Ericsson Technics[2, 3] denoted $\varepsilon$)
- *bij*, the input cost for the direct route between $i$ and $j$.

*Table 3. Data of Circuits Proceeding from the Tandem Points. Extract of Computer Output.*

```
from tandem t=  1          max
 j    atj  ntj  etj   v/a  ntj      a.j      btj
 1 196.10 223 .005   1.04 224    206.80        1
 2  98.13 120 .010   1.53 125    212.40      625
 3  59.72  77 .018   1.78  84    217.60     1500
 4  60.27  76 .021   1.80  95    265.10     1500
 5  62.17  80 .015   1.64  86    198.60     1425
 6  62.74  79 .019   1.66  86    238.60     1425
 7  62.74  79 .019   1.66  86    238.60     1425
 8  60.33  78 .014   1.58  83    171.50     1975
 9  60.77  77 .017   1.59  84    214.90     1975
10  55.27  72 .017   1.74  79    188.30     2150
11  55.27  72 .017   1.74  79    188.30     2150
12  51.63  68 .021   1.89  75    217.80     1650
 |     |    |    |      |   |       |        |
 |     |    |    |      |   |       |        |
 |     |    |    |      |   |       |        |
 |     |    |    |      |   |       |        |
62  45.64  41 .161   1.12   0     60.00     4775
63  43.56  40 .149   1.13   0     60.00     4425
64  43.08   0    1   1.32   0    101.00     3700
65  43.08  34 .203   1.32   0    101.00     3700
66  45.60  60 .015   1.43  65    143.30     3125
67  46.34  61 .015   1.42  66    143.30     3125
68  49.35  64 .016   1.49  70    159.00     3475
69  49.35  64 .016   1.49  70    159.00     3475
70  46.15  61 .017   1.58  67    165.20     2925
71  46.15  61 .017   1.58  67    165.20     2925
72  62.06  79 .020   1.91  88    256.90     2125
73  62.06  79 .020   1.91  88    256.90     2125
74 286.59   0    1   3.01   0   1262.10     4200

from tandem t=  1          max
 u    atu  ntu  etu   v/a  ntu      a..      btu
 2  63.60  81 .019   1.76  88    240.50     3750
 3 165.53 189 .019   1.87 202    627.70     3700
 4 286.59 321 .022   3.01 346   1262.10     4200
```

In table 3, which gives the result for tandem exchange $t = 1$,

- *atj* is the traffic between tandem exchange *t* and destination exchange *j*
- *ntj* the number of circuits corresponding to *atj* calculated for the mean congestion
- *etj* the resulting congestion
- *v/a* the degeneration factor
- *max ntj* the number of circuits for the final routes to the exchanges associated with the tandem point corresponding to a fixed value of the congestion on the final route
- *a.j* the traffic entering exchange *j* from other exchanges with the exception of direct-routed traffic
- *btj* the input cost per circuit between *t* and *j*

In the lower part of the table, showing the circuits between the tandem points,

- *u* is the destination tandem exchange
- *atu* the traffic between tandem exchange *t* and destination tandem exchange *u*
- *ntu* the number of circuits corresponding to *atu* calculated for the mean congestion
- *etu* the resulting congestion
- *v/a* the degeneration factor
- *max ntu* the number of circuits for the final routes corresponding to a fixed value of the congestion on the final route
- *a..* the total traffic offered to the exchanges in area *u*
- *btu* the input cost per tandem circuit between *t* and *u*.

Similar computer outputs are obtained for every exchange and tandem point.

## Some General Points of View on the Calculations

The profitability of introducing alternative routing is considerable in the case reported compared with either direct routing alone or tandem routing alone, as is evident from Fig. 6. Calculations of other networks have sometimes shown smaller differences, but the tendency has always been in favour of alternative routing. The additional advantage in the form of security in the network offered by alternative routing and the large number of tandem points can also be weighed against the insignificant difference in cost for different numbers of tandem points. The flatness of the cost curve for different numbers of tandem points has been confirmed in similar calculations of other networks. The case shown has also been studied for a period of about 20 years ahead and revealed that the cost difference between 4 and 9 tandem points is percentually reduced, whereas the real cost difference increases.

One may say that every network has its special character and that detailed investigations must be made for each particular case. No general guidance for the construction of a junction network can therefore be given.

In certain contexts it has proved that, from the point of view of cable economy, previously chosen tandem points can advantageously be replaced by new ones. The change in tandem equipment with growing subscriber density has been studied for the case reported (see table 4). It will be seen that the growth in tandem equipment does not increase proportionally to the subscriber growth. A study of this kind enables an estimate to be made of, among other things, the space requirement for the future tandem equipment.

In calculations of complex networks carried out on the above principles many means of saving costs have been discovered. An example is a saving of some 10 per cent on a project in which the original intention had been to route via zone centres by conventional methods, by simply eliminating these centres.

*Table 4. Growth of Inlets and Outlets at the Tandem Points as a Result of Increase of the Local Traffic.*

(The figures indicate the growth factor)

| Tandem area | Growth in subscribers' network | Growth in number of inlets to tandem | Growth in number of outlets from tandem |
|---|---|---|---|
| I<br>Ca. 370 000 subscribers | 1.4 | 1.4 | 1.3 |
| II<br>Ca. 30 000 subscribers | 8.2 | 2.5 | 2.4 |
| III<br>Ca. 60 000 subscribers | 3.0 | 1.8 | 1.8 |
| Total<br>Ca. 460 000 subscribers | 2.0 | 1.6 | 1.6 |

In many networks the "busy hour" for the traffic between local or trunk exchanges does not coincide. In such cases the maximum quantity of traffic rejected to the tandem routes is smaller than the sum of the maximum rejected traffic from the individual, direct, high-usage routes. If account is taken of this displacement in time of traffic peaks when computing the requirements of circuits on the tandem routes, essential savings can be made compared with the assumption that the traffic peaks coincide in time as in Fig. 6.

Since the capital invested in local and trunk networks amounts to some 60 % of the total plant cost, reliable planning both in the long- and short-term view is of the greatest economic significance.

The computer method described above provides quick and clear data for economic network planning. If carried out at suitable intervals such calculations enable the stages of expansion to be properly adapted to the need as renewed and improved forecasts of the subscriber and traffic growth come in.

## References


1. RAPP, Y.: *The General Plan for a Multi-exchange Area.* Ericsson Tech. *20*(1964): 2, pp. 171—182.
2. RAPP, Y.: *Planning of Junction Network in a Multi-exchange Area. I. General Principles.* Ericsson Tech. *20*(1964): 1, pp. 77—130.
3. RAPP, Y.: *Planning of Junction Network in a Multi-exchange Area. II. Extensions of the Principles and Applications.* Ericsson Tech. *21*(1965): 2, pp. 187—240.

# Modern Carrier Stations in Long Distance Networks

P. A. HALLBERG, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.722
621.395.44
LME 842

*The following article describes a carrier station in a long distance network, and as a complement to earlier articles also how through connection and distribution of frequency blocks is carried out. The practical construction of a station is shown, and its maintenance philosophy is developed.*

When planning a station with carrier equipment the starting-point is its role in the long distance network. Fig. 1 illustrates a part of such a network which is typical for most countries. According to circumstances, the h.f. line equipment connecting the carrier stations A–H with each other can, for instance, consist of radio links or coaxial line links using normal or small-diameter cable pairs. The traffic capacity of the h.f. lines varies with the demand; thus the line links to certain smaller stations in the network, for instance A and H, can consist of 300-circuit systems using small-diameter coaxial cables, while on certain main routes one or several 12 MHz systems providing 2700 circuits can be used. At the carrier stations part of the channels routed over the various line links may have to be terminated, i.e. brought to the respective telephone station while the rest is through connected and conveyed to other line links.

Through connection is arranged by splitting up the line frequency bands into standardized frequency blocks, supermastergroups, mastergroups, supergroups or groups. The various blocks from the respective line links can then be connected together as required. Fig. 2 gives a more detailed picture of this procedure at station C, which is assumed to have two 900-circuit systems and one 300-circuit system, 300 circuits being terminated. It should be emphasized from the outset that through connection should be performed in blocks as large as possible; this saves equipment and presents the traffic arrangement more clearly as well as giving better quality.

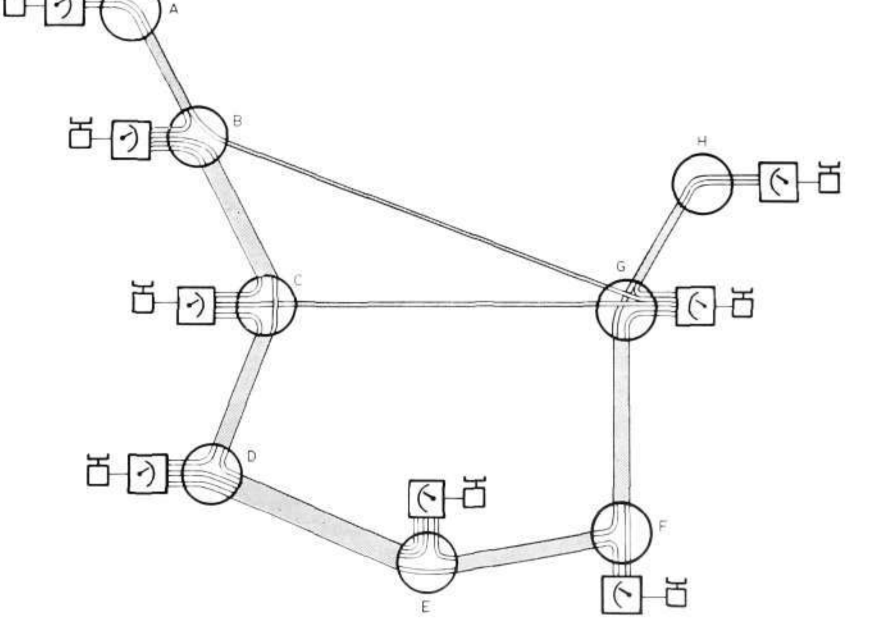



**Fig. 1**
**A section of a typical long distance network with illustration of through connection and termination at terminal stations.**
A-H Carrier terminal stations

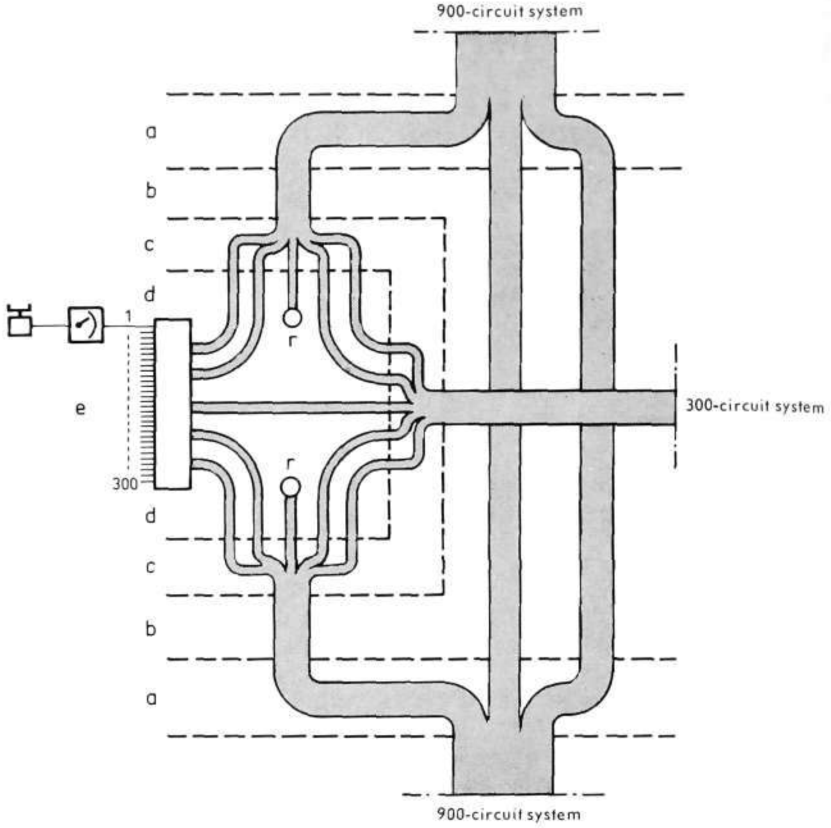



**Fig. 2**

**Illustration of through connection of mastergroups and supergroups and termination of 300 circuits.**

a Mastergroup translating equipment
b Mastergroup distribution and through connection
c Supergroup translating equipment
d Supergroup distribution and through connection
e Channel and group translating equipment
r Spare supergroups

In the example shown here it has been assumed that groups are not through connected. It is obvious that the use of such a small frequency block in large systems involves bulkier equipment and for this reason several administrations have chosen the supergroup as the smallest unit for through connection.

In through connection advantage should also be taken of the possibility of causing through-connected frequency blocks to change places within the line frequency bands. Hereby uniformity of transmission performance can be achieved, and furthermore any undesirable addition of certain intermodulation products from the h.f. lines can be prevented. Also, any rearrangements of frequency blocks, for instance in case of faulty h.f. lines, are made much easier by the use of larger units.

A more detailed example of a larger station is shown in fig. 3, where the functional division of the equipment is illustrated. The station is assumed to be connected to six 12 MHz systems corresponding to $6 \times 2700 = 16{,}200$ circuits, of which 7200 are terminated. The rest is through connected as supermastergroups, mastergroups and supergroups. The through connection of these frequency blocks from one line link to another is arranged via the distribution frames and through connection filters associated with the translating equipment of the respective carrier terminals. The h.f. line equipment is not shown in this article.

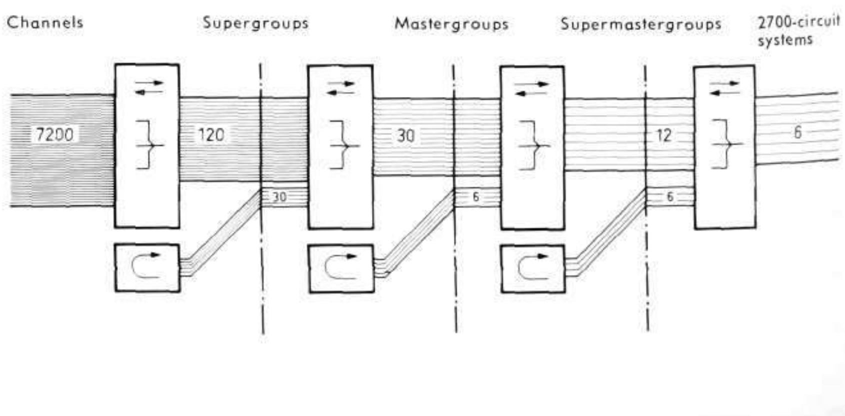



**Fig. 3**

**Schematic illustration of a large-capacity station with six 2700-circuit systems, 7200 circuits being terminated and the rest through connected as supermastergroups, mastergroups and supergroups.**

The figures denote the number of circuits and frequency blocks respectively

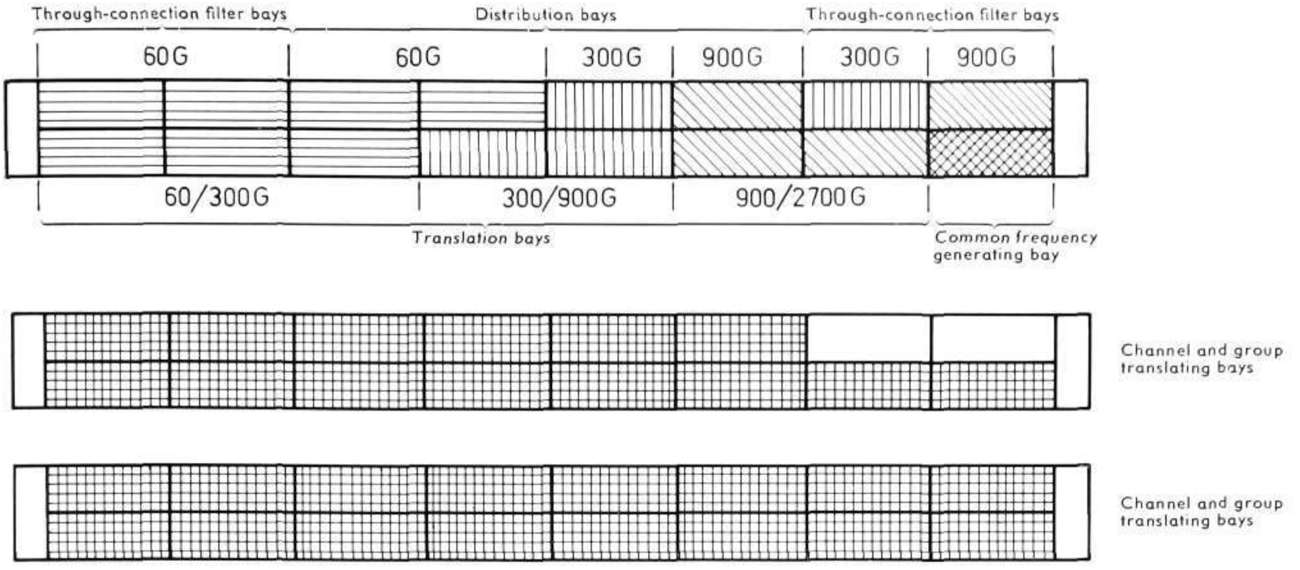



**Fig. 4**
**Location plan of a station according to fig. 3**

| | |
|---|---|
| 60 G | SG |
| 300 G | MG |
| 900 G | SMG |
| 60/300 G | SGTE |
| 300/900 G | MGTE |
| 900/2700 G | SMGTE |

In design *M4* the equipments shown in fig. 3 are constructed in shelf stacks containing functional units. See Ericsson Review, nos. 3, 1966, and 1, 1967. The shelf stacks are mounted in bays. In stations of this size the bays are "pure", i.e. the shelf stacks in a bay are mainly of one type, whereby station layout is simplified. In smaller stations it is possible to combine shelf stacks of various types in the same bay to obtain adaptation to various needs. However, in long-range planning the use of "pure" bays initially not fully equipped will prove to facilitate maintenance and further expansion. Therefore the use of such bays as widely as possible is recommended.

A location plan for a station with the equipment required for the above-mentioned typical example is shown in fig. 4. It shows that the channel and group translating equipments, which constitute the bulk of the station equipment, have been assembled in separate suites.

Further translating bays and the common frequency generating bay are located on the "inside" of the next suite, while the bays for through connection and distribution are located on the "outside". Thereby unnecessary contact with the translating equipment is avoided during connection operations, and a more convenient arrangement of the distribution equipment is obtained. The cabling from the distribution bays to the translation and through-connection filter bays is short and simple. The additional equipment required if groups also were to be distributed would, in a station of this size, be comparatively bulky.

A suite cabinet is provided at each end of the suite. One suite cabinet mainly contains equipment for current distribution, for instance circuit breakers and distributors of basic frequencies and pilot frequencies. For further information see the articles in Ericsson Review no. 1, 1967. Where necessary, the other suite cabinet can contain arrangements for connection of alarm wires and test trunks.

As a rule the terminal equipment also comprises distribution frames and bays with test jacks. This equipment will not be dealt with here, but the miniaturization of the carrier equipment can be illustrated by the following comparison of required floor area:

| | |
|---|---|
| Carrier equipment as in fig. 4 including gangways | c. 25 $m^2$ |
| The combination of distribution bays–test jack bays–distribution bays of 15 $m^2$ each | c. 45 $m^2$ |

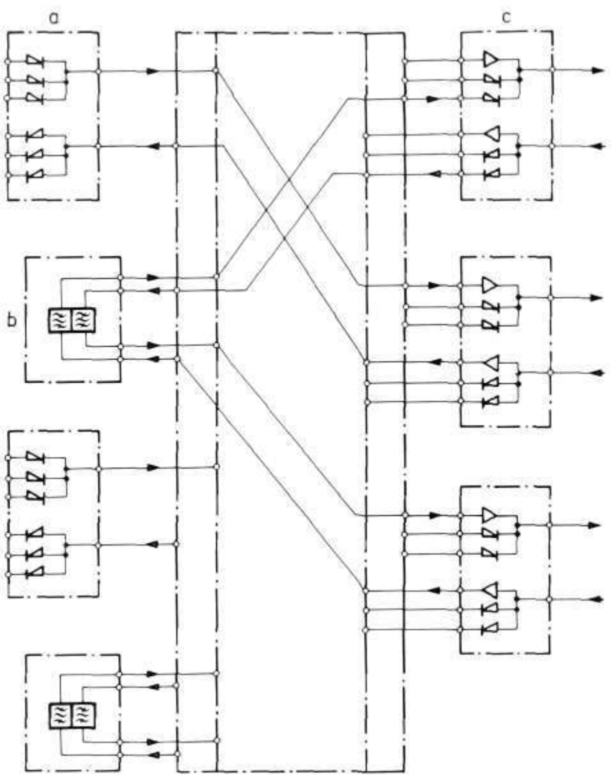



**Fig. 5**
**Distribution equipment**

Distribution bay surrounded by:

- a Lower translation stages (e.g. mastergroup/supermastergroup)
- b Through-connection filters
- c Higher translation stages (e.g. supermastergroup/2700-channel line group)

If test jack bays can be omitted, for instance by the introduction of automatic transmission measuring equipment (see Ericsson Review nos. 2 and 3, 1963), the second item is reduced to 15 m². In such a case, the access point which is located in L M Ericsson channel translating equipment is of great value. Some administrations have to a large extent dispensed with v.f. distribution, using group distribution only. In the future group distribution too may be abandoned, if frequency blocks as large as supergroups can be used in this connection.

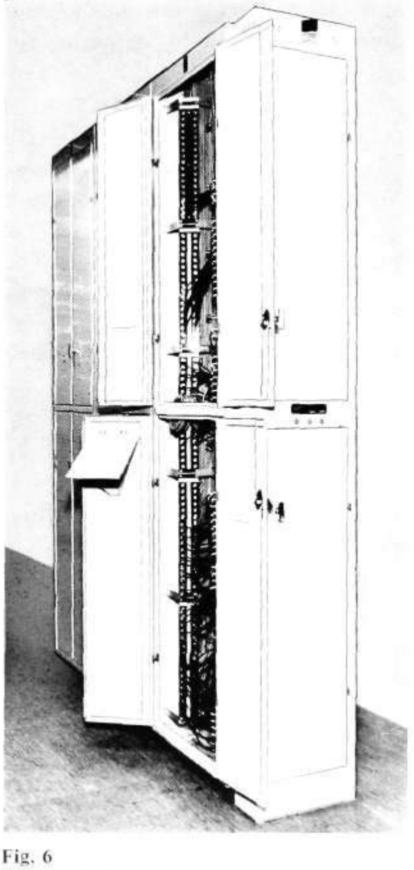


Fig. 6
Distribution bay

## Through-connection and Distribution Equipment

The through-connection and distribution equipment is used for marshalling standardized frequency blocks between different routes, a facility of vital importance for the attainment of flexibility of traffic in carrier transmission systems. In the middle of fig. 5 the schematic arrangement of distribution bays is shown, with the lower translation stages and through-connection filters to the left, and the higher translation stages to the right.

### *Distribution Bays*

The principle of a distribution bay is shown in the figure mentioned above. The send-receive pair of a higher frequency block is connected either to a through-connection filter or to a lower translation stage by means of a flexible cable. Fig. 6 shows a distribution bay, designed for a larger type of coaxial jacks suited both for 8 mm and 5.6 mm cables (see below), with space for 90 frequency blocks on each side. One variant of this bay is equipped with the smaller jack developed for the *M4* design. This jack is intended for 5.6 mm cable and permits 200 frequency blocks to be connected on each side. In another variant having a more convenient cable arrangement but half the capacity of the former, the flexible cables are provided with coaxial jacks, which can be fixed beside any wanted jack in the jack strip, connection being completed with the aid of U-links, which denote normal connection. When making temporary rearrangements the U-links are to be removed and connections are carried out by means of patch cords.

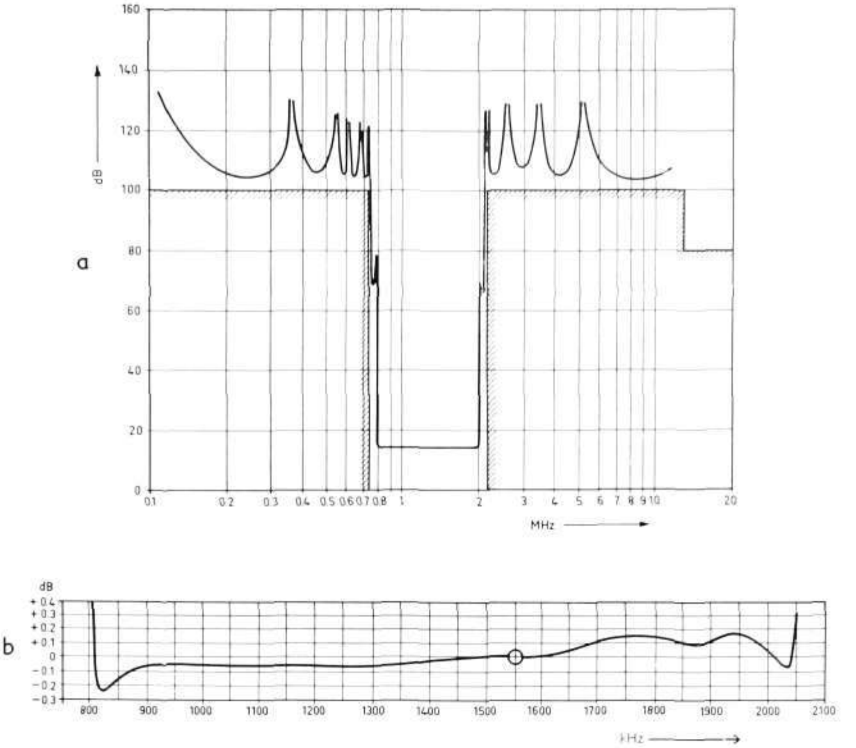



**Fig. 7**
**Typical attenuation curve for a mastergroup through-connection filter**
a Stop band
b Pass band

For cabling between the bay shelves—where connection is made with plug and jack as described in previous articles—and distribution bays, L M Ericsson have developed a coaxial cable *TZC 75005* with an external diameter of 5.6 mm. Like the 8 mm cable, *TZC 75001*, it has a double braid and on the whole has the same properties concerning crosstalk and impedance. The attenuation is approximately 5.4 dB/100 m at 12 MHz. From considerations of space this cable should be used wherever the attenuation permits it.

## *Through Connection*

By through connection is understood that a standardized basic frequency block is extended from one system to another.

After modulation a frequency block is surrounded by remnants of adjacent blocks. In subsequent modulation these are successively filtered out. In through connection, however, the block is introduced into entirely different surroundings, where these remnants would give rise to crosstalk in the adjacent groups, supergroups, etc. Therefore a *through-connection filter* is inserted to eliminate these remnants by a safe margin also regarding program channels. Through-connection filters are provided for all basic frequency blocks with the following data:

| *Basic frequency block* | *Pass band* | *Pass-band loss* | *Impedance* |
|---|---|---|---|
| Group | 60–108 kHz | 6 dB* | 75 ohms unbal. |
| Supergroup | 312–552 kHz | 5 dB | alt. 150 ohms bal.<br>75 ohms unbal. |
| Mastergroup | 812–2044 kHz | 13 dB | 75 ohms unbal. |
| Supermastergroup | 8516–12,388 kHz | 8 dB | 75 ohms unbal. |

* Further attenuation can be inserted.

A typical attenuation curve for a mastergroup through-connection filter is shown in fig. 7. It has been possible to design all the filters with passive elements only. They are assembled in hermetically sealed boxes, two of which fit into a shelf of the *M4* design; see fig. 8. In principle, such shelves can be mounted in any bay where free space is available, but at least in larger stations they should be placed into separate bays.

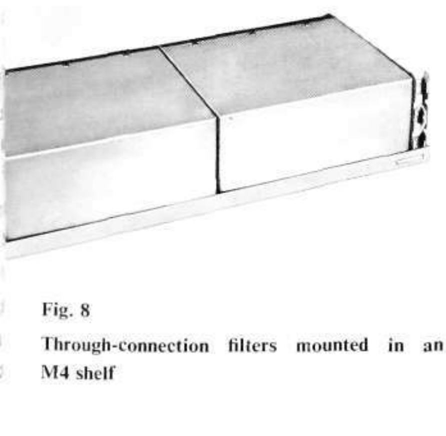


**Fig. 8**
**Through-connection filters mounted in an M4 shelf**

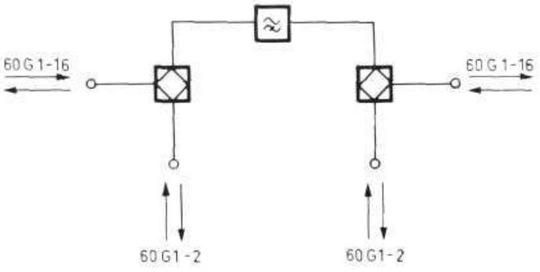



**Fig. 9**
**Branching equipment**
**60 G** Supergroup

## *Branching with Direct Through Connection*

Besides a high degree of flexibility, through connection in the basic frequency band has the advantage of permitting frequency blocks to change places in the line frequency band, whereby a better distribution of disturbances and noise is obtained. In certain cases, however, a somewhat simpler equipment is required, which can be achieved by dispensing with demodulation to the basic frequency band. This is performed by branching off together with direct through connection.

Two kinds of branching are used, namely leak dropping and stop dropping. When using leak dropping the translated channels in the line frequency band are both branched off and directly through connected, the number of terminated channels being determined by the scope of the channel terminating equipment of the respective intermediate and terminal stations. When using stop dropping the width of the through-connected band is determined by the filter which is inserted into the line group transmission path. Thus traffic can take place in the same frequency band from the intermediate station to both terminal stations. A typical case of dropping comprising supergroups 1 and 2 is shown in fig. 9. A special case of direct through connection is obtained when a 2700-channel line group is divided up into its constituent supermastergroups in the normal way but without demodulation of supermastergroups 1 and 2, these being extended directly to the next system in their allotted positions in the line frequency band; see fig. 10.

## Station Construction

For the mechanical construction of a station cable runways are required to carry the cabling to the bays, and also to join and stabilize them. Furthermore the use of suite cabinets at both ends of each bay suite is recommended to centralize common functions such as current distribution, frequency distribution and alarm indication. Fig. 11 shows a model of a station with equipment according to figs. 3 and 4, complete with cable runways and suite cabinets.

## *Cable Running Arrangements*

The equipment engineered in the M4 design is far more compact than that of other methods of construction. Consequently the cabling, which has not been reduced in volume to the same extent as electrical components, now requires relatively more space than in previous designs. A new mechanical construction for cable running systems has been developed. It is compatible with earlier designs—among other things the same height is used. Most of the cabling originates in the channel translating equipment. The width of the cable runway has been increased to 600 mm to enable it to house the cabling from 10 pairs of bays = 20 bays with such equipment, which corresponds to 4800 circuits with 240 60-pair cables and the appurtenant coaxial and power supply cables. In an unfavourable case they must be capable of being taken out in the same direction. The cable-run rung in earlier construction practices has been replaced by a more efficient cable run bracket. When building out existing installations, this bracket can replace the old rung without earlier station cabling arrangements needing to be broken.

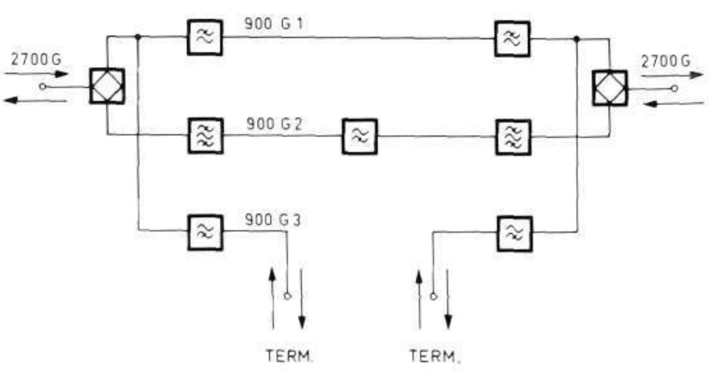



**Fig. 10**
**Direct through connection of supermastergroups**
**TERM.** Terminated supermastergroups
**2700 G** 2700-channel line group
**900 G** Supermastergroup

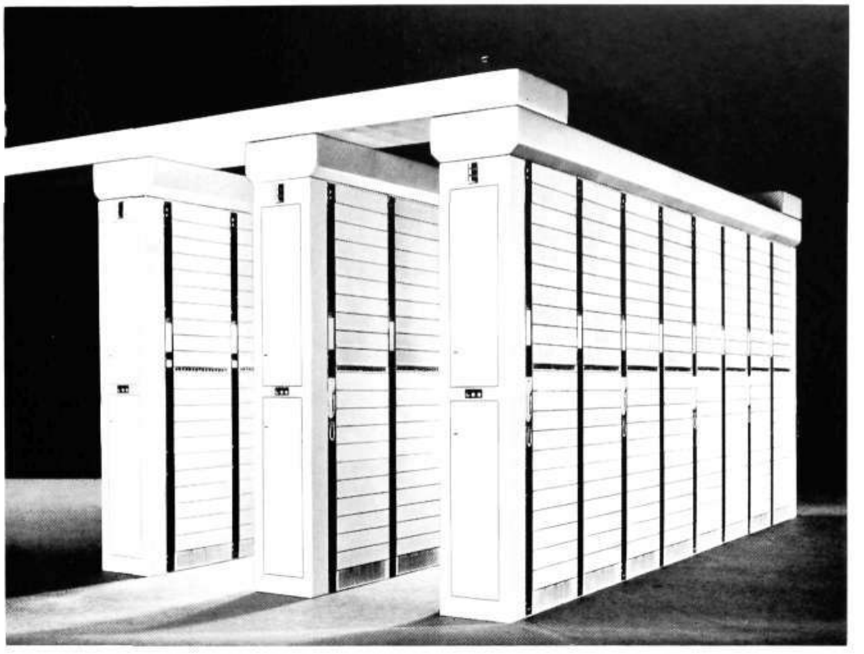


Fig. 11
Model of carrier terminal station according to figs. 3 and 4

## *Suite Cabinets*

The suite cabinet has been further developed in design M4 in order to agree completely with the bay construction; see fig. 12. There is, however, full compatibility between suite cabinets and bays in the *M3* and *M4* designs. Thus a bay suite can contain both *M3* and *M4* bays with *M3* or *M4* suite cabinets at the ends.

The suite cabinet has two doors. Above these, there are 3 bay suite lamps, and between the doors there are lamps for internal alarm functions, such as alarm from circuit breakers.

The suite cabinet can house:

- Connectors for power supply cables
- A box with circuit breakers
- A shelf for vertically mounted units designed for pilot and carrier basic frequency distribution, etc.
- Connection fields for trunks (v.f. as well as coaxial-type).

Where necessary these parts can be mounted in suite cabinets of the *M3* design too.

## Maintenance Principles

It goes without saying that every effort is made to reduce manual maintenance as far as possible. As is well known, manual routine maintenance has in itself a tendency to increase the failure rate. The present fully transistorized carrier equipment with components of high reliability is as a rule equipped with regulating and supervisory equipment of a self-checking type. This means a sufficient guarantee that any lasting fault in the frequency blocks will result in an alarm.

*Given this fact, it may be said that manual routine maintenance of terminal equipment is not required.* An exception is made only for the checking of master frequency and pilot generation. The introduction of automatic transmission testing arrangements, which is advantageous particularly in the case of extensive networks, involves that also the manual channel testing can be dispensed with.

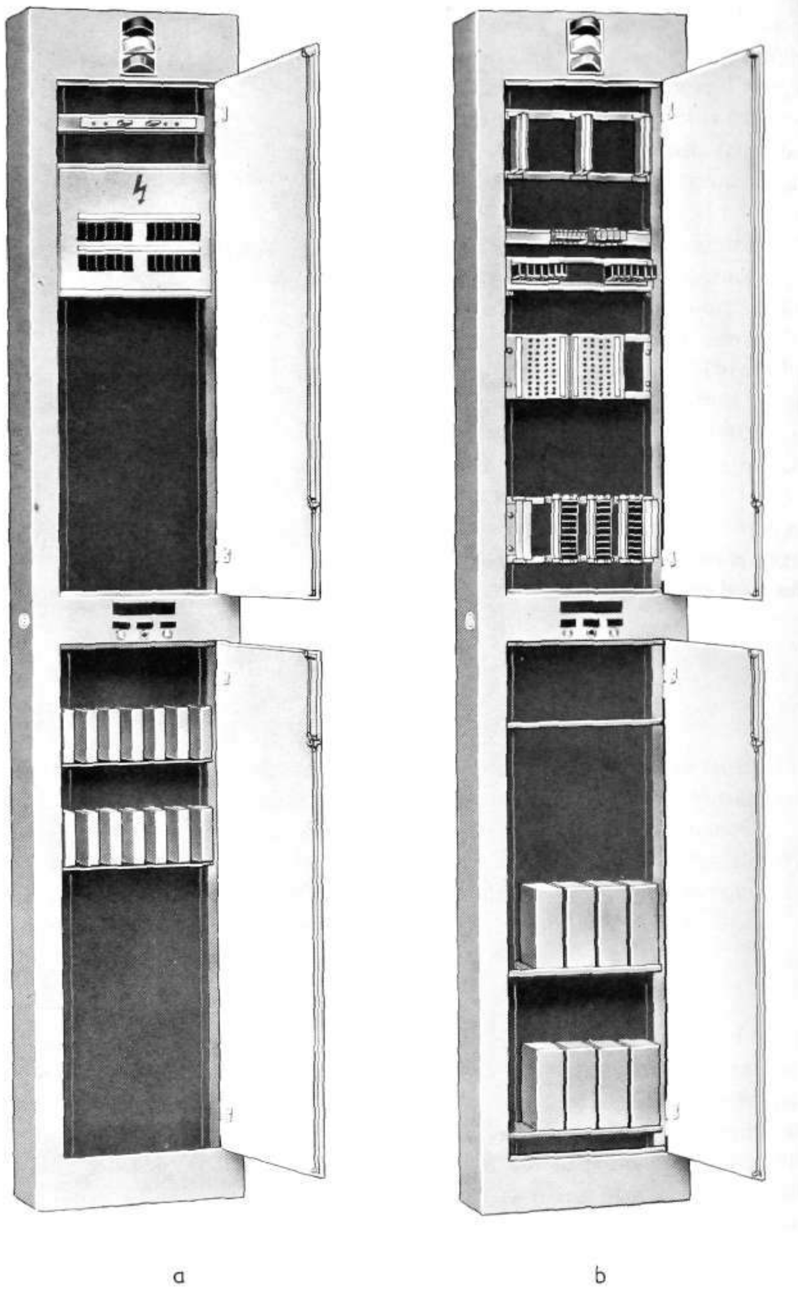


Fig. 12
**Suite cabinet**

a Equipped for current distribution at the top and distribution of pilot frequencies at the *bottom*
b Equipped with arrangements for connection of alarm wires and trunks

In order to obtain an accurate picture of the quality of certain group, supergroup etc. links, continuous monitoring by means of a recording device may be desirable. For this purpose a *recorder bay* has been developed, which can be equipped with 10 recorders, each with 4 pens. These recorders can be connected to pilot receivers, which in their turn are connected to the test outlets of the respective equipment.

Since it is important that the equipment should be allowed to work undisturbed, maintenance devices such as alarm panels, recorder bays etc., should be housed in *separate supervision rooms*, especially in large-capacity stations.

For service purposes there are as a rule service circuits between carrier stations. In a large network the number of service circuits connected to a station can be considerable. For this reason L M Ericsson have developed a simple automatic service circuit exchange. A telephone unit with a dial, mounted on the bay, is connected to this exchange.

# Largest PABX in Northern Europe in Operation at ASEA

**ASEA's new PABX at Västerås was officially put into service on April 4 in the presence of Mr. Bertil Bjurel, Director General of the Telecommunications Administration, Mr. Curt Nicolin, President of ASEA, and Mr. Björn Lundvall, President of L M Ericsson.**

This L M Ericsson code switch PABX type AKD 791 replaces ASEA's previous 20-year old PABX and 8-year old PAX. The new PABX has taken over all telephone traffic within ASEA with the exception of calls handled by a special exchange for the management.

The new exchange is the largest PABX in Northern Europe and would provide fully adequate telephone service for a town of nearly 12,000 inhabitants. It is based on a register-controlled bypath system and has 620 code switches. It also contains some 40,000 relays and extensive electronic equipment. Some 40 kilometres of cable link up the different parts of the system.

The PABX is at present divided into three groups of 1800 extensions, each divided into six subgroups of 300 extensions. With a view to future expansion the PABX has been so amply dimensioned that it can be extended to five groups of 1800 extensions. Internal calls are set up on 250 connecting circuits, which means that 500 persons can converse simultaneously.

### Heavy Internal Telephone Traffic

ASEA is a type of industrial enterprise for which telephony is assuming a growing importance and its telephone organization has already expanded very greatly.

The company acquired its first telephone set exactly 75 years ago and managed with this single set up to the end of the century. The number of employees was then 1062.

Today ASEA have some 10,000 employees and around 6000 telephone sets. These are used for some 14 million calls a year, of which 1.2 million incoming, 3 million outgoing and the remainder, i.e. 9.8 million, internal.

The heavy internal traffic was to a large extent the factor which decided the choice of type of PABX. Characteristic features of the AKD 791 system—apart from very short switching time—are its high reliability, flexibility, and excellent facilities for labour-saving and time-saving auxiliary services. These factors are of the greatest significance, particularly with a view to facilities for data transmission via the telephone network.

### Cordless Switchboards

The ordinary switchboards have disappeared and been replaced by small elegant operators' consoles, only a little larger than an intercom telephone. Incoming calls are distributed automatically among 14 operators who sit at separate desks in an attractive office room. Monitoring is no longer a problem—if an extension does not answer, the call is returned to the operator.

Transfer circuits are arranged between the operators. This ensures better customer service. Certain operators' positions can be allocated to specialists, e.g. in languages or company organization. Calls requiring such knowledge are switched to the specialists and the caller receives the service he needs.

### Auxiliary Services

Serial calls, recall facility, telephone dictation, interception service and speech recording are auxiliary ser-

*Cont. on p. 96*

**One of the operators, Mrs. May Svensson, demonstrates the operation of the console to (from left) Mr. Bertil Bjurel, Director General of the Telecommunications Administration, Mr. Curt Nicolin, President of ASEA, and Mr. Björn Lundvall, President of L M Ericsson.**

The signing of the contract between L M Ericsson and Malaysia at Kuala Lumpur. (From left) Mr. H. Augustinsson, LME, Mr. W. T. Sambanthan, Malaysian Minister of Communications, Mr. Tharmanason, Departmental Head of the Malaysian Telephone Administration, Mr. Jaffar bin Taha, Secretary to the Minister of Communications, Mr Chew Kam Pok, Director General of the Telephone Administration, and Mr. Navarathnam, Departmental Head of the Malaysian Telephone Administration.

## Prominent Malaysian Visitors to Sweden

# New 5-year Agreement Discussed with L M Ericsson

In May L M Ericsson was visited by the Malaysian Minister of Communications, Mr. W. T. Sambanthan, and the Director General of the Malaysian Telephone Administration, Mr. Chew Kam Pok. They were in Sweden on an official state visit at the invitation of Mr. Olof Palme, Minister of Communications.

*

Among other matters discussed with L M Ericsson were the Malaysian development plans within telecommunications on the basis of a long-term agreement signed between L M Ericsson and Malaysia at Kuala Lumpur a couple of months ago.

The long-term agreement covers an amount of 50 million kronor and was concluded in international competition with American, German, Belgian, British and Japanese telephone manufacturers. The agreement is intended to cover the Malaysian requirements of telecommunications within the coming 5-year period.

Deliveries will comprise primarily automatic telephone exchanges of L M Ericsson's crossbar systems for local and trunk traffic. It is possible that the agreement may be extended to comprise other equipment as well.

# Intensive Developments at EDB

Ericsson do Brasil (EDB) have installed new ARF exchanges at three large cities, Pôrto Alegre, Vitoria and São Paulo. The installations have proceeded very satisfactorily and in some cases the service has been opened prior to the contracted date.

The Pôrto Alegre exchange has 24,000 lines, which is the largest cutover in Brazil hitherto. The exchange was put into service at the end of January.

4000 lines were put in service at Vitoria on March 11. Here the ARF equipment interworks with 500-switch equipment.

The Jardim exchange in São Paulo was cut over on March 14 and was an extremely complicated technical operation. The capacity is 6000 lines. The Jardim exchange was the first of a series of 27 exchanges totalling 191,200 lines.

Prince Bertil of Sweden recently visited Jardim during his South American trip. Opposite the Prince in the photograph below is seen General Juracy Magalhães, Chairman of the Board of EDB, and in the centre Mr. Ragnar Hellberg, President of EDB.

## More CTC for Formosa

A few years ago L M Ericsson delivered a very large CTC plant to the Formosan railways, the Taiwan Railway Administration. The equipment was installed along a 148 km section of track between Tainan and Changhua (see map).


A new order has now been received for relay interlocking plant, block system and CTC for the Chunan-Wangtien line. This single-track line has 19 stations and is 80 km long. The signal plant will be controlled, like the previously supplied plant, from the CTC office at Changhua.

The plant is to be put in operation during 1968 and is being built on the same system as before. It will, however, comprise L M Ericsson's new electronic remote-control equipment.

Negotiations with Poland have been proceeding for some time and are drawing close to a conclusion. A Polish government delegation visited L M Ericsson at the beginning of April. The photograph shows, behind the vase of flowers, Dr. Stefan Jedrychowski, President of the Polish Planning Commission, with his interpreter, Dr. Kubylanski on his right. With them are Dr. Marcus Wallenberg (right) and Mr. Björn Lundvall.


The largest and probably the most comprehensive separate exhibition of Swedish industrial and art industry products ever arranged on private initiative in Latin America was opened on March 31 in Buenos Aires by Prince Bertil.

This exhibition, "Suecia en la Argentina 1967", is being held in the Sociedad Rural exhibition area in the centre of Buenos Aires and was arranged in conjunction with the 15th anniversary of the Swedish Chamber of Commerce in the Argentine.

The photograph shows Compañia Ericsson's large exhibit, which included most of the Group's products. It was viewed by nearly 100,000 visitors.

Mr. Olof Palme, Swedish Minister of Communications, and the Secretary of the Department, Mr. Lennart Johansson, visited L M Ericsson on March 9. They were taken on an unconventional tour of the Exhibition Room and of the parts of the factory in which code switches and relay parts are manufactured.

After a brief visit to the Long Distance Division, where they were shown the new M4 construction practice, the day concluded with a demonstration of the Ericsson TV Teaching Studio.

In the photograph below Mr. Olof Palme is seen with Mr. Björn Lundvall, L M Ericsson. Behind them are (from left) Mr. Malte Patricks and Mr. Arne Stein, L M Ericsson.

Mr. Ragnar Hellberg, President of Ericsson do Brasil (EDB), was awarded the Cruzeiro do Sul Order on April 12. The order was presented by Ambassador Sérgio Corrêa da Costa, deputizing for the Foreign Minister. (From left) General Juracy Magalhães, Chairman of the Board of EDB, Mrs. Majbritt Hellberg, Mr. Ragnar Hellberg, and Mr. S. G. Friberg, L M Ericsson, Stockholm.

## Ingmar Boberg in memoriam

Mr. Ingmar Boberg, Director of L M Ericsson Signalaktiebolag, was killed in a flying accident outside Barcelona. He was born at Perstorp in southern Sweden in 1921. After matriculating in 1940 he took an M.Sc. degree in 1944 and M.Econ. degree in 1951.

During his period of study and until 1954 he was employed by the Stockholm Tramways. In 1954 Ingmar Boberg was appointed sales manager of L M Ericsson's Signalaktiebolag and president of that company in October last year.

Ingmar Boberg was completely engaged in his job. He demanded much of his colleagues, but mostly of himself. He spared no pains in the carrying out of his tasks.

Through his work with foreign customers and associated companies Ingmar Boberg became an internationally known and reputed signal expert.

He was a skilled pilot, and aviation was both a pleasure and a relaxation for him.

Through unfortunate circumstances aviation has now put an end to Ingmar's promising career.

Many colleagues and others will feel the loss of Ingmar Boberg. He was a man with a strong personality. This and his mobile intellect and great technical and administrative ability gave him a dominating role in L M Ericsson's signalling activities.

*Håkan Insulander Knut Styrén*

# Ericsson Technique Helps the Handicapped

The ability of Ericsson techniques and components to solve the most varying technical problems is shown by a control equipment for severely paralysed patients recently designed by the Ericsson engineers, Harold Björk and Stig Zettergren, in co-operation with Professor Olof Hök of the Sahlgren Hospital at Gothenburg.

The control equipment is designed for connection to an electric typewriter and can be operated by electrodes placed on the patient's muscles.

Among earlier solutions to the typing problems of the totally paralysed the Possuma unit is the best known. It is a hydraulic apparatus and is operated by pumping movements. The new equipment is controlled by electric signals.

The electromechanical control equipment, operated by the muscle current, is so designed that, with a single electrical contact, all keys of the typewriter can be actuated and all normal typing operations carried out.

**Two electrical make contacts have been attached to a muscle in the arm of Professor Olof Hök. By contracting and relaxing the muscle he controls the typewriter. The equipment incorporates a lamp panel (on the left of Mr. Harold Björk's hand).**

### Largest PABX . . .

*Cont. from p. 93*

vices which the new PABX can already offer today. Among these services telephone dictation is an absolute novelty. Letters, messages and other communications are dictated via the PABX to a central dictating machine. Control of the machines is effected with a key on the handset and is as simple as the manipulation of an ordinary dictating machine in one's office. The arrangement was developed in cooperation between L M Ericsson, ASEA and the Board of Telecommunications.

### Facilities of the Future

Provision has been made for various other new features, which will be installed within about one year.

*Internal abbreviated dialling* is one such feature. This means that eight other extensions can be called by dialling a single digit for each.

*External abbreviated dialling* will be used in Sweden for the first time. This will enable the ASEA staff to communicate with all Swedish ASEA units outside Västerås by dialling a four-digit number.

*The setting up of conferences* during *external calls* is another new facility which will be used for the first time in Sweden. If any extension conversing with an external subscriber wishes to connect a third person to the line, he can do so by means of the conference connection.

Provision has also been made for the "new deal" of the Swedish Board of Telecommunications, namely *indialling*. This means that an external caller who knows the extension's number within the company can dial direct to the extension without the assistance of an operator.

## Grants

*The Telefonaktiebolaget L M Ericsson Foundation for Travel and Other Educational Grants* has awarded 49 grants among 135 applicants, 41 to employees of the Ericsson group and 8 to employees of the Swedish Telecommunications Administration. The total amount of the grants is 48,150 kronor.

# The Ericsson Group

## *Representatives*

Please turn page for list of associated and co-operating enterprises and technical offices

### • EUROPE •

**Austria**
Telecom Handelsgesellschaft m. b. H., *1140 Wien*, Schanzstrasse 33, tel: 72 26 21, tgm: teleric, telex: 116 38

**Belgium**
Allumage Lumière S.A. *Bruxelless 7*, 128-130, chaussée de Mons, tel: 22 98 70, tgm: allumalux, telex: 21582

**Greece**
Angelos Cotzias *Athens*, 39, Odos Acadimias, tel. 626-031, tgm: cotziasan, telex: 252

**Iceland**
Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

**Spain**
TRANSA Transacciones Canarias S.A., *Las Palmas de Gran Canarias*, Tomas Morales 38, tel: 21 85 08, tgm: transa, telex: 08-24

**Yugoslavia**
Merkantile Inozemna zastupstva *Zagreb* pošt pretinac 23, tel: 36941, tgm: merkantile, telex: 21139

### • ASIA •

**Burma**
Myanma Export Import Corp., Import Division (Electrical Stores) *Rangoon*, P.O.B. 403, tel: 146 18, tgm: myanimport

**Cambodia**
Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 23334, tgm: comink

**Cyprus**
Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

**Hong Kong och Macao**
Swedish Trading Co. Ltd. *Hong Kong*, P. O. B. 108, tel: 23 10 91, tgm: swedetrade

**Iran**
Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

**Iraq**
Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 87031, tgm: alhamra

**Japan**
Gadelius & Co. Ltd. *Tokyo C*, P.O.B. 1284, tel. 403-2141, tgm: goticus, telex: 242-2075

**Jordan**
The Arab Trading & Development Co., Ltd. *Amman.*, P.O.B. 1, tel: 25981, tgm: aradeve

**Korea**
Gadelius & Co. Ltd. *Seoul*, I.P.O. Box 1421, tel: 22-9866, tgm: gadeliusco

**Kuwait**
Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakot

**Lebanon**
Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 231624, tgm: skefko

**Malaysia and Brunei**
Swedish Trading Co. (M) Ltd. *Kuala Lumpur*, P.O.B. 2298, tel: 25316, tgm: swedetrade

**Pakistan**
TELEC Electronics & Machinery Ltd. *Karachi 2*, 415, Mehboob Chambers, Victoria Road, tel. 52648, tgm: elco

**Philippines**
U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: 722344

**Saudi Arabia**
Engineering Projects & Products Co. Ltd, Eppco *Riyadh*, P. O. B. 987, tel: Jamhur 271, tgm: eppcol

**Singapore**
Swedish Trading Co. (M) Ltd. *Singapore 1*, P. O. B. 2791, tel: 943 62, tgm: swedetrade

**Syria**
Constantin Georgiades, *Damas*, P.O. B. 2398, tel: 266 73, tgm: georgiades

**Vietnam**
Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, P. O. B. 1049, tel: 22660, tgm: telerad

### • AFRICA •

**Congo**
I.P.T.C. (Congo) Ltd. *Kinshasa 1*, P. O. B. 8922, tel: 5345, tgm: induexpan, telex: RC KIN 52.074

**Ethiopia**
Mosvold Company (Ethiopia) Ltd. *Addis Abeba*, P.O.B. 1371, tel: 14567, tgm: mosvold

**Ghana**
R.T. Briscoe Ltd, *Accra*, P.O.B. 1635, tel: 669 03, tgm: Briscoe, telex: 295

**Kenya, Tanzania, Uganda**
Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

**Liberia**
Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Streets, tel: 22222, tgm: radiolibe

**Libya**
ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 33906, tgm: adeco

**Mauritius**
Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

**Mozambique**
J. Martins Marques & Ca. Lda. *Lorenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

**Nigeria**
I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult, telex: shell bp 35

**Sudan**
Contomichalos, Sons & Co. Ltd. Engineering & Agencies Dept., *Khartoum*, P.O.B. 866, tel: 77 695, tgm: suconta, telex: 251

**South Africa, South-West Africa**
Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

**Tunisia**
Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

### • AMERICA •

**Bahama Islands**
Anglo American Electrical Company Ltd. *Freeport, Grand Bahama*, P.O.B. 104

**Bolivia**
Johansson & Cia, S. A. *La Paz*, Casilla 678, tel: 25 923, tgm: johansson

**Costa Rica**
Tropical Commission Co. Ltd. *San José*, Apartado 661, tel.: 22 55 11, tgm: troco, telex: CR-125

**Dominican Republic**
Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3445, tgm: gartier

**Guatemala**
Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira

**Guiana**
General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwlks

**Honduras**
Quinchón Leon y Cia *Tegucigalpa*, Apartado 85, tel: 2-5171, tgm: quinchon

**Jamaica and Brit. Honduras**
Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

**Netherlands Antilles**
S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao* P.O.B. 304, tel: 11200, 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, telex: PA 134.

**Paraguay**
S. A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

**El Salvador**
Dada-Dada & Co. *San Salvador* Apartado 274, tel: 21 66 66, 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, N.Y 10003*, 215 Park Avenue South, tel: (212) 677-8400, tgm: statelabs, telex: (212) 867-6996 (For electron tubes)

### • AUSTRALIA & OCEANIA •

**New Zealand**
ASEA Electric (NZ) Ltd. *Wellington C. 1.*, P.O.B. 3239, tel: 70-614 tgm: asea, telex: NZ 3431

# The Ericsson Group

## *Associated and co-operating enterprises and technical offices*

Please turn page for list of further sales offices

### • EUROPE •

**Denmark**

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson, telex: 9020 ericsson kh

Telefon Fabrik Automatic A/S *Søborg*, Telefonvej 6, tel: 69 51 88, tgm: automatic, telex: 5264

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

A/S Tele-Center *Glostrup*, Sandager 8, tel: 96 18 88

**Finland**

O/Y L M Ericsson A/B *Helsingfors*, P. O. B. 13018, tel: A 8282 tgm: ericssons, telex: 12—546

**France**

Société Française des Téléphones Ericsson *F-92-Colombes*, 36, Boulevard de la Finlande, tel: Paris (1) 242 35 00, tgm: ericsson colombes, telex: 62179 *F-75-Paris (17e)*, 147, rue de Courcelles, tel: Paris (1) 227 9530, tgm: eric paris

Centrum Electronic S. A. *Paris 17e* 32, Rue Legendre, tel: 267 30.10, tgm: centrumfrance

**Great Britain**

Swedish Ericsson Company Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Production Control (Ericsson) Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Centrum Electronics Ltd. *London S.W.I.*, tel: SLOane 0451, tgm: celefon telex: 26 13 81

**Ireland**

L M Ericsson Ltd. *Dublin 2*, 32, Upper Mount Street, tel: 61931, tgm: ericsson, telex: 5310

**Italy**

FATME, Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 4694, tgm: fatme, telex: 61.327 fatme

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

SIELTE, Soc. per Az. *00100 Roma*, C. P. 5100, tel: 577 8041, tgm: sielte

**Netherlands**

Ericsson Telefoonmaatschappij, N.V. *Rijen (N.Br.)*, tel: 01692-3131, tgm: erictel, telex: 54114

*Voorburg-Den Haag*, P.O.B. 3060, tel: 81 45 01, tgm: erictel-haag, telex: 311 09

**Norway**

A/S Elektrisk Bureau *Oslo 3*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 1723

A/S Industrikontroll *Oslo 6*, Grenseveijen 86/88, tel: Centralbord 68 34 64 tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.B. 500, tel: 83 76 50, tgm: kabel

A/S Norsk Signalindustri *Oslo 3*, P.B. 5055, tel: 46 18 20, tgm: signalindustri

A/S Tele-Systemer *Oslo 6*, Plogveien 3 B, tel: 68 62 95, tgm: gyllingsystem

**Portugal**

Sociedade Ericsson de Portugal Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 571 93, tgm: ericsson

**Spain**

Cia Española Ericsson, S. A. *Madrid 13*, Torre de Madrid, Plaza de España tel: 241 14 00, tgm: ericsson, telex: 7369

**Sweden**

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 08/19 00 00, tgm: telefonbolaget, telex: 199 10

AB Alpha *Sundbyberg*, tel: 08/28 26 00, tgm: aktiealpha telex: 10082

Casa Konsult AB *Älvsjö*, Huddingevägen 417—19, tel: 08/47 25 65, tgm: casakonsult

AB Ermi *Karlskrona 1*, tel: 0455/230 10, tgm: ermibolag

AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308 stockholm

AB Svenska Elektronrör *Stockholm-Tyresö 1*, tel: 08/712 01 20, tgm: electronics, telex: 1275

Instruktionsteknik AB, *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

L M Ericsson Data AB *Solna*, tel: 08/83 07 00, tgm: ericdata

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 08/68 07 00, tgm: signalbolaget

L M Ericsson Telemateriel AB, *Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00 tgm: ellem, telex: 1275

Sieverts Kabelverk AB *Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676

Svenska Radioaktiebolaget *Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio, telex: 10094

**Switzerland**

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *8032 Zurich*, Postfach, tel: 325184, tgm: telericsson, telex: 52669

**Turkey**

Ericsson Türk Ticaret Ltd. Sirketi *Ankara*, Rumeli Han, Ziya Gökalp Cda., tel: 123170, tgm: ellem

*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02 tgm: ellemist

*Izmir*, Izmir Bürosu, Kisilkaya Han, Kat 3. No 13, Halit Ziya Bulvari, tel: 378 32, tgm: ellemir

**West Germany**

Deutsche Ericsson G.m.b.H. Telematerial, *4 Düsselorf-Rath*, Postfach 136, tel: (0211) 63 30 31, tgm: erictel, telex: DSSD 8586871

Centrum Electronic Handels-GmbH, *3 Hannover*, Dornierstrasse 10, tel: 63 10 18, tgm: centronic, telex: 0922913

### • ASIA •

**Hong Kong**

Telefonaktiebolaget L M Ericsson Technical office *Hong Kong*, 1516 Union House, tel: 23 10 91, tgm: elleme

**India**

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: 45 44 94, tgm: inderic

*New Delhi 16*, L25, South Extension Part II, tel: 76505 tgm: inderic

**Indonesia**

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151—153, tel: 8294, tgm: javeric

*Djakarta*, Djalan Gunung Sahari 26, tel: OG 48531, tgm: javeric

**Iraq**

Telefonaktiebolaget L M Ericsson, Technical office *Baghdad*, P.O.B. 493, tel: 914 54, tgm: ellemco

**Kuwait**

Telefonaktiebolaget L M Ericsson, Technical office, *Kuwait, State of Kuwait*, P. O. B. 5997, tel: 25 151, tgm: erictel

**Lebanon**

Telefonaktiebolaget LM Ericsson, Technical office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, tgm: ellem

**Thailand**

Ericsson Telephone Corp. Far East AB *Bangkok*, P.O.B. 824, tel: 55511-2, tgm: ericsson

### • AFRICA •

**Egypt (UAR)**

Telefonaktiebolaget LM Ericsson, Technical office Egypt Branch *Cairo*, P.O.B. 2084, tel: 46581, tgm: elleme

**Morocco**

Société Marocaine des Téléphones Ericsson *Casablanca*, 38, rue Mohamed Sedki, tel: 788-75, tgm: ericsson

**Rhodesia, Botswana and Malawi**

Ericsson Telephone Sales Corporation AB, *Salisbury, Rhodesia*, P.O.B. 2891, tel: 25 737, tgm: ericofon

**Tunisia**

Telefonaktiebolaget LM Ericsson, Technical office, *Tunis*, Boîte Postale 780, tel: 240520, tgm: ericsson

**Zambia**

Ericsson Telephone Sales Corporation AB *Ndola*, P. O. B. 2256, tel: 3885, tgm: ericofon

### • AMERICA •

**Argentine**

Cia Ericsson S.A.C.I. *Buenos Aires* Casilla de Correo 3550, tel: 332071, tgm: ericsson

Cia Argentina de Teléfonos S. A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel

Cia Entrerriana de Teléfonos S. A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel

Industrias Eléctricas de Quilmes S. A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenos-aires

**Brazil**

Ericsson do Brazil Comércio e Indústria S. A. *Rio de Janeiro* C. P. 3601-ZC-00, tel: 43-0990, tgm: ericsson, telex: rio 310

**Canada**

L M Ericsson Ltd. *Montreal 9. P.Q.*, 2300 Laurentian Boulevard City of St. Laurent, tel: 331-3310, tgm: caneric, telex: 1-2307

Gylling Canada Ltd. *Montreal*, 1203, IBM Building, 5, Place Ville Marie

**Chile**

Cia Ericsson de Chile S. A. *Santiago*, Casilla 10143, tel: 82555, tgm: ericsson

**Colombia**

Cia Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 411100, tgm: ericsson

**Costa Rica**

Telefonaktiebolaget L M Ericsson, Technical office *San José*, Apartado L. M. E., tel: 21 14 66, 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. *Mexico D. F.*, Apartado 9958, tel: 464640, tgm: coeric

Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado 25737, tel. 49 36 50, tgm: latincasa

Teleindustria, S. A. de C.V. *Mexico I, D.F.* apartado 1062, tel: 464640, tgm: ericsson, telex: 017:7485

Telemontaje, S. A. de C. V. *Mexico 1, D.F.*, Apartado Postal 1062, tel: 46 78 11, tgm: ericssonmexicodf, telex: 017-7485

**Peru**

Cia Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson, telex: 3540202

Soc. Telefonica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060, tgm: telefonica

**El Salvador**

Telefonaktiebolaget LM Ericsson, Technical office *San Salvador*, Apartado 188, tel: 21-7640, tgm: ericsson

**Uruguay**

Cia Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

**USA**

The Ericsson Corporation *New York, N.Y. 10017*, 100 Park Avenue, tel: 68 54 030, tgm: erictel, telex: erictel 620484

L M Ericsson Centrum Inc. *New York, N. Y. 10016*, 16, East 40 Street, tel: 6791001, tgm: erictel, telex: 620149

North Electric Co. *Galion, Ohio 44833*, P.O.B. 688, tel: (419-)468—2420, tgm: northphone-galion-ohio, telex: 098-728

**Venezuela**

Cia Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson, telex: 734

### • AUSTRALIA & OCEANIA •

**Australia**

L M Ericsson Pty. Ltd. *Broadmeadows, Victoria*, P.O.B. 41, tel: 309 2244 tgm: ericmel, telex: AA 30555

*Sydney N.S.W.*, 134 Barcom Avenue, Rushcutters Bay, tel: 31 09 41, tgm: ericsyd

Teleric Pty. Ltd *Broadmeadows, Victoria* P.O.B. 41, tel: 309 2244, tgm: teleric, telex: AA 30555

*Sydney N.S.W.*, 134 Bacrom Avenue, Rushcutters Bay, tel: 31 09 41, tgm: teleric

ESSELTE AB, STHLM 67

# ERICSSON Review

3

1967

# ERICSSON REVIEW

Vol. 44 No. 3 1967

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

## CONTENTS



On cover: The manual switchroom at ASEA's head office, Västerås, where a PABX type AKD 791 has recently been installed.

# DIALOG with Microphone Amplifier and Tone Ringing

H. WANGENSTEEN & T. WESSEL, A/S ELEKTRISK BUREAU, OSLO

UDC 621.382.3
621.395.721
LME 822

*In 1964 L M Ericsson introduced on the world market a new telephone set—the Dialog—with improved transmission characteristics and mechanically designed on a, in many ways, revolutionary principle. This design principle was based on many years of experience of the practical maintenance of telephone sets and was also intended to facilitate the introduction of the improvements in design that were expected as a result of the rapid development both of new components and new methods of production. The design philosophy underlying the Dialog has also stood the test in practice.*

Despite the satisfactory reception on the world market accorded to the Dialog in its original form, development work on the set continued in order that telephone administrations and subscribers might as soon as possible benefit by the improvements made possible by technical developments, including those in the semiconductor field. The mechanical design of the original Dialog, through a favourable combination of new electroacoustic converters and electronic circuitry, led on to the "electronic variant" of the Dialog which L M Ericsson can today present as its first commercial automatic telephone set of this type. The set was developed by A/S Elektrisk Bureau, Norway, in cooperation with the Norwegian PTT, which has also introduced the instrument as standard telephone set in the Norwegian network as from 1967.

A/S Elektrisk Bureau has a long tradition in the development and design of telephone sets, dating back almost to the foundation of the firm in 1882.

The work which has led to the transistorized telephone set started at the end of the forties when the first transistors were marketed, but the price and quality of transistors at that time did not permit realistic solutions. In 1955, however, A/S Elektrisk Bureau were able to present their first model of a dial telephone with electrodynamic microphone, transistor amplifier and tone ringing. In the following years this model was further improved in step with the rapid development taking place in the semiconductor field, especially in respect of transistors. In 1960 a trial series of 300 transistor telephone sets was delivered to the Norwegian PTT, which was thus able to investigate subscriber reactions to the new type of set and to test its technical properties in practical use, especially in respect of reliability and maintenance requirement.

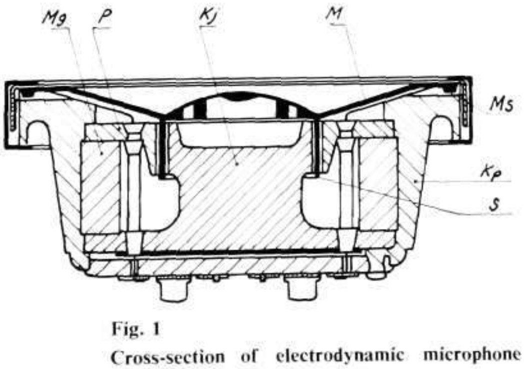



**Fig. 1**
**Cross-section of electrodynamic microphone**

The results of these tests were so positive that the PTT, when an entirely new telephone set was to be introduced, specified an electrodynamic microphone (corresponding to the receiver inset which the PTT was already using and wished to continue to use) and that this microphone should be used as sound source for the ringing signal. The advantages expected to be gained were both economic (reduced maintenance as a result of the disappearance of the carbon microphone, possible saving on the cable network as a result of the great transmitting efficiency of the telephone set) and technical (better

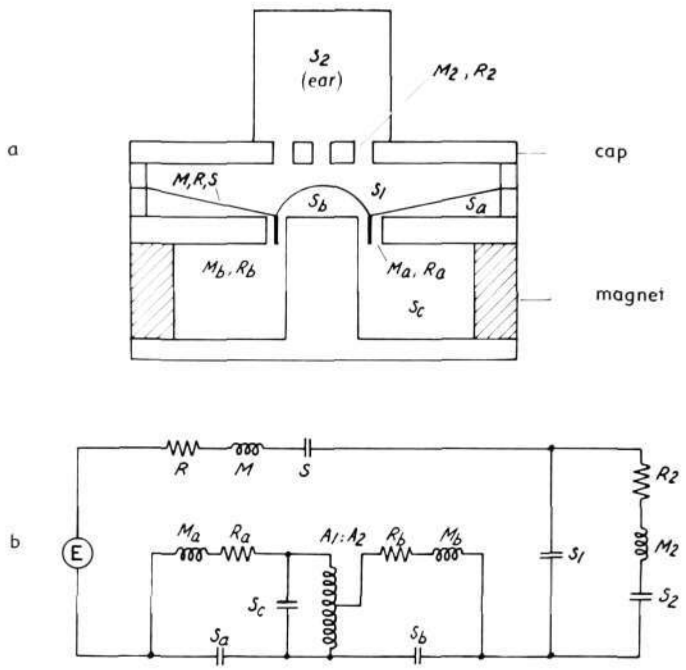



**Fig. 2**
**Equivalent diagram for electrodynamic microphone used as receiver**

and more stable quality of transmission). It was thought that these advantages would justify the price difference between the new transistor set and the more traditional telephone sets available on the market.

It seems clear that the replacement of the carbon microphone in a telephone set by an electrodynamic microphone with amplifier will, for the present at least, increase the production price. Nor is the higher price entirely counterbalanced by the possibility of replacing the bell in the set by a new signalling device. The price difference which at present exists between the new telephone set and conventional sets must therefore be weighed against the advantages offered by the new set, especially in respect of maintenance and quality of transmission.

## Electrical and Acoustical Properties of the Telephone Set

### *Electroacoustical converter*

As already mentioned, an electrodynamic converter is used both as microphone and receiver. The two insets are alike, whereas the mouthpiece and receiver cap with their systems of perforations are differently formed. In the design of the mouthpiece, attention has also been paid to the fact that the microphone must be a sound generator for the ringing signal.

A cross-section through the electrodynamic microphone is shown in fig. 1. The magnetic system consisting of an annular magnet *Mg* (of AlNiCo), the core *Kj* and the annular pole piece *P* (both of mild steel) are fitted together at the time of moulding into the plastic cup *Kp*, which is also formed with a diaphragm seating *Ms* having a guiding edge satisfactorily concentrical with the air gap. The diaphragm *M* is of plastic with moulded-in coil *S* and with a guiding edge which is satisfactorily concentrical with the coil and corresponds to the guiding edge in the plastic cup *Kp*. Between the cylindrical part of the upper surface of the pole piece and the part of the diaphragm in the air gap there is a layer of air 0.15 mm thick. The mass $M_a$ and the damping resistance $R_a$ of this air layer have an important role in the acoustical

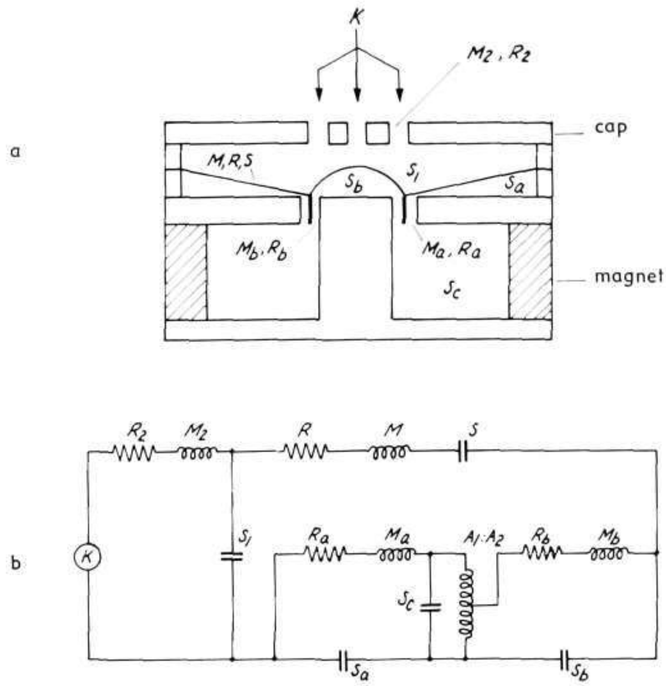



**Fig. 3**
**Equivalent diagram for electrodynamic inset used as microphone cap**

system of the microphone, the equivalent diagram of which is shown in fig. 2. This diagram applies to the microphone used as receiver. An analogous diagram for the inset used as microphone is shown in fig. 3. The mass $M_a$ and damping resistance $R_a$ are coupled together, via the hollow space with stiffness $S_a$, with the stiffness, mass and damping of the diaphragm. This produces a heavily damped system of coupled oscillating circuits which, when suitably dimensioned, yield the approximately linear course of the sound pressure curve aimed at in modern receivers (cf. fig. 4). For $M_a$ and $R_a$, both referred to the effective area $A$ of the diaphragm, the following expression may be set up:

$$M_a = A^2 \cdot \frac{6}{5} \varrho \cdot \frac{l}{\pi d \Delta}$$

$$R_a = A^2 \, 12\mu \cdot \frac{l}{\pi d \Delta^3}$$

where $\Delta$ is the thickness of the air layer (0.015 cm), $l$ the length of the air gap and $d$ the diameter of the air layer. With c.g.s. units $\mu$ becomes $1.84 \cdot 10^{-4}$ and $\varrho$ $1.2 \cdot 10^{-3}$. The formulae show that undesirable variations in $\Delta$ have a strong influence on $M_a$, and more so on $R_a$, and thus affect the course both of the sound pressure curve (fig. 4) and of the microphone response (fig. 5). The strict requirements which must be placed on a satisfactory value of $\Delta$, however, can be fulfilled by means of the technological methods which are used; this applies especially to the moulding of the coil into the diaphragm.

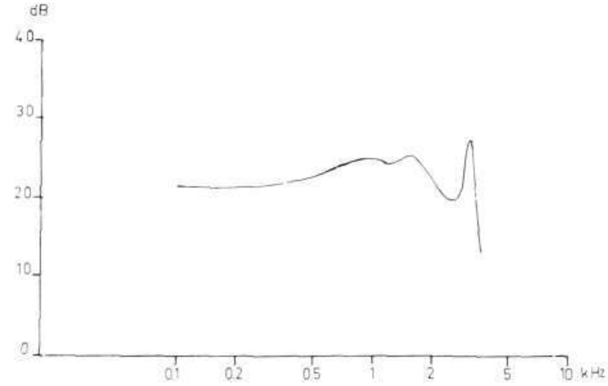



**Fig. 4**
**Frequency response of receiver**
Sound pressure $P_H$ in 6 $cm^3$ artificial ear at 1 mW power applied to the inset

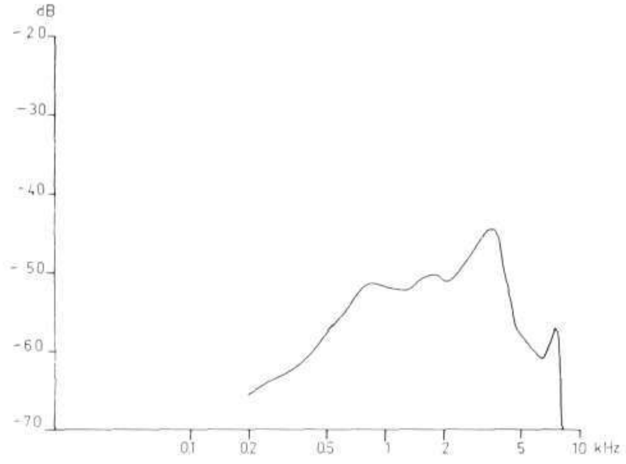



**Fig. 5**
**Microphone response**

**Open circuit voltage $E_i$ at constant sound pressure 1 N/m² in front of the microphone $E_i$ in db relative to 1 V**

The impedance diagram (fig. 6) for the inset loaded with an artificial ear of 6 cm³ volume shows a rather larger inductance than is otherwise usual in dynamic insets (but far less than for electromagnetic insets). In the *ringing position* the inductance of the inset forms a frequency-determining element in the voice frequency oscillator (see "Ringing signal").

## *Diagram of Telephone Set in Speaking Position*

The use of the electrodynamic inset is motivated partly by its simple, robust and reliable construction and partly by its electroacoustic characteristics, namely that it appears to be as well adapted as microphone as it is as receiver and that its impedance varies little with the frequency. As regards the sensitivity, this appears from fig. 4 to be about 3 db below the sensitivity for a modern balanced electromagnetic inset. This is of little consequence, however, in a telephone set which is presumed to contain a microphone amplifier of which the gain can be freely chosen within certain limits, since there is then reason to dimension the antisidetone coupling in such a way that the com-

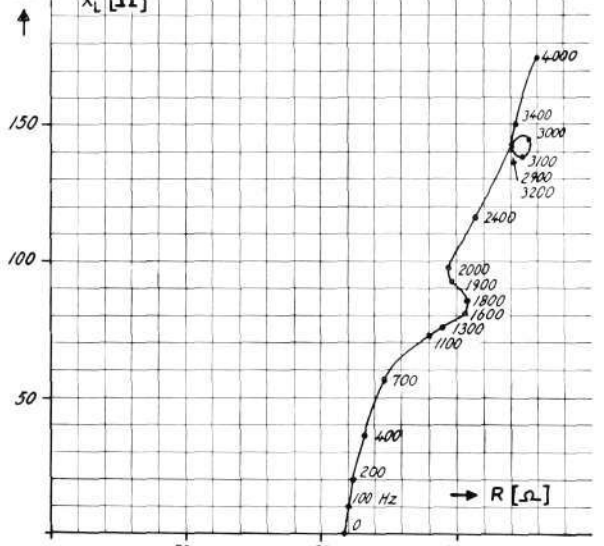



**Fig. 6**
**Impedance of electrodynamic inset with 6 cm³ artificial ear as acoustic load**

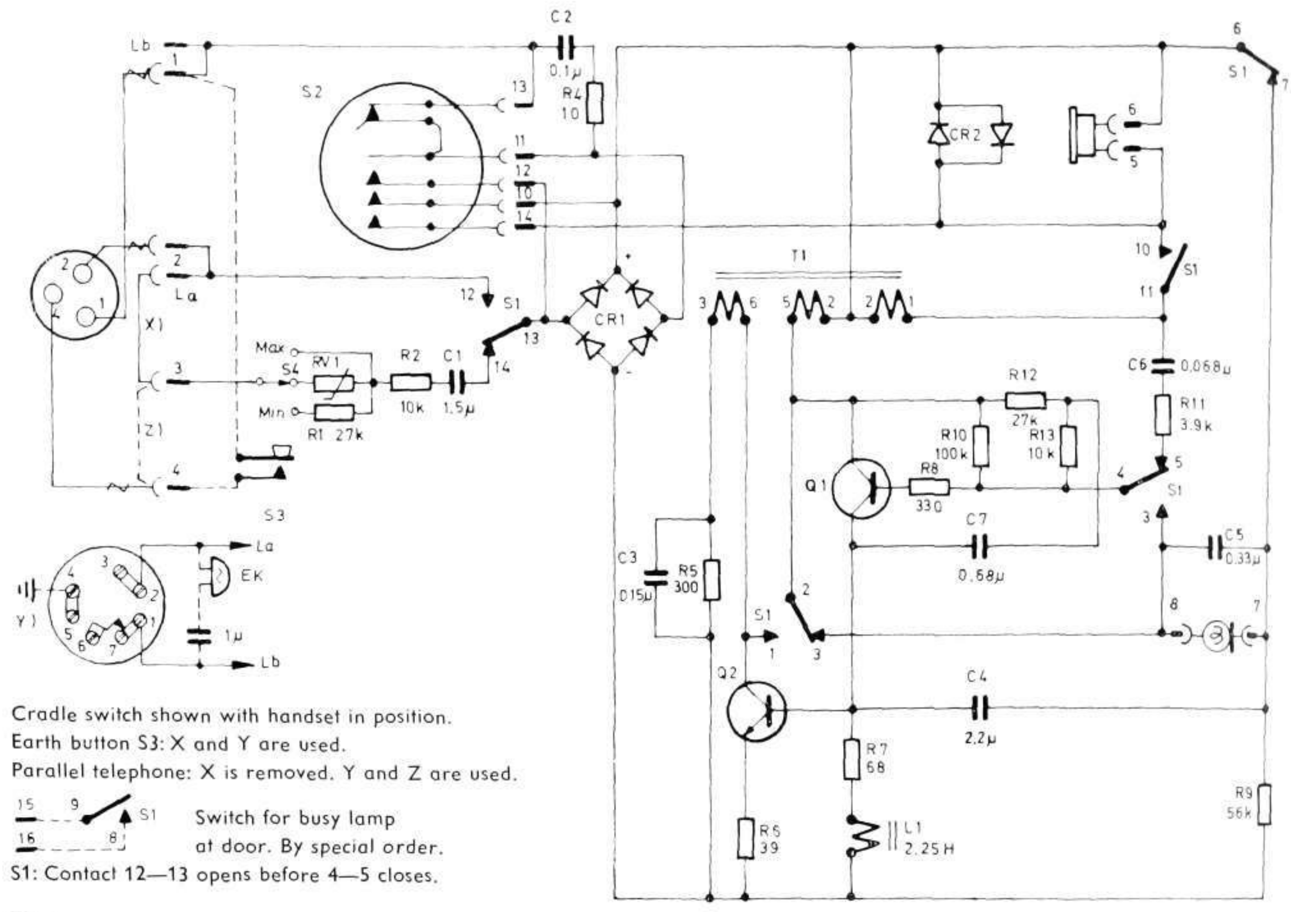



**Fig. 7**
**Diagram of telephone set with handset in position**

posite receiving attenuation is low. In the present case it is about 2 db at 1000 Hz. The composite sending attenuation will then, understandably, be fairly large (about 5 db at 1000 Hz), but this can be compensated by suitable adjustment of the microphone gain. Since the composite receiving attenuation is very low, the variations in the receiver impedance will affect the telephone set impedance fairly greatly. As the latter should not vary too much, it is an advantage to use an electrodynamic receiver of which the impedance varies little with the frequency.

The complete diagram of the telephone set is shown in fig. 7. For the sake of clarity the diagram in *speaking position* is shown in fig. 8.

The microphone *MK1*, as will be seen, is connected to a 2-stage, directly coupled common emitter/common collector amplifier, the output terminal of which forms the mid-branch in a balanced bridge coupling. One side-branch of the bridge consists of the winding 2–5 of transformer *T1* in series with the line which is connected through the rectifier bridge *CR1*. Another side-branch of the bridge consists of winding 3–6 of the same transformer in series with a balancing network consisting of resistor *R5* and capacitor *C3* in parallel. As a result of the low sensitivity of the microphone and because the antisidetone coupling is intentionally dimensioned for a high composite sending attenuation, a power gain of about 52 db is necessary.

A receiver capacitor is not needed since the receiver branch does not carry direct current. The receiver is connected across winding 1—2 of transformer *T1*.

Stabilization of the working point for transistor *Q1* takes place in a conventional way with the aid of the emitter resistor *R7* and a voltage divider

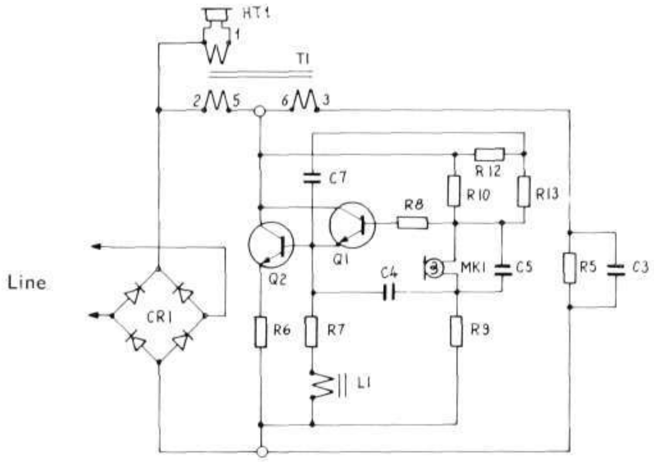
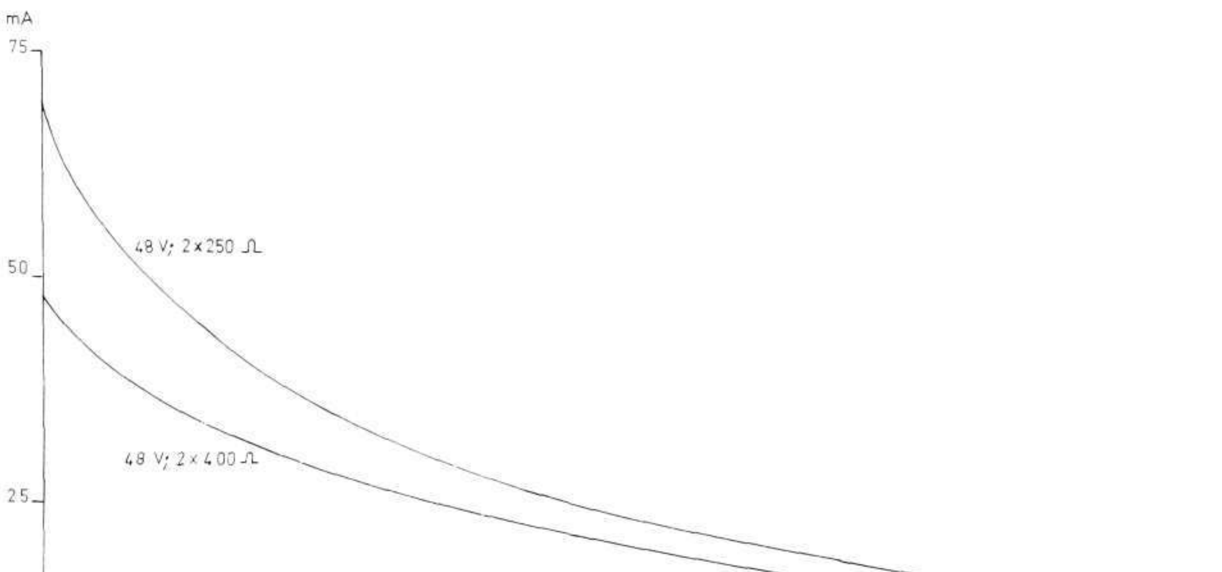



**Fig. 8**
**Diagram of telephone set in speaking position**

consisting of resistors *R9*, *R13* and *R12*. Capacitor *C7* is a decoupling capacitor. When the working point for transistor *Q1* is stabilized, the working point for *Q2* is also stabilized since the voltage drop across *R7* is equal to the sum of the voltage drop across *R6* and the emitter/base voltage of *Q2*, which varies little. Resistor *R10* gives the desired degree of negative feedback and contributes to stabilization of the sending level of the telephone set at various lengths of line and feed currents. As will be seen from fig. 9, the DC power supplied to the telephone set, when the line resistance varies between 0 and 2000 ohms and the supply system is 48 V, 2 × 250 ohms, varies between 715 mW and 81 mW, i.e. by 9 db. The corresponding variation in the sending level of the telephone is about 1 db. The feed loss, as known from earlier types of telephone set with carbon granule microphone, is in other words practically eliminated, which allows both an increased range and a reduction of the cable cross-section. By changing the resistance of *R10*, moreover, a minor adjustment of the sending level of the telephone can be fairly easily obtained when experience of practical operation with this type of instrument indicates that this is desirable.

**Fig. 9**
**Line current as function of line resistance**



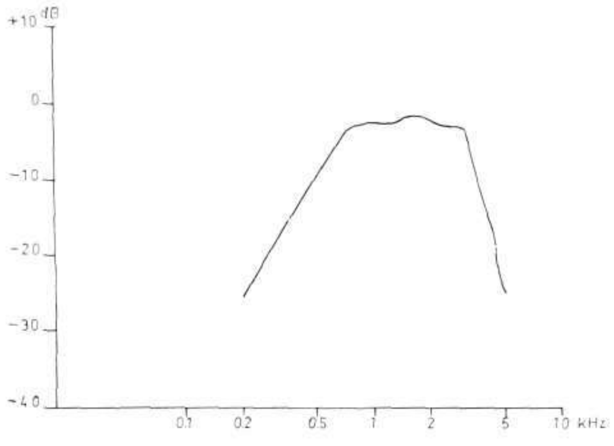



Fig. 10

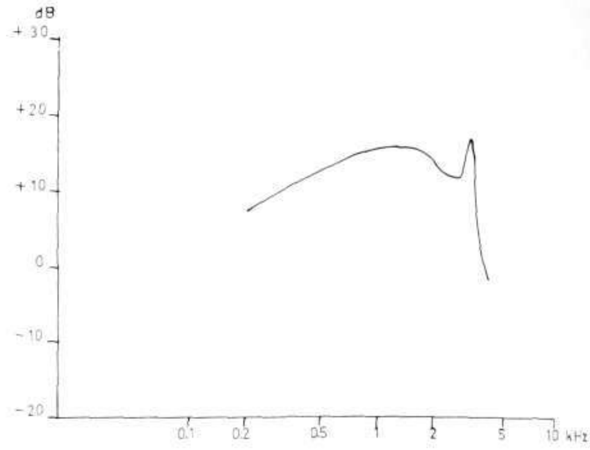



Fig. 11

**Fig. 10**
**Frequency response, sending**
**db relative to 1 V per N/m² (600 Ω load)**

**Fig. 11**
**Frequency response, receiving**
**db relative to 1 N/m² per V e.m.f. (600 Ω)**

## *Transmission Characteristics of the Telephone Set*

Figs. 10–17 illustrate graphically the essential transmission characteristics of the set. In fig. 10 the voltage $U_L$ is shown across a 600-ohm telephone set load as function of the frequency at constant sound pressure in front of the microphone. In a 48 V, 2 × 250-ohm supply system this curve has practically *the same* course for a 0 as for a 2000 ohm line, since the feed loss, as already noted, does not exceed 1 db. The curve may be said to have a favourable course but deviates somewhat from the microphone response (fig. 5) owing to the effect of the frequency characteristic of the microphone amplifier.

Fig. 11 shows the sound pressure $P_H$ in a 6 cm³ artificial ear as function of the frequency when the telephone set is assumed to be connected to a 1 V, 600-ohm generator.

The curve rises slightly more with the frequency than the sound pressure curve in fig. 4 since the voltage across the receiver rises. Fig. 12 shows the distortion factor as function of the line resistance when the sound pressure in front of the microphone is assumed to be so adjusted that the telephone set delivers a power of 1 mW at 1000 Hz to a 750-ohm bias resistor. As is seen, the distortion level is very low, and not until 2000 ohms line resistance does the distortion factor come up to about 10 %. The advantage of using the combination of dynamic microphone and linear amplifier instead of a carbon microphone in a very noisy environment should be well known.


**Fig. 12**
**Distortion factor at 1 mW, 1000 Hz, power output as function of line resistance at 48 V, 2 × 250 Ω supply**

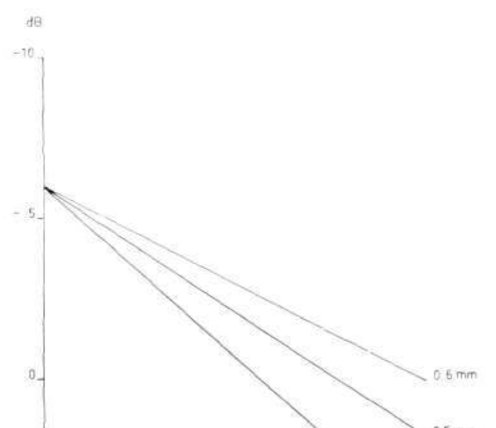
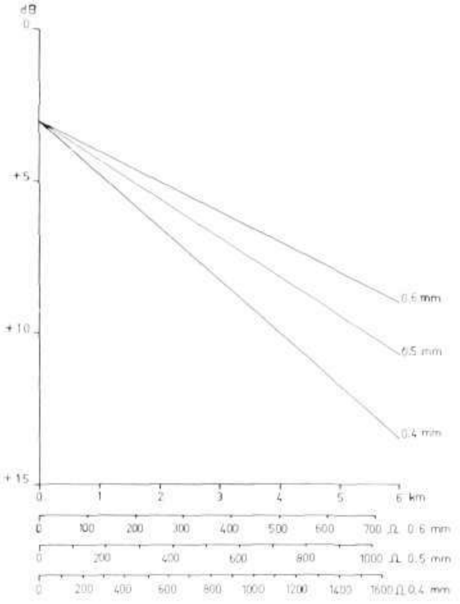



**Fig. 13**
**Receiving reference equivalent**
**MRE in db**

Fig. 14
Sending reference equivalent
SRE in db




Figs. 13 and 14 show the result of speech transmission measurements on the instrument. Fig. 13 shows the receiving reference equivalent relative to NOSFER (including attenuation in cable of up to 6 km length). The point of intersection of the curves with the vertical axis represents the receiving reference equivalent (MRE) for the telephone set alone. Fig. 14 shows the corresponding curves for sending. In this case the point of intersection of the curves with the vertical axis represents the SRE for the telephone set alone. SRE and MRE were adjusted in accordance with the desires of the Norwegian PTT. In this connection attention was paid also to the stability and sidetone of the instrument. The capacitor *C* in the balancing network has the function of balancing out the capacity component introduced into the telephone set load by the capacity of the cable. A perfect balance could not be attained since the telephone set load varies greatly with, among other factors, the length and cross-section of the cable. *C* must therefore be so dimensioned that, as far as possible, there is no disturbing sidetone in any of the cases which occur in practice.

Fig. 15 shows SIRE, i.e. the sidetone reference equivalent relative to NOSFER, for different cables terminated with 600 ohms. Use of the instrument in practice confirms that the sidetone is of reasonable magnitude.

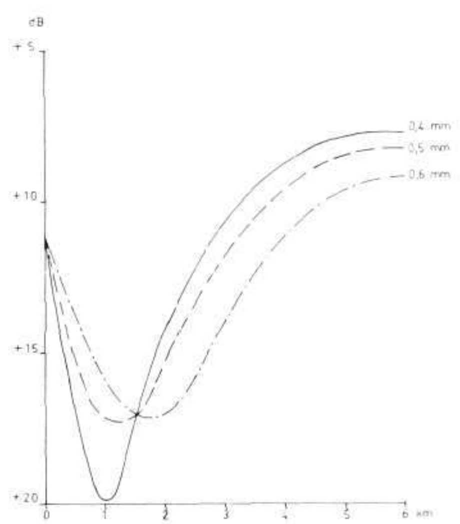



Fig. 15
Sidetone reference equivalent
SIRE in db

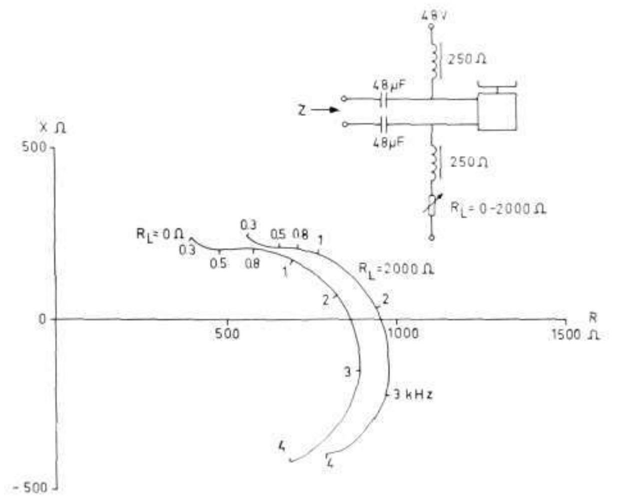



Fig. 16

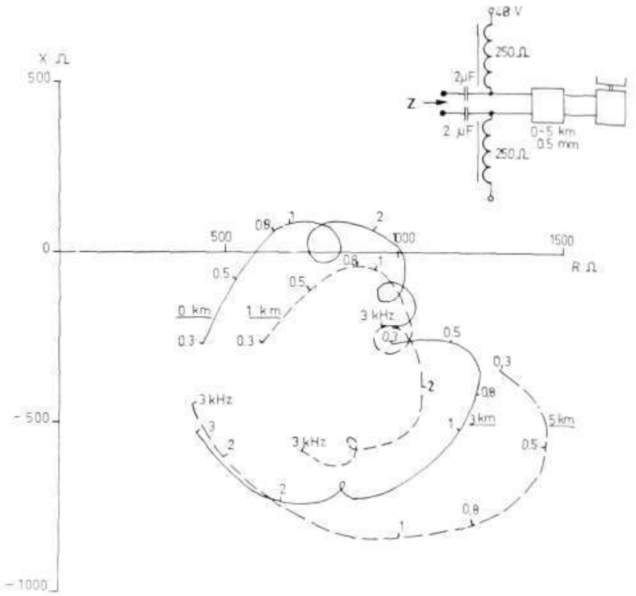



Fig. 17

**Fig. 16**
**Telephone set impedance at 0 and 2000 Ω line resistance**

**Fig. 17**
**Impedance of the local system as function of length of 0.5 mm cable**

Fig. 16 shows the impedance of the telephone set as function of the frequency at 0 and 2000 ohms line resistance in a 48 V, 2 × 250-ohm supply system and fig. 17 the impedance of the local system as function of the length of cable (0.5 mm).

## *Ringing Signal*

As already mentioned, the instrument has no bell. The acoustic ringing signal is instead sent from the microphone which, in the ringing position of the instrument, is connected to a 2500 Hz oscillator (fig. 18). This oscillator is produced through the fact that the cradle switch switches over the microphone amplifier. The voltage for operation of the oscillator is obtained by rectification in *CR1* of the 25 Hz ringing voltage which enters from the line. The rectified voltage is taken out across capacitor *C4* which, together with the choke *L1*, forms a low-pass filter for the voltage from the rectifier. Transistor *Q1* is the active element in the oscillator, whereas *Q2* does not participate in the oscillator function even if it is not entirely disconnected. The oscillating circuit, consisting of the inductive microphone inset *MK1* in parallel with the capacitor *C5*, is connected to winding 2–5 of the transformer, whereas the receiver winding ensures feedback to base through capacitor *C6* in series with resistor *R11*. The frequency of the tone is determined in the first place by the oscillating circuit, but is also influenced to some extent by *C6*, *R11* and *C4*.

The strength of the ringing signal can be regulated in two stages: loud and faint. In the first case, as will be seen from fig. 7, only resistor *R2* is connected in series with the rectifier, in the latter case both *R1* and *R2*.

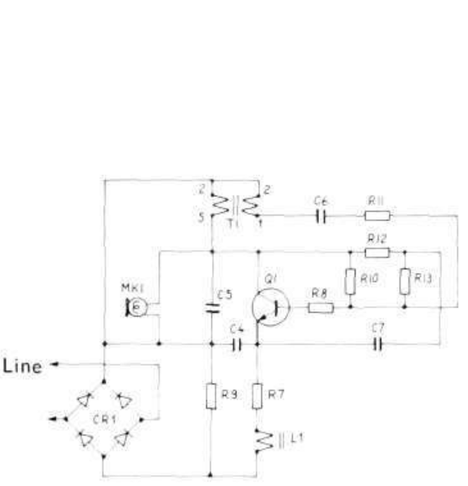



**Fig. 18**
**Diagram of telephone set in ringing position**

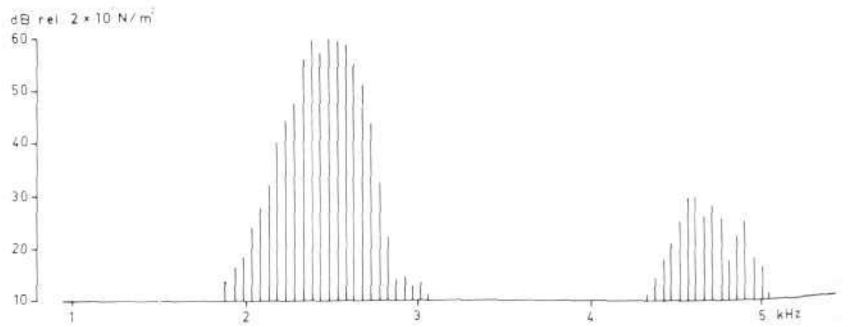



**Fig. 19**
**Spectrogram for voice frequency ringing signal 75 V, 25 Hz, 1 metre distance**

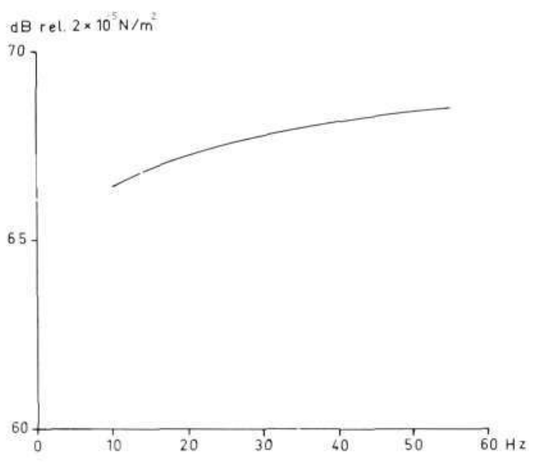



Fig. 20

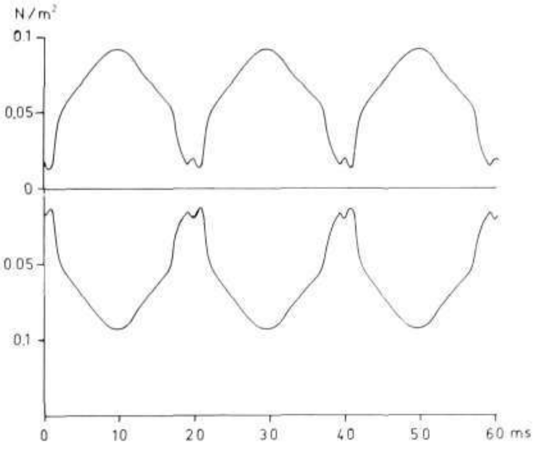



Fig. 21

**Fig. 20**
**Sound pressure as function of frequency**
1 m distance

**Fig. 21**
**Sound pressure level from microphone during ringing signal**
1 m distance

**Fig. 22**
**Sound pressure as function of distance**

**Fig. 23**
**Ringing signal current and voltage**

The varistor *RV1* in series with resistor *R2* provides a third possibility for adjustment of the ringing signal. The function of the varistor corresponds in this case to that of the bias spring in telephone sets with a bell, whereas *RV1* does not greatly affect the voice frequency ringing signal as long as the ringing voltage from the line is high, but owing to its non-linear characteristic it prevents a low alternating voltage from activating the oscillator. A voltage of this kind may occur, for example, on dialling from a parallel-connected telephone set. Fig. 19 shows a spectrogram of the voice frequency ringing signal.

Fig. 20 shows the levels for the ringing signal as function of the frequency and fig. 21 the sound pressure level from the microphone.

Fig. 22 shows the levels for the ringing signal as function of distance and fig. 23 the ringing signal current and voltage.

Fig. 22

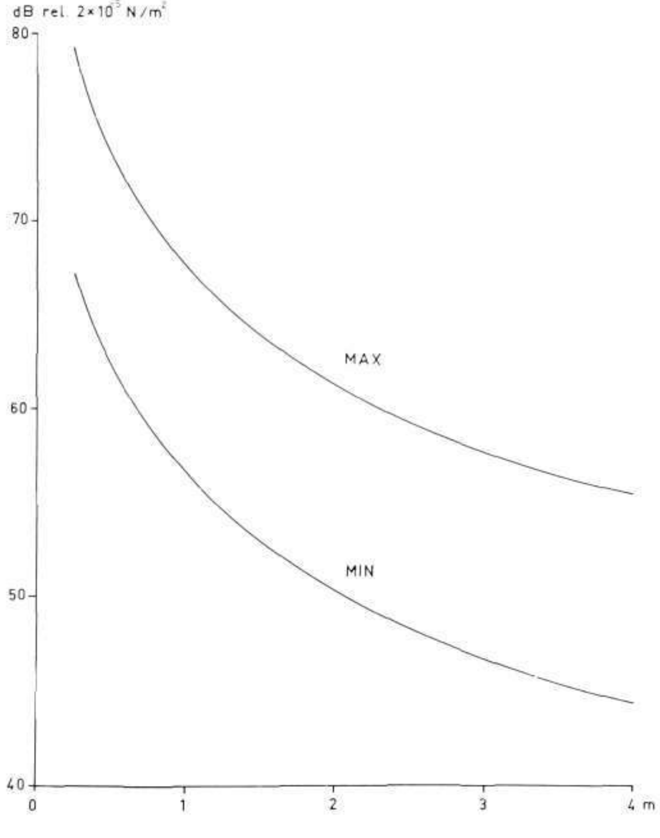
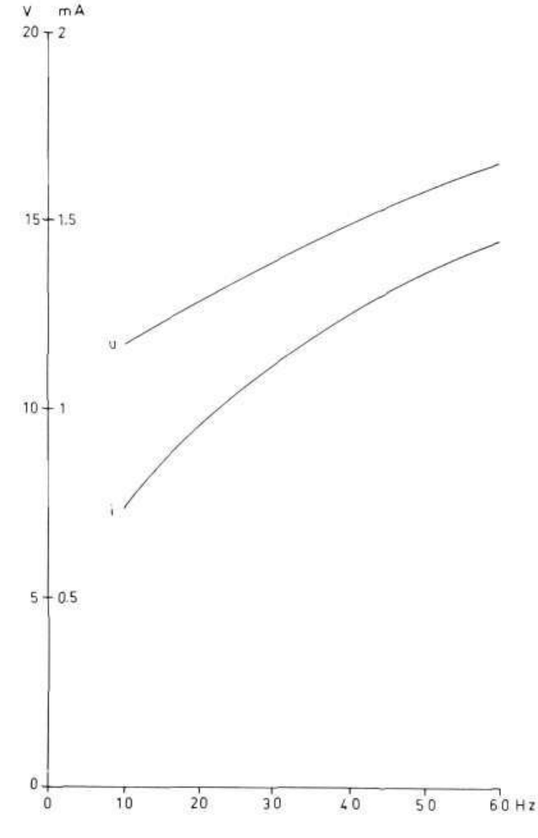



Fig. 23



# Mechanical Design of the Telephone Set

The telephone set is shown in fig. 24. Its external design is similar in its main features to that of the Dialog but the handset has slightly different dimensions. Fig. 25 shows the set with the major units dismantled and fig. 26 a section of the internal mechanism with, among other parts, the cradle-switch arrangement with springsets, components and cord terminals.

The base plate has bent up edges and a coined centre portion and forms a rigid construction even with the relatively thin sheet material. The base plate, as well as other parts, are of galvanized steel with a yellow chromate coating, which provides a very good protection against corrosion.

The material for the four pedestals of the telephone set is EVA (ethylene vinyl acetate). EVA is characterized by being little affected by chemicals, has no tendency to discolouring of light-coloured polished table surfaces, and is simple to produce.

On the printed circuit card is a frame, attached by a catch, which, in addition to carrying the cradle switch with its attachment, also serves to secure the complete printed circuit card to the base plate. The printed circuit card is locked to the base plate when the dial with its brackets is placed in position. Fitting of the printed circuit card and dial in the instrument can thus be done without any tool.

The cradle switch is shown in fig. 26 and consists of two vertically positioned springsets attached to a common mounting plate. Both springsets are operated by means of a lifting comb from a cradle carried in nylon bearings at the top of the frame. The cradle is held in position by a spring when the handset is raised. The springset is protected against dust by a common transparent plastic capsule.

The printed circuit card also carries a pole changer for regulation of the volume of the ringing tone. The pole changer is of simple construction but has silver contacts and can be adjusted from the underside of the instrument with a regulator projecting through a groove in the base plate.

**Fig. 24**
**The Dialog**

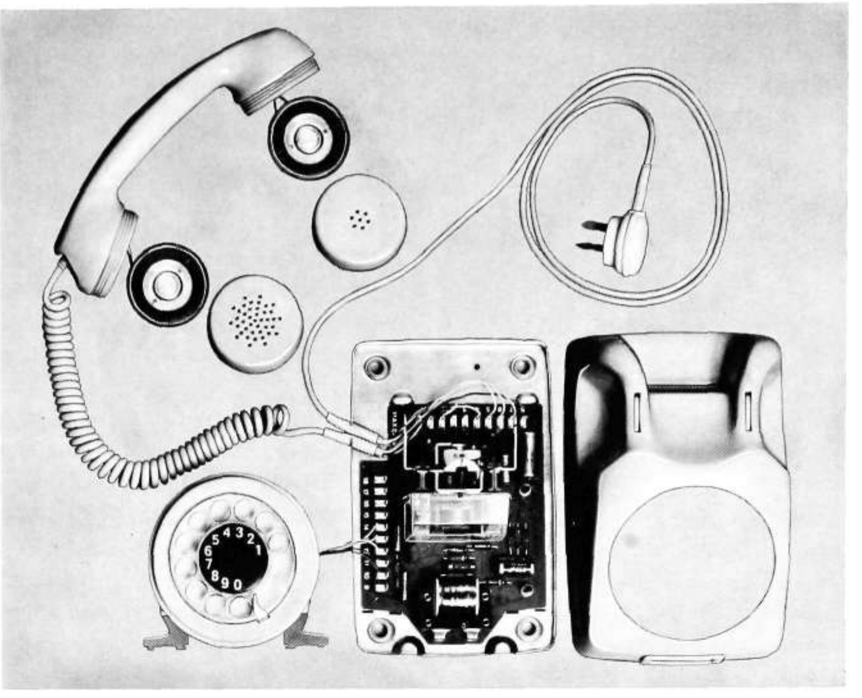


**Fig. 25**
**Dialog with major units dismantled**

The printed circuit card also has the necessary number of terminals for the connection of the cords. The actual terminals are duplicated and so designed that, apart from being suited for mounting on printed circuit cards, they can also take the plugs which are used on all the cords. These plugs are advantageous in that, among other reasons, they can be fitted and removed without a tool both in the factory and for servicing.

The dial is a modified version of the type used in earlier telephone sets. For adaptation to the new instrument the short-circuiting springset has had one spring added and the cords have five conductors instead of the previous four. The finger-plate is made of transparent plastic and the number disc of anodized aluminium is coloured a deep burgundy-red with aluminium-coloured digits. The dial rests on two brackets. Around the mounting plate for the dial is placed a conical plastic gasket to prevent the entry of dust.

The telephone set case and the resilient holder with which the case is held in position on the base plate are of ABS (acrylonitrile-butadiene-styrene polymer). The resilient label frame is also of ABS. The cradle-switch plungers are of acetal resin to ensure the most favourable possible friction with the case.

The handset handle with caps and microphone cup is designed for optimal transmission characteristics. The form is adapted to the electrodynamic inset of Elektrisk Bureau, which is used both as microphone and receiver. The inset is so designed that connections are made with AMP's FAST-ON terminals.

The cords are light and have PVC insulation. The handset cord is a 4-conductor spiral cord and the plug cord is a 3-conductor cord. The cords are provided with PVC cord protectors and FAST-ON terminals at both ends.

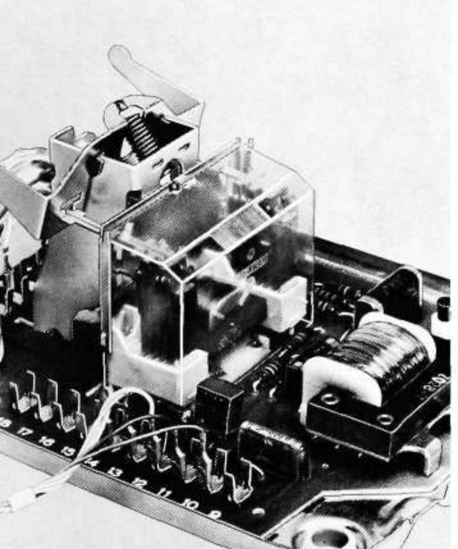


**Fig. 26**
**Section of internal mechanism with, among other items, cradle switch arrangement with springsets, components and cord terminals.**

Both the 3-wire plug and the jack are normally supplied in white plastic since they are usually fitted in the vicinity of wall switches and power sockets, which are usually supplied in this colour. The 3-wire plug is slightly modified in that the terminals, which on the earlier model were cylindrical, are now flat. The 3-wire plug has a fourth screw terminal connecting with a springset which closes when the plug is withdrawn. The cord is connected by AMP terminals on the plug. A complete set weighs 1.29 kg, of which the handset with cord 0.37 kg.

## Summary

The telephone set described—a Dialog with electrodynamic receiver, electrodynamic microphone and associated amplifier, and with tone ringing—clearly shows the flexibility in design of the Dialog since, while retaining the basic mechanical structure, widely varying circuitry can be employed to provide the desired transmission and signalling characteristics.

As appears from fig. 13 and 14, the reference equivalents of the telephone set at 0-ohm line are + 3 db for sending and − 6 db for receiving, relative to NOSFER. Both SRE and MRE for the telephone set are constant within a large range of variations of the supply current.

The optimal relationship between SRE and MRE (according to CCITT), namely $20.8 - 12.2 = 8.6$ db, appears to have been achieved in that the difference for the new set is $+3 - (-6) = 9$ db.

# Intercontinental Telephone and Telex Exchanges

J. S. CRISPIN, CANADIAN OVERSEAS TELECOMMUNICATION CORPORATION (COTC), MONTREAL

UDC 621.394.34:621.394.72
621.395.722
LME 808 830

*"Intercontinental" is the term given by the International Telegraph & Telephone Consultative Committee (CCITT) to indicate long distance communication such as transatlantic. The term is used in contradistinction to "international" which is utilized typically to indicate for instance intra-European and other relatively short-distance communication.*

*It is obvious that all switching centres have a great deal in common and it is the purpose of this article to stress the particular features of intercontinental telephony and telex exchanges. Facilities required by all exchanges will be included only as necessary to present a clear picture. It should also be mentioned that this article covers solely the particular viewpoint with reference to the Canadian situation as a partner in the Round-the-World Commonwealth Cable Scheme and does not pretend to represent a common viewpoint of all administrations with intercontinental exchanges or even the other Commonwealth cable network administrations.*

The first transatlantic telephone cable had a capacity of thirty-six circuits, each of four kilohertz bandwidth, when commissioned in September 1956, of which six telephone circuits terminated in Canada.

In December 1961 the Canada/Britain transatlantic telephone cable system (CANTAT) was put in service, providing another eighty channels of three kilohertz bandwidth.


**Fig. 1**
**COTC, Montreal**

Extra capacity will be made available later this year by utilization of Time Assignment Speech Interpolation (TASI) equipment on the CANTAT cable circuits.

These facts serve to illustrate how quickly intercontinental communication has grown, the approximate number of telephone circuits being considered and some of the diverse means of communication which influence intercontinental signalling and switching standards. These factors affect switching exchange provision in different ways.

The requirement to change from manual operation to semi-automatic operation in order to improve circuit utilization and to improve subscriber service caused an urgent need for an exchange to handle the Canadian terminal traffic. Following the inauguration of the Commonwealth Pacific (COMPAC) Cable in December 1963 between Vancouver (Canada) and Sydney (Australia) transit switching facilities were also required. While the change from manual to semi-automatic operation was the overriding requirement, it might also be recorded that this was the first application of transit switching to intercontinental switching exchanges.

## Common Considerations

In general, intercontinental circuits are far fewer than national or international circuits and are relatively very expensive to provide. Thus, efficient utilization of circuits is extremely important: consequently development of efficient switching schemes and telephone and telex exchanges necessary to implement these schemes is vital.

While the exchanges being considered are exceptional examples, the time difference existing between subscribers on different continents is a factor which obviously can be much greater than the normal time difference between the average international subscribers. There are no common office hours between Canada and Australia or between U.K. and Australia. Consequently, the common "waking hours" becomes the criterion in the case of telephone calls, whereas the one-way communication feature of telex with an unattended receiving machine provides obvious advantages. As implied, this time difference would not necessarily exist on North-South circuits.

The language problem is not a cause of great technical difficulty as far as exchange design is concerned; there is a language digit used in telephone signalling to bring in a suitable operator as necessary, but no special provision is made in telex.

Alternate routing is a feature that was not used to any great extent initially, but as the intercontinental network spreads and circuits increase in quantity, it assumes greater importance.

Barring of calls from non-allowed routings is another necessity, both to put administrative agreements into effect and to prevent technically unwanted alternate routing.

Bothway working, meaning the ability to initiate a call in either direction of transmission on a single trunk circuit, is also required since, with the time difference factor, there are periods of the day when the majority of calls are made from one country. This applies especially to telex calls where office hours dictate which way calls will be made at any particular time. For long and expensive routes, dedicated one-way circuits are a luxury one cannot afford. This "bothway" aspect of operation is further elaborated upon later under "Provision of Equipment".

Fig. 2
Intercontinental transit exchange, L M Ericsson type ARM 201, in Montreal

## Telephone Exchanges

Semi-automatic operation was introduced between Canada and U.K. in February 1964 using a signalling scheme under consideration by CCITT and, in fact, recommended with minor changes by CCITT as Signalling Scheme No. 5 in Juni 1964. This signalling scheme increases the efficiency of use of intercontinental trunks; the so-called "compelled" signalling generally requires a signalling answer to every signalling command, thus imposing greater control on the system and, in particular, providing against simultaneous calling in both directions. It might be said that any of the existing signalling schemes providing semi-automatic facilities would have been generally acceptable as providing the major advantage to be gained, but Signalling Scheme No. 5 seemed to have the best overall compatibility with national schemes as well as the other following features. The system is compatible with TASI and both 3 KHz and 4 KHz operation. Those principles of operation which were novel at the time of introduction were mainly on account of the necessity of being capable of operating over one or more TASI channels in tandem or over satellite circuits. The features of Signalling System No. 5 were:

- Separate line and register signalling systems (not novel).
- Link-by-link line and register signalling systems.
- Continuous sequence of selection signals.

In Montreal, connection was made to the Bell Telephone Company on the domestic side of the exchange, employing unidirectional trunks and line signalling carried on separate wire by direct current (E & M) signalling. The short distance involved did not warrant a more involved scheme.

## Telex Exchanges

The Montreal telex switching exchange went into service in 1965. CCITT had recommended two main signalling systems, at the time known as Type *A* and Type *B*. Additionally, a variation of Type *A* signalling is required to connect from the exchange to radio *ARQ* equipment where it is translated into signals as called for by CCITT Recommendation *U20*; this latter is often known as "*U20* signalling".

Canadian Overseas Telecommunication Corporation elected to be known as a "Type *B* dial" administration, which means that connecting administrations would, when calling Canada, send Type *B* dial and, conversely, COTC would call according to the signalling requested by the receiving country. This complies with the CCITT recommendation that allows the called country to nominate the signalling employed. On the domestic side, the connection is made on the basis of both-way operation Type *B* dial.

## Provision of Equipment

The foregoing may seem an extensive prelude considering that this article intended to concern itself with "exchanges" from the equipment point of view as well as system design aspects but, of course, the presentation of some details of the problem makes the solution in terms of equipment provision much more obvious. Perhaps the systems problem may be summarized by saying that both telephone and telex intercontinental signalling systems are fairly complex and an equipment solution is required which provides facilities mentioned in the foregoing plus other attributes which may be summarized as follows:

☐ *Exchange with inherent flexibility* to allow introduction of variations on various signalling systems.

☐ *Exchange with possibility of growth in modular form* so that, as new equipments are added, the interruption to traffic is kept to a minimum. This modular growth should also allow supplementary equipment to be added in those areas of an exchange which grow faster than anticipated.

☐ *Equipment requiring minimum maintenance* both because of the direct cost of maintenance staff and also because of the greater indirect cost of circuit inefficiency.

**Fig. 3**
**Telex operators at cordless positions supplied by L M Ericsson**

Fig. 4
Close-up of telex operator's position

☐ *Fault correction* can be considered as a separate subject although obviously related to maintenance. It is very desirable to know essentially which equipments are active in establishing a particular call if something goes wrong, especially if the fault was caused by a combination of effects.

☐ *Quiet equipment.*

☐ *Low cost equipment.*

☐ *Equipment provided with bothway operation capability.* The extra complication and cost of the line equipment is justified by the increased utilization of the long and expensive circuits involved. This increased complexity is necessary not only because of the need to perform "calling station" and "called station" functions but also because of the necessity of dealing with the possibility of dual seizure of circuits, which problem bothway working creates.

Above, say, 25 trunk circuits (telephone) the traffic pattern may indicate a certain proportion of one-way circuits is advantageous and this factor will obviously affect equipment provision. The telex case is the same in principle, but the number of bothway circuits relative to one-way circuits is likely to be much higher in any given relationship.

☐ *Register type equipment*—at least as far as this implies simplifying and increasing switch reliability. Registers were necessary to comply with Signalling System No. 5 because the link-by-link selection principle was adopted in this case.

Figure 5 is presented to show the basic features of a switching exchange using common control. When a call has been connected, line (calling) is joined to line (called) through line relay, four crossbar switch sections, line relay.

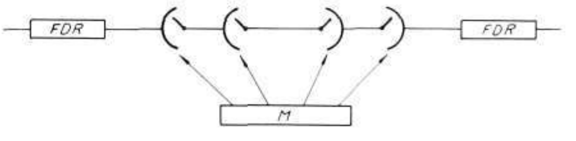



Fig. 5
Simplified block schematic
A, B crossbar switch stages
FDR line relay
M common control equipment

## Crossbar Switch

The crossbar switch sections are simple, robust, relatively cheap units which give continuous highly reliable service.

## Line Relays

The line relays perform some more sophisticated functions, but they are, in principle, functions that cannot be performed efficiently by the common control. Such functions include

- Signals necessary to clear an established call.
- Protection of subscriber against dialling tone noise (in the case of a telephone exchange).
- A continuous relaying function to electrically disassociated outside lines from the exchange. (In the case of telex.)

The line relays initiate other functions such as echo suppressor disabling as temporarily necessary for the establishment of a call or for the duration of transit and data calls.

## Common Control

The common control equipment actually consists of a number of units which are brought into and released from circuit as required. The register function of

Fig. 6
L M Ericsson crossbar switch racks

storage and transmission of selection signals has been mentioned as an example. It is the essence of a common control type of exchange that the relatively expensive, complicated common control units are used only when absolutely required, thus giving the exchange sophistication in terms of ability to perform switching functions at the least expense.

## Switching Centres at Montreal, Vancouver & Hawaii

Intercontinental telephone switching centres have been provided at Montreal, Vancouver and Hawaii; telex switching centres have been provided at Montreal and Vancouver.

Because of the small size of the exchanges, it was possible to reduce costs appreciably by using some common control equipment for both telephone and telex functions. It was also arranged to have telephone and telex exchanges immediately adjacent to ease installation and maintenance problems.

The stringent telex exchange design requirements in terms of the requirement to send Type *A*, Type *B* and *U20* did give cause for concern in the complexity of the line units, as this seemed to depart from the common control exchange principle of simple line units, but this was the price paid for the required initial flexibility.

## Future Growth of Intercontinental Telephone & Telex Exchanges

Exchanges of the future will obviously have to cope with more sophisticated system requirements. Fully automatic operation will be implemented intercontinentally at a rapid rate and the exchanges will be called upon to provide data to apply automatically to international, national and administrative accounting.

Greater facilities for traffic recording of various kinds will be required and intercontinental network management is being studied which could lead to exchanges being required to change routing controls according to the prevailing traffic conditions.

Increased circuit efficiency and increased use of alternative routing is continuously being studied.

Telex Type *C* signalling (CCITT Recommendation *U11*) is still being reviewed in some detail to achieve the above objectives, while Signalling System No. 6 is being formulated by CCITT with a view to achieving a substantial improvement in the Intercontinental Telephone Network.

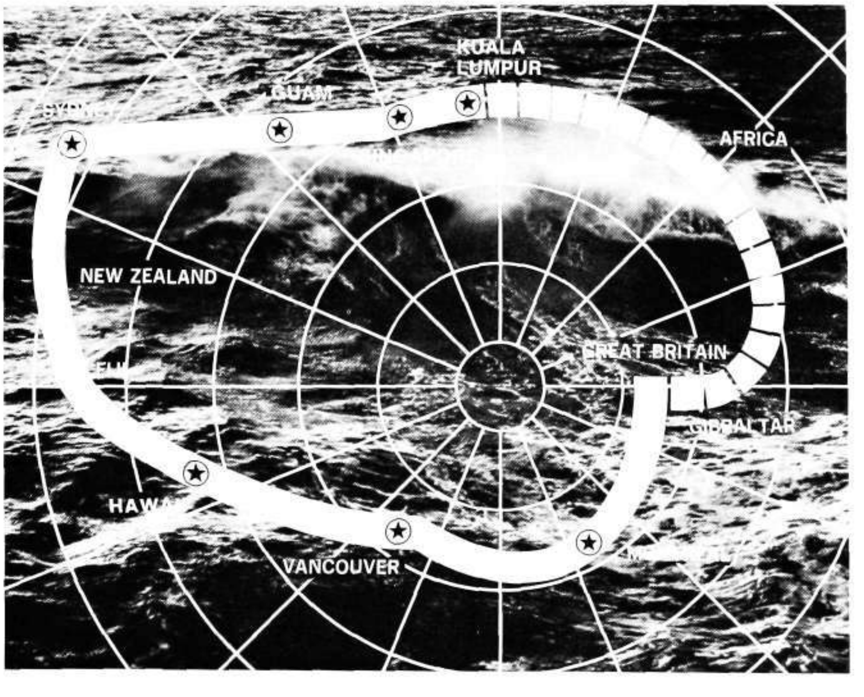



**Fig. 7**
**LM Ericsson's switching equipments (★) for telephony and/or telex used in the intercontinental telecommunications systems COMPAC and SEACOM**

# PABX for ASEA's Head Office and Plant at Västerås

J. E. JOHNSSON, HEAD OF OFFICE SYSTEMS DIVISION, ASEA, VÄSTERÅS

UDC 621.395.2
LME 8372

*The internal and external telecommunications of a company or industrial undertaking are often dealt with by a PABX.*

*In addition to external and internal telephone connections a modern PABX can be equipped with a number of time-saving facilities. These facilities help the company to rationalize its office work and, when incorporated in the PABX, the telephone installation becomes an integral part of the office organization. The larger the company, the more will the telephone system affect the smooth running of its daily business.*

*ASEA, the Swedish manufacturer of equipment for the generation, transmission and distribution of electric power, and of electrical equipment for industry, transport and private homes, is one of the word's largest, most technically advanced and highly reputed companies in its field.*

*ASEA is also an outstanding example of a company which makes full use of modern telecommunications.*

*The head office and certain major installations of the ASEA Group are situated in Västerås. The Group has 20 subsidiary companies and other factory installations, as well as a large number of branch offices and service shops in different parts of Sweden. Abroad it is engaged in widespread activities in altogether 73 countries. ASEA must therefore place very high requirements on its communication systems, especially at the head office and plant in Västerås.*

*Earlier ASEA had two separate telephone installations in Västerås, one for external and one for internal calls. For its new system ASEA has combined the two plants into a larger PABX system, the largest in northern Europe. The system also incorportes the most modern extra facilities provided for large private automatic branch exchanges.*

*ASEA's PABX has aroused a very great interest and its example will undoubtedly be followed by other large industrial undertakings.*

**Fig. 1**
**Night view of Västerås**

Fig. 2
ASEA's head office with the characteristic ASEA tower in the background

A chart of a company's routines shows the definite necessity for rapid and reliable communication. The purely physical transportation of the written word is easily definable and can be quite easily determined in respect of its significance and extent. The need for and the importance of communications based on the spoken word, on the other hand, are very much more difficult to indicate in measurable values but will undoubtedly have an increasingly great influence on the rational performance of office work. A decisive factor in this respect is the development which has taken place and continues to take place within telephony.

The significance of telephony for an industrial undertaking will be evident from a comparison of the rise in number of employees with the rise in number of telephones. ASEA started its activities in Västerås in 1892. It had initially 164 employees and only a single telephone connected to the Västerås public exchange. Up to the end of the century the staff increased by rather more than 1000 persons but by the end of 1899 the telephone stock had increased only to three instruments, which dealt with the entire, though obviously not very extensive, telecommunications of the company. The small number of telephones in relation to the number of employees is fully understandable in view of the technical limitations involved in the means of communication and of telephony at that time. Communications were instead sent by post.

From the beginning of this century up to our days the ASEA staff in Västerås has increased tenfold to rather more than 10,000 office and factory workers combined. The number of telephones has grown more than two-thousandfold and is now more than 6000.

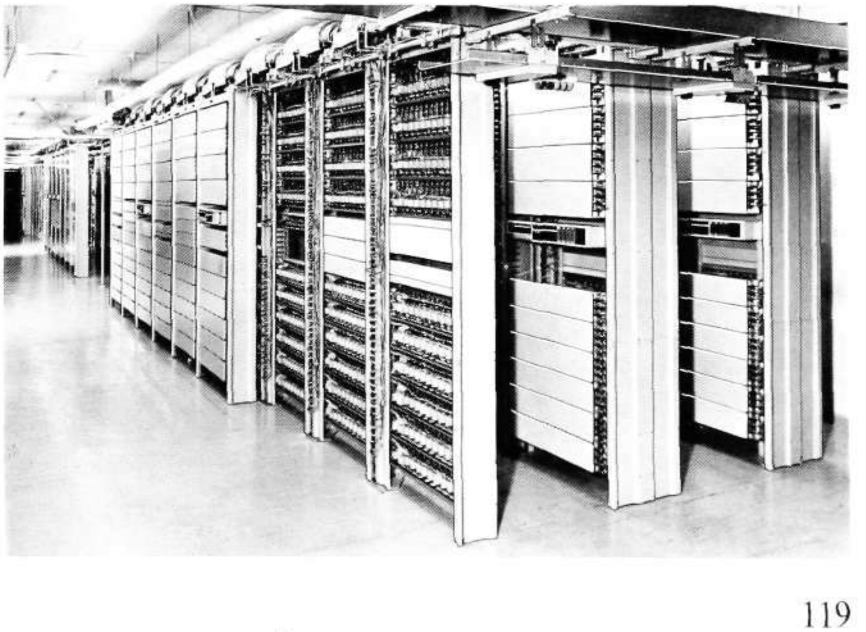


Fig. 3
The switchroom

Through the company's private exchange over 14 million telephone calls are now handled annually, of which 3 million outgoing, 1.2 million incoming and the remainder (about 9.8 million) internal. If these communications were in the form of written messages as at the beginning of the century, about 1 ton of paper would be used every day.

## Requirements on the New PABX

Within the ASEA Office Systems Division, which has had the administrative responsibility for investigations concerning and the procurement of the new PABX, the goal has been to acquire an exchange adapted to the special traffic configuration of the company and, as far as possible, to draw upon the means of rationalization which modern equipment provides. These problems were examined for the first time in 1956 when the existing PABX was found to be of too small capacity. But pending the development of a modern PABX system which would fulfil the main requirements placed on it, the shortage of capacity was met by procuring a privately owned PAX with associated cabling and telephones and using the PABX exclusively for external traffic. The subsequent investigations which resulted in the acquisition of the present PABX started in 1963.

In relation to most Swedish enterprises ASEA has a very special traffic configuration. Owing to its size and wide dissemination within Västerås a very large number of the calls through the exchange (some 70 %) are internal. This is reflected also in such figures as that some 4000 extensions (plus about 2000 parallel sets) require only 197 exchange lines and that the distribution of instruments is about 60 % non-restricted and 40 % restricted. Semi-restricted instruments are not used (see Trunk Discrimination below). The preponderance of outgoing over incoming calls, as illustrated by the figures above, is due to the fact that the ASEA head office is situated in Västerås. This means that enquiries both within the widespread sales network and to customers must often be made on the spot in the course of work on quotations and design.

More than 10 % of the outgoing calls are to the branch sales offices in Sweden. As a result of centralization of certain functions, including a large EDP installation, routines for data transmission on the telephone network and internal telex service are under development.

From the investigations that were made, the following desires for a new PABX crystallized out:

- Ultimate capacity 9000 extensions
- Great flexibility
- High traffic capacity
- Short "technical thinking time" and rapid connection
- Reliability
- Simple manual operation
- Easy introduction of work-simplifying and time-saving special facilities
- Possibility of connection of in-dialling equipment
- Possibility of connection of pushbutton telephones
- Possibility of direct connection of subexchanges at other places
- Possibility of simplified switching procedure for data transmission and internal telex.

Fig. 4
Operators' positions

## Choice of System

Our investigations on the PABX market showed that the *AKD 791* system made by L M Ericsson would largely meet these requirements. After very fruitful cooperation between the Swedish Telecommunications Administration, L M Ericsson and ASEA, the now installed PABX has acquired the form which gives us all reason to believe that it will not only fulfil the requirements placed on an important communications link of today but for a long time to come will permit the simple setting up of telephone calls which the constantly increasing activity of the company may require.

In its first stage the PABX is equipped for 5100 extension numbers, 87 outgoing and 110 incoming exchange lines and 14 operators' positions. The special facilities which have been ordered and will be discussed below are automatic call-back, absence supervision, central dictation, tape recording of conversations, conference connection on trunk calls, internal abbreviated dialling, external abbreviated dialling and trunk discrimination. The PABX is designed for the connection of in-dialling equipment and pushbutton telephones. Permanent tie lines with through-dialling facilities have been connected to the company's telephone exchange at Ludvika—one of the larger units outside Västerås. There are five such lines, which are rented from the Administration. Similar arrangements are being prepared for ASEA units in Stockholm and Hälsingborg. The automatic equipment, including MDF and a room for servicing personnel, takes up 447 $m^2$, and the manual service including rest room and space for the supervisor 119 $m^2$.

By special agreement with the administration ASEA's own distribution network—earlier used for internal telecommunication—is used for extension instruments at other ASEA units within the town of Västerås. This network, which was installed and was previously maintained by L M Ericsson, naturally complies fully with the Administration's specifications. Likewise, under a special agreement with the Administration, ASEA itself, with L M Ericsson's assistance, is responsible for new installations and the replacement of telephone sets within the network.

Fig. 5
Manual switchroom

As the operators' work is done from consoles, it was possible to furnish the operators' room as an ordinary office room. Transfer facilities between the operators permit specially trained operators, e.g. in languages or company organization, to deal with calls requiring such special knowledge. The number of waiting calls, and so the grade of service, can be seen from a queue thermometer. The supervisor—in addition to the usual facilities for operator control—has equipment which permits supervision of the condition of the exchange lines, equalization of the load on the operators, and indication of faults in the exchange.

Fig. 6
The supervisor's desk

## Special Facilities

The choice of special facilities was naturally given very thorough consideration. The aim has been to achieve simpler and quicker communication at a lower overall cost.

### *Automatic Call-back*

Automatic call-back is a great time-saver in a system with so high an internal traffic as at ASEA. Investigations have shown that more than one in every ten attempted calls results in busy tone. The saving provided by this special facility, therefore, well justifies the extra cost.

### *Telephone Answering Service*

The problem of locating a person in a company of the size and extent of ASEA can hardly be solved by means of conventional paging equipment. The attempt has instead been made to deal with the problem by using supervisory apparatus of different types, e.g. parallel telephone sets, two-line telephone sets or executive-and-secretary units, and by central supervision by the PABX. The latter is intended for use when an extension-user is absent for a long time, i.e. half-a-day or more. Every extension has this facility and, after a report to the operator, incoming calls are automatically transferred to an interception operator from whom the caller can obtain the required information.

## *Central Dictation*

Stenographers are used for dictation only in exceptional cases at ASEA. The normal practice is to use a dictating machine, which means, however, that a disproportionately large number of machines are used in the various offices. The introduction of central dictation via the PABX should greatly reduce the number of dictating machines, in that persons who dictate only occasionally, less than two hours a day, should be able to do this via the telephone system. Dictation is done from a special telephone set, the handset of which has a key with which the central dictating machine can be controlled in the same way as if it were placed in the person's office. By means of a PBX connection several dictating machines can be connected to the same call number, so that the desired number of dictators can be served in a rational way. Investigations show that an unaccustomed dictator finds it easier to learn to dictate via a telephone than on an individual dictating machine.

## *Recording of Important Conversations*

The possibility of recording telephone conversations through the PABX existed in the earlier telephone exchanges used by ASEA. This procedure is regularly employed on foreign calls, on which the quality of transmission and language difficulties often require that a conversation shall be listened to once again. Recordings of foreign calls are arranged by the operator without request, whereas recording of national calls must be specially ordered. To prevent unauthorized recording, a warning tone is issued during the period of the recording. Recording is done on dictating machines of the same type as the company's standard machines so that, if desired, the recording can be played back on any machine.

## *Conference*

In supplementation of the normal enquiry call facility provided by all private automatic exchanges an auxiliary service has been ordered which permits the setting up of conferences during an external call. It has often

**Fig. 7**
**Operator's position with recording machine**

proved desirable to bring in an ASEA colleague when conversing with an external subscriber. The connection is set up in the same way as an enquiry call, but by dialling a special code the third party can be connected to the line for conference. If so required, the third party can take over the call. A large number of enquiry calls are made at ASEA and, through this new conference facility, the total staff conversation time—and so the costs represented by conversation time should be reduced.

## *Abbreviated Dialling of Internal Calls*

With this facility calls between extensions who communicate regularly with one another can be made by dialling a single digit. Up to eight such connections can be arranged for every telephone set. The equipment was procured in order, as far as possible, to reduce the number of intercom systems which otherwise tend to grow up around a conventional telephone system.

## *Abbreviated Dialling of External Calls*

As already mentioned, a large part of the traffic consists of communication with ASEA units outside Västerås. To facilitate this traffic, external abbreviated dialling equipment was procured. This enables all non-restricted extensions to communicate with all ASEA units in Sweden by dialling merely a 4-digit number. Connection with the public exchange, dialling of area code and subscriber number and listening to the intermediate tones, is all performed by the automatic equipment. In addition to the relief to normal telephone traffic provided by this facility, it also simplifies the communications between a centrally situated computer and external terminals.

## *Trunk Discrimination*

The full automatization of the Swedish telephone network has unfortunately added to the telephone charges of most companies through the ringing of private calls from the companies' telephones. The connection to *AKD 791* of a trunk discrimination equipment was therefore considered a great advantage by ASEA. With this equipment every extension can be allowed access to the trunk network solely within the range required by each. Through a combination of the external abbreviated dialling and trunk discrimination equipment most unrestricted extensions can, therefore, be given a fairly limited range. Trunk calls outside the range of the extension can be booked with the operator. Through statistics of these latter calls, and thanks to the great flexibility of the PABX, changes in the degree of restriction can be quickly effected. Through the restriction in the number of dialled trunk calls this auxiliary service should soon pay for itself.

# AKD 791 at ASEA – a Large PABX in a Large Company

S. KILANDER & R. EDLING, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.2
LME 8372

*L M Ericsson's PABX system AKD 791, earlier presented in Ericsson Review No. 2, 1965, has recently been installed at ASEA, Västerås.*

*The ASEA PABX with its 5100 extensions, 200 exchange lines and 15 operators, and with an ultimate capacity of 9000 extensions, shows the adaptability of AKD 791 to the varying environments and requirements of rationally organized companies.*

The original capacity of *AKD 791* has been increased to cover the range 300–9000 extensions through the introduction of a fourth selector stage (*SLD*).

The facilities of the *AKD 791* system have been well utilized at ASEA. When all equipment ordered has been delivered, the PABX will contain such special facilities as

- automatic ring-back
- telephone answering service
- abbreviated dialling of internal calls
- abbreviated dialling of external calls
- trunk discrimination
- conference
- central dictation
- recording of telephone conversations
- fully automatic tie lines to ASEA, Ludvika.

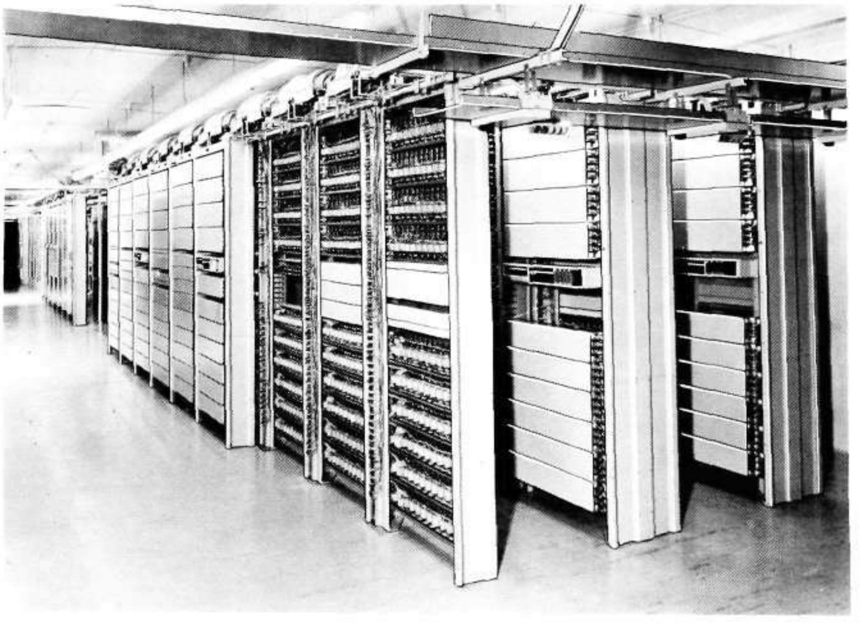


**Fig. 1**
**ASEA's switchroom, suites of racks**


Fig. 2
Operator's console with numerical indication of called extension

The operators have at their disposal a functional console of representative appearance. It has a teak case and built-in indicators which display the keyed extension number.

For supervision and control of the traffic there is a supervisor's desk containing, among other equipment, queue thermometers and lamp panels for exchange lines. The queue thermometer for incoming external calls is duplicated and readily visible on the wall.

Connecting with the switchroom is a maintenance control desk which informs the repair staff of disturbances which may arise in the operation of the exchange. The maintenance control desk also includes complete traffic supervisory equipment.

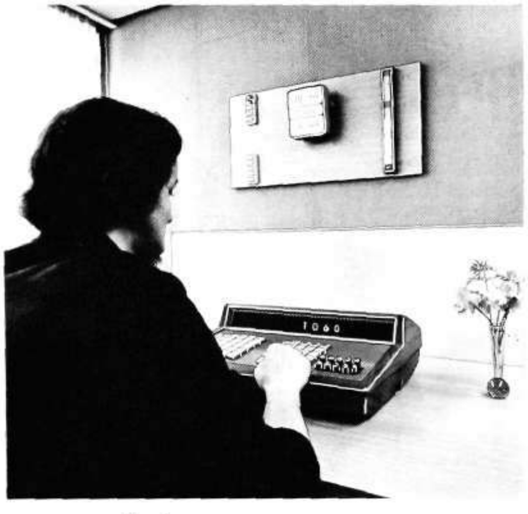


Fig. 3
Queue "thermometer" visibly placed on the wall in front of the operators. On the same panel there is also a time-and-date clock and two lamp panels.

## System Structure

*AKD 791* is a register-controlled system based on code switches (see trunking diagrams in fig. 5 and 6).

The extension stage *SL* can be made up of three substages (fig. 5) or four substages (fig. 6). The *SLA*, *SLB* and *SLC* substages are built up in 300-line groups which are connected in parallel to the *SLC* multiple. In the three-stage version this is the common multiple for the traffic-carrying devices. In very large exchanges the 300-line groups are combined into 1800-line groups with access to the common multiple via the *SLD* stage. The maximum capacity is five 1800-line groups, i.e. 9000 extensions.

The switching stage *FS* consists of two substages *FSA* and *FSB* and allows connection of up to 450 exchange lines.

## Extension Facilities

In addition to the automatic setting up of internal and external calls, and the enquiry and transfer facility, the extensions have a number of new facilities which make for greater simplicity and efficiency.

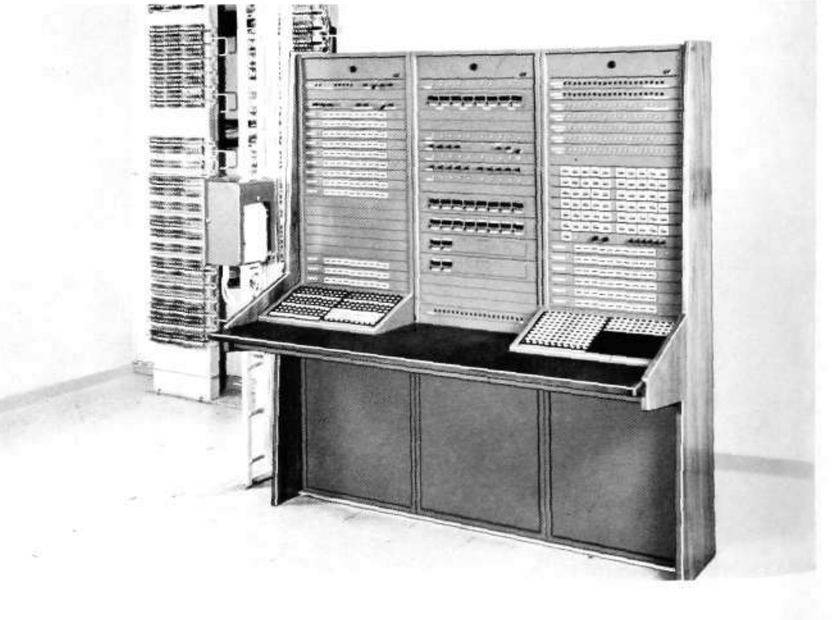


Fig. 4
Maintenance control desk

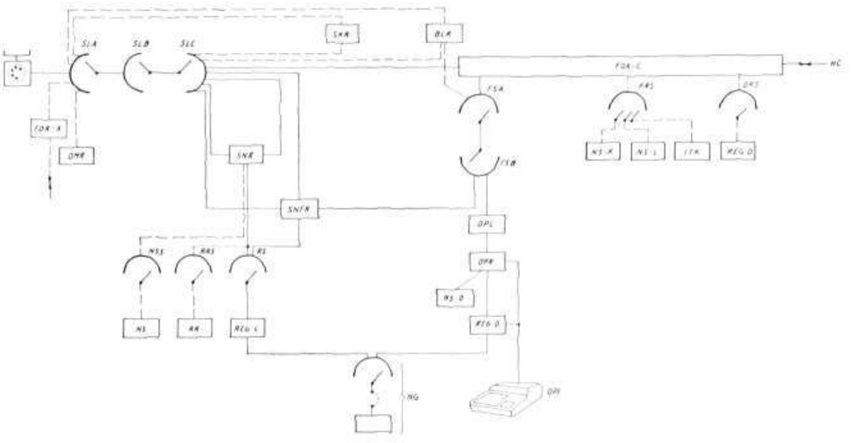


Fig. 5
Trunking diagram for AKD 791 with three substages

## *Ring-back*

The ring-back equipment allows supervision of an engaged extension line and establishment of a connection automatically as soon as the extension becomes free. In the meantime the caller who has set up the ring-back circuit is free to use his telephone both for outgoing and incoming calls. At ASEA equipment has been installed for simultaneous supervision of 50 extensions, with the possibility of increasing this number to 160.

## *Trunk Discrimination*

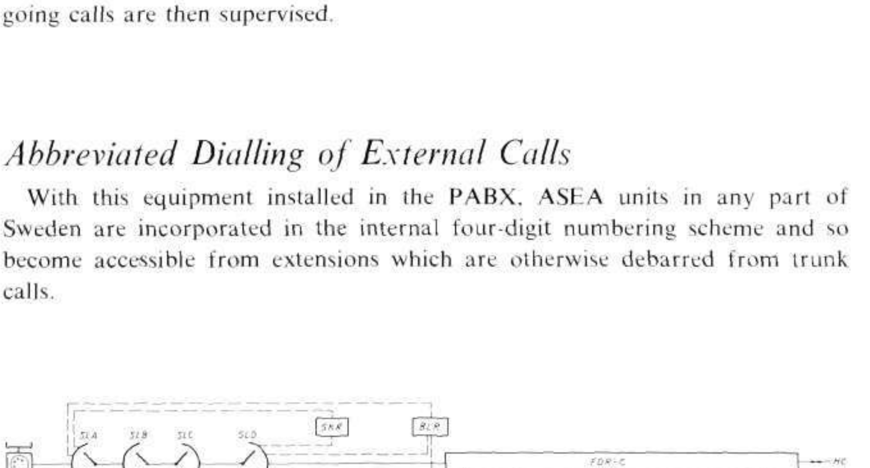
This equipment supervises external calls made by extensions and restricts the facility of dialling trunk calls. Various groups of extensions can be allowed access to various trunk zones selected according to the work on which they are engaged. The route determination is effected on a terminal field common to all lines. If it is desired that the supervision shall be stricter after office hours, a button is pressed on the supervisor's desk and all outgoing calls are then supervised.

## *Abbreviated Dialling of External Calls*

With this equipment installed in the PABX, ASEA units in any part of Sweden are incorporated in the internal four-digit numbering scheme and so become accessible from extensions which are otherwise debarred from trunk calls.

Fig. 6
Trunking diagram for AKD 791 with four substages

| | |
|---|---|
| SLA, B, C, D | Extension stage |
| SNR | Local cord circuit |
| RS | Register finder |
| REG-L | Local register |
| SNFR | Enquiry line |
| NG | Number group |
| HC | Public exchange |
| FDR-C | Exchange line |
| FSA, B | Switching stage |
| OPL | Operator's link |
| OPR | Operator's relay equipment |
| REG-O | Operator's register |
| NS-O | Register for translation of pushbutton dialling code (operator) |
| OPI | Operator's console |
| SKR | Combined cord circuit |
| DMR | Tie line to dictating machine |
| FDR-X | Tie line to other private exchange |
| ITK | Trunk discrimination |
| REG-D | In-dialling register |
| RRS | RR-finder |
| RR | Call-back unit |
| NS-L | Register for translation of pushbutton dialling code (extension) |
| NSS | NS-finder |
| NS-K | Equipment for external abbreviated dialling |
| DRS | In-dialling finder |
| FRS | Register finder |
| BLR | Record circuit |
| NS | Code sender |



When one of these numbers is dialled, a code sender *(NS-K)* is connected to the outgoing junction relay set. The dialled number is translated by an analyser into the area code and subscriber number of the called unit and transmitted to the code sender, which then sets up the connection.

## *Abbreviated Dialling of Internal Calls*

The abbreviated dialling equipment allows direct access, from an ordinary extension telephone, to eight optional extensions by dialling a single digit. This provides rapid communication with the members of the staff with whom each extension communicates most.

The registers understand a call to be a direct access call if a second digit is not received within a specific time.

The supplementary information required to form a complete extension number is received from the identity of the *A* extension stored in the internal register. In this way the abbreviated dialling procedure will employ the normal traffic routes in the PABX.

## *Telephone Answering Service*

One of the methods chosen by ASEA for solving the problem of unanswered calls is automatic transfer to an interception operator.

Each extension can place a request with the interception operator to have his number supervised. The operator keys a code which causes all calls to that number to be redirected to the interception operator, to whom they are signalled by display of the number on a panel.

The operator can thus inform callers of the situation. An intercepted call can be extended by the interception operator to another extension or back to the wanted extension.

## *Parking of Enquiry Call*

If supplementary information is needed during conversation with an external subscriber, an enquiry is normally made to the extension who possesses such information. If the question cannot be immediately answered, the caller can return to the external conversation. The consulted extension leaves his handset off the receiver rest until he can reply and then summons the caller's attention by dialling a digit. A tone is sent to the conversing parties in time with the dialled pulses. The extension who initiated the enquiry then dials a digit and is reconnected to the consulted party.

## *Conference Equipment*

The conference equipment with which the PABX is supplied is designed to meet the need for conferences on external lines. The setting up of a conference is initiated by a normal enquiry call to a third party. When connection is established all three parties can be interconnected by dialling a digit. The normal transfer and enquiry facility can be used on a conference connection as on other connections. When a third party enters or leaves the circuit a short warning tone is always transmitted.

## *Central Dictation*

A company like ASEA has a great need for dictating equipment. Central dictation via the PABX has been introduced in order to limit the number of dictating machines.

To make central dictation as simple as dictating to a machine of one's own, the central machine can be controlled by a key on the handset. It can also be controlled, however, from the dial of an ordinary telephone. Telephone sets with key on the handset require a three-wire line.

## *Recording of Telephone Conversations*

An extension can place a booking with the operator for recording of a telephone conversation. This can be done at the time of dialling the call or in the course of conversation. As an indication that recording is taking place a tone of 0.5 sec. duration is issued on the circuit every 15th second.

# Operators' Facilities

The goal in the design of the automatic equipment for the operators' consoles has been to simplify their work and provide facilities for good service.

All the operators' work is done from consoles containing push-buttons, lamps and numerical indicators. The number of manual operations per answered incoming call has been reduced to a minimum. The PABX can be programmed for through-connection of incoming exchange line calls, i.e. the operator receives only an audible signal before communication is established with the calling exchange line. The PABX can also automatically extend calls to a non-restricted, free extension. If both these facilities are used, the only job for the operator in normal cases is setting-up of requested numbers. The PABX also makes sure that the operator does not forget that an external call has been set up to an extension who has not answered or on a waiting circuit to an engaged extension, etc. After some time the operator is recalled. When she answers, the console shows all information concerning the call, such as the extension number and condition of the extension's line.

## *Queuing*

With a high rate of incoming exchange line traffic unanswered calls may accumulate. To avoid long delays in answering by operators the standard form of *AKD 791* is equipped with a queuing device which ensures a fair distribution of incoming calls to the operators. The queuing function can be divided so as to provide each incoming group of lines with its own queuing function.

## *In-dialling*

To make it easier for external subscribers to get through to an extension, ASEA have requested the in-dialling facility, i.e. an equipment which allows external subscribers to dial directly through to PABX extensions. This facility will be provided as soon as the public exchange has been equipped for the purpose.

In addition to the obvious advantage of requiring a smaller number of operators, in-dialling means that external subscribers need only pay for calls which are established with extensions, and that they can get into contact with extensions after office hours.

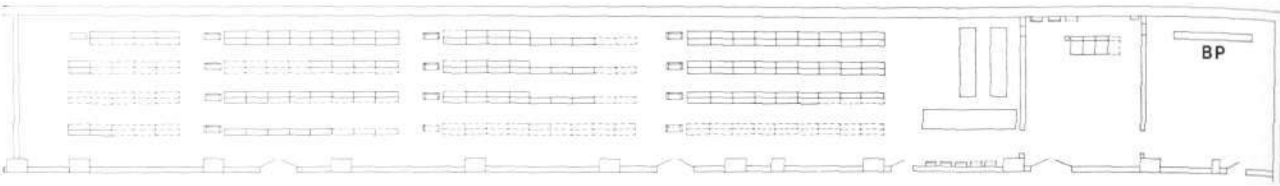



Fig. 7
Rack layout for AKD 791, ASEA

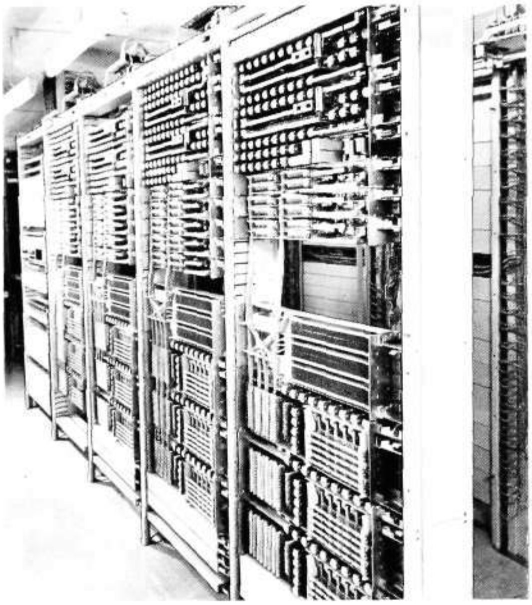


Fig. 8
Number group rack

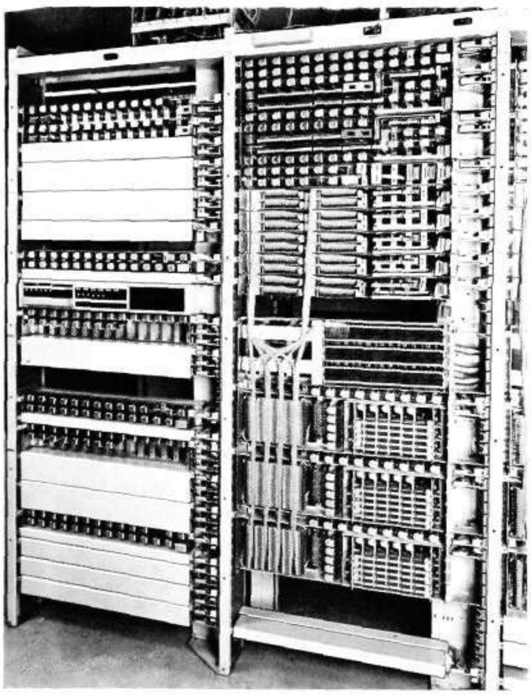


Fig. 9
Number group rack for 1500 numbers with strapping inserted

In the event of a complication such as link congestion in the PABX or a call to a vacant number or, if so required, when an extension is engaged, the incoming call is redirected to an operator. In this case the operator receives full information of the call, i.e. the wanted extension's number displayed on an indicator and the condition of the extension's line.

In-dialled calls have the same facilities in respect of enquiry and transfer as operator-extended calls.

## Mechanical Features

### *Space Requirement and Rack Layout*

The racks in *AKD 791* are of the same type as those used for L M Ericsson's public crossbar exchanges. The rack layout, equipment layout and cabling are therefore similar in the two cases.

Fig. 7 shows the space requirement and rack layout for the PABX.

The relative positions of the various units were chosen to comply with the cabling arrangements and to allow the equipment to be expanded for 7500 extensions within the present switchroom. Additional switchroom space is available at ASEA, however, if required.

### *Racks and Relay Sets*

The racks are of L M Ericsson's standard type *BDH 203* and *BDH 213*. Blocking buttons and lamps, test jacks and individual fuses etc. are centrally placed on a jack box in the middle of the rack.

Incoming cables terminate on plug-and-jack units at the top of the rack. This has meant that the cabling between different rack units, such as those for the switching stages, can be made up in the factory.

All relay sets are connected to the racks by plug and jack.

### *Number Group*

*AKD 791* is equipped with a number group (fig. 8) which may be described as a translating unit between directory number and multiple position. This allows a directory number to be associated with any desired multiple position. The transfer of extension numbers to other multiple positions to obtain a more uniform distribution of traffic in the PABX, therefore, or when an extension moves to another office, does not affect the telephone directory, which can thus be kept up-to-date for a longer period.

The number group is an important prerequisite for the auxiliary equipments on the *AKD 791* program. It has been made up in units of 3000 directory numbers. Each unit consists of two 1500-line racks.

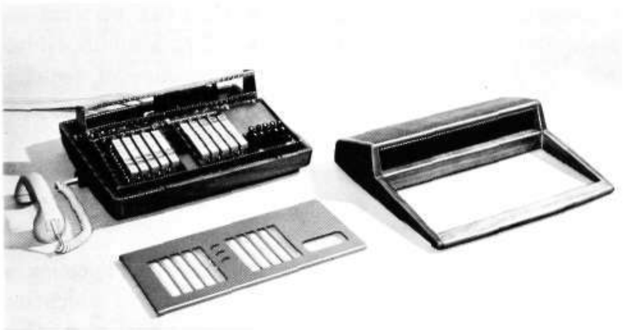


Fig. 10

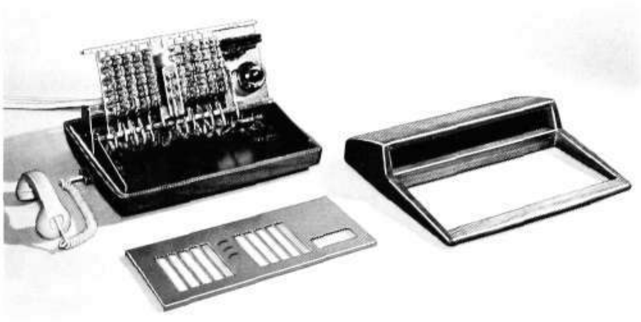


Fig. 11

**Fig. 10**
**Operator's console with cover removed**

**Fig. 11**
**Operator's console with cover removed and chassis folded up**

Strapping for indication of directory number is done by L M Ericsson's new direct wiring method with a wire guide "pen" and nylon-insulated wire which is soldered without being stripped. In addition to the increased reliability so attained, the new system allows the relay sets in the number group to be connected by plug and jack. Fig. 9 shows a close-up of a number group rack with strapping inserted.

## *MDF and Test Terminal Blocks*

The MDF is placed outside the switchroom. It is made in accordance with the standard practice of the Swedish Telecommunications Administration and with test jack strips. This allows the splitting of lines to test whether a fault is on the PABX or public exchange side.

The equipment *BP* shown in fig. 7 has test terminal blocks only, similar to the test jack strips on the MDF. No jumpering is done on this equipment. The equipment is used solely by the repairmen for testing in conjunction with the use of traffic route testers and similar maintenance control equipment.

## *Operators' Equipment*

The operator's console, as already mentioned, has a teak case and built-in indicators for display of the keyed extension number. This numerical information is of great help to an operator in conjunction with recall, unanswered calls and waiting calls, since she can immediately see which extension number was requested. The handset can be connected either from the right or left of the console to suit a right-handed or left-handed operator.

The console is designed to facilitate the operators' work and maintenance. Merely by releasing two screws on the back of the console the entire upper portion can be removed. The chassis can then be easily folded up, which provides access to all parts for replacement or inspection (fig. 10 and 11).

# Supervisory Equipments

## *Service Observation*

In the design of system *AKD 791* great emphasis has been placed on the aids for maintenance and fault tracing. The service observation equipment developed for the PABX comprises test points from all common units. The

**Fig. 12**
**Fault tracing with the transportable supervisory equipment**

seizure and fault information pulses from the marker units can be used for service alarm. The service observation also includes manual or automatic fault tracing, information of congestion on all traffic-carrying groups of switches and, finally, complete supervision of operators' equipments.

The service observation equipment is accommodated in a maintenance control desk as shown in fig. 4.

The function of the marker relay set can be followed by connecting a transportable supervisory equipment with lamp panel (fig. 12), on which the lamps follow the relay operations of the marker unit. In the event of a disturbance the relays concerned are locked and their positions can be read on the lamp panel. The remaining information can be used for fault tracing or transferred to a centralograph for statistical analysis. A number of lamp panels can be connected in parallel, each panel recording the particular situation when a fault occurs in any equipment.

For ease of fault tracing *AKD 791* offers the following facilities. From a special test category extension position a predetermined route through the PABX can be selected for supervision. By route is here meant a vertical, link, connecting circuit, register and exchange line. The desired "route" is blocked against normal extension calls but is seized by the test category extension. This procedure means that a test call can be made under normal traffic conditions.

**Fig. 13**
**Supervisor's desk for incoming traffic**

## *Check of Incoming Traffic*

The supervisor's desk (fig. 13) consists of three units (fig. 14), each comprising equipment for six operators and 90 exchange lines. From the supervisor's desk the type of the incoming traffic can be decided for every operator's position, and whether through-connection should be adopted. There are also queue thermometers for four incoming routes. The equipment can issue an audible alarm at a preset queue value.

# ERICSSON News from All Quarters of the World

# Is This What the Telephone of the Seventies Will Look Like?

**In order to obtain proposals for a new telephone L M Ericsson announced a competition a year ago, open to all employees of the Group. The object was to produce sketches or models of an "entirely different" telephone–a 1970-model adapted to modern tastes and environments.**

**The jury, consisting of Mr. Malte Patricks, Dr. Christian Jacobæus and Mr. Per Ahlström, all of L M Ericsson, and the company's consultant on design, Mr. Torbjörn Olsson, have now completed their work and presented the results. Three proposals received monetary rewards, four were purchased, and three received honourable mention.**

The result of the competition is considered to be very satisfactory. Of the sixty or so proposals submitted several contain ideas for further development. Some of them, moreover, were extremely carefully worked out. It is especially encouraging that the entries were of so global an extent-proposals came from almost all parts of the worldwide Ericsson Group.

## PRIZE-WINNING PROPOSALS

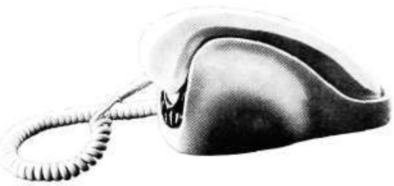
The first prize was awarded to Adrianus van Son, 37 years of age, designer since 1955 at L M Ericsson's subsidiary ETM, Breda, Holland. The jury considered Mr. van Son's proposal to have been very excellently worked out and that it represented a very good compromise between the requirements of design, handling, technique and technology. The proposal combines in a simple manner a desk and wall set.

The second prize went to Raymond Thomas Bear, 29 years of age, engineer at L M Ericsson Pty. Ltd. in Australia. The proposal shows originality, good design, and strict concentration, despite which it is considered to be spacious enough to contain the necessary components. In the present state of technology the model is considered to be usable only as a non-loudspeaking telephone.

The third prize went to Giovanni Pallini, 29 years of age, draughtsman at FATME, Rome, Italy. The model

*Cont. on p. 136*

**1st prize**
**Adrianus van Son, ETM, Breda, Holland**



**2nd prize**
**Raymond Thomas Bear, L M Ericsson Pty. Ltd., Australia**

**3rd prize**
**Giovanni Pallini, FATME, Rome, Italy**

**The prizewinner in L M Ericsson's competition "What will the telephone of the seventies look like?", Adrianus van Son, from Holland, visited L M Ericsson for a few days to receive his prize from the company management. He is here seen with Mrs. Annemiek van Son *listening to* Mr. Malte Patricks' congratulatory speech.**

**Mr. Björn Lundvall, President of L M Ericsson, in the rostrum at the 1967 Maintenance Conference held at Midsommarkransen at the end of May and beginning of June. This year's theme was maintenance of line, transmission and switching equipments.**

## Maintenance Conference 1967

Delegates from the telephone administrations of some ten Spanish-speaking countries and Brazil were invited to a conference in Stockholm from May 29–June 2 concerning the maintenance of line, transmission and switching equipments.

It was the first occasion on which Chile, Costa Rica, Curaçao and Spain took part in these maintenance conferences which L M Ericsson have arranged since 1956. Maintenance experts from Swedish, Finnish, Danish, Dutch and Australian administrations were present as visiting lecturers.

A great interest was taken in the presentation by the Danish and Swedish administrations of equipments and methods for supervision of trunk traffic; and likewise in the principles of centralized maintenance sketched by representatives of administrations of Finland and Australia.

In order that special problems might be discussed in greater detail the delegates were divided into groups dealing with the maintenance of line plant, subscriber, transmission and switching equipments.

Representatives of the Swedish Administration reported on the general principles for the new maintenance organization. Delegates had the opportunity to see how these principles worked out in practice through a visit to the Örebro Area.

At the conclusion of the conference the delegates were invited to spend a week in Finland, where they visited the Turku, Tampere and Helsinki telephone administrations.

The representatives of the participating countries put forward many interesting and valuable points of view during the conference. As on earlier occasions, therefore, L M Ericsson is pleased to state that the goal of the conference has been attained, viz., through the exchange of experience between supplier and qualified representatives of the maintenance divisions of telephone administrations, to acquire information and points of view which will be of use in the efficient further development of telephone equipments.

## Ericsson Technics

The 22nd annual volume of Ericsson Technics is now complete after the issue of No. 4, 1966.

The first number for the year, with three articles, was reviewed in Ericsson Review No. 2, 1966.

Ericsson Technics No. 2 comprises two articles, "Submillimeter Wave Amplification in a Periodic Structure", by J. M. Meyer and "High Frequency Conductivity, Carrier Waves, and Acoustic Amplification in Drifted Semiconductor Plasmas" by K. Blötekjær.

No. 3 consists of a doctor's thesis, "Congestion Studies in Telephone Systems with Overflow Facilities" by B. Wallström.

No. 4 contains the following articles: "Image Parameter Analysis of Pulsed Filters" by T. Laurent, "Non-Linear Coupling between Slow and Fast Waves in a Waveguide Partially Filled with a Plasma" and "Wave Propagation in a Parallel-Plate Waveguide Partially Filled with a Hot and Inhomogeneous Plasma", both by P. Hedvall, "Synthesis of Non-Minimum-Phase Microwave Filters" by T. Fjällbrant.

## L M Ericsson Cooperates with Industrial Security Company

L M Ericsson and Allmänna Bevakningsaktiebolaget (ABAB) have concluded an agreement for cooperation within the field of industrial security. The agreement is aimed at the development of systems and equipment for supervision of different kinds of premises and plant, including military stores.

Among the aims are to develop efficient automatic supervisory equipment, new components for alarm and protection, and recording equipment. Reliable systems for automatic supervision over large areas are also scheduled for investigation. It is hoped that large plants will be computer-controlled.

The Ericsson Group can draw upon its great experience within the industrial security field.

ABAB is a government-owned enterprise which is in charge of the supervision of government plant, including military plant, for which the security requirements are very high. ABAB works not only within the government sphere but also competes on the private market with other industrial security companies.

**At the end of last year a seminar was held at Taipei, Taiwan, on modern crossbar switching technique for the technical management of the Taiwan Telecommunication Administration. The journal "Voice of Telecommunications" in Taipei reported the event, as appears in the cutting below. On the left in the photograph is seen Mr. Hien-Chee Fang, President of Taiwan Telecommunication Administration, and Mr. K. Albertsson, L M Ericsson, Stockholm, in front of a crossbar switch.**


合辦縱橫制交換機技術研討會

# Opening of Exchange in Mendoza

(From left) The exchange is inspected by, in the left foreground, Col. G. Eppens, President of the Mendoza Telephone Administration, General J. E. Blanco, Governor of the Province, and Sr. P. C. Figueroa of Cia Argentina de Teléfonos (CAT).

The photograph on the right shows the inaugural ceremony. (From left) Sr. L. M. Magistocchi, Minister of Public Works, Governor J. E. Blanco, Mr. A. Nyberg, President of CAT, Mr. B. Lundvall, President of L M Ericsson, Monseñor O. S. Maresma, Sr. P. C. Figueroa, CAT, Dr. I. Brero, CAT, and Sr. H. Lottero, Chairman of the Provincial Association of Trade and Industry.

In the lower photograph: musical entertainment during the asado.

A new automatic exchange at Villa Nueva in the Mendoza Province of the Argentine, with a final capacity of 10,000 ARF lines, was opened during the visit of Mr. Björn Lundvall to the Argentine in May. Sr. Hugo Lottero, Chairman of the Provincial Association of Trade and Industry, in a speech on the occasion, recalled "the long friendship between Mendoza and Compania Argentina de Teléfonos" (CAT), which, especially in the province of Mendoza, has proved "its efficiency in the indispensable telephone service", and stated that the opening of the exchange was regarded as a milestone in the new work planned by the company within the province.

Sr. Lottero recalled that, "even when the entire country appeared to be in the throes of depression", CAT had always given evidence of its confidence in the future.

He emphasized the significance of CAT's constantly increasing investments in and extensions and improvements of the telephone service in the province. He issued a hearty welcome to the President of L M Ericsson, through whose cooperation and support CAT has been able to accomplish such important improvements in the telephone service.

The business community of Mendoza, said Sr. Lottero, were well aware of the difficulties encountered by CAT in their development plans, but he hoped that the problems would now be overcome since the country had entered into a stage of vigorous recovery and that, with renewed efforts, the lost time would soon be made up.

Sr. Lottero congratulated CAT and LME on the opening of the Villa Nueva exchange and hoped that CAT would continue in its activities which it had pursued with such enthusiasm. He assured CAT of the cooperation and support of his association in the conviction that they would thus be contributing to the increased welfare and progress of the province.

In conjunction with the opening of the exchange a large "asado" was held at Tuspungato, a small community on the slopes of the Andes, for 500 persons including the staff of CAT.

Mr. B. Lundvall and his wife attended the "asado" at which barbecued calf, strongly spiced sausage, wine, fruit, etc. were served.


At a Space and Aviation Exhibition in Paris from May 26—June 4 L M Ericsson had its own stand and also exhibited jointly with other Swedish firms (Swede-group). The photograph shows the L M Ericsson stand with a model of the radar for the 37 Viggen aircraft as eyecatcher. The aircraft radar was made by L M Ericsson and the central and line-of-sight indicator by SRA.

# Change of President in Holland

Dir. J Badon Ghijben

Dir. E Brandsma

Mr. J. Badon Ghijben retired on pension on June 30, 1967, from the presidentship of Ericsson Telefoonmaatschappij, N. V., Rijen, Holland. In conjunction therewith he was appointed a member of the company's board.

After graduation from the Delft Institute of Technology in 1929 Mr. Badon started as sales engineer in the Telephone Division of Koopman & Co., Amsterdam, who were then L M Ericsson's agents in Holland. When the Group opened its own sales office in the Hague in 1932, he entered the company's service and, at the merging of the sales office with L M Ericsson's manufacturing company in Rijen a few years later, he was transferred there. He was appointed president of ETM in 1945.

Under Mr. Badon's leadership the company has developed vigorously and now has more than 700 employees at the factory in Rijen, the sales office in the Hague and the installation departments in Rotterdam and Amsterdam.

He has also held a number of honorary positions outside the company. For his contributions to Swedish industry Mr. Badon was made a Knight of the Swedish Vasa Order in 1955. He is also one of the few members of the Group outside Sweden who has been awarded an L M Ericsson Gold Medal.

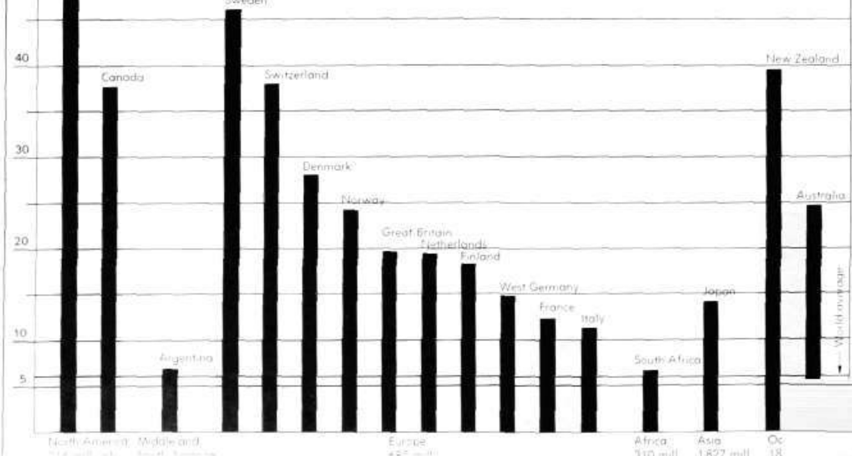
On the day of his retirement Mr. Badon was made Knight of the Dutch Oranje Nassau Order and was awarded the Medal of Honour of the Rijen Municipality. Through his admirable personal attributes and warm and incessant interest in the personal welfare of the staff Mr. Badon has won a large number of friends both inside and outside the company, who now wish him well in his well deserved retirement.

*

Mr. E. Brandsma, Executive Vice President, has been appointed President of ETM as from July 1, 1967. After taking an engineering degree in 1931 Mr. Brandsma worked in the Dutch PTT, and thereafter in a similar position in Java. After the end of the war he returned to Holland and in 1947 joined ETM as head of the Telephone Exchange Division. He became Executive Vice President in 1966.

---

**At the beginning of 1966 the number of telephones in the world exceeded 200 million, which is twice as many as ten years ago. During 1965 alone the figure rose by 12,8 million. The diagram shows the telephone density on January 1, 1965, according to "The World's Telephone".**




**Is this what . . .**
*Cont. from p. 133*

has an elegant form. Both the body of the telephone and the handset are subordinated to the design requirements. The model is usable both for loudspeaking and non-loudspeaking telephones.

## PURCHASED PROPOSALS

Bengt Reimers, Laszlo Mersich, Stig Eriksson, all employed within the Erga Division, presented a joint proposal which was considered worthy of development and was purchased. The value of their proposal lies in its originality.

The idea of a divisible sphere, the upper part of which is used as handset and the lower part as telephone casing, conceived by Juan Arpa of the Head Office staff, was also purchased.

The proposals submitted by Gösta L. Hellström and Bengt Romare of the Erga Division were also purchased. Mr. Hellström's proposal was considered by the jury to be original having regard to the fact that it is based on a traditional handset and dial of Dialog type. Mr. Romare has attempted to combine a non-loudspeaking and loudspeaking telephone within a handset-like form.

## HONOURABLE MENTIONS

Pedro Aybar Garcia, of the Head Office staff, received an honourable mention for his idea of a videophone. Stefano Bassetti of FATME, Italy, received an honourable mention for a telephone recessible in a desk. The third honourable mention went to Alfred Schreyer, of L M Ericsson, Rio de Janeiro, Brazil, who presented an ingenious method of building a shoulder support onto the handset for use when both hands are engaged.

# SIB Merges with Parent Company

For greater efficiency of the Ericsson Group activities within the signalling field-by, in other ways, better utilization of the parent company's resources-L M Ericsson Signalaktiebolag (SIB) will be merged in the parent company as from January 1, 1968, and will thereby cease to operate as an independent company.

Externally, the activities will be conducted in the same way as hitherto; internally, the MI Division of L M Ericsson will be allocated a new department–Signalling Department–with Mr. Gösta Neovius as head.

## Representatives

Please turn page for list of associated and co-operating enterprises and technical offices

### • EUROPE •

**Austria**

Telecom Handelsgesellschaft m. b. H., *1140 Wien*, Schanzstrasse 33, tel: 72 26 21, tgm: teleric, telex: 116 38

**Belgium**

Allumage Lumière S.A. *Bruxelles 7*, 128-130, chaussée de Mons, tel: 22 98 70, tgm: allumalux, telex: 21582

**Greece**

Angelos Cotzias *Athens*, 39, Odos Acadimias, tel. 626-031, tgm: cotziasan, telex: 252

**Iceland**

Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

**Spain**

TRANSA Transacciones Canarias S.A., *Las Palmas de Gran Canarias*, Tomas Morales 38, tel: 21 85 08, tgm: transa, telex: 08-24

**Yugoslavia**

Merkantile Inozemna zastupstva *Zagreb* pošt pretinac 23, tel: 36941, tgm: merkantile, telex: 21139

### • ASIA •

**Burma**

Myanma Export Import Corp., Import Division (Electrical Stores) *Rangoon*, P.O.B. 403, tel: 146 18, tgm: myanimport

**Cambodia**

Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 23334, tgm: comink

**Cyprus**

Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides
S.A. Petrides & Sons Ltd. *Nicosia*, P. O. B. 1122, tel. 2788, tgm: armature

**Hong Kong och Macao**

Swedish Trading Co. Ltd. *Hong Kong*, P. O. B. 108, tel: 23 10 91, tgm: swedetrade

**Iran**

Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

**Iraq**

Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 87031, tgm: alhamra

**Japan**

Gadelius & Co. Ltd. *Tokyo C*, P.O.B. 1284, tel. 403-2141, tgm: goticus, telex: 242-2075

**Jordan**

The Arab Trading & Development Co., Ltd. *Amman.*, P.O.B. 1, tel: 25981, tgm: aradeve

**Korea**

Gadelius & Co. Ltd. *Seoul*, I.P.O. Box 1421, tel: 22-9866, tgm: gadeliusco

**Kuwait**

Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat

**Lebanon**

Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 231624, tgm: skefko

**Malaysia and Brunei**

Swedish Trading Co. (M) Ltd. *Kuala Lumpur*, P.O.B. 2298, tel: 25316, tgm: swedetrade

**Pakistan**

TELEC Electronics & Machinery Ltd. *Karachi 3*, 415, Mahboob Chambers, Victoria Road, tel: 52648, tgm: elco

**Philippines**

U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: 722344

**Saudi Arabia**

Engineering Projects & Products Co. Ltd, Eppco *Riyadh*, P. O. B. 987, tel: Jamhur 271, tgm: eppcol

**Singapore**

Swedish Trading Co. (M) Ltd. *Singapore 1*, P. O. B. 2791, tel: 943 62, tgm: swedetrade

**Syria**

Constantin Georgiades, *Damas*, P.O. B. 2398, tel: 266 73, tgm: georgiades

**Trucial States, Muscat Oman**

DOLPHIN Trading & Contracting Establisament, *Dubai, Trucial States*, P. O. B. 1566, tel: 0639, tgm: dolphin

**Vietnam**

Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, P. O. B. 1049, tel: 22660, tgm: telerad

### • AFRICA •

**Congo**

I.P.T.C. (Congo) Ltd. *Kinshasa 1*, P. O. B. 8922, tel: 5345, tgm: induexpan, telex: RC KIN 52.074

**Ethiopia**

Mosvold Company (Ethiopia) Ltd. *Addis Ababa*, P.O.B. 1371, tel: 14567, tgm: mosvold

**Ghana**

R.T. Briscoe Ltd, *Accra*, P.O.B. 1635, tel: 669 03, tgm: Briscoe, telex: 295

**Kenya, Tanzania, Uganda**

Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

**Liberia**

Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Streets, tel: 22222, tgm: radiolibe

**Libya**

ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 33906, tgm: adeco

**Mauritius**

Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

**Mozambique**

J. Martins Marques & Ca. Lda. *Lorenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

**Nigeria**

I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult, telex: shell bp 35

**Sudan**

Contomichalos, Sons & Co. Ltd. Engineering & Agencies Dept., *Khartoum*, P.O.B. 866, tel: 77 695, tgm: suconta, telex: 251

**South Africa, South-West Africa**

Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

**Tunisia**

Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

### • AMERICA •

**Bahama Islands**

Anglo American Electrical Company Ltd. *Freeport, Grand Bahama*, P.O.B. 104

**Bolivia**

Johansson & Cia, S. A. *La Paz*, Casilla 678, tel: 25 923, tgm: johansson, telex: 5211

**Costa Rica**

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel.: 22 55 11, tgm: troco

**Dominican Republic**

Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3445, tgm: gartier

**Guatemala**

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira

**Guiana**

General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwlks

**Honduras**

Quinchón Leon y Cia *Tegucigalpa*, Apartado 85, tel: 2-5171, tgm: quinchon

**Jamaica and Brit. Honduras**

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

**Netherlands Antilles**

S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao* P.O.B. 304, tel: 11200, 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, telex: PA 134.

**Paraguay**

S. A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

**El Salvador**

Dada-Dada & Co. *San Salvador* Apartado 274, tel: 21 66 66, 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, N.Y 10003*, 215 Park Avenue South, tel: (212) 677-8400, tgm: statelabs, telex: (212) 867-6996 (For electron tubes)

### • AUSTRALIA & OCEANIA •

**New Zealand**

ASEA Electric (NZ) Ltd. *Wellington C. 1.*, P.O.B. 3239, tel: 70-614 tgm: asea, telex: NZ 3431

# The Ericsson Group

## *Associated and co-operating enterprises and technical offices*

Please turn page for list of further sales offices

### • EUROPE •

**Denmark**

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson, telex: 9020 ericsson kh

Telefon Fabrik Automatic A/S *Søborg*, Telefonvej 6, tel: 69 51 88, tgm: automatic, telex: 5264

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

A/S Tele-Center *Glostrup*, Sandager 8, tel: 96 18 88

**Finland**

O/Y L M Ericsson A/B *Helsingfors*, P. O. B. 13018, tel: A 8282 tgm: ericssons, telex: 12—546

**France**

Société Française des Téléphones Ericsson *F-92-Colombes*, 36, Boulevard de la Finlande, tel: Paris (1) 242 35 00, tgm: ericsson colombes, telex: 62179 *F-75-Paris (17e)*, 147, rue de Courcelles, tel: Paris (1) 227 9530, tgm: eric paris

Centrum Electronic S. A. *Paris 17e* 32, Rue Legendre, tel: 267 30.10, tgm: centrumfrance

**Great Britain**

Swedish Ericsson Company Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Production Control (Ericsson) Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Centrum Electronics Ltd. *London S.W.I.*, tel: SLOane 0451, tgm: celefon telex: 26 13

Centrum Rentals Ltd. *London S. W. I.*, Terminal House, Grosvenor Gardens, tel: Sloane 0451, tgm: celefon, telex: 2613

**Ireland**

L M Ericsson Ltd. *Dublin 2*, 32, Upper Mount Street, tel: 61931, tgm: ericsson, telex: 5310

**Italy**

FATME, Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 4694, tgm: fatme, telex: 61.327 fatme

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

SIELTE, Soc. per Az. *00100 Roma*, C. P. 5100, tel: 577 8041, tgm: sielte

**Netherlands**

Ericsson Telefoonmaatschappij, N.V. *Rijen (N.Br.)*, tel: 01692-3131, tgm: erictel, telex: 54114

*Voorburg-Den Haag*, P.O.B. 3060, tel: 81 45 01, tgm: erictel-haag, telex: 311 09

**Norway**

A/S Elektrisk Bureau *Oslo 3*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 1723

A/S Industrikontroll *Oslo 6*, Grenseveijen 86/88, tel: Centralbord 68 34 64 tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.B. 500, tel: 83 76 50, tgm: kabel

A/S Norsk Signalindustri *Oslo 3*, P.B. 5055, tel: 46 18 20, tgm: signalindustri

A/S Tele-Systemer *Oslo 6*, Plogveien 3 B, tel: 68 62 95, tgm: gyllingsystem

**Portugal**

Sociedade Ericsson de Portugal Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 571 93, tgm: ericsson

**Spain**

Cia Española Ericsson, S. A. *Madrid 13*, Torre de Madrid, Plaza de España tel: 241 14 00, tgm: ericsson, telex: 7369

**Sweden**

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 08/19 00 00, tgm: telefonbolaget, telex: 199 10

AB Alpha *Sundbyberg*, tel: 08/28 26 00, tgm: aktiealpha telex: 10082

Casa Konsult AB *Älvsjö*, Huddingevägen 417—19, tel: 08/47 25 65, tgm: casakonsult

AB Ermi *Karlskrona 1*, tel: 0455/230 10, tgm: ermibolag

AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308 stockholm

AB Svenska Elektronrör *Stockholm-Tyresö 1*, tel: 08/712 01 20, tgm: electronics, telex: 1275

Instruktionsteknik AB, *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

L M Ericsson Data AB *Solna*, tel: 08/83 07 00, tgm: ericdata

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 08/68 07 00, tgm: signalbolaget

L M Ericsson Telemateriel AB, *Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00 tgm: ellem, telex: 1275

Sieverts Kabelverk AB *Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676

Svenska Radioaktiebolaget *Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio, telex: 10094

**Switzerland**

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *8032 Zurich*, Postfach, tel: 325184, tgm: telericsson, telex: 52669

**Turkey**

Ericsson Türk Ticaret Ltd. Sirketi *Ankara*, Rumeli Han, Ziya Gökalp Cda., tel: 123170, tgm: ellem

*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02 tgm: ellemist

*Izmir*, Izmir Bürosu, Kisilkaya Han, Kat 3. No 13, Halit Ziya Bulvari, tel: 378 32, tgm: ellemir

**West Germany**

Deutsche Ericsson G.m.b.H. Telematerial, *4 Düsselorf-Rath*, Postfach 136, tel: (0211) 63 30 31, tgm: erictel, telex: DSSD 8586871

Centrum Electronic Handels-GmbH, *3 Hannover*, Dornierstrasse 10, tel: 63 10 18, tgm: centronic, telex: 0922913

### • ASIA •

**Hong Kong**

Telefonaktiebolaget L M Ericsson Technical office *Hong Kong*, P. O. B. 13478 tel: 23 10 91, tgm: elleme

**India**

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: 45 44 94, tgm: inderic

*New Delhi 16*, L25, South Extension Part II, tel: 76505 tgm: inderic

**Indonesia**

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151—153, tel: 8294, tgm: javeric

*Djakarta*, Djalan Gunung Sahari 26, tel: OG 48531, tgm: javeric

**Iraq**

Telefonaktiebolaget L M Ericsson, Technical office *Baghdad*, P.O.B. 493, tel: 914 54, tgm: ellemco

**Kuwait**

Telefonaktiebolaget L M Ericsson, Technical office, *Kuwait, State of Kuwait*, P. O. B. 5979, tel: 25 151, ext. 29, tgm: erictel

**Lebanon**

Telefonaktiebolaget LM Ericsson, Technical office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, tgm: ellem

**Thailand**

Ericsson Telephone Corp. Far East AB *Bangkok*, P.O.B. 824, tel: 58041-,43 tgm: ericsson

### • AFRICA •

**Egypt (UAR)**

Telefonaktiebolaget LM Ericsson, Technical office Egypt Branch *Cairo*, P.O.B. 2084, tel: 46581, tgm: elleme

**Ethiopia**

Telefonaktiebolaget L M Ericsson, Technical office, *Addis Ababa*, P. O. B. 3366

**Kenya**

Telefonaktiebolaget L M Ericsson, Technical office, *Nairobi*, P.O.B. 9063, tel. 271 06, tgm: ellem

**Morocco**

Société Marocaine des Téléphones Ericsson *Casablanca*, 38, rue Mohamed Sedki, tel: 788-75, tgm: ericsson

**Rhodesia, Botswana and Malawi**

Ericsson Telephone Sales Corporation AB, *Salisbury, Rhodesia*, P.O.B. 2891, tel: 25 737, tgm: ericofon

**Tunisia**

Telefonaktiebolaget LM Ericsson, Technical office, *Tunis*, Boite Postale 780, tel: 240520, tgm: ericsson

**Zambia**

Ericsson Telephone Sales Corporation AB *Ndola*, P. O. B. 2256, tel: 3885, tgm: ericofon

### • AMERICA •

**Argentine**

Cía Ericsson S.A.C.I. *Buenos Aires* Casilla de Correo 3550, tel: 332071, tgm: ericsson

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel

Industrias Eléctricas de Quilmes S. A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenos-aires

**Brazil**

Ericsson do Brazil Comércio e Indústria S. A. *Rio de Janeiro C. P.* 3601-ZC-00, tel: 43-0990, tgm: ericsson, telex: rio 310

**Canada**

L M Ericsson Ltd. *Montreal 9, P.Q.*, 2300 Laurentian Boulevard City of St. Laurent, tel: 331-3310, tgm: caneric, telex: 1-2307

Gylling Canada Ltd. *Montreal*, 1203, IBM Building, 5, Place Ville Marie

**Chile**

Cía Ericsson de Chile S. A. *Santiago*, Casilla 10143, tel: 82555, tgm: ericsson

**Colombia**

Cía Ericsson Ltda, *Bogotá*, Apartado Aéreo 4052, tel: 411100, tgm: ericsson

**Costa Rica**

Telefonaktiebolaget L M Ericsson, Technical office *San José*, Apartado L. M. E., tel: 21 14 66, 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. *Mexico D. F.*, Apartado 9958, tel: 464640, tgm: coeric

Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado 25737, tel. 49 36 50, tgm: latincasa

Teleindustria, S. A. de C.V. *Mexico I, D.F.* apartado 1062, tel: 464640, tgm: ericsson, telex: 017:7485

Telemontaje, S. A. de C. V. *Mexico 1, D.F.*, Apartado Postal 1062, tel: 46 78 11, tgm: ericssonmexicodf, telex: 017-7485

**Peru**

Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson, telex: 3540202

Soc. Telefonica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060, tgm: telefonica

**El Salvador**

Telefonaktiebolaget LM Ericsson, Technical office *San Salvador*, Apartado 188, tel: 21-7640, tgm: ericsson

**Uruguay**

Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

**USA**

The Ericsson Corporation *New York, N.Y. 10017*, 100 Park Avenue, tel: 68 54 030, tgm: erictel, telex: erictec 620484

L M Ericsson Centrum Inc. *New York, N. Y. 10016*, 16, East 40 Street, tel: 6791001, tgm: erictel, telex: 620149

North Electric Co. *Galion, Ohio 44833*, P.O.B. 688, tel: (419-)468—2420, tgm: northphone-galion-ohio, telex: 098-728

**Venezuela**

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson telex: 734

### • AUSTRALIA & OCEANIA •

**Australia**

L M Ericsson Pty. Ltd. *Broadmeadows, Victoria*, P.O.B. 41, tel: 309 2244 tgm: ericmel, telex: AA 30555

*Rushcutters Bay N.S.W.*, 134 Barcom Avenue, tel: 31 09 41, tgm: ericsyd

Teleric Pty. Ltd *Broadmeadows, Victoria* P.O.B. 41, tel: 309 2244, tgm: teleric, telex: AA 30555

*Rushcutters Bay N.S.W.*, 134 Bacrom Avenue, tel: 31 09 41, tgm: teleric

ESSELTE AB. STHLM 67

# ERICSSON Review

4
1967

# ERICSSON REVIEW

Vol. 44 No. 4 1967

RESPONSIBLE PUBLISHER: CHR. JACOBÆUS, DR. TECHN.

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

## CONTENTS



On cover: In the Tunis area L M Ericsson have installed automatic telephone exchanges of crossbar system ARF. The cover shows the Carthage exchange installed in 1962.

# Maintenance of Telephone Exchanges in Tunis

HABIB BEN CHEIKH, CHIEF ENGINEER, TUNISIAN PTT

UDC 621.395.722.004.5
LME 154

*The installation and cut-over in 1962 of the automatic exchanges in Tunis, comprising 23,000 lines of* **L M** *Ericsson's crossbar system* **ARF** *10, were described in Ericsson Review No. 1, 1963. These exchanges were Carthage I (8000 lines), Carthage II (4000 lines), Belvédère (5000 lines), Kasbah (4000 lines), Le Kram (1000 lines) and La Marsa (1000 lines).*

*Other exchanges in the area, Megrine (1000 lines) and Hammam-Lif (1000 lines), have since been added. The Carthage, Belvédère and Le Kram exchanges have been extended.*

*Recently* **ARM** *exchanges have been installed in Tunis, Bizerte, Sousse and Sfax, which earlier had* **ARF** *10 equipment. The telephone traffic between these towns is now fully automatic.*

*The object of this article is briefly to describe the tests carried out in conjunction with the take-over of the first* **ARF** *10 equipments in the Tunis area. It will also deal with the general principles adopted for their maintenance.*

*The results in respect of the later* **ARF** *and* **ARM** *equipments, which have not yet been taken over, will be reported later.*

**Fig. 1**
**The Carthage exchange in Tunis**

## Take-over Tests

In accordance with the contract, eighteen months after the cut-overs final take-over tests were made for the local (Carthage, Belvédère, Kasbah) and suburban Tunis exchanges (Le Kram and La Marsa) in order to find out the fault rates of the various equipments.

Simultaneous calls (four for each type of traffic) were made locally and between the exchanges from ordinary telephone sets during normal traffic periods.

For approval the failure rate for each type of traffic was not to exceed 1 %.

Table 1 shows the distribution of the test connections, failures and failure rates. Failures comprise the calls which were not established owing to faults or congestion.

*Table 1*

| From \ To | Carthage I | Carthage II | Belvédère | Kasbah | Le Kram | La Marsa | Special services |
|---|---|---|---|---|---|---|---|
| | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 400 |
| Carthage I | 1 | 2 | 3 | 1 | 0 | 1 | 0 |
| | 0.1 % | 0.2 % | 0.3 % | 0.1 % | 0 % | 0.1 % | 0 % |
| | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 400 |
| Carthage II | 1 | 1 | 5 | 2 | 1 | 8 | 1 |
| | 0.1 % | 0.1 % | 0.5 % | 0.2 % | 0.1 % | 0.8 % | 0.25 % |
| | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 400 |
| Belvédère | 3 | 2 | 2 | 3 | 1 | 1 | 4 |
| | 0.3 % | 0.2 % | 0.2 % | 0.3 % | 0.1 % | 0.1 % | 1 % |
| | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 400 |
| Kasbah | 4 | 1 | 9 | 0 | 1 | 1 | 2 |
| | 0.4 % | 0.1 % | 0.9 % | 0 % | 0.1 % | 0.1 % | 0.5 % |
| | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 400 |
| Le Kram | 3 | 1 | 2 | 1 | 0 | 2 | 1 |
| | 0.3 % | 0.1 % | 0.2 % | 0.1 % | 0 % | 0.2 % | 0.25% |
| | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 400 |
| La Marsa | 1 | 9 | 5 | 7 | 1 | 4 | 2 |
| | 0.1 % | 0.9 % | 0.5 % | 0.7 % | 0.1 % | 0.4 % | 0.5 % |

Thus for 38,400 calls 100 failures were recorded, the average failure rate being 0.25 %.

## Maintenance Organization

As already mentioned, this study is limited to the maintenance of the Tunis group of exchanges. The general maintenance organization for all *ARF* and *ARM* exchanges in the Tunisian network will be the subject of a future study.

The introduction of the new crossbar exchanges in Tunis and environs called for a radical change of the maintenance principles employed for the earlier rotary switch exchanges. The latter required purely preventive methods with frequent mechanical adjustment of switches and relays; these measures took up much time and necessitated a fairly large staff.

The principles of maintenance for the new Ericsson crossbar exchanges are entirely different. Experience during more than two years of operation has confirmed that these exchanges require no preventive maintenance whatsoever and that the number of fault repair actions is very low, of the order of 15 per 1000 lines per annum.

The now exclusively Tunisian personnel were trained in Sweden by L M Ericsson. This training, which lasted eight months for heads of exchanges and four months for technicians, produced excellent results. After the period in Sweden all the personnel trained there took part in the installation and testing of the exchanges in Tunis. This supplementary training gave them additional experience in preparation for their future tasks.

Carthage, the most important exchange, was chosen as maintenance centre for the group of exchanges concerned (3 in Tunis and 4 in its environs). Carthage has two permanently installed automatic traffic route testers from which test calls can be made on all routes in the zone. The maintenance effort is based on the measured quality of service.

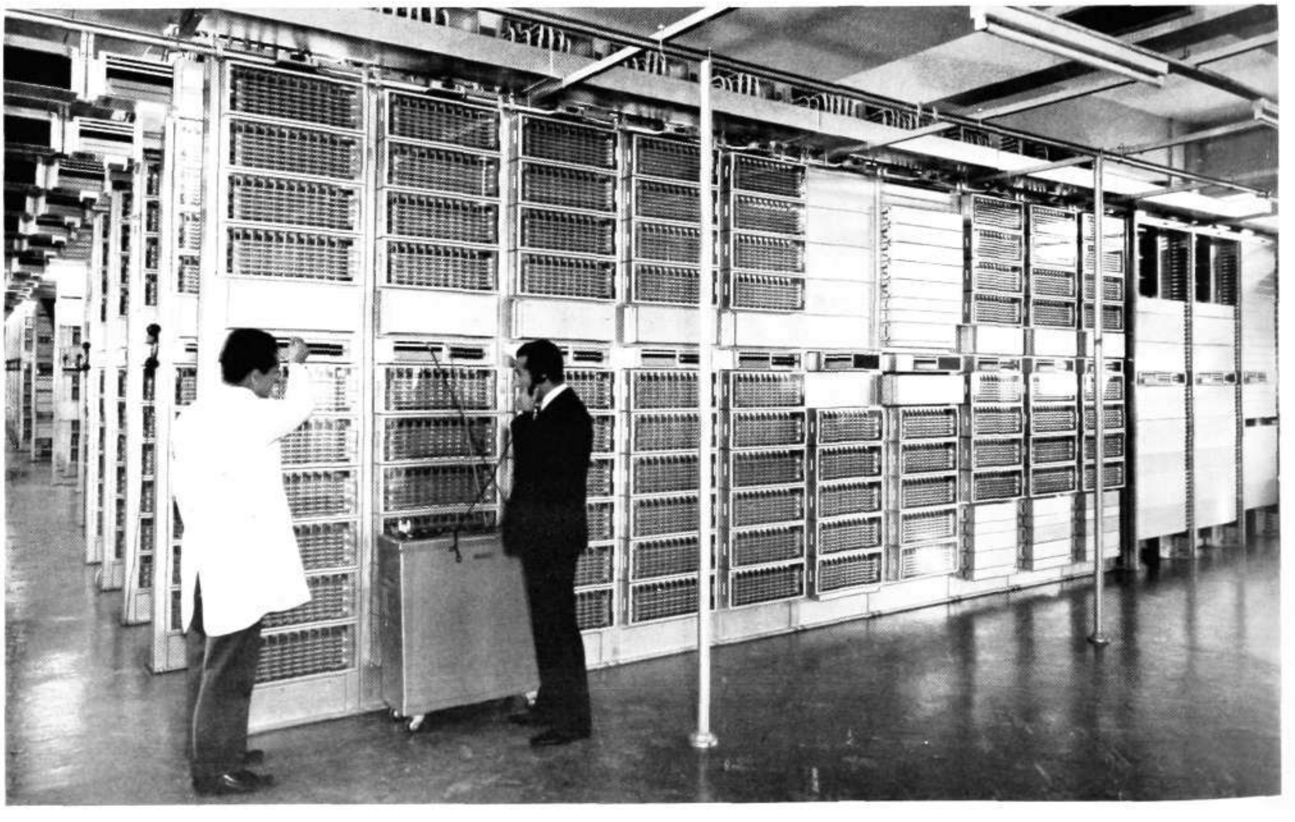
Carthage, with its 12,000 lines and traffic route testers, has six technicians. Three of them are responsible chiefly for the maintenance of the *ARF* equipment. The route tests are done by a fourth technician, and the two others form a maintenance team responsible for tests and fault tracing at exchanges in the environs.

The Carthage personnel work under the supervision of the head of the exchange, who is also responsible for the subscribers' test desk (new subscribers' installations, tracing of faults in subscribers' apparatus etc.) and rentals.

At Belvédère there is a head of exchange and one technician who looks after the maintenance of the 5000-line *ARF* equipment.

At the Kasbah exchange, comprising 4000 *ARF* lines for ordinary subscribers, 2000 *ARF* lines for government departments and 120 operators' positions for trunk and international traffic, there is a head of exchange and two technicians, one of whom is responsible for the maintenance of the *ARF* equipment and the other for the manual equipment.

**Fig. 2**
**The Carthage ARF exchange with a capacity of 12,000 subscriber lines**



This trial period in the maintenance organization, with the entire group of exchanges regarded as a single unit, is intended as a step towards a more general maintenance organization comprising all *ARF* and *ARM* exchanges throughout the country.

When the Administration takes over these exchanges in the near future, the maintenance principles will be based on the preliminary experience gained in the Tunis group.

## Maintenance Methods

For the present exchanges it was decided that maintenance should be based on a measure of the quality of service from the subscribers' point of view. This implies that testing for faults in individual switching units is done only in response to subscribers' complaints or when the failure rate for a given type of traffic or switching unit exceeds a stipulated value.

Measurement of the quality of service is done with the two aforesaid traffic route testers. These are connected to reserved test numbers (five per 1000-line group) and test all types of traffic in the zone in accordance with a predetermined programme. The test programme is arranged to be completed in about one month. If more than 1 per cent failures is found in any test cycle, immediate action is taken and checks are made with an exchange tester until an acceptable value is obtained.

Table 2 shows the number of calls, failures and failure rate for the various exchanges in a representative test cycle with a traffic route tester.

*Table 2*

| Route | Number of calls | Number of failures | Failure rate |
|---|---|---|---|
| Kasbah-Kasbah | 2,874 | 8 | 0.27 |
| Kasbah-Carthage I | 12,433 | 38 | 0.30 |
| Kasbah-Carthage II | 11,565 | 4 | 0.03 |
| Kasbah-Belvédère | 4,215 | 14 | 0.33 |
| Kasbah-Le Kram | 562 | 38 | 6.75 |
| Carthage I-Kasbah | 7,540 | 15 | 0.20 |
| Carthage I-Carthage I | 24,391 | 24 | 0.09 |
| Carthage I-Carthage II | 9,333 | 17 | 0.18 |
| Carthage I-Belvédère | 5,473 | 15 | 0.27 |
| Carthage II-Kasbah | 2,371 | 6 | 0.25 |
| Carthage II-Carthage I | 3,836 | 0 | 0 |
| Carthage II-Carthage II | 10,613 | 4 | 0.04 |
| Carthage II-Belvédère | 5,584 | 9 | 0.16 |
| Belvédère-Kasbah | 4,442 | 35 | 0.79 |
| Belvédère-Carthage I | 14,647 | 17 | 0.12 |
| Belvédère-Carthage II | 5,717 | 22 | 0.38 |
| Belvédère-Belvédère | 880 | 0 | 0 |
| Le Kram-Kasbah | 1,000 | 3 | 0.3 |
| Le Kram-Carthage I | 500 | 4 | 0.8 |
| Le Kram-Carthage II | 900 | 9 | 1.0 |
| Le Kram-Le Kram | 600 | 3 | 0.5 |
| La Marsa-Kasbah | 500 | 4 | 0.8 |
| La Marsa-Belvédère | 500 | 5 | 1.0 |
| La Marsa-La Marsa | 4,600 | 1 | 0.02 |

The table snows that the quality of service was below standard on the routes Kasbah–Le Kram, Le Kram–Carthage II and La Marsa–Belvédère. Fault tracing and repairs were therefore instituted on these three routes. The exceptionally high failure rate on the Kasbah–Le Kram route was found to be due to a fault in one of the registers. Other routes were within the stipulated standard and therefore no individual tests or fault tracing were done on them.

Apart from the route tests a periodic check is made of the occupation counters and fault counters for each marker. If the rejection owing to faults is abnormally high for a given marker, immediate action is taken to repair that marker.

No periodic maintenance is done on the switching equipments and only the batteries and switchboard cords are inspected at regular intervals.

## Fault statistics

The faults which are considered necessary to repair in order to maintain the desired quality of service are recorded with indication of cause and component concerned.

Table 3 presents a summary of fault reports during a ten-month period. The results for each exchange are shown in Table 4.

From Table 3 it will be seen that the number of faults in switches is very low, 12 % of the total, which signifies about 0.025 fault per switch per annum. In other words an L M Ericsson crossbar switch has, on an average, one fault every 40th–50th year. The corresponding figure per relay is about every 400th year.

*Table 3*

| | Component | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Switch | | | | | Relay | | | | Miscellaneous | | | | | | | | | | | | | |
| Cause of fault | Contact | Horizontal | Vertical | Coil | Miscellaneous | Contact | Coil | Armature | Miscellaneous | Resistors | Capacitors | Rectifiers | Tubes, transis. | Meters | Jacks | Cabling | IDF | Cords | Miscellaneous | Total faults | Faults per annum | *Faults/1000 lines/year* | Faults/rack/year |
| Dust | 2 | | | | | 4 | | | | | | | | | | | | | | 6 | 7 | | |
| Adjustment | 3 | 15 | 15 | | | 147 | | 22 | 4 | | | | | | 2 | | 1 | | 3 | 12 | 256 | | |
| Open | 1 | | 5 | 6 | | 3 | 9 | 1 | 1 | 2 | 1 | 1 | | | 7 | 11 | 1 | | 1 | 50 | 60 | 2,5 | |
| Soldering | | 1 | | 3 | | 9 | 2 | | 12 | 1 | | | | | 8 | 34 | 4 | | 6 | 80 | 96 | 4,0 | |
| Leakage | 3 | 1 | | | | 20 | 4 | 3 | 3 | 8 | 3 | | | | 12 | 26 | 2 | | 1 | 86 | 103 | 4,4 | |
| Wear | | | | 1 | | 9 | 4 | 3 | 1 | 1 | | | 19 | | | 3 | | | 1 | 41 | 48 | 2,0 | |
| Locking | | | | | | | | 1 | | | | | | | 1 | 1 | | 1 | | 4 | 5 | 0,2 | |
| Wiring | | 1 | | | | | | | | | | | | 4 | | 8 | | | 1 | 14 | 17 | 0,7 | |
| Miscellaneous | | 1 | | | 1 | | | | | 5 | | | | | | 1 | | | | 8 | 10 | 0,4 | |
| Total | 9 | 19 | 20 | 10 | 1 | 192 | 19 | 30 | 21 | 17 | 4 | 1 | 19 | 4 | 29 | 84 | 8 | 1 | 13 | 501 | 602 | 25,0 | 0,81 |
| Faults per 100 units/year — Sub-comp. | 0,39 | 0,80 | 0,85 | 0,42 | 0,04 | 0,16 | 0,02 | 0,03 | 0,02 | | | | | | | | | | | | | | |
| Faults per 100 units/year — Components | 2,5 | | | | | 0,23 | | | | 0.01 | 0.01 | 0,004 | 0,45 | 0,017 | | | | | | | | | |

Fig. 3

Test desk for testing subscriber's lines and receiving complaints

*Table 4*

| Exchanges | Lines | Total/10 months | Fault reports per annum | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Total | Per rack | Per 1 000 nos. | |
| Carthage | 12,000 | 310 | 372 | 1.1 | 31 | attended |
| Belvédère | 5,000 | 76 | 91 | 0.69 | 18 | attended |
| Kasbah | 4,000 | 96 | 115 | 0.63 | 29 | attended |
| Le Kram | 1,000 | 13 | 16 | 0.50 | 16 | unattended |
| La Marsa | 1,000 | 6 | 7 | 0.22 | 7 | unattended |

Table 4 shows an interesting figure, the number of faults per rack per annum, which varies between 0.22 and 1.1 for practically all racks irrespective of the equipment contained on the rack.

The unattended exchanges Le Kram and La Marsa, moreover, have a decidedly lower fault rate per rack than other exchanges.

In conclusion it may be said that the Ericsson *ARF 10* crossbar exchanges in the Tunis area have fulfilled the expectations placed on them in respect both of traffic handling, low failure rate and small maintenance requirement.

Any misgivings that major faults might interrupt the service for large groups of subscribers or routes can be entirely eliminated. After more than three years' operation one may say that the quality of service has been very good both from the subscribers' and the Administration's point of view despite the fact that, at the smaller exchanges, certain important common control units are not duplicated.

Finally it should be mentioned that the personnel have shown great enthusiasm and conscientiousness in quickly gaining a command of the new technique, both theoretically and practically, and that their achievement has greatly contributed to the excellent results obtained.

# European Cooperation in Telecommunications

C. JACOBÆUS, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 001.83:654.1
LME 016.80

*This report was presented to the European Telecommunication Conference arranged by the British Council of the European Movement in London on 15–16 June 1967. The report constitutes Appendix III of the main reports to the Conference.*

*By telecommunications is meant in this report telephony, telegraphy, telex, data transmission, video transmission and video telephony.*

## The general role of telecommunications in our age

To measure the value of telecommunications in the world today is a difficult task. Telecommunications are a part of modern life, without which our society could not function. All our everyday activities are so intimately associated with telecommunications services of different kinds that we could not do without them. The economic value of telecommunications cannot be assessed, partly because there is no alternative to take their place.

One can approach the problem, however, from another aspect. One must assume that the spread of telecommunications services is related to their use. For the main part, at least in the long-term view, there is a free market for telecommunications. People procure a telephone and use it to an extent dependent on the price of the service in relation to its value to them.

The most important telecommunications service is telephony. This report will start with a few statistical data about the telephone situation in some of the European countries and the United States.

*Table 1. Statistical data of telephone situation in some European countries and the U.S.A.*

| | Telephone Density | | | Investments average 56–64 | | Charges | |
|---|---|---|---|---|---|---|---|
| | Tel. per 100 inh. | | In-crease 56–64 % | In rel. to GNP % | Per new tel. Sw.Cr. | Local calls Sw.Cr. | Trunk calls 200 km Sw. Cr./3 min. |
| | 1956 | 1964 | | | | | |
| U.S.A. | 35.9 | 46.2 | 28.7 | 0.40 | 5 000 | 0.26 | 5.20 |
| Sweden | 30.2 | 41.9 | 38.7 | 0.53 | 3 800 | 0.10 | 1.40 |
| U.K. | 13.5 | 17.3 | 28.1 | 0.48 | 6 500 | 0.12 | 2.50 |
| Germany | 8.2 | 14.0 | 70.7 | 0.45 | 4 100 | 0.23 | 2.80 |
| France | 7.6 | 11.8 | 55.3 | 0.30 | 4 000 | 0.33 | 2.25 |
| Holland | 11.2 | 17.9 | 59.8 | 0.35 | 2 600 | 0.07 | 0.80 |
| Denmark | 20.6 | 27.6 | 34.0 | 0.60 | 5 300 | 0.08 | 1.20 |
| Norway | 17.7 | 23.4 | 32.2 | 0.73 | 8 500 | 0.18 | 1.80 |

Another point of interest would be the running costs per annum, but there is no available statistic in this respect.

The investments have been calculated per added subscriber. This is a simplification since, of course, administrations have expenses for progressive automatization and for meeting the increase of traffic generated by already existing subscribers.

One observes that the difference between countries is very great. It is difficult to explain why the conditions differ so much even in countries of similar structure. There are presumably certain chance phenomena which affect the situation. In some cases, however, purely geographical conditions are obviously an important factor, as also is the population density. It is more expensive to build telephone plant in a sparsely populated, mountainous country like Norway than in a thickly populated, flat country like Holland.

In this report we wish to lay particular emphasis on the conditions in Sweden. After the U.S.A. Sweden has the highest telephone density in the world and is far ahead of other European countries. Despite high wages the investment per new telehone is lower than in any other country except Holland. The tariffs are also low – Denmark and, again, Holland being the only countries with a cheaper telephone service. Sweden's leading position can be traced back to the conditions prior to 1918, when there were two competing administrations which really exerted themselves to provide a service at a low price and which also pursued an extremely active subscriber acquisition policy. This competition resulted in a rationalization of operation and plant construction. The telephone density rose to a high level, tariffs were lowered – all of which advantages have been maintained or further reinforced.

The Swedish telephone administration has been able to preserve a cost-minded attitude and is open to modern efficiency methods. It has been actively supported by the Swedish government, which has accepted that the administration makes free use of depreciation funds for new investments. These depreciation funds have also been generously calculated, being based on the replacement value and not on the booked value.

It cannot be proved that a stimulation of investments in telephony beyond the requirements of "natural growth" provides a greater yield from the national

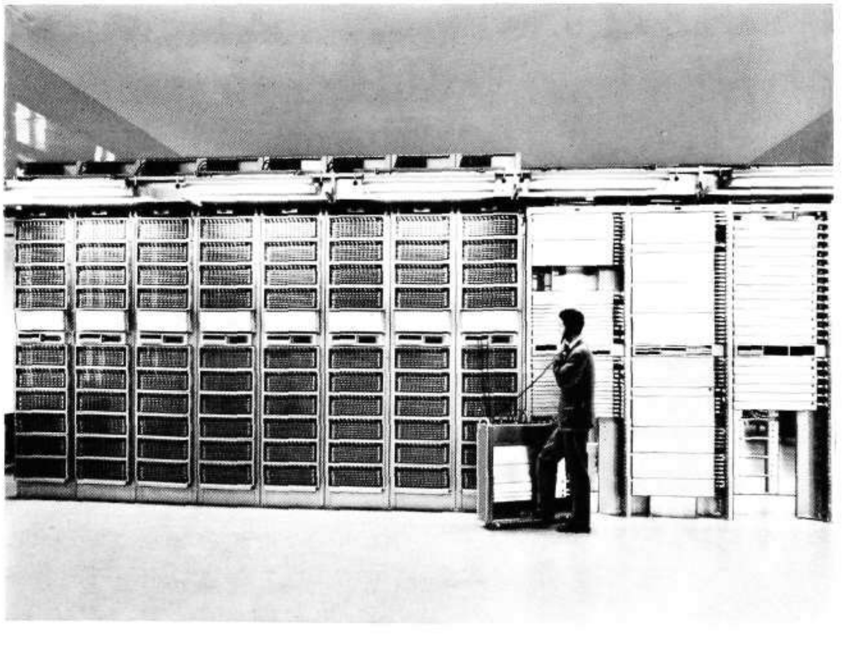


**Fig. 1**
**L M Ericsson ARF exchange in Rotterdam, Holland**

point of view than other competitive investments. The Swedish example – since the fusion of the administrations – should, however, show that the advantages of large-scale operation also apply to the telecommunications field. Competition between administrations within a country is in our days unrealistic on structural grounds. The administrations have therefore a great handicap compared with other enterprises which have the stimulus of competition. Cost-mindedness and efficiency must nevertheless be maintained.

## Factors which affect the growth of telecommunications

If one regards the growth of telecommunications as a problem of supply and demand and, for the moment, disregards the capital question, one finds that the supply side is dependent partly on the means of production and partly on the supply of manpower. The physical means of production, such as manufacturing points, are hardly a limiting factor. They can at all events be expanded fairly quickly. The capital for such expansion can undoubtedly be found if a fairly long-term, profitable market can be assumed.

The supply of technically trained labour is a problem in many countries. The difficulty is especially in attracting technicians for planning of new plant. The often rigid wage systems of administrations may be an obstruction to recruitment of capable personnel. The remedy should be a more flexible wage system and extended facilities for training, both within the framework of the administration and through normal educational facilities. In many cases the suppliers should be able to offer planning and project management.

Personnel problems may also arise within the operations sector. Apart from the usual training schemes attention should be paid to the rationalization of maintenance and operation. In the planning of plant and in the choice of equipment the decisive factors – apart from the purchase conditions – should be quality, reliability, and simplicity of maintenance.

An important factor is the form for conducting telephone operations. The form of organization existing in Sweden and some of the European countries, namely a commercially operating government department, would appear to be ideal. It may be compared most nearly with a utility undertaking with the government as shareholder. Through its terms of reference the Administration is relatively free within its sphere of activities and in its method of operation. The alternative form of a telecommunications ministry undoubtedly leads to greater bureaucracy and less efficiency. It also becomes dependent on temporary political currents, which does not promote a sound development of telecommunications.

A well managed telecommunications administration should hardly need to count on an increase of personnel for a normal increase in volume of its business – rationalization measures should maintain at least the same rate as the expansion of the business.

The factor which has been most obstructive to growth since the war has been the shortage of capital. Many countries have been unable to make funds available to their administrations for the necessary expansion. Through the continuous industrialization and bureaucratization and, naturally, owing to the rapid rise in the standard of living for all population strata, a demand has been created which could not be met within the narrow limits determined by governments. Waiting-subscriber lists now exist in many European countries. At the same time trunk automatization has been neglected in many places. One of the most important tasks for those who are convinced of the necessity of a first-class telephone service is to find means of improving the capital supply for the administrations. Different means have been tried in different countries. One has been subscriber financing, i.e. new subscribers have had to loan money to the administration as a condition for having a telephone, corresponding roughly to the investment cost for the subscriber line with its share of the switching equipment and installation charges. In other cases suppliers have had to give credit. These courses are obviously emergency solutions and, probably, expensive for the administration. The correct course, naturally, is to convince the government that it is necessary to meet the capital requirement from the national budget or through the capital market in the normal manner. Ministers of finance are best convinced by offering them the prospect of profitable investments, which in turn calls for a method of accounting by the administration in which income, expenditure and profits for each part of the business are based on strictly commercial accounting principles. A particular point to notice is that the postal business must be kept separate from the telecommunications business in the accounts.

On the demand side, we may first consider *tariff questions*. Tariff schedules should be based on purely business principles. The level of tariffs should naturally be such as to bring a reasonable profit. Telephone operations in large cities and also trunk traffic usually result in a very good profit. Rural areas, on the other hand, do not as a rule yield an interest on capital investment. The matter cannot be viewed in this limited light, but it must be considered that urban subscribers also benefit from being able to speak to rural subscribers. The latter, therefore, will further improve the utilization of capital in the urban areas. There are also social reasons for providing sparsely populated districts with telephones on reasonable conditions.

The distribution of income from different parts of the business is greatly affected by the tariff scales. In the same way it is inevitable that the demand within different sections will be influenced by the tariffs. An example may be taken from the telegraph sector. In most administrations telegraphy runs at a loss. The administration attempts systematically to reduce the attraction of telegraphy by raising the tariffs (concurrently with a deterioration of service) and, instead, to stimulate the use of telex, which requires less personnel at the administration.

Politicians may perhaps be tempted to exaggerate the social element in the fixing of tariffs. This imposes a load on the "productive" subscribers, i.e. in business and industry. It is reasonable that the latter should pay something to enable remote subscribers to have a telephone. If the situation is taken too far, however, the subsidizing of these subscribers should be done through the national budget.

For some governments telephony has become a milch-cow. The practice of using a national monopoly relating to a public utility for fiscal purposes is a dubious one. It is also debatable, naturally, whether telephony should carry general taxes of the purchase or surplus value type. The important point is that telephony should not be discriminated in relation to other government or private activities. Ministries of finance should be contented with the satisfactory yield on invested capital that an effectively managed administration can bring them, especially as, with the growth of telephony, the yield becomes still greater.

The demand will naturally be dependent on the services offered by the administration. In the sequel the various telephone services will be considered from the point of view of what is now customary and what subscribers should be entitled to demand now and in the future.

## Telephony

*In most countries local automatization* has advanced very far.

*Trunk automatization* is also well developed in the industrial countries. Here, of course, the subscribers' demand is for a sufficient number of circuits so that subscriber trunk dialling is not merely an illusion.

*The waiting time* for a telephone varies in different countries.

It is reasonable that subscribers should not have to wait longer than they have to do for any comparable utility, e.g. a television set. Installation and connecting up should preferably be done in the daytime. This is often impossible, however, in sparsely populated districts.

*Push-button dailling* instead of ordinary dialling is an obvious advantage to subscribers and should be introduced. Administrations should draw up a plan for conversion to push-button dialling within their respective areas. Subscribers are undoubtedly prepared to pay the extra cost in the form of higher installation charges and charges for calls.

## New telephone traffic facilities

New traffic facilities have been introduced in the United States and Sweden in conjunction with the new stored-programme-controlled exchanges. These are as follows:

### *Abbreviated dialling*

A subscriber can be allowed access, by dialling a 2-digit number within a given series (e.g. 70–79), to subscribers of his choice, usually those to whom he makes most calls.

### *Call-back*

A subscriber having dialled the number of a busy subscriber dials a code number and replaces his handset. He is then automatically called back as soon as the called subscriber is free. Thus the need for redialling is not necessary.

### *Automatic Transfer*

The subscriber has the choice of two alternatives. Incoming calls can be automatically transferred either when his line is busy or when incoming calls are left unanswered.

### *Enquiry and Transfer*

During the course of a telephone conversation a subscriber may make an enquiry call to a number within the exchange area. Should he so desire he can also transfer the call to such subscribers.

### *Conference telephone*

The subscriber may initiate and administer a multi-party conference.

### *Time-Calling or Alarm-Clock Service*

The subscriber can register in the exchange the time of day or night at which he wishes to be called. This alarm-clock service requires the dialling of 4 digits in accordance with the international 24 hours practice.

The traffic facilities should be tested and, if a reasonable market can be foreseen for them, the administration should draw up a plan for their introduction.

An important point for the goodwill of a telephone administration is that the special services offered to the public are well organized and well developed. Among these are number inquiries, complaints and repair services in general. The administration should also have a sales department which gives the customers advice as to what they should buy. At one place at least within the country there should be a planning department to assist large firms and institutions in organizing the relation of their internal telephone service to the external service. It is becoming increasingly important that administrations have expert groups of this kind owing to the tendency of large enterprises to work in scattered units and also because modern technical facilities allow several alternatives which must be compared.

Maintenance is neglected in many places. This makes it difficult for subscribers to put through their calls. Repeated call attempts must be made, which results in loss of time and irritation. The quality of transmission may render easy conversation impossible, and so on. It is necessary that administrations do not lower their sights in this respect.

## Telex, telegraphy

Telex is the special telecommunications service of the business community. It is also made much of by the administrations, as it is a strongly growing service and provides a good income. Telex is of special importance for traffic with other parts of the world.

The subscribers may demand that administrations plan the service satisfactorily so that subscriptions can be obtained at fairly short notice. This is not the case at present in many places.

Telegraphy is a service which is dying out as the telephone becomes more widespread and provides instantaneous service. Telex has become a better solution for the business community.

## Data transmission

Data transmission is a service which is expected to be of very great significance in the future. Administrations are poorly prepared to meet the need, however. It is an absolute requirement that business subscribers shall be able to book circuits for data transmission at different speeds. Alternatively it should be permissible to connect their own data transmission equipments to rented circuits.

## Video telephony

The business community will presumably demand video telephony in the future. It is desirable that administrations start to take an interest in this service. Fundamental parameters must be determined in respect of the quality of the picture, i.e. resolution and picture frequencies. A switchable system between moving pictures (human beings) and documents may possibly be required. International standardization is necessary.

## Paging system

Demands have been presented for a system which permits access to a person wherever he may be in a country. Administrations should study how such a service should best be arranged. At the same time industry should start research work on the technical requirements.

It should perhaps be pointed out that a person should have the choice of deciding himself whether he wishes to be accessible to paging.

## Telecommunications and the aim of the European Movement

This report has hitherto been concerned with aspects of telecommunications services from the national point of view. The reason is, of course, that international traffic cannot function satisfactorily unless there are well organized national telecommunications services. The international service hardly requires any special equipment. It is actually a matter of cooperation between national telecommunication services across the frontiers. This gives rise to technical problems, operational problems and problems for the subscribers.

Administrations throughout the world have in CCITT an organ for cooperation in technical and operational questions. CCITT has done very extensive standardization work in respect of the technical and operational conditions of international traffic. Extremely close cooperation exists within the CCITT, in which the large suppliers also have a part. The European administrations also have their own organ, CEPT, for special European questions.

When it comes to traffic within Europe, the purely technical questions are hardly in the foreground. Economic solutions exist to the main problems. In the field of operations there are still some problems remaining, associated with fault tracing and maintenance, but it may be expected that standards in these respects will be established by CCITT fairly soon.

If one sees the problems from the subscribers' point of view, a number of desires become apparent. The principle should be that it is as easy to telephone internationally as nationally. At the present there is fully automatic international traffic only between certain European countries, and often covering only the larger cities. The reason is that certain investments are required which are only defensible in major contexts. It is naturally very desirable that this fully automatic traffic should be extended as far as possible. The administrations should be conscious that automatization of this kind always leads to an increase of traffic, which should repay the investment reasonably soon.

One difficulty is tariffs. The ordinary method of charging on subscriber meters does not allow more than a given maximum tariff. The international tariff should be lowered, however, to a level corresponding to the national tariff for the same distances. There is hardly any reason to have higher charges for international calls.

From the charging as well as from the investment aspect the realistic view is to count on semiautomatic traffic internationally for a considerable time to come. The operators are a bottleneck, however, and in many countries it has been difficult to recruit operators with the necessary knowledge of languages. By means of long-term planning of training and recruitment the administrations should make sure that the need can be covered. For large enterprises, hotels, government departments, etc., it will be desirable to have a special service allowing full automatic international traffic from their PABX. The internal operator should have at her disposal one or more circuits to the international exchange, on which she can set up automatic international connections. These circuits could be equipped with special charging devices which could absorb the higher international tariff. In this way the administration could do without most of the international operators.

It is, of course, especially important to have a good quality of transmission on international connections. Otherwise the language difficulties are magnified. Questioning and repetition prolong the conversation – an increase of cost to subscribers which is unwelcome as it lies outside their control. Misunderstandings also become more common.

There should be sufficient circuits, so as to avoid delays. As in national traffic, one may expect a greater flow of traffic if calls are handled immediately – fully or semiautomatically.

Large enterprises have now interconnected their various establishments in PABX networks on a national basis. In future it may be necessary to have international networks of this kind as well. Permanently rented circuits between the units may be possible for major traffic requirements, while in other cases ordinary network circuits can be used.

The length of international numbers owing to the international and national prefixes is a disadvantage. Only in special cases can this be avoided by introducing abbreviated dialling for international calls. One might consider a variant of the old trunk number system which was earlier used in some countries. Large enterprises, hotels etc. in Europe were given numbers in a special series with, perhaps, not more than 5 digits. Access to this number series was obtained through a special prefix. Such subscribers should, of course, also be accessible on their ordinary national numbers. Administrations should study this possibility in conjunction with industry.

The subscribers' wants list also includes a number of practical questions which are becoming increasingly significant the greater the amount of travel and of international contact in general. The business community would like a concentrated telephone directory for Europe, listing subscribers who have large quantities of international traffic. It would also be valuable if the directories were edited in the same way so that there is no difficulty in finding a subscriber in a foreign directory.

It is, of course, important to have standardized dials and keysets. All prefixes should be numerical and not alphabetical. The latter are especially troublesome in international contexts as spelling may give rise to misunderstandings.

Tones and signals are standardized by CCITT and it is desirable that administrations follow the CCITT recommendations. A certain standard in coin boxes would also be desirable, a very important point for travellers.

Among other telecommunications services may be mentioned telex, perhaps the most international service. Duplex traffic now exists between the majority of countries.

In the data transmission field we may expect a great international expansion as well. Here the administrations must tackle standardization questions in conjunction with CCITT. It is important that at least provisional solutions are attained within the near future so that administrations can offer this service internationally.

# Telephone Traffic Theory – Present Status and Future Trends

C. JACOBÆUS & A. ELLDIN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 513.21:654.15.02
621.395.31
LME 807

*The purpose, development and methods of telephone traffic theory. Theoretical description of telephone traffic and its counterpart in reality with reference to such factors as traffic variations, stationarity and repeated call attempts. The background necessary for computation of new telephone systems. Service criteria in relation to traffic variations and general objects in view. The present and future use of computers for switch and circuit calculations and theoretical development work. The need for more observations on real traffic for surveying the significance of the seasonal variations of traffic.*

The theory of telephone traffic and its applications are used to determine the quantities of switches and circuits needed in a telephone system. The theory is also used to check that a telephone system has the correct traffic structure, i.e. that the system functions in a logical and suitable way in relation to the existing traffic conditions. The creation of an economic and efficient telephone system is, to quite a large extent, dependent on proper application of the arguments of the theory of telephone traffic.

Like all other engineering sciences, the task of telephone traffic theory is to describe the most essential characteristics of the reality. Its applications are used to find the most suitable arrangement of selectors and switching devices and to determine the necessary quantities of these devices. The result of calculations depends partly on how correctly the quantities of traffic have been estimated and partly on how well the plant has been adapted to the variegated requirements of the traffic. Both these factors, in turn, are dependent on the experience possessed of traffic and its variations and on how well this is reflected in the theory. To create efficient and economical telephone systems with the correct traffic structure, therefore, the theory must reproduce the most essential part of the reality.

Telephone traffic theory follows the development of telephony and throughout its history has attempted to describe the characteristic features of telephone systems. Work on the theory started at the beginning of the century when the attempt was made, by mathematical and empirical methods, to determine the number of circuits and the number of operators needed in telephone plant at that time. The initial phase may be said to have terminated with the presentation of Erlang's theories (1909–21). The essential feature and the stroke of genius in Erlang's method is his assumption of statistical equilibrium and of independence between successive calls and between simultaneous occupations, as well as his use of the exponential distribution.

The following phase, between the two wars, saw the breakthrough in earnest of the automatic systems, and the need to be able to calculate the necessary number of switching devices increased. During that period Erlang's theories were studied, accepted and further developed in hard competition with the German school, the advocates of which, Langer and Lubberger, based their theories on more empirical but, theoretically, less clear premises. The main interest was still in calculating the congestion in full availability groups and gradings. During that period important contributions were made by, among others, Vaulot, Fry and, at the end of the period, by the Swede, Conny Palm.

After the second world war the crossbar switching systems based on the link principle were introduced. Estimation of the traffic capacity of link systems placed further requirements on the methods of calculation. It was no longer sufficient to calculate the congestion in a full availability group but it was necessary also to master the traffic distributions in the various switching stages of a link system. This required a stricter systematization of how the distributions for each switching stage should be theoretically described (Jacobæus 1950). A better understanding was obtained of the properties of the various distributions. During that period much work was done on developing expressions which could be simply calculated with the aid of tables and desk calculators.

The introduction of rapid automatic electronic computers has had a great influence on the subsequent development within telephone traffic theory. They proved to be an effective aid both as automatic calculator and for simulating different groupings and were very quickly made use of. In 1955, at the First International Teletraffic Congress in Copenhagen, the Swede, Neovius,[43] presented simulations of a grading carried out on the Swedish computer BESK. Since then innumerable simulations have been made and are today a part of the natural routine for testing of theories and grouping arrangements. Equally important has been the possibility of making numerical calculations in accordance with given formulae. It was now possible to carry out numerical calculations on a number of alternatives and to chart the characteristics of telephone systems. More knowledge and more numerical facts were undoubtedly produced during that period, which started around 1955 and is still proceeding, than had evolved in the past 50 years or so. Today the computer is an essential aid for the telephone traffic technician.

Concurrently with the development of the theory a successive, though sporadic, study has been made of telephone traffic. It is very probable that Erlang came by his pioneering ideas by observing how the number of occupations changed in real traffic. In this way reality may have provided a stimulus for his theories. Other landmarks are the observations of the Englishmen, O'Dell and Berkley, on the congestion in different types of gradings at the end of the twenties. Of very great significance for the future development of telephone traffic theory are undoubtedly the measurements made in 1941 in Stockholm by the Swede, Conny Palm,[28] who studied how the traffic varied during the hours of the day and presented a brilliant theoretical description of this phenomenon. Furthermore all field tests of new systems, made by measuring the traffic properties of the systems in operation, have been of great significance for checking the realism of the theory. In the past few years CCITT's interest in computing the number of international circuits has required measurements on real traffic. This meant studying the significance of the variations in traffic, and especially the seasonal variations. Throughout the whole history of the telephone, moreover, measurements have been carried out in order to discover how the traffic increased and to check that the operational conditions were satisfactory. All this collective experience has provided the backbone and the realism required for a telephone system to function as intended. All observations on real traffic, however, whetted the appetite and indicated that more observations should be made and that still more should be known about traffic.

If one attempts to prophesy the future development of telephone traffic theory, one can guess that it will be characterized by the availability of better, larger and quicker computers. One may also guess that there will be better equipment for collection of observed data from real traffic. Both the computing capacity and the data collection capacity may be expected to increase, and this will lead to a greater knowledge which will influence the future development of the theory. We shall thus be able to build still better and more economical telephone systems. In this development it will often be necessary undoubtedly to reexamine the theoretical description of telephone traffic, how it is generated and how its variations are to be described. Methods of computation and simulation must also be developed to deal with new technical arrangements for telephone systems. At the same time we must investigate what demands can reasonably be placed on the grade of service in a telephone system, having regard to the properties and variation of the traffic and to how the cost of the telephone system is affected by the traffic. Practical rules must be found for how investments in telephone plant should be made at the right point and at the right time. The three factors – system cost, traffic properties and service requirements – are not independent of one another but must be viewed as components of a common complex of problems (fig. 1).

## Real telephone traffic and its theoretical description

The basis for the theory of telephone traffic is the theoretical description of real telephone traffic. The theoretical model should describe the most essential features of the traffic. Does it do so?

The first answer to this question must be that the Erlang description provides the most essential features of telephone traffic in a stationary state. By assuming statistical equilibrium and independence between successive calls and between simultaneous occupations, and by using the exponential distribution, a model has been obtained which is a compromise between realism and mathematical simplicity. The model has also proved to tally with reality in certain sporadic observations. It provides satisfactory facilities for varying the assumptions in accordance with the specific conditions which prevail at different points in a telephone system. In this way a practical method has been developed for calculating the necessary number of switching devices, which perhaps would not have been possible if other courses had been adopted.

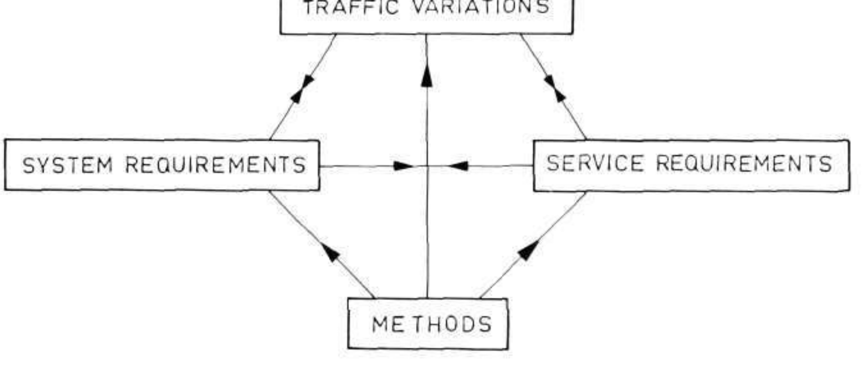



Fig. 1

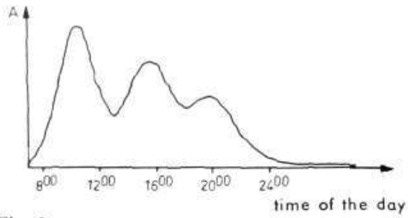


**Fig. 2**
**Variation of the traffic during the day**

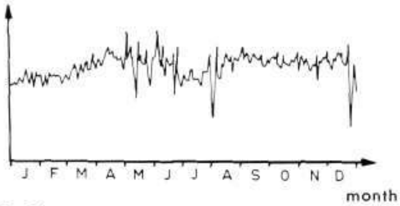


**Fig. 3**
**Daily busy hour traffic flow values during a year**

The concept of statistical equilibrium implies that one assumes that the growth in number of occupations and decline in number of occupations are equal. If this were not so, either the growth or the decline would predominate, the traffic would be either infinitely great or there would be no traffic at all.

$$Growth = Decline \tag{1}$$

The probability of the number of simultaneous occupations in a group can generally be calculated as follows.

Assume that the number of engaged devices in a group is denoted $p$ and its probability $[p]$. The intensity of growth is denoted $\lambda_p$ when there are $p$ occupations and the intensity of decline is denoted $\mu_p$. According to (1)

$$\lambda_{p-1} \cdot [p-1] = \mu_p \cdot [p] \tag{2}$$

By recursions from $p=1$ and upwards

$$[p] = \frac{\prod\limits_{\nu=0}^{p-1} \lambda_\nu}{\prod\limits_{\nu=1}^{p} \mu_\nu} \cdot [0] \tag{3}$$

Obviously

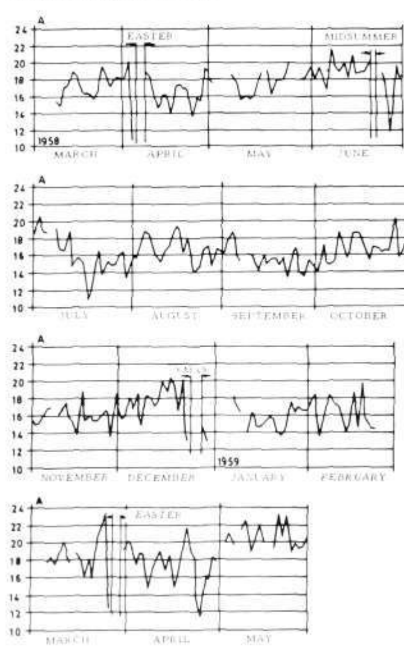
$$\sum_p [p] = 1 \tag{4}$$

where the probabilities of state $[p]$ are summed for all possible states $p$.

The assumption of exponentially distributed holding times implies that the intensity of decline $\mu_p$ is proportional to the number of occupations $p$:

$$\mu_p = p \tag{5}$$

**Fig. 4**
**The busy hour traffic day by day during one year on a trunk route in Sweden (Malmö—Gothenburg 1958—59)**




This applies if one uses the mean holding time in the group as time unit, which is convenient. The call intensity $\lambda_p$ can be written

$$\lambda_p = A(p) \cdot W(p) \tag{6}$$

where $A(p)$ is the call intensity, which may be assumed to depend on the number of free sources. The expression $W(p)$ is the probability that an occupation can take place when the group already has $p$ occupations. This probability may be assumed to depend on the internal conditions of the group or on the conditions after the switching stage under consideration, while $A(p)$ may be said to be dependent on the conditions prior to the group under consideration.

The call intensity $A(p)$ can be given the following expressions:

$$A(p) = (N-p) \cdot \alpha \tag{7a}$$

$$A(p) = A \tag{7b}$$

$$A(p) = a + b \cdot p \tag{7c}$$

The three expressions for $A(p)$ give a calling intensity which in (7a) diminishes with the number of engaged devices, in (7b) is constant and in (7c) increases with the number of engaged devices. With these three expressions and with $W(p)=1$ we get the three known traffic distributions Engset, Erlang and the negative binomial distribution. This applies to a lost call system in which it is assumed that lost calls do not give rise to renewed attempts.

By giving $\lambda_p$ for $p=n$ different values $\geq 0$, one can in theory distinguish between a lost call and a delay system. In a lost call system

$$\lambda_n=0 \tag{8a}$$

In the delay system

$$\lambda_n > 0 \tag{8b}$$

For a delay system there is a further possibility of varying the assumptions concerning the delay. One may assume that all callers wait until they are served or that waiting callers give up in accordance with some probability distribution (PALM[30]). For a delay system there is also a possibility of varying the handling of the queue. It is customary to calculate mean waiting times and waiting time distributions.

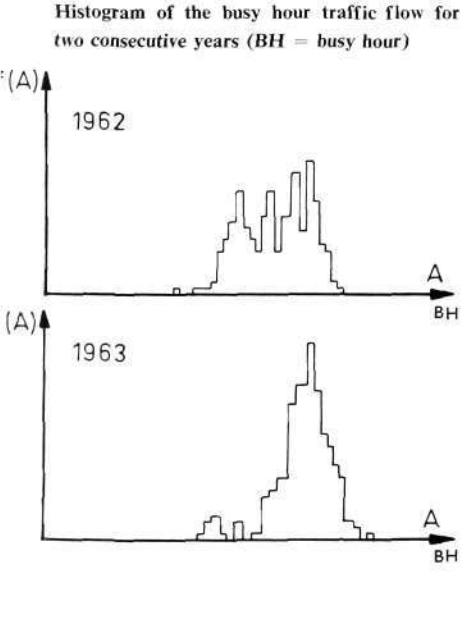
All these variants have been calculated and expressed, and today there is no difficulty in calculating with a computer whatever variant assumption one needs. The applications are not limited to the full availability group, but methods of calculation exist for gradings and link systems and for composite delay systems. The only difficulties, generally speaking, are those of numerical calculation, i.e. how to handle a computer.

The number of cases and variants studied grows rapidly in the literature.

It follows from the foregoing that the telephone traffic theory has good possibilities of varying its assumptions to correspond to the requirements of variations existing for different groupings. This is a way of trying to bring out the most essential features of telephone traffic. It applies, however, only to traffic in a stationary state.

A study of traffic during lengthy periods shows that it has the following variations:

**Fig. 5**
**Histogram of the busy hour traffic flow for two consecutive years (BH = busy hour)**




- Variation during the day with one, two or three peaks (fig. 2).
- The peak traffic may occur at different times on different days.
- The peak traffic varies seasonally with often high values before a public holiday and low values after a holiday, in accordance with human activity (figs. 3 and 4).
- Different weekdays often have systematically higher traffic than others.
- The traffic has a general tendency to increase with time. This increase may differ for high and low traffics (fig. 5).

These conditions are described in figs. 2–5. Fig. 6 summarizes the result of traffic values during a lengthy period, both for the time-consistent busy hour and for all 8760 hours during a year. Fig. 7 shows how the congestion in a group may vary during the year.

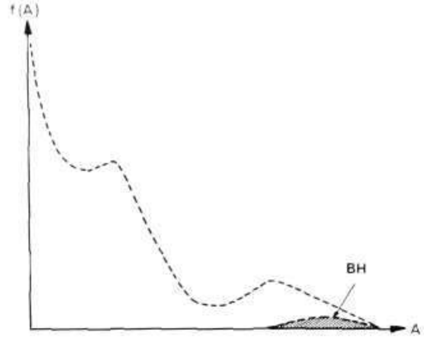



**Fig. 6**
**Hypothetical histogram for all one-hour traffic flow values during a year. The shaded section is the contribution from the busy hours.**

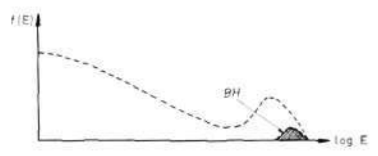
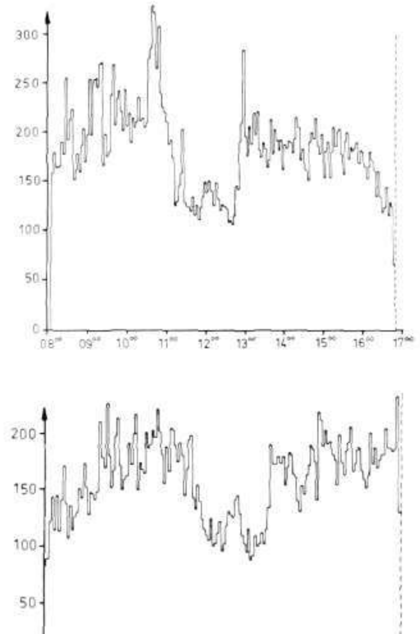



**Fig. 7**
**Hypothetical histogram for the congestion during all hours of one year. The shaded section is the contribution from the busy hours**

**Fig. 8**
**Number of calls per 3 minute interval in a PBX during two days. When can the call intensity be considered as stationary?**




The following questions arise. For what traffic values shall calculations be made? What is most important? How is an increase of traffic described? Furthermore, how is the overall variation in a network described when each traffic may be expected to vary separately and there may be a certain dependence or independence between high values, so that they occur simultaneously or not, at several points in the network? These questions can only be answered by extensive observations of real traffic. This is a matter for the future. Only when the traffic variations have been thoroughly charted can one obtain a further insight into the applicability of the Erlang models. It may prove that they need to be extended and modified.

Another constant problem is to check how the methods of calculation agree with reality. The following questions must be answered. What is the counterpart in reality to statistical equilibrium? How much or how little may the traffic change in order that statistical equilibrium may be considered to exist? (Fig. 8) Or can the concept of statistical equilibrium be substituted by a less strict and more realistic condition?

When we compare theory and reality it must be clearly realized that theory can never reproduce reality in detail, since theory must confine itself to the most essential features of reality. It is therefore necessary to make abstractions in the theories so that they reproduce the main features of a variegated reality. Experience and good judgement of the researcher are important factors in this respect.

When comparing calculated values and values measured from real traffic one encounters a further problem, namely the reproducibility of real traffic. Should one expect to obtain agreement in principle between theory and reality after 1, 10, 100, 1000 observations? It may well happen that real traffic does not repeat itself as quickly as one would expect from theoretical calculations. These conditions have great practical significance for circuit computation. For they determine the margins one must count on in the switch provision. One may perhaps find that the traffic on one day is Erlang-distributed, the text day Bernoulli-distributed, on the third day of negative binomial type.

It may be necessary to modify the theories to some extent as a result of discoveries made later on. Perhaps it will be found that it does not pay to be too precise in all details of the calculation. Other details may prove to be more important.

A consequence of this may be that certain approximations prove to agree better with reality than more exact solutions. This may occur if the theoretical assumptions prove to be less realistic and the approximations correct this condition. Such conditions have in some cases already been found from measurements of real traffic. As a rule, however, an exact solution should give a surer result than an approximate solution provided that the assumptions are truly realistic. Through the increased use of computers it will become less and less necessary to make use of approximations.

A circumstance which has not found a satisfactory description in the classical telephone traffic theory is the occurrence of repeated calls (figs. 9 and 10). It may be possible to work this into existing theoretical models in a practical way by assuming that rejected traffic sources increase their calling rate until they succeed in getting through (ELLDIN[67]). Figs. 11 and 12 show symbolically

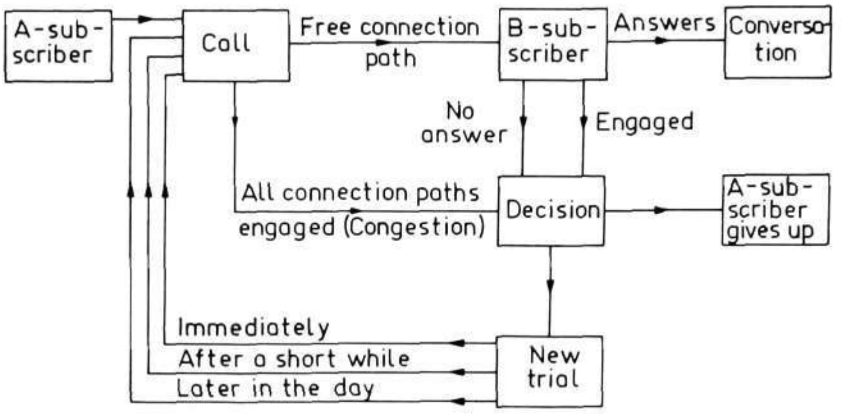



**Fig. 9**
**Possible outcome of a call from a subscriber A to a subscriber B**

how all kinds of failures to set up connections between subscribers can be theoretically described by a feedback of repeated calls to the inlets of the considered group.

## Computation of new systems

Computation of new systems is one of the main tasks of telephone traffic theory. This requires more than simply the use of computation formulae. Otherwise the result is likely to be unsatisfactory.

For the design and computation of a new system a knowledge is required of the actual traffic, its variations, and the demands it will place on the equipments. One must also be sufficiently well versed in telephone traffic theory to apply it in the correct way. An adequate computer capacity is required so as to be able to examine different alternatives. One must also have practical experience of numerical computations in a computer in order to produce the required numerical data.

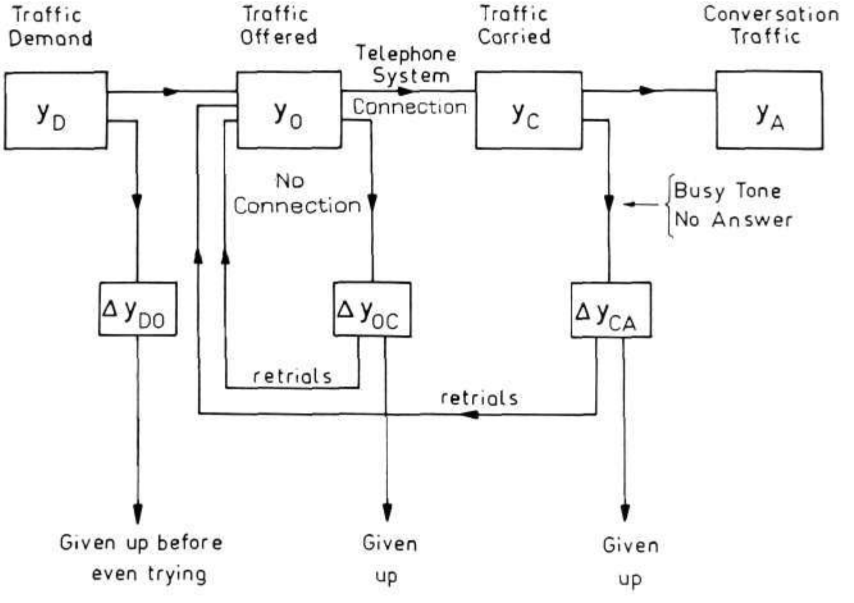



**Fig. 10**
**Development of call intensity in a telephone network**

In the past 10–15 years the following types of problems have been solved for L M Ericsson's telephone systems:

- Practical methods for calculation of link systems[32, 36, 40, 42]
- Application to all existing LME systems
- Methods of calculation for marker systems[58]
- Application to all existing LME systems
- Development of general rules for gradings[46, 47]
- Application to existing gradings
- Development of calculation methods for alternative routing[54, 55, 56, 57, 59, 60, 62, 68]
- Application to a large number of projects.

As a basis for this work the following studies and research have been necessary:

- Development of theories for link systems in general and for overflow problems[30, 32, 36, 40, 42, 48, 51, 52, 65]
- General studies of theories governing the properties of overflow traffic [52, 65]
- Theories of gradings, especially for gradings with random hunting[46, 47]
- Theories for delay systems[58]

Experience has been collected from the following sources among others:

- Measurements on equipment in operation[28, 36, 40]
- Measurements of traffic for study of its variations[49, 64]
- Simulations of different switching arrangements[43, 48, 52, 65]
- Study of the accuracy of measured statistical parameters
- Calculation of different grouping methods and determination of optimal groupings under different assumptions
- Development of metods of numerical calculation for different cases.[69]

To fulfil these tasks it would be desirable to have ready-made methods of calculation before the new systems are invented. This means that one should work on a fairly broad basis. This is especially necessary since the modern telephone systems offer so many facilities for variation in design as regards groupings and common control.

A perhaps especially important question is to find out how systems behave under overload. Here it must be taken into account that the various switching stages do not function independently of other parts of the system. A bottleneck at the start of a switching process may protect subsequent parts of the system against overloading. On the other hand the bottleneck near to the outlets of a system may have the opposite effect.

Studies of the overloading conditions also provide information as to where the bottleneck lies and whether the system is uniformly dimensioned.

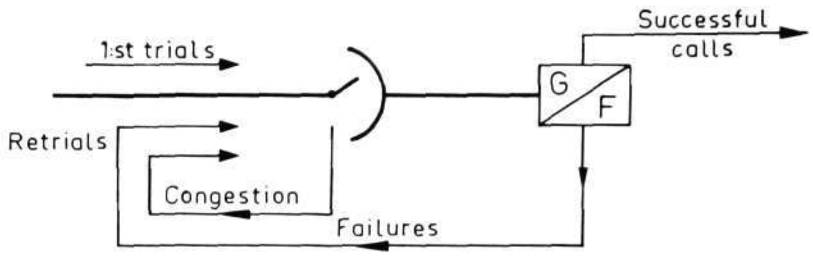



Fig. 11
Symbolical description of a selector stage. Failure and congestion may cause retrials.

## Service criteria

The income from telephone traffic derives from the traffic carried. This corresponds to the mean value of the annual distribution shown in fig. 6 for all hours of the year. The expenditure on switching equipment and for extension of the traffic-dependent parts of the telephone system, on the other hand, depends on the peak traffic. It is a minimum requirement that the income from traffic shall carry all costs caused by the traffic including, of course, the capital cost of the plant. An optimal investment, therefore, depends both on the total income and on how high the traffic peaks are and may be expected to be in the future. If too few switches are installed, this might reduce the income to some extent. The subscribers' service demand would also be less well catered for. On the other hand, too many switches make the plant less economical.

There is today no method of determining what is a suitable grade of service in a telephone plant. The number of switches has been calculated in accordance with more approximate, traditional and common-sense methods. The assessment of what is a satisfactory grade of service has thus been non-numerical. The generally accepted and rather arbitrary procedure of specifying a particular level of congestion for some busy hour traffic value has naturally turned out differently well at different places and on different occasions.

$$\left.\begin{aligned} E(A_{BH}) &\leq E \\ P(A > A_{BH}) &= ? \end{aligned}\right\} \tag{9}$$

Owing to the great variation of traffic the mean utilization per switch in a telephone plant will always be low. It is only during a few hours, say 200 of the 8760 hours of the year, that the plant is really utilized to a high degree. It has hitherto been a question of non-numerical estimation of how high the grade of service should be on these peak traffic occasions. The problem has sometimes been dealt with by overestimating the traffic, so leading to a certain overinvestment, at least at the start of a period of expansion.

It may be said without exaggeration that a telephone plant always is and should be overdimensioned when an expansion has just taken place. This is, of course, reasonable since additions to the equipment usually take place at fairly long intervals of from six months to five years. On the other hand it may be desirable to reduce the investments and apply them to those points in the system where they are of most use.

A main point at which to keep down investments, of course, is on expensive circuits such as international circuits. It was therefore that CCITT became interested in the question of the provision of international circuits to take

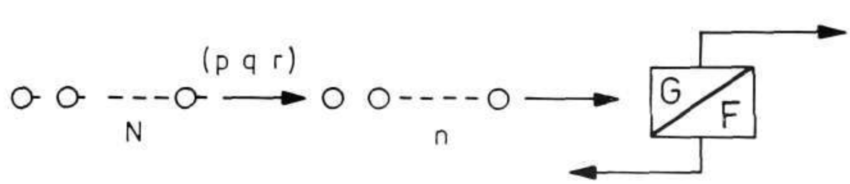



Fig. 12
Full availability group with N sources and n devices. G = (1 — F) is the probability that an occupation in the group leads to conversation. The group has p occupations and q "disturbed" sources. Of the p occupations r do not result in conversation and are of short duration. The r occupations will later become "disturbed" sources with a higher call intensity than the other N — p — q free sources.

into account traffic variations. In 1964 a recommendation was published which takes into account the highest traffic during the year. The recommendation is that the congestion for the average of the thirty highest busy hour values during the last 12 months' period shall be below a given value, $E_1$ (1 %), and that the mean of the five highest busy hour values during the same period shall be below another value, $E_2$ (7 %).

$$\left.\begin{aligned} E(\bar{A}_{30}) &\leq E_1 \\ E(\bar{A}_5) &\leq E_2 \\ E_1 &< E_2 \end{aligned}\right\} \tag{10}$$

One may wonder whether it will be considered satisfactory in the future to have congestion standards of the type of (9) and (10). The overall result during a period will be seen from fig. 7, which shows how the congestion varied during a lengthy period. Should not this be recorded and should one not make up a forecast in advance of what this distribution, $f(E)$, will look like? There are no theoretical and technical difficulties in recording and calculating these distributions. The recording can be done by ordinary data processing routines, which include outprint of the distribution. As long as it can be theoretically assumed that the peak traffic is in statistical equilibrium, the congestion can be simply calculated by known methods. The existence of different congestion values is determined by how often the traffic has the corresponding value.

If one knows how the traffic varies, so that it can be described by a statistical distribution, $f(A)$, the existence of a given congestion value, $E$, can also be described as a frequency function $f(E)$.

The next problem is to decide how high levels of congestion can be allowed and how often. This can perhaps be expressed by means of any of the following service criteria:

$$\bar{E} = \int_A E(A) f(A) \mathrm{d}A \leq E_2 \tag{11}$$

$$\overline{AE} = \int_A A E(A) f(A) \mathrm{d}A \leq E_3 \tag{12}$$

$$\left.\begin{aligned} P(E > E_4) &= \int_{A \geq A_4} f(A) \mathrm{d}A \leq E_4 \\ E(A_4) &= E_4 \end{aligned}\right\} \tag{13}$$

$$P(t_E > t_5) = \int_{t_E \geq t_5} f(t_E) \mathrm{d}t_E \leq E_5 \tag{14}$$

In these formulae $E(A)$ is the congestion at a traffic $A$ for a given grouping arrangement with a given number of switching devices. The frequency function value for a traffic $A$ is $f(A)$. This function can be expressed either as the distribution for the busy hour traffic or for the traffics for each hour during the whole year. Of special interest for the computation, obviously, is the occurrence of high traffic values, as the congestion is a function of the traffic which yields measurable values and contributions to the integrals in (11)–(14) only at high traffics. In the criterion (14) $t_E$ signifies the length of times when congestion prevails. Obviously a longer continuous period of congestion is more disturbing for subscribers than if the same time is divided into shorter intervals, with intermediate periods without congestion.

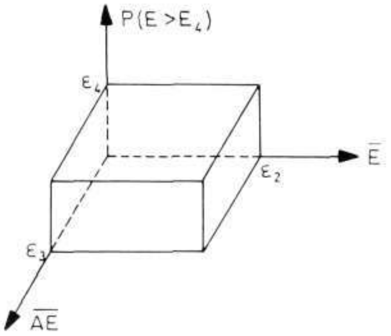


Fig. 13
Three-dimensional service criterion, as given in (11), (12) and (13)

For full availability groups the traffic variation can be expressed by a simple one-dimensional distribution, $f(A)$. For gradings and link systems the conditions may be more complicated. In these cases the traffic from several directions is combined in the same group. It may therefore be necessary to express the traffic variations as a multidimensional distribution, $f(A_1, A_2, \ldots, A_n)$. In principle there is no difficulty in this, but for realistic computation one must know the dependence between the different traffics $(A_1, A_2, \ldots, A_n)$.

An absolute condition for the formulation of new service criteria (computation criteria) is that one acquires experience of how the traffic varies during lengthy periods and how the congestion varies during the same period. The next step is to attempt to describe the variations of traffic by means of some statistical distribution. One also needs to know how this distribution changes with time, i.e. the pattern of the traffic increase. When this has been determined, the next problem is to develop methods of calculation which permit computation of the necessary number of switching devices in accordance with given criteria.

These criteria may be formulated either according to expressions (11)–(14) or as a multidimensional criterion (fig. 13). It seems likely that attempts are made to avoid very high congestion too often, i.e. that a number of criteria will be used of the type (13) in which different values are chosen to limit the upper tail of the distribution of the congestion, $f(E)$, see fig. 7.

When sufficient experience has been gained of the result of used service criteria, one may imagine a further step, namely to determine directly from observations of the service measure at what time the equipment should be extended and by how much. Fig. 14 illustrates an imaginary case of this kind. This lies far in the future, however, and requires many years of measurements and many hours of calculation in a computer before we get that far. It is nevertheless a not too distant goal.

## Methods

Computers have been adopted as a necessary aid in telephone traffic technique. There is no reason to suppose that within the foreseeable future we shall be independent of them. It may be expected rather that they will be used still more in the future than they are now. The existing methods of studying theoretical conditions and carrying out practical calculations are therefore being continuously adapted to computer potentials such as they are today and will be tomorrow. Methods of calculation as well as simulation technique will be further developed.

There is a great difference between the way in which the computer is used and the way in which manual calculations were carried out. In today's computers

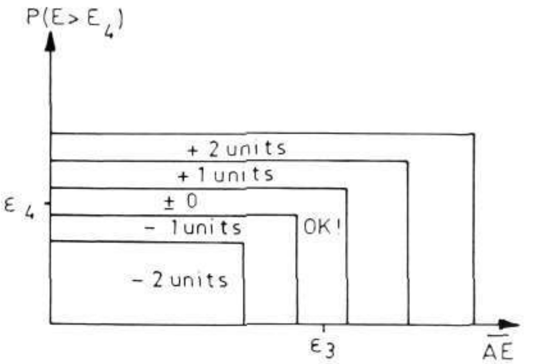


Fig. 14
Rules for change of the number of devices from the situation of the service measure point [($\overline{AE}$, P (E > E$_4$)]. The diagram is based on a two-dimensional service criterion according to (12) and (13)

it is usually simplest to make use of recursive and iterative procedures. Simple mathematical operations take an extremely small time, whereas hunting for numerical values in a memory may take a longer time. Much time was earlier spent on simplifying and approximating complicated formulae. Only a small part of this time is now spent on programming the complete expressions. More reliable data are now obtained without uncertain approximations.

To arrive at the searched values in calculations, automatic iterative methods are required. These methods involve convergence problems among others. Certain problems of this kind have already been solved, but new problems are constantly arising as new methods of calculation are developed. The problems apply both to practical and to theoretical calculations.

Of very great significance for the development of traffic theory is the simulation technique. In earlier phases use was made of traffic machines, i.e. analogue machines, which simulated the traffic and the occupations of the switching devices. Among such traffic machines may be mentioned that used by Kruithof (1946)[29] and the Swedish Traffic Machine owned and used by the Board of Telecommunications and L M Ericsson jointly, which was in operation between 1953 and 1965. The Swedish traffic machine was planned by Conny Palm among others.

It was fairly soon realised that simulations could equally well be made on a computer. Kosten (1943, 1949) and Jensen (1952) pointed the way. The Swede Neovius made the first simulation on a telephone traffic problem in 1955. A few years later Wallström (1958) carried out simulations on a two-stage link system. Today the simulation technique is wellknown and widely used. The practical problems of today are how to generate random numbers and how to organize the administration of the simulation programmes so that simulations can be carried out in a reasonable time in a computer.

Simulations in a computer are an efficient tool for checking a theory or an approximation. The result, however, is never more certain than the assumptions on which the simulation is based. Simulations take a longer time today than calculations and can therefore not replace theoretical and practical calculations. The theory is always needed, moreover, to explain what actually happens. A disadvantage of simulations when they were first used was that one forgot to observe real traffic. Everything was described by the computer, and so why should one make troublesome measurements on real traffic!

The development in the computer field hitherto has led to shorter programming and computation time. The processing times have been reduced as computers have become quicker and have got a larger memory capacity. The programming costs, however, are still probably greater than the machine costs. The programming work was reduced through the introduction of problem-oriented languages both for calculation and simulation. It is to be hoped that a further development in this sphere will lead to still simpler programming and that a programming language will be usable on different types of computer.

The situation today, unfortunately, is that a programme language for a computer cannot be simply transferred to another computer. Translated into the telephony field this would mean that a subscriber connected to a telephone exchange made by one manufacturer could not talk to a subscriber connected to another exchange made by another manufacturer. Nor could two subscribers connected to an older and a newer telephone system made by the same manufacturer be able to speak to one another! This shows that there are great advances pending within the programming field in the future. When we get common programming languages, the possibility of borrowing programmes from common libraries will facilitate the work still further.

## Final remarks

Telephone traffic theory has from the start been ahead of other applied sciences. Operation research was employed long before the name operation research was coined. Erlang made use of stochastic processes before the concept had been explained theoretically. There is no reason to expect that in the future the theory will remain in strictly rigid forms, but one may expect continued vigorous approaches to the problems from new angles. The significance of a well developed telephone traffic technique is so great that the theoreticians are quite simply forced to produce practically usable results.

A large amount of excellent and ingenious work has been carried out within telephone traffic theory. Today, therefore, we have a very good survey of the traffic conditions. But much remains to be done. It can be done now, since there are computers to help us and since the theory itself is so well developed. In fact it is merely a question of available computer time for attacking still greater problems than hitherto. And the solution to these problems is within reach!

The most time-consuming obstruction to continued development is the need for more measurements. The theory cannot be developed further, it can merely become more complicated unless more experience is collected of real traffic. Realistic results can only be obtained if the building of theoretical models is combined with measurements so that they fertilize one another. By observing real traffic one can distinguish between satisfactory and less satisfactory theories. It is the only means one has when judging whether theory is usable or not.

The continued development will cost money. These amounts, however, should be quickly repaid through the avoidance of overdimensioning. Subscribers will also be given the service intended and which they pay for.

A properly conducted activity within the traffic theory field and correct applications of it is one of the basic conditions for the development of efficient and economical telephone systems.

## References


1. Erlang, A. K.: *Probability Calculus and Telephone Calls.* [In Danish.] Nyt Tidsskr. Mat. *B 20*(1909): pp. 33—39.

2. Erlang, A. K.: *Solution of Some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges.* [In Danish.] Elektroteknikeren *13*(1917): 2, pp. 9—13.

3. Erlang, A. K.: *Telefon-Ventetider. Et stykke Sandsynlighetsregning.* Mat. Tidsskr. *B* 31(1920): pp. 25—41.

4. O'Dell, G. F.: *Theoretical Principles of the Traffic Capacity of Automatic Switches.* Post Off. Elect. Engrs. J. *13*(1920): 3, pp. 209—223.

5. Molina, E. C.: *The Theory of Probabilities Applied to Telephone Trunking Problems.* Bell Syst. Tech. J. *1*(1922): 2, pp. 69—81.

6. Langer, M.: *Calculation of Switches Required in Automatic Exchanges.* [In German.] ETZ *45*(1924): 11, pp. 203—208.

7. Rückle, G. & Lubberger, F.: *Der Fernsprechverkehr als Massenerscheinung mit starken Schwankungen.* Berlin 1924.

8. Vaulot, E.: *Application du calcul des probabilités à l'exploitation téléphonique.* Rev. Gén. Elect. *16*(1924): 11, pp. 411—418.

9. Holm, R.: *The Validity of Erlang's Trunk-Congestion Formula.* Post Off. Elect. Engrs. J. *17*(1924/25): 4, pp. 318—321.

10. Erlang, A. K.: *Some Applications of the Method of Statistical Equilibrium in the Theory of Probabilities.* P. 201. Den sjette skandinaviske Matematikerkongress i København 1925, Copenhagen 1926, p. 157.

11. O'DELL, G. F. & GIBSON, W. W.: *Automatic Trunking in Theory and Practice.* Inst. Post Off. Elect. Engrs. Paper 1926: 107, 46 pp.

12. MOLINA, E. C.: *Application of the Theory of the Probability to Telephone Trunking Problems.* Bell Syst. Tech. J. *6*(1927): 3, pp. 461—494.

13. O'DELL, G. F.: *An Outline of the Trunking Aspect of Automatic Telephony.* J. Inst. Elect. Engrs. *65*(1927): 362, 181—222.

14. VAULOT, E.: *Extension des formules d'Erlang au cas où les durées des conversations suivent une loi quelconque.* Rev. Gén. Elect. *22*(1927): 26, pp. 1164—1171.

15. FRY, TH. C.: *Probability and its Engineering Uses.* New York 1928. 2nd ed. 1965.

16. ELLIMAN, E. A. & FRASER, R. W.: *An Artificial Traffic Machine for Automatic Telephone Studies.* Post Off. Elect. Engrs. *22*(1929/30): 1, pp. 31—39.

17. MOLINA, E. C.: Appendix to: *Interconnection of Telephone Systems—Graded Miultples* by R. I. Wilkinson. Bell Syst. Tech. J. *10*(1931): 4, pp. 561—564.

18. WILKINSON, R. I.: *The Interconnection of Telephone Systems—Graded Multiples.* Bell Syst. Tech. J. *10*(1931): 4, pp. 531—561.

19. BERKELEY, G. S.: *Traffic and Trunking Principles in Automatic Telephony.* London 1934; 2nd ed. 1949.

20. VAULOT, E.: *Étude du trafic téléphonique reçu par des lignes explorées dans un ordre déterminé.* Rev. Gén. Elect. *38*(1935): 20, pp. 601—656.

21. LANGER, M.: *Studien über Aufgaben der Fernsprechtechnik.* Berlin & München 1936.

22. PALM, C.: *Calcul éxact de la perte dans les groupes de circuits échelonnés.* Ericsson Tech. *4*(1936): 3, pp. 41—71.

23. LUBBERGER, F.: *Beobachtungen, Vorschriften und Theorien der Schwankungen im Fernsprechverkehr.* In: Wahrscheinlichkeiten und Schwankungen, F. Lubberger, pp. 41—65, Berlin 1937.

24. PALM, C.: *Inhomogeneous Telephone Traffic in Full-Availability Groups.* Ericsson Tech. *5*(1937): 1, pp. 3—36.

25. PALM, C.: *Étude des délais d'attente.* Ericsson Tech. *5*(1937): 2, pp. 39—56.

26. PALM, C.: *Analysis of the Erlang Traffic Formulae for Busy-Signal Arrangements.* Ericsson Tech. *6*(1938): 4, pp. 39—58.

27. KOSTEN, L.: *On the Frequency Distribution of the Number of Discharges Counted by a Geiger-Müller Counter in Constant Interval.* Physica, *10*(1943): 9, pp. 749—756.

28. PALM, C.: *Intensitätsschwankungen im Fernsprechverkehr.* Ericsson Tech. 1943: 49, pp. 3—189.

29. KRUITHOF, J.: *Rotary Traffic Machine.* Electl. Commun. *23*(1946): 2, pp. 92—211.

30. PALM, C.: *Research on Telephone Traffic Carried by Full Availability Groups.* Tele 1957: 1, pp. 1—107. English ed. [In Swedish 1946.]

31. VAULOT, E.: *Délais d'attente des appels téléphoniques traités au hasard.* Comptes Rend. Acad. Sci. Paris 222 (1946): T 5, pp. 228—269.

32. JACOBÆUS, C.: *Blocking Computation in Link Systems.* Ericsson Rev. *24*(1947): 3, pp. 86—100.

33. JENSEN, A.: *An Elucidation of A. K. Erlang's Statistical Works through the Theory of Stochastic Processes.* In: The Life and Works of A. K. Erlang by E. Brockmeyer, H. L. Hallström & A. Jensen, Copenhagen 1948: pp. 23—100.

34. KOSTEN, L.: *On the Measurement of Congestion Quantities by Means of Fictitious Traffic.* PTT-Bedrijf *2*(1948/49): 1, pp. 15—25.

35. BROADHURST, S. W. & HARMSTON, A. T.: *An Electronic Traffic Analyzer.* Post Office Elect. Engrs. J. *42*(1950): 4, pp. 181—187.

36. JACOBÆUS, C.: *A Study on Congestion in Link Systems.* Ericsson Tech. 1950:48, 66 pp.

37. INOSE, H.: *An Artificial Call Generator Employing Random Noise Resistors.* J. Inst. Elect. Commun. Engrs. Japan *36*(1951): 4, pp. 177—181.

38. JENSEN, A.: *Calculations of Loss in Automatic Crossbar Exchanges.* [In Danish.] Teleteknik *3*(1952): pp. 176—200.

39. EKBERG, S.: *The Telephone Traffic Machine.* [In Swedish.] Tele 1953: 3, pp. 150—155. Ibid. Engl. ed. p. 51, 1953.

40. ELLDIN, A. & JACOBÆUS, C. & VON SYDOW, L.: *Traffic Measurements with Lamp Panel.* Ericsson Tech. *10*(1954): 1, pp. 107—187.

41. EKBERG, S.: *Telephone Traffic Research with the Aid of the Swedish Traffic Analyzer.* Tele 1955: 1, pp. 1—29. Engl. ed.

42. ELLDIN, A.: *Automatic Telephone Exchanges with Crossbar Switches. Switch Calculations. General Survey.* Book B 11265, 1955, 3rd ed. 1967, Book No. 18720.

43. NEOVIUS, G.: *Artificial Traffic Trials Using Digital Computers.* Ericsson Tech. *11*(1955): 2, 279—291.

44. WILKINSON, R. I.: *Theories for Toll Traffic Engineering in the USA.* Bell Syst. Tech. J. *35*(1956): 2, pp. 421—514.

45. COHEN, J. W.: *Basic Problems of Telephone Traffic Theory and the Influence of Repeated Calls.* Philips Telecommun. Rev. *18*(1957): 2, pp. 49—100.

46. ELLDIN, A.: *Further Studies on Gradings with Random Hunting.* Ericsson Tech. *12*(1957): 2, pp. 175—257.

47. CARLSSON, S.-G. & ELLDIN, A.: *Solving Equations of State in Telephone Traffic Theory with Digital Computers.* Ericsson Tech. *14*(1958): 2, pp. 221—244.

48. WALLSTRÖM, B.: *Artificial Traffic Trials on a Two-Stage Link Using a Digital Computer.* Ericsson Tech. *14*(1958): 2, pp. 259—289.

49. ELLDIN, A. & TÅNGE, I.: *Long-Time Observations of Telephone Traffic.* Tele 1960: 1, pp. 21—40. English ed.

50. SYSKI, R.: *Introduction to Congestion Theory in Telephone Systems.* Edinburgh & London, 1960.

51. ELLDIN, A.: *On the Dependence between the two Stages in a Link System.* Ericsson Tech. *17*(1961): 2, pp. 183—259.

52. WALLSTRÖM, B.: *Alternative Routing in a Two-Stage Link System, Congestion Theory and Simulated Traffic Studies.* Ericsson Tech. *17*(1961): 2, 261—285.

53. ELLDIN, A. & LIND, G.: *Elementary Telephone Traffic Theory.* (L M Ericsson Dhu 105A Ue) 2nd ed. Stockholm 1964.

54. RAPP, Y.: *Planning of Multi-Exchange Networks with Aid of a Computer. I. Locations and Boundaries of Exchanges in Multi-Exchange Areas.* Ericsson Rev. *39*(1962): 2, pp. 44—47. [Swedish, English, Spanish, German.]

55. RAPP, Y.: *Planning of Multi-Exchange Networks with Aid of a Computer. II. Inter-Exchange Traffic.* Ericsson Rev. *39*(1962): 2, pp. 47—50. [Swedish, English, Spanish, German.]

56. RAPP, Y.: *Planning of Multi-Exchange Networks with Aid of a Computer. III. Planning of Junction Circuits in Multi-Exchange Networks. Some Fundamental Principles.* Ericsson Rev. *39*(1962): 4, pp. 102—104.

57. RAPP, Y. & OLLUS, Y.: *Practical Application of the Planning of Multi-Exchange Networks with Aid of a Computer. Exchange Locations and Boundaries.* Ericsson Rev. *39*(1962): 4, pp. 105—111. [Swedish, English, Spanish, German.]

58. BJÖRKLUND, M. & ELLDIN, A.: *A Practical Method of Calculation for Certain Types of Complex Common Control Systems.* Ericsson Tech. *20*(1964): 1, pp. 3—75.

59. RAPP, Y.: *Planning of Junction Network in a Multi-Exchange Area. I. General Principles.* Ericsson Tech. *20*(1964): 1, pp. 77—130.

60. RAPP, Y.: *The General Plan for a Multi-Exchange Area.* Ericsson Tech. *20*(1964): 2, pp. 171—182.

61. WRIGHT, E. P. G.: *Conclusions and Recommendations of Working Party No. 5 of CCITT Study Group XIII,* Fourth Int. Teletraffic Congr. London 1964, Doc. No. 92.

62. RAPP, Y.: *Planning of Junction Network in a Multi-Exchange Area. II. Extensions of the Principles and Applications.* Ericsson Tech. *21*(1965): 2, pp. 187—240.

63. CCITT, Blue Book, Measurement of Traffic Flow Recommendation E 90, Volume II, pp. 193—194, or, Recommendation Q80, Volume VI, pp. 119—121. The International Telecommunication Union. Geneva, 1965 and 1966, resp.

64. ELLDIN, A. & WESTERBERG, S.: *Traffic Growth and Seasonal Variations in Subscriber Habits. Some Results from seven Years Daily Measurements on two Trunk Routes in Sweden.* Third Int. Symp. on Human Factors in Telephony, The Hague 1966, PTT Bedrijf *15*(1967): 1/2, pp. 175—196.

65. WALLSTRÖM, B.: *Congestion Studies in Telephone Systems with Overflow Facilities.* Ericsson Tech. *22*(1966): 3, pp. 187—351.

66. ELLDIN, A.: *Dimensioning for the Dynamic Properties of Telephone Traffic.* Fifth Int. Teletraffic Congr. New York 1967 and Ericsson Tech. *23*(1967): 3, pp. 305—344.

67. ELLDIN, A.: *Approach to the Theoretical Description of Repeated Call Attempts.* Fifth Int. Teletraffic Congr., New York 1967 and Ericsson Tech. *23*(1967): 3, pp. 345—407.

68. RAPP, Y.: *Planning of Junction Network in a Multi-Exchange Area. III. Optimum Types of Physical and Carrier Circuits.* Fifth Int. Teletraffic Congr., New York 1967.

69. SZYBICKI, E.: *Numerical Methods in the Use of Computers for Telephone Traffic Theory Applications.* Fifth Int. Teletraffic Congr. New York 1967.

ERICSSON News from

## All Quarters of the World

(From left) Mr. Gunnar Svala, North Electric Company, and Nr. Kurt Katzeff, L M Ericsson, with their recently awarded IVA gold medals. (Right) Dr. Christian Jacobæus, Technical Director of L M Ericsson.

# IVA–Gold Medals for All-Electronic L M Ericsson Exchanges

The Gold Medal of the Swedish Academy of Engineering Sciences (IVA) has been awarded to Mr. Gunnar Svala, North Electric Co., and Mr. Kurt Katzeff, L M Ericsson, for their work within the field of automatic electronic exchanges. The a-auards were the development and at the meeting of the Academy on October 24.

The particular grounds for the awards were the development and delivery of the electronic exchanges for the US Air Force System 412 L. These exchanges were probably the first all-electronic exchanges for permanent use. The contract was completed in 1963 and is still the largest for all-electronic exchanges. The exchanges have also operated extremely efficiently.

The basic development and design work on these exchanges was done at L M Ericsson in 1960–62. North Electric Co. was responsible for all production documentation and matching to American standards. They were also in charge of the production and installation.

The organization of the work on 412 L was throughout in the hands of Svala and Katzeff and now stands out as a pioneering technical achievement.

Earlier LME recipients of the IVA Gold Medal have been Knut Kåell (1940), Sune Överby (1945) and Nils Palmgren (1950).

IVA's Large Gold Medal was awarded in 1941 to Hemming Johansson, Director of LME, and in 1948 to Waldemar Borgquist, Chairman of the Board.

# Eight Month Report of the Group's Activities

An interim report on the operations of the Ericsson Group during the first eight months of 1967 was presented in October.

As various measures affecting stated net income are introduced in the final annual accounts, a direct comparison cannot be made for a part of the year.

The statement does not include the results of the telephone operating companies in Argentina and Peru.

An extract from the interim report is printed below.

### NEC-United Merger

The Boards of Directors of United Utilities, Inc. of Kansas City, Missouri, U.S.A. (United) and North Electric Company of Galion, Ohio, U.S.A. (NEC), have agreed to propose to their stockholders a merger of NEC into United. The proposal will be submitted at special meetings scheduled to be held in December.

### Sales and Order

Group sales for the first eight months of 1967 amounted to $ 269,474,000 compared with $ 230,513,000 for the same period of 1966, an increase of 17 percent. Group sales were distributed as follows: 71 percent within Europe, 18 percent within Latin America and 11 percent in other markets.

Shipments to customers in Mexico and Brazil increased considerably.

Orders booked totalled $ 303 million, exceeding orders booked during the first eight months of 1966 by 14 percent.

The backlog of orders amounted to $ 523,270,000 at the end of August, the highest in Group history. One-third of the backlog will be shipped to customers in Latin America.

### Earnings

Group income for the first eight months of the year was $ 32,486,000, amounting to 12.1 % of sales. For the same period in the preceding year the income was $ 31,711,000, 13.8 % of sales. Exchange differences, special adjustments and income taxes are not included in the report.

# Hugo Lindberg in memoriam

Hugo Lindberg

Hugo Lindberg died on November 17, 1967.

He was born in Landskrona on December 3, 1896. After graduating from a technical college he continued at the Telecommunications Administration Training Centre and joined the Administration in 1914. In 1921 he transferred to the Board of Telecommunications, where he advanced to First Secretary. During his period at the Board of Telecommunications his services were put to use in many ways, among which as Secretary and Member of the Committee of Inquiry into Rural Automatic Telephony. He also wrote an extensive report on "Conversion of the Stockholm Telephone Network to Automatic Operation". His command of the Swedish language was also drawn upon in his collaboration with Dagens Nyheter from 1926–28 and Svenska Dagbladet from 1928–32.

The then Director General of the Telecommunications Administration, Helge Eriksson, who became President of L M Ericsson in 1942, persuaded Hugo Lindberg to join LME in 1944. It was undoubtedly an important decision for the then 48-year-old Lindberg to start out on an entirely new career in an industrial undertaking. He began as Assistant Director with responsibilities especially for personnel and internal questions, and was appointed a Director of the company in 1950. In 1954 he was appointed Executive Vice President and Deputy for the President and held that appointment until 1963. From 1963 until his death in 1967 he continued to work for L M Ericsson as consultant on questions of which he had particular experience. Hugo Lindberg's greatest achievements were in conjunction with L M Ericsson's great programme of expansion during the fifties and sixties. He showed a sure judgment and great wisdom in the acquisition of sites and properties which were an important integral part of the expansion programme. His great skill as negotiator has often been testified to by his colleagues in the company as well as by his opposite numbers at the negotiating table.

Behind a rather austere facade Hugo Lindberg concealed a genuinely human and very shrewd mind which always tried to coordinate duty with humanitarian considerations.

Hugo Lindberg's capacity was drawn upon by many Ericsson companies, of which he was a member of the board and in some cases chairman. He was also an active member of the board of certain outside companies such as Söderhamns Verkstäder, Svenska Maskinverken and Hansa Mälaren.

In his youth Lindberg was an outstanding athlete, especially in the decathlon. His athletic interests were later concentrated on tennis and he continued to be a skilled tennis-player even after pensionable age. His considerable organisational abilities were also drawn upon in tennis contexts. He was treasurer and chairman of the Executive Committee of the Swedish Tennis Association from 1946 to 1950.

Hugo Lindberg leaves an aching void both among his colleagues at the company and his large number of friends.

He leaves as closest relatives his wife Siri Lindberg, née Lundberg, his son Per Lindberg, Vice President of Asea, and grandchildren.

*Sven T Åberg*

# UAC 1600 Premiere in Stockholm

A process computer system called UAC 1600 has been developed by the MI Division of L M Ericsson.

At the Seventh Exhibition of Instruments and Measuring Techniques held in Stockholm from 6 to 12 November this computer system was shown to the public for the first time.

The process computer system is based partly on technique and experience gained in conjunction with other data processing systems and was developed especially to meet the high requirements of reliability, flexibility and other factors needed in industrial applications.

Process control requires a real time computer with different priority levels for analysing data of different urgencies and quantities received from the process.

Process control units are an integral part of the system. The latter are

*Cont. on page 172*

**L M Ericsson's new computer UAC 1600 for control of industrial processes had its premiere at the Exhibition of Instruments and Measuring Techniques in Stockholm in November 1967. The photograph shows the part of L M Ericsson's exhibit comprising the process computer.**

# Gunnar Sträng, Swedish Minister of Finance, Visits Ericsson do Brasil...

In conjunction with the meeting arranged by the International Monetary Fund in Brazil at the end of September this year Mr. Gunnar Sträng, Swedish Minister of Finance, and his wife visited L M Ericsson's subsidiary company Ericsson do Brasil (EDB) at São José dos Campos outside the town of São Paulo.

The invitation came from the Swedish-Brazilian Chamber of Commerce, which suggested the visit to EDB owing to the company's predominant position among Swedish industrial undertakings in Brazil.

Mr. Sträng arrived at EDB in São José dos Campos on October 3 by helicopter loaned from the Governor of the Province of São Paulo. After addresses of welcome he was shown round the factory — in the photograph he is seen with (left) Ragnar Hellberg, President of EDB, and (right) Robert Bruun, Factory Manager.

EDB's great expansion in the past years has led to an increasing need for space. Building work is therefore proceeding apace. By the beginning of 1968 the factory premises will have been doubled through the addition of a 15,000 $m^2$ production building, which Mr. Sträng was also able to have a look at.

A round-table conference, at which Mr. Sträng showed a special interest in taxation questions, inflation and wages, was attended by Mr. Erik Svedelius, Swedish Consul General in Brazil, Mr. Gunnar Westerberg, Swedish Minister in Rio, and Mr. Arne Hultén, Chairman of the Swedish-Brazilian Chamber of Commerce.

Mr. Erskine Childers, Ireland's Minister of Communications, was on an official visit to Sweden cum holiday from 11 to 30 September. During his tour of the country Mr. Childers visited the Visby and Östersund factories of L M Ericsson. On September 27 he was at the Head Office. Mr. Björn Lundvall, President of LME, presented Mr. Childers with the statutes for a grant to be awarded to an Irish engineer.

*

Ten tons of equipment for the first public crossbar exchange, type ARF 10, of 2000 lines, ordered by GPO, Zambia, in March this year, was shipped by charter aircraft to Lusaka, where it is to be installed. The contract comprises altogether 5000 lines to be installed at two exchanges and is the first order received by L M Ericsson from Zambia. One of the exchanges will be opened at the beginning of 1968.

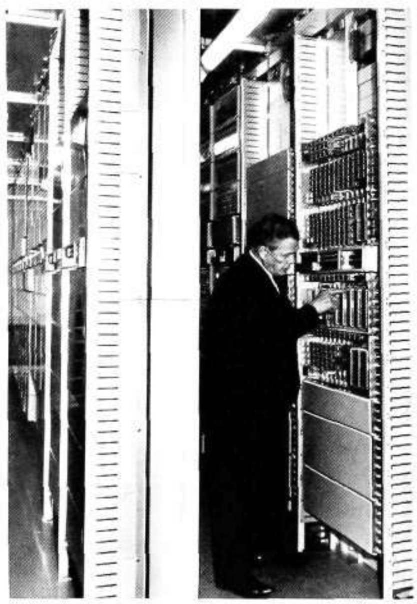
The photograph shows the equipment being unloaded at the international airport at Lusaka.


## ...and Gunnar Lange, Minister of Trade, the L M Ericsson Exhibit at Brno

The Ericsson Group was represented for the first time at the Brno Fair in Czechoslovakia, the largest machinery fair in the world, which started in 1959. There were 41 Swedish exhibitors. The Fair lasted from 10 to 19 September and may be regarded as a gateway to the majority of the East European markets. Among the products exhibited by the Group may be mentioned Dirivox and Dialog telephones, Tyfon alarm system and a traffic route tester. The photograph shows Mr. Gunnar Lange, Minister of Trade, being welcomed to the LME stand by Mr. Nils Kallerman, L M Ericsson.

*

Mr. Bjarni Forberg, Iceland PTT, is seen inspecting the new ARF exchange at Grensás, Reykjavik, which was opened on April 1, and was extended to 4000 lines on September 1 this year.



# Gunnar Beckman in memoriam

Gunnar Beckman

Gunnar Beckman died on August 22, 1967.

He was an unusual man in many respects; he also had an unusual career, mostly within the telephony field. He graduated from the Örebro Technical College in 1924 and then took a course at the Telecommunications Administration. After a brief period with the Administration he went out to Mexico in 1929 and was taken on by the Traffic Division of the Mexican Telefon AB L M Ericsson. Within a short time he advanced to the managership of this important division. In 1930 he became Assistant Director and at the age of 31 head of Empresa de Teléfonos Ericsson. The company prospered under his management and in 1947 was reformed into Teléfonos de Mexico. Beckman realized at an early stage the untenable situation created in Mexico by two competing telephone companies, one owned by L M Ericsson, whereas ITT (Cia Mexicana de Teléfonos) held the majority interest in the other; L M Ericsson also held a minority interest in the latter company. The merging of the Ericsson and ITT companies, for which Beckman worked hard, took place in 1950 with Beckman as president of the enlarged Teléfonos de Mexico.

To be the head of a telephone company in Mexico in which the chief shareholders were two so ardent competitors as Ericsson and ITT was, to be sure, no easy task, but Beckman, with his shrewdness and powers of leadership, was undoubtedly the man to carry it off.

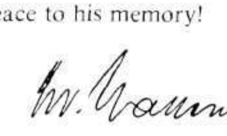
The final solution to the organization of Mexico's telecommunications came at the end of the fifties, largely as a result of Beckman's energetic efforts. L M Ericsson and ITT then sold their holdings in the joint telephone company to a group of Mexican financiers. Gunnar Beckman remained the head of the company. If it had earlier been a difficult task to lead the company through all the Mexican labyrinths, it became even more difficult with a fully Mexican-owned company, of which the main suppliers were still L M Ericsson and ITT.

During the postwar period the company had very great problems, both in financing of the quickly growing business and in negotiations with the trades unions, which were especially difficult during those times of social adjustment. Beckman's greatest triumphs were perhaps in the handling of these negotiations, and there were numerous complicated situations in which his coolness, sureness and negotiating skill warded off apparently inevitable conflicts.

Even if his life's work lay within the telephony field, Gunnar Beckman's multifarious achievements for the benefit of other Swedish companies, both as advisor and as board member, should also be mentioned. Swedes who came to Mexico never needed to apply in vain to Gunnar Beckman for advice and help. He was also Swedish Consul General from 1950 to 1965.

Gunnar Beckman and his wife Margit, née Ljungqvist, were a very hospitable couple – in recent years at their hacienda San Gaspar outside Cuernavaca. They also shared an ardent interest in horse-racing and Gunnar Beckman was an outstanding rider of the audacious kind which was in keeping with his temperament. As he had given nearly forty years of his life to work in Mexico, it was a logical consequence that he became a Mexican citizen about fifteen years ago.

Peace to his memory!



## LM Ericsson Exchanges in World Telecommunications Network

An exchange for intercontinental and international telecommunications traffic was opened in July at Kuala Lumpur, capital of Malaysia. The exchange is a link in the development of an all-automatic world telephone network.

Malaysia is in the news in another way as well. The agreement concluded between L M Ericsson and the Malaysian Administration earlier this year, comprising telephone equipment for about 65 million kronor, has now resulted in the first order – an automatic exchange for the local network. It is to be installed in the centre of Kuala Lumpur.

## Merger between AB Svenska Elektronrör and AB Rifa

To reinforce the electric components section of the Ericsson Group the Group Management has decided to combine development, manufacture and sale of capacitors, semiconductors, electron and cold cathode tubes, reed switches and similar products within a joint company. AB Svenska Elektronrör is to be merged with AB Rifa for this purpose as from January 1968. The company will operate under the name of AB Rifa.

The President of the new company will be Mr. Torsten Skytt. Mr. Svante Granler will be on the management with the responsibility for coordinating and dealing with questions concerning development, production and sale of electron tubes, reed switches and semiconductors. Mr. Granler will also act as local manager at the company's plant at Bollmora.

**UAC 1600 ...**

*Cont. from p. 170*

designed as modules, so that a unit can be easily constructed to suit each application.

Apart from the delivery of all hardware for an installation L M Ericsson can offer all the required system and programming work. The need for computer-controlled process regulating systems is expected to grow rapidly, especially within the paper and pulp and iron and steel industries. Other areas of interest are ships, hospitals and schools.

# Representatives

Please turn page for list of associated and co-operating enterprises and technical offices

## • EUROPE •

**Austria**
Telecom Handelsgesellschaft m. b. H., *1140 Wien*, Schanzstrasse 33, tel: 92 26 21, tgm: teleric, telex: 11638, "11638 TELCOM A"

**Belgium**
Allumage Lumière S.A. *Bruxelles 7*, 128-130, chaussée de Mons, tel: 229870, tgm: allumalux, telex: 21582, "ALLUMALUX BRU"

**Greece**
Angelos Cotzias *Athens*, 18, Odas Omirou, tel. 626-031, tgm: cotziasan, telex: 252, "COTZIASAN ATHEN"

**Iceland**
Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

**Spain**
TRANSA Transacciones Canarias S.A., *Las Palmas de Gran Canarias*, Tomas Morales 38, tel: 21 85 08, tgm: transa, telex: 824, "MAVAC LPE"

**Yugoslavia**
Merkantile Inozemna zastupstva *Zagreb* pošt pretinac 23, tel: 36941, tgm: merkantile, telex: 21139, "21139 YU MERTIL"

## • ASIA •

**Burma**
Myanma Export Import Corp., Import Division (Electrical Stores) *Rangoon*, P.O.B. 403, tel: 146 18, tgm: myanimport

**Cambodia**
Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 23334, tgm: comink

**Cyprus**
Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

S.A. Petrides & Sons Ltd. *Nicosia*, P. O. B. 1122, tel. 2788, tgm: armature

**Hong Kong och Macao**
Swedish Trading Co. Ltd. *Hong Kong*, P. O. B. 108, tel: 23 10 91, tgm: swedetrade

**Iran**
Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

**Iraq**
Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 87031, tgm: alhamra

**Japan**
Gadelius & Co. Ltd. *Tokyo C*, P.O.B. 1284, tel. 403-2141, tgm: goticus, telex: 2422075, "GOTICUS TOK"

**Jordan**
The Arab Trading & Development Co., Ltd. *Amman.*, P.O.B. 1, tel: 25981, tgm: aradeve

**Korea**
Gadelius & Co. Ltd. *Seoul*, I.P.O. Box 1421, tel: 22-9866, tgm: gadeliusco

**Kuwait**
Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat

**Lebanon**
Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 231624, tgm: skefko

**Malaysia and Brunei**
Swedish Trading Co. (M) Ltd. *Kuala Lumpur*, P.O.B. 2298, tel: 25316, tgm: swedetrade

**Pakistan**
TELEC Electronics & Machinery Ltd. *Karachi 3*, 415, Mahboob Chambers, Victoria Road, tel: 52648, tgm: elco

**Philippines**
U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: 722344, "USIPHIL 7222144"

**Saudi Arabia**
Engineering Projects & Products Co. *Riyadh*, P. O. B. 987, tel: Murraba 264, tgm: eppcol

**Singapore**
Swedish Trading Co. (M) Ltd. *Singapore 1*, P. O. B. 2791, tel: 943 62, tgm: swedetrade

**Syria**
Constantin Georgiades, *Damas*, P.O. B. 2398, tel: 266 73, tgm: georgiades

**Trucial States, Muscat Oman**
DOLPHIN Trading & Contracting Establisament, *Dubai, Trucial States*, P. O. B. 1566, tel: 0639, tgm: dolphin

**Vietnam**
Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, P. O. B. 1049, tel: 22660, tgm: telerad

## • AFRICA •

**Congo**
I.P.T.C. (Congo) Ltd. *Kinshasa 1*, P. O. B. 8922, tel: 5345, tgm: induexpan, telex: 327, "IPTC KIN"

**Ethiopia**
Mosvold Company (Ethiopia) Ltd. *Addis Ababa*, P.O.B. 1371, tel: 14567, tgm: mosvold

**Ghana**
R.T. Briscoe Ltd, *Accra*, P.O.B. 1635, tel: 669 03, tgm: Briscoe, telex: 295, "BRISCOE ACCRA"

**Kenya, Tanzania, Uganda**
Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

**Liberia**
Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Streets, tel: 22222, tgm: radiolibe

**Libya**
ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 33906, tgm: adeco

**Mauritius**
Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

**Mozambique**
J. Martins Marques & Ca. Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

**Nigeria**
I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult, telex: 235, "SHELLBP LAGOS"

**Sudan**
Contomichalos, Sons & Co. Ltd. Engineering & Agencies Dept., *Khartoum*, P.O.B. 866, tel: 77 695, tgm: suconta, telex: 251, "CONTOLOS"

**South Africa, South-West Africa**
Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

**Tunisia**
Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

## • AMERICA •

**Bahama Islands**
Anglo American Electrical Company Ltd. *Freeport, Grand Bahama*, P.O.B. 104

**Bolivia**
Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 25 923, tgm: johansson, telex: 5211, "BOOTH LPZ 5211"

**Costa Rica**
Tropical Commission Co. Ltd. *San José*, Apartado 661, tel.: 22 55 11, tgm: troco

**Dominican Republic**
Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3445, tgm: gartier

**Guatemala**
Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira

**Guiana**
General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwlks

**Honduras**
Quinchón Leon y Cia *Tegucigalpa*, Apartado 85, tel: 2-5171, tgm: quinchon

**Jamaica and Brit. Honduras**
Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

**Netherlands Antilles**
S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao* P.O.B. 304, tel: 11200, 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, telex: 134, "PA 134 SONITEL"

**Paraguay**
S. A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

**El Salvador**
Dada-Dada & Co. *San Salvador* Apartado 274, tel: 21 66 66, 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, N.Y 10003*, 215 Park Avenue South, tel: (212) 677-8400, tgm: statelabs, telex: 8676996, "ROMCO PGH" (For electron tubes only)

## • AUSTRALIA & OCEANIA •

**New Zealand**
ASEA Electric (NZ) Ltd. *Wellington C. 1.*, P.O.B. 3239, tel: 70-614 tgm: asea, telex: 3431, "ASEAWELL NZ 3431"

# The Ericsson Group

## *Associated and co-operating enterprises and technical offices*

Please turn page for list of further sales offices

### • EUROPE •

**Denmark**

L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericsson, telex: 9020 "ERICSSON KH"

Telefon Fabrik Automatic A/S *Søborg*, Telefonvej 6, tel: 69 51 88, tgm: automatic, telex: 5264, AUTOMATIC KH"

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

A/S Tele-Center *2600 Glostrup*, Sandager 8, tel: 96 18 88, tgm: telekommun

**Finland**

O/Y L M Ericsson A/B *Helsingfors*, P. O. B. 13018, tel: A 8282 tgm: ericssons, telex: 12546, "ERICSSON HKI"

**France**

Société Française des Téléphones Ericsson *F-92-Colombes*, 36, Boulevard de la Finlande, tel: Paris (1) 242 35 00, tgm: ericsson colombes, telex: 62179, "ERICSSON CLOMB" *F-75-Paris (17e)*, 147, rue de Courcelles, tel: Paris (1) 227 9530, tgm: eric paris

Centrum Electronic S. A. *Paris 17e* 32, Rue Legendre, tel: 267 30.10, tgm: centrumfrance

**Great Britain**

Swedish Ericsson Company Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Production Control (Ericsson) Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Centrum Electronics Ltd. *London S.W.I.*, tel: SLOane 0451, tgm: celefon telex: 2613, "CELEFON LDN"
Centrum Rentals Ltd. *London S. W. I.*, Terminal House, Grosvenor Gardens, tel: Sloane 0451, tgm: celefon, telex: 2613, "CELEFON LDN"

**Ireland**

L M Ericsson Ltd. *Dublin 2*, 32, Upper Mount Street, tel: 61931, tgm: ericsson, telex: 5310, "ERICSSON DUBLIN"

**Italy**

FATME, Soc. per Az. 00100 *Roma*, C. P. 4025 Appio, tel: 4694, tgm: fatme, telex: 61327, "61327 FATME"

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

SIELTE, Soc. per Az. *00100 Roma*, C. P. 5100, tel: 577 8041, tgm: sielte

**Netherlands**

Ericsson Telefoonmaatschappij, N.V. *Rijen (N.Br.)*, tel: 01692-3131, tgm: erictel, telex: 54114, "ERICTEL RIJEN"

*Voorburg-Den Haag*, P.O.B. 3060, tel: 81 45 01, tgm: erictel-haag, telex: 31109, "ERICTEL DENHAAG"

**Norway**

A/S Elektrisk Bureau *Oslo 3*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 1723, "ELEKTRIKEN O"

A/S Industrikontroll *Oslo 6*, Grenseveijen 86/88, tel: Centralbord 68 34 64 tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.B. 500, tel: 83 76 50, tgm: kabel

A/S Norsk Signalindustri *Oslo 3*, P.B. 5055, tel: 46 18 20, tgm: signalindustri

A/S Telesystemer *Oslo 6*, Plogveien 3 B, tel: 68 62 95, tgm: gyllingsystem

**Portugal**

Sociedade Ericsson de Portugal Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 571 93, tgm: ericsson

**Spain**

Cia Española Ericsson, S. A. *Madrid 13*, Torre de Madrid, Plaza de España tel: 241 14 00, tgm: ericsson, telex: 27369. "7369 ELEME E"

**Sweden**

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 08/19 00 00, tgm: telefonbolaget, telex: 19910, "19910 ERICTEL S"

Casa Konsult AB *Älvsjö*, Huddingevägen 417—19, tel: 08/47 25 65, tgm: casakonsult

AB Ermi *Karlskrona 1*, tel: 0455/230 10, tgm: ermibolag, telex: 4819, "ERMI KKR"

AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308, "ELRIFA STH"

Instruktionsteknik AB, *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

L M Ericsson Data AB *Solna*, tel: 08/83 07 00, tgm: ericdata, telex: 10 93, "ERICDATA STH"

L M Ericsson Telemateriel AB, *Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00 tgm: ellem, telex: 1275, "1275 TELERGA S"

Sieverts Kabelverk AB *Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676, "SIEVKAB STH"

Svenska Radioaktiebolaget *Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio, telex: 10094, "SVENSKRADIO STH"

**Switzerland**

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *8032 Zurich*, Postfach, tel: 325184, tgm: telericsson, telex: 52669, "TELERICSSON ZCH"

**Turkey**

Ericsson Türk Ticaret Ltd. Sirketi *Ankara*, Rumeli Han, Ziya Gökalp Cda., tel: 123170, tgm: ellem

*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02 tgm: ellemist

*Izmir*, Izmir Bürosu, Kisilkaya Han, Kat 3. No 13, Halit Ziya Bulvari, tel: 378 32, tgm: ellemir

**West Germany**

Deutsche Ericsson G.m.b.H. Telematerial, *4 Düsselorf-Roth*, Postfach 136, tel: (0211) 63 30 31, tgm: erictel, telex: 8586871, "8586871 ERIC D"

Centrum Electronic Handels-GmbH, *3 Hannover*, Dornierstrasse 10, tel: 63 10 18, tgm: centronic, telex: 922913, "922913 CELEC D"

### • ASIA •

**Hong Kong**

Telefonaktiebolaget L M Ericsson Technical office *Hong Kong*, P. O. B. 134781 tel: 23 10 91, tgm: elleme

**India**

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: 45 44 94, tgm: inderic

*New Delhi 16*, L25, South Extension Part II, tel: 626505 tgm: inderic

**Indonesia**

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151—153, tel: 8294, tgm: javeric

*Djakarta*, Djalan Gunung Sahari 26, tel: OG 48531, tgm: javeric

**Iraq**

Telefonaktiebolaget L M Ericsson, Technical office *Baghdad*, P.O.B. 493, tel: 914 54, tgm: ellemco

**Kuwait**

Telefonaktiebolaget L M Ericsson, Technical office, *Kuwait*, *State of Kuwait*, P. O. B. 5979, tel: 26 855, tgm: erictel

**Lebanon**

Telefonaktiebolaget LM Ericsson, *Technical office Beyrouth*, *Rue du Parlement*, Immeuble Bisharat, tel: 252627, tgm: ellem, telex: 876, "ELLEM BERYT"

**Thailand**

Ericsson Telephone Corp. Far East AB *Bangkok*, P.O.B. 824, tel: 58041-,43 *tgm: ericsson*

### • AFRICA •

**Egypt** (UAR)

Telefonaktiebolaget LM Ericsson, Technical office Egypt Branch *Cairo*, P.O.B. 2084, tel: 46581, tgm: elleme

**Ethiopia**

Telefonaktiebolaget L M Ericsson, Technical office, *Addis Ababa*, P. O. B. 3366, tel: 492 60, tgm: ericsson

**Kenya**

Telefonaktiebolaget L M Ericsson, Technical office, *Nairobi*, P.O.B. 9063, tel. 271 06, tgm: ellem

**Morocco**

Société Marocaine des Téléphones Ericsson *Casablanca*, 38, rue Mohamed Sedki, tel: 788-75, tgm: ericsson

**Rhodesia, Botswana and Malawi**

Ericsson Telephone Sales Corporation AB, *Salisbury, Rhodesia*, P.O.B. 2891, tel: 25 737, tgm: ericofon

**Tunisia**

Telefonaktiebolaget LM Ericsson, Technical office, *Tunis*, Boite Postale 780, tel: 240520, tgm: ericsson

**Zambia**

Ericsson Telephone Sales Corporation AB *Ndola*, P. O. B. 2256, tel: 3885, tgm: ericofon

### • AMERICA •

**Argentine**

Cia Ericsson S.A.C.I. *Buenos Aires Casilla de Correo 3550*, tel: 332071, tgm: ericsson, telex: 0122196, "CATEL BA"

Cia Argentina de Teléfonos S. A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel, telex: 0122196, "CATEL BA"

Cia Entrerriana de Teléfonos S. A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel, telex: 0122196, "CATEL BA"

Industrias Eléctricas de Quilmes S. A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires, telex: 0122196, "CATEL BA"

**Brazil**

Ericsson do Brazil Comércio e Indústria S. A. *Rio de Janeiro* C. P. 3601-ZC-00, tel: 43-0990, tgm: ericsson, telex: 310, "ERICSSON RIO"

**Canada**

L M Ericsson Ltd. *Montreal 9. P.Q.*, 2300 Laurentian Boulevard City of St. Laurent, tel: 331-3310, tgm: caneric, telex: 1-2307

Gylling (Canada) Ltd. *Montreal*, 1203, IBM Building, 5, Place Ville Marie

**Chile**

Cia Ericsson de Chile S. A. *Santiago*, Casilla 10143, tel: 82555, tgm: ericsson

**Colombia**

Cia Ericsson Ltda, *Bogotá*, Apartado Aéreo 4052, tel: 411100, tgm: ericsson, telex: 044507, "ERICSSON BOG"

**Costa Rica**

Telefonaktiebolaget L M Ericsson, Technical office *San José*, Apartado L. M. E., tel: 21 14 66, 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. *Mexico D. F.*, Apartado 9958, tel: 464640, tgm: coeric, telex: 0177485, "ERICSSON MEX"

Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado 25737, tel. 49 36 50, tgm: latincasa

Teleindustria, S. A. de C.V. *Mexico l, D.F.* apartado 1062, tel: 464640, tgm: ericsson, telex: 0177485, "ERICSSON MEX"

Telemontaje, S. A. de C. V. *Mexico 1, D.F., Apartado Postal 1062, tel:* 46 78 11, tgm: ericssonmexicodf, telex: 0177485, "ERICSSON MEX"

**Peru**

Cia Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson, telex: 3540202, "ERICSSON 3540202"

Soc. Telefonica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060, tgm: telefonica

**El Salvador**

Telefonaktiebolaget LM Ericsson, Technical office *San Salvador*, Apartado 188, tel: 21-7640, tgm: ericsson

**Uruguay**

Cia Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

**USA**

The Ericsson Corporation *New York, N.Y. 10017*, 100 Park Avenue, tel: 68 54 030, tgm: erictel, telex: 620484, "ERICTEC 620484"

L M Ericsson Centrum Inc. *New York, N. Y. 10016*, 16, East 40 Street, tel: 6791001, tgm: erictel, telex: 620149

North Electric Co. *Galion, Ohio 44833*, P.O.B. 688, tel: (419-)468—2420, tgm: northphone-galion-ohio, telex: 987-428, "NORTELEC GAON"

**Venezuela**

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson telex: 734, 734, "ERICSSON VE"

### • AUSTRALIA & OCEANIA •

**Australia**

L M Ericsson Pty. Ltd. *Broadmeadows, Victoria*, P.O.B. 41, tel: 309 2244 tgm: ericmel, telex: AA 30555

*Rushcutters Bay N.S.W.*, 134 Barcom Avenue, tel: 31 09 41, tgm: ericsyd

Teleric Pty. Ltd *Broadmeadows, Victoria* P.O.B. 41, tel: 309 2244, tgm: teleric, telex: AA 30555

*Rushcutters Bay N.S.W.*, 134 Bacrom Avenue, tel: 31 09 41, tgm: teleric

ESSELTE AB. STHLM 67