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LM ERICSSON

STORED PROGRAM CONTROLLED SWITCHING SYSTEM AKE

TUMBA, SWEDEN

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CONTENTS

Front Cover:
Data processing room at the AKE exchange, Tumba, Sweden.

INTRODUCTION

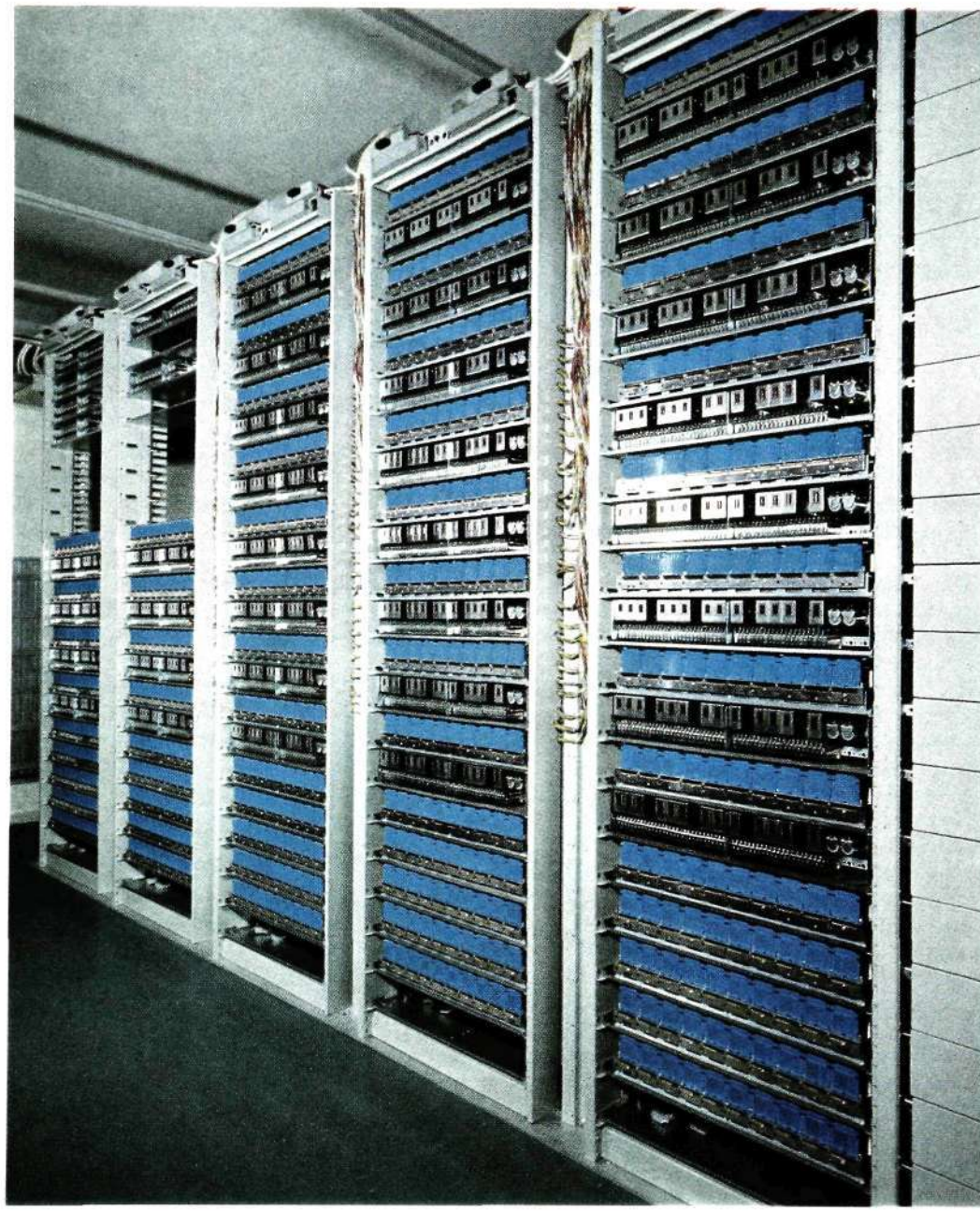
This booklet describes the L M Ericsson telephone switching system AKE with stored program control and it's application in the zone centre of Tumba, Sweden.

System AKE is an electronic switching system using L M Ericsson designed computers and code switches.

L M Ericsson Telephone Company thankfully acknowledge the kind cooperation of The Swedish Telecommunications Administration in connection with the Tumba project, the checking of the manuscript and the permission to release this booklet for publication.

Switching room, Tumba. Subscriber stage employing code switches in the speech paths. Plug and jack design throughout, including interrack cabling. Protective covers removed.

Fig. 1



1. DEVELOPMENT OF THE AKE SYSTEM

L M Ericsson started research and development work aimed at designing electronic telephone systems as early as in 1947.

An important step was taken at the beginning of the sixties with a major delivery of electronic exchanges to the United States Air Force. As these exchanges were specifically produced for military communication requirements, they were of no immediate benefit to civilian administrations. Their design, however, proved to be of utmost value for the continued research and development in the field of public electronic telephone systems which is evident in the subsequent design and manufacture of the AKE stored program controlled switching system.

By presenting subscribers with an entirely new series of valuable and time saving service facilities, additional revenue may be obtained by telephone administrations. Further, by introducing a new approach to system integration, operational supervision and computer controlled maintenance, running costs may be substantially reduced.

The principles of stored program control were elaborated in close cooperation with The Swedish Telecommunications Administration but the computers and the code switches are of L M Ericsson's own design.

The AKE is a multi-purpose, common control electronic switching system and may be used either as local exchange, trunk exchange or combined local and trunk exchange, as district centre, zone centre or large group centre.

The use of stored program control centralizes the system intelligence, allowing the AKE system to comply with the requirements of any type of network. Variations in and extensions of the switching network are simply carried out by changing or adding standardized units which are all connected to the system intelligence.

2. AKE PROJECTS

The exchange put into service in the zone centre of Tumba, Sweden, is the first telephone exchange of system AKE. It will be described in more detail in forthcoming publications and therefore only a general outline is presented in this booklet.

A stored program controlled trunk exchange with an initial capacity of 4 800 lines and an estimated final capacity of 30 000 lines will be supplied to Rotterdam, Netherlands.

Another exchange for automatic and semi-automatic national and international trunk traffic with an initial capacity of 4 000 lines will be supplied to Helsinki, Finland.

Further, the Swedish Royal Air Force have placed an order for a number of stored program controlled exchanges for use in their telecommunications network.

3. AKE PHILOSOPHY

The steadily progressing automatization of national, international and intercontinental telephone traffic together with the increasing need of providing telephone administrations and subscribers with additional service facilities, forced switching engineers to think along new lines. L M Ericsson engineers found that in order to design a telephone system which would not only cater for the requirements of today but would also adapt itself to any future requirement, it would be desirable to incorporate some form of stored program control. Once this decision had been made, the speech path circuitry had to be determined. At that time, hermetically sealed contacts were favoured in the United States. After having studied their economical and functional properties, The Swedish Telecommunications Administration and L M Ericsson decided to use some form of electromechanical switch for the establishment of speech paths.

The L M Ericsson code switch proved to be suitable for operation with electronic program control as it is pulse switched, employs 7 binary coded code bars and consumes no current in operated resp. released position. The code switch is therefore used in the speech paths of the AKE-system. Normal telephone instruments, signalling methods and line voltages can thus be retained in the network, whilst at the same time utilising all the advantages of stored program control.

The AKE stored program controlled telephone exchange system using code switches in the speech paths contains the following functional blocks:

The Switching Network
The Transfer Circuitry
The Data Processing System

The Switching Network

The switching network contains code switches connected according to the link principle and relay sets employing ordinary telephone relays without logic, storing, timing or translating functions as these functions are concentrated in the data processing system. The relay functions have thus been reduced to mere signal sending and receiving duties. The data processing system tests the contacts of the signal receiving relays and operates the signal sending relays. Operation and testing take place in accordance with the program stored in the data processing system. Thus, only a few types of uncomplicated relay sets are used for different methods of signalling. Markers and registers common in conventional link systems are not required.

The Transfer Circuitry

The transfer circuitry acts as an adapter between the switching network and the data processing system. It enables the high speed data processing system to interwork with the code switches and telephone relays of the switching network without loss of speed.

The Data Processing System

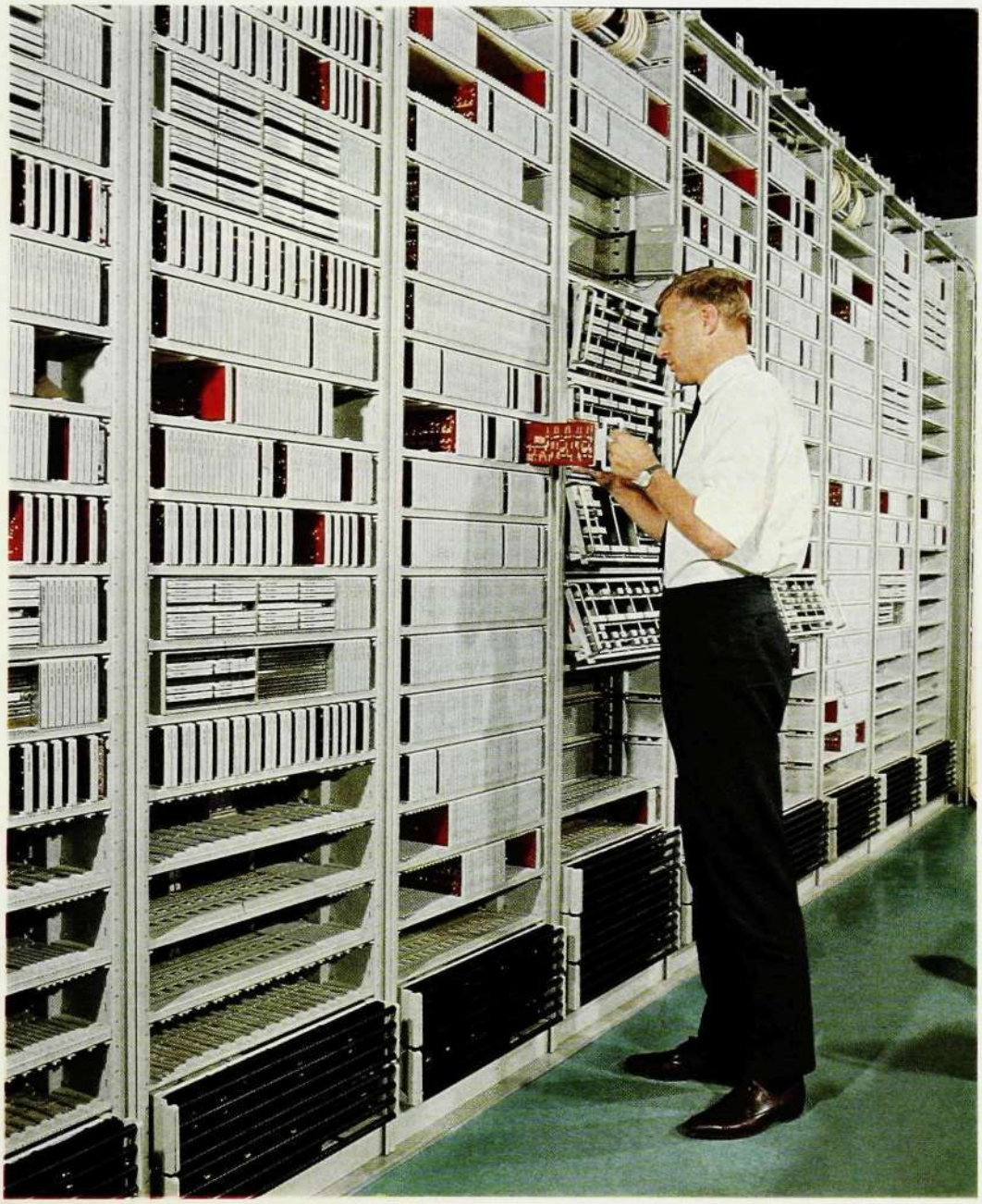
The data processing system in the AKE exchange comprises the processor and its various programs.
In order to ensure excellent operational reliability, all vital units in the processor, e.g. central processing unit, program and table store unit as well as data store unit are duplicated. Consequently the processor is normally divided into two parallel operating groups of units which are synchronously controlled by the same clock source. The results are continually checked for exact correspondency, but only one of the groups is executive at any one time. Any disparity is detected by a supervisory unit, which starts a fault locating routine, isolates the faulty unit and writes out a fault report on a teletypewriter. The one group of units then shares the corresponding healthy unit with the other group of units until the fault has been corrected. In this way several faults may occur without actually impairing the traffic handling or operational properties of the exchange.
The programs are contained in special stores which constitute a vital part of the processor. Generally speaking all stores are alike in different AKE exchanges and vary only in physical size and contents. The main program administers a number of sub-programs. These sub-programs carry out standardized functions which reoccur in several types of AKE exchanges. Therefore L M Ericsson keep a library of such sub-programs.
Further details of the switching network, transfer circuitry and data processing system at the Tumba exchange are given on pages 12—14.

4. TRAFFIC FACILITIES

The AKE system can incorporate any type of traffic facility and conform to the requirements of even the most progressive administration. A new traffic facility can easily be added at any time. Consequently it is not necessary to include more facilities in the initial stage than actually required at that moment. Subscriber push button dialling and centralized PABX facilities are, however, included as standard features. Some additional subscriber facilities are described on pages 16—18.

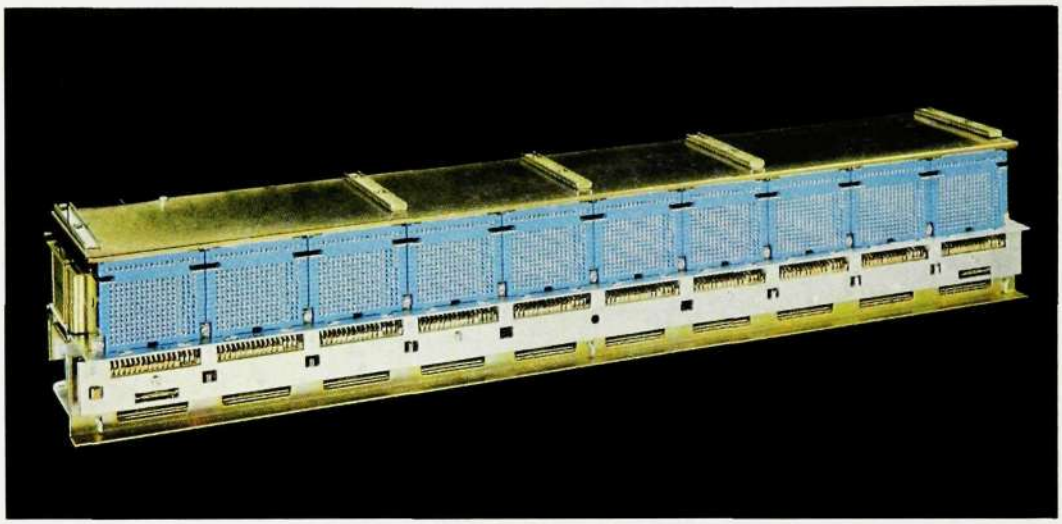
Data processing room at the AKE exchange, Tumba, Sweden. Racks of bookshelf design containing printed circuit component boards connected by plug and jack for easy inspection.

Fig. 2



The L M Ericsson code switch measures 650×160×120 mm, has built-in horizontal multiple, 10 verticals with 17 multiple positions, each with 13 make contacts. Each vertical has a two-pole capacity of 66 outlets.

Fig. 3



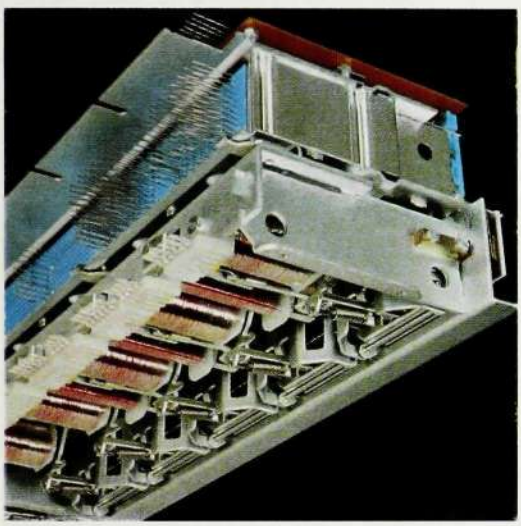
5. THE CODE SWITCH

Besides what has been mentioned on page 5, the L M Ericsson code switch possesses a number of other properties which are noteworthy.

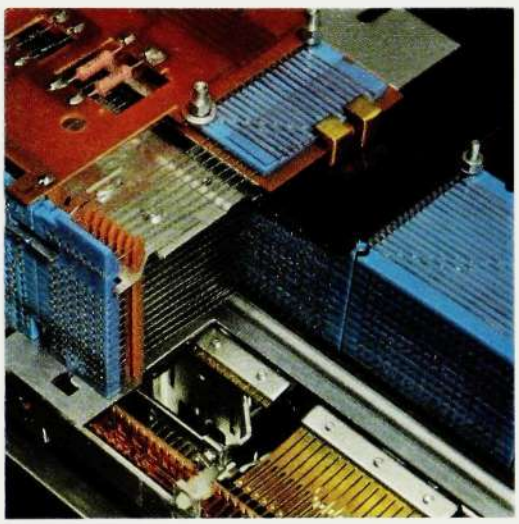
- It occupies much less space than any other electromechanical switch with the corresponding number of inlets and outlets. See fig. 3.
- The vertical magnets are pulse switched and employ mechanical latching. See fig. 4.
- The built-in horizontal multiple makes the code switch virtually dust-proof. See fig. 5.
- The new design of the contacts, where a cylinder shaped moving contact presses into a V-shaped fixed contact, results in a reliable, self-cleaning, twin contact unaffected by vibration or impact. See fig. 6.
- A built-in vertical has 17 multiple positions, each with 13 make contacts (see fig. 7). The 7 code bars control the selection and result in a flexible multiple capacity suitable for the AKE system.

A detailed description of the L M Ericsson code switch is given in Ericsson Review, No. 3/1964.

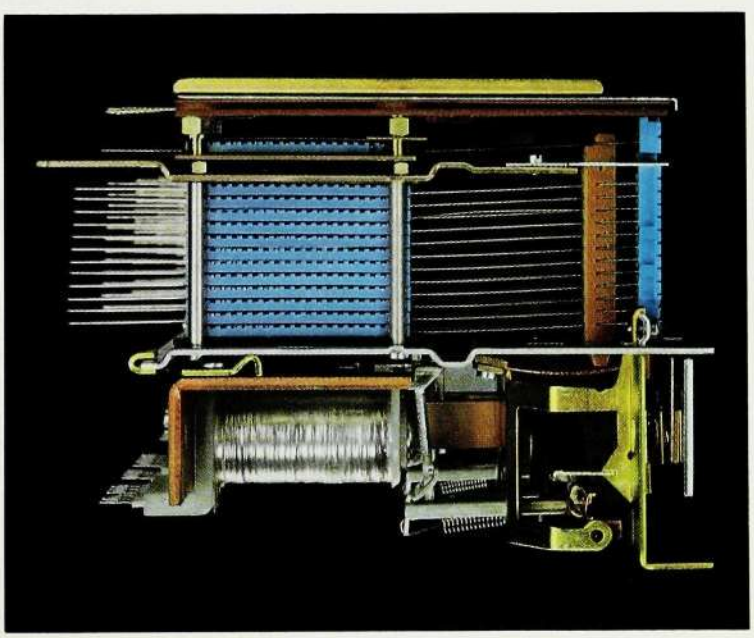
View from underneath showing vertical magnets. Fig. 4



Crosscut through built-in multiple down to code bars. Fig. 5

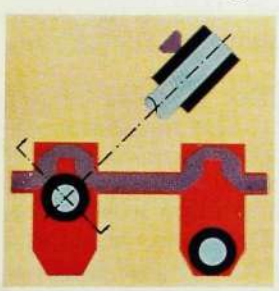


End view of L M Ericsson code switch showing contact wires of cylinder shaped moving contacts, vertical magnet assembly and code bars. Fig. 7

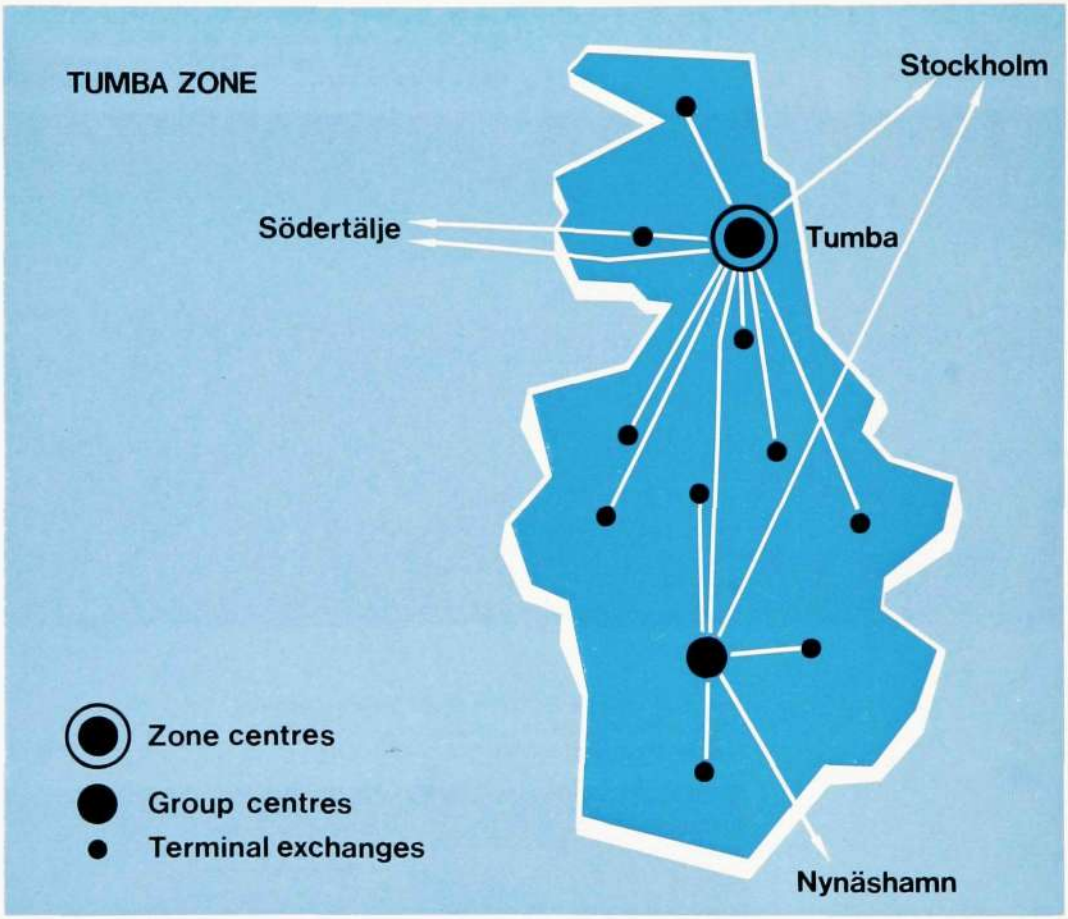


Enlarged view showing how the cylinder shaped moving contact presses into the V-shaped fixed contact, establishing a self-cleaning and vibration proof twin contact.

Fig. 6



The Tumba area with adjacent switching centres. Fig. 8



6. THE AKE EXCHANGE AT TUMBA, SWEDEN

6.1 Location in the Network

Tumba is a zone centre close to Stockholm, connected to the district centre of Stockholm. It also has a direct route to the zone centre of Södertälje, a town some 30 km (20 miles) from Stockholm. There are 7 terminal exchanges and 1 group centre connected to the Tumba exchange. In order to give a clear picture of the Tumba zone in relation to the total network fig. 9 shows the whole of Sweden divided into various telephone areas. Fig. 8 represents the Tumba zone itself.

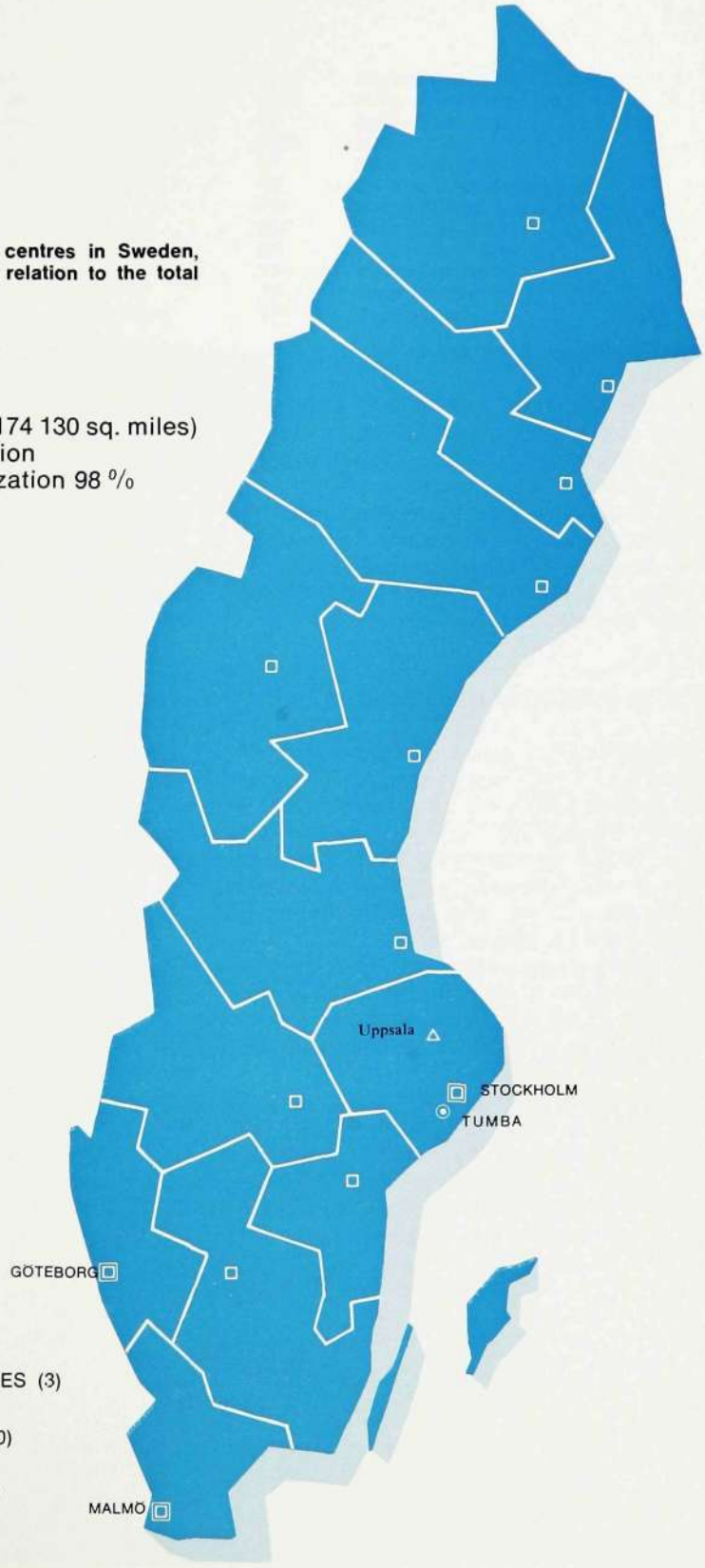
The Tumba zone has an area of 370 sq.km (145 sq.miles) and has a population of 17 000 with a telephone density of 41.2 telephones per 100 inhabitants. The average density for Sweden is 45.8 telephones per 100 inhabitants, being the second highest in the world.

Fig. 9

Map of principal telephone centres in Sweden, showing the Tumba zone in relation to the total telephone network.

Statistics:

Total area 449 000 km² (174 130 sq. miles)
Total population 7.8 million
Percentage of automatization 98 %



6.2 Trunking Diagram

The Tumba zone centre is a combined local and trunk exchange. The initial capacity of the exchange is 4 800 subscriber lines and 530 trunk lines.
Fig. 10 shows a simplified diagram of the Tumba exchange. The switching network, the transfer circuitry and the data processing system are shown in light, medium and dark blue respectively.

6.3 The Switching Network

The subscriber stage SLV is built up in groups of 1 600 lines in steps of 200 lines. As system AKE incorporates the number group translation facility, it is independent of the conventional 1 000-grouping. The B-switches are 2-pole, each vertical using 64 outlets. The A-switches utilize a 3rd pole for operating the cut-off relay and have a capacity of 52 outlets.
The local group selector stage GVL is arranged in units of 1 200 inlets and 1 300 outlets. It is a 2-pole stage, each vertical using 65 outlets.
The trunk group selector stage GVN is arranged in units of 400 inlets and 800 outlets. Although at present the trunks are 2-wire, it is planned to change over some 2-wire trunks to 4-wire trunks in the future. Therefore the stage is 4-pole with a vertical capacity of 42 outlets.

6.4 The Transfer Circuitry

The transfer circuitry acts as buffer stage by matching the electronic speed of the data processing system with the electromechanical speeds of the switching network.
The state of the switching network is scanned by the processor via line test units LT and relay test units RT as ordered by the program. Upon a change being detected in the switching network, the programs analyze this change and order operation of switches and relays via the buffer stores SMR and operating units VMR and RMR respectively.
The test units and buffer stores contain transistor gates and flip-flops, whilst the operating units contain transistors, reed relays and ordinary telephone relays.

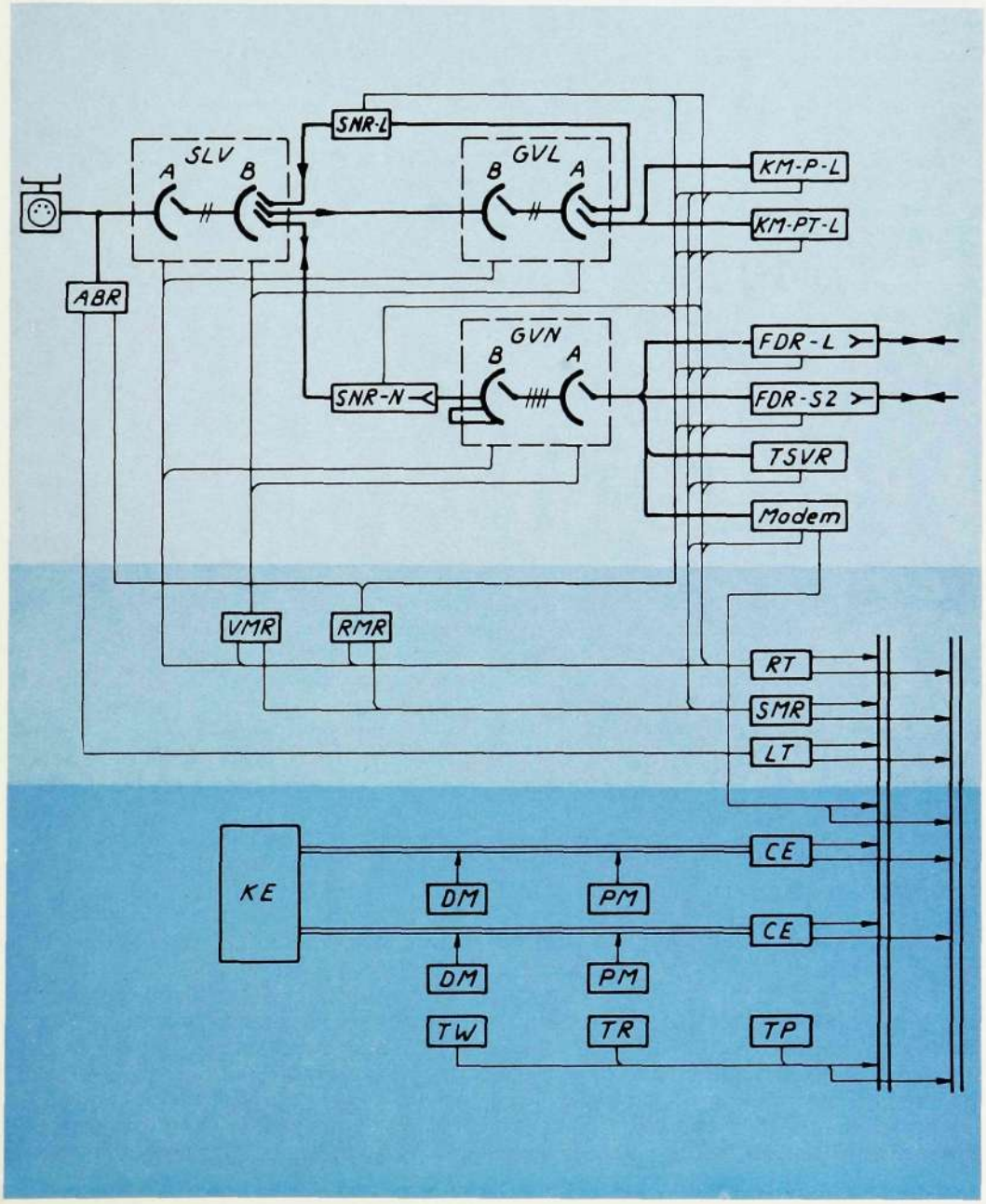
6.5 The Data Processing System

As mentioned earlier the data processing system (computers) is also of L M Ericsson's own design and is especially developed for telephone switching purposes. It is a digital, solid state, electronic type system. Ferrite cores are used as storing devices and the system operates on real time basis with clock-break facilities.

Legend:

SLV	Subscriber Stage	VMR	Switch Operating Unit
GVL	Local Group Selector	RMR	Relay Operating Unit
GVN	Trunk Group Selector	RT	Relay Test Unit
ABR	Subscriber Line Circuit	SMR	Buffer Store
SNR-L	Local Link Circuit	LT	Line Test Unit
SNR-N	Trunk Link Circuit	CE	Central Processing Unit
KM-P-L	Code Receiver, Dial	PM	Program and Table Store Unit
KM-PT-L	Code Receiver, Pushbutton	DM	Data Store Unit
FDR-L	Junction Line-DC	KE	Supervisory Unit
FDR-S2	Junction Line-S2	TW	Teletypewriter
TSVR	Telephone Answering Machine	TR	Tape Reader
Modem	Data Link Terminating equipment	TP	Tape Punch

Fig. 10



The AKE system applied in Tumba has the following characteristics:

Numerical representation	Binary
Word length	16 bits (4 charact.)
Clock frequency	5 MHz
Storage cycle	6 μs
Storage type	Coincident current ferrite core
Data store capacity	3×4×4 096
Program and table store capacity	2×4×4×4 096
Parity check	The store contains a 17th bit for checking the store read-out
Instruction list	84 instructions
Logic	Diode transistor logic with silicon elements

The processor consists of three parts, the central processing unit CE, the program and table store unit PM and the data store unit DM.

The central processing unit CE contains logic circuits such as process registers, an arithmetic and logic unit and a control unit. The control unit reads the instructions one by one from the program store, translates them and controls all processing.

The program store contains the exchange program, whilst the table store contains exchange data such as information for the conversion of directory numbers, area codes, routing information and other tables.

The data store unit contains all the temporary information about occupations, states and digits which in a conventional electromechanical exchange is stored in line and cut-off relays, link circuits, junction line relay sets, markers and registers. All store information is electrically changeable and it is therefore easy to add programs or change data whenever new facilities are to be introduced.

As mentioned on page 6 the AKE system includes two identical groups of vital processor units. These units operate synchronously on the same task, but only one of the groups is executive. The central processing units each have an internal bus system. Both systems are continuously checked for exact correspondency by a supervisory unit KE. A disparity automatically starts a primary fault locating routine which feeds the central processing units with a special test program, the correct results of which have been stored beforehand in the program store. As soon as a faulty answer is obtained, the faulty unit is taken out of service, and a fault report is typed out on the teletypewriter TW.

6.6 Input and Output Devices

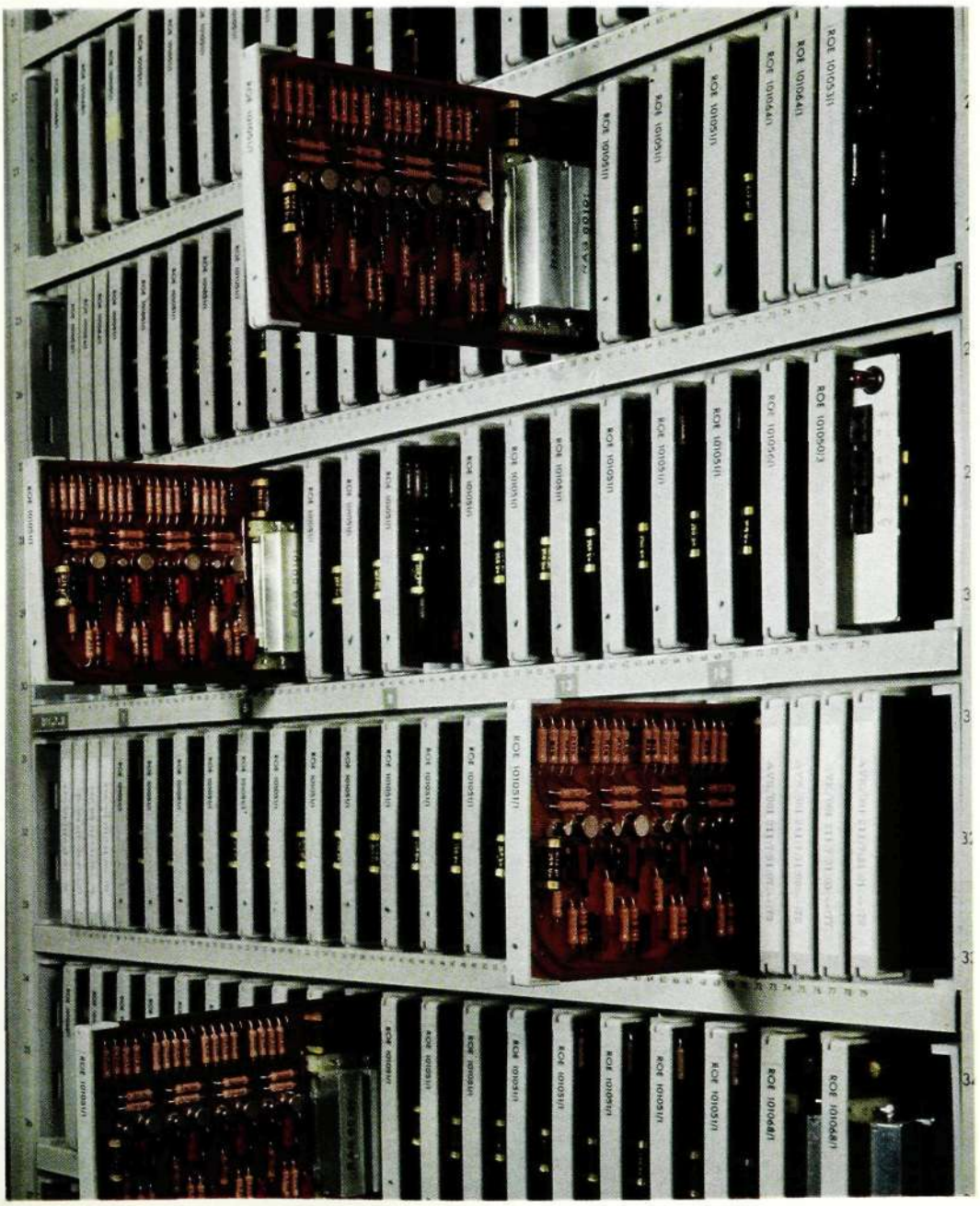
The data processing system has access to various input and output devices such as teletypewriter TW, tape reader TR and tape punch TP.

The teletypewriter is used by maintenance personnel to give orders to the data processing system. Such orders may be, for example, read-in of a new program, change of subscriber connection data or class of service, blocking of switching devices, etc. The teletypewriter is also used as an output device for the automatic typing out of statistics, congestion and alarm information. A type written journal of all measures taken by the exchange personnel is automatically obtained.

The tape reader TR is used for loading the stores with programs and exchange data at the starting up of the exchange and is thereafter used for other large inputs.

The tape punch TP is used for large outputs, e.g. writing out of metering information.

Buffer stores SMR in the transfer circuitry. **Fig. 11**



6.7 Call Processing

The processor is programmed for the continuous checking of the state of all subscriber line circuits ABR. This scanning procedure covers 16 subscribers simultaneously, with all subscribers having been scanned every 320 ms. When a subscriber lifts his handset, the change in the state of his line circuit ABR is detected within a scanning cycle.
The call detection activates a second program which selects a free code receiver, either KM-P-L for dial type instruments or KM-PT-L for push button type instruments, and a free switching path through the subscriber stage SLV and the local group selector stage GVL. A third program completes the actual connection, resulting in the dialling tone being sent to the subscriber from the code receiver.
The signal receiving relay of the code receiver operates in harmony with the pulses comprising the B-subscriber's number. Upon transfer via the relay test unit RT these pulses are detected by the processor and stored, digit by digit, in the data store unit. This detection takes place every 10 ms and covers 16 different code receivers simultaneously.
A local call is switched via local link circuit relay set SNR-L and the subscriber stage SLV to the B-subscriber, whilst a trunk call is established via a trunk link circuit relay set SNR-N and the trunk group selector stage GVN to the required route.

6.8 Additional Subscriber Facilities

At the initial stage the AKE exchange at Tumba incorporates the following additional subscriber facilities:

Enquiry and Transfer

During the course of a telephone conversation a subscriber may make an enquiry call to a number of preselected subscribers within the Tumba exchange area. Should he so desire he can also transfer the call to such subscribers.

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.

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 both subscribers are free. Thus, the need for redialling is dispensed with.

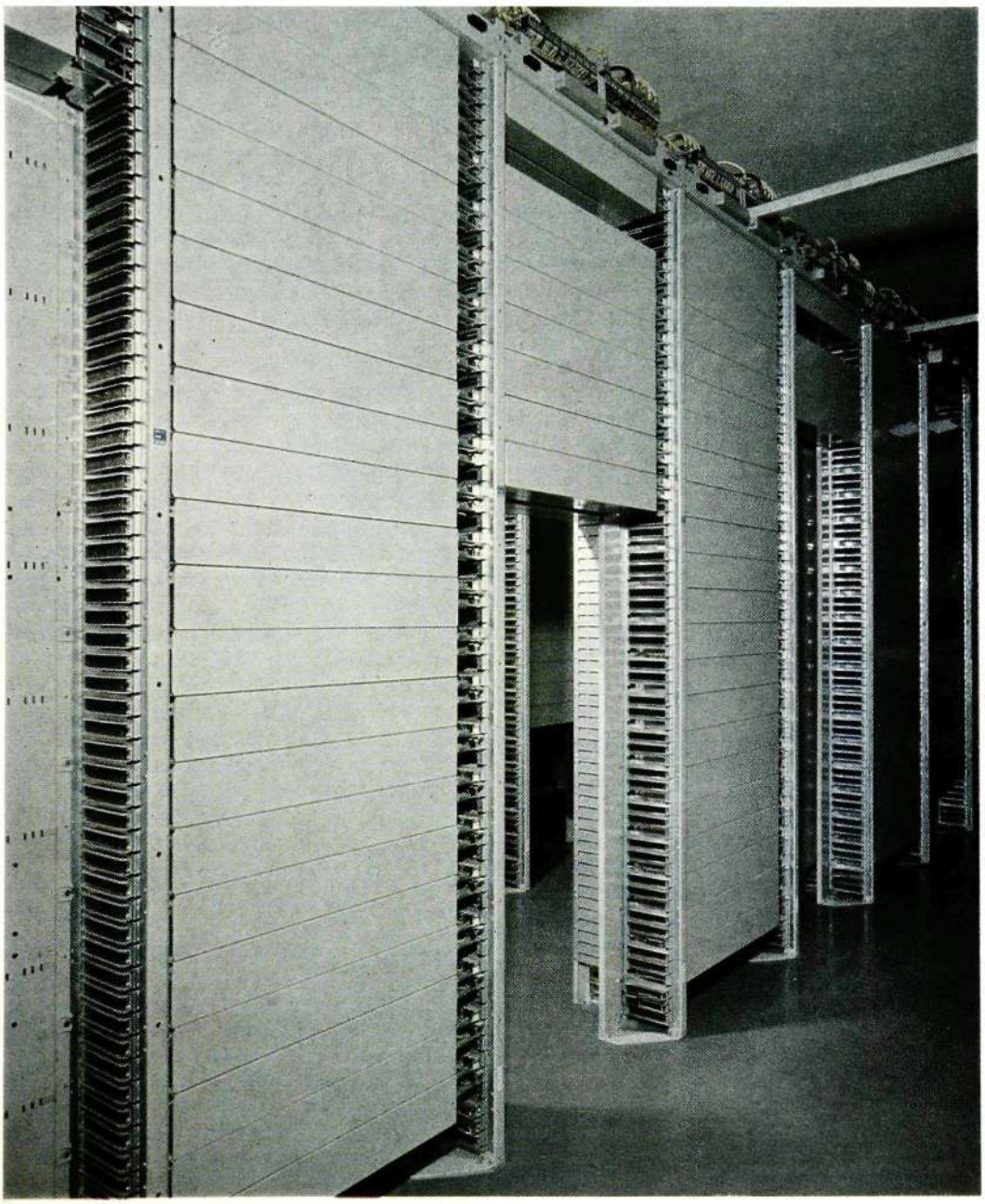
Temporary Transfer (or "Follow Me")

The subscriber is able to transfer temporarily all his incoming calls to another subscriber's instrument.

Abbreviated Dialling

A subscriber who frequently calls another subscriber may, in order to shorten the dialling procedure, have that other subscriber's normal directory number substituted by a short code number.

Interior of the AKE exchange at Tumba, Sweden. Fig. 12



Time Calling or Alarm-clock Service

The subscriber has the possibility to 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 hour practice.

Call Listing

The data pertaining to a telephone call may be listed. This listing may specify the particulars of either incoming or outgoing calls or both. It offers the possibility to register a variety of statistical information regarding subscribers' calling habits.

Subscriber's Meter Check

The total of a subscriber's call charging units, the number of charging units per call as well as call-meter readings may be registered and typed or punched out for checking purposes.

Malicious Call Recording

As a result of the called subscriber not replacing his handset, the line lock-out facility comes into operation and records both subscribers' numbers.

Indialling

Subscribers may dial directly to private automatic branch exchange extension instruments without the assistance of the private operator.

In addition to the facilities described above it is planned to introduce other new traffic facilities in future, amongst these all the facilities which today are incorporated in advanced L M Ericsson PABX systems.

7. COMPATIBILITY WITH OTHER TELEPHONE SYSTEMS

The AKE system allows the connection of any type of telephone instrument, private branch exchange, coin-box instrument or time limiting device and can interwork with any other telephone system available. All known signalling systems for either two-wire or four-wire circuits can be used in the AKE exchange system. Full availability exists on trunk lines and as a result of the number group translation facility, subscriber and area numbering are independent of the exchange multiple positions.

8. CENTRALIZED ADMINISTRATION AND SUPERVISION

Stored program controlled electronic exchanges of the AKE type enable administrations to considerably reduce the amount of time spent on administrative and maintenance duties.

Changes in traffic routing, subscriber class of service etc. may be carried out by means of remote control from a central point in a multi-exchange area. The same applies to fault and traffic statistics information.

Subscribers' meters are not required in an AKE exchange. The call charging operation of an entire network may also be concentrated in one central point, to which centre the individual subscriber's metering information is transmitted at suitable intervals and where call charging may be done automatically.

The data processing system also detects faults automatically either during test traffic or real traffic conditions, isolates the faulty circuit, reports the fault on a teletypewriter and actuates visual and audible alarms.

Guided by these reports, the maintenance staff corrects the fault and the data processing system checks that the formerly faulty circuit performs correctly before returning it to normal duty.

Automatic supervisory tests of subscribers' lines are made on randomly selected calls before dialling tone is sent to the calling subscriber and ringing signal to the called subscriber. Any line fault encountered is reported on the teletypewriter stating also the number of the subscriber in question.

The operational data thus obtained at each individual exchange in a network may be retransmitted automatically to a common supervision centre, thereby enabling highly qualified analysis on a centralized basis.

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