ERICSSON REVIEW

ELECTRONIC TELEPHONE SETS

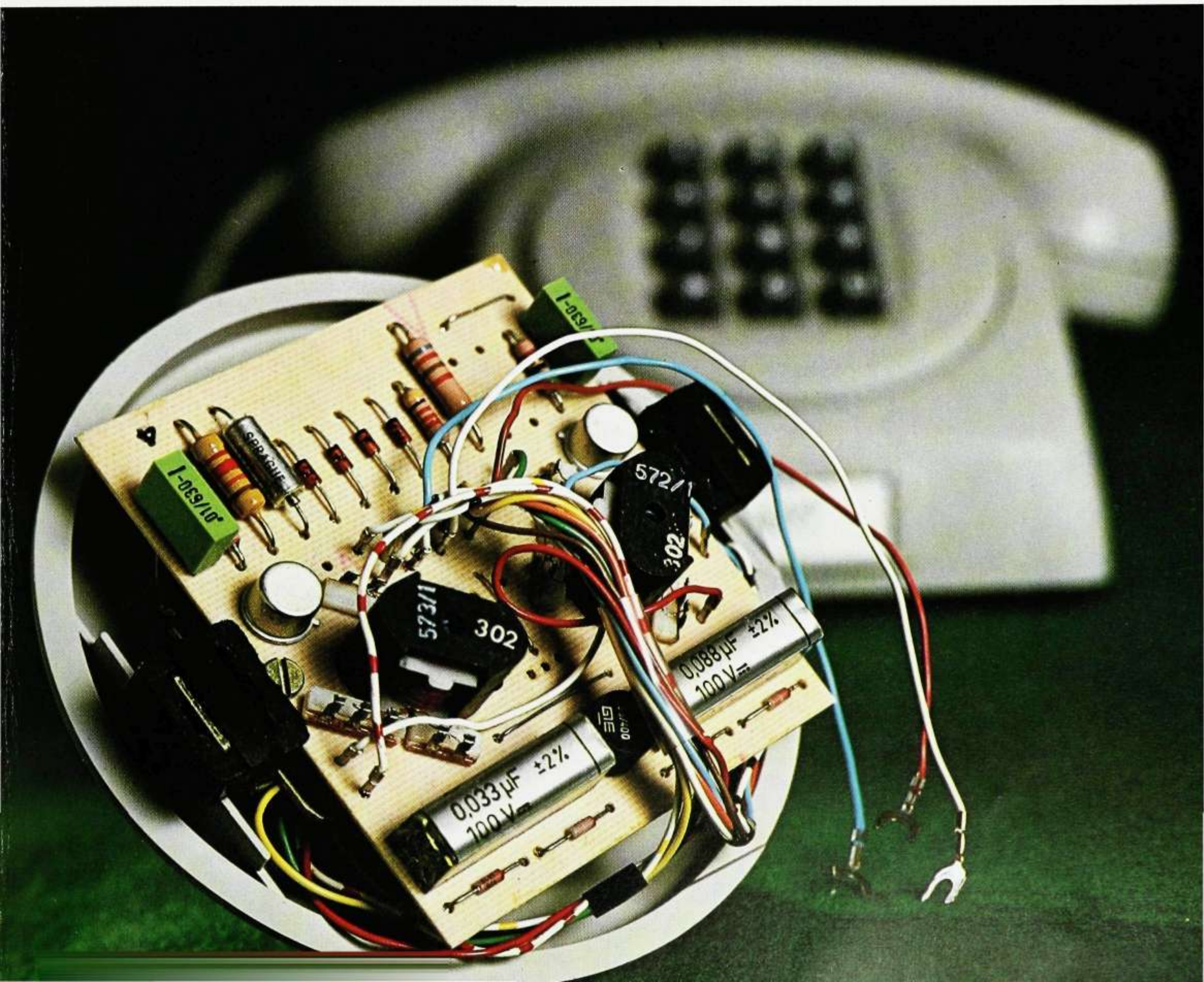
COAXIAL CABLE SYSTEMS

AUTOMATIC TRANSMISSION MEASURING EQUIPMENT

FIFTIETH ANNIVERSARY OF ERICSSON REVIEW

WORLDWIDE NEWS

1 1974



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Contents

Ericsson Review celebrated its half-centenary at the expiry of 1973. An article in this issue presents a retrospect of the fifty-year history of the journal — a very long period for a journal of this type. Typographically the journal has undergone changes on several occasions, but over a period of many years they have been small superficially. This has also been a strength — people have learnt to recognize Ericsson Review. The editor has nevertheless considered the time ripe for a more radical metamorphosis, both of the cover and of the general layout. What the editor hopes is that in its new form Ericsson Review will be still easier to read and that, in appearance, it will continue to hold its own in comparison with corresponding journals.

The Editor

COVER

Pushbutton dialling unit with LC oscillator for DIALOG telephone.
The round plate carries on the front the pushbutton set seen on the telephone set in the background.

Electronic Telephone Sets

Arne Boeryd

This article is a revised version of a paper presented at the IEEE Meeting EUROCON-71 in Lausanne, October 18—22, 1971.
The author discusses from the technical and economic aspects the possibility of introducing electronics in telephone sets and reports the development at LM Ericsson in this field up to 1974.

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The chief functions of a telephone set, as is known, are largely

1. to close a DC loop connecting the subscriber to the exchange via the local cable,
2. to generate coded signals representing digits and/or letters needed by the exchange machinery for setting up the connection,
3. to convert electrical signals from the exchange into acoustic signals from the telephone set in order to attract the attention of the called party,
4. to convert acoustic signals (speech) into electrical signals for transmission to the other party's receiver,
5. convert the electrical signals back into audible speech.

A future telephone set should therefore be able

6. to generate code signals representing digits and letters for transmission to computers and present the answers issued by the computer in visual and/or acoustic form to the subscriber.

During the nearly one hundred years that the telephone set has been in use, functions 1—5 have been achieved by means of metallic springsets, magnetic circuits and carbon granules.

The component which has permitted transmission of speech signals without amplification over considerable distances is the carbon transmitter which, besides converting the acoustic into electrical signals, at the same time introduced amplification of 40—50 dB with a feed voltage of about 3—4 V.

The next important step in the history of the development of the telephone set was taken in the twenties when the CB telephone set was equipped with a dial, which permitted the subscriber himself to transmit the coded signals for setting up of the connection. During the thirties an electrical hybrid circuit was introduced which separates the transmitted and received signals from one another and balances them for optimal sidetone attenuation on connection of the 4-terminal network to the 2-wire local line.

The next step in the development came in the fifties when semiconductor devices were introduced in the sending and receiving channels to adjust their sensitivity as function of the line resistance and thereby compensate for variations in the sending channel in the local exchange and in the receiving channel in the telephone set. This compensation of the local line attenuation is most simply done in the receiving channel. To achieve compensation in the sending channel is more complicated owing to the DC supply loss of the carbon transmitter and its non-linear current-voltage characteristic.

With the exception of the developments indicated above, active electronic elements such as vacuum tubes, transistors etc. for improvement of the characteristics and/or reliability of the telephone set have not been used to a great extent. The main reason for this has been economy, but also to a very great extent the limited DC power available in the telephone set.

Electronic microcircuits, LSI (Large Scale Integration) components, both linear and digital, together with resistors and capacitors in film technique, became of great significance in the design of telephone sets as from the 1970's. This new technique, however, must prove its economic and maintenance superiority compared with existing technique before it comes into use on a wide scale. An advantage of microelectronics for transmission, signalling and ringing is, of course, the almost complete freedom offered in the external design of telephone sets. Greater attention can be paid both to practical and aesthetic points of view.

Existing exchange equipments and telephone sets have a fairly long life and several decades elapse before a

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new technique has become fully established in a telephone network. During this time, therefore, the old equipment must be able to work together with units which have better and different characteristics. The manufacturing technique for today's telephone sets, moreover, is strictly rationalized and in some respects automatized, which means that the transition to a new technique will take a relatively long time and involve heavy investments both for manufacturer and user. Owing to these factors the introduction of electronics in the telephone set takes place only when the new technique has proved its operational and economical superiority.

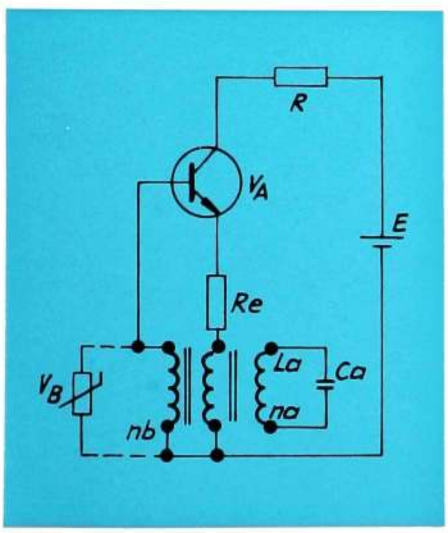
Electronic circuits and DC characteristics of the telephone set

To allot to the subscriber's line as great a portion as possible of the permissible loop resistance and to give the telephone set as low a resistance as possible during dialling, the DC resistance for a telephone set has traditionally been as low as possible, of the order of 100—300 ohms. The direct currents needed to operate line relays etc. in existing systems are of the order of 20—10 mA. With unchanged telephone set resistance these currents result in a working voltage of only 4—2 V for eventual electronics.

In the borderline case there is practically no working voltage left after a polarity guard, if any, unless a circuit for voltage conversion of the direct current is introduced in the telephone set for feed of the circuits.

An ideal voltage to drive the electronics would be 12—15 V. The voltage can be reduced to an order ot 5—6 V, apart from the addition for the polarity guard. The problem can be overcome by making use of the fact that the line relay will hold to a much lower current than is required for its operation. By short-circuiting of the telephone set during the first 100—200 ms the function of the line relay on connection is ensured and a higher voltage drop can be allowed during dialling and transmission.

Fig. 1
LC oscillator, circuit diagram



Dialling

Frequency generation with analogue technique

The component in a telephone set which necessarily requires active electronic circuits is the pushbutton audio frequency dial, in which each digit is characterized by two simultaneous frequencies instead of the number of DC pulses corresponding to the digit dialled with a rotary dial.

As is known, the following frequencies are recommended by CCITT:

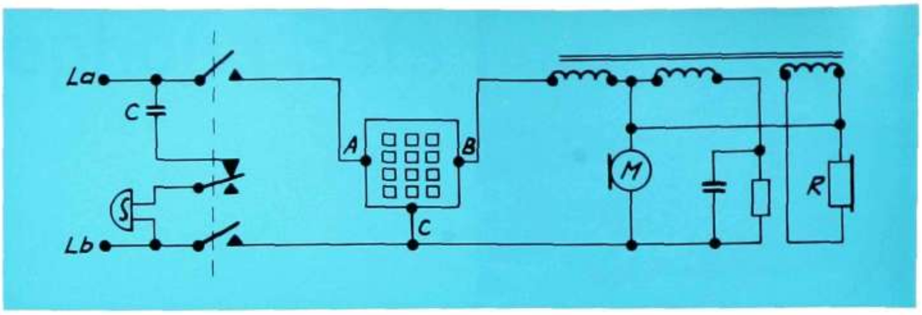
Hz	1209	1336	1477	1633
697	1	2	3	A
740	4	5	6	B
852	7	8	9	C
941	*	0	#	D

The frequency tolerances under all working conditions between + 50° C and — 30° C during the lifetime of the dial, and including manufacturing tolerances, must lie within ± 1.8 %. This requires a careful choice of components and temperature compensation.

The oscillators for pushbutton dialling which have been used hitherto are of LC type. Figs. 1—3 show the LC oscillator at present made by L M Ericsson. The amplifier is an emitter-follower with a gain of $\leq$ 1. The feedback circuit is connected between the base and emitter and the winding of the tuned circuit is connected inductively to the coil in the feedback circuit. To maintain the oscillation the transformer ratio between emitter and base must be $\geq$ 1. To minimize the build-up time of the oscillator, magnetic energy is stored in the coil through the voltage drop which takes place across diodes V6—V7 when the handset is raised. The oscillator is connected directly to the line in the same way as the dial.

The LC oscillator, however, has several disadvantages. The ferrite coils are physically fairly large and, in their attachment, are mechanically sensitive to shock. The trimming procedure in manufacture is time-consuming and must be done manually, which prevents an automatic production technique.

Fig. 2
LC oscillator, functional diagram



As a consequence of the development of integrated linear amplifiers and film circuit technique, with the possibility of automatic trimming of resistances to a sufficiently high accuracy, the RC oscillator becomes attractive. Of the various film circuitries available the tantalum technique appears to be the most appropriate, since resistors and capacitors can be produced in analogue processes. Resistors and capacitors in tantalum technique, furthermore, show great stability to aging; temperature compensation is achieved by matching the temperature coefficients for the resistors and capacitors to the same value but with different signs, which gives a temperature coefficient close to 0 for the necessary frequencies within the temperature range of interest.

L M Ericsson's RC oscillator is shown in fig. 4. The oscillator consists of two identical amplifiers, each having a frequency selective feedback network which is brought into oscillation at the desired frequency. The feedback circuit is a twin T resistance-capacitance network. The accuracy of the capacitors is of an order of 2 % and the resistors can be individually trimmed to 0.1 % of their nominal value. The final trimming of the circuit is done by adjustment of a resistor in a given frequency group, giving a final accuracy of all frequencies of an order of 0.3 %.

Through a low-pass filter the feed circuit of the oscillator has been separated from its AC output. The oscillator amplifiers work with a voltage drop practically independent of the line current, and determined by a suitable choice of diode resistance network. On a long line the main part of the line current passes through the diode resistance network. With increased line current, base voltage arises in a current regulating circuit which counter-

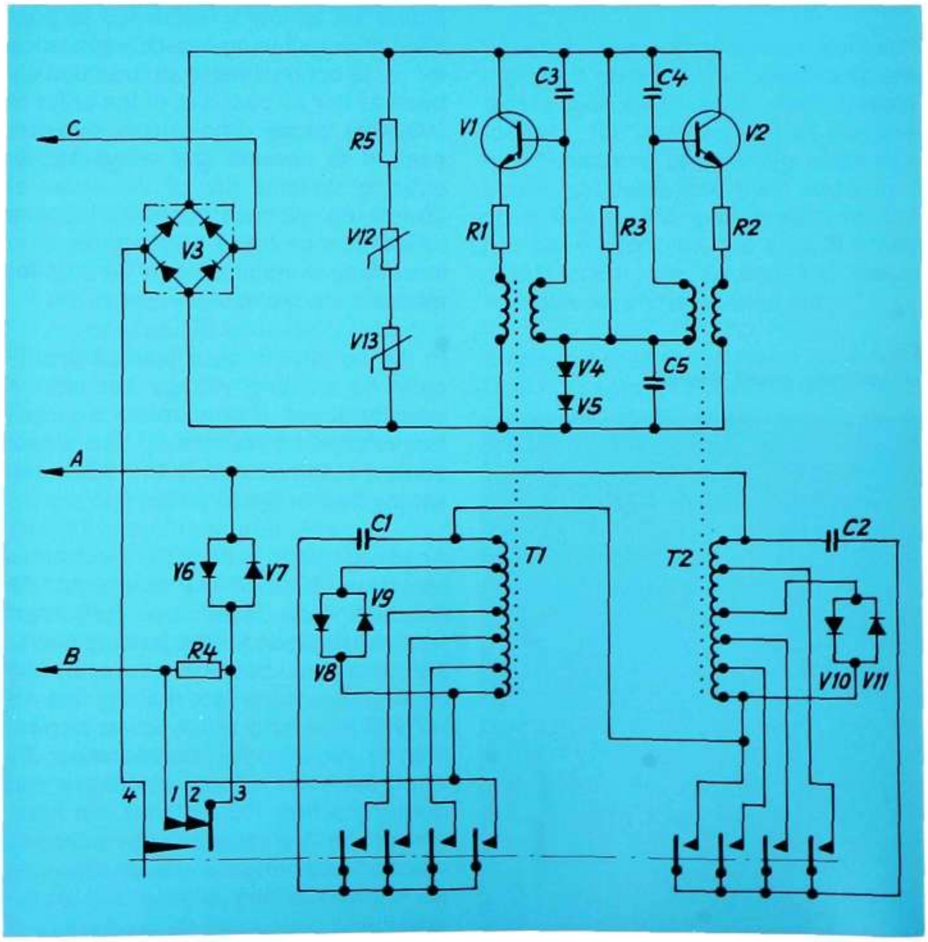


Fig. 3
LC oscillator, connected in telephone set

acts the rise of voltage across the feed circuit of the oscillator. From the DC point of view the oscillator exhibits a variable resistance which on a short line draws more current than would a constant resistance. In this way one obtains a DC characteristic for the oscillator unit which is practically identical to that of the transmission circuit, so that the risk of transients owing to sudden change of a voltage drop on switching between telephone set circuit and dialling circuit is eliminated.

The output impedance of the oscillator and the levels for the two frequency groups are selected individually and are entirely independent of the current regulating circuit.

Frequency generation by digital technique

The development of the MOS (Metal Oxide Silicon Gate) technique, resulting in digital counters and storage circuits of LSI type with extremely small power requirement for their function, opens the way to the solution of frequency generation for pushbutton dialling by using digital technique.

The principle is shown in fig. 5. A crystal oscillator, with a frequency of 1 MHz passing through the two binary counters AD and BD, of which AD is a 10-bit counter and BD a 9-bit counter, gives the larger counter a division factor up 1024. This results in a minimum frequency of 976 Hz. For a 9-bit counter the corresponding division factor is 512, giving a minimum frequency of 1953 Hz. By adding an extra flip-flop in each output one obtains a division factor of 2, which results in minimum frequencies of 488 and 976 respectively. Through the gates GA and GB and pushbutton contacts each counter can be zeroed after four division factors within the range of the bit speed for

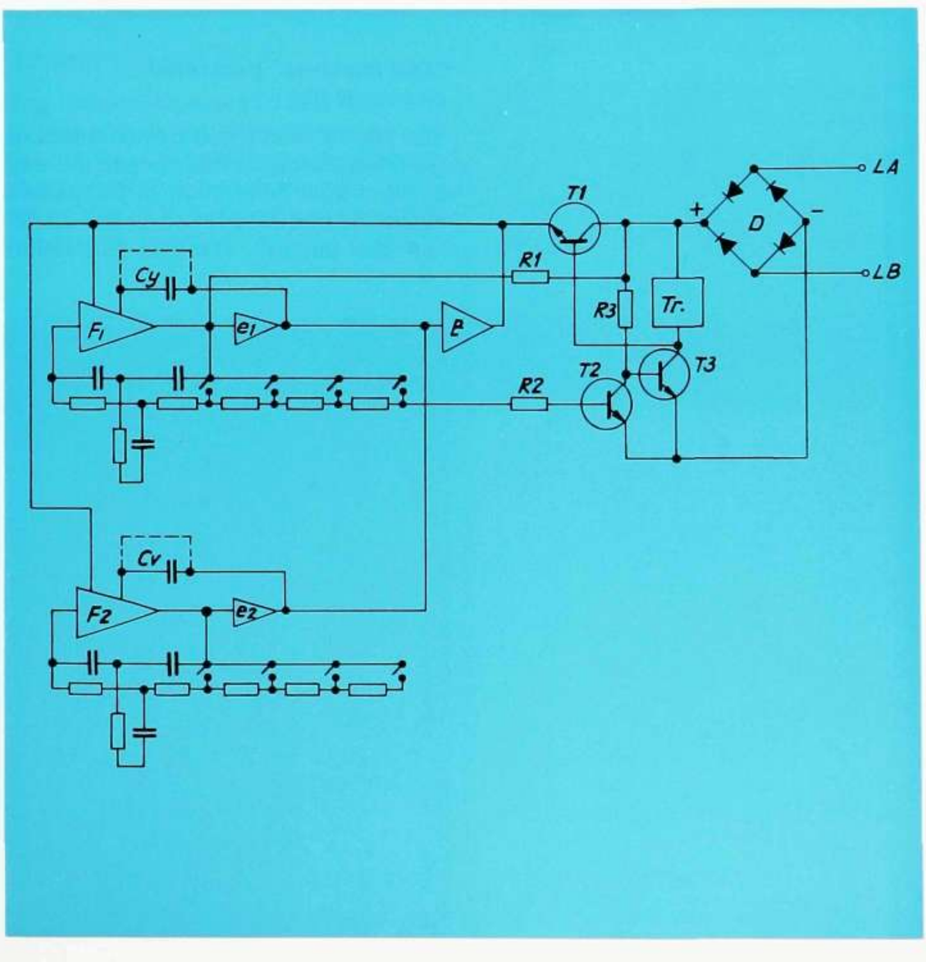


Fig. 4
RC oscillator, circuit diagram
F_1 oscillator amplifier, frequency group 1
F_2 oscillator amplifier, frequency group 2

each counter. In this way a frequency stability of 0.15 % is obtainable for the necessary pushbutton dialling frequencies.

The filtering of the output can be achieved in different ways, for example with a low-pass filter on each oscillator output. With an active low-pass filter, three capacitors and three resistors, the overall distortion can be kept below 5 %. The output level for the oscillator is then determined by the amplifier which connects the two oscillators to the line.

The introduction of audio frequency pushbutton dialling systems, except in the USA, has hitherto taken place only on a limited scale. In parallel with field trials of audio frequency pushbutton dialling systems, decadic electronic pushbutton dialling systems for resistance diode dialling have been tried out on a large scale by, among others, the Swedish Telecommunications Administration.

"Dial impulses" generated electronically

The earlier mentioned development of the MOS technique has opened the way to electronic generation of DC pulses within the frequency interval 10—20 Hz, i.e. "dial pulses". The first generation of decadic electronic pushbutton dialling units for generation of dial pulses were fed from a chargeable battery. The battery either received a continuous charge, about 2 mA, during ringing (parallel charge) or, during conversation, from the line current of the telephone set (series charge). The power requirement for the available binary storage and counting circuits has successively diminished, so that pushbutton units for dial pulses can be constructed today for feed from the line current with auxiliary current from a buffer capacitor (1,000—300 μF). A block schematic of L M Ericsson's batteryless electronic pulsing unit is shown in fig. 6. The frequency selective element of the oscillator unit consists of a 3-component RC network. The oscillator generates a square wave with frequency 20 kHz. The generated voltage pulses serve both as clock signal generator and feed voltage for the storage and logic unit. The feed voltage (approx. 15 V) is obtained through the fact that the oscillator generator passes a 3-step cascade generator of diodes and capacitors.

The storage and logic unit consists of code converters for conversion of pushbutton code to 4-bit binary code, four parallel working 20-bit shift registers for storage of up to 20 digits, a count-down chain for division of 20

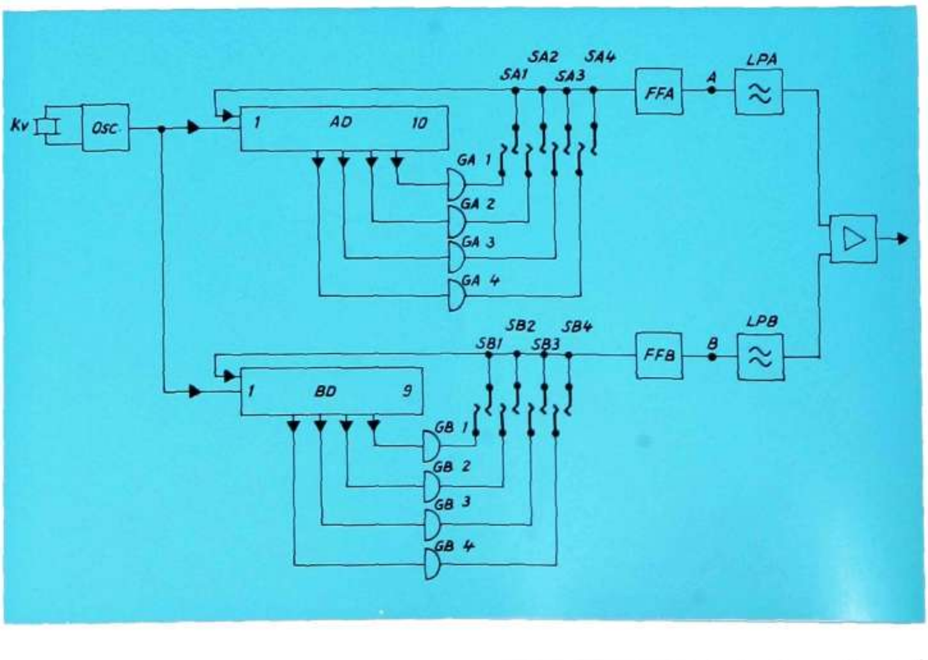


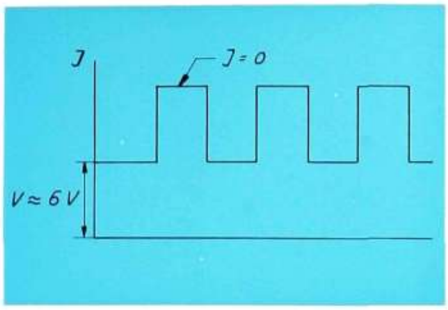
Fig. 5
Frequency generation for pushbutton dialling

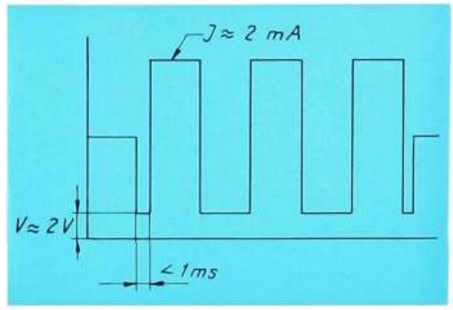
AD 10-bit counter
BD 9-bit counter
FFA Flip-flop filter, frequency group A
FFB Flip-flop filter, frequency group B
LPA Low-pass filter, frequency group A
LPB Low-pass filter, frequency group B

Fig. 7

Decadic electronic pushbutton dialling with transistor switch (10—20 Hz)

a "open circuit" current 0
"short circuit" voltage drop approx. 6 V
b "open circuit" current approx. 2 mA
"short circuit" voltage drop approx. 2 V





kHz to 10, 16 or 20 Hz, and logic for coordination of the desired frequency, pulse ratio and interdigit pause.

In transmission position the capacitor C is charged to the working voltage of the transmission circuit. When a button is pressed, circuit B opens and the voltage across the capacitor rises, so starting the oscillator. When a sufficient working voltage has been attained, the storage unit is zeroed by circuit F, after which the storage and counter unit receive the code from the pushbutton set. A is disconnected and the pulsing is carried out by circuit B on orders from H. The pulsing, which is done with a transistor switch, can either be carried out in accordance with fig. 7 a, in which case the "open circuit" current is 0 and the "short-circuit" voltage drop about 6 V, or in accordance with fig. 7 b, in which case the "short-circuit" voltage drop is about 2 V and the "open circuit" current about 2 mA. The pulsing unit is connected to the telephone in exactly the same way as the conventional dial.

Transmission unit

The transmission quality of a telephone connection is entirely determined by the quality of the sending and receiving channel of the telephone set. Every effort should therefore be made to improve their quality.

The availability of microcircuit amplifiers today offers the means for a great step forward in the improvement of the speech quality, both as regards speech level and naturalness. Conversation and listening tests have been carried out at different laboratories in the world in order to find the optimal range as regards transmission level. Studies have also been made of actual telephone calls for the same purpose. Expressed in reference equivalents relative to NOSFER these studies indicate an optimum of 5 to 15 dB, to be compared with the recommendation of max. 36 to 40 dB.

The future target set by several telephone administrations for the overall attenuation between two local exchanges is 10 dB. Assuming the same balance between sending (SRE) and receiving (RRE) reference equivalents as recommended at present, the desired values at the limiting line resistance will be:

$$\mathrm{SRE} + \mathrm{RRE} + 10 = 15$$
$$\mathrm{SRE} - \mathrm{RRE} = 8.6$$
$$\mathrm{SRE} = 7 \qquad \mathrm{RRE} = -2$$

Assuming the limiting line resistance to be 1,500 ohms (5 km 0.4 mm cable) with a weighted attenuation of 8.5 dB, the sensitivity of the set at the limiting line current will be

$$\mathrm{SRE} = -1.5 \qquad \mathrm{RRE} = -10.5\ \mathrm{dB}$$

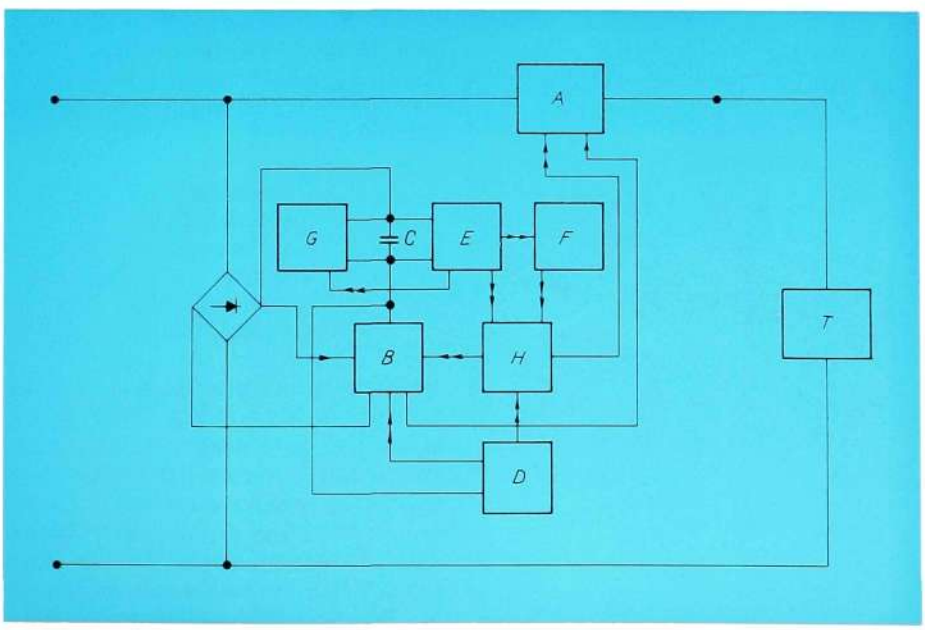
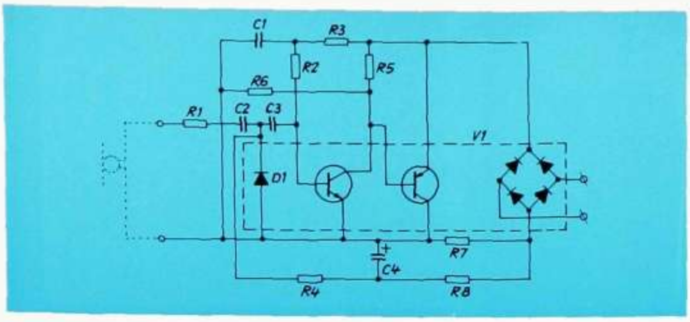


Fig. 6

Pushbutton dialling unit for decadic pulsing (10—20 Hz)

A Break contact. Voltage drop max. 2 V
B Pulsing and series control circuit
C Buffer capacitor
D Pushbutton selector
E Oscillator — time base
F Zeroing circuit
G Shunt control circuit
H MOS circuit
T Transmission circuit



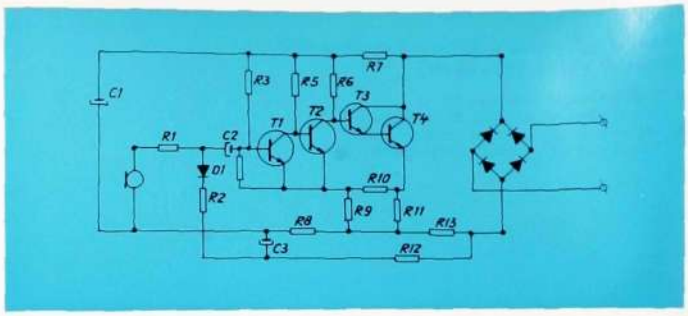
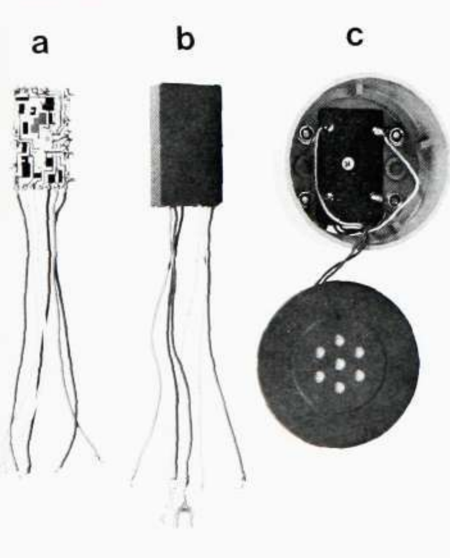


Fig. 8 (left)
Microphone amplifier with discrete component

Fig. 9 (right)
Microphone amplifier in integrated design

Fig. 10
The DIALOG has the transmitter and speech circuit placed within a common cover

a *Electronic speech circuit, non-encapsulated*
b *Electronic speech circuit, encapsulated*
c *Speech circuit with associated transmitter*



On change of the gain factor by $5.6 \cdot 10^{-3}$ dB per ohm line resistance for both sending and receiving channels, the overall reference equivalent will be within the optimal range 5—15 dB, both during conversation between local subscribers and on long-distance calls, with maximal loss of 10 dB between the local exchanges. This is on the assumption that the telephone sets are equivalent.

The relation between the average speech power in dBm and the sending reference equivalent in dB has been empirically found to be

$$P = -SRE - 7 \text{ dBm}$$

The mean speech power will thus be — 14 dBm with a standard deviation of ± 5 dB and a peak-to-peak factor of about 12 dB.

To prevent speech clipping even at the maximum speech voltages the amplifiers should transmit voltages up to 3 V free of distortion, which requires a working DC voltage for the amplifier units of 6 V.

Transmitters of the future

The goal of optimal transmission level for all subscribers can in practice not be attained with carbon transmitters. Linear microphones designed on different principles will in future be available for use in telephone sets.

Among the types which may be considered are

piezo-electric
piezo-resistive
semiconductor
electret
electromagnetic
electrodynamic

Of these various principles the electret appears to offer the greatest advantages, both technically and economically, and is therefore being intensively studied by leading telephone manufacturers. Thorough experience of design and production exists, on the other hand, within the field of electromagnetic and electrodynamic microphone elements and these principles can therefore be put to immediate use.

If the goal of optimal transmission level for all subscribers is to be attained, sensitivity control of the two directions of transmission is required, as noted earlier. This is desirable in order to avoid too high speech levels in the telephone network, to reduce the risk of crosstalk, and to permit effective sidetone attenuation and prevent acoustic feedback. This sensitivity control can be regulated either by variations in the direct current of the local line or by equipping the telephone set with automatic level control, which both limits the outgoing speech signals and provides a constant sound level during reception.

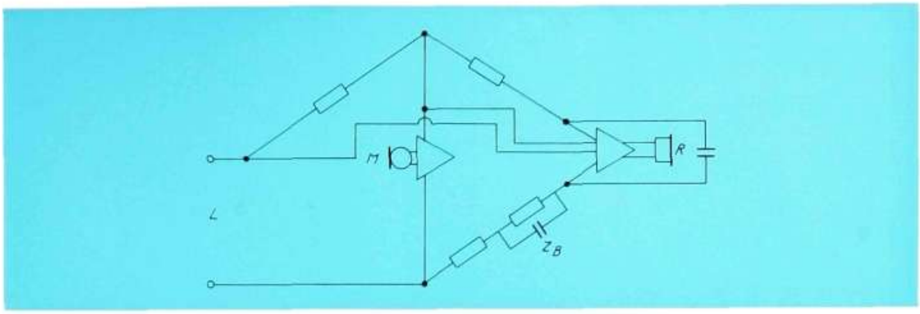
The non-linear characteristics of the carbon transmitter, which prevent its detection of moderately high noise levels and limit the power at high speech levels, should also be noted. The necessity of simulating this power when using a linear transmitter with associated amplifier has been studied in conversation tests. The limited advantages revealed by these studies, however, do not appear to justify the complexity of such a design. The automatic sensitivity control during reception may also have catastrophic consequences in the event of line noise in combination with low speech levels.

Figs. 8 and 9 show a solution adopted by L M Ericsson for sensitivity control of the sending channels. The change of sensitivity as a function of the line current (line resistance) is determined by the value of the resistances R7, R8 in fig. 8, the voltage drop across which causes a variable attenuation in the network R1—D1 on the amplifier input.

The placing of the sensitivity control circuit in the amplifier input ensures low output distortion. Furthermore, the control circuit does not affect the amplifier output impedance, which remains practically constant at different line currents.

Fig. 9 shows a further development of the sending amplifier designed for integrated film circuitry as regards amplifier elements and passive compo-

Fig. 11
Electronic speech circuit, functional diagram



nents. This microphone amplifier together with an electromagnetic microphone or electret microphone can be connected to existing types of inductive transmission circuits for telephone sets.

The mere replacement of the carbon transmitter by a linear microphone and amplifier admittedly brings an improvement of quality. The cost of the improved unit, however, will during the foreseeable future be considerably higher than that for the carbon transmitter. This cost situation can, however, be essentially changed if available technique is used for replacement of all circuit elements for the transmission unit in the telephone set. On the basis of microphone amplifiers as in fig. 9, which in field trials have exhibited the expected satisfactory characteristics as regards transmission and maintenance, an electronic speech circuit has been developed. In this speech circuit most of the amplifiers for sending and receiving have been collected together in a linear monolithic amplifier. The amplifiers are placed on a thick film circuit which contains the necessary resistances for trimming and wiring. The necessary capacitor chips are also placed on the thick film circuit. As protection against mechanical and climatic action the complete transmission unit is enclosed in an epoxy capsule.

A problem which may be expected to arise in conjunction with the introduction of amplifier elements in telephone sets is the risk of detection of radio signals. This can be counteracted to some extent by electric decoupling of critical points in the amplifier. Furthermore, transmitter elements should be placed immediately adjoining the amplifier. In the design produced by L M Ericsson for the DIALOG telephone the transmitter and speech circuit (fig. 10) are placed in one unit and the complete unit can be easily screened against electromagnetic radiation. The speech circuit has been designed for use either of an electromagnetic microphone or an electret microphone. In the case of an electromagnetic microphone identical components have been chosen for transmitter and receiver, namely L M Ericsson type RLD 517.

The functional diagram of the speech circuits is shown in fig. 11. Transmission data in the form of reference equivalent relative to NOSFER for sending, receiving and sidetone are shown in fig. 12. DC characteristics and telephone set impedance will be seen in figs. 13 and 14, and the sending fre-

Fig. 12 (left)
Sending (SRE), receiving (RRE) and sidetone reference equivalent (SIRE) relative to NOSFER as function of length of line

Cable = 0.4 mm
R = 280 ohm/km
C = 50 nF/km
Feed
48 V, 2×400 ohm
48 V, 2×250 ohm

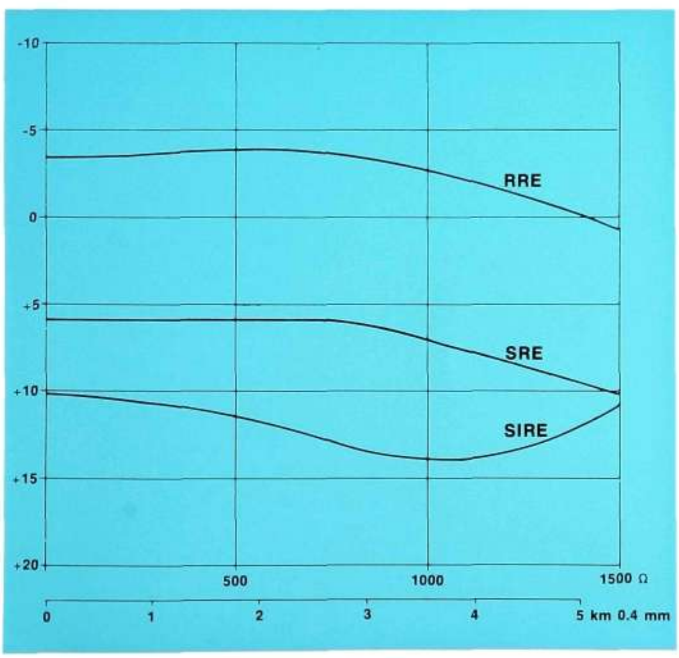
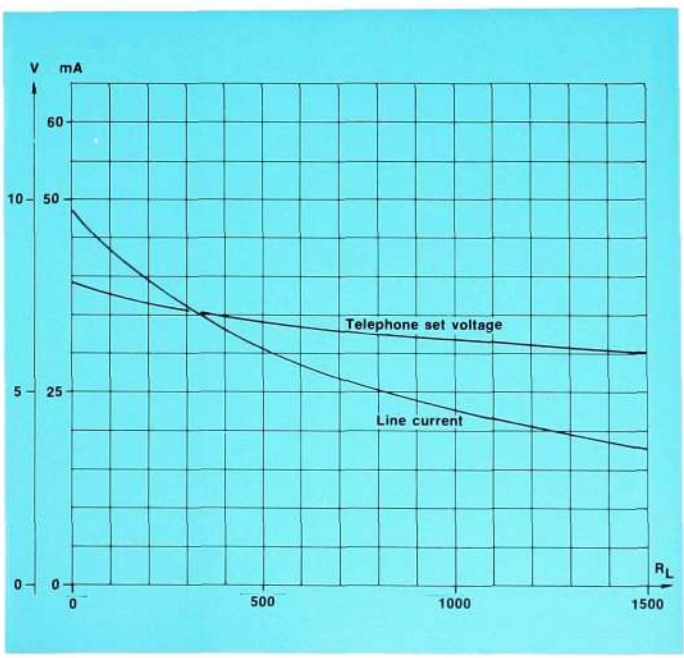


Fig. 13 (right)
Electronic speech circuit

DC data as function of line resistance
Feed
48 V, 2×400 ohm



quency characteristics in fig. 15 (electromagnetic microphone). Fig. 16 shows the receiving frequency characteristic.

A transmission unit of this kind greatly improves the speech transmission quality with undistorted and almost equal speech signal irrespective of the length of subscriber line. The transmission data of the telephone set, furthermore, remain constant during the entire life of the set. Transmission values in the form of reference equivalents for sending and receiving are such that the design of local networks can be simplified. The length of local line and the line resistance are determined entirely by the signalling conditions of the exchange equipment as they are at present. If the signalling conditions are maintained, the transmission data recommended by CCITT will be fulfilled with a good margin to spare. For telephone sets with carbon transmitter the local line is usually designed to comply with the transmission characteristics of the telephone set, and conductor diameters of 0.5—0.6 mm have had to be used for long local lines. Since the electronic speech circuit permits the use of conductor diameters of 0.4—0.32 mm, considerable savings can be made in the expansion of new local networks if the possibilities of the electronic speech circuit are utilized. The elimination of the carbon transmitter, which at present is the weakest link in the telephone set from the maintenance point of view, has a favourable effect on the maintenance cost of a telephone set.

Ringer

The method of calling the subscriber's attention has hitherto been an electromagnetic bell. This bell can be replaced by an electronic ringer which produces the desired signal within the audio frequency range. In the future it may be desirable to replace the present 20—25 Hz, 90—100 V ringing signal by signal voltages of other magnitude and type. This will require replacement of the electromagnetic bell.

Electric tone calling devices have already been introduced to a certain ex-

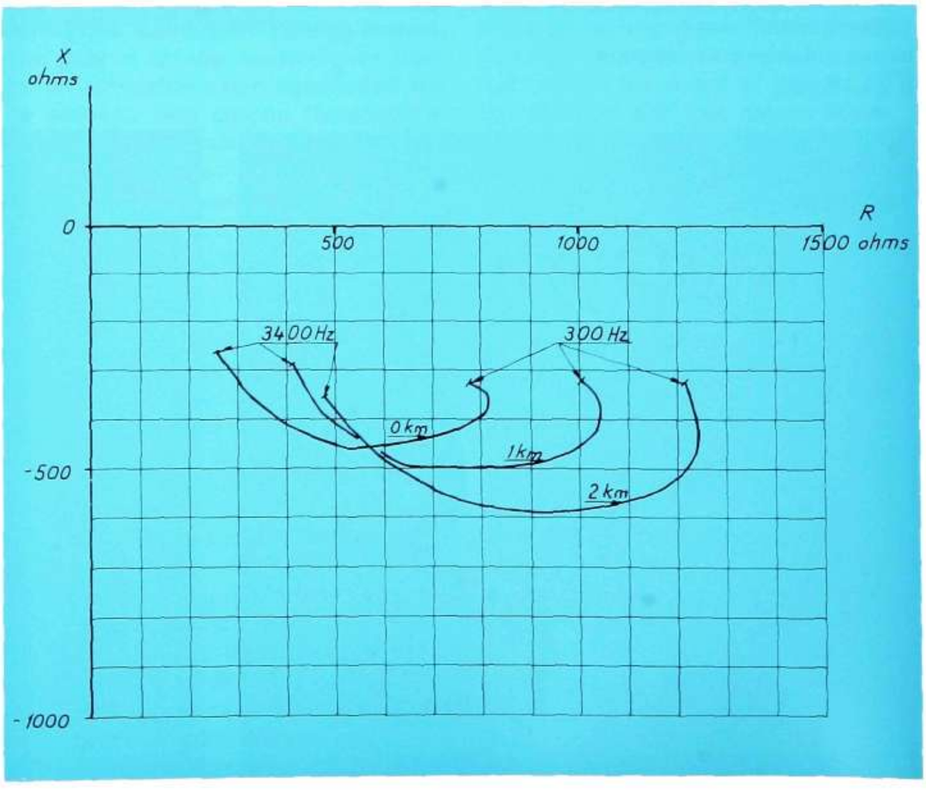


Fig. 14
Impedance of local network (0—2 km, 0.4 mm cable)

tent, mainly for luxury telephone instruments. The ERICOFON is an example of such an instrument. The cost of such devices has, however, not yet proved competitive compared with the ordinary electromagnetic ringer.

Figures 17 and 18 show two designs of tone calling devices which have come into commercial use. Figure 17 shows a circuit which for several years has been used in the DIALOG and which was introduced by the Norwegian Telecommunications Administration.

The active element in this tone ringer is for economical reasons the same as is used for sending amplification. The linear microphone (electrodynamic) is used in the on-hook position as a sound source for the ringer. The oscillator is fed by the rectifier voltage across C4. The oscillation is produced by the feedback circuit for the receiver, i.e. the inductive transmitter, in parallel with the capacitor C5 and inductively connected to the transistor base through the induction coil T1. The oscillator is tuned for a frequency of around 2,500 Hz modulated by the ringing frequency.

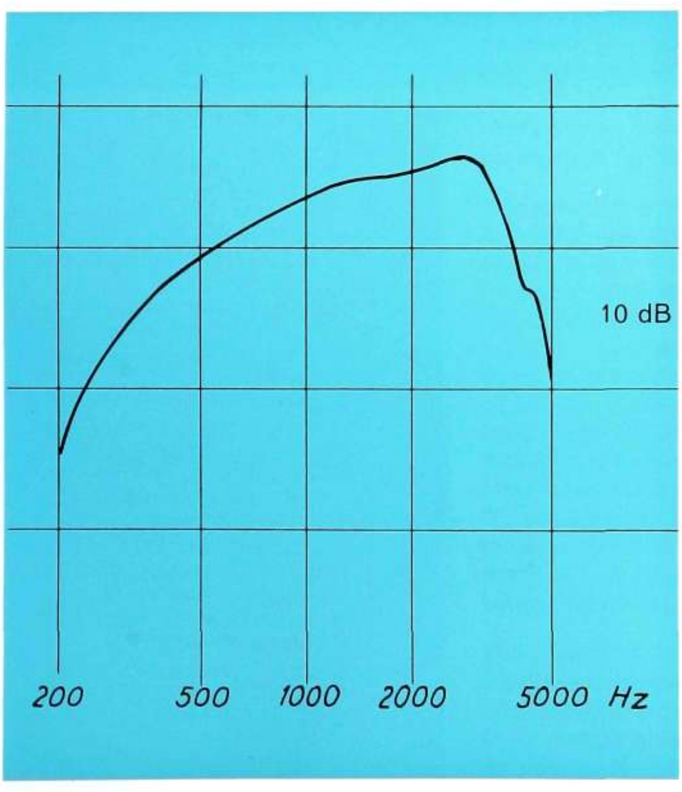
Figure 11 shows a tone ringer working as blocking oscillator. The on-off ratio is determined by the capacitor C1 and the audio frequency by capacitor C3 and the inductance of the sound source (receiver). The audio frequency for signalling is around 1,800 Hz and the blocking frequency 10—15 Hz with a pulse-pause ratio 1—1. This solution is used in the ERICOFON.

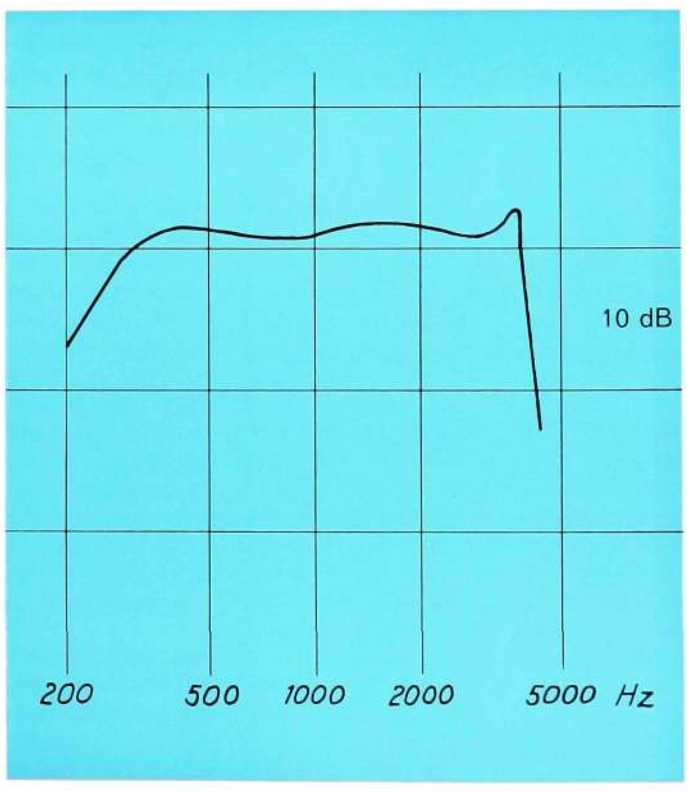
Summary

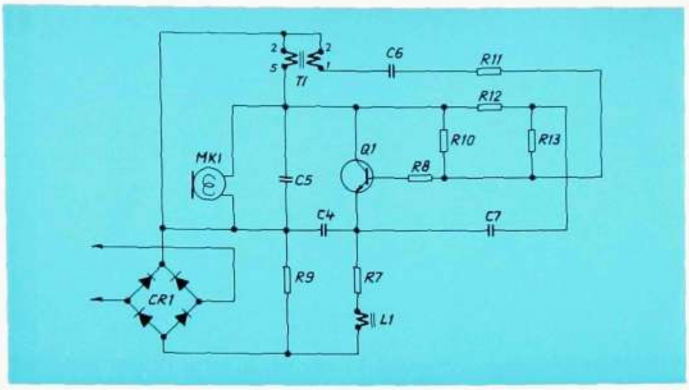
Some of the electronic solutions have been described which can be used today for the primary functions of the telephone set. When all of these functions may come to use in one and the same set is, however, hard to predict. The different possibilities as regards dialling, transmission and tone ringing will probably be introduced gradually and separately in existing telephone instruments, initially for large-scale field trials in order to gain experience of the reliability of the circuitry and of subscribers' reactions to electronic solutions.

Fig. 15 (left)
Frequency response, sending

Fig. 16 (right)
Frequency response, receiving







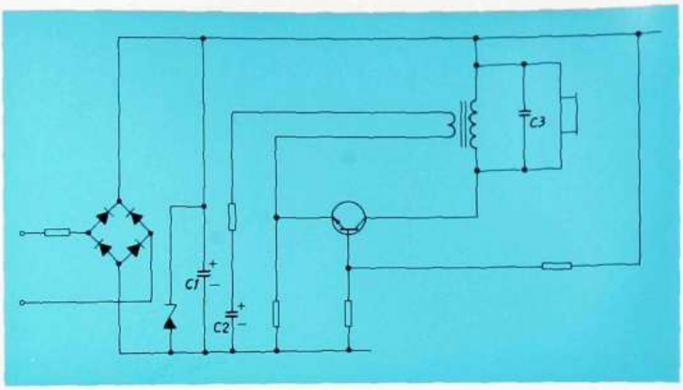


Fig. 17 (left)
Tone ringer with microphone amplifier in feedback circuit

Fig. 18 (right)
Blocking oscillator as tone ringer

No mention has been made of the electronic solutions which will be required in future private and private branch exchange systems in the event that analogue transmission is replaced by digital transmission of speech signals, with encoding and digital/analogue conversion in the actual telephone set. A description of the telephone set functions concerned belongs logically to an account of these systems.

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Coaxial Cable Systems: Operational Experience and Future Prospects

Nils-Göran Englund

It is now about ten years since the first transistorized coaxial cable systems were introduced. The design of these systems was very naturally influenced by the experience gained from valve-type systems, particularly as regards maintenance.
Transistorized systems have, however, proved to be so reliable that a substantial simplification is possible. Changed economic conditions and development in network planning also influence the design of the coaxial cable systems of today. This article discusses the operational experience gained from existing systems and also gives some viewpoints regarding modern system design.

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Valve-type coaxial cable systems require relatively comprehensive preventive maintenance. When the first transistorized systems were discussed at the beginning of the 1960s, a certain amount of uncertainty prevailed concerning several essential factors. There was insufficient information available about the life and ageing characteristics of transistors. It was difficult to assess the amount of maintenance that would be required. The result was that transistorized systems were provided with test points, alarm and fault location facilities to the same extent as in valve-type systems. Thus each buried dependent repeater was equipped with a test terminal strip above ground for checking the power feeding voltage, the regulation condition etc. A need was foreseen of equipment for intermodulation supervision and noise blocking at the terminal stations.

L M Ericsson's first transistorized system ZAX 300 had a capacity of 300 channels (1.3 MHz). This was quickly followed by a 960-channel system (4 MHz), ZAX 960. Experience from these systems resulted in certain modifications, all of which had been carried out when the 2700-channel system ZAX 2700 (12 MHz) was introduced in 1968. Since then a large number of systems have been installed. The operation of the systems has been followed up very closely, and long-term tests have been made in cooperation with the Swedish Telecommunications Administration.

The results of these investigations are discussed below. The requirements and objectives that a modern coaxial system must satisfy in order to achieve an economic optimum are also given.

Reliability

The first systems to be installed very naturally had a number of teething troubles. The most serious of these was that the amplifiers were damaged by induced overvoltages in connection with lightning strikes. Sweden is a country with a relatively moderate lightning intensity, but as the conductivity of the earth is very low, the cables and amplifiers are subjected to large stresses.

Extensive tests were undertaken in order to arrive at an adequate protection for the amplifiers. The aim was that the electronic equipment should be able to withstand the same electric stresses as the cable. In the solution finally decided upon, the primary protection is provided by gas-type arresters that are supplemented by a secondary protection in the form of diode bridges. This protection satisfies all reasonable requirements. As an example it can be mentioned that a direct strike 12 metres from a dependent repeater did not cause an interruption of the traffic although some of the supervisory pairs in the cable were damaged.

At the same time that the lightning problem was solved, a special classification was introduced for the components used in the line amplifiers. This classification is roughly equivalent to military specifications for similar components. On the basis of the fault statistics for multiplex equipment that have been compiled by L M Ericsson it has been possible to calculate the expected reliability. This reliability, expressed in MTBF (mean time between failures), is estimated to be between 800 and 1,000 years per one-way line amplifier.

The reliability of the 12 MHz system has been kept under observation since the system was introduced in 1968. Hitherto only four amplifier faults causing traffic disturbances have been reported. This number is so small that any statistical calculations would be quite meaningless, but on the other hand this result is not incompatible with the calculated values of MTBF. Of the four faults that have been reported, three were the result of dry joints and the other was a transistor failure.

NILS-GÖRAN ENGLUND
Telefonaktiebolaget L M Ericsson,
Transmission Division,
Head of the Line Systems Section

With a MTBF value approaching 1,000 years per amplifier, breakdowns due to component failures can be expected to occur once every ten years on small-core coaxial cable systems of 100 kilometres. For purposes of comparison it may be mentioned that the number of cable faults in the Swedish long-distance network is approximately three per 100 km and year. Thus cable damage is the predominant reason for breakdowns on coaxial cable systems. Consequently, as far as the reliability of a coaxial system is concerned, there is nothing to be gained by making the requirements for the electronic equipment even more stringent.

Equalization and regulation

The deviations from the nominal levels that occur in a coaxial cable system can be divided up into two groups:

- fixed deviations, which are obtained because the gain of the line amplifier does not compensate the cable attenuation exactly
- deviations that vary with time, mainly caused by the temperature variations of the cable, which give rise to attenuation changes of approximately 0.2 per cent per deg. C.

The fixed deviations are corrected at the time that the coaxial system is installed. General purpose, manually adjusted equalizers (for example cosine or bump equalizers) or fixed, individually constructed equalizer networks are used for this. The general purpose equalizers make possible a rapid adjustment of the level, but they are relatively expensive. Fixed equalizer networks require more work at the installation stage, but they are very much cheaper.

The traditional method of correcting the level deviations that vary with time is to utilize a pilot signal, the frequency of which lies above the frequency band of the transmitted line group. The level variations of the pilot signal are used for controlling an automatic regulating network which holds the output of the amplifier at a constant level.

During recent years a number of alternative regulation principles have gained a certain degree of popularity, for example temperature control and remotely controlled regulation.

With temperature control, the variations in ambient temperature are used for direct regulation of the gain. At first glance such a solution appears to be very attractive because the temperature variations of the cable are the main

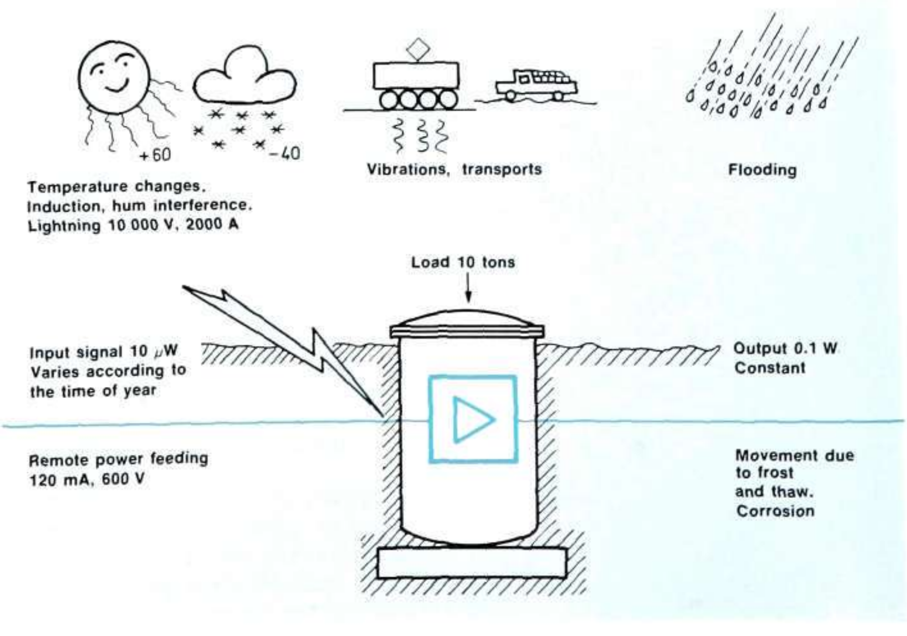


Fig. 1
An amplifier must be able to function under varying environmental conditions

cause of the level changes on the route. It is, however, technically complicated to utilize the cable temperature direct, and thus it is usual to include a temperature sensing component in the amplifier.

In order to protect the repeater housing against local temperature variations caused by rain, insolation etc., it should be buried completely, so that the lid is about 50 cm below the surface of the ground. However, burying the housing in this way would be disadvantageous from the point of view of cable maintenance, and for this purpose it is extremely desirable that the coaxial tubes are readily accessible for testing. Consequently many administrations specify that the housing must be installed with the lid above the surface of the ground, see fig. 1. If temperature controlled amplifiers are to be used, it is not possible to utilize existing repeater housings when converting older, valve-type systems. Even if the housing is completely buried, there are certain restrictions that must be observed when carrying out the installation:

— the cable and the repeater housing must be laid in similar ground

— the cable must not be laid under bridges or in tunnels without taking special measures

— the repeater housing must not be placed in a manhole.

Apart from the above factors there are other disadvantages:

— thermal equilibrium is not obtained in the housing until about five hours after the power has been switched on. This complicates the work in connection with the line-up of the system and is very inconvenient when faults occur.

— the temperature in the housing is affected by the number of systems in operation. This means that if one system is installed initially and another system is added later, the level of the first system must then be adjusted to compensate for the change in temperature.

— it is doubtful whether temperature control, even under ideal conditions, provides any economic advantage.

Another way of carrying out the level regulation is to remotely control the amplifiers from the terminal stations. At the receive side the level of the incoming pilot is checked. Variations in the level are reported to the send side, which then transmits control signals to the regulating amplifiers. The biggest disadvantage of this method becomes apparent when the temperature variations in the cable are not the same over the whole of the pilot section (for example under bridges, in tunnels, or when the ground is thawing out). In such cases large level variations can

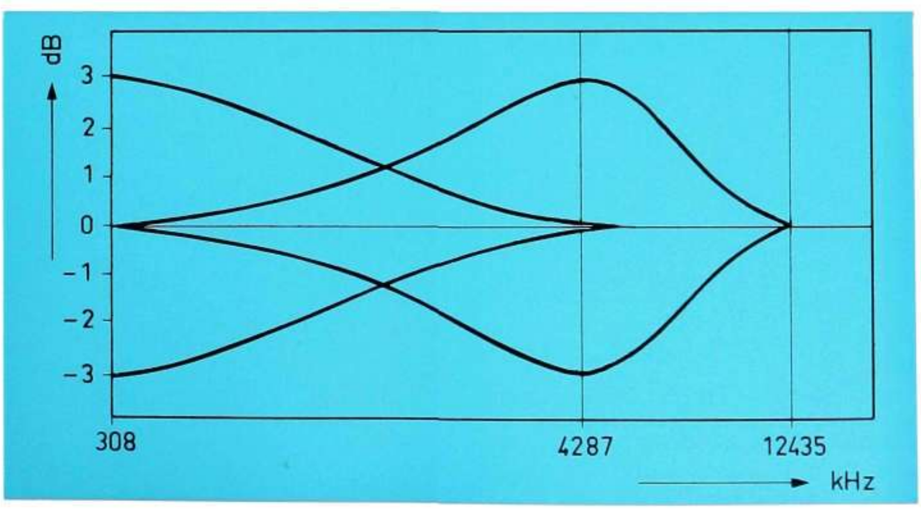
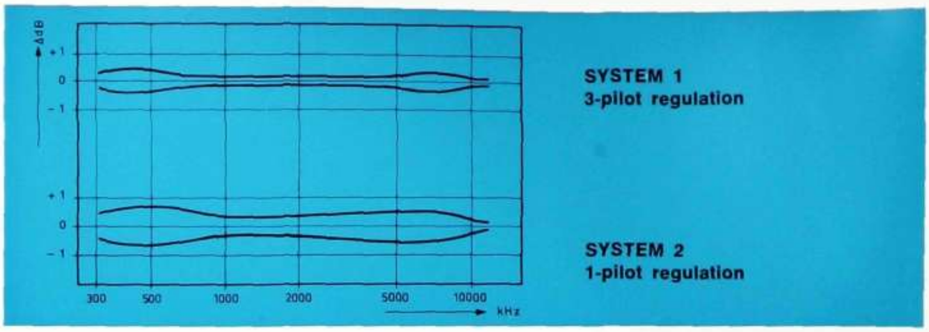


Fig. 2
Pilot regulation.
12435 kHz is used as the main pilot. On long routes equipment for automatic regulation, controlled by the 308 kHz and 4287 kHz pilots, can be equipped at the terminal stations

Fig. 3

Level stability.

Results of long-term tests, over a period of one year, on a 240 km route. The temperature variation in the cable was ±6 deg. C



be obtained out on the route, despite the fact that the levels at the terminal stations are correct. This can give rise to an increase in the noise and a reduction of the overload margin.

In the L M Ericsson ZAX 300 and ZAX 960 systems all the line amplifiers are equipped with pilot regulation. In the ZAX 2700 system pilot regulation is usually provided only for the amplifiers at every fourth repeater, the remainder having fixed gain, in order to reduce the costs for the regulating equipment. Regulation at every fourth repeater is sufficient if the temperature variations are $< \pm$ 10 deg. C, which is the case in most countries, for underground cables. For special applications, for example if the cable is taken under a bridge and is subjected to large temperature variations, the distance between pilot regulated repeaters can be reduced.

Pilot regulation gives a reliable and flexible system. The efficiency of the system is then independent of the way that the cables are run and the exact siting of the repeaters. When converting from one system to another the existing repeater housings can be used without restriction. Long-term tests, which have been carried out on L M Ericsson's 12 MHz system in order to check the level stability, have given very good results. Measurements have been made regularly during the course of one year on a 240 km route, equipped with two systems. On one of the systems only the main regulating pilot 12435 kHz was used. On the other system the terminal stations had been provided with equipment for automatic regulation controlled by the pilots 308 kHz and 4287 kHz, see fig. 2.

During the course of the tests the maximum deviation from the nominal level at the mean temperature was as shown in fig. 3. The system with one-pilot regulation showed a maximum variation approaching ± 0.7 dB. This value was reduced to ± 0.4 dB if three-pilot regulation was used.

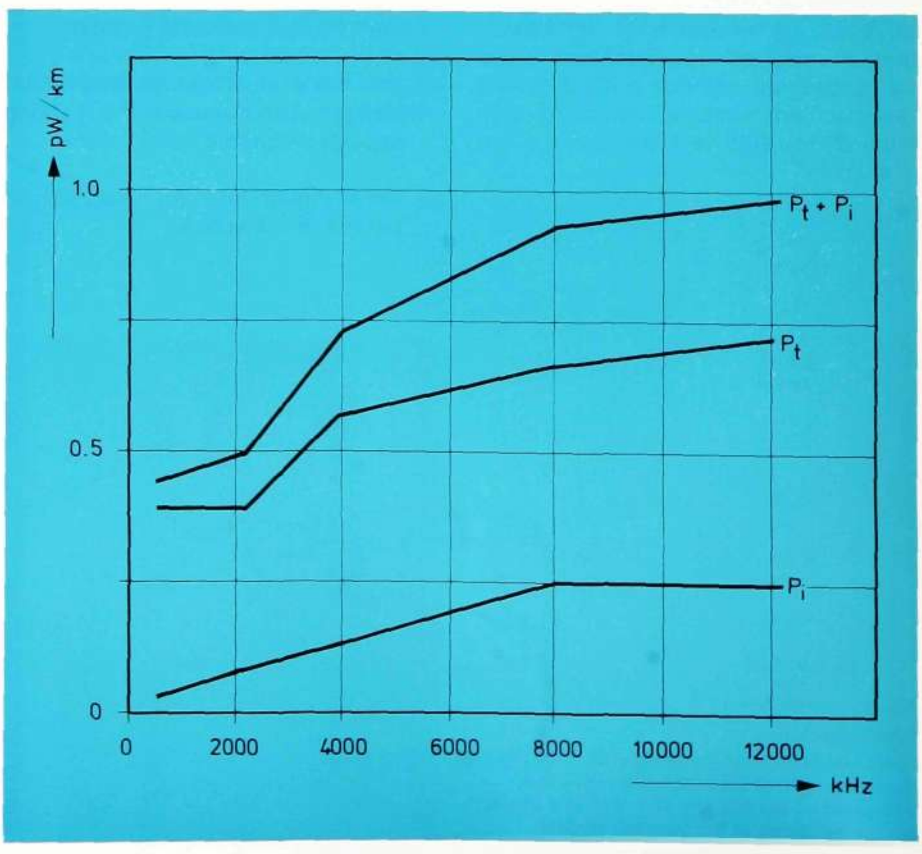


Fig. 4

Noise.

Test results from a 240 km route. The system was loaded with white noise with a power equivalent to —15 dBmO/channel

P_i intermodulation noise

P_t thermal noise

Fiftieth Anniversary of Ericsson Review

SIGV. EKLUND

The need for a company journal designed to serve as mouthpiece for the L M Ericsson Telephone Company and for the subsidiary companies of the Group had been discussed already in the early twenties. In 1924 the thought was realized through the issue of the first number of "The L. M. Ericsson Review".

Fifty annual volumes of the journal have now been published. The following brief notes about its life and different forms during half a century may perhaps be of interest.

SIGV. EKLUND, DHS
Editor of Ericsson Review 1943—1972

The first years, 1924—1932

"The intention of this journal is to spread a knowledge of the work done by the company and its associated enterprises and to form a link between the latter and the parent company."

These lines are taken from the introduction to *The L. M. Ericsson Review — Tidskrift för Allmänna Telefonaktiebolaget L. M. Ericsson*, when the new journal issued its first number in Swedish in 1924. Apart from an article on "the development and present size of the L M Ericsson Group", there was a 10-page description of the company's automatic 500-line selector system, illustrated by a few photographs of the recently opened automatic exchange in Rotterdam, one of the first major exchange equipments to be delivered up to that time.

As appeared from the description of the Group the company had already branched out in a number of directions. With its manufacturing companies, operating companies, sales and installation companies, and an extensive chain of agents, it formed a worldwide network. A Swedish-language addition alone could not fulfil the purpose of being an information medium for an international readership. From the start, therefore, English and Spanish editions were issued with the same content as the Swedish. The need to make the journal available within other language areas led in 1927 to the addition of French and German editions.

The object of the journal, as formulated in its first number, was realized through articles describing the company's products and through the news items and brief articles informing about various aspects of the company's life — orders received, installations carried out, and also biographical data. Naturally a large number of the articles at that time were concerned with the field of automatic telephony. LM Ericsson's 500-line system had then started its triumphant march across the world. Apart from automatic telephony, general telephone equipment design and the telephone conditions on foreign markets, many articles were devoted to the description of telecommunication plants of different kinds, and also railway interlocking and signalling plant.

Reorganization of the journal in 1933

The contents of The L. M. Ericsson Review at that time had to a fairly large extent consisted of purely theoretical articles, as was especially noticeable after

The first number of The L. M. Ericsson Review

Ericsson News started in 1927 as a separate news sheet

material of a more general nature was introduced as from 1927 in *Ericsson News*. It was therefore questionable whether its emphasis at that time was consistent with its original object. This, in conjunction with the considerable cost increases, called for a review of the company's publication. After the composite number 4/6 1932 no further number was issued during that year. Attention was instead concentrated on preparations for reorganization of the journal.

What appeared especially to have been lacking in The L. M. Ericsson Review was articles of acquisition value for sales. It was considered that a new journal should contain, for example, popularly written descriptions of new products, descriptions of interesting plants, popular articles on telephone operation, notices of major orders within the Group, and also biographical data and advertisements of Ericsson products. An impartial, chiefly technical, publication accompanied by news items was the goal to be aimed at.

The planned reorganization, however, had as its object not merely a partially new editorial programme but also a reduction of costs, and at the same time a typographical metamorphosis. It was found, for example, that a tidying up of the typography could lead to an improved economy as a result of better use of paper and reduction of the typesetting costs.

After the half-year pause in its publication the journal came out again in 1933 in a new and considerably more modern form. Product and plant descriptions now dominated the contents and an editorial innovation was resumés of the contents of the simultaneously started publication *Ericsson Technics*. The latter formed a separate organ for the purely scientific material which had been published in The L. M. Ericsson Review prior to the reorganization, and was intended to present a representative picture of the scientific development work of the Group.


L. M. Ericssons
Nya Telefonapparater

Av G. GRÖNWALL

Kopplingen.

ERICSSON REVIEW

In 1933 a radical change was made in the entire journal, which was given a more modern form

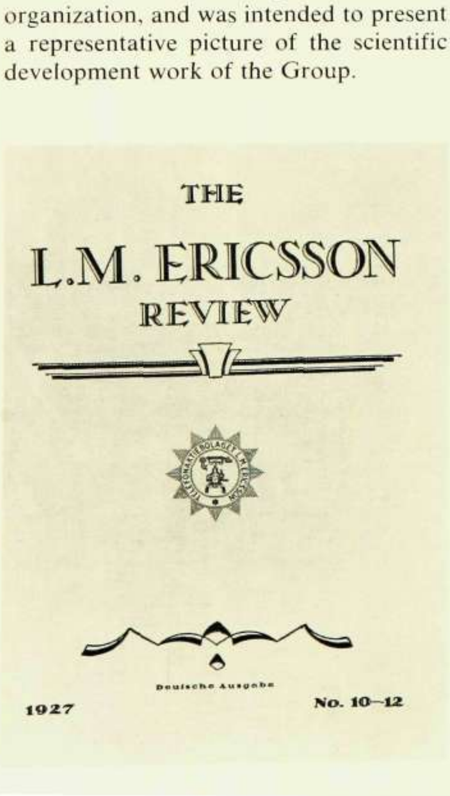
Purely typographically The L. M. Ericsson Review appeared in 1933 as a new journal. The cover, with the name printed in display colour, contained a full-page photograph with a motif associated with the work of the Group. Gothic type was introduced in headings and ingresses, the illustrations were adapted to the type page width, three-column type and smaller size of type started to be introduced for less important material.

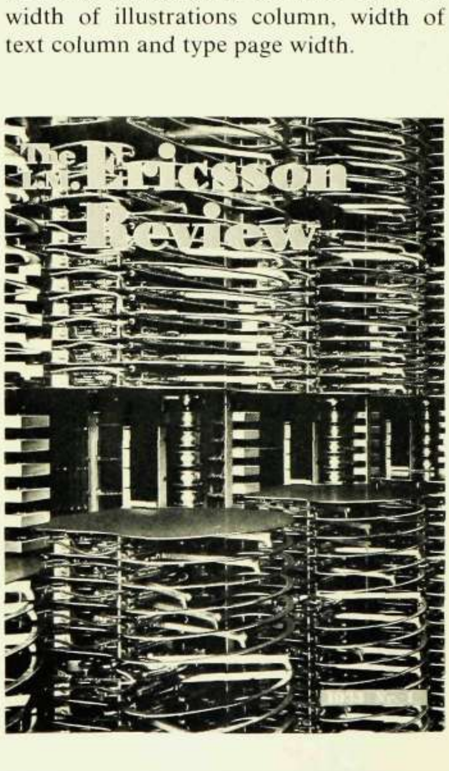
During 1934 the same course was followed both as regards content and typography, but in 1935 new changes were made, chiefly for cost-saving purposes. The 2- and 3-column type was replaced by a single broad double-column page with a single-column margin on the left for illustrations. The size of illustrations was also standardized to three formats: width of illustrations column, width of text column and type page width.

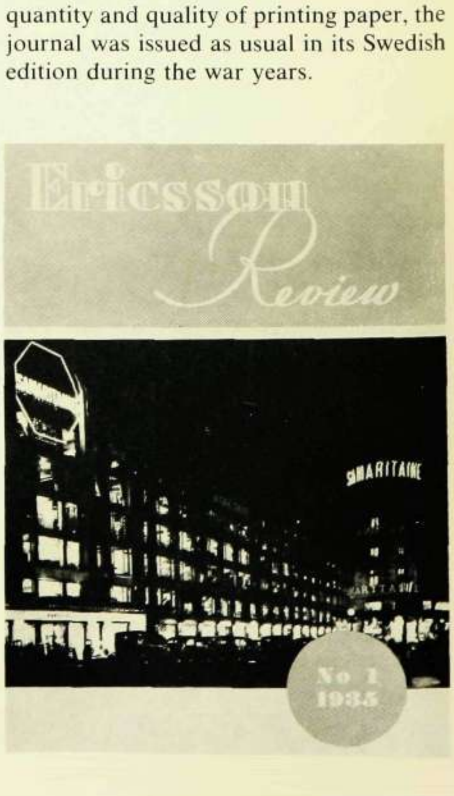
The war years 1940—1945

As from the outbreak of war in 1939 the situation for the company's journals quickly changed. Ericsson Review for the last quarter of the year, however, was issued in all languages. In the following year, 1940, the situation was such that four numbers were issued in Swedish alone, but supplemented somewhat later by two Spanish numbers which contained the chief contributions from the four Swedish numbers. This procedure, which was used in order to some extent to cater chiefly for the South American markets, was repeated in the 1941 volume.

Apart from the fact that the paper situation necessitated a reduction both of quantity and quality of printing paper, the journal was issued as usual in its Swedish edition during the war years.







In 1935 Ericsson Review was given the appearance which it has largely retained until 1974

With the end of the war in 1945 the issue of foreign editions was resumed, but not to the same extent as before the war. The German and French editions were shelved pending the return of normal conditions. The long break in publication of the English edition made it advisable to collect some of the articles published during the war in a composite English-language edition in 1945. A similar composite number was issued in supplementation of the normal Spanish edition.

Owing to the stoppage of the flow of technical information concerning the company's activities during the war years and to the positive attitude to the composite numbers issued in 1945, the 1946 English and Spanish editions as well were increased by two numbers each.

The German edition was not resumed until 1950, the French edition not until 1964. The publication of foreign language editions was then the same as before 1940.

Ericsson News — a news sheet

At an early stage it was considered that the interests of the company and of the readership would not be fully met within the normal scope of the journal and with the previous frequency of publication, usually six double numbers per annum. After the first three annual volumes, therefore, it was decided to add to Ericsson Review a separate news sheet which, under the name *Ericsson News*, would be published once a month. This should contain brief notices concerning orders and deliveries of major interest, and data concerning the activities and development of the company and its associated enterprises.

The new Ericsson News was published for the first time in April 1927 and distributed to all who had hitherto received The L. M. Ericsson Review, but also to persons and institutions who might be assumed to be interested in brief articles and notices concerning the activities of the Group. Owing to the heavy rise of costs and the serious crisis for the company in 1932, Ericsson News was discontinued for the time being.

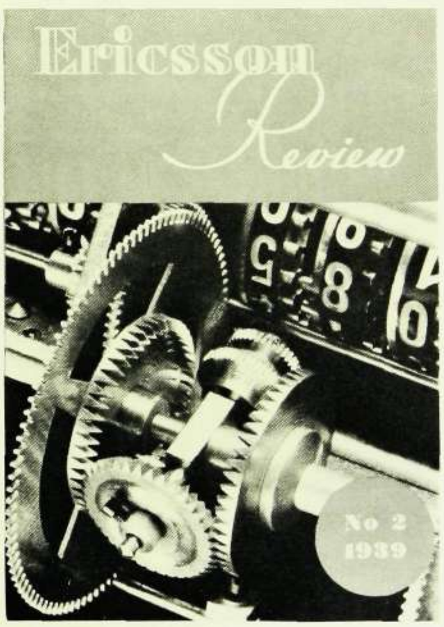
At the end of the thirties the need to distribute general news material concerning the Group again came to the fore. The thought was therefore brought up again, this time in the form of four pages in the Swedish edition of Ericsson Review, of creating a "journal within the journal".

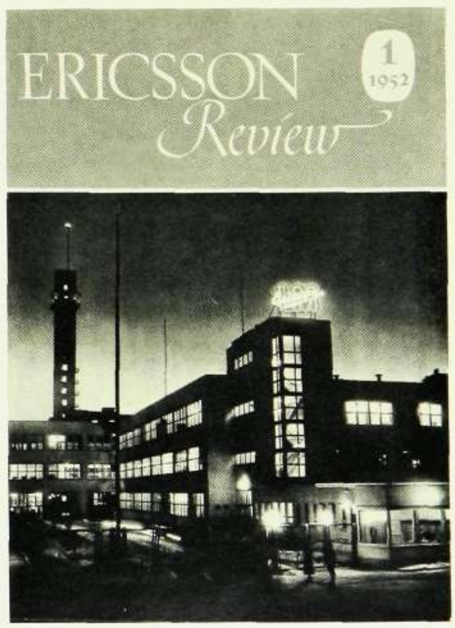
The resumed news sheet, however, came to a stop again with the outbreak of war in the autumn of 1939. To quote from No. 4/1939: "In view of the present world situation and the necessity of not spreading news of Swedish industry's deliveries and activities in other respects, it has become difficult to make the contents of Ericsson News as comprehensive as would be desirable. As the journal can therefore no longer fulfil its function of being of use to its readers, its publication will cease for the time being."

The much tried 4-page news section could be reintroduced in 1952, this time under the name *Ericsson News Throughout The World*, later changed to *Ericsson News*. To a large extent it was edited on the same principles as its predecessors, even if typography and illustrations were changed to meet the demands of the time, and was introduced in all language editions. The limited space now necessitated, as before, a considerable sifting of the contents, in which a fairly abundant illustrational material from the working life of the Group had also to be given space as a counterweight to the other more technical content.

The goals and their realization

The goals of *Ericsson Review*, to which the name was simplified after "The L. M." had been discarded in 1935, had from its





start in 1924 been those which are set out in the introduction to this article. It was to be a technical journal comparable to any other good technical publication, but limited to the subject-field and sphere of interests associated with the activities of the Group.

The editorial pattern and layout which the journal received in broad outline after the radical reorganization in the thirties have been mainly retained, as this appeared best to correspond to its purpose from functional and economical aspects. Minor adjustments have naturally been made in the course of the years, but the journal has retained its character with but little influence from changes of typographical mode.

In its contents the journal has come to reflect in the course of the years the Group's development work and results in the form of equipment and system design. The articles of earlier volumes concerning the 500-line selector system have been followed by articles concerning increasingly complicated telephone exchange systems. The subject-group which may be said to have been introduced as early as No. 2/1933 of the journal, with an introduction to L M Ericsson's carrier systems, has recurred increasingly often in the list of contents in step with the development of carrier telephony.

Many articles in Ericsson Review can hardly be said to be light reading. The reason is that a technique which in time has becoming increasingly complicated demands special knowledge in order to be understood, a knowledge which even the technically fairly well oriented reader often lacks. The articles are, however, directed to specialists within our circle of customers and are therefore not only defensible but inevitable if the journal is to correspond to its renommé.

Authors of Review articles have been mainly members of the Group staff, who naturally possess the greatest knowledge concerning its products and systems. Articles from outside sources, especially among our customers, have however been welcome owing to the impartiality which may be expected in a writer from outside the Group. It may be desirable to point out that contributions also from members of the staff have never been allowed to


Ericsson NEWS

HEMMING JOHANSSON

Produktiv forskning

No 2 1938

At the end of the thirties News became a "journal within the journal"


Ericsson NEWS from All Quarters of the World

L M Ericsson Equipment for the Stockholm—Gothenburg Coaxial Cable

The First »Speaking Clock« in South America

Ericsson News, after its stoppage in 1939, was reintroduced—now under the name "Ericsson News Throughout The World" and with three text columns

deteriorate into a one-sided eulogization which might damage the sound technical reputation the journal has attempted to create for itself.

Production, technique and sales are so many-faceted within the telecommunications field, and the spheres of interest represented by different groups of the readership are so different, that *one* number could not possibly give all readers the technical content that would be desirable. The editor's task has had to be limited to providing in the long term a successive technical flow of information which extends through the annual volumes.

In this task of judging readers' reactions the editor of a journal with mainly free distribution is only partially able to draw upon the signs which increases or reductions of circulation otherwise give. The reactions of other kinds which spontaneously come to the hearing of the responsible publisher, authors or the editor are also few in number. It is therefore difficult to say whether Ericsson Review has fully succeeded in its task. It is, however, undeniable that a perusal of the 50 volumes provides rich information concerning the colossal advances that have been made within telecommunications during half a century. It also gives a picture of a company that is indefatigably moving ahead within its field. If the readership has the same opinion, part of the goals will have been achieved.

Responsible Publishers and Editors of Ericsson Review have been:

Responsible Publisher	*Editor*
1924—1954 Hemming Johansson	1924—1925 Torsten af Geijerstam
	1926—1932 Woldemar Brummer
	1933 Anders Byttner
	1934—1942 Sven A. Hansson
1955—1966 Hugo Lindberg	1943—1972 Sigvard Eklund
1967— Christian Jacobæus	1973— Gustaf O. Douglas

The total cable attenuation of the 240 km route is approximately 2000 dB at 12 MHz. The temperature variation, which during the tests reached ± 6 deg. C caused a variation of the cable attenuation of ± 24 dB. Thus this variation was compensated so accurately that the residual error was only ± 0.4 dB. As far as is known, such a good level stability has never before been achieved on any coaxial cable system.

Noise and intermodulation

As a basis for the design of transmission systems, CCITT has recommended that the total noise contribution from a hypothetical reference circuit of 2,500 km shall not exceed 10,000 pW. Of this the noise contribution from the line equipment shall not exceed 7,500 pW, which is equivalent to 3 pW/km.

Modern transistorized systems are designed to satisfy this requirement with a good margin. Measurements made on L M Ericsson's 12 MHz system shows a noise contribution that increases up to approximately 1 pW/km in the worst channel, see figs. 4 and 5.

Several administrations, particularly in countries with long system lines, now specify very much lower noise contribution values than 3 pW/km, and in many cases these more stringent requirements are fully justified. It is, however, unfortunate if the noise contribution from a coaxial system is used as the most important measure of the system quality.

Optimization of a system means striking a balance between conflicting objectives. It is not at all certain that the best

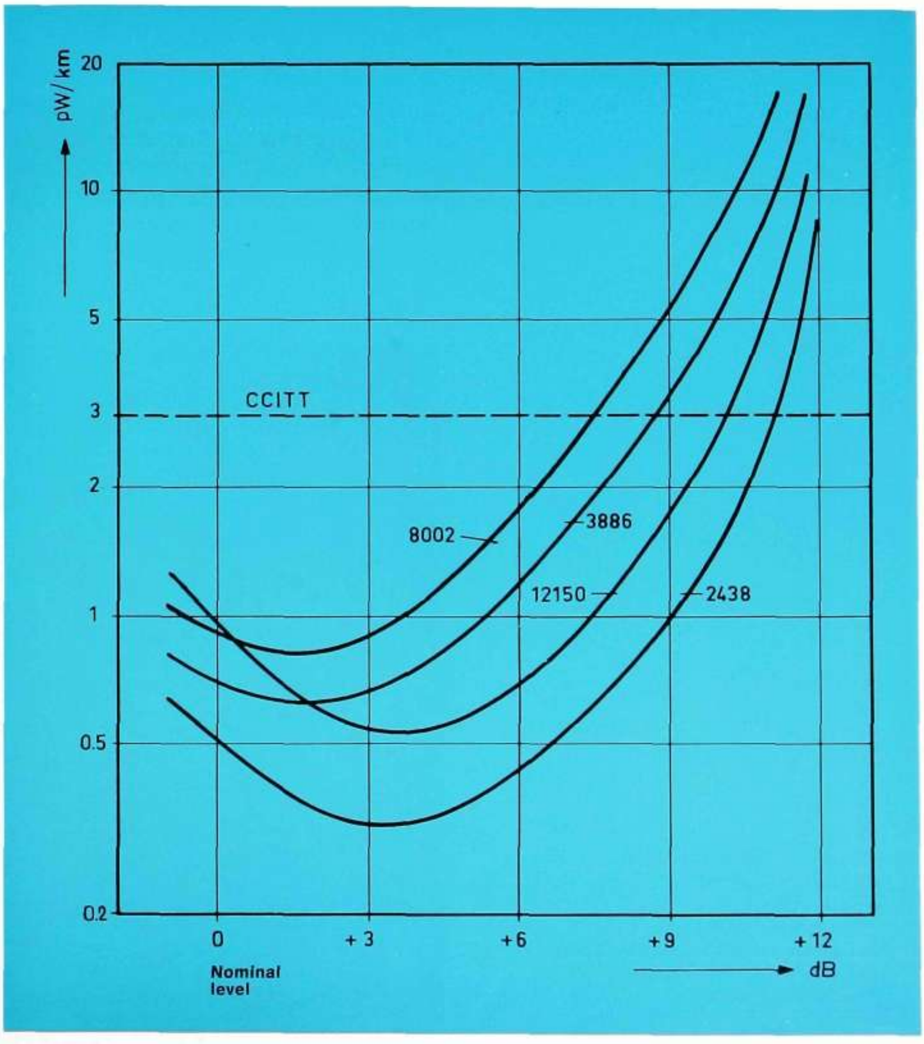


Fig. 5
Noise as a function of the level for four different frequencies

solution will give the lowest noise contribution, for example, for the following reasons:

— *in order to increase the margin* to the overload limit it is desirable to keep the nominal level out on the line as low as possible. This naturally leads to an *increase in the thermal noise* in relation to the signals, but on the other hand it reduces the risk of overloading, which is an advantage, for example when data is to be transmitted over a large number of channels.

— a low nominal level also gives low *intermodulation noise*, which is important when transmitting signals with high-level discrete frequencies, for example television and video telephony.

Maintenance, supervision and fault location

A characteristic feature of modern coaxial systems is their very high reliability. Preventive maintenance has, *in the main, been eliminated.* This means that an ever increasing number of stations can be unattended.

The faults that do occur, and which are mainly the result of cable damage, can have very serious consequences because of the large number of circuits involved. Traffic disturbances can however be limited by taking various measures when planning the long distance network, for example by

— building up a mesh-shaped network

— dividing up the routes on several different paths

— routing basic groups or whole line groups over the standby routes.

When a fault occurs, an alarm is obtained that points out the part of the equipment that is faulty. Alarms at unattended stations are transmitted to the control station for the route. On the basis of the *information obtained*, standby routes are connected up either manually or automatically.

Bearing in mind the very few failures that occur on transistorized equipment, the maintenance staff's knowledge of the system construction and function is likely to be less than in the case of the corresponding valve-type systems. It is therefore important that

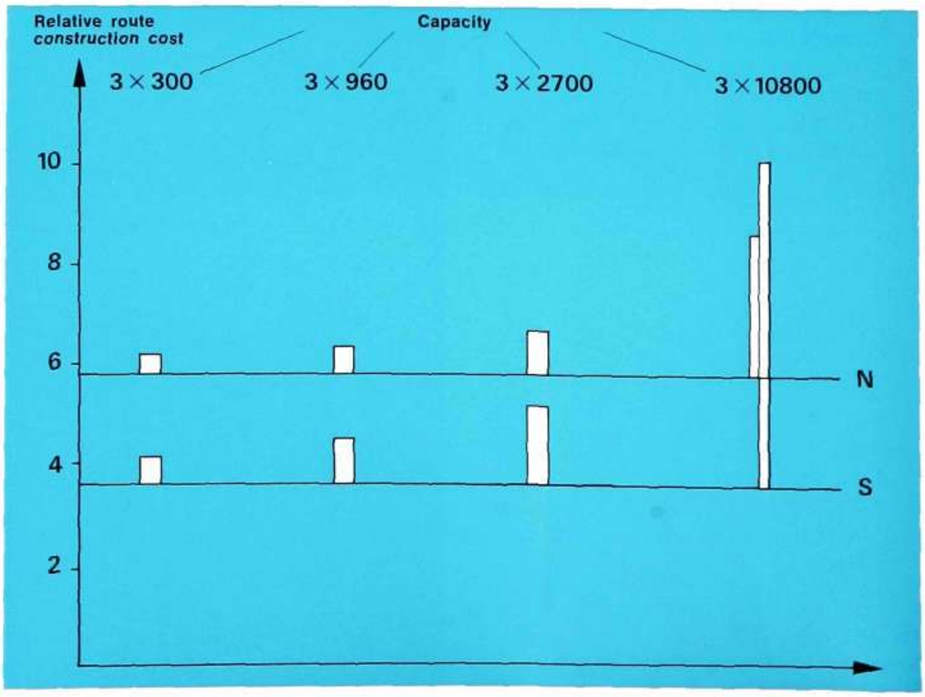


Fig. 6

Relative route construction cost.

The calculations have been made for a 100 km route with a 6-tube cable

N = normal coaxial cable (2.6/9.5 mm)
S = small-core coaxial cable (1.2/4.4 mm)

repeater equipment

the fault locating equipment is a simple and reliable as possible.

In the L M Ericsson 12 MHz system, a d.c. method is used for locating cable faults. The faulty repeater section is indicated on an instrument at the power feeding station. Faults in the repeater equipment are located with the aid of oscillators, one of which is included in each repeater housing. Each oscillator transmits an individual frequency.

Equipment faults are cleared by fitting a spare unit in place of the faulty one. Cable faults can be repaired temporarily with the aid of special rapid connection devices, which connect through the coaxial tubes in the damaged cable. The final permanent repair can then be undertaken at a suitable time when there is very little traffic.

Economic aspects

At the time of valve-type systems there was a balance between the cost of the electronic equipment and the cost of the cable in a coaxial system. With the introduction of transistorized systems, however, the cost of the electronic equipment was drastically reduced. Developments in the field of electronic components during the last ten years has made possible even further price reductions, whereas cable prices and the cost of laying cables has by and large risen in step with the general increase in prices. This development shows that, from an economic point of view, an optimum result is obtained by

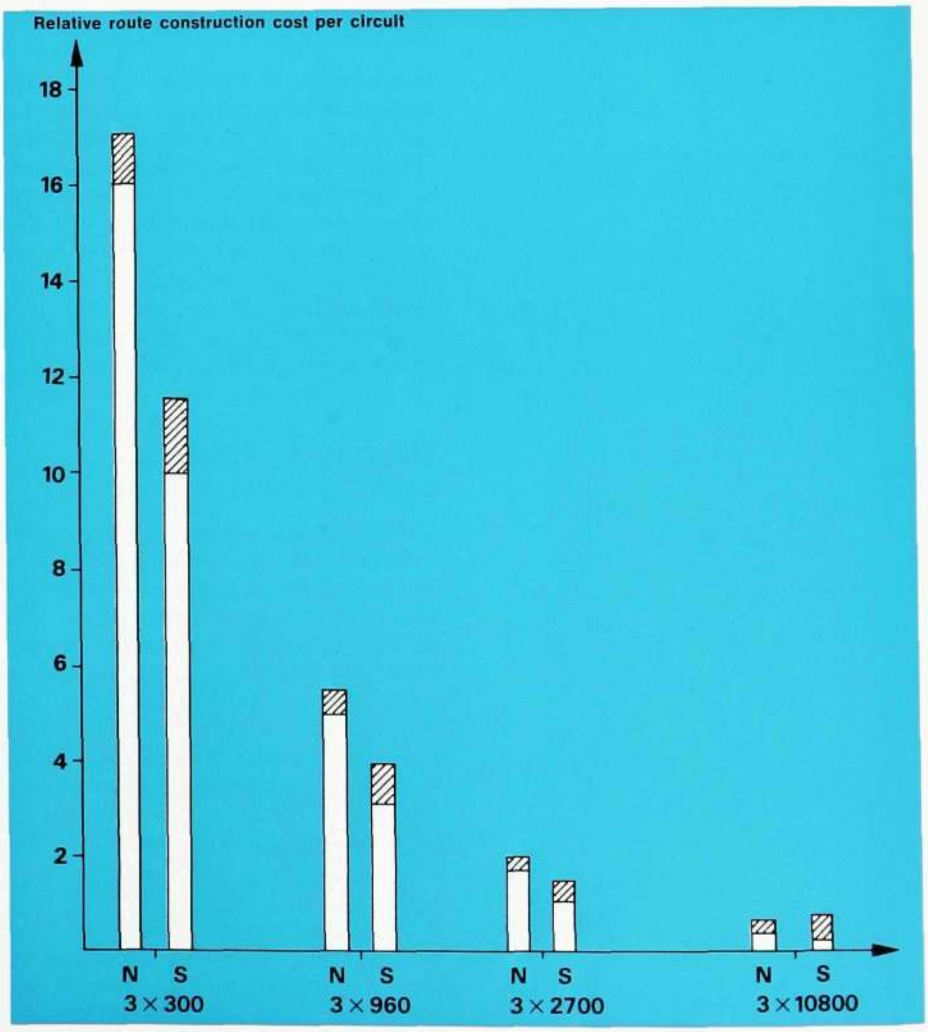


Fig. 7

Relative route construction cost per circuit. (The same prerequisites as in fig. 6.)

N = normal coaxial cable (2.6/9.5 mm)
S = small-core coaxial cable (1.2/4.4 mm)
repeater equipment
cable

utilizing the cable for even larger systems. Nowadays the normal coaxial cable (2.6/9.5 mm) is justified only for 60 MHz systems.

Small-core coaxial cable (1.2/4.4 mm) is very suitable for 12 MHz systems and even for 4 MHz systems when the traffic requirement is limited. On the other hand it is very doubtful whether it will be possible to justify 1.3 MHz systems in the future.

Fig. 6 shows a comparison of the route construction costs for different coaxial cable systems. The calculations have been carried out for a line section of 100 km with normal and small core coaxial cable respectively. The cost of the cable and the laying costs have been included and also the cost of the repeater equipment and its installation. The distribution of the route construction costs per circuit kilometre is shown in fig. 7.

The change to transistorized coaxial systems also resulted in a substantial reduction of the operational and maintenance costs. Power consumption fell by more than a power of ten, preventive maintenance was eliminated and repair costs were reduced. All in all the direct operational and maintenance costs for transistorized systems constitute only about 5 % of the corresponding costs for valve-type systems.

The future of coaxial cable systems

Coaxial systems and radio-relay links have been the dominating transmission media in the long-distance network for telephony for very many years. This development can be expected to continue for another ten years or so, before digital systems with high capacity have left the experimental stage and become commercially competitive. Naturally for certain applications satellites and sea cables are attractive alternatives, but quantitatively these are not so important.

The choice between coaxial systems and radio-relay links is influenced by a number of factors. As a general rule radio-relay links have the advantages that the route construction costs are lower and the time needed to install them is less. On the other hand the coaxial cable alternative provides the possibility of successively increasing the number of circuits by converting to larger systems. The cables that were originally intended for 4 MHz systems (960 circuits) have proved to be satisfactory for 60 MHz systems (10,800 circuits). The long life of coaxial cables, the conversion possibilities, their reliability and the low maintenance costs makes for a very competitive annual cost per circuit.

Even the traditional "radio-relay link countries" have begun to evince an increasing interest in coaxial systems during recent years. Contributory reasons for this are that

— the traffic requirement on certain routes is so great that the capacity of radio-relay links is insufficient

— the frequency bands that are allocated for radio-relay links are already exploited to such a high degree that the introduction of further radio-relay links is becoming increasingly difficult. This applies particularly in the vicinity of most of the large cities and towns in the world.

The coaxial cables that are installed represent a very large capital investment, and there are very strong reasons for increasing their capacities even further. Investigations that have been undertaken recently indicate that the existing tube construction can be used for frequencies well above 60 MHz. Preliminary investigations of systems with bandwidths in the region of 150 to 200 MHz are going on in several countries. Another alternative, which appears to be promising, is to introduce digital coaxial systems with high capacity. This development line is favoured by a general tendency towards the digitalisation of telephony. A digital system with a capacity in the order of 1 Gbit/s (equivalent to roughly 15,000 telephone channels) can become a reality within 10 years. Compared with waveguides and optical fibres such a coaxial system should prove to be extremely competitive.

Automatic Transmission Measuring Equipment, ATME 2, for International Telephone Circuits

Arnold Söderberg

LM Ericsson started ten years ago to manufacture the automatic transmission measuring equipment described in Ericsson Review[1], [2] 1963. It is made in two models, ATME 1 for international circuits and ATME N1 for national. As a result especially of the experience gained with ATME 1 and of new technical depelopments, CCITT have drawn up new recommendations for an automatic transmission measuring equipment for international circuits, ATME 2. LM Ericsson have been represented on the working group concerned within CCITT and have since developed ATME 2 in accordance with these recommendations[3]. ATME 2 has considerable advantages over ATME 1.

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The need for automatic measurement of transmission characteristics on international circuits becomes more acute with the rapid increase of international traffic. A number of administrations have already experienced through ATME 1 the considerable technical and economical advantages provided by such a measuring equipment. Compared with ATME 1, ATME 2 offers the following significant advantages among others:

— the signalling system for communication between directing and responding equipments is less sensitive to disturbances. The signalling functions partly on the compelled sequence principle and the frequencies of system No. 5 are used.

— the absolute noise value can be measured instead of merely setting a threshold which indicates accept/reject.

— the speed of attenuation and noise measurement is five times greater, so that three sets of circuit measurements can be made per minute. This reduces the circuit occupation time and the entire measurement program can be carried out more quickly.

— TASI circuits and circuits containing echo suppressors can be measured.

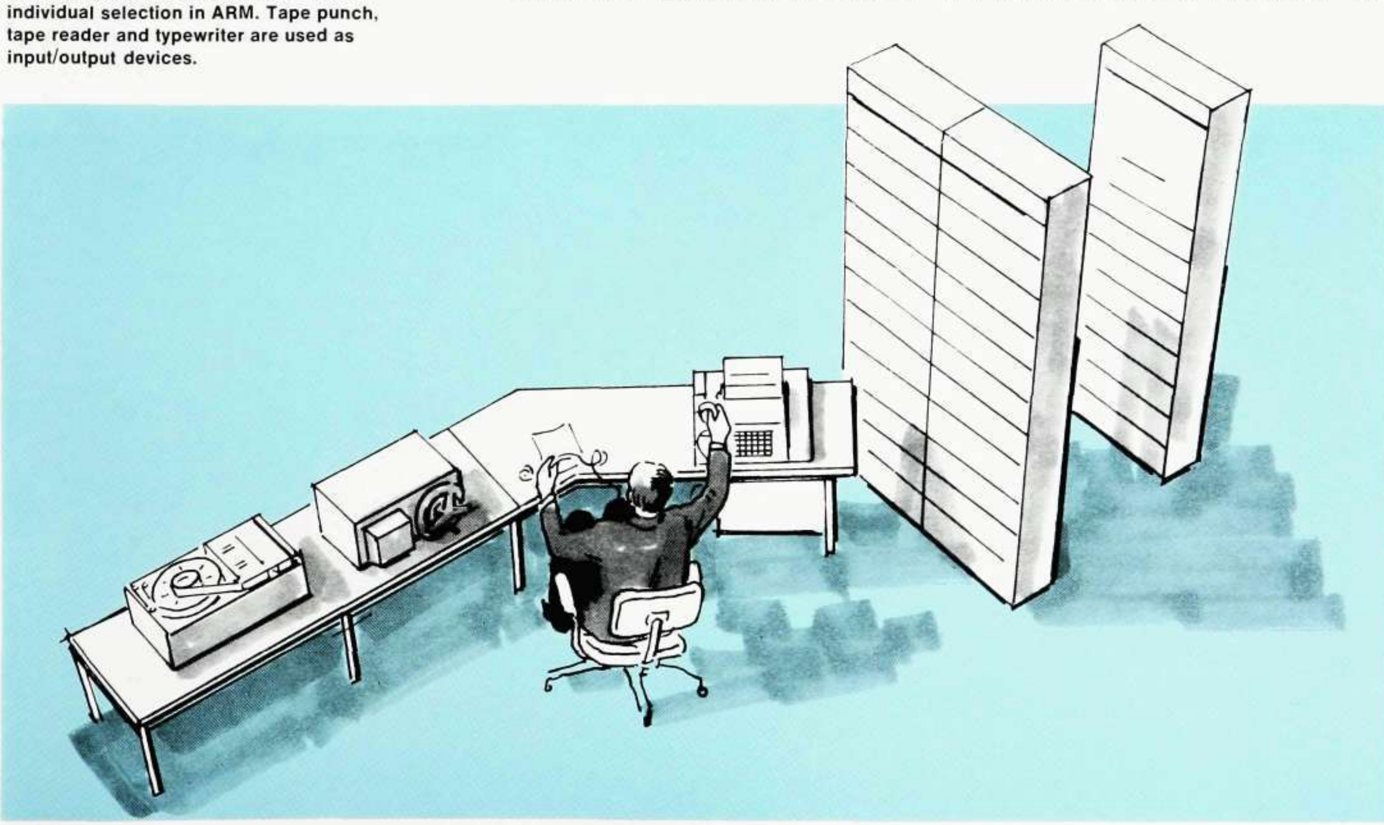
— ATME 2 can be called up by a maintenance centre from which it can be controlled and to which the results of measurements can be transmitted.

— three stores for individual line data have been introduced which, among other things, increase the measurement capacity.

The speed has been achieved through the use of electronic equipment. The

Fig. 1

Transmission measuring equipment ATME 2 with directing and responding equipment Type a on the left-hand rack. On the right-hand rack exchange interface equipment and responding equipment Types b and c. On the rack to the rear, individual test block for individual selection in ARM. Tape punch, tape reader and typewriter are used as input/output devices.



ARNOLD SÖDERBERG
Telefonaktiebolaget LM Ericsson.
Responsible for design of ATME 2 system

sole exception is the interface unit for the international exchange, which is based on conventional relay technique in order to be able to interwork with the exchange equipment in the most suitable way.

ATME N1 and N2 for national networks

L M Ericsson have also delivered automatic transmission measuring equipment ATME N1 for national networks. A more advanced equipment called ATME N2 is at present being designed. It will contain the same measuring device as ATME 2. In national networks it is necessary to be able to make remote-controlled measurements of circuits proceeding from another exchange, which is possible with ATME N2. The corresponding need does not exist in the international network. This fact, and the circumstance that R2 signalling frequencies are used in the national variant, constitute the main differences between ATME 2 and ATME N2.

Operation and measuring facilities, ATME 2

With ATME 2 attenuation measurements can be automatically made at 400, 800 and 2,800 Hz, noise measurements on the absolute value principle, and certain line signals and busy flash signals can be tested. The measurement program and line data are fed into ATME 2 from an electrical typewriter and tape reader, whereas the results of measurements are recorded on an electrical typewriter or tape punch (fig. 1).

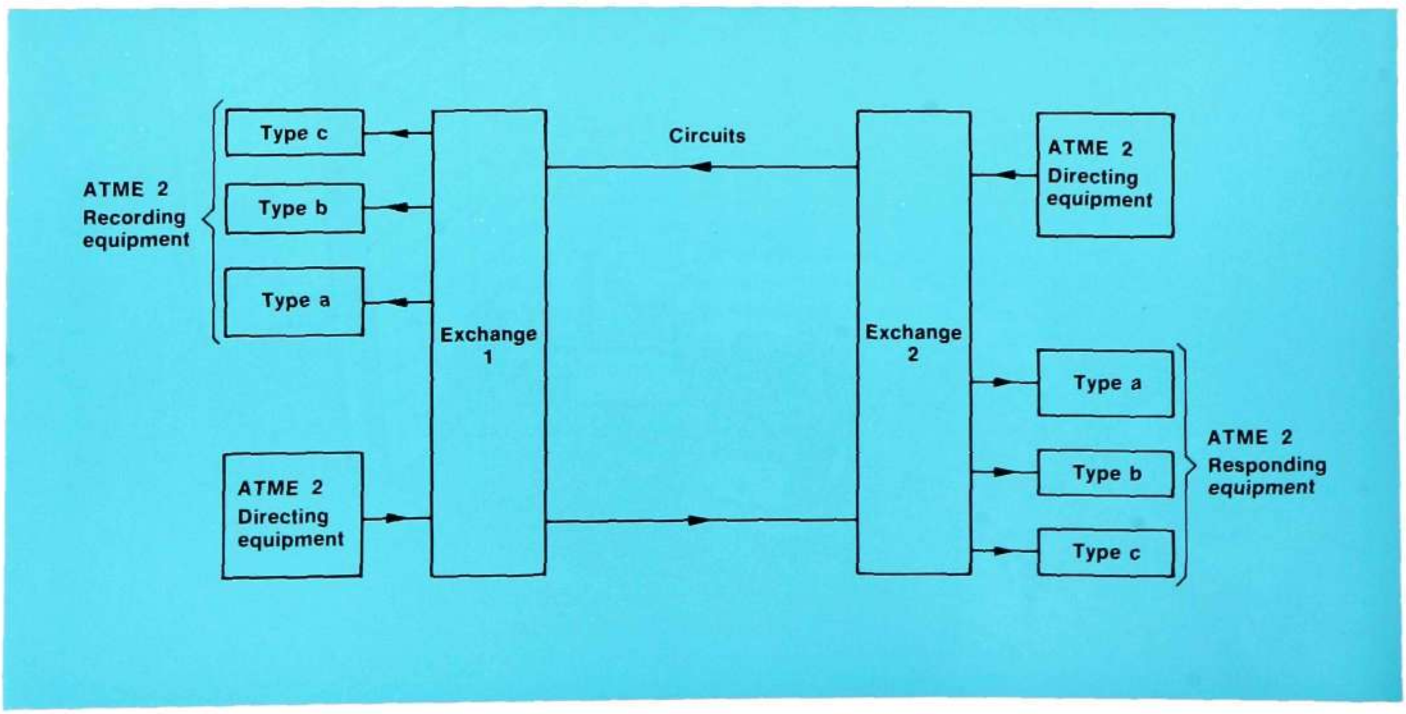
Measurements of circuits between two international exchanges are made with a directing equipment in the exchange from which the measurements are programmed and where the results are recorded, and with a responding equipment at the remote exchange (fig. 2). If ATME 2 is to be used for measurements both of outgoing and incoming circuits, it is provided both with directing and responding equipment. Otherwise it is equipped solely for the measurement task in question. The directing and responding equipments are therefore designed to work entirely independently of one another. They can be placed on separate racks and in separate exchanges.

Directing equipment

Input and output units I/O (fig. 3) are included in the directing equipment for input of measuring programs and out-

Fig. 2

Directing and responding equipment of ATME 2. Directing equipment is required at the exchanges from which, and responding equipment at the exchanges to which, measurements are to be made. The arrows indicate the direction of connection for measurement.



put of the result. There may be two groups of such devices and each group can incorporate an electrical typewriter, a tape reader and, if desired, two tape punches. One group of devices can then be directly connected and the other group placed centrally and connected via modem. CCITT's alphabet no. 5 is used for communication in both directions.

The typewriter is used for input of data common to all circuits and for printed output of the results. Input of circuit and route data is done with the tape reader.

One tape punch is used for recording of the results of measurement and the other for recording of input data for circuits which have been engaged too long and were therefore not available for measurement. The tape from the latter punch can be inserted in the tape reader for input, whereupon these circuits are reintroduced into the measuring program. The interworking between I/O units and the directing equipment is controlled by the interface IOG.

The logic unit IOL is in charge of input, recording and output of data. The logic process in IOL and the transfer of data

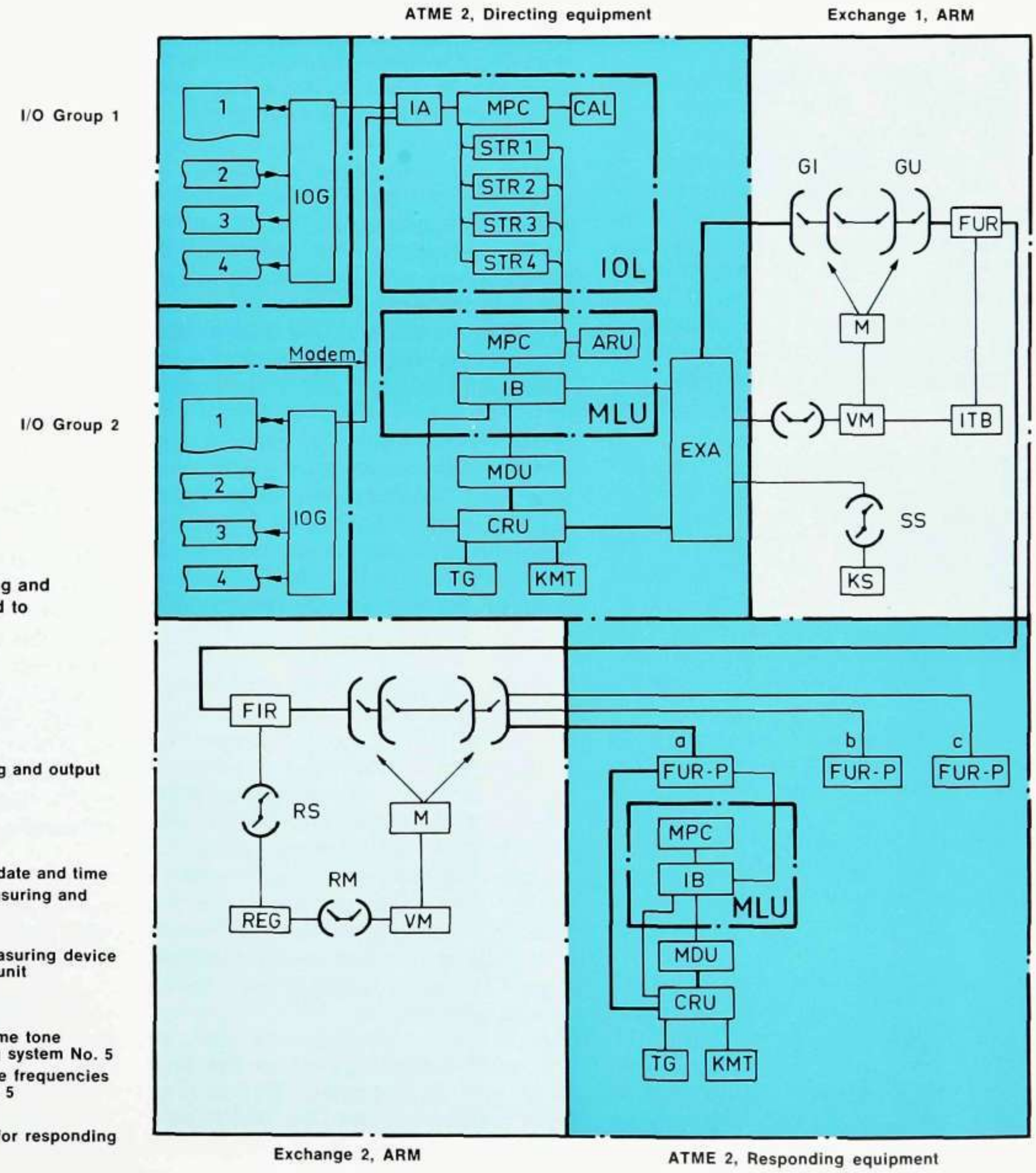


Fig. 3

ATME 2, block schematic. Directing and responding equipments connected to exchanges of type ARM.

I/O	In- and output units
1	Typewriter
2	Tape reader
3, 4	Tape punches
IOG	I/O interface
IOL	Logic for input, recording and output of data
IA	I/O interworking unit
MPC	Microcomputer
STR1—4	Data stores
CAL	Calendar unit, indicates date and time
MLU	Logic and control of measuring and signalling sequence
ARU	Arithmetical unit
IB	Interworking unit for measuring device and exchange interface unit
MDU	Measuring device
CRU	Connecting unit
TG	Tone generators with same tone frequencies as signalling system No. 5
KMT	Tone receivers with same frequencies as signalling system No. 5
EXA	Exchange interface unit
FUR-P	Exchange interface unit for responding equipment

are controlled by a microcomputer MPC which has a fixed program. The program store has a maximum capacity of 4,096 instructions and is extendable in modules of 256 or 512 instructions. Data from I/O units are converted in the interworking unit IA from series to parallel form and thereafter recorded in the stores. A store STR 4 is intended for common data for the circuits to be measured. There are also three stores STR 1—3 for individual circuit data, which means that three circuits can be recorded simultaneously. This increases the measurement capacity and reduces the number of circuits which must be remeasured owing to their being engaged, as will be explained below. When data for a circuit have been read into a store, an attempt is made to connect to this circuit. If it is engaged, an attempt is made with another circuit recorded in the next store. If this circuit as well is engaged, an attempt is made with the third circuit. Data for engaged circuits are left in the stores for 15 min, except in the case when all three circuits are engaged simultaneously. In the latter case the time is reduced to between 0 and 9 min. The time can be programmed according to local requirements.

Noise measurement is done during heavy traffic periods, during which the increased measurement capacity is especially advantageous as it reduces the number of circuits which must be reintroduced into the measuring program on account of their having been engaged too long.

The results of the measurements are recorded in the particular store which holds the input data of the circuit. The output of data to the output units is controlled by the microcomputer MPC which forms part of IOL. For the circuits which have been accessible for measurement the result is delivered together with the identity numbers of the circuits. For non-accessible circuits input data are delivered on punched tape. The tape is used in a new attempt at measurement.

In conjunction with printout the time must also be indicated. This is read from a calendar unit CAL which delivers particulars of month, day, hour and minute. CAL is set to the correct time from the typewriter and a check recording is obtained.

The logic unit MLU for control of the measuring and signalling sequence receives the information stored in the various stores and thereafter transfers the necessary data via an interface unit EXA to the exchange for connection to the circuit concerned, control of measuring and signalling sequences, and transfer of the measurement results to the stores. MLU interworks with other units via an interworking unit IB consisting of test and control devices. The logic process in MLU is controlled by a microcomputer MPC. The microcomputer is of the same type as that in IOL, but is in this case programmed for control of the logic process in MLU.

Measurements are normally made on the assumption that the nominal loss of the circuit is 0.5 dB, but other nominal values of loss may naturally occur in practice. The actual loss of the circuits must then be fed into a store in the directing equipment, in which case the measured values are not recorded until they been adjusted by the arithmetical unit ARU in MLU.

The performance of the measuring device MDU is dealt with below and the principle of its structure is described later under a separate heading.

MDU is all-electronic and its components and circuitry have been selected for high rapidity, accuracy of measurement and reliability. For instance field effect transistors are used for the stepwise connection of pads during comparative measurements. A measurement of attenuation at *one* frequency is carried out, for example, in max. 170 ms as compared with CCITT's recommendation of max. 500 ms.

Attenuation measurements can be made at 400, 800 and 2,800 Hz. The send level, which is nominally +2 dBm, can be adjusted within an accuracy of ± 1 mB. The nominal level on the receive side is — 9 dBm with upper and lower measurement limits of — 3.9 and — 18.9 dBm.

For noise measurement the speech channel is terminated at one end with

600 ohms and the absolute value of the psophometrically weighted circuit noise is measured at the other end. The receiver on the measuring side has a nominal level of — 9 dBm with upper and lower measurement limits of — 39.0 and — 74.0 dBmp.

Should the result of any of the measurements fall outside the limits, this is indicated to the control equipment with corresponding printout as a result.

The circuit to be measured is connected to the connecting unit CRU via the exchange interface unit EXA. Under the control of MLU, CRU connects circuits as required to the measuring device MDU or to tone generators TG and code receivers KMT. All measurement paths are connected through covered relays with mercury-wetted contacts.

Tone generators TG and code receivers KMT are used for signalling between the directing and responding equipment after receipt of an answer signal from the responding equipment. The frequencies of signalling system no. 5 are used, but the signalling scheme is specific to ATME. The logic process of the signalling is entirely controlled by MLU, while TG and KMT merely control the sending and receiving of the signal frequencies ordered.

The exchange interface unit EXA connects ATME 2 to the international exchange, which may be of different types. Only in exceptional cases need the regular equipment of the exchange be altered.

If the exchange is of type ARM 20 (fig. 3) there is an individual selection facility, in which case the circuit to be measured is accessible on the regular individual selection number via the regular selector stages of the exchange. In an exchange lacking this facility, on the other hand, the interface unit must contain special access selectors in order to provide access to the circuits for measurement. In the case of different register signal systems one register type is usually required per system.

For matching of the measuring device to different levels depending on the geographical situation of the exchange etc. the interface unit contains pads and amplifiers which are set according to the level plan of the exchange once and for all.

Responding equipment

In accordance with CCITT's recommendations there are three types of responding equipment (fig. 3): *Type a* for transmission measurement and signalling system functional testing: *Type b* for signalling system functional testing of the same kind as in Type a and intended for use when Type a is lacking or entirely occupied by transmission measurements: and *Type c* for check of busy-flash line signal.

Responding equipment Type a contains, from the hardware aspect, the same control unit MLU as the directing equipment but programmed to fulfil the requirements placed on the responding equipment. The measuring device MDU, tone generators TG, code receivers KMT and connecting unit CRU are identical to those of the directing equipment. The exchange interface unit FUR-P is of line relay type and must be adapted to the exchange in question.

On a call from the directing equipment to a free responding equipment an answer signal is transmitted. Exchange of signals thereafter takes place in accordance with the special signalling scheme of ATME 2, based on the frequencies of system no. 5, after which the logic process in the responding equipment is controlled by MLU.

On connection for measurement of a circuit a check is made that its normal line signalling functions satisfactorily. The clearback signal is not checked, however, so that equipment of Type a has been supplemented for the following signalling system functional tests.

After receipt of the answer signal the directing equipment sends an assistance operator signal if included in the normal signalling scheme. In reply to this signal the responding equipment sends a clearback signal and after 500 ms a new answer signal. When this signal has been received by the directing equipment the circuit is cleared. If there is no assistance operator signal, code 11 in ATME 2's signalling scheme is sent instead.

Responding equipment Type b is designed as an independent code answering equipment and performs the same function in respect of signal system test as described for Type a.

Responding equipment Type c is used for supervision of the busy flash signal and is a busy-marked code answering equipment. It sends a busy flash signal when called. This equipment, however, can often be replaced by strapping in the regular exchange registers. The strapping results in busy on a call to the number reserved for the purpose.

Salient feature of the measuring device

Measurement of one speech channel of a four-wire circuit is done in the directing equipment. Thereafter the other speech channel is measured in the responding equipment and the result is transferred to the directing equipment with ATME 2's own signalling system. In the following survey the measurements only in one direction will be dealt with, since they are performed in the same way in the other direction (fig. 4).

Send unit

The three measurement frequencies 400, 800 and 2,800 Hz are generated by a corresponding number of oscillators with level supervisors and alarm circuits. For the special locking tone required for tests of TASI circuits, 2,800 Hz is also used. Disconnection of echo suppressors is done with 2,100 Hz tone generated by a separate oscillator. Instead of an oscillator for 800 Hz, a 1,000 Hz oscillator can be supplied on request.

Attenuation measurement

The measurement tone sent from the send unit is received at the other end of the circuit by the receive unit. There it passes through amplifier F, contact R and signal detector D1, where it is rectified and fed to one input of the comparison unit J (fig. 4). To the other input of this unit is fed a reference DC voltage generated by the reference voltage source UREF. The reference voltage passes through the pads DL, in which it can be lowered by altogether 35 dB in steps of 0.1 dB. The pads are connected into circuit by field effect transistors which permit an extremely rapid measuring process. The successive connection of the pads is controlled indirectly by the clock oscillator OSC. The latter is started by a pulse from the control unit ST when the measuring sequence is to stop and feeds a counter chain RK, which in turn steps the pads DL in steps of 0.1 dB.

In the comparison unit J a comparison is made between the level of the meas-

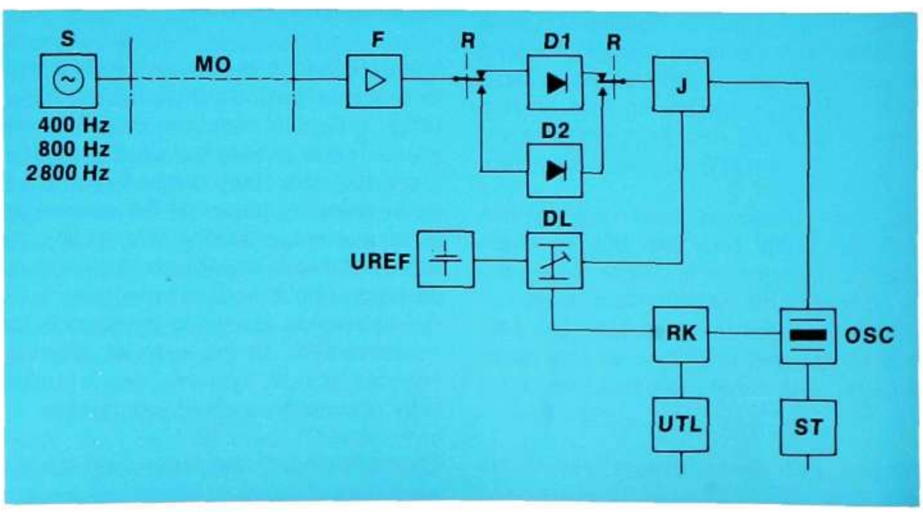


Fig. 4
Principle of measuring device

S	Sending unit
MO	Object to be measured
F	Measuring amplifier
R	Relay for switching between noise and attenuation measurement
D1	Detector for attenuation measurement
D2	Detector for noise measurement
J	Comparison circuit
DL	Pads
UREF	Reference voltage source
RK	Counting chain
OSC	Clock oscillator
UTL	Read-out circuit
ST	Control unit

uring signal received from the circuit and the reference DC voltage. When, after passing through the pads, this voltage has fallen to the same level as that of the measuring signal, the comparison circuit J sends a stop signal to the clock oscillator and stepping of DL ceases. The time during which stepping of DL has taken place is proportional to the attenuation connected. The stepping time is translated into an attenuation value which via UTL is fed to the control unit.

Noise measurement

The control unit connects a 600-ohm termination at one end of the speech channel. At the other end the measurement is carried out. The circuit noise passes through amplifier F and relay contact R1, after which it is fed to detector D2, which consists of a psophometric filter, a square-wave rectifier and an integrator. In the comparison unit J the integrated DC voltage is compared with the reference voltage from the cascade-connected pads DL on the same principle as for attenuation measurement.

Supervision

Before each measurement the measuring device automatically supervises the programmable pads. In the event of a fault the equipment is blocked and an alarm is issued. The outgoing send level is also supervised automatically.

The measuring device can also be supervised by measurement of supervisory pads connected into circuit by the control equipment. The result is printed out and an automatic indication is obtained as to whether the values are within the permissible limits. By means of a special supervisory unit, equipment can also be calibrated manually.

Input and output

Input of circuit data and output of the results of measurements are done with the I/O devices in the following manner.

Circuit and route data

From a typewriter the following common data can be fed in as required:

— numbers of the routes to be measured

— measuring routine, which together with the individual class number of the circuit decides which measurements are to be carried out

— printout of all results of measurements or only of those outside the tolerance limits

— control of measuring time common to all routes through indication of start and possibly also stop time.

The following individual circuit and route data are fed in from the tape reader:

— control of measuring time per route through indication of start and stop time

— identity number of circuit

— circuit access number

— individual class number of circuit

— call number of responding equipment

— nominal loss of circuit and permissible deviation

— measuring signal level either 0 dBm0 or — 10 dBm0.

Printout of results

With the arithmetical unit ARU a check is made that measured values are within the tolerance limits. There are two such limits. One marks that the circuit must be repaired and the other that it must be removed from service.

The results of measurements can be printed out on the typewriter and in parallel on a tape punch, or solely on a tape punch. It is possible to print out on the typewriter only those values which are without the tolerance limits and, on the tape punch, all measurement results. The latter can then be analysed statistically in a computer.

Some examples follow of the information — apart from the exact values of measurement — which can be quickly read from the printout for a circuit.

— "For attenuation and noise measurement and for the signalling system test all results were within the tolerance limits."

— "For attenuation and noise measurement the level at 800 Hz in the direction A—B and the noise level in the same direction were outside the tolerance limits."

— "In the signalling system functional test no clearback signal was obtained."

Signalling

All signalling for setting up of a measurement connection is done with the line and register signal systems normally used between exchanges on the directing and responding sides. One thus obtains a good functional check in conjunction with the connection of a circuit for measurement.

Signalling between directing and responding equipment for control of the measurements and transfer of the results is done with a signalling scheme specific to ATME 2, which uses the same frequencies as signalling system no. 5. The results of measurements in such case are transmitted in pulsed form. Sending of measurement orders, on the other hand, is done in compelled sequence in order that the connection and disconnection of the measuring device may take place synchronously on the directing and responding sides.

Components, construction practice, power supply

The logic units and measuring device are made up of integrated circuits of TTL (Transistor Transistor Logic) type.

The various stores are of semiconductor type, whereas miniature relays are used at various control points. All measurement paths are connected via enclosed relays with mercury-wetted contacts.

The components are placed on printed circuit boards plugged into shelves. The latter in turn are plugged into a rack of height 2,900 mm.

The exchange-dependent interface unit is made up of normal relays assembled in plug-in relay sets.

An ATME 2 with directing and responding equipment and interface unit for ARM 20 normally consists of two racks.

The electronic equipment requires + 12 V and + 5 V. These voltages are generated by DC—DC converters which are fed with 48 V from the exchange batteries.

Summary

With the increasing automatization of international and national long-distance traffic it has become necessary to carry out automatic transmission measurements and other tests, e.g. of the setting up and clearing of connections. For more than 10 years L M Ericsson have supplied suitable equipment for this purpose in the form of ATME 1 and ATME N1, which have been admirable aids in the maintenance work of administrations. With the greatly improved models ATME 2 for international circuits and ATME N2 for national circuits, administrations now have even better means for improvement of the quality of transmission at reduced cost and, in general, for better service of subscribers.

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WORLDWIDE NEWS

Worldwide expansion of LM Ericsson's computer-controlled exchanges

L M Ericsson now have altogether 24 computer-controlled telephone exchanges in operation or on order for eight countries. The first was put into service at Tumba outside Stockholm in 1968. The total capacity of these exchanges is 170,000 trunk lines which, expressed in terms of subscriber lines, is equal to about 1 million lines.

L M Ericsson is alone in having put into service computer-controlled transit exchanges in which the operational and supervisory functions are controlled by several pairs of processors working in parallel, the so-called multiprocessor system.

This technique offers considerable advantages for meeting the extremely varying requirements placed especially on automatic trunk exchanges for long distance national, international and intercontinental telephone traffic.

The first multiprocessor-controlled trunk switching centre in the world was placed in service in Rotterdam two years ago and L M Ericsson are still alone in the world in having so advanced a technique in operation.

Present orders represent a value of over US $ 20 million and include three completely new exchanges, at Aarhus in Denmark, at Guadalajara in Mexico, and a second exchange of the same types as before at Rotterdam. Extensions have also been ordered for the already contracted computer-controlled exchanges at Helsinki and Åbo in Finland and Monterrey in Mexico.

The many new orders and the satisfactory experience of operation show that L M Ericsson's computer-controlled exchange system has become an international success. Since the opening of the first exchange at Tumba in 1968 computer-controlled trunk exchanges have been put into operation in Rotterdam, in Mexico City, Aalborg, Copenhagen and Stockholm.

In Sydney, Australia, L M Ericsson have recently put into operation a computer-controlled exchange for intercontinental telephone traffic, the first in the southern hemisphere.

The telephone building in Copenhagen is the illustration on the cover of a booklet on a new computer-controlled exchange, kh nc.

CTC with integrated circuits

The first plant based on L M Ericsson's recently developed CTC system JZA 700 is now being installed on the Zaragoza-Lerida-San Vicente de Caldes railway line in Spain.

System JZA 700, which is based on integrated circuit technique, is the third generation in the development of CTC systems by L M Ericsson over more than twenty years.

Although JZA 700 requires considerably less space than the relay systems for corresponding control and indication capacity, system JZA 700 has a number of facilities which are lacking in the relay system. The transmission speed is also considerably higher.

The system consists of a basic unit and, as the number of stations, information requirement etc. increase, extension units can be installed precisely in the number required. The customer need therefore not pay for unutilized overcapacity and the initial investment is low.

JZA 700 is also adapted for interworking with a computer-based electronic train describer system and stored-program-controlled train dispatching.

Apart from the earlier mentioned installation, L M Ericsson have orders for six other JZA 700 plants.

Rifa develop bipolar LSI

The Semiconductor Laboratory of AB Rifa are developing a bipolar LSI (Large Scale Integration) technique with high packing density. The technique is called Collector Diffusion Isolation (CDI), and was originally developed by Bell. Rifa's CDI differs, however, in certain respects from the earlier CDI structure. The Rifa process includes lateral PNP transistors and Schottky diodes, which are lacking in other CDI structures. Rifa have also made use of the distinct advantages offered by the CDI technique for making of ion-implanted n-type precision resistors with a high sheet resistivity.

The CDI transistors differ from conventional planar IC transistors in that the low-resistivity collector diffusion becomes the active collector, whereas in the standard technique the high-resistivity epitaxial material acts as the collector. The thin epitaxial layer, which is only 1.5 μm in the CDI technique, becomes the p-type base. The isolation between the components is achieved by means of an n-type collector isolation ring which at the same time acts as a deep collector contact and thus reduces the saturation voltage of the transistors.

The very thin structure and the current-sinking capability of the transistors allows very compact design.

An interesting application is low-power Schottky TTL in which, in the more complex circuits, the active area can be reduced to about 30 % of that needed with conventional technique.

A good balance sheet result 1973

Ericsson Group order bookings rose in 1973 by 39.9 percent to US $ 1,559.1 million from 1,114.3 million in 1972. Markets outside Sweden accounted for 86.8 percent of the bookings. The order backlog at the year-end was US $ 1,493.4 million (1,071.4 million at year-end 1972.)

Group sales increased by 21.4 percent to US $ 1,145.6 million as against 943.8 a year earlier. Sales outside Sweden accounted for US $ 940.2 million (765.2 million) or 82.1 (81.1 percent).

Income before special adjustments and taxes was US $ 194.2 million (118.9 million) equal to 17.0 percent of sales (12.6 percent).

The reported net income in 1973 was US $ 61.5 million (39.6 million).

Consolidated income statement (Mill. of dollars)	1973	1972
Net Sales	1,146	944
Share in earnings less losses of non-consolidated subsidiaries and associated companies	7	1
Interest income	33	28
Other revenue	9	8
	1,195	981
Cost of products and services sold	610	527
Selling, administrative, research and development expenses	308	266
Depreciation	44	36
Interest	39	34
Income before special adjustments and taxes	194	119
Special adjustments		
Transfer to reserve for accounts receivable and investments outside Sweden, net	10	6
Transfer to (from) special inventory reserve	7	(2)
Transfer to reserves for future investments	21	17
	38	21
Income before taxes	156	98
Taxes on income	77	46
	80	52
Minority interest	18	13
Net income	62	40
Adjusted net income	76	48
Adjusted net income per share US $	4.94	3.14

Adjusted net income represents net income increased by special adjustments and reduced by the income taxes which would have been paid if the adjustments had not been made. In the adjustment of the net income the minority interest has been included where relevant. The calculated depreciations accord closely with the booked depreciations.

Capital expenditures for property plant and equipment totalled US $ 86 million in 1973 (81.5 million).

The number of employees at the year-end was 75,630 (70,650), of whom 28,560 (27,400) in Sweden.

Unappropriated earnings of the parent company at December 31, 1973 amounted to US dollars 57.8 million.

The Board of Directors propose a dividend of Swedish Kronor 5: 50 per share (5.00 on the capital as increased in 1973).

All amounts are expressed in US dollars using the rate of Swedish Kronor 4.55 to 1 US dollar. Consolidated and Parent Company figures are subject to audit.

The Annual Meeting of Shareholders to consider the Board's proposal was held in Stockholm on May 28, 1974.

Production technicians from L M Ericsson factories in various countries gathered in February/March on a six-week course on production mechanization at the head factory in Stockholm. The aim of the course was to give participants a more profound and up-to-date knowledge within the sphere of industrial automation. Classroom instruction alternated with visits of study to most of the Swedish production units of the Ericsson Group. The author of all compendia and head instructor was Oskar Möre, L M Ericsson (left in the photograph). On his right is seen Joe Young, L M Ericsson Pty, Australia; Michele Bartoletti and Michael Jones from FATME, Italy; Waldir Alves Pereira, Ericsson do Brasil; Blackery Graham, L M Ericsson Pty, Australia; and Håkan Ledin, LME, Stockholm, who is showing the participants a model of L M Ericsson's main plant in Stockholm.

CTT converts without interruption of traffic

On the Lisbon—Oporto route a conversion has recently taken place of a 960 to a 2,700 channel system without any interruption of traffic in the course of the work.

Portugal's two largest cities, Lisbon and Oporto, have for a long time been linked by 6-pair coaxial cable and the traffic has earlier been transmitted by means of two vacuum tube 4 MHz line equipments. To meet the increased traffic requirement between the two cities, the Portuguese telephone administration, CTT, plans to replace the older 4 MHz equipments by 12 MHz equipment on the existing coaxial cable.

For the implementation of these plans CTT placed an order with L M Ericsson for the delivery and installation of a 12 MHz system which in the first stage will replace one of the 4 MHz systems. For the 375 km coaxial cable it was necessary to insert some fifty intermediate repeaters and to install new equipment in as many existing station buildings.

500 selector jubilee

The first automatic exchange in Stockholm, Norra Vasa, celebrated its 50-year jubilee on January 13.

It was on January 13, 1924, that the exchange was opened for public traffic and L M Ericsson's 500 selector system (AGF) thereby made its debut in Sweden. The world premiere for the system had been in Rotterdam in May of the previous year *(Ericsson Review 2/73).*

More than 2 million subscribers in Sweden are connected to 500 selector exchanges constructed by L M Ericsson. Since 1923 the company has delivered 500 selector systems serving more than 5 million subscribers throughout the world.

Joint telecommunications venture in UK

Thorn Electrical Industries Ltd and L M Ericsson have established a joint British company in order to uphold the interests of Thorn and L M Ericsson on the rapidly growing telecommunications market in the UK.

The new company, Thorn-Ericsson Telecommunications Ltd., is capitalized initially at £ 1 million with Thorn holding 51 per cent and L M Ericsson 49 per cent of the equity.

Thorn Ericsson Telecommunications Ltd (TEL) owns the shares in Swedish Ericsson Telecommunications Ltd, earlier one of L M Ericsson's subsidiaries in the UK, and a production company Thorn-Ericsson Telecommunications (Mfg) Ltd. TEL is responsible for the direction and supervision of the two companies and also for certain common functions such as administration, financing and coordination of sales efforts to the British Post Office Corporation. Swedish Ericsson will continue its successful penetration of the UK private market, while Thorn-Ericsson Telecommunications (Mfg) Ltd will be responsible for product development and manufacture within the scope of the venture.

Mr G. J. Strowger (left), Managing Director of Thorn Electrical Industries Ltd, and Björn Lundvall, President of L M Ericsson, sign an agreement for the formation of a joint company, Thorn-Ericsson Telecommunications Ltd.

The chairman of the Board of Thorn Ericsson Telecommunications Ltd is Mr G. J. Strowger (Managing Director of Thorn Electrical Industries), and the deputy chairman Fred Sundkvist (Executive Vice President of L M Ericsson). The Board consists of four other members, two from Thorn and two from L M Ericsson.

The General Manager is Mr. E. T. Stephens, who remains Managing Director of Swedish Ericsson Telecommunications Ltd and Thorn Ericsson Telecommunications (Mfg) Ltd.

Saudi Arabia orders worth $ 15 m.

L M Ericsson have received three orders totalling over $ 15 million from Saudi Arabia.

One of the orders signed with the Saudi Arabian Ministry of Communications covers switching equipment, telephone instruments and line equipment valued at about $ 6.5 million. This equipment is to be delivered within the next two years. It will be used for extensions of existing installations and for new installations in nine cities in the country.

Another order from the Ministry of Communications is an extension, worth around $ 4 million, of the $ 17 million order received by L M Ericsson from Saudi Arabia a year ago.

At the same time L M Ericsson in partnership with the British cable manufacturer BICC has been awarded a substantial order for telephone cable from Saudi Arabia. Ericsson's share of this order is approximately $ 4.5 million. The cable ordered is to be delivered within the next 18 months.

President of Mexico opens new LM Ericsson factory

Teleindustria Ericsson's factory for telecommunications equipment has been opened by the President of Mexico, Luis Echeverria Alvarez, at Tlalnepantla outside Mexico City. More than US $ 8 million has been invested in the factory hitherto.

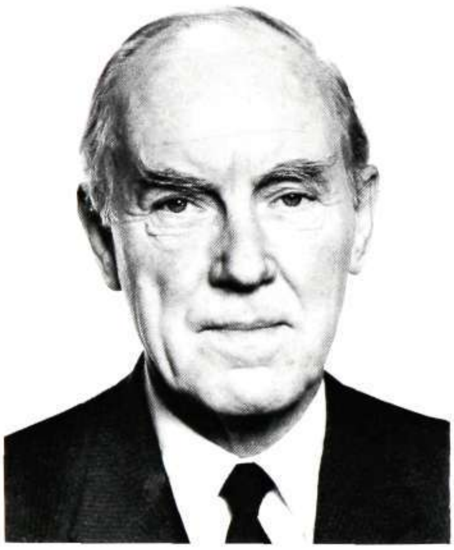
Present at the opening ceremony were also the Ministers of Industry and Education, the Governors of the three Mexican Federal States, the Mayor of Tlalnepantla, and a large number of prominent Mexicans. Sweden was represented by, among others, Dr Marcus Wallenberg and the President of the Group, Björn Lundvall.

From the opening ceremony at Teleindustria Ericsson's factory at Tlalnepantla outside Mexico City: The President of Mexico, Luis Echeverria Alvarez (centre) and the Governor of the Federal State of Mexico, Prof. Carlos Hank Gonzales (right) are shown round the factory by the President of Teleindustria, Nils Kjellander.

In conjunction with the opening ceremony L M Ericsson made a donatiton of 1 million pesos (c. US $ 80,000) for educational purposes. Dr Wallenberg, in his opening address, spoke of the great significance which the transfer of technical and production know-how through a company such as Teleindustria has for the development of a country like Mexico. This transfer of know-how, stated Dr Wallenberg, has a great significance not only for the company's customers and employees but also for its native subcontractors.

L M Ericsson have been active in Mexico for nearly 70 years. The new plant, which employs 1,700 persons, accommodates not only factory buildings, but also office, laboratories and a training centre for Latin American telecommunications technicians. The total floor area is around 35,000 m². As a result of the rapid expansion of the company the new premises are already too small and an extension of 14,000 m² has been started upon. This involves an investment of around US $ 2.5 million and is expected to be completed by the end of this year.

Harald Alexandersson In Memoriam



Harald Alexandersson died at his home at Torremolinos, Spain, on January 31, after recently attaining the age of 70 years.

Harald Alexandersson joined L M Ericsson in 1928. He soon became engaged in railway telephony and, during the thirties, using a new principle, succeeded in designing a new selective calling telephone system which has since been standardized by a number of railway administrations, among which the Swedish. The system is still being produced. After a period as director at AGA Baltic AB, Harald Alexandersson became President of Svenska Radioaktiebolaget in 1944. It fell to his lot to solve the troublesome problems of returning to civil production after the end of the war. As from 1950 Harald Alexandersson was Departmental Head and later Chief Engineer at L M Ericsson. He was in charge of the work of mechanical design within the telephone exchange field. A number of new designs saw the light of day under his management. The item that is particularly associated with the name of Harald Alexandersson is the code switch. This switch, which was designed at the end of the fifties, has come into wide use in PBX's, rural exchanges and also in the stored-program-controlled exchanges of AKE type. The code switch is probably one of the most reliable switches that has been produced.

Harald Alexandersson was an extremely ingenious and imaginative designer. He had a real talent for creation. He also possessed a thorough general knowledge of precision mechanics and electronics. His contributions were therefore of great value to L M Ericsson. Harald Alexandersson really ennobled the work of design to an engineering art.

We who worked with Harald Alexandersson or followed his work have lost a good friend and comrade. We were all aware of the enthusiasm and joy in creation which he radiated. We join with his nearest relatives in expressing our regret at his loss.

Christian Jacobæus

World telephone statistics

The total number of telephones in the world increased during 1972 by 7.4 % and, according to AT&T's latest annual statistics "The World's Telephones", was 312.9 million at Jan. 1, 1973. The corresponding increase in 1971 was 6.8 %.

The average telephone density in the world increased during 1972 from 7.8 to 8.2 telephone sets per 100 inhabitants.

During the last ten-year period the total number of telephone sets in the world has increased by 94.2 %.

The telephone density per 100 inhabitants on the various continents was on January 1, 1973 (preceding year's figures in brackets):

North America 61.3 (58.4)
Central America 3.4 (3.1)
South America 3.3 (3.3)
Europe 16.0 (14.8)
Africa 1.0 (1.0)
Asia, including the Asiatic parts of Turkey and the Soviet Union 2.0 (1.8)
Oceania 29.4 (29.2)

The country with the highest telephone density is the U.S.A. with 62.75 telephone sets per 100 inhabitants, followed by Sweden with 59.25, Switzerland 53.95, Canada 49.98, New Zealand 44.61 and Denmark 37.93.

Five small countries reported a telephone density of more than one telephone per two inhabitants.

Automatic traffic is accessible to 96.8 % of the world's telephone subscribers and has been introduced on a 100 % basis in 64 countries.

Information service per telephone

Information for telephone subscribers can now be provided by special tape recorders, the control equipment of which has been designed by L M Ericsson.

The equipment is now ready for introduction on the world market.

The information may consist of a general news service, weather forecasts, sports results, train running times, or publicity announcements. The content can be easily changed and the length of message varied from 5 seconds to 5 minutes.

The equipment consists of rack-mounted tape recorder units, distribution equipment and control panel with microphone for recording.

When a call from the telephone exchange is received by the information unit, the message is played back from the tape recorder. At the end of the message the tape is automatically wound back to starting position.

Two tape recorders are placed on one rack. When one tape recorder is connected for playback, the other is connected for recording. These functions can be switched over from the control panel at any time.

NEW BOOKS

● **"Maintenance of L M Ericsson Crossbar Exchanges in Rural City and Transit Networks — Customer Findings"** is the title of a compilation of four articles published in Ericsson Review during the last two years.

The authors, representatives of telephone administrations in Denmark, Tunisia, the Netherlands and Yugoslavia, confirm the many advantages attained through the introduction of L M Ericsson's *Controlled Corrective Maintenance* (CCM) method.

● **"Why Intercom?"**— this question is asked in the title of a new brochure on internal telecommunication systems produced by L M Ericsson Telematerial AB. It presents the results of measurements made by the company at four Swedish organizations.

The measurements show that each of the 1,093 intercom telephones at these organizations is used for no less than 3,000 calls per annum. The measurements also show that the average length of an intercom conversation is 42 seconds.

International Conference on Computer Communication

An **International Conference on Computer Communication (ICCC)** is to be held in Stockholm on August 12—14, 1974.

The host of the conference is the Swedish Telecommunications Administration, assisted by Swedish enterprises within the computer and telecommunication field, among which L M Ericsson.

A folder with information about the conference is being distributed with this issue of Ericsson Review.

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With associated companies and representatives

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2. L M Ericsson Telemateriel AB
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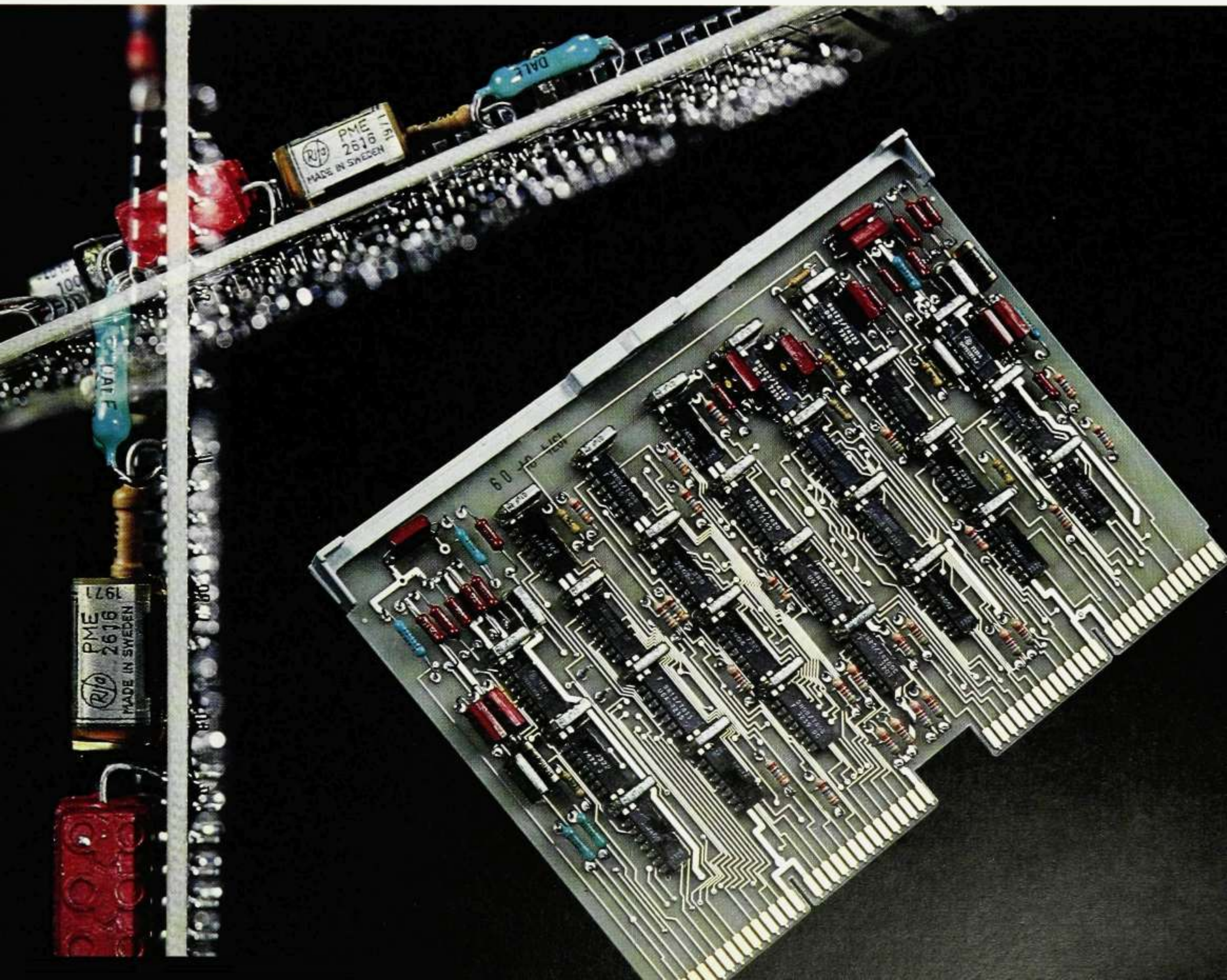
ERICSSON REVIEW

2 1974

SOFTWARE SYSTEM FOR AKE 13
A NEW GENERATION OF LINE SYSTEMS FOR COAXIAL CABLES
LINE AMPLIFIER FOR 12 MHz SYSTEMS
WORLDWIDE NEWS



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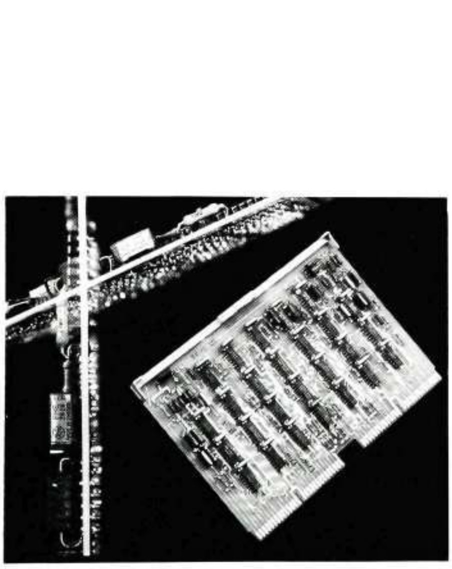

COVER

Printed circuit board in the data processing equipment for stored-program-controlled exchanges

Software System for AKE 13

Lars-Olof Norén and
Siwert Sundström

Ericsson Review No. 2, 1973[1]*, contained a description of the transit exchange system AKE 132, its properties and basic structure. The same number presented the experience from the first year of operation in Rotterdam*[2]*.*
The good handling properties of the AKE system and its flexible adaptability to different market requirements have been confirmed by the exchanges already put into operation.
The market adaptation of a stored program controlled (SPC) system is done chiefly by programming and program tests, for which reasons high requirements are placed on the software system. The present article presents the requirements which have formed the basis for development of the system and describes the organization, basic functions and manageability of the software system.

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Basic requirements

The introduction of SPC technique in telephony opens the way to centralized and more efficient operational and maintenance routines, with the means of altering data electrically.

During the life of an exchange it must also be possible successively to add new facilities which have been wholly or partially unknown previously. By means of SPC technique, functions can to a large extent be altered and added by means of programming instead of by redesign and alteration of the hardware. In order to be able to make effective and economical use of this facility, the software system must be well thought through and systematized. This applies particularly to exchanges working on a high level in the network, and great care has therefore been expended on the software system for AKE 13. The following basic requirements may be placed on a software system of this format.

Efficiency. AKE 13 was developed for medium-sized up to very large national, international and intercontinental transit exchanges. The central computers have therefore been designed as a multiprocessor system, each processor having as high a data processing capacity as modern technique allows. To reduce to a minimum the number of processors for a given size of exchange, a highly efficient software system is required.

Flexibility. Since AKE 13 is being introduced on a large number of markets, the functional requirements will greatly vary. The software system must therefore be easy to adapt to new requirements without total reprogramming. The central, application-independent functions are therefore generalized as far as possible, with well defined standard interfaces between them and the application-dependent functions. Standard and application-dependent functions must also be programmed so as to be independent of the number of processors, number of switch matrices etc. It must also be possible to alter these parameters during operation without change of program.

Reliability. Through centralization of the functions in a telephone exchange system there is not the same subdivision of the control functions as in conventional systems, in which each fault has a limited consequence. The reliability requirements on the control equipment in SPC systems are therefore very high, and this applies of course both to software and hardware. It must also be possible to maintain operation despite residual errors in the software.

Maintenance. The software in an SPC exchange is subject to constant changes. During the initial period of operation some fault clearing and modifications will be required. During the entire life of the exchange, functions will be successively added and data will be updated when new circuits and kinds of traffic etc. are introduced. This means that programs and data must be systematically and modularly constructed and that there must be methods and means for checking the state of operation of the programs.

System organization

The block diagram of the system (fig. 1) and its main components have been presented in an earlier article[1]. As appears from the block diagram the central computer is divided into a number (1—8) of data processing blocks (DPB). Each DPB, which contains both the central processor (CP) and program

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Head of the Section for System Specification within System Design Department I

and data stores (PSI and DSB), is connected via a transfer control block (TCB) to its own section of the test and operation subsystem. The latter contains matrices of test and operation points which give the data processing block access to relays and switches in the corresponding part of the switching equipment. The program store in each DPB contains programs for all switching functions, while the data store contains data associated with the switching hardware for that part of the system.

The program and data structure allows entirely free assignment of the functions to the various data processing blocks, so that each DPB either can perform all types of functions for its part of the switching equipment (sectional task assignment) or certain specific functions for all calls or devices (functional task assignment). In most cases only one DPB is required in the initial stage. New DPB's are added during the life of the exchange as and when required. The sectional principle in such case allows the connection of new switching equipment to new DPB's while the existing connections between switching hardware and processor remain unchanged. From the point of view of reliability as well sectional is better than functional task assignment and is therefore normally applied.

Data structure

Data comprise all types of information processed by different programs. Data may consist of internal data, which are

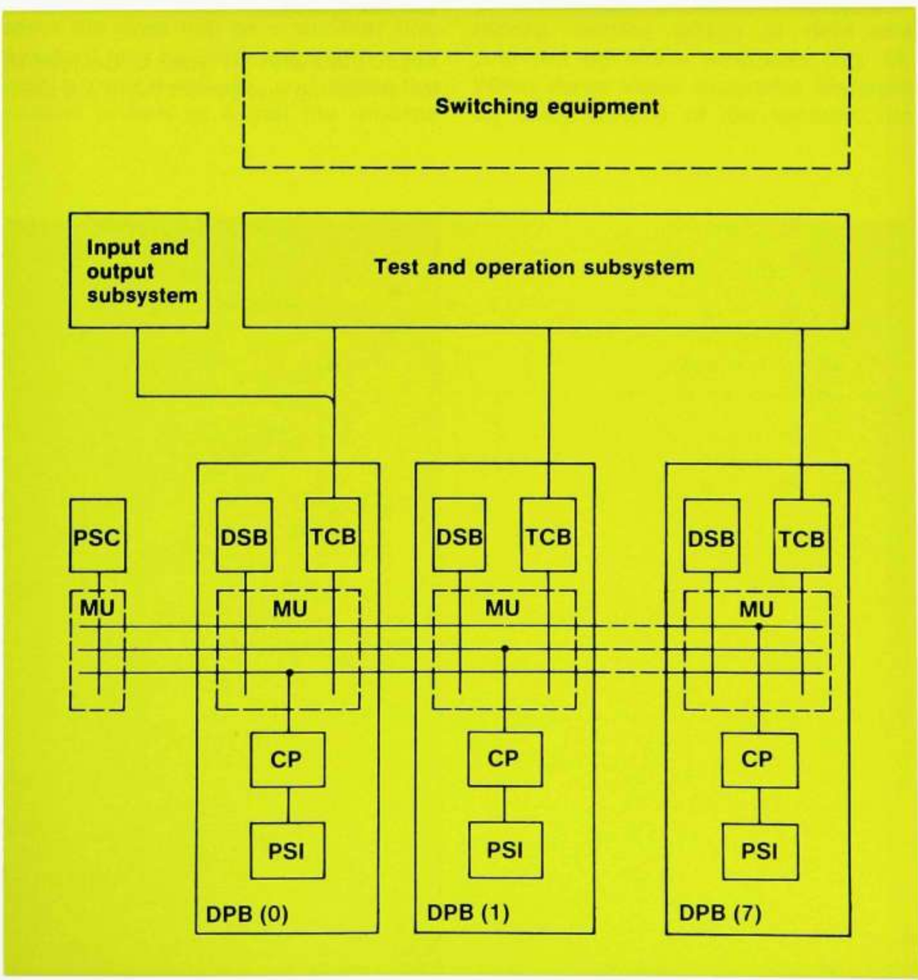


Fig. 1

Hardware block diagram

CP	Central processor (duplicated)
DPB	Data processing block
DSB	Data store block (duplicated)
MU	Multiplexor (duplicated)
PSC	Common program store (duplicated)
PSI	Internal program store (duplicated)
TCB	Transfer control block (duplicated)

stored in data store blocks (DSB), and of external data, i. e. the states of switches and relays in the switching equipment which can be accessed in matrices in the test and operation subsystem via the transfer control block (TCB). The data stored in DSB are of two kinds, permanent data in the form of tables of exchange parameters, and variable data, i. e. up-to-date information about the state of connections in progress.

The system is data-oriented in such a way that states and changes of states of data initiate the various measures performed by special programs. A strict subdivision of the data into different types and a standardized data structure are therefore essential components in the philosophy of the data processing system. The data structure will here be described with reference to the traffic-carrying functions, but the same principles are adopted throughout the system.

Associated with all types of devices in the switching equipment there are files, each type of device having a separate file (fig. 2). Within each type of device or file each individual device has its own data organized in a record. A record may be divided into groups to permit different independent operations on the device at different times, e. g. signal transmission or blocking. Each group, finally, can be subdivided further into terms. A term is the smallest addressable unit for a particular type of data. The format of a term is selected entirely independently of the function associated with its data. Examples of terms are a 6-bit term for 2-out-of-6 signalling, 4-bit counters for time measurement, or a single blocking bit.

For a given type of device, i. e. for a file, all groups of a certain type are collected into a continuous array of consecutive addresses in the data store. On the other hand the various arrays need not be stored next to one another. On the contrary certain arrays in a file may contain permanent data and therefore be placed in a special write-protected area, while others are placed in

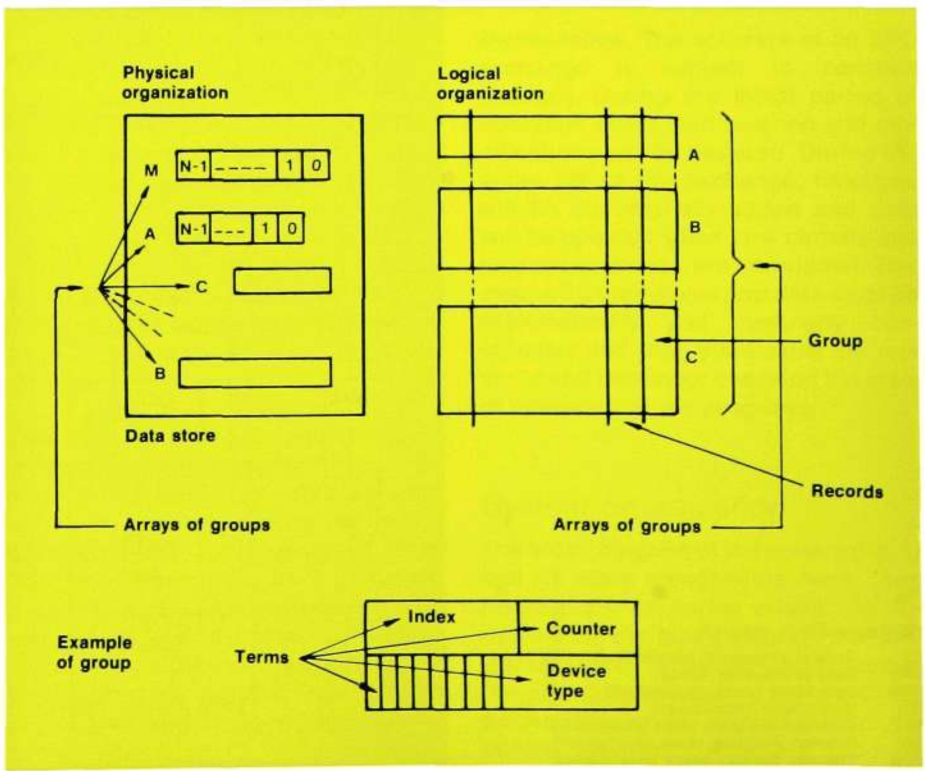
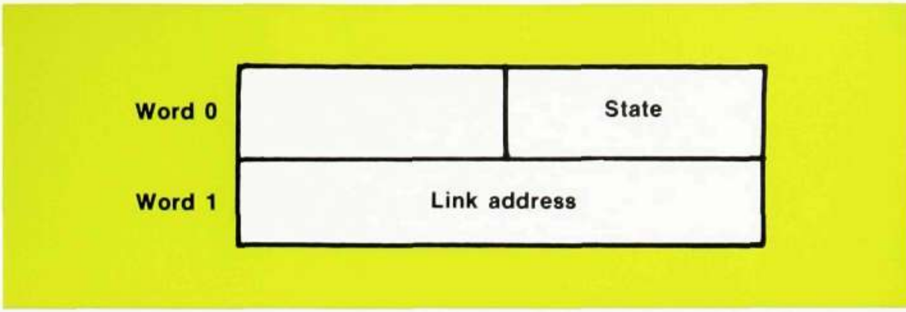


Fig. 2
File organization in the data store

Fig. 3
Main group containing common standard functions for the various records



the area for variable data. The physical location of the various arrays is indicated in a base address table in each data store block. This table is used by the programs for adressing of arrays in any data processing block. A file does not need, of course, be associated with a physical device. The register records with their digit stores are examples of this. Within each record the subdivision into groups depends on the corresponding division into functions related to the device or data record. Certain standard functions are common to all records and a standardized format is used for this type of group, called main group. As appears from fig. 3, certain terms in this group (state and link address) have standardized functions.

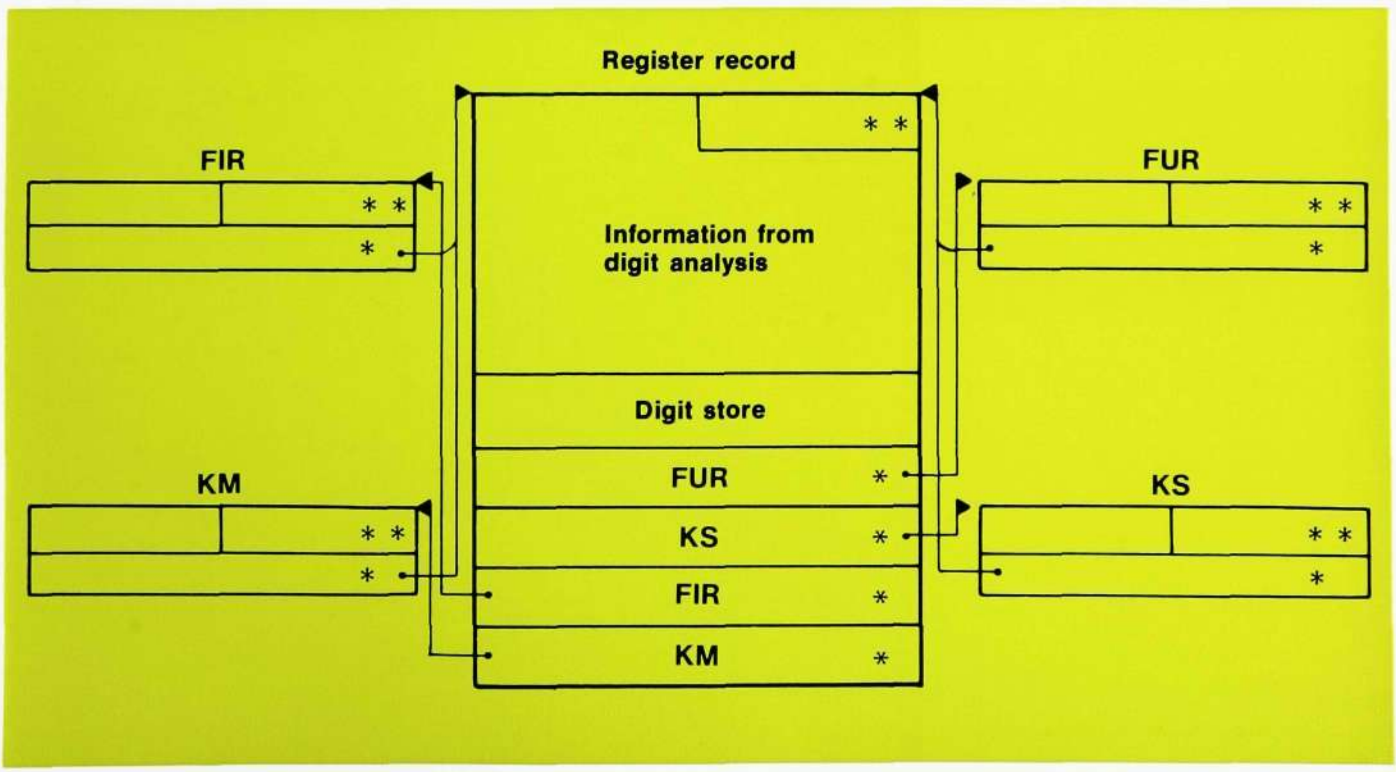
The state term provides information about the working state or processing phase for the group or device. The link address is used for linking of the record to some other record either in the same file (free list) or in another file. A record may be associated with a device, a route, a call etc., and during the various phases of a call the records can be linked to one another in different combinations. Since the format of the link address is sufficient to contain the absolute address to any word in any data store block, any two records or devices can be linked together. Fig. 4 shows an example of linking together of a register record with records for incoming and outgoing signalling circuits in the register position for a call.

Program structure

As already noted, the system is data-oriented, which means that the data in each data store block and transfer control block indicate what data processing is to be performed, and when. The programs specify how the processors are to carry out this data processing. Since each data store block can contain any type of data, all processors contain identical programs. The processors are thus universal tools. At regular intervals, specific to each type of record, certain arrays of data are scanned by index programs (fig. 5). When these index programs discover an event in one of the records, for

Fig. 4
Linking together of records in register signalling phase

* Link address
** State



example an incoming signal on a trunk, a task program is called to perform the requested action. The type of event, together with the present state of the record, defines which task program is to be called. Since the calling of a task program from an index program is a very frequent operation, a special computer instruction has been introduced for this purpose. The index programs are thus repeated regularly, while the task programs are only called when required. Scannings of arrays in the data store are done with a special field scanning instruction in the index programs, while scannings of data in test matrices, i. e. of information from the switching equipment, are done by an autonomous scanner at the initiative of the index program. The scanner has an entirely standardized program stored in a read-only store. The time at which a special index program is to be executed is indicated by a job table stored in the data store block. The job table is scanned by a control program, called job monitor, in the operating system. Each position in the job table contains a counter, the content of which is reduced by one every time the position is scanned by the control program. The position thus contains the storage address of the index program to be called when the counter reaches zero.

The scanning of the job table, stepping of the counter in each position and jump to the index program when the counter reaches zero are done by a special computer instruction developed for the purpose. The job monitor program is executed once per 5 ms interval at the initiative of a clock interrupt signal generated in the hardware.

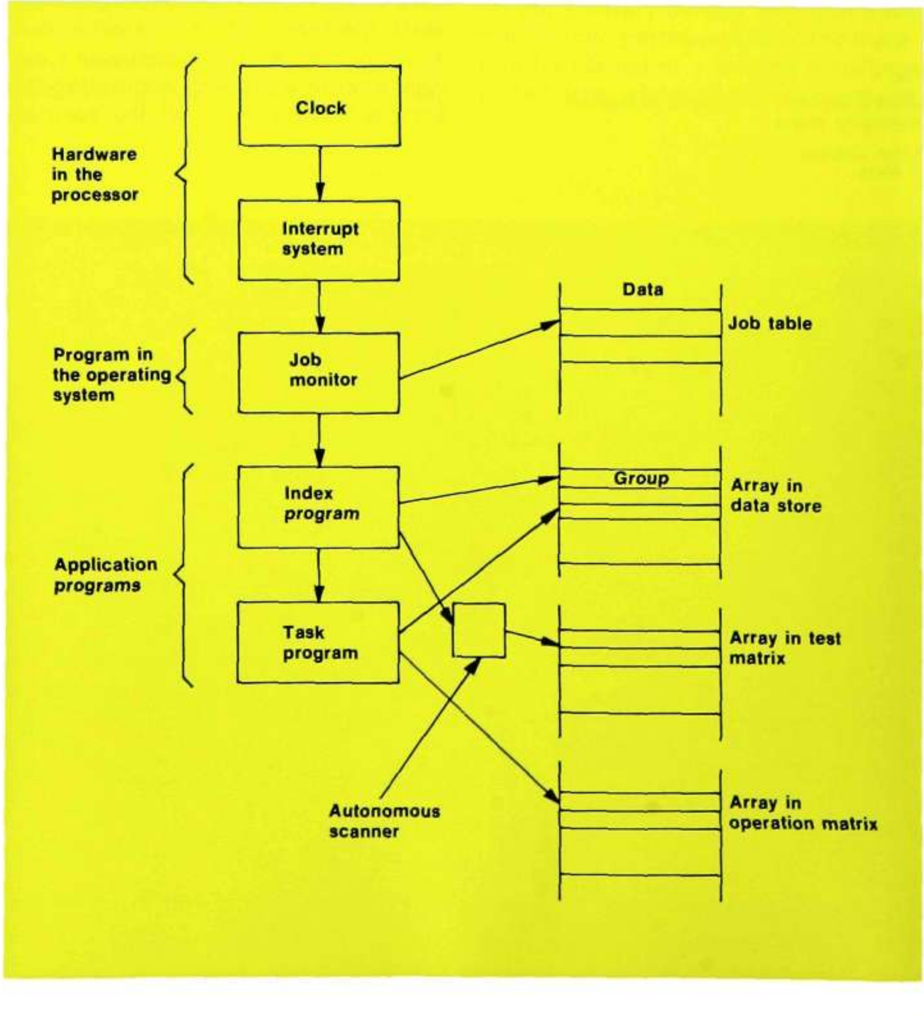


Fig. 5
Program handling principles for the various program levels

Fig. 6 shows an example of the relation between the program levels when two arrays in the data store are scanned during execution of a job table.

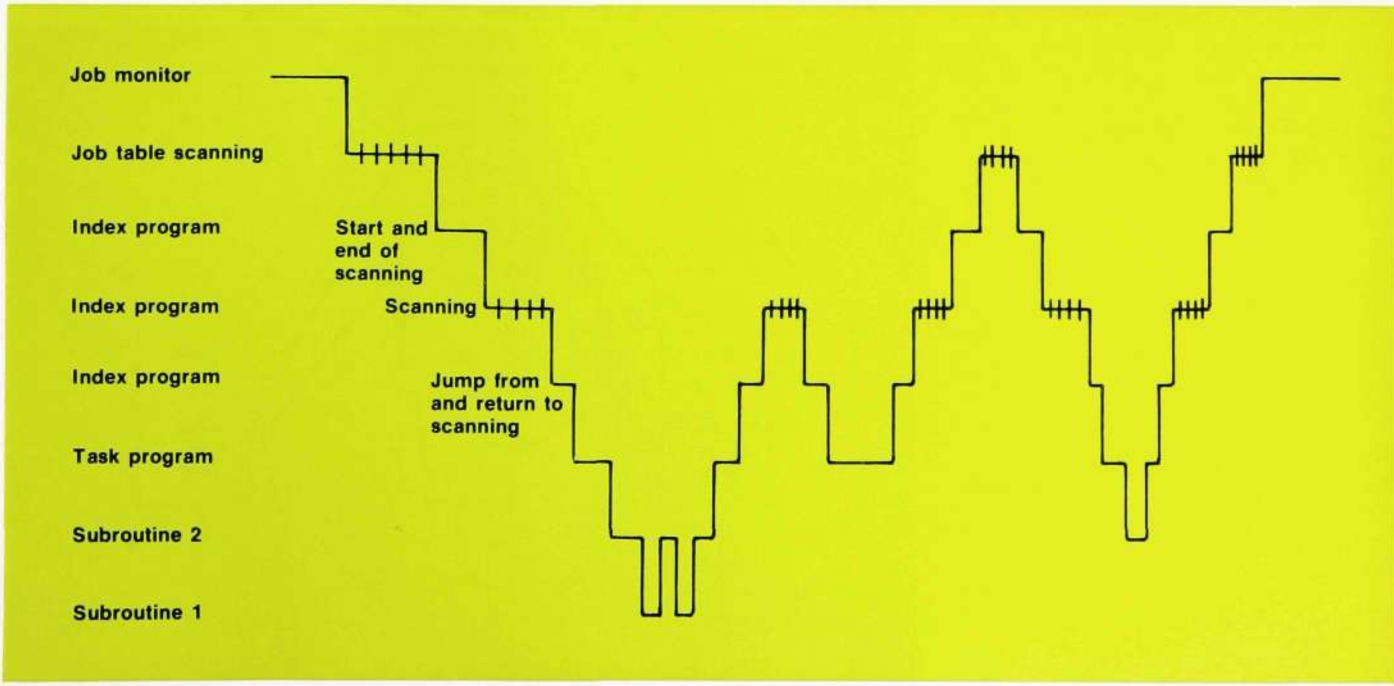
The requirements of accuracy of timing vary greatly between different measures. Different priorities are therefore given to different index programs. This is done by division of the job table into several parts which are scanned at different hardware priority levels. From the hardware point of view this is administered by means of the interrupt system of the processor. At a low processor load all levels with traffic-carrying programs are run through during each primary interval, but at a higher load the work on lower levels can be interrupted and postponed to a later interval. In this way the data processing capacity of the processor will be utilized in the most effective manner.

The records in the data store block and corresponding transfer control block are scanned only by the processor in the same data processing block. Each data store block, therefore, has its own job table. Differences between the job tables may exist owing to differences in the set of records in the respective data store blocks. This is dependent in turn on the types of switching equipment connected to the corresponding transfer control block. The interworking between the data processing blocks is effected by task programs reading or writing in the records concerned. The records may be placed in any data store block.

Block structure

The entire software for the AKE 13 system is divided into blocks, each block containing programs and data. Certain hardware, e. g. relay sets for trunk circuits or code receivers, may also belong to a block. Primarily a block constitutes a functional unit with distinctly specified properties. The block is therefore a suitable module both as design task for the programmers and as project planning unit. The block structure also serves the purpose of separating standard functions from application-dependent functions. Most of the software will thereby be unaffected by adaption of the system to different exchanges. New standard functions can also be added to the system continuously.

Fig. 6
Example of interworking between different program levels



For full utilization of the advantages of the block structure the interfaces between the blocks must be clearly specified and standardized. The only permissible manner of exchanging information between the blocks is to use a set of approved "signals", which are normally programmed by means of macroinstructions. The signals are function-oriented, signal names such as "seizure", "send next digit" being used.

Fig. 7 shows the block diagram for the traffic-handling blocks which are similarly oriented as in the trunking diagram[1]. Each type of incoming trunk circuit is associated with a FIR block, each type of outgoing trunk circuit with a FUR block, etc. The FIR and FUR blocks therefore contain software for line signalling, while KM and KS blocks contain software for register signalling. The task of the signalling blocks is to translate different line and register signals into a standardized signal language which is used internally in the system. A new signalling system can thus be introduced merely by adding the appropriate signalling block. The other parts of the system will be unaffected.

The coordinator block (COR) performs a central function in the system by analysing the traffic situation based on information received from other blocks, defining the necessary steps to be taken and interworking with other blocks to order performance of this work. Since these analyses and coordinating functions are performed centrally, the other blocks can work in the ordinary way regardless of the type of traffic.

The COR function is a counterpart chiefly of the register function in a conventional system. COR contains a set of register records and one record is seized for each new call (fig. 4). In this record is stored all information required during the setting up of the connection (e. g. the called subscriber's number, link addresses to other records such as FIR, KM etc.) When the connection reaches the conversation phase, the register record is released (it is linked to other vacant register records in a chained list) and the FIR and FUR records are linked together.

The analysis block (AND) contains functions for analysis of received digits, for notification of outgoing route, charging etc.

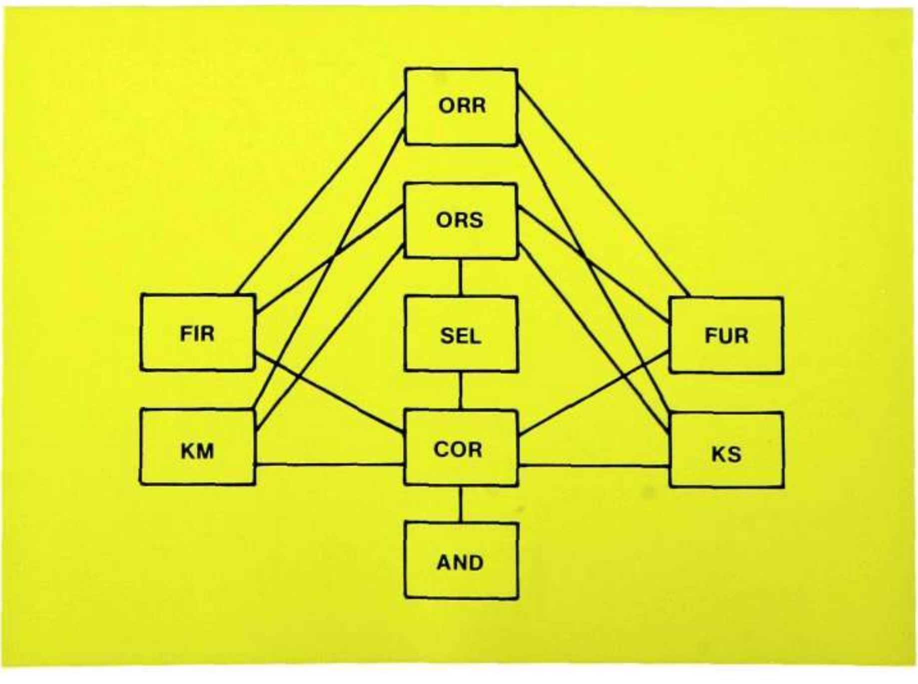


Fig. 7

Simplified diagram of traffic-handling software blocks

AND	Digital analysis
COR	Coordinator
FIR	Incoming line signalling
FUR	Outgoing line signalling
KM	Register signal reception
KS	Register signal transmission
ORR	Relay operation
ORS	Switch operation
SEL	Selection of devices and paths

The programs for transmission and receiving of signals between the signalling blocks and the central blocks are independent of the type of signalling block affected, and of their number. An example a call signal from an incoming line will be notified to COR in the same way irrespective of which signalling block delivers the message, i.e. irrespective of which type of line has signalled.

The central blocks are thus surrounded by a standard interface in order, as noted, to avoid the need for reprogramming every time a new signalling system is introduced. This interface has been achieved by means of standardized macroinstructions, which in some cases utilize computer instructions specially designed for this purpose. A brief description of the setting up of a connection with these blocks will be found in ref. 1.

The block diagram (fig. 7) shows only pure traffic-handling functions. The AKE 13 system also contains an extensive operation and maintenance system made up of blocks in the same way as described earlier. The signalling between these blocks and traffic-handling blocks also makes use of the same principles. For example, on any interesting event in a connection, COR sends a signal to the traffic recording block TRR, which records the event and can then sum up events in different ways and present result outputs in different forms.

The blocks mentioned in this section comprise the switching functions and the operation and maintenance functions associated with them. The system also has a number of application-independent blocks associated with the data processing system. This group is called the "operating system" (OS) and comprises the following types of functions:

— The job monitor which, with the aid of a job table, calls each index program at its specific time and interval. The job monitor also contains aids for measurement of execution time for individual programs and for measurement of the processor load.

— Input and output programs which are used as standard aids for input of operation and maintenance commands and for output of alarm and fault printouts, charging and measurement data. The programs are also used for output of total store content for reloading after serious faults.

— loading programs for loading of fixed programs and data in conjunction with cut-over, functional changes etc., and for loading of movable programs called as required by the corresponding function.

— program testing programs which comprise aids for fault tracing in and correction of programs during testing as well as operation.

— maintenance programs for tracing of faults in the data system and for automatic reconfiguration of the system when faulty units are to be taken out of service.

Multiprocessor interworking

The software for AKE 13 is independent of configuration, i. e. the number of processors in an exchange can be increased from one to eight without changing the content of the program store. Only certain data in the data stores need be modified to create a larger system. The programs are so designed, furthermore, that the traffic capacity per processor is practically independent of the number of processors.

The program store in all DPB's contains programs for all switching functions and each central processor, controlled by a job table in the data store, performs the functions relating to its special sections of the switching equipment. A processor performs, for example, independently the signalling functions for all incoming and outgoing lines connected to the corresponding part of the switching equipment. An incoming call on a line is detected by a signalling block in the corresponding DPB and is therafter processed by the same DPB as long as this is possible. A register record in the data store is seized and, if a free code receiver of the correct type exists within the switching equipment of the associated DPB the record of this code receiver in the data store is seized. Otherwise a code receiver record in another data store is seized by the DPB of the calling line and the digit reception program is initiated by a marking in a record. At the same time the code receiver is connected to the calling line. To avoid seizure of the same code receiver by several DPB simultaneously an interference protector (1 bit in every code receiver record) must be operated by the seizing processor. A special computer instruction has been introduced to allow for operation of this protective function without capacity loss.

The digit reception is carried out by the DPB which has the code receiver in question in its part of the switching equipment, and the digits are stored in the register record seized in the DPB of the incoming line. This DPB analyses each digit and seizes an outgoing line on the route selected through its analysis when a sufficient number of digits have been received. Since, on grounds of reliability, the routes are spread over more than one DPB, the selection of outgoing line is done in a randomly selected data store block. In this case as well, accordingly, the earlier described interference protection function must be used. The signalling on the outgoing line is now done by the processor in the data store of which the line has been seized. In the same way as for the code receiver, a code sender is selected either in the same DPB as the outgoing line or, if there is no free code sender available, a code sender is sought in another data processing block. After the code sender has been connected to the outgoing line, digit transmission is done by the processor in the data store of which the code sender has been seized. The latter collects the digits one by one in the register record in the data store of the incoming line. When the signalling has been completed, the processor containing the register record orders clearing of code receiver and code sender by markings in their respective records. The operation of switches is therafter done by the respective processors, initiated by the markings in the record. The incoming line is connected to the outgoing line, likewise by marking in the respective records of the switch vertical. Finally the records for incoming and outgoing lines are linked together by writing of the address of the outgoing line record into the incomning line record, and vice versa. At the same time the code receiver, code sender and register records are freed. The connection has now reached the conversation phase and the two lines are supervised by their respective processors.

Reliability aspects

The basis for reliable operational software is a low fault rate in all software functions. Through a well planned system organization, well developed design routines and various auxiliary systems for testing and maintenance of software, the necessary means exist for attainment of high reliability. There is nevertheless always a risk of software faults. To remedy this situation and to meet the reliability requirements, the following methods are used. Certain of the functions mentioned below are also of special value in the case of faults caused by wrong handling.

Failure detection

Throughout the system a consistency check is made at interworking points between software functions. Essential data fields are continuously scanned for the detection of deviations. The program handling is checked both by hardware and software functions in the system. Facilities for store protection, as also protection facilities for processor and priority level interference, are built into the hardware of the processor.

Fault dispersion

A strict block structure with well defined and standardized interfaces is used throughout the system. Standardized data structures with the smallest possible number of links between different data fields are used. In the case of serious faults in the period of run-in of a new program it is possible to return to the old program package by automatic system restart (see below). The same measure is used in the case of serious faults during the period of run-in of newly loaded exchange data.

Restart

Correction measures for individual calls or other functions are always initiated immediately on discovery of a fault. Automatic system restart preserving calls in conversation phase is effected on discovery of a serious fault. Manual restart with or without reloading from the back-up stores by means of simple commands can be done in the case of a total system breakdown.

The system has facilities for storage of the complete store contents in back-up stores, which facilitates reloading.

Fault localization

Standardized print-outs of available fault-describing data can be made at any time on discovery of a fault. Normally, however, a print-out takes place only when a predetermined fault level has been exceeded. The system contains an extensive test system which generates printout when predetermined conditions, defined in commands, have been fulfilled. At system restart the content is punched in predetermined data fields on paper tapes. Tracing of connections and signal and state recording functions are included in the system for analyses of the various phases of a connection. Print-out is initiated when predetermined conditions, defined in commands, have been fulfilled.

Correction of faults

The test system contains functions which facilitate the introduction of program corrections in the programmer's own language (source code) and automatic coordination takes place also on the introduction of a series of associated corrections. Coding technique, which does not allow a simple correction procedure, has been strictly avoided.

Test of commands

Apart from a consistency test of commands a test is made also that the input device — including tape recorders and tape readers — has permission to transmit the command in question. For console typewriters a key system has also been worked out with which the operator can indicate his authority.

Generation of exchange parameters during operation

Exchange parameters are generated by auxiliary programs which can be loaded and executed during operation. The daily administration of an exchange can therefore be performed through simple, easily handled commands.

Automatic parameter transmission on changes of function

On the introduction of a new program package the store layout is usually changed, especially if the change is combined with an extension of an exchange. To obtain a quicker loading procedure and to reduce manual operations, the existing exchange parameters are automatically converted to fit the new store layout. They are thereafter transferred to the newly loaded, separated half of the processor complex.

Software Handling

The introduction of data processing in telephony has led to entirely new aspects on production and handling of software. The new experiences are principally the large program volumes per exchange and the fact that software is serially produced for a large number of exchanges with considerable variations of function.

The blocks constitute the main parts in the system software. On the basis of functional requirements an indication is given primarily of which blocks are required for the exchange. In the case of new functional requirements which are not fulfilled by any of the existing blocks, a design frame is draw up for a new block and programming of this block and design of the corresponding hardware unit (normally a line relay set) are carried out. The blocks which especially may require new programming for new markets are the signalling blocks. The programming of these blocks has therefore been rationalized. An example of such rationalization is the introduction of standardized macroinstructions for measures occurring in most signalling blocks, for example "start time measurement" or "change state".

In the engineering of a telephone exchange it is, of course, desirable from the economic aspect that the programming work is reduced as far as possible. The greatest possible number of blocks, therefore, are made so as to be able to cover the greatest possible variation in the functional requirement. In this way existing software can be utilized to a very great extent. On the other hand it is too expensive to allow non-utilized parts of the software to take up unnecessary storage space in the exchange. In AKE 13, therefore, the possibility exists, in programming, of indicating which program sequences are necessary for fulfilment of different functional requirements. This is done by means of sets of questions in the program's source code. Answers to the questions are given in the form of parameters which are allotted different values in the engineering of the exchange. In the generation of the exchange software only such sequences as are required for the exchange are delievered automatically, whereas sequences which the sets of questions find irrelevant disappear. An example of a parameter of this type is the statement whether the exchange has one-way or two-way switching stages. Both the route selection function and several operation and maintenance functions are dependent on this information. Instead of introducing double block variants for all these functions the same variant can contain program sequences for both cases without cost to the plant. Through this method the quantity of block variants can be kept low without thereby affecting the plant cost.

The choice of suitable sequences from existing programs for adaptation to a specific exchange is done by the programming system APS. This system, which utilizes computers of type IBM 370, contains a large number of facilities for handling of the software both in conjunction with design and testing and with filing and generation of loading packages for AKE exchanges.

All existing blocks for the AKE 13 system are filed in a library file. When new blocks have been programmed and tested in a design file, they are transferred to the library file (fig. 8). In conjunction with the engineering of a given exchange a project file is built up by transfer of suitable blocks from the library file. In the project file all programs and data are collected which are to be allocated to a given exchange. In conjunction with the transfer to this file an indication is also given, through the aforementioned parameters, as to which part of the standard blocks is required for the exchange. These data, as well as start data for the exchange records, are fed into the system in the form of so-called model documents. The project file is used also as aid for system testing of newly designed functions in a suitable environment. No block may be stored in the library file until it has been tested in conjunction with some project.

As last step before the output from the project file an automatic store layout program for programs and data (allocation) is run through. The loading information, which is thereafter delivered on magnetic or punched tape from the IBM computer, is finally loaded into LM Ericsson's AKE test plant for a final test prior to the delivery to the site of installation.

The project files normally contain solely the application software, while the operating system (OS) is fed into the APZ computer of the test plant from a standard file where it is stored in allocated form.

The faults discovered in programs and data during the testing of the delivery package in the test plant must be immediately correctable if the test is to be able to continue. The turnaround time and the costs of a new output from the project file would have a negative effect on the delivery time. The operating system has therefore been equipped with correction aids with which, through a single command, changed sequences can be inserted in the programs or at a free area which the system searches for. Only when an alteration has been finally tested in the test plant can it be entered in the project

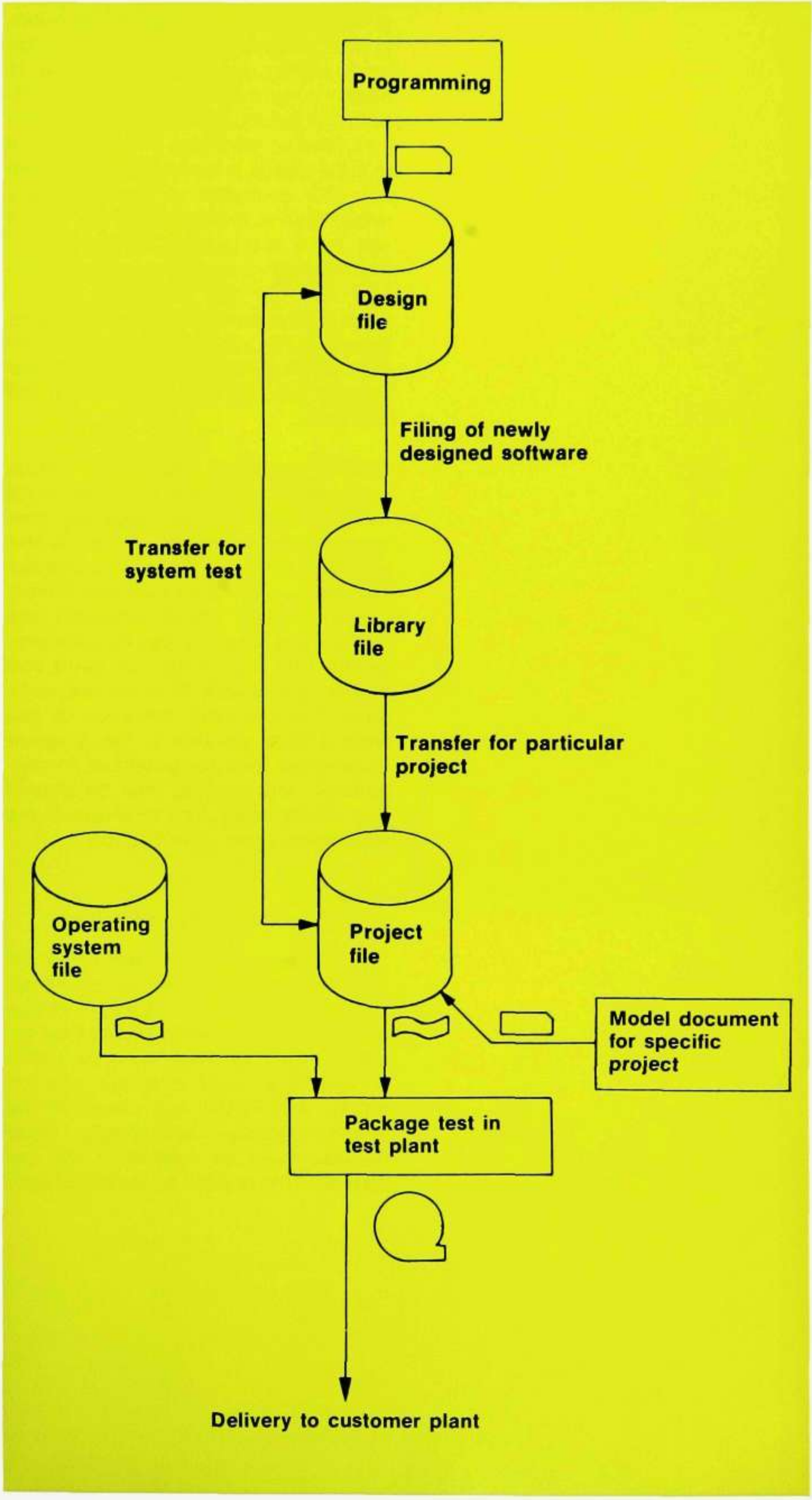


Fig. 8
Software handling

or library file. (As regards the introduction of entirely new or changed functions during operation, reference is made to the description of the procedure for functional changes in ref. 1.) The loading package to be delivered to the excange is therefore fed out from the APZ computer of the test plant rather than from the project file. In this way there is a greater assurance that the delivery is complete and serviceable and that the necessary corrections have been made. Output can also take place in a computer-oriented format, which yields the quickest possible loading into the APZ computer of the exchange.

Certain programs, chiefly for operation and maintenance functions, have so low a frequency of usage that they need not be constantly stored in the program store of the APZ computer but, when required, can be read in from magnetic tape. These programs are delivered in the same way as other programs after test in the test plant and output in loadable form on magnetic tape. The programs, however, do not have a fixed position in the program store of the APZ computer but, in conjunction with loading, can be placed in a momentarily free field which the loading program searches for.

Loading of exchange data

The loading package delivered to the exchange has been furnished in advance with permanent data such as size of exchange etc., while records for variable exchange data such as traffic routing data, route data etc. are left empty. After input and check of the loading package, accordingly, these records must be loaded in the exchange. This is done by means of special exchange data commands which, with the aid of the IO program of the exchange, load the necessary data and from them build up the necessary tables for, for example, digit analysis. This type of data must, of course, be changeable also after cut-over of the exchange, for example in conjunction with the introduction of new circuits, routes, traffic destinations etc. The exchange data commands have therefore been given such a form that they can be used during operation without risk of interruption of traffic.

On safety grounds, after every major change of exchange data a complete output of the store content is arranged on magnetic tape, in a form which allows rapid reloading. This safety measure is necessary in order to be able to restore the store content in the event of such severe faults that the content has been destroyed.

Summary

The software system in AKE 13 has been built up around the block structure, which is aimed at simple and convenient production of all software, and with satisfactory operating properties.

Within the blocks a strict standardization of the software and data organization has been arranged, which has resulted in a system that is easily adaptable to various market requirements.

The operation reliability is attained through, among other measures, a well planned system organization, well developed design routines, various auxiliary systems for testing of software maintenance, and well developed fault tracing and restart functions.

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A New Generation of Line Systems for Small-core and Normal Coaxial Cables

Ove Källgren

In this article the author presents a new generation of line systems for coaxial cables and describes the first member of the family, ZAX 2700-4.

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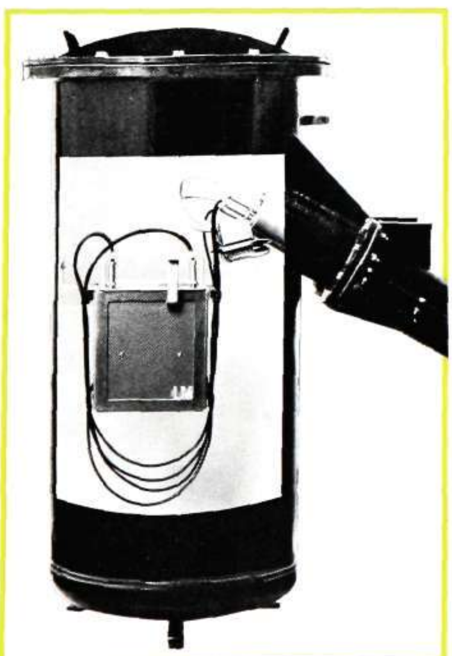
Fig. 1
"X-ray picture" of a repeater housing with a line repeater. (The other line repeaters are placed one behind the other into the picture.)



Presentation of the line system family

The following systems will be included in the new family of line systems:

ZAX 960, 4 MHz for small-core coaxial cables

ZAX 2700, 12 MHz for small-core and normal coaxial cables

ZAX 10800, 60 MHz for normal coaxial cables

The design of these systems will be very similar. Consequently the system characteristics for ZAX 2700-4, which are described in this article, will in the main also apply for the other members.

Design considerations

L M Ericsson now introduce a new generation of transistorized line systems against a background of 10 years' experience of such equipment. This experience has enabled a big step to be taken towards an optimum line system. It has now become possible to dispense with many of the facilities that were previously included as a precautionary measure, for example measuring facilities, alarm functions, mechanical components etc., at the same time that the increased confidence in active components has made possible the use of more complex electrical circuits.

The main requirement for a system is that it should be reliable. When a new equipment is designed it is easy to yield to the temptation to include a number of technical refinements. However, equipment capable of good performance and having technically interesting design solutions is not worth much if it does not at the same time have the high degree of reliability that the large number of channels calls for.

The quality of the components used in the line amplifiers, which are buried in the ground and which are connected in cascade in the transmission path, is of the utmost importance. As in earlier systems, the components used in the line amplifiers are specially classified. Mechanical components, such as relays or mechanical devices for adjusting the gain, have been avoided entirely.

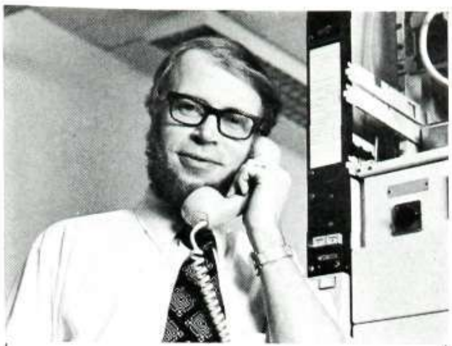
A 12 MHz system for small-core coaxial cable

Since the first generation of line systems was introduced, the economic development has gone towards an increase in the cable cost while it has been possible to keep down the prices of the electronic equipment. As a result the use of small-core coaxial cable is economically justified even for the 12 MHz system, and the demand for improved performance made on the new equipment is to a great extent a result of the increased use of this type of cable.

The attenuation of small-core coaxial cable is just over twice as high as that of the normal coaxial cable, which means that a larger number of repeaters must be installed along the cable. For the 12 MHz system the distance between repeaters is 2 km for small-core and 4.65 km for normal coaxial cable.

The larger number of repeaters required for small-core cable as compared with normal coaxial cable naturally means that the noise per unit length is higher, that the number of regulators is greater and that the distance between power feeding stations is smaller. Through the use of improved circuit solutions the new line amplifier has much lower noise, a typical value being 1.5 pW/km for small-core coaxial cables and less than 1 pW/km for normal coaxial cables in accordance with CCITT's definition.

In order to increase the length of the power feeding sections, the voltage per repeater has been reduced to 10 V and at the same time the maximum feeding voltage has been increased to approxi-



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Telefonaktiebolaget L M Ericsson, Long Distance Division

mately 1000 V. This means that in a 12 MHz system 30 dependent repeaters can be fed from each power feeding station, or in other words, the distance between power feeding stations can be as much as 120 km for small-core coaxial cables and no less than 280 km (1 homogeneous section in CCITT's hypothetical reference circuit) for normal coaxial cables, see fig. 2. The possibility of using such long power feeding sections is very important from an economic point of view. It often avoids the cost of an extra power feeding station and also the problem that might sometimes arise when the line passes through a very sparsely inhabited area of providing a suitable power supply.

A large number of regulated repeaters in cascade has meant more stringent requirements for the envelope gain, that is, the undesirable characteristic of the regulators of amplifying a low frequency variation in the pilot level. An improvement has been achieved by compensating the transfer function of the thermistor in the preceding d.c. stage. This has not only resulted in a lower envelope gain but has also reduced the residual error (the deviation of the pilot from the nominal value at the output of the amplifier) to approximately 0.15 dB.

Careful studies of the advantages and disadvantages of temperature control and other forms of gain adjustment have been carried out, but the disadvantages have proved to be appreciably greater than the advantages. Hence the principle of pilot regulation using a thermistor as the regulation element has been retained.

As a rule, every fourth repeater will be regulated in all systems.

Regulation memory

Several Telecommunications Administrations have requested that the regulation should be equipped with some form of memory, so that in the case of a sudden interruption of the pilot the regulation will remain in the state that it was in just before the pilot interruption occurred. Actually this form of memory is unnecessary if a new pilot is injected each time the composition of the transmitted frequency band is changed.

It is true that some Administrations use very long pilot sections in order to avoid the addition of residual errors from a number of short sections, but as the residual error, as explained above, is only 0.15 dB, a number of pilot sections can be connected in cascade without the level error becoming unduly large. Despite these arguments against the inclusion of a memory in the regulation function, the wishes of the customers have been complied with and the regulated line repeaters have been provided with a memory in the form of an analogue-digital converter, which takes over control of the thermistor if the pilot is interrupted. The introduction of the memory is actually a departure from the principle of increasing the reliability through simplification, but no fault that might occur in the memory could cause an interruption of the traffic. The only result of such a fault will be that if the pilot fails the gain of the repeater in question will change by a few dB.

3-pilot regulation

Normally only the main regulating pilot 12435 kHz is used, but on long routes, for example when a power feeding intermediate repeater has to be resorted to, a further two regulating pilots, 308 kHz and 4287 kHz, can be used for regulation in the line terminal equipment.

Fault location

Faults on the line can be divided up into cable faults and repeater faults. In many countries where excavators are used, cable faults occur about ten times more often than repeater faults. Faults in the cable are located with the aid of the power feeding. If the cable is short-circuited, the constant current is still fed out on to the line, and hence it is only necessary to read off the voltage fed out. With a knowledge of the voltage drop per repeater section it is then an easy matter to calculate where the short circuit is located. If, on the other hand, the inner and outer conductors are not in contact with each other at the place where the cable is damaged, a constant voltage of 600 V

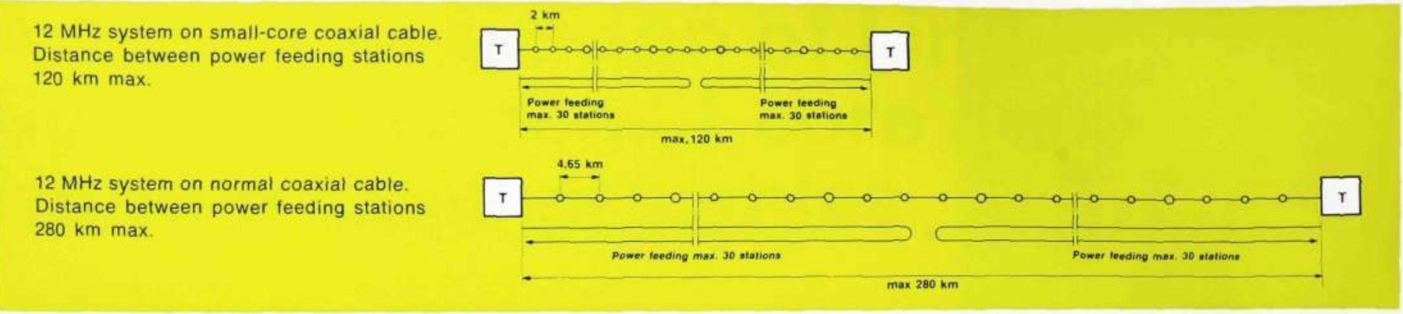


Fig. 2

By reducing the voltage per repeater to 10 V and increasing the voltage fed out to 1000 V, the length of the power feeding sections has been increased considerably

is applied with the same polarity as the normal power feeding voltage. Each two-way repeater contains a resistor, in shunt between the two inner conductors. The fault is located by reading off the sum current on an instrument that is calibrated directly in terms of the number of repeater stations up to the fault.

For locating faulty repeaters, each repeater station on the route has a built-in fault location oscillator having a specific frequency. Faulty repeaters are located by measuring the fault location frequencies at the receive terminal. In the 12 MHz system these frequencies lie between 12750 and 13002 MHz with 4 kHz spacing. This gives 64 frequencies, which is sufficient for the maximum number of repeater stations that can be set up between two power feeding stations. This also applies in the case of the 4 MHz systems, in which the maximum number of frequencies is 56 at 2 kHz intervals (4500—4610 kHz).

12 MHz universal line amplifier

In the 12 MHz system the same type of line amplifier is used for both normal and small-core coaxial cables. The only thing that has to be done is to select the required gain with the aid of a strap (2 km small-core coaxial cable corresponds very nearly to 4.5 km normal coaxial cable, while 4.65 km requires approximately 1.4 dB additional gain). This provides an interesting possibility of mixing the two cable types. If, for example, small-core coaxial cable is normally used for a particular route, but when planning it is found that at some place it is difficult to position an intermediate repeater station, it is then possible to resort to normal coaxial cable and thereby leave out one station.

Conversion

The fact that the different systems are very similar in their design and construction simplifies the conversion from a lower capacity system to a higher one. This is particularly so in the case of the conversion from a 4 MHz system to a 12 MHz system. At the terminal stations the whole rack including the power feeding unit can then be retained, and it is only necessary to change a few units, for example the pilot oscillator and pilot stop filter and the stop filter for the fault location frequencies. Quite naturally the repeaters at the intermediate repeater stations must be changed.

When commissioning a 4 MHz system it can in many cases be advantageous to prepare for a later conversion by installing empty through-connected repeater housings in the transmission path at the same time. A conversion can then be carried out very easily, and the time that the line is out of service will be a minimum.

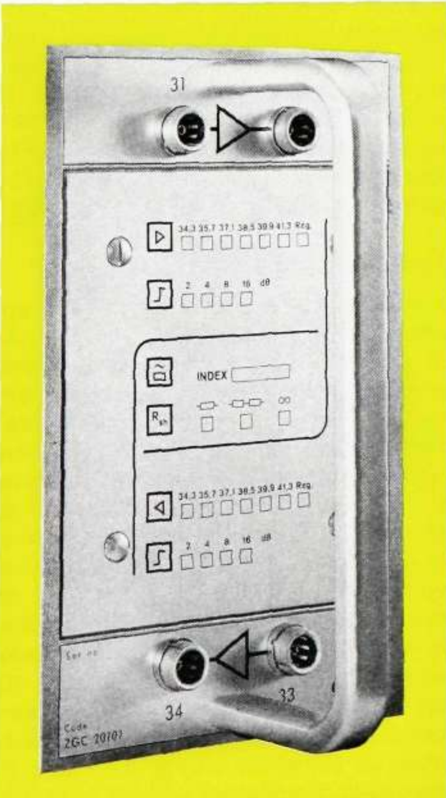
Repeater equipment

The line repeaters, which are two-way, are available in two different designs, regulated and unregulated. The regulated repeater contains a pilot receiver and a thermistor and can regulate ± 4 dB. The gain of the unregulated repeater can be set to any one of six positions in 1.4 dB steps. The terminal repeater has the same mechanical construction as the line repeaters, but unlike these it has different functions in the two directions of transmission. The repeater in the send direction is unregulated and can be set to the desired gain while the repeater in the receive direction is regulated. Moreover, the terminal repeater is designed for local feeding from 12 V and has outputs for a pilot alarm and a recorder.

Line building-out networks can be installed in all the different types of repeaters. In the 12 MHz system the maximum attenuation of these networks is 30 dB in steps of 2 dB. A fault location oscillator has been built in in each line repeater. This has been done in order to make the systems included in the same cable as independent of each other as possible. Test points are not provided. A special measuring adapter is used when measuring input or output levels. A plate, fig. 3, is provided on the upper side of the line repeater for recording the gain setting and selected line building-out for each direction of transmission and also the frequency of the fault location oscillator etc.

Fig. 3

The top cover of the line repeater also serves as a designation plate on which the selected settings can be recorded



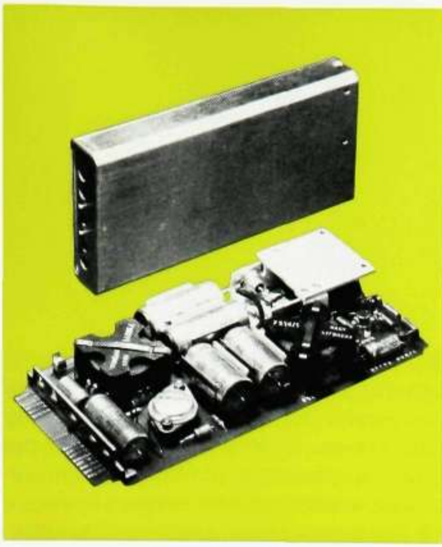
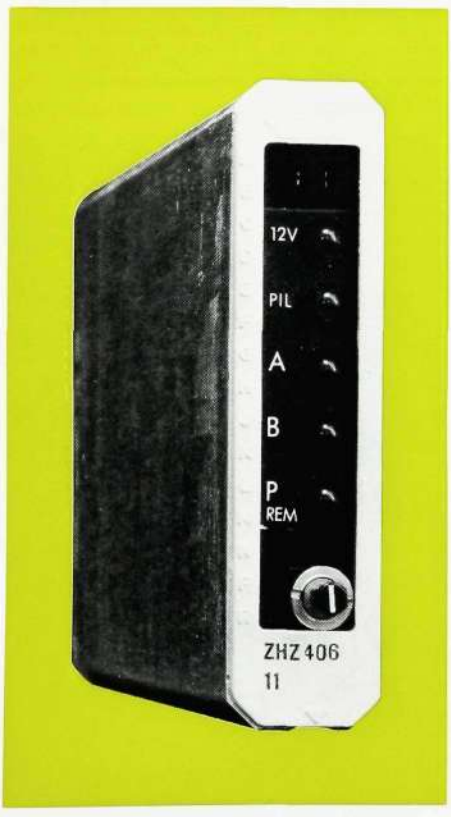


Fig. 4

This compact DC/DC converter provides the power for the terminal equipment for one system. It has an output power of 25 W at 12 V

Fig. 5

The A and B alarms for one system are brought together and indicated on the front of the alarm unit. The front of the unit also contains the reminder indication switch etc.



Adapters containing high-pass and low-pass filters are provided for feeding in and looping the remote power feeding current. The looping adapter is placed immediately above the line repeater and the power feeding adapter is mounted in the power feeding shelf in the terminal rack.

Terminal equipment

The terminal rack, which accommodates the equipment for three systems, is constructed in accordance with L M Ericsson's normal method of construction, M4, with certain simplifications. One common principle that has been applied in the design of the terminal rack has been to make the different systems entirely independent of each other. Thus any faults occurring in one system cannot cause traffic disturbances in another system. The power feeding has been arranged so that each system has its own converter for converting the battery voltage to 12 V, which is the bay supply voltage, see fig. 4. Furthermore each system has its own alarm unit, see fig. 5, to which all the alarms in the system are taken and in which the type of alarm, A (urgent) or B (non-urgent), or P (the reminder indication) is indicated. The corresponding lamp, A, B or P, also lights at the top of the rack.

Test points and alarm indicators (diode lamps) are normally placed directly on the front of the unit in question. However, alarms from the 12 V converter and pilot alarms from the terminal repeater are indicated in the alarm unit, mentioned above.

Thanks to the fact that the terminal repeater has been constructed so that it takes up such a small space, it has been possible to place the cable entry glands directly in the terminal rack, see fig. 6, instead of in a special rack. Apart from the cable entry gland, the upper part of the rack includes a fuse strip containing the fuses for the pairs in the cable. The power feeding adapters are equipped beneath this part of the rack. These adapters are used to combine the constant direct current from the remote power feeding unit with the line frequency band for feeding out on to the cable. The remote power feeding units, which are placed immediately under the adapters, deliver a constant current of 125 mA for the 12 MHz system and 100 mA for the 4 MHz system. The voltage varies between 20 V and 1040 V depending on the length of the route. The current and voltage fed out can be read off on separate measuring instruments.

In order to prevent persons being injured in the case of a cable break, the remote power feeding unit has been equipped with a high resistance centre-point earth. The highest current that can be fed out between the inner conductor of the coaxial tube and earth is approximately 2 mA and is quite harmless. The current that can be taken out between the two inner conductors is also not dangerous as it is not until the current exceeds 250—300 mA that persons can be seriously injured.

If a cable should be cut through, the outer conductor is usually drawn over the inner conductor so that it is not possible to come in contact with the inner conductor.

As an additional safety measure the remote power feeding unit has been designed so that its voltage falls to zero if the output power feeding current is cut off, and so that the power feeding must be restarted manually. However, this extra safety measure can be disconnected if desired, in which case the unit provides an idling voltage of 1160 V. The remote power feeding unit also contains equipment for locating cable breaks.

The repeater shelf is under the remote power feeding unit and contains the terminal repeaters. These are fed with 12 V from the line terminating shelf in which the regulation pilot is generated and stopped respectively and in which equalization is also provided for both the station cable attenuation and the residual error of the line system.

As shown on the block diagram of fig. 7, the line terminating shelf has two entirely similar inputs and outputs in the direction towards the LGDF (line group distribution frame), both in the send and the receive direction. One of

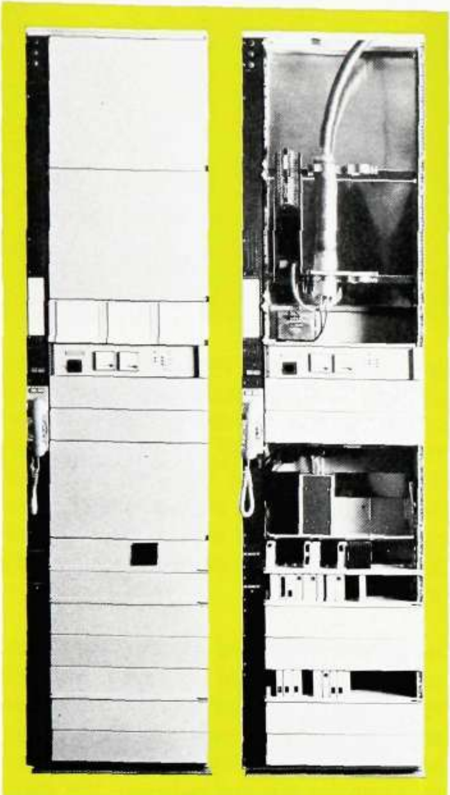


Fig. 6

The terminal rack equipped for one system. (The right-hand picture shows the same rack with the cover plates removed)

Fig. 7

The terminal equipment for one system. (The pilot regulation shelf is necessary only for long routes.) The *repeater has a built-in fault* location oscillator. It can also be equipped with line building-out networks

these is permanently connected in while the other is available for, for example, making measurements, which can be carried out quite easily while the system is in operation if intergroup pilots are used.

Pilot regulation shelves (one per system) are mounted at the bottom of the rack when required. These contain oscillators, regulators and stop filters for the auxiliary pilots 306 kHz and 4287 kHz.

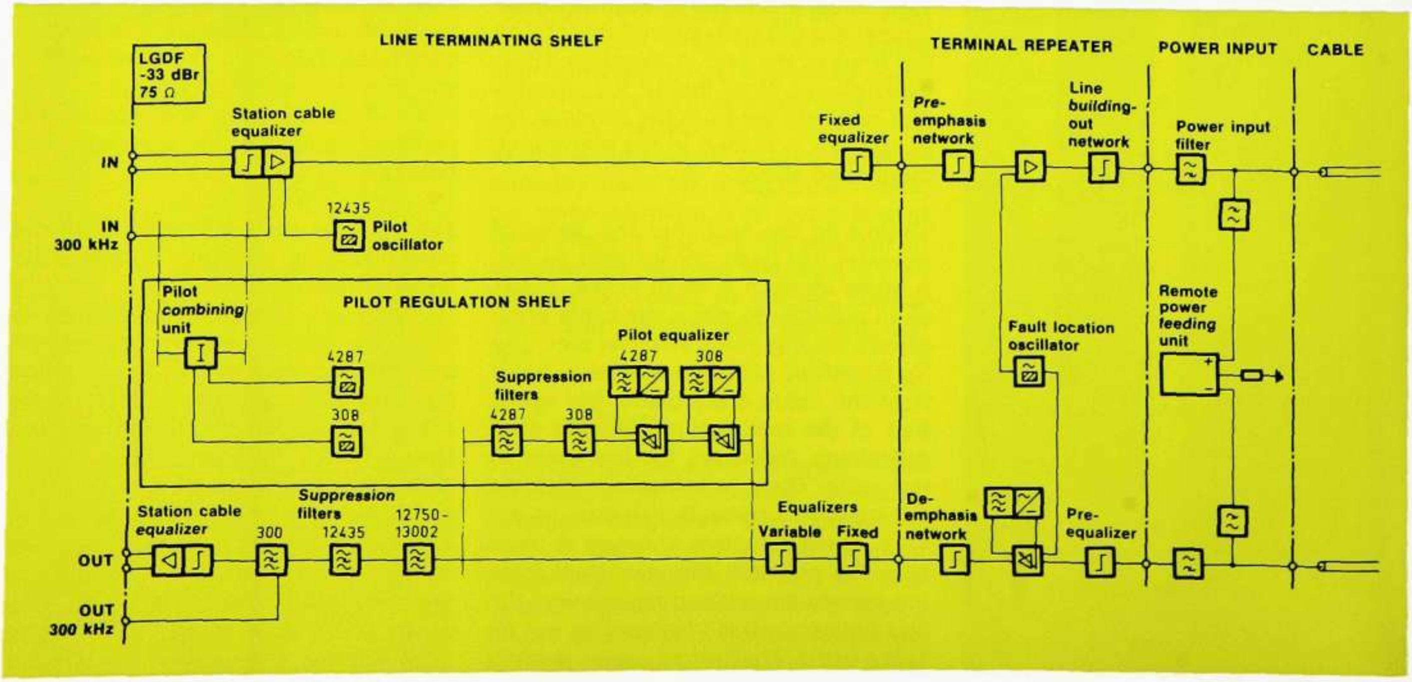
The left-hand rack side contains alarm lamps, a telephone set for a speaker circuit, a magnetic fast acting fuse for each system and one for the speaker circuit shelf. This shelf is placed immediately under the repeater shelf and has space for two speaker circuits. The speaker circuit is arranged as a four-wire circuit over loaded pairs in the centre of the coaxial cable. Amplification is provided at the terminal repeaters. The dimensions and loading of the pairs should be chosen so that the attenuation at 800 Hz between amplifier points does not exceed 40 dB. By using two loaded 1 mm pairs the speaker circuit for the intermediate repeater stations can be taken a distance of 280 km without amplification. With 0.6 mm pairs the corresponding distance is 120 km.

New repeater housing for dependent repeater stations

The new generation of equipment also includes a new housing, ZDD 514, for dependent repeater stations. This has the two cable entry glands placed sloping in relation to the body of the housing, whereby the cable is made directly accessible for making measurements and for fault location (see fig. 1). The main cable is jointed directly to these entry glands using the same type of straight joint that is used for other joints on the cable. Thus there is no stub cable with this type of housing.

The signal path through the rack is as follows: The signal comes in from the LGDF (line group distribution frame) via a station cable. The frequency-dependent attenuation of this cable is compensated in the combined station cable equalizer — combining unit. The *combining part of this unit* is used for feeding in the main regulation pilot *and when applicable the auxiliary pilots and a* frequency comparison pilot. Fixed equalization *(pre-equalization)* can then be included if necessary before the signal is taken to the send side of the terminal repeater where the pre-emphasis is carried out. Before the signal goes out on the cable it passes through an adapter containing a separation filter, with the aid of which the constant current from *the remote power feeding unit is fed in on the signal path.* In the receive direction the signal passes through *the other part of the adapter and into the receive* side of the terminal repeater where regulation is carried out with the aid of the main regulating pilot. The sensitivity of the pilot alarm can also be selected in the repeater. The indicator (diode lamp) for the pilot alarm is placed on the alarm unit on the line terminating shelf. De-emphasis takes place at the output of the terminal repeater.

In the line terminating shelf the signal is first equalized, either *with the aid of only a fixed* equalizer or in combination with a cosine equalizer. *In cases where 3-pilot regulation is* used, this is followed by automatic equalization in the regulators controlled by the auxiliary regulating pilots. The suppression filters stop in turn the auxiliary *regulation pilots, the fault location pilots, the* main regulating pilot and finally the frequency comparison pilot before the signal reaches the station cable equalizer — separation unit and goes on to the LGDF.



The sealing of the previous housing, ZDD 512, has proved to be very good, and consequently this type of sealing, a toroidal ring seal, has been retained. The housing can be pressurised via the cable through a pneumatic resistance. Alternatively the gas pressure in the cable can be bridged over to the following cable section.

Ring seals are also used in the newly designed cable entry glands, among other things for sealing the coaxial connectors. Only the pairs in the cable that are taken into the housing are embedded in the cable entry gland.

The line repeaters are placed in a metal frame and are connected to the cable entry gland by means of flexible cables. In this way it has been possible to avoid the complicated terminal panel which was used in the earlier housing. There is now only a small angle bracket with contacts for the speaker circuit and for through-connection of the pairs in the cable. The metal frame that holds the repeaters can quite easily be insulated from the housing if the arrangement known as the semi-floating system is chosen. All metal parts in the housing are then earthed automatically when the cover of the housing is opened. However, as long as there is no powerful hum induction there is no reason why the system should not be permanently earthed.

The type of housing described above has been developed in consultation with the Swedish Telecommunications Administration and has now been accepted as the standard in Sweden. It is to be used, for example, in conjunction with the extension of the Swedish 60 MHz network and can be used together with repeaters supplied by different manufacturers. When the housing is used for L M Ericsson's equipment it accommodates three systems. It is then unnecessary to provide any thermal insulation under the lid of the housing, even if the lid is above ground.

Technical data for ZAX 2700-4

Cable type	Normal coax. (2.6/9.5 mm)	Small-core coax. (1.2/4.4 mm)
Frequency range	300—13000 kHz	300—13000 kHz
No. of channels	2700	2700
Nominal levels at the LGDF. Send/rec.	—33/—33 dBr	—33/—33 dBr
Impedance, input and output	75 Ω unbal.	75 Ω unbal.
Gain per intermediate repeater at the pilot frequency 12435 kHz	38.5 dB	37.1 dB
Repeater spacing	4.65 km approx.	2 km
Typical value of weighted noise per channel at the zero level point for a loaded system (—15 dBm0/channel)	< 1 pW/km	1.5 pW/km
Near-end crosstalk attenuation per station within and between systems	≥ 93 dB	≥ 93 dB
Main line regulating pilot	12435 kHz	12435 kHz
Auxiliary regulating pilots	308 kHz, 4287 kHz	308 kHz, 4287 kHz
Pilot level	—10 dBm0	—10 dBm0
Regulation range per regulated repeater at 12435 kHz	±4 dB	±4 dB
Residual error at 12435 kHz	≤ ±0.2 dB	≤ ±0.2 dB
Frequency comparison pilot	300 kHz	300 kHz
Fault location frequencies	12750—13002 kHz	12750—13002 kHz
Remote power feeding	series, d.c.	series, d.c.
Maximum number of dependent repeater stations per power feeding unit	30	30
Max. distance between power feeding stations	280 km	120 km
Feeding current	125 mA	125 mA
Feeding voltage, max.	950 V	1040 V

References

1. Englund, N.-G.: *Coaxial Cable Systems, Operational Experience and Future Prospects.* Ericsson Rev. *51* (1974): 1, pp. 13—20.
2. Breuer, H.-J.: *Line Amplifier ZGC 201 for 12 MHz Systems.* Eriksson Rev. *51* (1974): 2, pp. 54—60.

Line Amplifier ZGC 201 for 12 MHz Systems

Hans-Jürgen Breuer

Line amplifier ZGC 201 for 12 MHz systems on small core coaxial cables belongs to a new generation of coaxial cable systems, ZAX 2700-4. The design is based on almost ten years' experience of transistorized line systems, but it also includes many new ideas, particularly as regards the circuit engineering. Additional improvements in the noise characteristics have been achieved. The mechanical design is extremely simple. Both as regards the components and the degree of reliability the requirements set for the ZGC 201 amplifier are as stringent as those set for earlier generations [1, 2].

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Line amplifier ZGC 201, shown in fig. 1, functions as a complete dependent repeater for one system. Thus it consists of:

amplifier equipment for both directions of transmission

line building-out networks for increasing the cable attenuation by a maximum of 30 dB

fault location equipment.

Two variants of the amplifier are available:

Unregulated, with a gain that can be switched to any one of six positions between 34.4 dB and 41.3 dB, at a frequency of 12435 kHz, in steps of 1.4 dB. These positions correspond to the following cable lengths for:

small-core coaxial cable: 1.9—2.3 km

normal coaxial cable: 4.2—5.0 km

Regulated, with a fixed output level for the line frequency band, which is obtained by regulating to give a predetermined pilot level. In this way the amplifier compensates input variations within 8 dB at the pilot frequency, by a frequency dependent gain corresponding to the attenuation characteristic of the coaxial cable. If the pilot fails, the gain to which the amplifier is set is maintained to within 0.5 dB by a digital memory.

The line amplifier is contained in a die-cast aluminium case.

Fig. 1
Line amplifier ZGC 201.
(In the lower picture the covers have been removed)

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Electrical design

The block diagram of the line amplifier is shown in fig. 2. The diagram includes only the equipment for one direction of transmission.

A separation filter connected to the input and output of the amplifier is used to separate and combine the signals of the line frequency band and the power feeding current of 125 mA d.c.

The signals of the line frequency band first pass through a pre-equalizer, which for noise reasons equalizes only the low frequency part of the band. The amplifier that follows provides the final equalization.

In the regulated variant of the line amplifier the pilot receiver checks the output level and controls the thermistor, which adjusts the gain by changing the feedback.

The power feeding paths for the two directions of transmission are electrically separate and no coupling takes place between them inside the line amplifier. In this way a very high crosstalk attenuation is obtained between the two directions of transmission with a small number of components. As both the power feeding paths have the high potential of the inner conductors of the coaxial pairs, this method of connection results in the lowest possible number of high voltage capacitors and other sensitive components. The only connection between the two directions of transmission is the connection over which the fault location signal is transmitted to the opposite direction. The fault location oscillator is driven from the power equipment in one or the other of the transmission directions.

The driving voltage of 10 V required by the unregulated line amplifier is obtained from a power zener diode, whereas the voltages for the amplifier and pilot receiver in the regulated line amplifier are obtained across two such zener diodes connected in series.

Fig. 2

Block diagram of the line amplifier. One direction of transmission, A—B

A	**Amplifier**
PE	**Pre-equaliser**
PR	**Pilot receiver**
LBO	**Line building-out network**
FO	**Fault location oscillator**
DT	**Overvoltage protection**

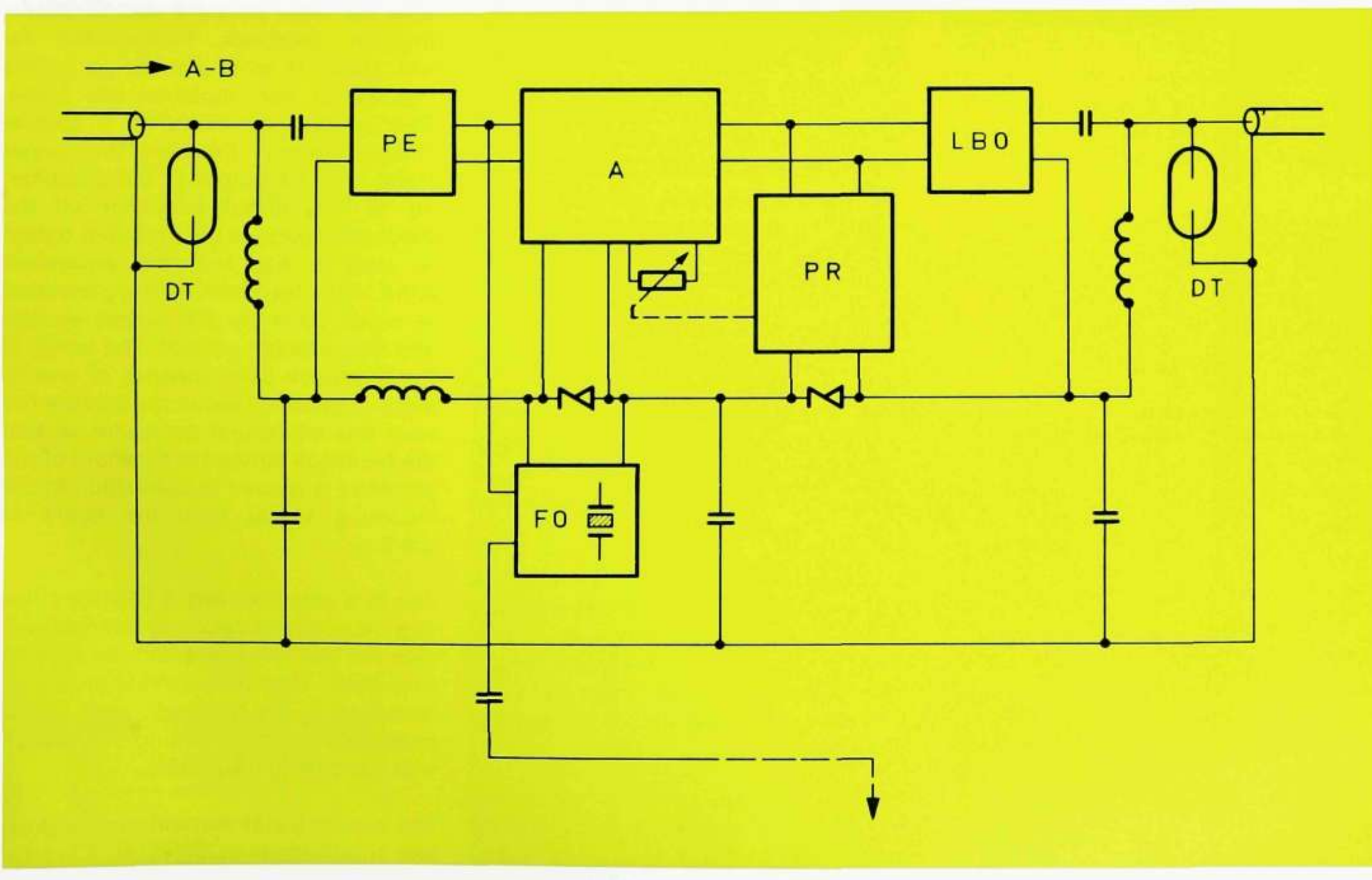
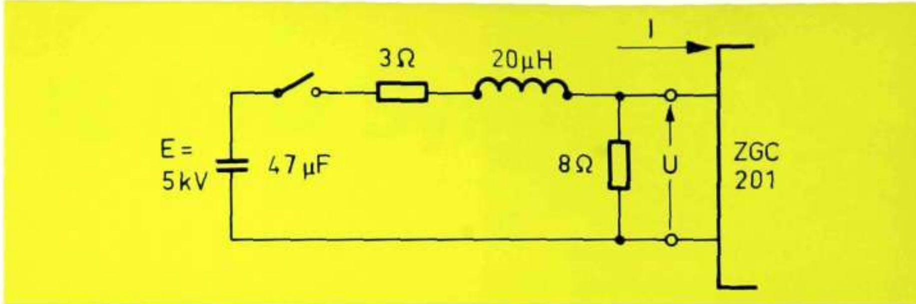


Fig. 3

Overvoltage test of the amplifier using a high voltage pulse generator



The overvoltage protection for the line amplifier consists of built-in gas-type arresters having a 1400 V static striking voltage, supplemented by additional protection. A higher dynamic striking voltage can occur because of the front slope of the overvoltage. The line amplifiers are therefore tested with 3000 V between the inner conductor of the connectors and earth. This provides a good margin for the type of arrester used, even for front slopes steeper than are normally encountered with lightning strokes. The amplifiers are also type tested using a high voltage pulse generator, see fig. 3.

For this surge test the front slope is the same as that used in the test proposed within CCITT for transistorized line amplifiers[3]. Moreover, when the gas-type arrester strikes, the current load on the amplifier connectors and internal connections is several times greater than in the case of the CCITT test, see fig. 4.

The amplifier

In addition to compensating for the attenuation of the preceding cable section, the amplifier must provide the terminating impedances for the cable sections at its input and output. The amplifier is a three stage amplifier with feedback and consists of an active part, a feedback network with a regulation network and special input and output circuits for providing the required terminating impedances, see fig. 6.

The active part of the amplifier consists mainly of a thick film hybrid circuit. It contains the semiconductors (transistors and protection diodes), capacitors and resistors in the signal path and is enclosed in a sealed capsule.

A hybrid circuit is used in order to achieve a high component density and short electrical paths. This makes possible a high degree of feedback, which in its turn provides accurate equalization and high attenuation of intermodulation products.

The output stage contains two power transistors connected in parallel. The power loss in the output stage is approximately 0.9 W, which includes 0.4 W in each of the two power transistors. These are mounted directly on the hybrid substrate as chips. The substrate in its turn is placed on a copper heat sink and consequently the temperature of the junction during operation rarely reaches + 100° C. A low junction temperature is advantageous as regards reliability and attenuation of intermodulation products.

Apart from the hybrid circuit, the active part includes another transistor, T (fig. 6). This checks the d.c. in the output stage and, via a separate regulation loop, holds the operating point of the stage constant. This transistor is placed outside the heated hybrid, which gives the operating point of the output stage a high thermal stability at the cost of only a small part of the driving voltage.

Frequency-dependent output circuit

The signal from the output stage must reach the output of the line amplifier, and thus the following cable section, with the least possible loss of power through feedback. Furthermore the line amplifier must provide an output impedance that matches the cable. This is done by including a special "output circuit" between the output stage and the output of the amplifier, fig. 5. This circuit branches off the feedback signal at the amplifier output in such a way that the equivalent e.m.f. in the feedback path is generated in equal parts by the output voltage and the outgoing current. The whole of the feedback path consists of one or more attenuation networks that are fed from this equivalent generator so that the feedback voltage at the input of the amplifier is placed in opposition to the incoming signal from the cable at point s.

The line amplifier has a relatively low degree of amplification at low frequencies but this increases with increasing frequency. This corresponds to low attenuation in the feedback path at low frequencies and increasing attenuation with increasing frequency.

The conventional method of designing line amplifiers is to allow the e.m.f. for

Fig. 4.

Surge test of the amplifier.
Time sequence for the voltage U and the current I

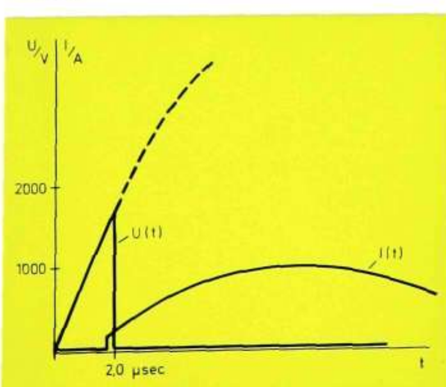
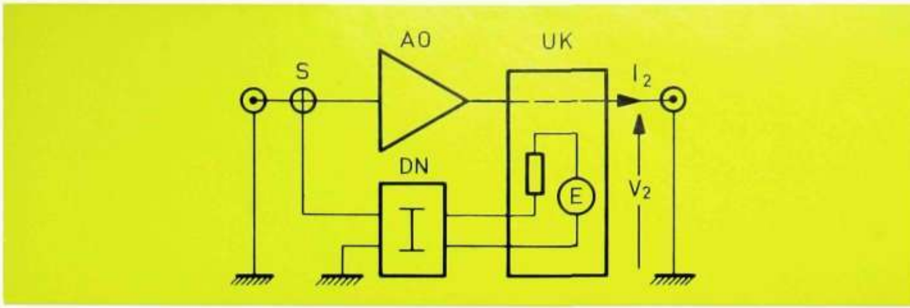


Fig. 5

Equivalent diagram of the amplifier

AO Active part
UK Output circuit
E Equivalent generator
DN Attenuation network
S Summing point



the feedback path to be generated in a non-frequency dependent output circuit, with normally a winding on the output transformer and a resistor for sensing the output voltage and output current respectively. In this way an e.m.f. is obtained for the feedback path that is constant over the whole of the signal frequency band, and which has a value that is determined by the lowest gain obtained at low frequency. This means that an unnecessary amount of signal power is branched off to the feedback path at the higher frequencies, which later must be dissipated in a following frequency dependent network in order to obtain the necessary attenuation.

In the new amplifier an output circuit is used that contains reactive and thus frequency dependent impedances, Z_1 and Z_2 (fig. 6). By this means the e.m.f. in the feedback path is given a value that becomes less with increasing gain at higher frequencies. Consequently, with increasing frequency the amount of power branched off to the feedback path becomes successively less and an ever increasing part of the limited power from the output transistor can be fed to the next cable section. The intermodulation requirements for an amplifier are most difficult to satisfy at high frequencies, and consequently this saving of power is of great value in very wideband systems. By selecting Z_1 and Z_2 as dual impedances, the output impedance of the amplifier is made independent of the frequency. Moreover, the impedance of the generator for the feedback path (in the output circuit) is independent of the frequency, which is desirable for a symmetrical gain regulation.

With this type of output circuit the output transformer becomes a rather uncomplicated component, as it affects the feedback very little at frequencies well outside the signal frequency band. In practice almost the whole of the frequency dependence of the gain is in the output circuit.

Regulation and fine equalization

As described earlier, the output circuit constitutes a generator, the e.m.f. of which varies with frequency and the impedance of which is independent of the frequency. The generator feeds the feedback path, designed as a voltage divider in which the longitudinal impedance varies through a variable resistance in the form of strapped resistors (unregulated amplifier) or a thermistor (regulated amplifier). The frequency dependence of the regulation is provided by a special regula-

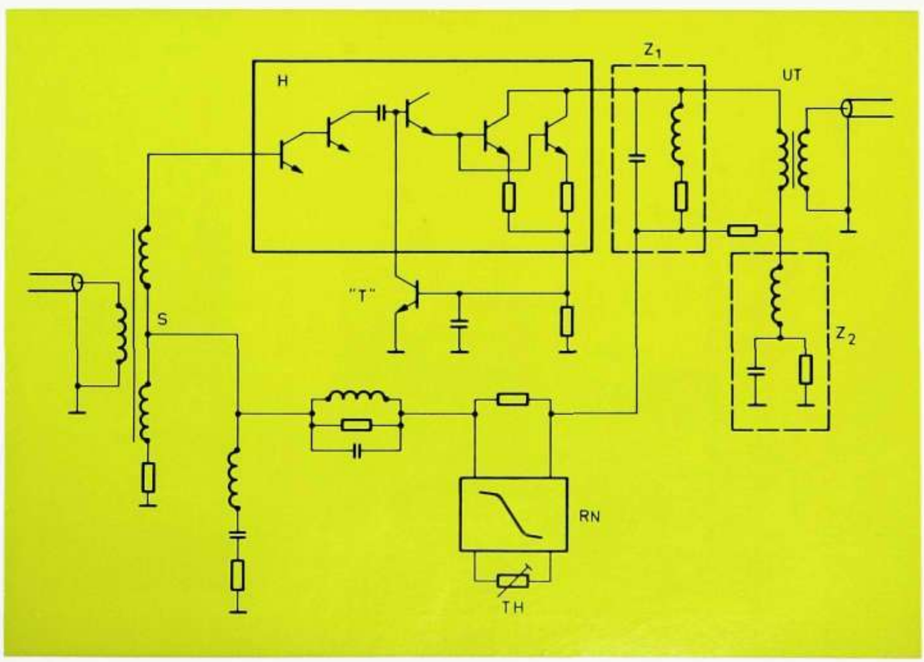


Fig. 6

Simplified circuit diagram of the amplifier

H Active part (hybrid circuit)
UT Output transformer
RN Regulation network
TH Thermistor
S Summing point
T Control transistor
Z_1, Z_2 Frequency dependent impedances

tion network between the variable resistance and the signal path. The transverse impedance of the voltage divider consists of a half link having frequency dependent attenuation and constant input resistance. The final fine equalization of the amplifier curve takes place in this half link.

Finally, the voltage from the half link is combined with the amplifier input signal in a conventional input circuit with a transformer, so that the correct amplifier input impedance is obtained.

Pilot receiver

The output level of the amplifier is regulated to a constant level with the aid of a regulation loop, which includes a thermistor as the regulation element. The current through the thermistor is changed in proportion to the change of the amplifier input level.

Apart from a conventional crystal filter and pilot amplifier, the regulation loop, fig. 10, includes a low level rectifier for the pilot signal, followed by d.c. amplification. Special care has been paid to the amplitude and phase in the regulation loop over the frequency range 0 to approximately 1000 Hz, in order to avoid a residual amplification of any low frequency modulation of the pilot signal (envelope gain). For this purpose it has been necessary to compensate for the far too great roll-of in the transfer function (heater current—resistance change) of the thermistor with increasing frequency, by giving the d.c. amplifier a gain that increases with frequency.

Memory

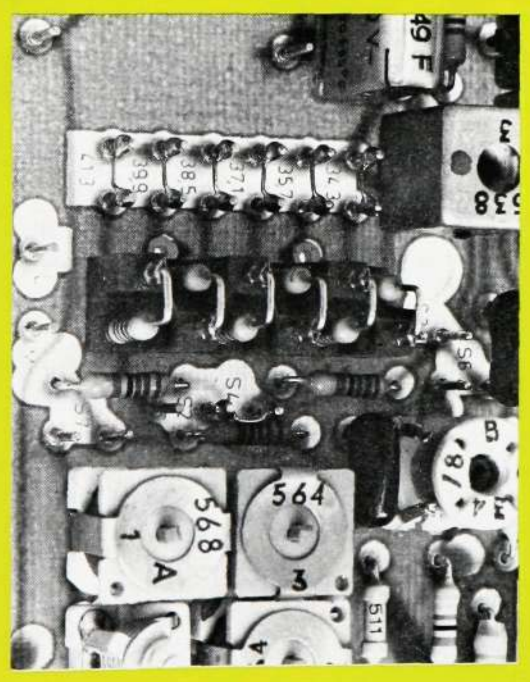
In order to meet the requirement to retain the gain value if the pilot fails, the actual heater current, and thus the input level, is continuously reproduced quantified at 0.5 dB intervals via a digital 4-bit shift register, with the aid of A/D—D/A converters and a low frequency clock, at a special memory output. If the pilot voltage falls by more than 8 dB the clock stops and the memory output is connected to the thermistor, which by and large retains its existing resistance value.

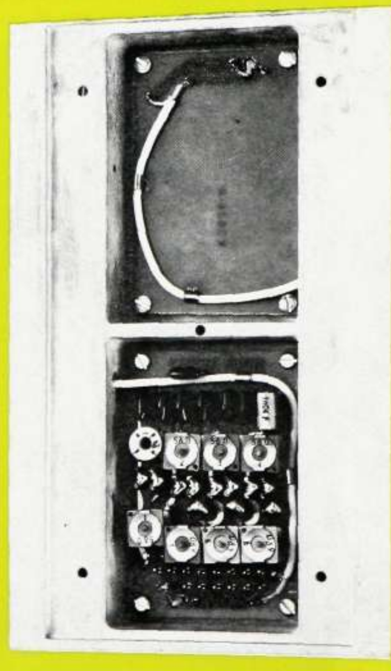
It is naturally possible to exploit the supervisory and memory functions to

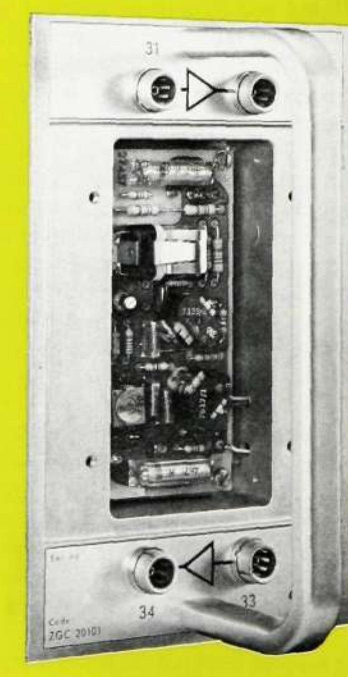
Fig. 7
Strapping field for selection of the gain in steps of 1.4 dB

Fig. 8
Line building-out network (only for one direction)

Fig. 9
Fault location oscillator







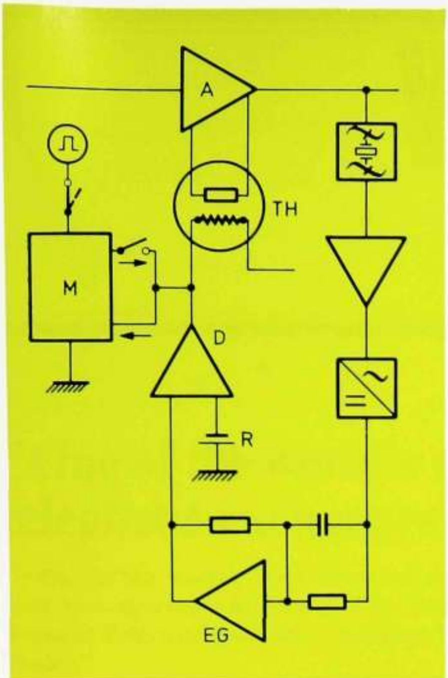


Fig. 10
Gain regulation

A	Amplifier
TH	Thermistor
EG	DC amplifier with envelope gain compensation
R	Reference voltage
D	Differential stage
M	Memory

a much greater extent by an increased use of electronics. However, from the point of view of reliability certain limitations must be applied, as the number of components in the supervisory equipment should not be allowed greatly to exceed the number in the actual transmission path. The risk of faults in the supervisory equipment must naturally not be greater than in the actual transmission path. The memory circuit is connected in in such a way that the normal function of the line, with the pilot connected in, is not affected if a fault should occur in the memory circuit.

Mechanical design

The different parts of the line amplifier are mounted in a die-cast aluminium case. Several electrical functions are brought together in mechanical units, each of which is mounted in a separate compartment, see fig. 11.

All the compartments are securely enclosed by means of tightly fitting aluminium covers. They are made in such a way that short leads can be taken through the walls between the compartments. The leads consist of concentric conductors and insulators that provide very simple and reliable interconnections with good electrical insulation.

The construction method using die-cast cases has been used with great success for the units included in L M Ericsson's 60 MHz multiplex equipment. The sub-units are built up on glass-fibre reinforced plastic wiring boards. In order to obtain sufficient space for the power separation filter, the component side has been turned inwards so that the depth of the compartment is utilised. Interconnections are made on the foil side. In the unregulated amplifier the required gain is selected by cutting the unused straps in a strapping field with soldering pins fitted on the amplifier board, see fig. 7. Naturally straps can also be re-soldered in this field. The fault location oscillator, fig. 9, is placed in the top part of the case under the handle. Once the cover has been removed it is an easy matter to fit the crystal which gives the amplifier its identity in the circuit.

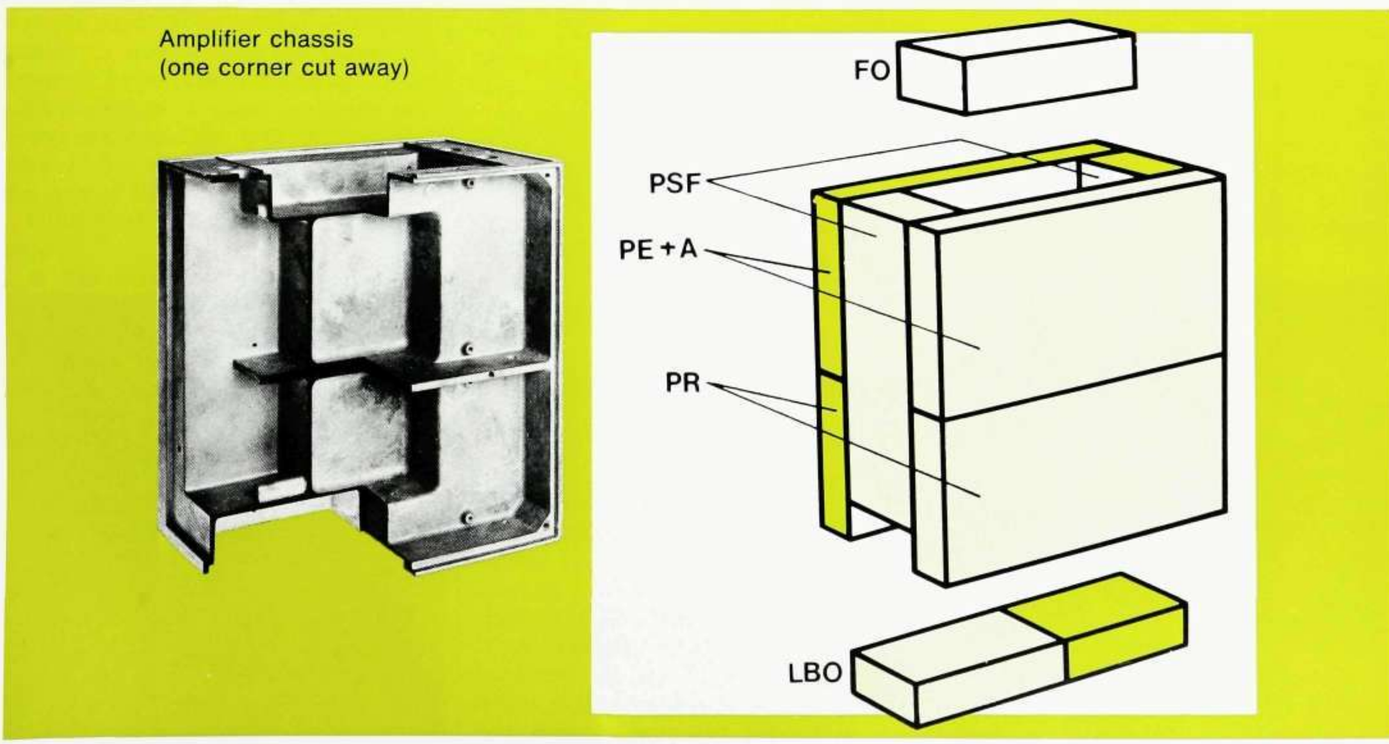


Fig. 11
Mechanical lay-out of the line amplifier

FO	Fault location oscillator (common)
PE+A	Pre-equaliser+amplifier (one unit)
PSF	Power separation filter
PR	Pilot receiver
LBO	Line building-out network
(light)	Direction A—B
(yellow)	Direction B—A

Technical data for the regulated amplifier

Nominal gain	37.8 dB at 12435 kHz
Frequency characteristic in accordance with the data for the coaxial cable	1.2/4.4 or 2.6/9.5 mm
Gain deviation, max.	± 0.10 dB
Return loss, input/output	> 26 dB
Regulation range	± 4 dB
Envelope gain/4 sections	0.03 dB
Noise factor	4 dB
Intermodulation attenuation for the frequency 2×11.3—10.3 MHz = 12.3 MHz and with 0 dBm per tone	94 dB
Overload point	+ 22 dBm
External dimensions of the line amplifier	210×130×230 mm
Weight	4.5 kg approx.

Components

In the main the same types of components are used in the line amplifier as are used in L M Ericsson's other transmission equipment. These components satisfy very high demands as regards function, reliability and life.

The line equipment, however, is more inaccessible than other transmission equipment. Consequently, if a fault occurs it can cause a major traffic disturbance. For this reason each component that is used in the line-amplifier is tested individually in order to ensure that it will function correctly and without faults. This investigation often comprises operational tests for the purpose of sorting out any components in which the most important characteristics change considerably. Components that are approved constitute a special component class for buired equipment. As a result of this reliability selection the line amplifiers have a very even quality and have been shown to have a low failure rate.

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WORLDWIDE NEWS

"One of the world's most advanced telephone exchanges" — now in operation

"One of the world's most advanced computer-controlled telephone exchanges has gone into operation in Sydney. The new international exchange is installed at the Overseas Telecommunication's building, Broadway International Telecommunications Centre."

So wrote the Australian daily *The AGE* at the end of March after the first stored-program-controlled telephone exchange for intercontinental traffic in the southern hemisphere had been put into operation in Sydney and handed over by LM Ericsson to the Australian OTC(A).

The exchange, denoted OTC/BW/CT1, is worth mention for several reasons. *The Australian Financial Review* formulates it as follows:

"As well as being Australia's first operational computer-controlled exchange, another claim is it also one of the first in the world capable of handling a new internationally adopted telephone signalling system."

The Sydney exchange uses CCITT signalling system no. 6, which means that all signalling is separated from the speech transmission and is carried on separate data channels. One advantage of this is that the signalling is quicker and the repeaters are simpler. (For that matter LM Ericsson have earlier delivered to the same customer a small computer-controlled test exchange, OTC/FT6, of type AKE 13 for international field tests with this type of signalling.)

Other brief data concerning the Sydney project:

- The design of the market-dependent software, output of the program package and testing of the software were carried out in Sydney by a working group formed in 1971 with staff from LM Ericsson's Australian subsidiary (LM Ericsson Pty. Ltd.) and from OTC(A).
- Installation and testing of the AKE exchange were carried out under the guidance of staff from the same working group.
- The testing of the newly designed software started in mid-1972 using OTC/FT6 AKE 13.
- At the start of 1973 more extensive tests of the software — system tests — were initiated on the computer equipment APZ in OTC/BW/CT1. This equipment had then been installed at OTC(A) Paddington Terminal Building. All types of traffic were tested with special software facilities.

Broadway Terminal Building in Sydney, Australia

- During June 1973 the APZ was moved from Paddington and installed in Broadway Terminal Building, Sydney, where the installation of the switching equipment of the exchange has proceeded since the beginning of the year.
- The system tests were completed at the beginning of January 1974 and, after about two months' acceptance tests, the AKE exchange was handed over on March 7th — 14 months after the start of installation in Broadway Terminal — to the Australian P.O. The exchange was cut over on March 11.

Five times more transient voltage protectors

The manufacturing capacity for transient voltage protectors at AB Rifa's factory at Bollmora outside Stockholm is quickly increasing and in the next few years is expected to have reached five times the present figure.

The manufacture of transient voltage protectors has old traditions at Rifa. In recent years considerable advances have been made in respect of the composition, structure and pretreatment of the component materials, the design of the protectors and the manufacturing processes.

A recent impartial investigation at the Swedish Institute for High Voltage Research confirmed that Rifa's transient voltage protectors have extremely high speed in transient contexts, higher than any of the simultaneously investigated protectors of other makes.


Double-furnace equipment for vacuum pumping, gas filling and soldering of transient voltage protectors at the Rifa factory at Bollmora outside Stockholm.

New telephone system for Australia and Finland

The new crossbar system, LM Ericsson type ARE 11, with electronic register processors, has now started to be marketed in several countries. The first exchange of this type will be put into operation at Salisbury, Adelaide, Australia, in mid-1975.

The first country in Europe to order the system was Finland, which was also the first country in which LM Ericsson's crossbar system of conventional type was introduced in Helsinki in 1950.

The ARE 11 system is equipped with an electronic register processor organization which, under the designation ANA 30, can also be installed in already existing crossbar exchanges. It then replaces the conventional electromechanical registers. This change of registers has been done at Mundelstrup, Denmark, as a result of which the exchange could be given facilities fully on a level with fully stored-program-controlled systems.

The Ericsson Group invested 360 Mkr in research and development in 1973

At a speech at the London Society of Investment Analysts by reason of LM Ericsson's successes on the rapidly growing British telecommunications market, the President of the Ericsson Group, Mr Björn Lundvall, spoke about the company's investments in research and development.

Here are some abstracts from his speech:

- Seven per cent of the Group's sales is invested annually in R & D — last year the amount was in round figures 360 Mkr. At present about 5,600 of the Group staff are engaged on the development and design of new products or adaptation and modernization of existing products.

Solely within the parent company 7,000 m² of newly built and well equipped laboratories have been taken into use in the past two years.

- R & D is both centralized and decentralized. Centralized in the sense that it is coordinated and supervised in Stockholm. Decentralized in the sense that an increasing proportion of the work is being shifted to foreign subsidiaries in, for example, France, Italy, Norway and Australia, which possess or are building up their own research facilities. Technical Development Councils, composed of experts from the parent and subsidiary companies, serve to bridge the gap.
- It is important to keep in mind that the rapid development of electronics creates serious problems both for telecommunications administrations and manufacturers. Both are confronted with a new, complex technology. Both face development costs on a scale never before experienced, and both appreciate that the expenses for new generations of equipment will continue to soar until a plateau of relative stability is reached. Under the circumstances it is both logical and natural for the administrations to seek to draw closer to their suppliers in an effort to pool resources and know-how in a more efficient way.
- Over the years the Ericsson Group has built up strong ties with telephone administrations on many different markets. These ties are being increasingly reinforced by joint manufacturing ventures, joint development projects and cooperative agreements. The agreement with Spain involves participation by the Spanish Telephone Company (CTNE), and both in Sweden and France LM Ericsson have entered into research companies in association or close cooperation with the domestic administrations. With these two countries there are also agreements on production cooperation that will make it possible for the various partners to concentrate their efforts in the areas of technology and production in which they have the greatest experience and competence.

Unique maritime telecommunication service

The Swedish Telecommunications Administration is alone in the world in being able to offer an automatic telecommunication system, Maritex, specially tested for shipping and entirely developed by the Administration. The system is based on short-wave communication with automatic scanning of calls from coastal radio stations and eliminates the manual adjustment to different frequencies. Messages can be automatically received at any time of the day and the operator avoids the necessity of maintaining a routine radio watch.

There is said to be a great international interest in Maritex since its introduction in 1972.

Through the introduction of this system some 30 Swedish vessels hitherto have acquired better connections with land — all over the world they can be reached on their ordinary Swedish telex numbers.

Through this automatic telex service several facilities are offered to shipping lines and charterers. By way of example my be mentioned the direct connection between a Maritex system and a process computer in the machine-room on two Swedish supertankers. The computer automatically starts the telex system and operating data are transmitted directly to the shipping line, which has better means of optimizing the operation of the vessels.

Telesignalling system from LM Ericsson standard on many vessels

On most new ships leaving the west-Swedish yards the LM Ericsson Telemateriel AB telesignalling system is installed as standard. During the next two years such equipment will be delivered on an average once a week.

The tanker T/T "Norse Queen" of 232,500 dwt was delivered at the end of April from the Uddevalla yard to the Norwegian shipping line Odd Godager & Co. On this ship LM Ericsson have installed a 100-line PABX type AKD 471, an extensive fire alarm system, and a music reproduction and public announcement system with built-in "talkback facility". The latter implies that a paging call can be answered from any of the installed loudspeakers.

Only a few days previously the M/S "Lappland" had been delivered from the Eriksberg yard to Ångfartygs AB Tirfing. The LME equipment consists of some 20 fire alarm sections with about 50 smoke and flame detectors and 200 thermal detectors. The ship also has a PAX with some 50 extensions interworking with an electronic intercom exchange of type ASE 434.

Equipment of exactly the same type is installed on the sister vessel M/S "Atland" and on the world's largest dry-cargo vessel M/S "Svealand" of 282,450 dwt, both from the Eriksberg yard.

Special requirements are placed on the telecommunications equipment on ships. The equipment must fulfil both national regulations and international classification requirements.

The Norwegian supertanker T/T "Norse Queen", one of many vessels with telesignalling equipment from LM Ericsson Telemateriel AB

Major orders:

Coaxial connection Saudi Arabia – Kuwait

For a long distance connection between Kuwait City in Kuwait and Damman, Saudi Arabia, LM Ericsson have signed a contract with the ministries of communication of the two countries, amounting to 40 Mkr.

The orders comprise the delivery and installation of multiplex equipment, coaxial cable and repeater equipment for 960 channels, and for power supply and line equipment.

Algeria

From Algeria LM Ericsson have received an order for the delivery and installation of telephone exchange and transmission equipment amounting to 50 Mkr. The equipment is intended for the Oran region.

Ecuador

LM Ericsson have signed a contract with the Ecuador telephone administration for transmission equipment to a value of 18 Mkr.

The equipment consists of multiplex and radio link systems within the microwave band an lower frequency bands. The deliveries will start this year and be completed in 1977.

Thailand

ECAFE has signed a contract with Ericsson Telephone Corporation Far East AB for the delivery and installation of a PABX type AKD 791 for the ECAFE new building in Bangkok. The new PABX will have 900 extensions and will be one of the largest in Thailand.

Syria

With Arab Co. for Electronic Industries (SYRONIC) LM Ericsson have signed a contract for the delivery of complete manual exchanges and equipment and materials for local manufacture. The contract, which runs over a period of ten years, comprises in the first stage about 40,000 lines and was awarded after being put out to international tender.

Apart from the delivery of materials, production tools and test equipment, the order includes the training of Syrian technicians in LM Ericsson undertakings.

Finland

After the successful introduction of 60 MHz multiplex equipment in Sweden LM Ericsson have now received a first order for such equipment from Finland.

This consists of two terminals for long distance telephony with a transmission capacity up to 10,800 simultaneous telephone connections. The equipments are to be installed during 1975 in Helsinki and Tavastehus.

Libya

LM Ericsson Telemateriel AB have received an order for telesignalling equipment for delivery to New Tripoli General Hospital, a new training hospital with 1200 beds in the capital Tripoli.

The order consists of a complete telesignalling plant to a value of 17.5 Mkr. It is the largest order hitherto received by LM Ericsson Telemateriel AB since its start in 1966.

The equipment comprises principally a PABX for 1000 extensions, intercom systems with about 900 stations, patient bedside telephones, closed-circuit TV equipment, sound distribution, radio and paging equipment, fire alarm, and master clock system.

In the photograph taken at the signing of the contract is seen (centre) Joseph F. El Haj, ECAFE, O. Morander, LM Ericsson (right), and Thavisakdi Chandrvirochana from the Ministry of Public Works

New computer-controlled test system for microcircuits

The most important part of the computer-controlled test system is the test station (nearest to the camera) which can be equipped with up to 64 sector cards for serving as many outputs and/or inputs on the test object

The first computer-controlled test system of type Tekronix S-3260 was put into operation during April at LM Ericsson's head office in Stockholm. Its field of application is the evaluation, reliability testing and acceptance testing of microcircuits of TTL, MOS and hybrid types. The advantages of the new system, which was purchased for 1.7 Mkr, are manog others:

- More reliable selection of components through better knowledge of the properties of each tested microcircuit.
- Fewer defective microcircuits mounted on printed boards, which implies great savings in the production stage.
- More extensive facilities in respect of reliability evaluations.

The system is administered by a minicomputer type PDP 11/40 with 40 k word core store and two 1.2 M word disc stores for storage, respectively, of operative systems and test programs and of test values. For communication with the system there are two visual display terminals for graphic and alphanumerical presentation, a tape recorder station, tape reader/tape punch and line printer.

The most important part of the system, the test station, can be equipped with up to 64 sector cards. Each sector card serves one output and/or input on the test object.

Every terminal on the test object can also be connected via a 50-ohm matrix to systems built into the test station for time, voltage and current measurement or to external instruments such as oscilloscope and pulse generator.

LM Ericsson's system contains 56 sector cards which are divided between two

(Cont. p. 64)

New member of Royal Swedish Academy of Sciences

Dr *Christian Jacobæus*, Executive Vice President of Telefonaktiebolaget LM Ericsson, has been elected member of the Royal Swedish Academy of Sciences, Class for Technological Sciences.

The Royal Academy of Sciences was founded in 1739 and has both Swedish and foreign members. One of the tasks of the Academy is to allot the annual Nobel Prizes for Physics, Chemistry and Economics.

Telephone equipment 70 % of Swedish electronic exports

No less than 70 % of Sweden's exports of electronic equipment consist of telephone equipment in accordance with the official statistics of the Swedish Ministry of Industry for 1973. Of these 70 %, telephone exchange equipment accounted for 55 %, other telephone equipment for 15 %.

During 1973 the exports of the Swedish telecommunications industry amounted to 2.1 thousand million kronor — the predominant portion of which from LM Ericsson.

Imports of telephone equipment to Sweden last year amounted to slightly more than 100 Mkr.

Conference on systematic training

For the discussion of experience and new features within LM Ericsson's Systematic Training System for factory operators, ST 69, some seventy representatives of the Group's factories in Sweden and abroad gathered at a conference. On practical grounds two roughly similar conferences were arranged. The second was an English-language conference held in Stockholm on March 25—29.

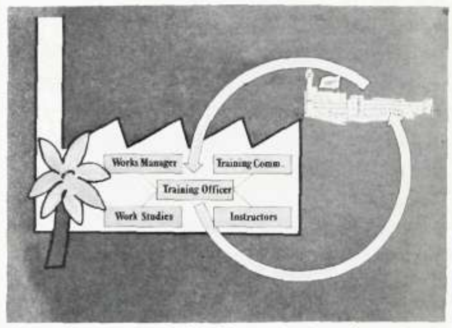
Among the many points on the conference programme may be mentioned video, which has acquired an increasing significance within ST 69 as an aid in the teaching of working methods primarily to methods engineers, supervisors and instructors.

There are now more than 20 hours of LME-produced video programmes with information on working methods for the manufacture of, among other items, crossbar switches, telephone sets and relay sets.

The participants at the ST 69 conference were enabled to study and discuss several of these video programmes, and also programmes produced by other companies.

Among other points on the conference may be mentioned quality and rationalization questions, new working methods and, of course, discussions and group work.

Systematic training came into use in 1969 and involved the coordination of different training activities, but has later been developed to comprise also the transfer of know-how between the factories of the Group. The expressed aim is "to prepare instructions for common methods within LM Ericsson factories throughout the world".



Coordination of ST 69 activities throughout the world is done at the Labour Training Centre in Stockholm. (Drawing from still film on ST 69)

Researchers wish to manufacture new type of semiconductor at Rifa

AB Rifa — the components enterprise of the Ericsson Group — is cooperating with a Swedish state researcher team in the development of new semiconductor components for telecommunications. The main item is high-frequency DMOS components, a new type of transistors for integrated circuits.

AB Rifa already possess extensive knowledge and equipment for manufacture of integrated circuits and are thus well equipped for the production of new semiconductor components. Compared with present transistors the high-frequency DMOS components are considered to be competitively superior and to have a very great development potential.

The newly formed consortium for this project consists of eight researches from three state institutions.

New metropolitan exchange group selector ANC 11

A group selector for very large exchange areas, the metropolitan exchange group selector ANC 11, has been designed at LM Ericsson. ANC 11 consists of reed switches which are controlled by stored-program-controlled technique. Integrated circuits (TTL), core and semiconductor stores are used in the system.

The new group selector was introduced primarily in order to obtain better utilization of the junction line network. It has also a number of new operational and maintenance facilities.

ANC 11 can be used to advantage as first group selector in ARF and ARE exchanges and as an independent local transit switching stage. It can also be used advantageously as incoming group selector or as combined first and incoming group selector. ANC 11 is adapted for direct interworking with ARF and ARE exchanges.

The metropolitan exchange group selector has an ultimate capacity of 6,144 inlets and 6,144 outlets. 256 routes with max. 256 outlets per route can be connected. Full accessibility thus exists and no *grading or the accompanying interconnection work* is required. The system offers a first choice and four alternative choices.

When ANC is used, for example, as first group selector, it permits connection of several 10,000-line groups to the same switching stage. This results in larger routes and better utilization of the network.

New computer-controlled ... cont. from p. 63

test positions, one of which is equipped with a temperature chamber and automatic feeder. The system also contains a 14 GHz sampling oscilloscope with digitizer.

The operative system developed by Tekronix, is disc-oriented. Programming is done in Tektest III, which is a problem-oriented high level language.

Functional tests can be made with up to 20 MHz test frequencies. Comparators and drivers have individually settable levels for each sector card. Time measurement can be done with 1 ns resolution. DC measurements can be made within the ranges 1 mW — 100 V and 1 μA — 200 mA.

The testing speed with feeder is max. 2500 packages/hour. The feeder permits testing at temperatures between 0 and 125° C.

The software allows direct processing of test data and the production of statistics.

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2. Sales and installation company
3. Associated sales company with manufacturing
4. Associated company with sales and installation
5. Other company
6. Other associated company
7. Technical office

TELEFONAKTIEBOLAGET LM ERICSSON

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ERICSSON REVIEW

MOBILE CARRIER EQUIPMENT
A NEW TYPE OF COAXIAL CABLE
ELECTRONIC TRAFFIC ROUTE TESTER
SIMULATION OF TELECOMMUNICATION TRAFFIC SYSTEMS
WORLDWIDE NEWS

3 1974

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Contents

COVER
Coaxial cable testing at the LM Ericsson cable factory

Mobile Carrier Equipments ZAG 4M–4 and ZAG DM–4

Knut Østby

Multiplex equipment for a small number of channels that is flexible in operation as regards mobility, capacity, connection possibilities and utilization has many practical applications.
A/S Elektrisk Bureau in Oslo, Norway, an associated company of L M Ericsson's, therefore developed and marketed a mobile carrier equipment which because of its modular design can be equipped with up to 24 speech channels and 12 telegraph channels.
When designing the equipment, special importance was paid to making the equipment reliable, robust, compact and simple to operate.

UDC 621.395.44
LME 84219

The carrier equipment is designed for transmission over 4-wire telephone cable or radio links.

It is dimensioned mainly for military use. However, because of the high degree of system flexibility and the fact that it conforms to CCITT recommendations, the system also has many public and private fields of application. The system can be used, for example, for providing temporary circuits in connection with installation work, for police work and in cases where a better utilization of the existing network is wanted, such as between islands and the mainland.

The various systems are built up using two main units:

4-channel terminal ZAG 4M-4

Group modem ZAG DM-4

These are shown in fig. 1. The simplest system configuration is obtained by connecting two 4-channel terminals via a four-wire cable. Such a system has a capacity of four telephone circuits, two telegraph circuits and an order wire circuit. The maximum distance between terminals is 20 km. The distance between terminals can of course be greater than this if transmission is via a radio link.

The equipment is designed in accordance with CCITT recommendations and normal telephone sets, a central switchboard and teleprinters can be connected to the low frequency side. The 4-channel terminal provides a constant current of 40 mA for the directly connected teleprinters. When used with normal two-wire field cables, the distance between the terminal and the teleprinters can be as much as 5 km, which corresponds to a loop resistance of 1,500 ohms.

The terminal has built-in circuits for signal compression and expansion. This greatly improves the signal-to-noise ratio when transmitting over lines with a high noise level.

When the capacity of the 4-channel system is insufficient, up to three 4-channel terminals can be combined in a group modem as shown in fig. 2. The system thereby obtained has a capaci-

Fig. 1
Mobile carrier equipment for up to 24 telephone channels and 12 telegraph channels. The equipment was awarded the Norwegian design prize for 1971.
Above: 4-channel terminal ZAG 4M-4
Below: Group modem ZAG DM-4

KNUT ØSTBY
A/S Elektrisk Bureau, Oslo — a company associated with LM Ericsson

ty of 12 telephone channels, 6 telegraph channels and 4 order wire channels. The figure also shows how the circuits in a larger system can be distributed geographically. As the units have their own power and frequency generation, they can be connected via cables, with lengths of up to 10 km between the 4-channel terminals and the group modem and up to 5 km between the modem and the radio link. Furthermore the length of the subscriber lines from the 4-channel terminals to the individual subscribers can have a maximum length of about 10 km. Provided that these cable lengths are not exceeded, the automatic regulation will give the correct level at the subscriber. Two such 12 channel systems can be combined to form a 24 channel system.

Both the 4-channel terminal and the group modem have cable equalizing networks, which with the aid of pilot signals automatically compensate for the cable attenuation. Thus the 4-channel terminals do not need to be set up in the same place as the group modem. Hence the 4-channel terminals can be located at different places where they can serve as communication centres.

Frequency arrangements

The frequency arrangement for the 4-channel terminal is shown in fig. 3.

The four telephone channels in the frequency band 4—20 kHz each take up a frequency band of 0.3—3.4 kHz before modulation and have a signalling frequency of 3,825 Hz. The order wire channel is unmodulated and has a bandwidth of 0.3—2.5 kHz. The band 2.5—4 kHz is utilized for two telegraph

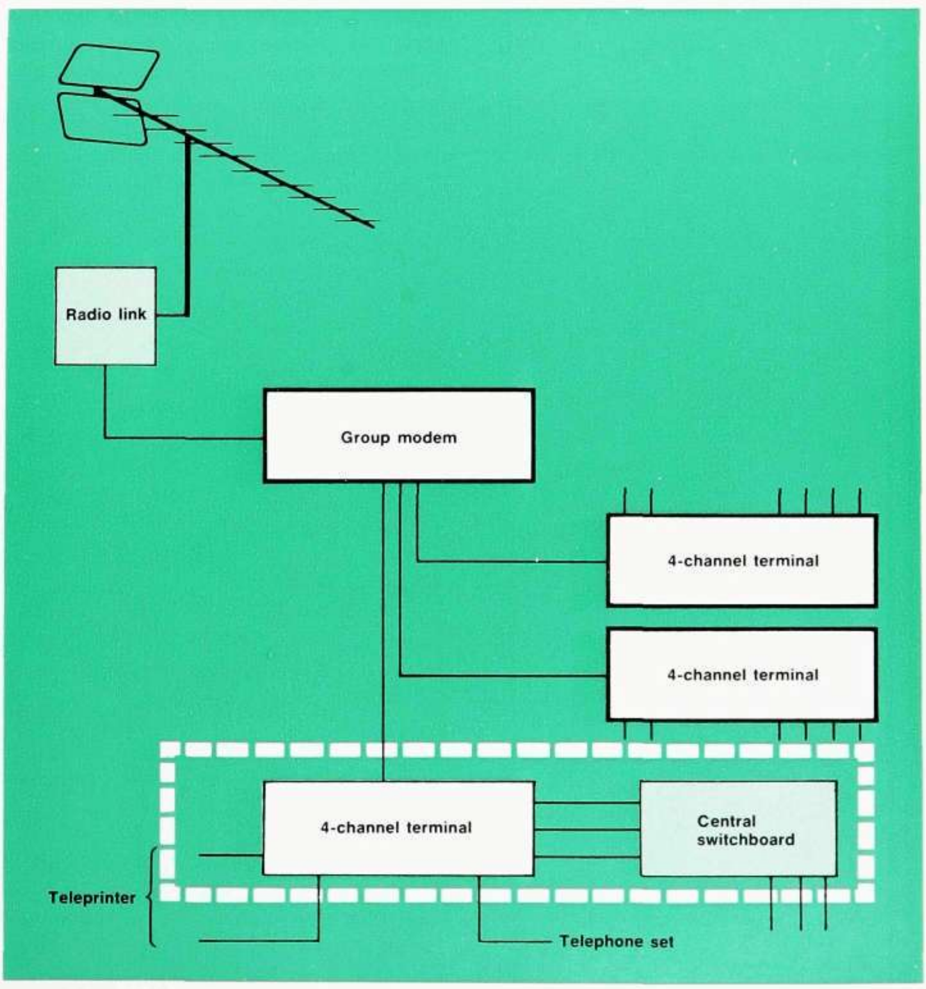


Fig. 2
Build-up of a 12-channel system
Capacity:
12 telephone channels
6 telegraph channels
1 order wire channel for each 4-channel terminal

channels. These operate in accordance with the frequency shift method and can work at speeds of up to 200 bauds. The pilot frequencies shown on the frequency arrangement of fig. 3 are used for automatic regulation in the system.

In the 4-channel terminal the 20 kHz pilot, which is the main pilot, controls the level regulation system at the receive side. The 4 kHz pilot is an additional pilot which, after the frequency band for the 4 channels has passed over a transmission medium (cable or radio link), controls an automatic cable equalizing network. In the group modem only one pilot is transmitted. With nominal input level into the receiver the frequency response is flat. If the input level falls, the regulation system interprets this as though a cable with a certain attenuation had been inserted, and the combined level and cable equalizing network regulates in accordingly. The group modem has a choice of frequency bands on the line side. For 12-channel operation any one of three different frequency bands can be selected with a switch on the front of the modem. The different alternatives, which are shown on fig. 4, are as follows:

frequency band 1
12 telephone channels in the band 60—108 kHz, 3 order wire channels and 6 telegraph channels in the band 108—120 kHz.

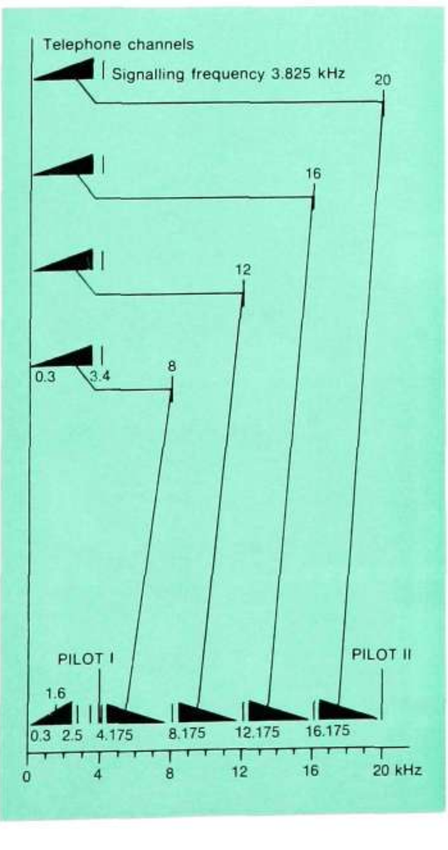
frequency band 2
12 telephone channels in the band 6—54 kHz, 3 order wire channels and 6 telegraph channels in the band 120—132 kHz.

frequency band 3
12 telephone channels in the band 6—54 kHz, 3 order wire channels and 6 telegraph channels in the band 68—80 kHz.

The pilot frequencies are
84.08 kHz for the band 60—108 kHz and 29.92 kHz for the band 6—54 kHz.

In the 24-channel system one 12-channel system operates in the band 60—108 plus 108—120 kHz and the other system in the band 6—54 plus 120—132 kHz.

Fig. 3
Frequency arrangement for a 4-channel system



Connection and operation

The automatic regulation and cable equalization simplifies the connection and operation of the equipment. The switches on the front are intended only for selection of the type of operation, and hence the setting up only has to be carried out once when setting up the connection.

The control devices for the 4-channel terminal provide the following facilities:

For each telephone channel
Level test, selection between 2-wire or 4-wire connection and with the compander in or out of circuit.

For each telegraph channel
Level test, selection between 2-wire or 4-wire connection with internal voltage source or 4-wire through-connection.

— The order wire channel can be connected in on all channels that are operating 2-wire, and it can be allocated either to the operator or to a subscriber.

— The level in the telephone channel can be adjusted in steps of 2 dB.

The level in the telephone channel can be checked by means of an acoustic method via the handset. The check is made by setting the switch on the telephone channel to the test position. If a pulsed tone (1,000 Hz) is heard, the level is correct. Too low level is indicated by an even tone and too high level by a buzzing tone in the telephone receiver.

An alarm for a pilot break or faulty pilot level is indicated by a high pitched tone in the microtelephone of the order wire channel and also by an alarm lamp.

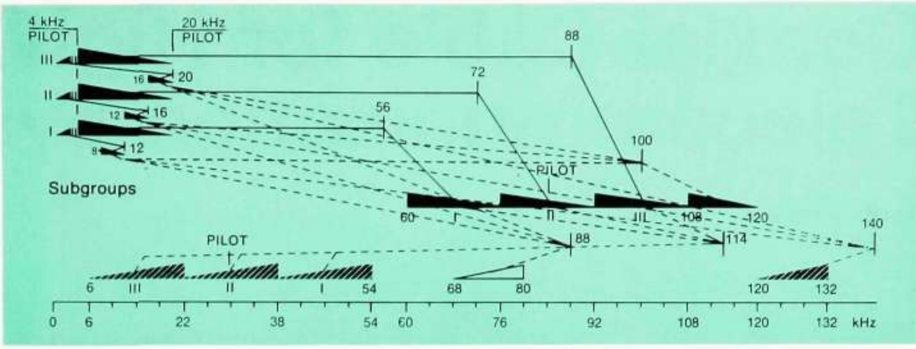
The control devices on the group modem provide facilities for:

— selection of the line frequency

— measurement of pilot levels and test tones in the subgroups

— connection of the handset for an omnibus connection to the order wire channel in each subgroup

Fig. 4
Frequency arrangement for a 12-channel system



Technical data

Electrical data in accordance with CCITT recommendations.

Operational temperature range: — 40° C to + 55° C.

Climatic and mechanical robustness as specified for mobile equipment in the British Ministry of Defence Specification DEF 133.

Dimensions 130 × 310 × 480 mm (the 4-channel terminal and the group modem have the same dimensions and weight).

Weight: 19 kg

When the pilot level on the line or on one of the subgroups is faulty, an alarm is indicated by the lighting of lamps and also by a tone of short duration in the microtelephone of the order wire channel.

All connections are made with plug terminated cables.

Mechanical design and maintenance

Fig. 5 shows how the units are placed in a robust cast silumin case.

Faults are located using the built-in test equipment. A spare circuit board can be inserted and the equipment will function correctly without any adjustments having to be made. Readily accessible components and numbered test points, at which the nominal levels are given, simplify the repair of faulty boards.

The components and mechanical design have been selected to give the equipment a high degree of reliability with large climatic and mechanical stresses.

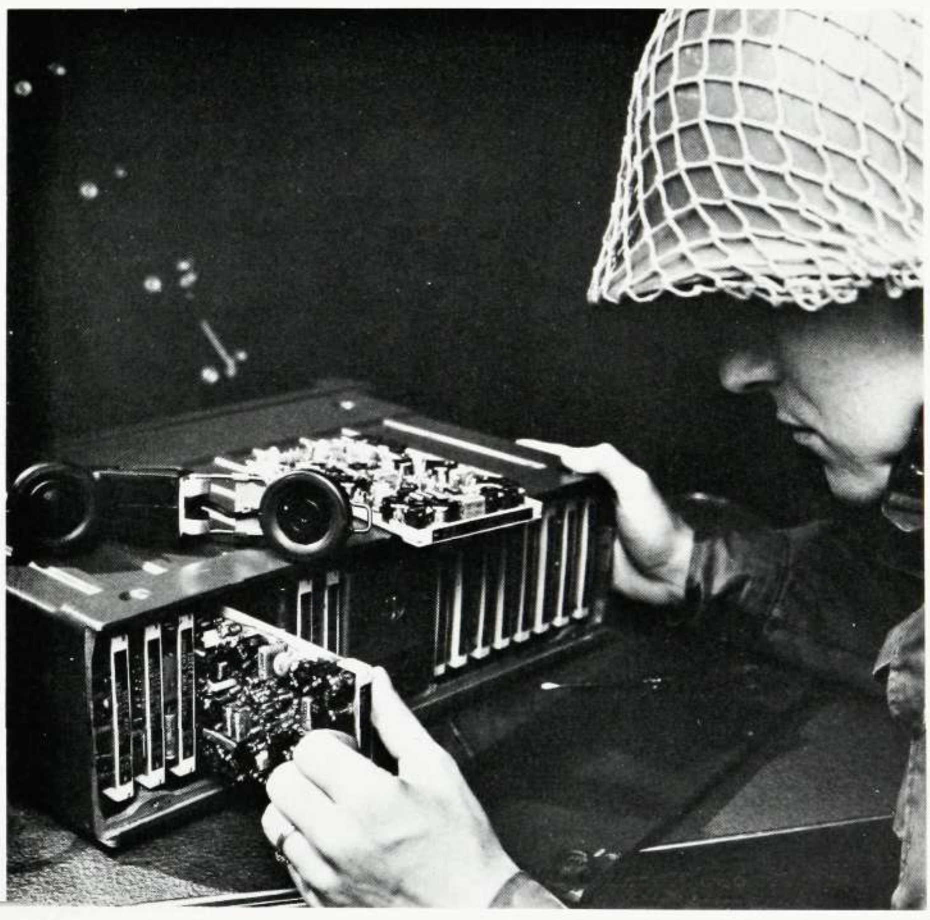


Fig. 5
4 channel terminal with rear cover removed

Coaxial Cable for High Frequency Telecommunication Systems

Arne Ernbo

In 1972 the Swedish Telecommunications Administration took into service a new carrier system having a transmission capacity of 10,800 telephone circuits over two coaxial pairs and with an upper frequency limit of about 60 MHz. The cable that was used for this purpose was an existing coaxial cable that had been in service for many years. Since 1973 L M Ericsson's Telephone Cables Division have had a new type of coaxial cable in production which is suitable for use in connection with the continued development of the high frequency telecommunications network.
In the article the author gives an account of the background to the development work on the new cable and also describes the manufacturing and measuring methods.

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The type of cable that is being used on the roughly 90 km route of the first commercially exploited 60 MHz system is about 25 years old. This same type of cable has been utilized for several different transmission systems. The late 1940s saw the beginning of the build-up of coaxial networks with systems for 600 and 960 channels and with bandwidths up to 4 MHz, using a coaxial pair with a diameter of 9.5 mm. Since then the bandwidth has been increased without changing the cable. Thus it seems as if it should be possible to use the same coaxial cable for arbitrary high frequencies, if it was only possible to design suitable amplifiers. In principle this is also true, despite the fact that as the bandwidth is successively increased it becomes increasingly difficult on long routes with the old type of coaxial pair to satisfy the transmission quality requirements that can be considered as reasonable for a modern telecommunication circuit and which are summarized by CCITT in the "Green Book".

Another factor in favour of a redesign of the present coaxial cable pair, designated CBn, which has been manufactured since the end of the 1940s by Sieverts Kabelverk and L M Ericsson's Telephone Cables Division, was the

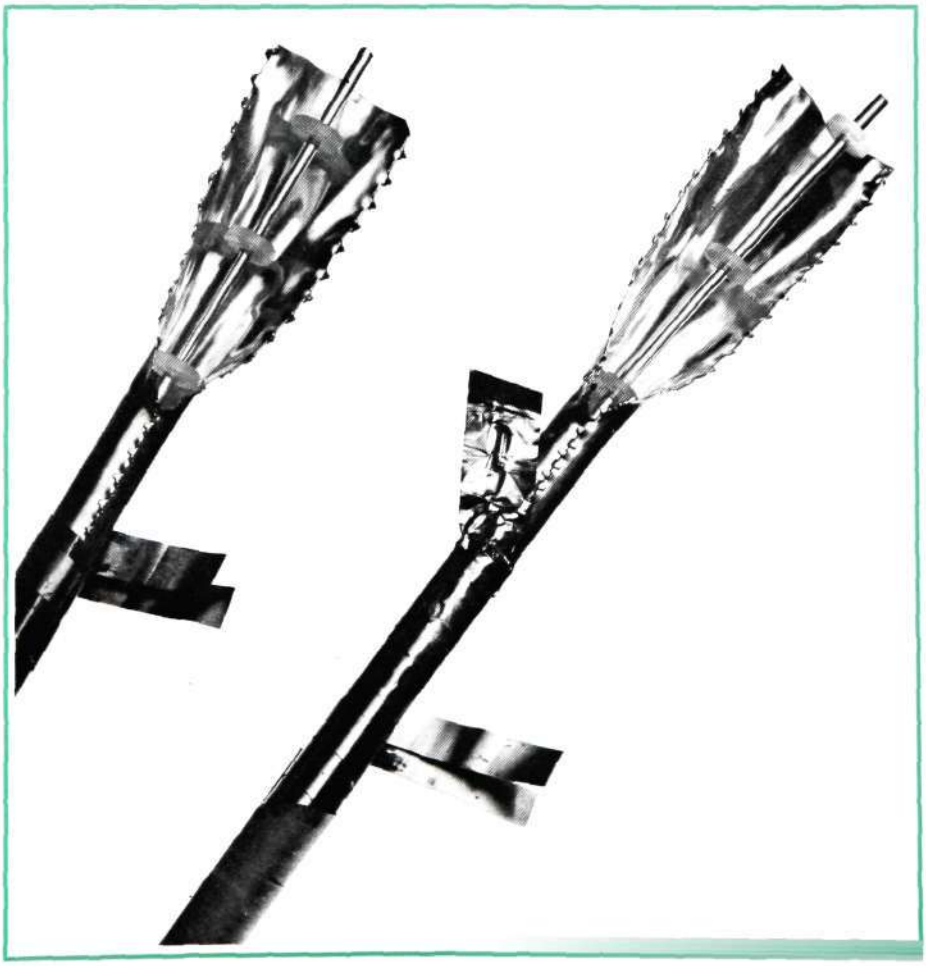


Fig. 1
Coaxial pairs. Above the CBn coaxial pair and below the new coaxial pair

ARNE ERNBO
LM Ericsson's Telephone Cables Division

desire to standardize in accordance with CCITT recommendations for coaxial pairs.

Development of the new coaxial cable

When developing the new cable the aim was to produce a coaxial pair that was electrically in accordance with CCITT recommendations but at the same time retained as much as possible of the earlier design, such as an inner conductor of copper, insulation in the form of polyethylene discs, outer conductor of copper tape and a magnetic screen of two steel tapes, see fig. 1. More stringent tolerances were required if it was to be possible to use the cable for 60 MHz systems over long distances. For this reason both the thickness and the diameter of the outer conductor were retained. The steel tapes were also kept to the same dimensions as in the old CBn cable. As before, the outer conductor was provided with toothed edges which fit into each other when the tube is formed so that the tube has a well defined serrated seam. As this type of seam has earlier been shown to give rise to a certain amount of crosstalk because of the leakage of HF energy through the seam, it was covered with thin copper tape. Incidentally this method has already been applied on the older coaxial pairs for a number of years, with good results. In order to further improve the crosstalk attenuation and at the same time to provide the possibility of separating the coaxial pairs electrically, the pairs were provided with two layers of paper outside the steel tapes.

The changes to the outer part of the coaxial pair described here do not affect the electrical transmission characteristics over the frequency range utilized by the 60 MHz system, which is approximately 4—62 MHz. In order to get these characteristics to agree with CCITT recommendations it was necessary to change the inner conductor and the dielectric. The requirements to be met concerned the attenuation and characteristic impedance of the coaxial pair.

Attenuation

At the frequencies of interest here, the attenuation can be given by

$$A = A_0 + A_1 \sqrt{F} + A_2 F \text{ dB/km}$$

where F is the frequency in MHz.

A_0 is a small term which is independent of F.

$A_1 \sqrt{F}$ is completely dominating as regards the resistance attenuation caused by the resistance of the copper conductors. This increases according to $\sqrt{F}$ because of the skin effect in the conductors.

$A_2 F$ is the leakage attenuation caused by the dielectric losses in the insulating material (polyethylene discs). The losses are directly proportional to the frequency. However, this term also includes the effect of the resistance of the copper conductors if this does not conform to the $\sqrt{F}$ law. If the resistivity of the copper increases towards the surface of the conductor, A_2 will also increase. In order to keep this term low it was necessary to use copper with good surface purity, what is known as DIP copper, and a polyethylene with an extra low dissipation loss.

The new 2.6/9.5 mm coaxial pair was dimensioned for the following attenuation at 10° C:

$$A = 0.014 + 2.319 \sqrt{F} + 0.0014 F \text{ dB/km}$$

where F is the frequency in MHz.

The formula gives 18.06 dB/km at 60.0 MHz, which satisfies the CCITT requirement of 18.00 ± 0.30 dB/km at the same frequency.

A temperature dependence of approximately 0.2 % per degree is included in the A_1 term. This is because the resistivity of the copper, ρ, varies by about 0.4 % per degree and A_1 contains $\sqrt{\rho}$.

At 60 MHz the total attenuation of a homogeneous section of 280 km in a CCITT reference circuit is over 5,000 dB, and such a section contains approximately 180 repeaters. In the completed installation the frequency dependent cable attenuation is compensated to better than 1 dB deviation by the repeaters that are connected in at intervals of 1.5 km. Thus the requirements for correct compensation are extremely stringent. It is apparent that even very small deviations from the correct frequency dependence can lead to unacceptable errors. As far as the cable is concerned, a spread in the

A_1 term of the formula above is not the most serious problem in this respect, despite the fact that it constitutes the incomparably greater part of the total attenuation. Instead it is the variations in the A_2 term that have the most serious influence. This can be explained by the fact that within quite wide limits the repeaters are able to compensate for the changes in the A_1 term, which are in fact caused by temperature variations along the cable route. This is possible because the system is provided with automatic gain regulation, for example with the aid of a pilot signal at 61.16 MHz. The pilot signal then always corrects the cable section to the right gain at 61.16 MHz and the remaining frequencies are corrected proportionally to $\sqrt{F}$.

Consequently variations in A_1 do not lead to any serious deviations, whereas changes in A_2 give rise to attenuation errors that are not regulated out except at the pilot frequency 61.16 MHz. The correction procedure just described is illustrated in fig. 2.

The difference between the measured attenuation at 61.16 MHz on a repeater section *(A)* and the nominal attenuation *(B)* must not exceed ± 0.18 dB/km (± 1 % of the nominal attenuation).

Between *D* and *E*, however, a maximum difference of only ± 0.02 dB/km is all that can be permitted, because the repeaters do not automatically equalize the variations in the A_2 term.

Apart from variations in the coefficients A_1, A_2 and A_3 the cable can have narrow band attenuation fluctuations around the smooth function

$$A = A_0 + A_1 \sqrt{F} + A_2 F$$

If these fluctuations occur randomly from cable length to cable length, no serious phenomenon will occur as long as the fluctuations are of a reasonable size. If on the other hand there are systematic attenuation changes at the same frequency on many cable lengths, there will soon be an unacceptable attenuation distortion. These attenuation changes cannot be detected direct when measuring the attenuation in the factory, because only a relatively few test frequencies are used. Instead requirements have been specified for the reflection factor of the coaxial pair measured using a sine-wave signal, as this has a direct theoretical relation-

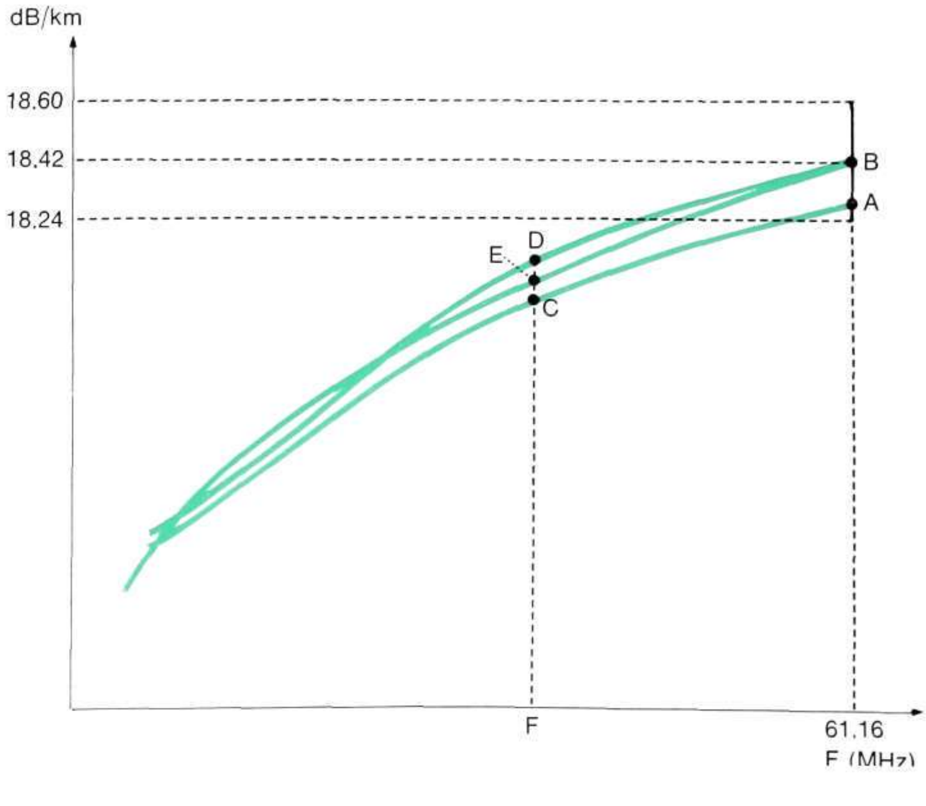


Fig. 2

Attenuation process showing the principle for the tolerance specification

- **A** Measured attenuation at 61.16 MHz on a repeater section
- **B** Nominal attenuation at 61.16 MHz on a repeater section
- **C** Measured attenuation at the measuring frequency concerned
- **D** Derived from C when the attenuation curve through A is corrected to the nominal value B. At other frequencies than 61.16 MHz the curve is then moved in proportion to $\sqrt{\frac{F}{61.16}}$
- **E** Nominal attenuation at frequency F

	New coaxial pair	CBn coaxial pair
Inner conductor, external diameter, mm	2.60	2.55
Outer conductor, inner diameter, mm	9.47	9.47
Distance between discs, mm	33	25
Thickness of the discs, mm	1.7	2.2
Outer conductor, thickness, mm	0.3	0.3
Wrapped with two layers of steel tape	yes	yes
Wrapped with two layers of paper tape	yes	no
Type of seam	toothed	toothed
Copper tape over the seam	yes/no	yes/no

Fig. 3

Comparison between the new coaxial pair and the older CBn coaxial pair

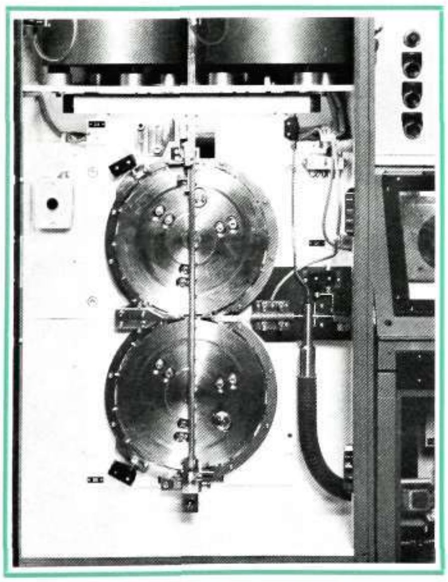


Fig. 4

Fitting the discs on the inner conductor. The conductor is passed from left to right. The discs are fed in via two vertical channels to the two wheels, each of which

ship with the attenuation fluctuations. As this measurement, SRL (Structural Return Loss), can be carried out by sweeping the frequency over the whole of the band of interest, any defects can be detected quite quickly. The SRL measurement, like the attenuation deviations, is particularly sensitive to dimensional errors in the coaxial pairs, which in themselves may be very small but which occur periodically. Such errors may be the result of, for example, small imperfections in the driving wheels in the machines. This will result in the formation of a series of reflections, which, when the distance between them is one or several half wavelengths of the applied a.c. voltage, return to the transmitter in phase and thus build up a large reflected voltage. Consequently less energy reaches the receiver, or in other words, the cable attenuation will be greater at that particular frequency. Random variations in the dimensions of the coaxial pairs cause reflections that do not return to the transmitter in phase, and hence they have far less effect on the attenuation.

In order that the attenuation deviations in an analog 60 MHz system shall keep within ± 1 dB for 280 km, the SRL must be -35 to -40 dB or better. To achieve this, special attention must be paid to both the machines and the materials used in the manufacture.

Digital systems are much more tolerant as regards SRL errors. Values of up to -20 dB can be tolerated at individual frequencies as long as the mean value of the reflected power in, for example, a 10 MHz wide band is not too great. This has a very important bearing on the use of coaxial cables for digital systems over 60 MHz, as the systematic periodic deformations that arise when assembling the coaxial pairs cause a marked peak at a frequency that is related to the pitch of the coaxial pairs. For example, if the pitch is 500 mm there will be an SRL peak at 270—280 MHz.

Impedance

The new coaxial pair was dimensioned so that the real part of its characteristic impedance was 75.0 ohms at 25 MHz. The complete expression for the characteristic impedance of the coaxial pair is thus

$$Z(F) = 74.8 + \frac{0.94\,(1-j)}{\sqrt{F}}$$

where Z is in ohms and F in MHz.

This impedance function meets the requirements of the CCITT recommendations as $Z(2.5) = 75.4$ ohms is within the range 75 ± 1.0 ohms permitted by CCITT. The deviation from the nominal value that is allowed in the factory is $\pm 0.5\ \Omega$, which means that even the coaxial pair that deviates most is still well within CCITT limits.

Dimensioning of the coaxial pairs

As has already been discussed, the dimensions of the outer conductor were retained. In order to meet the CCITT requirements of lower attenuation and higher impedance it was necessary to increase the diameter of the centre conductor from 2.55 to 2.6 mm, increase the distance between the insulating discs from 25 to 33 mm and reduce the thickness of the discs from 2.2 to 1.7 mm.

A summary of the mechanical characteristics of the new coaxial pair is given in fig. 3. For the sake of comparison the data for the CBn coaxial pair is also given in a separate column.

Manufacture of coaxial cables

As has been mentioned earlier, the coaxial pair consists of a centre conductor with insulating discs, an outer conductor with covering tape, steel tapes and paper insulation.

A copper wire with exact diameter is first fitted with polyethylene discs with the aid of two feeding wheels, the peripheral speeds of which coincide with that of the wire and each one of which threads on alternate discs on to the wire, fig. 4. The centre conductor with the discs threaded on is then passed into a forming cabinet, fig. 5, where a copper tape is bent round the centre conductor. The edges of the copper tape have stamped-out teeth which are interlocked during the forming process and thereby effectively close the coaxial pair. The width of the tape at the root of the teeth determines directly the diameter of the coaxial pair and hence its characteristic impedance. This dimension must therefore be fixed very accurately. The thin copper tape for covering the serrated seam is also run into the forming cabinet where it is bent round a part of the periphery of the coaxial pair.

The completely formed coaxial pair is then taken through a steel tape wrapping machine, in which it is bound with two soft steel tapes, and then through a paper tape wrapping machine where two layers of paper tape are added. In this condition the coaxial pair is then taken up on drums with a large diameter so as not to bend the coaxial pair unduly. Factory lengths of the coaxial pair are then tested as described later. After completion of the tests the coaxial pairs are then taken for assembling into cables.

The main part of the planned 60 MHz network in Sweden is based on cables with six coaxial pairs and with supervisory and control pairs laid up in the centre of the cable. The one or more outer layers of quads that were normally wrapped round the coaxial pairs on earlier types of cables are no longer included because of the changed network requirements. The coaxial pairs are identified in the cable by coloured yarn in the interstices between the pairs. A number of layers of paper are wrapped round the cable core thus formed as electrical insulation and protection against heat generated externally in connection with sheathing and cable jointing.

The laying up of the contents of the cable and the wrapping with paper are carried out in a stranding maching, see fig. 6, which is able to take 12 coaxial pairs in one operation. As can be seen from the figure, the machine is of impressive dimensions. This is because of the large drums used for the pairs. After stranding the cable core is dried out in low heat and a vacuum. In the standard design the cable is provided with a corrugated extruded aluminium sheath which is protected against corrosion by two layers of polyment, a bitumen-based compound, which is covered with a polyethylene sheath. In this condition the cable is used for laying in concrete ducts or plastic pipes. If the cable is to be laid directly into the ground it is provided with armouring consisting of zinc coated flat steel wires with a rather long pitch, what is known as flat wire armouring. The flat wires are held together by a helix of zinc coated steel tape or polyester tape wound in the opposite direction. A third variant is the submarine cable which is armoured with round steel wires.

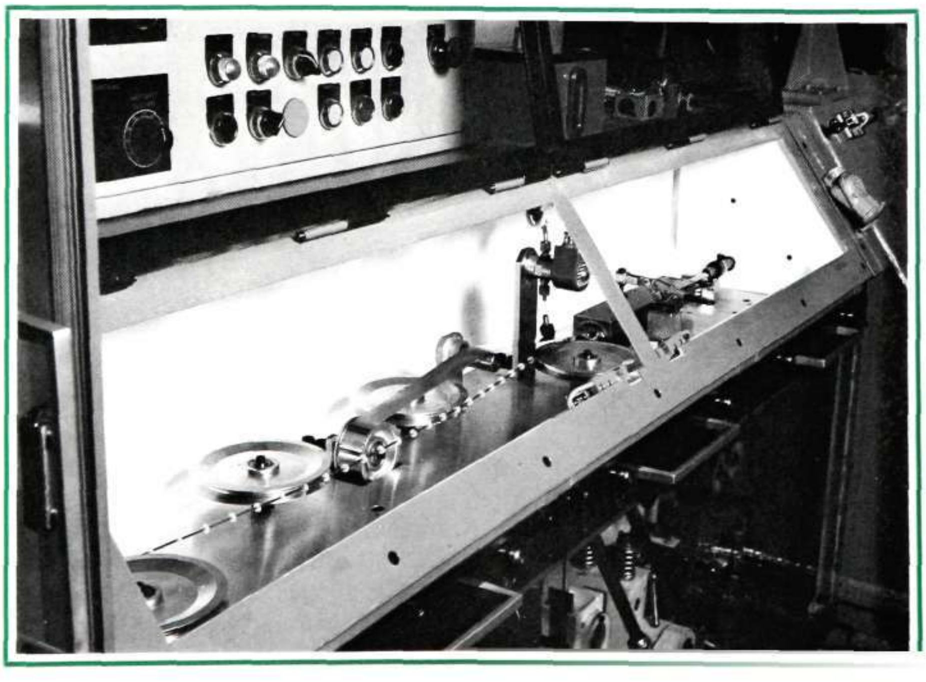


Fig. 5

Forming the coaxial pair. The inner conductor with insulation discs comes in from the left. The outer conductor tape, with stamped out teeth, is bent round the outside of the discs. The covering tape over the seam is added at the right-hand side of the picture

The object of the armouring is to give the cable good tensile strength, which combined with the low weight (coaxial pairs, Al sheath) of the cable makes possible long laying lengths, and also to provide a good earth for the sheath currents that can arise as a result of lightning or induction from power lines. The armouring is joined to the aluminium sheath at the splicing points between the cable lengths. The contact with the aluminium sheath is necessary in order to prevent large voltages building up between the sheath and the armouring.

The coaxial cables are manufactured in the factory of the Telephone Cables Division in Hudiksvall in North Sweden.

Testing coaxial cables

Testing of coaxial cables to be used for 60 MHz systems can be divided up into three different parts: mechanical, resistance and high tension and transmission measurements. The mechanical measurements comprise checks of the thickness of the sheath, pressure tightness etc. and will not be discussed further.

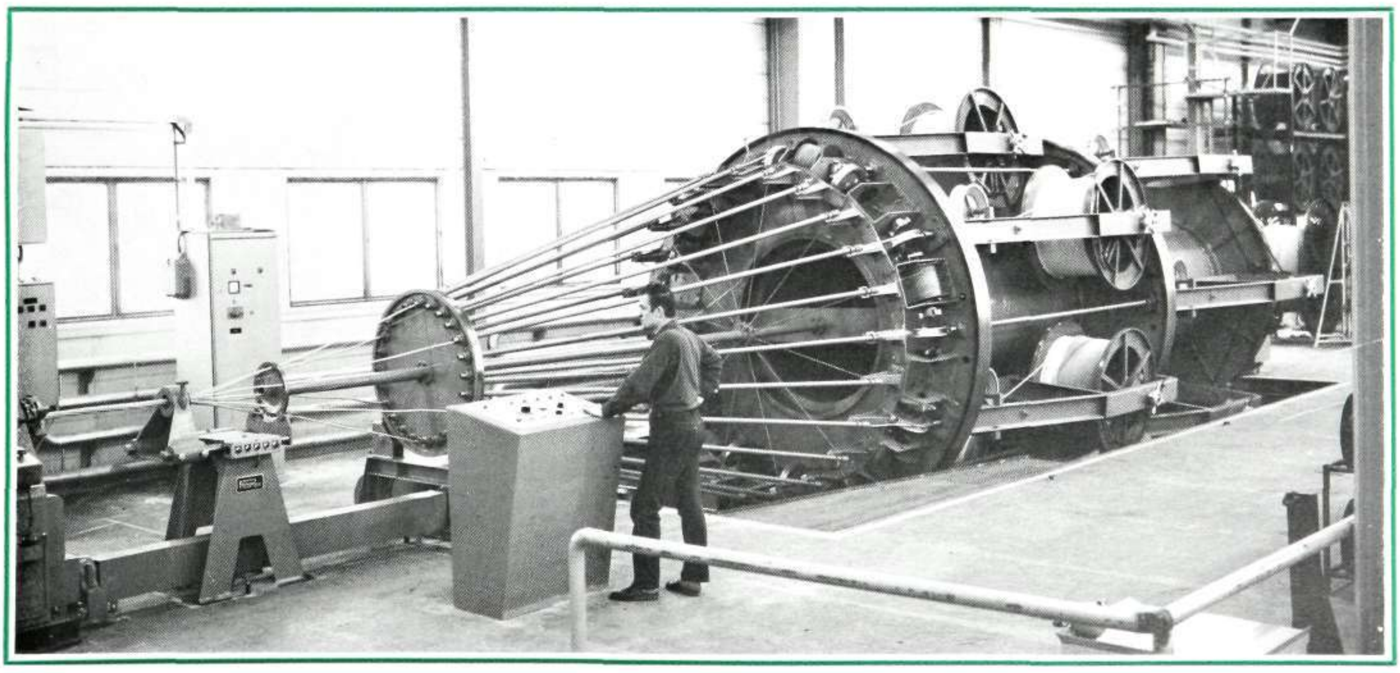
The object of the voltage measurements can be said to be to guarantee that the cable has satisfactory dielectric strength against induced overvoltages caused by lightning, power lines etc. Such measurements check that the coaxial pairs and other parts of the cable can withstand high voltages and meet high insulation requirements. Breakdown tests are carried out both with d.c. and a.c. voltages. The d.c. resistance of the coaxial pairs is measured accurately, because resistance measurements are extremely important, among other things for determining the cable temperature in the field and in connection with fault location.

The most important consideration regarding the carrier system is naturally how the cable behaves at high frequency, and then particularly as regards impedance, transmission attenuation, and return loss. The return loss is usually defined both by means of pulse measurements (pulse echo measurements) and steady-state (sine-wave) measurements (measurement of SRL).

The impedance is measured, in principle, in a Wheatstone bridge in accordance with fig. 8. As it is usual to combine the impedance measurements with pulse echo measurements, generator V is a pulse generator that sends out sine-squared pulses with a half amplitude of 10 or 50 ns. As a result of the propagation time of the pulse in the coaxial pair, a reproduction of the non-uniformities along the length of

Fig. 6

Stranding machine for laying up a maximum of 12 coaxial pairs in one operation. The picture shows the machine during assembly



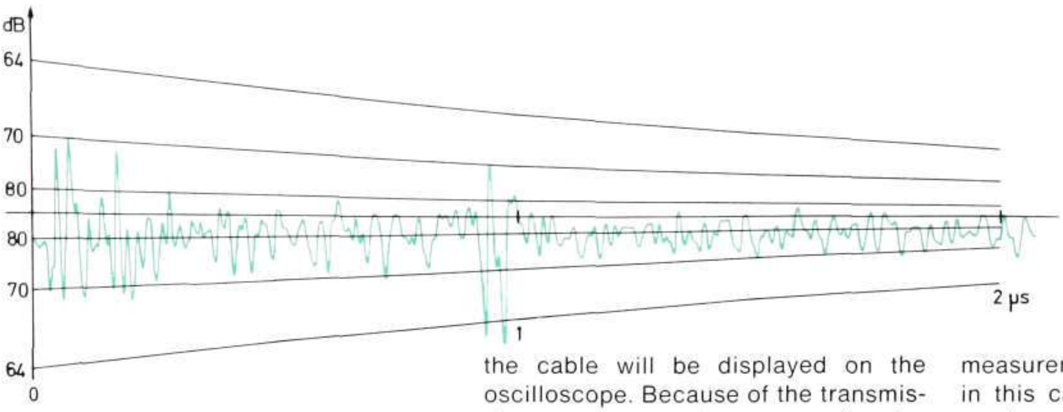


Fig. 7

Pulse reflection curve from a coaxial pair 300 metres long, measured with a 10 ns sine-squared pulse

Horizontal scale: 1 μs/approx. 145 m coaxial pair. The curve is not corrected for the transmission attenuation of the coaxial pair, but this is taken into account through the non-linear vertical scale.

Fig. 8

The principle of pulse echo and SRL measurements

The item to be measured (cable with termination) is compared in a bridge with a reference impedance. For pulse echo measurements the bridge is fed with pulses and for SRL measurements a sine-wave signal is fed in. The output voltage from the bridge is proportional to the cable reflection factor. An oscilloscope is used as the indicating device. Its X deflection is controlled by the time or the frequency respectively

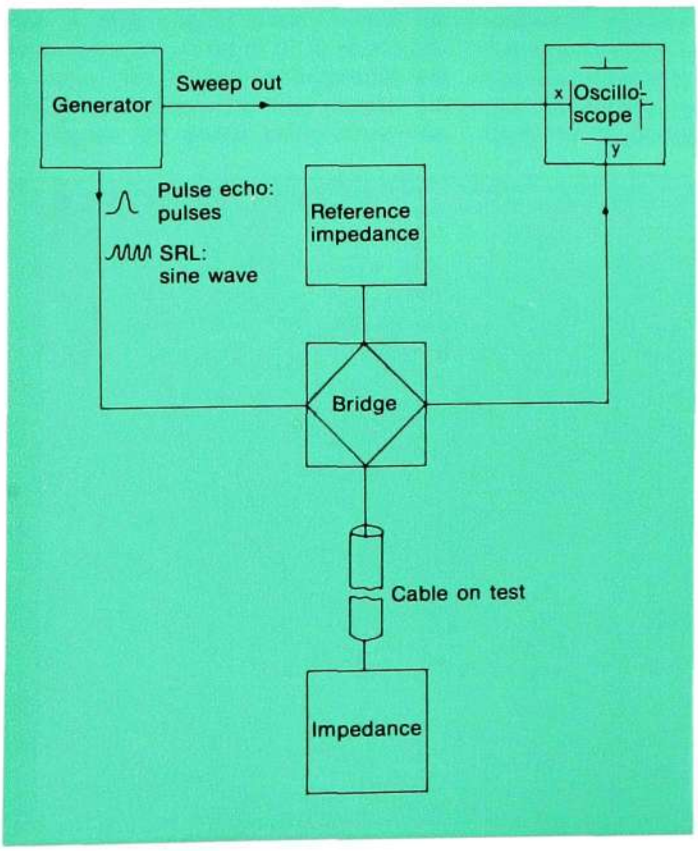
Fig. 9

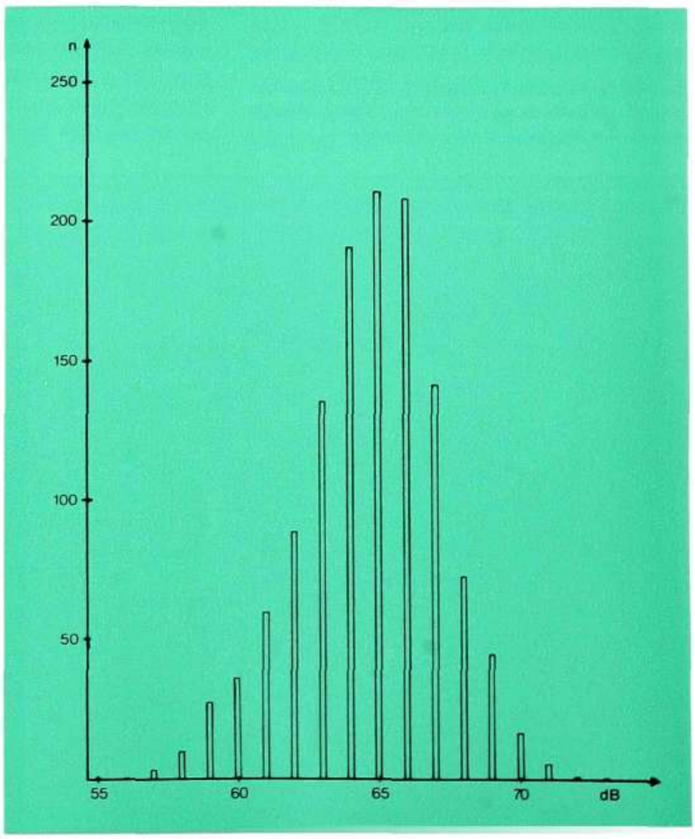
The worst pulse echo attenuation in a population of approximately 1,200 coaxial pairs at the time of delivery, measured with a 50 ns sine-squared pulse

the cable will be displayed on the oscilloscope. Because of the transmission attenuation, the greater the distance along the cable to the reflection points the lower will be the amplitude of the reflected pulse. Certain instruments contain automatic correction for this. Fig. 7 shows a curve on which a number of reflection points can be seen with reflections clearly above the basic "noise" level. (The attenuation is not corrected on this curve.) A "normal" value for the echo amplitude on a coaxial pair is −60 to −70 dB, i.e. 0.03—0.1 per cent of the transmitted pulse is reflected. The limit specified for the maximum permissible echo amplitude in a cable length is −52 dB. Moreover, the mean square value of the three largest reflections must be better than −56 dB. Fig. 9 shows the distribution of the worst echo amplitude in a population of approximately 1,200 coaxial pairs at the time of delivery.

Return loss measurements with a sine-wave signal (SRL measurements) can be carried out in principle in the same Wheatstone bridge as the pulse echo measurements. The difference is that in this case the bridge is fed with a continuous HF voltage at a frequency within the band it is desired to investigate. As this is a steady-state measurement the whole cable will show a standing wave pattern and it will not be possible to carry out a distributed reproduction on the oscilloscope. Instead the oscilloscope is used to display SRL as a function of frequency by allowing the generator to sweep over the whole frequency band. The sweep must naturally be slow enough to actually give a "stationary" oscillatory condition in the cable. As the whole cable contributes to the reflection value, normally a higher reflection value is obtained with an SRL measurement than with a pulse echo measurement. A typical value would be between −40 and −50 dB.

Fig. 10 shows the distribution of the worst SRL value in the band 4—60 MHz in a population of 72 coaxial pairs selected at random from the production, and fig. 11 shows an example of an SRL curve.





By transmission attenuation is meant the attenuation that the transmitted signal undergoes on its path along the cable to the receiver. It is usual to differentiate between the insertion loss, by which is meant the attenuation between a transmitter and a receiver having, in this case, an impedance of 75 Ω, and the image attenuation, by which is meant the attenuation between a transmitter and a receiver having the same impedance as the cable. Normally the difference is quite small, and in the Hudiksvall factory measurements are carried out as insertion loss measurements, in which the cable is compared with a precision standard, see fig. 12.

The transmitter power is divided up into two equal parts, one part for the cable and the other for the standard attenuator. A switch connects the cable and the standard attenuator alternately to he receiver. A difference meter, which is connected to the output of the receiver, shows the difference between the cable attenuation and the standard attenuation. In this way it is possible to interpolate between the smallest steps on the standard attenuator to a resolution of approximately 0.001 dB. However, the absolute accuracy of the system is only in the 0.01 dB class. A better accuracy can be obtained by measuring the attenuation at a number of frequencies in the relevant band and, using a computer and the least squares method, adapting a curve in accordance with

$$A = A_0 + A_1 \sqrt{F} + A_2 F$$

to the measured values.

An example of such a calculation is shown in fig. 13, from which it can be seen that, with 95 per cent confidence, A_1 and A_2 can be determined with an uncertainty of 0.5 per cent and 15 per cent respectively, even when the measurements are made at only a relatively few frequencies. It can also be seen that in this case the mean square value of the error of the individual measurements is 0.004 dB. As the attenuation varies by approximately 0.2 per cent per degree Celsius, the temperature of the cable must be known to very close

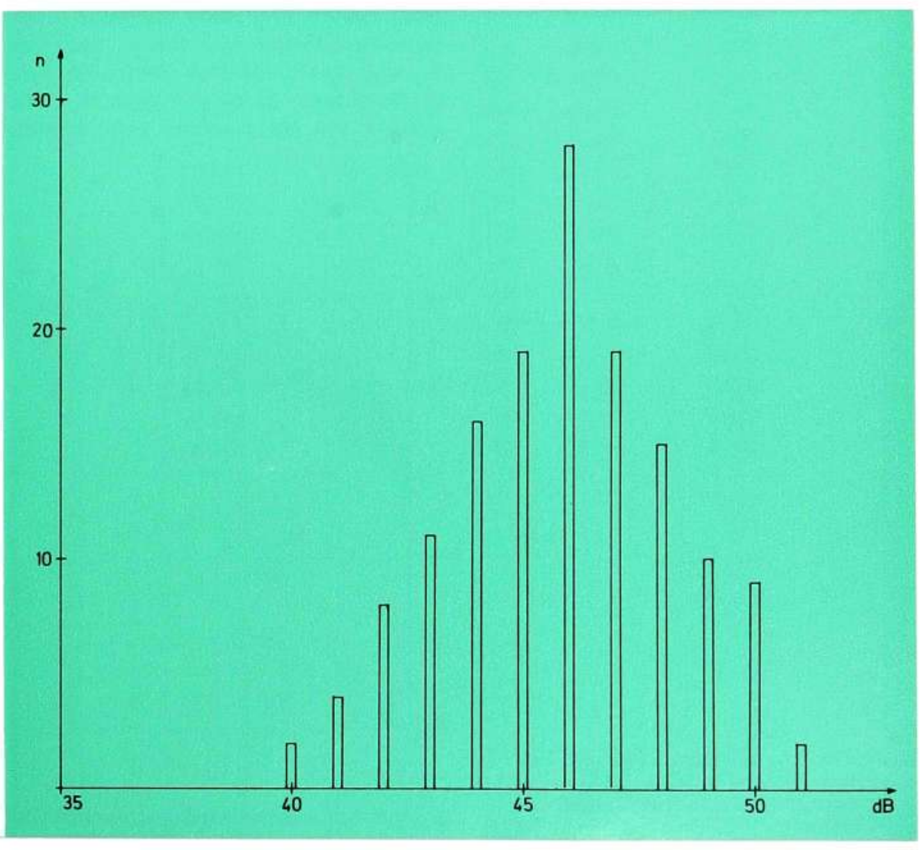


Fig. 10

The worst return loss for a sine-wave (SRL) up to 65 MHz for 72 randomly selected coaxial pairs that have been included in a trial laying. The values were measured after the laying. Measurements were carried out from both ends of the coaxial pairs

limits and must also be constant when the measurements are carried out. For this reason the measurements are carried out in a temperature controlled room (see the picture on the front cover).

Laying a coaxial cable in the ground

At the present time the Swedish Telecommunications Administration uses mainly the following methods for laying coaxial cables of the type discussed here:

— laying of unarmoured cables in concrete ducts or plastic pipes

— laying or running out armoured cable into dug or blasted cable trenches

— ploughing armoured cable into ground which is suitable for this method (arable land etc.)

In order to ascertain whether the laying had any detrimental effect on the transmission characteristics of the new coaxial cables, test lengths were used for measuring impedance, echo and SRL both before and after laying. A comparison between the curves recorded at the times of the measurements showed that, as in the case of older cables, the echo values were slightly better after laying. The SRL values were also somewhat better. For instance, it was discovered that a certain elastic deformation, no doubt caused by the winding up on the drum, had completely disappeared during the laying of the cable.

Certain phenomena regarding longitudinal relationships between the contents of the cable and the outer cover have been observed during the laying of the cables and are the subject of further study.

Crosstalk measurements have also been carried out in the field. The problem with such measurements has been that the test equipment available hitherto has not been sufficiently sensitive. The dynamic range of the equipment up to 100 MHz was about 170 dB and measurements were carried out on cable lengths of 300—500 m without any definite crosstalk being detected. Measurements have also been carried out in the factory up to 500 MHz on a 300 m length of cable with a dynamic range which gradually deteriorated from 170 dB at 100 MHz to 150 dB at 500 MHz, without any crosstalk being detected. Further measurements are now being made with an even greater dynamic range up to 100 MHz in order, if possible, to provide more reliable information.

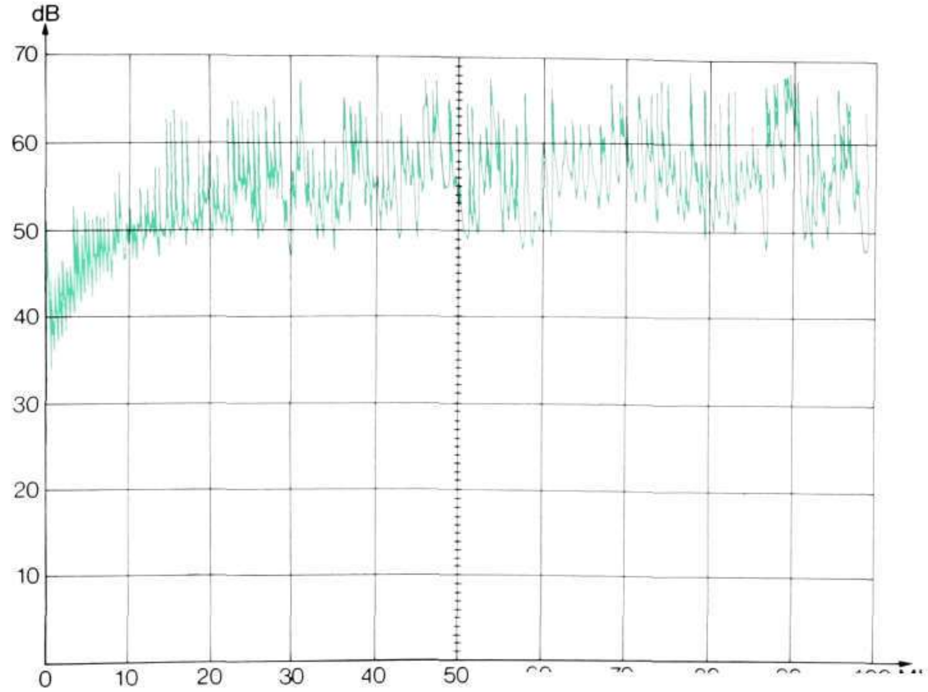


Fig. 11

SRL curve for a laid coaxial pair of 300 m. The poorer values at low frequencies are due to the fact that the reference impedance was a resistor

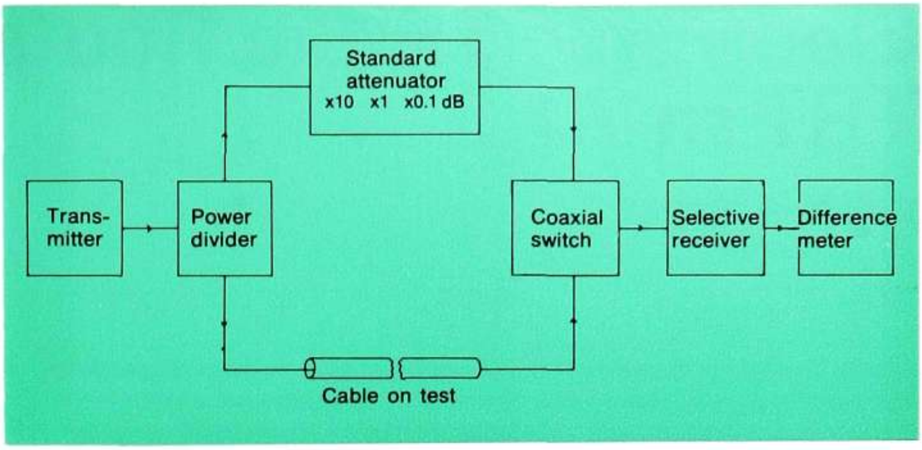


Fig. 12

The principle for the measurement of transmission attenuation. The cable is compared with a standard attenuator. The residual attenuation difference is read off on a difference meter

Future prospects

With the introduction of the 60 MHz system the transmission capacity of the telecommunications network has been increased considerably and it is unlikely that development will stop at this. Analog systems with bandwidths in the region of 200 MHz are already being studied. However, there is a frequency that it is not possible to exceed with a coaxial pair using discrete discs as the insulation. This is the limit frequency of some GHz, which is set by the fact that, because of the discs, the coaxial pair is actually a low-pass filter. Another possibility of increasing the transmission capacity above that of the 60 MHz system is the introduction of wideband digital systems. Such systems with bit rates in the order of 1 GHz are already being developed and at the same time theoretical and measurement investigations are being carried out to determine the characteristics of the new coaxial cable in the frequency range concerned. Bearing in mind the rapid developments in the digital field and the rapid introduction of digital systems into the telephone network, it is very probable that in the future we will have digital multichannel systems on coaxial cables.

F	A	A′	A—A′	$A'/\sqrt{F}$
3.158	7.000	7.000	0.000	2.379
4.127	8.000	7.999	0.001	2.378
6.452	10.000	9.999	0.001	2.377
9.301	12.000	12.003	−0.003	2.377
12.676	14.010	14.012	−0.002	2.377
16.530	16.000	16.001	−0.001	2.377
20.900	18.000	17.994	0.006	2.377
25.798	20.000	19.994	0.006	2.377
31.245	22.000	22.006	−0.006	2.378
37.195	24.010	24.014	−0.004	2.378
43.610	26.000	26.006	−0.006	2.379
50.524	28.000	27.997	0.003	2.379
57.995	30.000	30.001	−0.001	2.379
65.934	32.000	31.994	0.006	2.380

$A_0 = 0.014$
$A_1 = 2.369$
$A_2 = 0.0011$

$\sigma = 0.004$
$A_1K = 0.0004 \cdot T(12)$
$A_2K = 0.00007 \cdot T(12)$

Fig. 13

Computer calculation of the attenuation of a cable of 1.654 km, at a cable temperature of 20.0° C

- $A_0A_1A_2$ — constants in the attenuation formula $A = A_0 + A_1\sqrt{F} + A_2F$ per km of cable
- F — frequency in MHz
- A — measured attenuation in dB of the test length concerned
- A′ — attenuation in dB of the test length concerned as calculated by the computer
- A-A′ — measurement error + calculation uncertainty for the test length concerned
- $A'/\sqrt{F}$ — calculated in order to make it easier to show the deviations from the $\sqrt{F}$ dependency; per km cable
- σ — the mean square value of the (A-A′) values
- A_1K — half the confidence interval for A_1
- A_2K — half the confidence interval for A_2
- T(12) — t-distribution with 12 degrees of freedom ≈ 2.2 for 95 % double-sided confidence

Electronic Traffic Route Tester TRT m 70

Sven-Bertil Broby

A traffic route tester is an excellent aid for automatic and efficient supervision of the quality of service in telephone networks. It generates test traffic that is similar to normal subscriber traffic. Tests with a traffic route tester form an important part of L M Ericsson's modern maintenance method (controlled corrective maintenance). L M Ericsson's first traffic route tester[1] immediately proved to be extremely practical and time saving and hence has come into use on a large scale. Improvements are being made to the traffic route tester continuously. In the article the author describes the latest design, an electronic traffic route tester TRT m 70 with a memory that can be changed electrically, and which can be programmed from an electric typewriter.

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The electronic traffic route tester TRT m 70 can be used for checking the quality of service in a telephone network by means of generated test traffic of the same type as ordinary subscriber traffic. When the quality of service has fallen below a certain predetermined value an alarm is given, and it is only then that fault clearing is undertaken. In this way the maintenance costs are kept at an optimum low level.

The TRT m 70 enables the checks to be carried out even more simply and efficiently than hitherto because

— the flexible construction makes possible test programs of varying size and form

— the test program can be made very much more comprehensive and can be divided up into suitable phases during each 24-hour period. Different programs can be programmed in for a maximum of 99 days.

— the different phases for a 24-hour period can include different types of quality of service tests and special supplementary quality checks for tariff metering and a careful check of the transmission level

— the programming and changing of the program is carried out very simply from an electric typewriter with a tape reader and tape punch.

— the processed result is typed out on the typewriter, which can be remotely connected via a point-to-point modem circuit.

Design

The equipment is connected to the exchanges concerned in the same way as normal telephone sets, and among other things it is independent of the type of exchange. The switching paths are randomly selected, and convenient statistical analysis methods are used for processing the results.

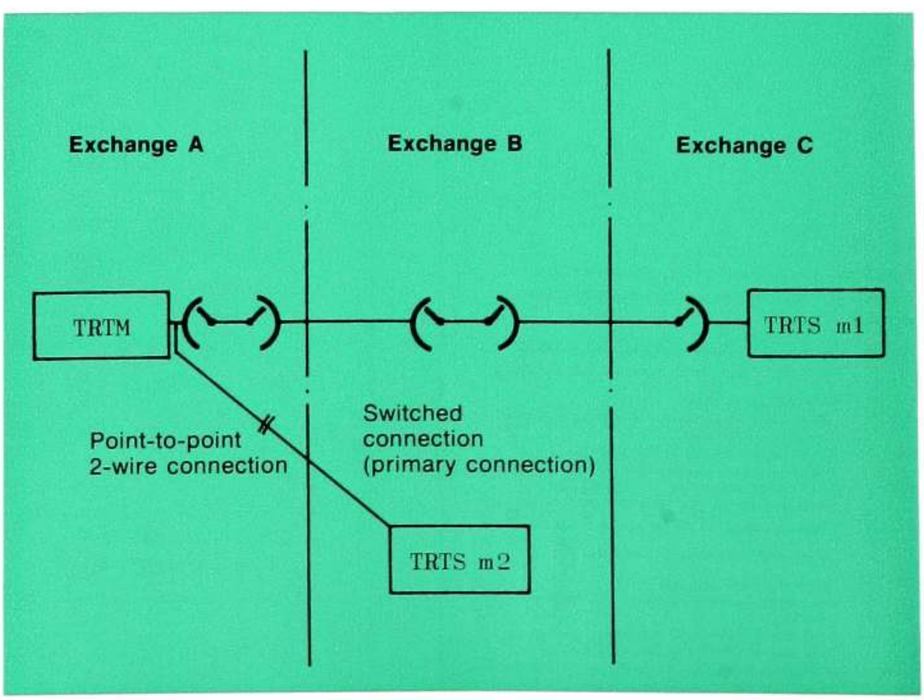

Fig. 1
Co-operation between the central and controlling unit TRTM and the terminating and traffic generating unit TRTS

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The test program can be made versatile and efficient because a large quantity of test numbers can be programmed. The traffic route tester includes the following three units which together cover all types of exchanges in a test area. The central and controlling unit TRTM which is placed in an exchange situated at the central point in the network. The combined terminating and traffic generating unit TRTS and the purely terminating equipment CA, which are placed in the remaining exchanges.

The test traffic from TRTS can be generated in accordance with two principles: with TRTS m 1 controlled by TRTM over a switched connection or with TRTS m 2 controlled over a point-to-point two-wire line, see fig. 1. As in both cases VF signals are used for signalling over the control connections, the connections can consist of cables, radio links etc. The switched connection to TRTS m 1 is called the primary connection and the tested connection from TRTS m 1 the secondary connection. All units are controlled by TRTM, fig. 2. All information regarding the test program to be performed is stored in the semiconductor memory MEM in TRTM. The program is loaded either from a tape reader or direct from a typewriter. CCITT alphabet no. 5 is used for communication in both directions.

A program consists of a number of sub-programs, which for example can comprise the tests of immediate interest from the given A test lines to the given B test lines in two or more exchanges. The number of A and B test lines included in a sub-program can be varied at will within the framework of the available storage capacity in MEM. For example, a sub-program can comprise 18 A and 60 B test lines with up to 1080 connections or 2 A and 3 B test lines

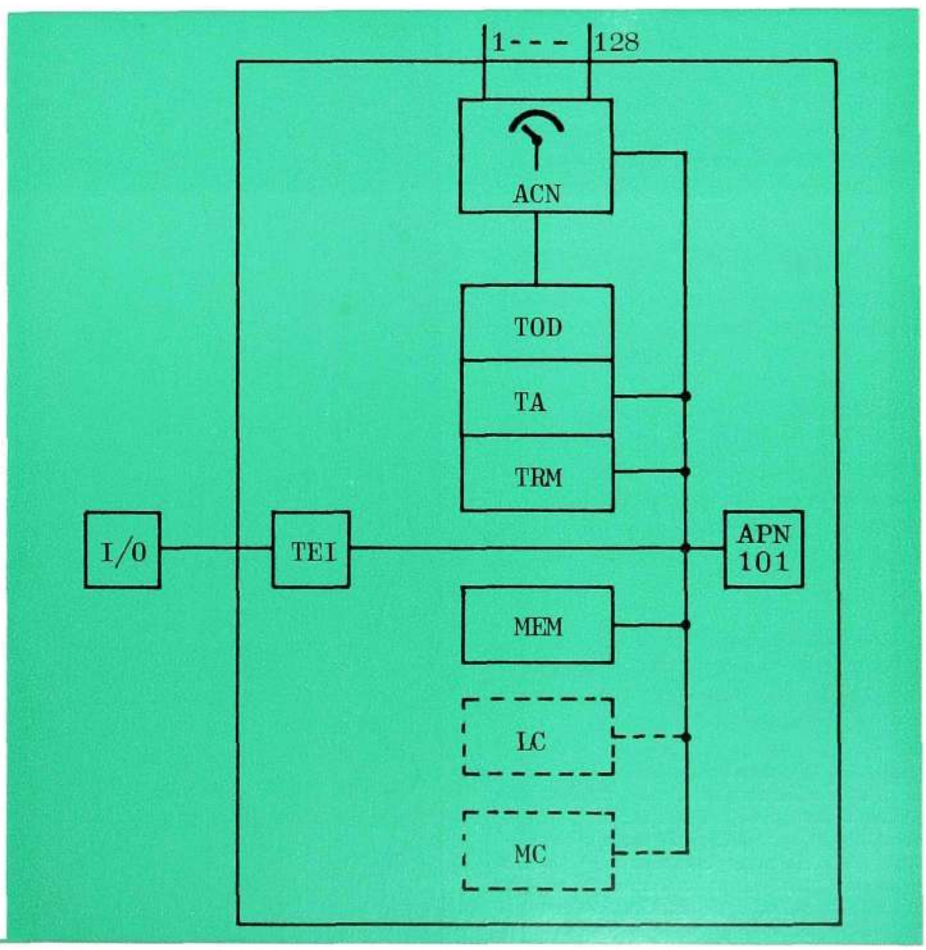


Fig. 2
Block diagram of TRTM

APN 101 Processor
ACN Access switch
TOD Tone detector
TA Tone analyzer
TRM Tone sender
TEI Terminal matching
MEM Memory
LC Transmission check (auxiliary equipment)
MC Tariff metering check (auxiliary equipment)

with up to six connections. Fig. 3 shows the relationship between the storage capacity, the number of test lines and the number of sub-programs.

The testing sequence is controlled by a processor APN 101 (fig. 2). The selected test line is connected via tone detector TOD to the tone analyzer TA by means of the access switch ACN. The tones sent out from the exchanges during a test connection are received by TA, which can check up to five different tones, including the tone from the code answering equipment CA, and can also ascertain whether they fail to arrive. Digits for setting up the test connection can be sent by dial impulsing or tone frequency key sending. The processor program is used to check that TA receives the correct tone in the different phases of the test connection. The test connection is approved or rejected depending on the outcome of the check. The tone transmitter TRM is used for signalling from TRTM to TRTS.

TRTS is built up in a similar way with access switch ACN to provide access to the required test line, a tone detector and tone analyzer and also a tone transmitter for signalling between TRTM, TRTS and CA. The processor APN 101 is also used in TRTS to control the logic sequence.

Test facilities and programming principles

In connection with tests for establishing the quality of service (including congestion) and the technical quality (excluding congestion), a check is made of the dialling tone, ringing con-

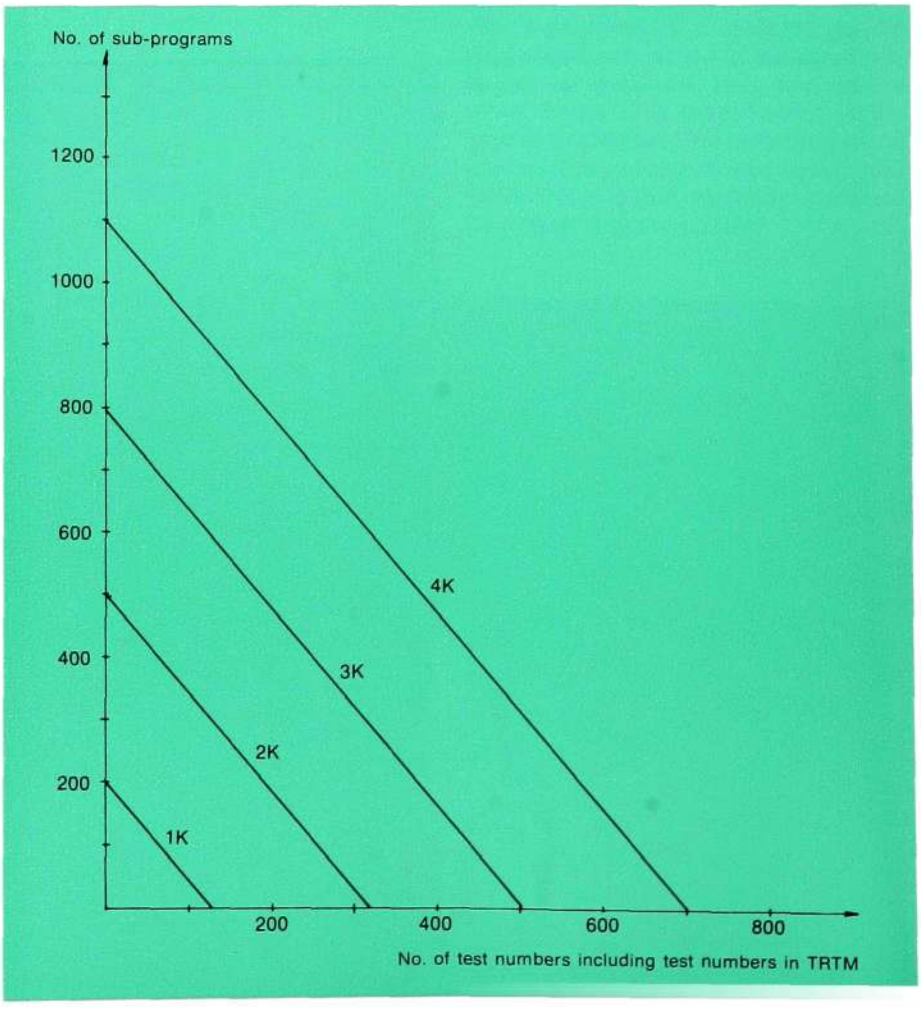


Fig. 3

Connection between the number of test numbers and the number of sub-programs with a certain storage capacity in MEM.
The storage capacity is given in steps of 1024 words (1K). The average number length is taken to be six digits. Shorter number length enables more test numbers to be included for the same storage capacity

Fig. 4

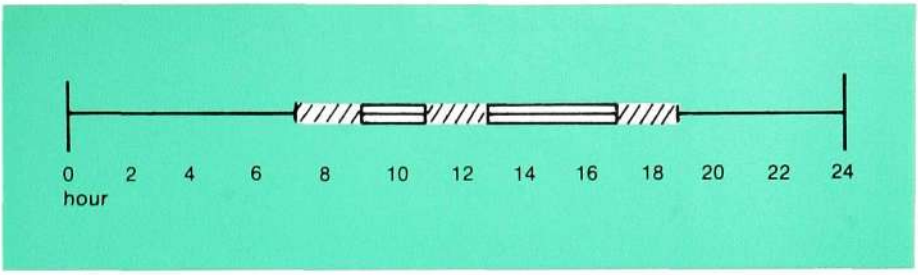
Example of insertion of the test programs in different time intervals.

The programs for checking the quality of service are included during the busy hour and those for checking the technical quality during the low-traffic time

Programs for checking quality of service

Programs for checking technical quality

Programs for special checks



trol tone, connection to the correct subscriber, signals and transmission level. The traffic route tester can also be provided with auxiliary equipment for checking the tariff metering and making a careful check of the transmission level. The programs for checking the quality of service are performed during the busy hour and those for checking the technical quality during low-traffic time. A certain number of sub-programs are dealt with during a fixed time interval in a 24-hour period. A program for the whole 24 hours is shown schematically in fig. 4. The composition of the program can be changed from day to day as necessary and a complete program for up to 99 days can be fed in at one and the same time.

Depending on the nature of the sub-programs they are dealt with in accordance with two different principles. Sub-programs for quality control (service and technical quality) are controlled completely by sequential analysis, while sub-programs for special checks give the result primarily as the total number of failures for a given number of calls and secondly in accordance with the sequential analysis method, which will be discussed in more detail later.

When an approved or not approved result is obtained for a sub-program for quality checking, the traffic route tester continues with the next sub-program of the same type. If a definite result is not obtained for a sub-program within the allotted time interval, the results obtained during the interval are stored and the tests are continued from a corresponding point when the sub-program is again connected in later on in another time interval. If the whole of a sub-program for special checks is completed before the allotted time interval is ended, the traffic route tester will stop and will not start up again until the next start time is reached. If a result in accordance with the sequential analysis method has been obtained before the end of the time interval, a print-out of the result will also take place.

The traffic route tester normally carries out quality or special checks. If any faults are discovered in the process they are recorded and printed out, while the test program continues. The traffic route tester can, however, be used for direct tracing of the fault, in which case the tester stops when a fault is discovered. The tester then gives a fault print-out and holds the connection until the fault has been traced, when a command is sent from the electric typewriter, whereby the traffic route tester goes back to the test connections.

The principle of the sequential analysis method mentioned earlier is made clear by fig. 5. After each connection TRTM then investigates whether it is possible to decide whether the sub-program in question is approved or not approved. If a decision can be made the processing of the program is complete, but if not, the investigation continues. It is possible to choose between a number of different characteristic curves, for sequential analysis. Each characteristic curve consists of parameters which determine the lines A and B and the positions of points C and D. More information about the sequential analysis method has been given in Ericsson Technics[2], in which G. Lind describes the supervision of the telephone network using statistical methods.

Contents of the program

The test program for the traffic route tester, which is stored in the memory MEM, includes

— *for each A test line:* information regarding the number of the line in TRTM or in TRTS m 2, the type of equipment to which the line is connected and whether tone frequency key sending or dialling is to be used

— *for each B test line:* information regarding any number that the line has in TRTM or in TRTS m 2, the type of equipment to which the line is connected and the subscriber number

— *for each sub-program:* which lines are to function as the A and B test lines, the type of sub-program, the number of times the sub-program is to be carried out or how many connections it is to carry out, any special checks required and the wanted characteristic curve for sequential check

— *for the whole test sequence:* the number of times it is to be carried out, the desired 24-hour program, the number of ringing control tones that are to be checked, whether quality or fault finding is required, the time for breaking off the test sequence and the characteristic curves for sequential analysis.

It is easy to add to, change or exclude a sub-program or test numbers because the program of the traffic route tester only needs to be changed in the affected part of the memory MEM. Moreover, each test line can be blocked without the necessity of erasing its memory information, which is an advantage, for example when a test line is faulty.

Operation and print-outs

As has been mentioned earlier, input and changes to the test program and also output take place using an electric typewriter and the connected auxiliary equipment consisting of a tape punch and a tape reader. The typewriter is connected to TRTM either direct or via a point-to-point modem circuit. Input of the program from the tape reader is approved only if the tape contains the same exchange code as is programmed in TRTM, otherwise the tape gives no result. A simple command language is used for communication with TRTM. Print-outs initiated by the operator are separated from those initiated by TRTM. All print-outs can be done either on the typewriter or on the tape punch.

Each test connection is registered on *statistical counters and sequential* analysis units. When a fault occurs, a print-out takes place giving the cause of the fault, the connecting phase when the fault was detected, the time and the A and B numbers. A print-out is made at each start and finish of a sub-program or when a sub-program is interrupted. The print-out contains information about the sub-program, the time and the content of the statistical counter. The result of a sequential analysis

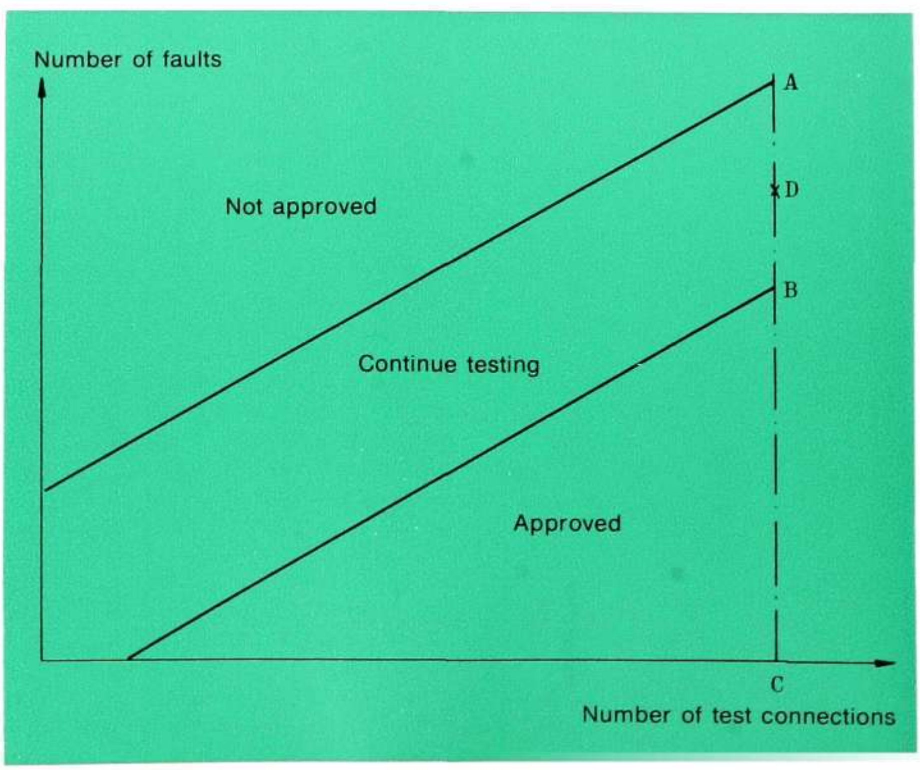


Fig. 5

Analysis of a sub-program

If the number of faults exceeds curve A the result is not approved.
If the number of faults is less than curve B the result is approved.
If no result is reached by the time the number of test connections has reached point C, the result is approved if the number of errors is less than point D and not approved if the number exceeds point D

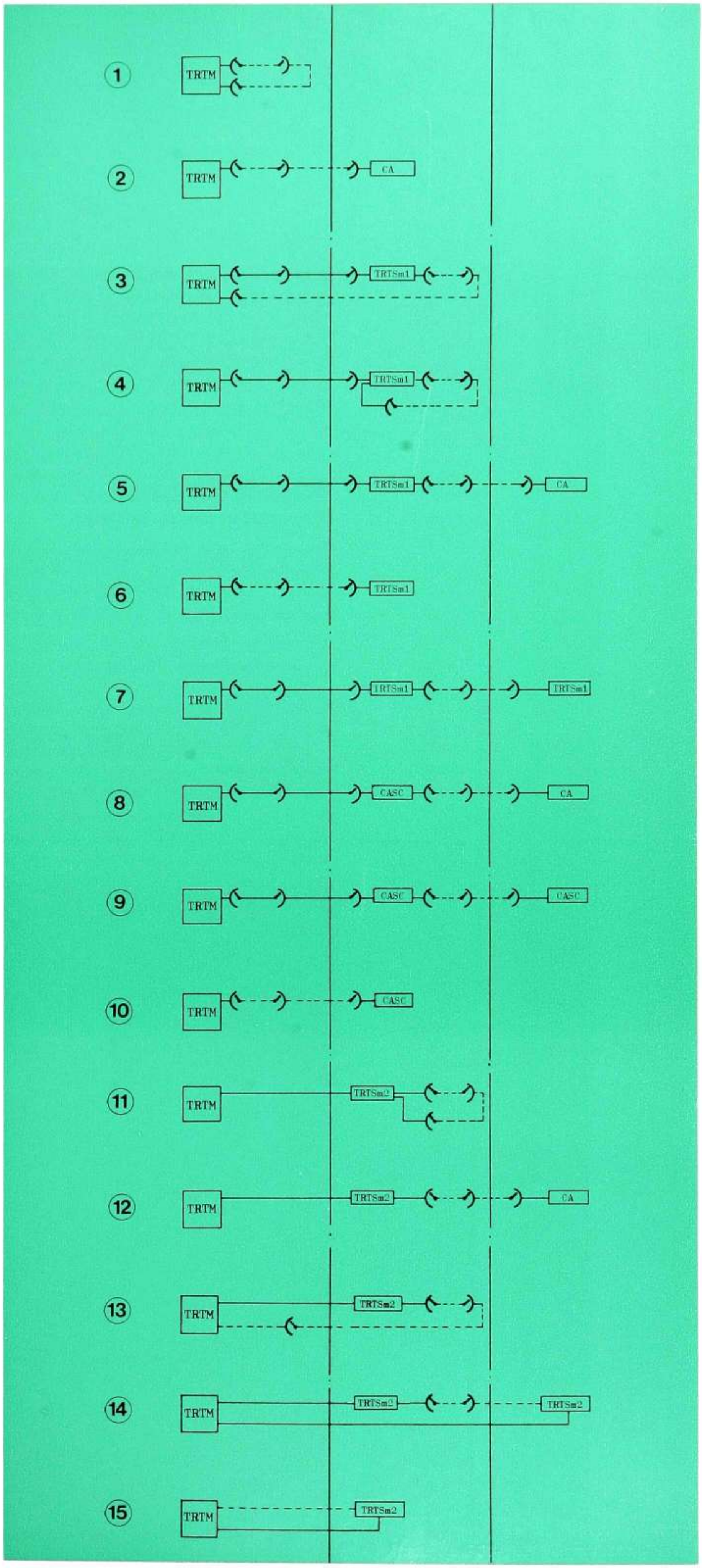


Fig. 6
Test facilities using TRT m70

Tested connection – – – – –
Control connection ————

is printed out as approved or not approved, with information regarding the number of connections and the number of faults. If TRTM discovers a fault in its own switching sequence a fault print-out is carried out giving the type of fault.

Examples of the use of the traffic route tester

The traffic route tester can be used for supervision of a large number of traffic routes. The following traffic categories can be tested, fig. 6.

a) Within TRTM's own exchange — case 1

b) From the TRTM exchange to another exchange — cases 2, 6, 10, 15

c) Within own TRTS exchange — cases 4, 11

d) From a TRTS exchange to the TRTM exchange — cases 3, 13

e) From a TRTS exchange to another exchange — cases 5, 7, 8, 9, 12, 14

TRTM can work together with older equipment of the CASC type and with code answer, which have been described in detail in Ericsson Review[3]. CASC has a similar function to TRTS and can thus initiate secondary connections controlled from TRTM. Unlike TRTS, however, CASC has permanently strapped information regarding the B numbers to which test connections are to be set up.

TRTM can be placed in, for example, the centre of the network, fig. 7, while TRTS equipment is included at subordinate exchanges. If it should be sufficient to be able to test to but not

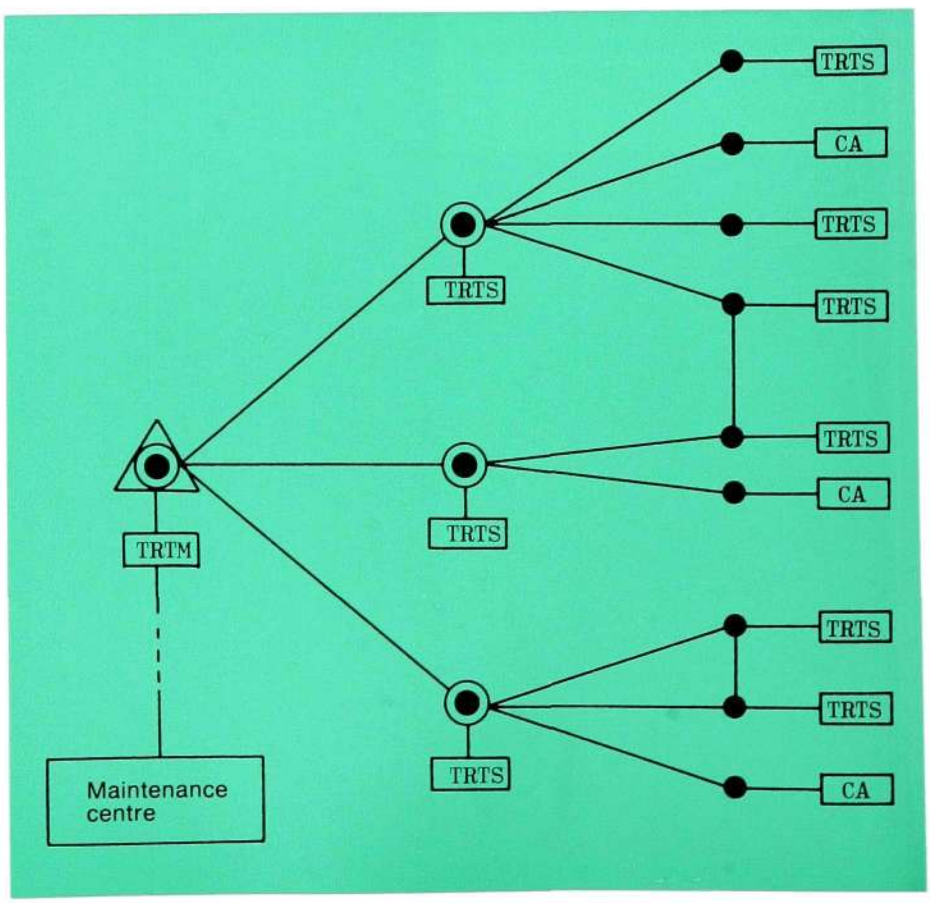


Fig. 7
Example of the use of TRT m 70 in a network

Capacity

TRTM		Building-out stages
No. of test lines	128	8
Length of the total program	99 days	
Coordination with TRTS m 2	16 TRTS m 2/TRM	
TRTS m 1 No. of test lines	40	8
TRTS m 2 No. of test lines	128	8

from an exchange, the exchange in question is provided with code answer equipment, CA. Internal traffic can be tested at all exchanges except those provided with CA equipment. Equipment TRTS m 2 should be used when the distance between TRTM and TRTS is so short that there are good technical and economic grounds for using a permanent two-wire line, otherwise TRTS m 1 should be used.

Components, mechanical design and power requirements

TRTM and TRTS are built up of integrated circuits and relays (in the access switch) mounted on printed circuit boards. The boards are mounted in shelves and the shelves are fitted in racks. The racks can have a height of either 1460 mm, in which case they only need to be fixed to the floor and in consequence are easy to move, or 2900 mm, when they must be installed in the normal way. In the latter case two TRTM units can be placed in the same rack.

The + 5 V and + 12 V voltages required by the equipment are generated by d.c. converters mounted in the rack. The converters are fed with either −48 V or −60 V from the exchange batteries.

Conclusion

To reduce maintenance costs to a minimum and at the same time maintain a good quality of service is an important goal for all telecommunication administrations. That this can be achieved with the aid of the traffic route tester is substantiated by, for example, an article published in Ericsson Review, "Six years' experience of CCM in the Rotterdam telephone district". To quote from this article: "As an example it may be mentioned that the time per line and year for maintenance in the local exchange at Dordrecht during 1971 was 0.075 hours".

As a result of the great improvements that have been incorporated in TRT m 70 compared with the earlier design, the role of the traffic route tester is now even more significant, because TRT m 70 can cover larger areas, carry out a greater variety of tests, be programmed for up to 99 days and change the 24-hour programs as and when required during these 99 days.

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Simulation of Telecommunication Traffic Systems

Magnus Anderberg and Knut Martin Olsson

*During the last twenty years simulation in computers has become an increasingly important aid in determining the traffic handling capacity of telecommunication traffic systems. The article gives the historical background and then describes how a simulation program is prepared. The relevant statistical problems are elucidated. The advantages and disadvantages of simulation as against analytical methods are discussed and also the possibility of combining these methods.**

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Historical background

During the last twenty years simulation in computers has come to play an increasingly important role in determining the characteristics of various systems. The simulated systems can concern quite different fields, such as national economy, industrial stores, air terminals and telecommunication traffic systems.

Briefly the simulation of a telecommunication traffic system can be said to mean creating a model of the real system in the computer and with the aid of random numbers imitating the calling process towards, and the seizures in, the model. By for example counting the total amount of calls offered and the number of lost calls, an empirical value for the probability of call congestion is obtained. This may be the only possible substitute for the analytical method of determining the theoretical value for the probability of congestion, a method which is often impossible to apply for complicated systems.

The method of using the relation between probabilities and relative frequencies in order to obtain a numerical estimate of an unknown quantity is not new. One of the earliest known instances is probably Buffon's needle game, which originated in the first half of the 18th century. The game is played with a needle of even thickness, which is thrown at random on to a horizontal board having a number of parallel lines at a distance from each other of twice the length of the needle. The number of times that the needle falls on a line is counted. Geometrical probability calculations give the value $1/\pi$ for the probability of hitting a line. This means that if, with random throws, the number of throws is divided by the number of hits, an empirical value is obtained for π. Experiments that were carried out seemed to confirm that this conclusion was correct and it was seriously proposed that in this *empirical* way more detailed determinations of π should be carried out than was possible with the imperfect *analytical* methods of that time. One could say that we are in an analog situation today as regards the study of complicated systems. Two published attempts to determine π with Buffon's needle game can be related.[1] In 1889 S. Levänen and his assistants made 30,000 throws and obtained the empirical value 3.14136. Twelve years later Lazzerini issued a statement that with 3,408 throws he had obtained the value 3.1415929, in which no less than six decimals are correct. We will return to these two experiments in the section "Statistical problems".

Simulation of telecommunication traffic systems has quite naturally only been carried out during modern times. The results of "manual" simulations have been published. By manual is meant that the only aids used were pen and paper and tables of random numbers. G. S. Berkeley has described such a simulation carried out within the British Post Office for the purpose of determining the congestion in gradings.[2] The holding times were assumed to be constant and randomness occurred only in connection with the determination of the calling times. Carrying out such a simulation on the basis of the constant holding time and the calling times acquired with the aid of random numbers involves a considerable amount of work for investigating seizures and releases of the equipment in the grading and the recording of any congestion. The method used contains a basic fault, in that there is a fixed number of calls during a fixed simulation period. As a matter of curiosity it can be mentioned that the tables of random numbers were obtained from the telephone directory, by noting the second from last digit in successive subscriber numbers.

The difficulties inherent in manual simulations led to work being started in many countries on the design of "traffic machines". The first traffic machine was completed as long ago as the late

* The character of the subject of this article is such that statistical terminology must be resorted to. The authors hope that even those readers who are not acquainted with statistics will get some conception of the importance of the simulation method in the study of telecommunication traffic systems.


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1920s[3], and several came into use during the following decades. Such a machine always contains equipment that is analogous to the system one wants to investigate. This equipment is usually quite specialized and allows only a limited number of variations. The traffic machine must also provide facilities for reproducing such stochastic elements as calling times and holding times. Most machines assumed constant holding times so that, as in the case of the manual simulation described above, randomness was only applied in connection with calling. In some machines the randomness was achieved by such physical random means as radioactive material or thermal noise. In the Swedish traffic machine, designed by Conny Palm and used jointly by the Swedish Telecommunications Administration and L M Ericsson, see fig. 1, the calling times were obtained with the aid of what may be called pseudo-random numbers. This concept is explained below. The Swedish machine was put into operation in 1953. It was only used for the simulation of gradings. Initially it was the intention to design the machine so that other systems, for example link systems, could also be investigated. However, these simulations were never realized. The machine was in use until 1964 and when it was taken out of operation more than 2,500 runs had been recorded. It was in frequent use, among other things in connection with the preparation of two doctoral theses.[4, 5] The machine has been described in detail in an article in TELE,[6] the magazine issued by the Swedish Telecommunications Administration.

Simulation in computers

A telecommunication traffic system can be regarded as a number of components which all interact in one way or another. If one wants to investigate the traffic handling capacity or reliability aspects of such a system, the first step is to describe the system by means of a model, in which only those components and conditions are included that are relevant in this connection. This applies regardless of whether the investigation is to be carried out by means of mathematical analysis or by simulation. The traffic machines mentioned in the previous section can be considered as physical models of the systems, whereas abstract models are used for analysis as well as for manual simulation and simulation in computers.

The changes in time that the states in a system undergoes can be described with a number of variables, which together constitute what is usually called a process. If one or more of

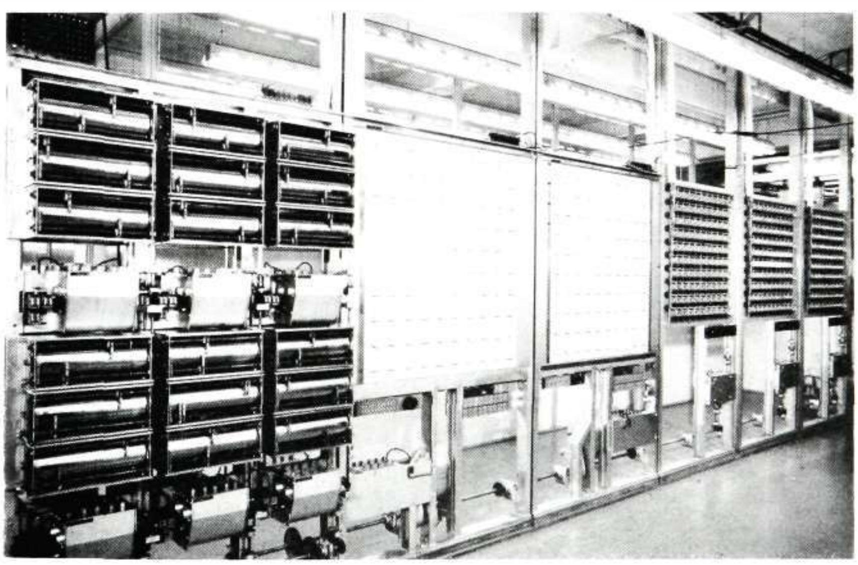


Fig. 1
A part of the Swedish traffic machine. The figure shows a rack containing call generators, millisecond meters and holding time generators

these variables are non-deterministic, i.e. they do not take a given value at a given time but instead, depending on some random element, take one of a number of possible values, the process is said to be stochastic. When setting up models for telecommunication traffic systems, only stochastic models are possible. In investigations of traffic handling capacity the stochastic elements are call intervals and holding times, and in connection with reliability they are quantities that influence the occurrence of faults and the repair times.

Before the work on building up a model is started, one must be quite clear as to what problems one wishes to solve. This greatly influences the structure of the model.

The first question that one is often faced with when building up a model is whether it is to comprise the whole system or only parts of it. For example, in selector networks where the connection to the various selector stages takes place successively, the stages can quite well be analyzed separately. However, this is not possible in those cases where connection is made through several selector stages simultaneously, i.e. conditional selection. Another question is whether the model is to include both the selector network and the common control equipment that is used mainly in connection with the setting up of calls. A model that includes both these is normally likely to give a better description of the system, but it may constitute a considerable complication compared to the alternative of two separate models.

In most cases nowadays it is possible to set up models that give a very good description of the function of a system, even when the requirements are rigorous. However, when it comes to solving the set problems by means of mathematical analysis one soon finds that exact solutions can only be obtained in exceptional cases. By introducing simplifying approximations it is sometimes possible to solve the problems by analysis without introducing significant errors. However, as the complexity of the telecommunication traffic system increases, this possibility becomes increasingly rare. In those cases where the problems cannot be solved by means of reasonable approximations, or where the consequences of such approximations cannot be foreseen, there always remains the possibility of solving the problems experimentally by means of simulation. Usually it is then not necessary to simplify the model to any great extent even if it has a very high degree of precision. For example, various forms of uneven loading, overloading or fault occurrences, which can be of considerable importance for the traffic handling capacity of a system, can be reproduced quite well in a simulation, which would hardly have been possible when attempting to find a solution by analysis.

Today almost without exception all simulations of telecommunication traffic systems are carried out with the aid of computers. The first published article that described such simulation was probably an article in Ericsson Technics in 1955.[7] Compared with the traffic machines a much higher degree of flexibility has been achieved. It is possible to study any system using one and the same computer, if a special program is prepared for each system. In the case of large systems it is of course assumed that the computer used has adequate storage capacity. Apart from greater flexibility, quite another speed is achieved with a modern computer. Nowadays a simulation of a grading that took 24 hours in the Swedish traffic machine can be carried out by a computer in less than a minute.

Most of the work carried out during a simulation can be considered as pure routine work, for example checking whether a device is free or engaged. As is well known, computers are very suitable for such routine work. The human effort can be concentrated on the often far from routine work of preparing the simulation program.

Generating random numbers

In the section dealing with traffic machines the existence of physical random devices was mentioned. Such devices are not used for simulation in computers. Instead, "pseudo-random numbers" are used exclusively. By this is meant numbers that have been obtained by means of purely deterministic calculations, but which exhibit such statistical properties as are to be found in pure random sequences.[8] As it is usual to generate a very large quantity of random numbers during a simulation, it is desirable to have a fast generation method available. However, it is far more important that the abovementioned statistical properties are obtained. As a sequence obtained by means of purely arithmethical operations must have a certain periodicity it is important that this is longer than the number of random numbers used in the simulation. The demand for randomness would not be satisfied if the same sequence of numbers is repeated. On the other hand the deterministic method of generating a sequence of pseudo-random numbers means that the sequence is reproducible, and this fact can be used to improve the statistical accuracy. We will return to this in the section "Statistical problems".

It can be shown that the generation of random numbers having a certain distribution can always be traced back to the generation of random numbers that have a rectangular distribution (uniform distribution) in the interval 0 to 1. Among the methods suggested for generating such numbers, the "multiplicative congruency method" is probably the predominant one today. In this method module multiplication is used, which is carried out in the following way. In order to obtain a number in the sequence, the previous number is first multiplied by a suitably selected, constant multiplier. From the product obtained the last bits are kept, the number of these being the same as the word length of the computer used (not including the sign bit). The multiplications are carried out in integer arithmetic and always result in a number in the interval 0 to 1 because a binary point is assumed in front of the first numerical bit.

In order that it shall be possible to consider a number sequence generated by means of deterministic calculations as equivalent to a sequence of independent random numbers having a rectangular distribution, the sequence must pass certain statistical tests.[8]

As has been mentioned above, it is possible to obtain numbers having another predetermined distribution function if a sequence of random numbers having a rectangular distribution is available. This is done by calculating, using the random numbers with rectangular distribution as the argument, the inverse function that corresponds to the distribution function. This means, for example, in the case of the negative exponential distribution that the logarithm of the numbers having a rectangular distribution is calculated and the (always negative) sign changed.

In a simulation it is often necessary to generate integers in a given interval with equal probabilities. This can always be brought back to the following fact. If one multiplies a random number having a rectangular distribution by an integer, N, and only the integral part of the product is used, one will obtain with equal proabilities one of the integers between 0 and $N - 1$. An integer obtained in this way can be used, for example, to select with equal probability one subscriber out of a group of subscribers. Another frequent use of such a number is as an index when one wants to make a random selection from a table. The values in the table can, in their turn, consist of a probability distribution in numerical form.

Designing a simulation program

Programming can be said to mean the conversion of the model in question into a language that the computer can understand. A program for simulation of a telecommunication traffic system contains, in principle, the following main parts:

- one for reading data, by means of which diverse variable system parameters are determined, such as the amount of traffic or the number of devices in a certain stage in the system.
- one that is analogous to the system and in which the traffic is generated and the switching of calls through the system is controlled. This part usually constitutes the greater part of the whole program.

— one for collection of statistics, in which for example counting of lost calls, calculation of the waiting times that have arisen or measuring of the traffic handled is carried out

— one for printout of the results obtained.

The above will be illustrated by a very simple example: a group of devices with full availability, arranged as a loss system.

The call intervals are assumed to be independent, having a distribution function designated *A*. The holding times are assumed to be independent of each other and of the call intervals, and as having the distribution function *B*. These two distribution functions are assumed to be given in numerical form. The lines are hunted sequentially.

The result wanted from the simulation is the congestion. The input data consists of the distribution functions *A* and *B*, which are stored in tables in the memory, the number of lines *N* and the number of calls *M* that the simulation is to comprise.

The memory contains a special cell, designated *KL*, in which the times at which the successive calls occur are to be found. At the start of the simulation *KL* is 0 and it is increased successively by the call intervals selected at random from the table for *A*. The *N* lines are each represented by one cell. These cells have been brought together in a table designated *L*. Line number *K* is reached in the program by the address *L(K)*. During the simulation the cell contains information as to the time when the line in question will become free or last became free. Each time a line is seized a number, which consists of the contents of *KL* increased by a holding time selected at random from the table for *B*, is written into the corresponding cell. In order to determine whether a line is free at the instant a call is made it is only necessary to compare in a loop the contents of *KL* with the contents of the line cells, fig. 2. As soon as a free line is found, a jump is made from the loop to that part of the program where the new release time for the found line is calculated and written into the corresponding cell. If the loop is run through *N* times without any free line being found, a part of the program is reached where the contents of a cell, *SPR*, increases by 1. After *M* calls have been simulated the ratio *SPR/M* is calculated, after which this congestion value is printed out.

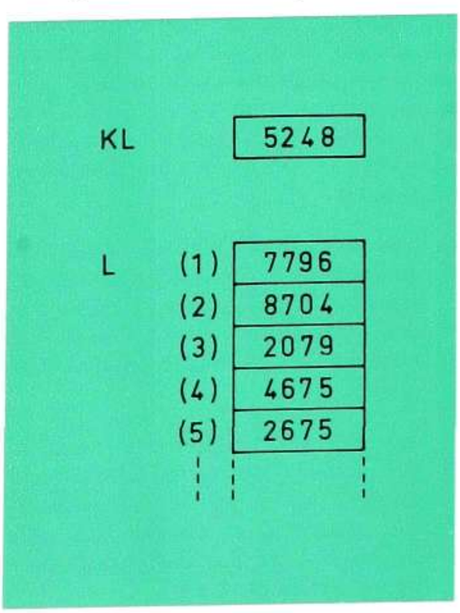
Simulation of a link system, which contains several stages, can in principle be carried out in the same way. However, in this case there is the additional choice of paths between the various stages. If the system is symmetrical, it is often possible, by suitably numbering the various links, to obtain the numbers of the links over which hunting is to be carried out in a certain stage as simple functions of the numbers of the links that were occupied in previous stages. In those cases where this is not possible, it is necessary to convert the hunting rules into numerical form. This information can be held unchanged in the program. However, it is more usual to design the program to provide the possibility of variation, so that the information in question is specified for each run of the program and then read in as input data.

It is often possible to assume, with good approximation, that the call intervals and holding times in the system to be investigated have an exponential distribution. This applies primarily for systems in which the dominating load consists of conversation times. In such cases the simulation can be arranged in a special way, which often means a considerable saving of both time and storage space in the computer. The method means that, with the given assumptions, it is not necessary to generate times for the individual events, and instead the sequence of changes of state is studied without regard to the times at which the changes take place.[9, 10]

In order to illustrate this method, let us again consider the simplest possible example: a group of *N* devices having full availability. We assume that the call intensity has the constant value *y*, and that the holding times have an exponential distribution with a mean value that we select as the time unit. It can then be shown that if at one in-

Fig. 2

The value 5248 denotes a calling time. Lines 1 and 2 are released at times 7796 and 8704 respectively. Line 3 was released at time 2079, and hence this line, being first in the hunting order, will be seized by this call



bability that the next event to occur will be a call or a call disconnection is $y/(y + p)$ and $p/(y + p)$ respectively. The simulation can then be carried out in the following way.

During the course of the simulation the number of engaged lines, p, is recorded in a cell. A random number having a rectangular distribution is generated. If this is between 0 and $y/(y + p)$ the contents of the cell are increased by 1 unless the contents equal N, in which case congestion is recorded. If the random number is greater than $y/(y+ p)$ then contents of the cell are instead reduced by 1, see fig. 3.

If one wants to supplement the congestion count obtained in this way with for example measurements of the states of the system, this can be done in the following way. The choice between two alternatives described above is changed to a choice between the three possibilities call, call disconnection and measurement. The interval is then divided into three parts that are proportional to y, p and a quantity g, designated the measurement intensity. Depending on in which part of the interval the generated random number falls, we obtain a call, call disconnection or measurement. In the last case the number of devices engaged at the measuring instant is recorded in a table, the contents of which are converted to relative frequencies and printed out when the simulation is completed. The measuring method described corresponds to measurements on a real group of devices, in which the measurement intervals are allowed to be random in accordance with an exponential distribution with the mean value $1/g$. This seems unlikely ever to occur in practice. It can be shown, however, that this measuring method gives unbiassed results.[11]

The method described here can be said to mean, from the mathematical point of view, that a Markov process in continuous time is studied by simulation of the Markov chain inbedded in the process, supplemented by random measurements.* The method can obviously be used in more complicated cases than that described above, and it is probably the most common method used in connection with simulation of large selector networks. In these cases it is necessary, as in the case of the previously described "time-true" simulation, that rules concerning the choices in the various selector stages are included in the program.

A great advantage of the Markov chain method, compared with time-true simulation, is that there is no need to record the times when the separate links are released. It is sufficient if, during the course of the simulation, one has recorded for each link whether it is engaged or free. Only one bit is required for this, for example 0 for a free link and 1 for an engaged one. It is thus possible in a single word to collect information about the condition of as many links as there are bits in the word. In time-true simulation one word is required for each link, which can mean that in the case of large systems the core memory will not be sufficient.

Statistical problems

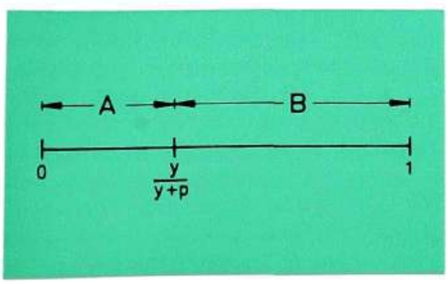
When attempting to determine a probability value empirically, by means of the statistical repetition method, one must realize that this method contains an inaccuracy that depends only on the number of eperiments, a "threshold value". For example, if one tried to determine the probability of "heads" by making only two throws with a coin, the only possible results are 0, $1/2$ and 1. Thus the smallest change that the test result can undergo is $1/2$, which constitutes the threshold value in this case. As a general rule the threshold value is $1/N$ with N repeats. When giving a probability value that has been determined empirically, the number of decimal places included should never go beyond the first decimal in the threshold value that is not zero. If the division is not even, a value having any number of decimals can be obtained, but in view of the threshold value there is only a limited number of decimals that have any real meaning.

Let us, from this point of view, take a look at the experiments mentioned at the beginning of the article for determining empirically the value of π with the aid of the needle game. With 30,000

* A Markov process is characterized by the fact that the probability for the future development is dependent only on the present state and is independent of how this state was reached.

Fig. 3

In order to determine whether the next event will be a call or a call disconnection, a random number with rectangular distribution is generated in the interval 0 to 1. If the number is in the interval A a call is connected, otherwise a call is disconnected



throws the relative threshold value is about 0.0001, and thus the answer should be given only to four decimal places. The number of hits with 30,000 throws that gives the most favourable values of π is 9,549, which gives 3.14169, and 9,550, which gives the value 3.14136 obtained by Levänen. Thus it is quite obvious that Levänen was extremely lucky. With 3,408 throws the relative threshold value is approximately 0.001, and hence, from the point of view of measuring technique, not more than three decimal places should be included in the empirical value 3.1415929.

The above discussions will of course also be valid for the values obtained from a simulation. If this consisted of approximately 1,000 calls, the congestion value obtained should not be given to more than three decimal places. As the congestion values often lie in the area around a few tenths of one per cent, this means that the threshold value is of the same order of magnitude as the congestion value. However, the number of calls in a simulation is usually in the region of 100,000, and hence the threshold values are relatively small. Of greater importance is the fact that the values obtained from a simulation are to be considered as samples and therefore have statistical inaccuracies. Thus a value obtained by simulation can never be considered as exact. At the very most one can say that a measured congestion value will fall within a given interval with a certain measured probability, for example: "With offered traffic of 100 erlangs this system has a congestion value that, with a 95 % degree of confidence, lies in the interval 0.9 % to 1.1 %." In order to make such statements one must know the statistical variation of the quantities that are obtained in the simulation. As a simulation is usually resorted to because it has proved impossible to calculate a desired value by analytical means, in general it can be said that the possibility of calculating analytically the variations that occur in connection with the simulation constitutes a problem with at least the same degree of difficulty. For this reason one should ensure that the simulation results are obtained in such a form that they can be used for estimating the statistical accuracy. To enable this to be done, one of the first measures is to divide up the whole simulation into a number of stages and to print out the result of each stage separately. Instead of one congestion value determined from 100,000 calls one can thus obtain 10 sub-results, each determined from 10,000 calls. By studying the variation between these 10 values it is possible to express an opinion as to the accuracy of the mean value obtained[12], fig. 4.

The accuracy can be improved by using simple formulas from what is known as the regression analysis. It is not only the congestion values that vary from stage to stage, but also (because of the randomness) the amount of traffic in the various stages. Thus it should be possible to explain a part of the congestion variation by a functional relationship between congestion and traffic offered. If the approximative assumption is made that the congestion, in the usually relatively small area of variation for the traffic offered, is a linear function of this quantity, confidence limits for the congestion can be set that are often considerably narrower than if the functional relationship is disregarded[13].

Another field in statistics that is used in this connection is sequential analysis. When studying a system, the main question is often how large a traffic the system can be loaded with for a given congestion value. Formerly this question was answered by first estimating the traffic offered and then carrying out a simulation. If the congestion value thereby obtained was too far from the desired value, a new simulation was carried out using a new traffic value, which was selected taking into consideration the previous result. This procedure was then repeated until an acceptable result was obtained. When applying this method it is almost inevitable that the initial traffic value will contain a certain error. The greater this error, the greater should be the possibility of discovering it at an early stage of the simulation and thereby avoiding an unnecessarily long run. The problem is apparently analogous to the one that occurs in statistical quality control. By using the sequential analysis method for use in this field, in combination with a simple method for calculating a new value for the traffic offered, it has been possible to reduce the required computer time to a not inconsiderable extent[14].

One method for increasing the statistical accuracy of simulations, which has been studied recently, is the use of what is known as antithetical random numbers[15]. This can be done in different ways, one of which will be described here. Instead of carrying out a one-stage simulation of for example 10,000 calls, two runs of 5,000 calls each are made. If the sequence of random numbers with a rectangular distribution that is generated during the first run is designated $\{R_i\}$, the sequence of corresponding random numbers in the second run may be given by $\{1-R_i\}$. The marked negative correlation that is then obtained between the random sequences gives a more or less marked negative correlation between the congestion values obtained from the simulation. If the mean of the results of the two runs is calculated, a result is obtained that is unbiassed and often has less variance and hence greater statistical accuracy than the result that would have been obtained from a single simulation comprising 10,000 calls.

As was mentioned previously, when estimating the traffic handling capacity of a system it is usually the conditions under statistical equilibrium that are of interest. However, a simulation usually starts with an empty system, which means that unless suitable measures are taken there will be a systematic error in the congestion values obtained. In order to eliminate this error as far as possible, the simulation is started with a transient stage during

Fig. 4

Example of computer printout from a simulation. As can be seen, apart from mean values the confidence intervals for the quantities determined by the simulation are also obtained

```
ROUTE NO.  8

    NO. OF CIRCUITS          10

    AVAILIABILITY            10

    NO. OF STAGES             3

    CONGESTION               0.2241   (0.1979 - 0.2502)

    NO. OF REJ. CALLS       670

    OVERFLOW TO ROUTE NO.     2


                              MEAN VALUE  ( CONF. INT.)      VARIANCE  ( CONF. INT.)     NO. OF CALLS

     DIR. OFF. TRAFFIC: INPUT        10.00
     DIR. OFF. TRAFFIC: MEASURED     10.07  (  9.58 -  10.56)   10.47  (  8.76 -  12.19)        2990
     TOTAL OFFERED TRAFFIC           10.07  (  9.58 -  10.56)   10.47  (  8.76 -  12.19)        2990
     CARRIED TRAFFIC                  7.88  (  7.71 -   8.04)    3.39  (  2.84 -   3.94)        2320
     OVERFLOW-TRAFFIC:  TOTAL         2.19  (  1.79 -   2.60)    4.76  (  3.78 -   5.74)         670
     OVERFLOW-TRAFFIC:  CARRIED       2.19  (  1.79 -   2.60)    4.76  (  3.78 -   5.74)         670
```

which no statistics are recorded. In order to make this stage as short as possible, the program can be designed so that during this stage, or at least the beginning of it, all disconnections are eliminated and thus the conditions that usually exist with statistical equilibrium are obtained more rapidly[12].

Combining simulation and analytical methods

When investigating a system it is not normally a question of whether simulation or mathematical analysis should be used. As far as possible one should utilize a combination of both. The system may be such that certain quantities can be determined exactly by analytical means, whereas this is impossible for other parameters in the system. A simple example of this is given below.

In a group of devices with full availability, arranged as a delay system, the effect of certain technical apparatus on the delay time distribution was to be investigated. Equipment that would ensure queueing in strict order of arrival would be fairly expensive. In order to avoid a more or less random handling of the queue there was the possibility of using technical apparatus designated "gates", which constituted a compromise between an ordered queue and a queue served at random. The more gates used, the closer would be the approach to the conditions of an ordered queue. In the example the calling intervals and holding times could be considered as being well described by a negative exponential distribution. The fraction of the calls that were delayed and the average delay time was not affected by the queueing discipline and could be calculated with the well-known Erlang formulas. However, there is no analytical method for determining the distribution of the delay time in a system with several gates. Hence the simulation program was designed so that as soon as one queue had been cleared, the next event that occurred was automatically a new call, which resulted in the forming of a new queue. In this way the simulated process was prevented from ever being in the states where there was no delay, i.e. states the analytical description of which is well known. For a run of the simulation program that would have resulted in for example 10 % delayed calls, it was thus possible to reduce the number of simulated calls to one tenth of the number that would have been required if the whole process had been simulated, and this was done without losing any information that was of interest for the particular problem.

In the example described above, a great saving in the required computer time can be said to have been achieved by simulating only that part of the process that could not be treated analytically. Computer time can also be saved when simulating systems having a certain symmetry. In this case the saving is obtained because one run is able to provide all the information required for calculating, with the aid of simple recurrence formulas, the congestion of the system for various values of traffic offered. Using this method not only is the total congestion determined, but the simulation also gives a sequence of congestion values as a function of the various states of the system. One case in which it has proved possible to use this method is homogeneous gradings having a rotating starting point for the hunting.

As has been mentioned previously, when studying a system it is sometimes possible to introduce simplifying assumptions, which make possible approximate analytical solutions. A serious difficulty is how to determine the accuracy of the approximation. Often the best way of answering this question is to simulate the system. If it is found that for an adequate number of parameter combinations there is good conformity between the approximate solution and the simulated results, the approximate solution can also be used with confidence for other parameter combinations. It is often possible to save computer time in this way, especially if the study involves a large number of parameter combinations. Good approximate solutions for many important problems have been achieved, for example, by using combinatorial analysis and moment methods[16, 17]. It must be emphasized that the value of cided only if it is possible to obtain a clear estimate of the degree of approximation.

Summary

The grade of service offered the subscribers in a telecommunication traffic system is dependent on both the traffic offered and the design and dimensioning of the system. By making measurements on systems in operation it is possible to make direct observations of the service and often also correct it by means of changes in the dimensioning. However, it must be considered as a necessity to be able to estimate the traffic handling capacity before the system is taken into service. This applies even at an early stage in the design, for example in order to be able to make a choice between different conceivable alternatives. These estimates must be based on mathematical analysis or simulation, or a combination of the two methods.

In connection with the international teletraffic congresses (ITC), held every third year, contributions are published that deal with such subjects as simulation of telecommunication traffic systems[18].

Hitherto, descriptions of the traffic have been based mainly on assumptions regarding random traffic. It must be considered as desirable, however, that if possible more realistic traffic models are set up in which consideration is paid to such phenomena as variations in call intensity and the repetition of unanswered or lost calls or calls where the B-subscriber was engaged. When estimating the traffic handling capacity of a system, using these more general assumptions, the use of simulation is likely to become of greater importance.

The dominating costs in connection with simulation are programming costs and the cost of computer time. In order to reduce the former, special computer languages are already available for simulation programs. Further specialization in this field would seem to be desirable, with direct application to telecommunication traffic systems, especially delay systems.

For reducing the cost of computer time, methods should be sought that will increase the efficiency of the simulation programs. Finding new methods of variance reduction should perhaps be the primary aim. In this context advanced mathematical-statistical analysis can play an important role.

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WORLDWIDE NEWS

Maintenance conference 1974 – the 14th and largest

During the last week in May 79 delegates, representing 28 telecommunications administrations and 21 countries, assembled in Stockholm for L M Ericsson's Maintenance Conference — the fourteenth to be held since the conferences began in 1956.

Just over fifty papers were read, covering a wide range within the fields of operation and maintenance of telecommunication plant. This can be illustrated by some examples of the subject groups and the papers that were presented.

- Organizational and staff questions were dealt with in a part of the conference devoted to "Human Factors" in, for example, a paper read by Mr G. Moot from APO, Australia, entitled "The Effect of Human Factors on some Aspects of Australian Post Office Maintenance Operations" and also in a paper by Mr T. Larsson from the Swedish Telecommunications Administration with the title "Productivity—Results Pay—Cooperation —Service (PRS)".

- Operation and maintenance of telephone exchange equipment was the subject of several papers among which may be mentioned "Maintenance and Operation of an International Network" by Mr R. Button, IMTR, Great Britain, which dealt with the maintenance and operational aspects of large networks and exchanges.

The Netherlands contributed two papers, one by Mr J. A. Hamers, "Experiences of AR-systems in the Netherlands", and the other by Mr J. J. M. Spoorenberg, "Experience from the Operation of Rotterdam DC II", in which an account was given of two and a half years' operation of a stored-program controlled exchange (AKE 13).

- A whole day was devoted to cable questions. Mr J. Carlemalm, Swedish Telecommunications Administration, spoke about "Rationalization of Installation and Maintenance Operations for Cable Networks in Sweden" and Messrs I. Broberg and B. Balkstedt each read a paper as an introduction to a visit to the Stockholm telecommunication area and the cable tunnels under Stockholm.

L M Ericsson contributed a number of papers dealing with various fields. Two that attracted particular attention were the papers presented by Dr C. Jacobæus, "Some Problems within the Telecommunications Field" and Mr B. Svedberg, "Systems Development at the Telephone Exchange Division".

An account of the Swedish Telecommunications Administration's experience of TVP supervision of network zones was given in a paper read by Mr E. Strömberg entitled "Experience of Centralized Service Supervision".

- Transmission questions were discussed in the group called the T group. The discussions were based on five papers. Four of these dealt with experiences from system lines for FDM systems and PCM systems. The fifth contribution was devoted to aspects of the selection of electronic components suitable for use in transmission equipment. The discussions illustrated that FDM transmission equipment has undergone a gradual improvement in several respects and has attained a high degree of reliability.

The last discussion point concerned the detective work carried out by the component section of L M Ericsson's Long Distance Division, where reliable component types are separated from those that are not so good.

All those taking part in the discussion were agreed that carefully selected components are necessary in order to produce equipment that satisfies the reliability requirements of the various administrations.

- Three papers were read within the group discussing subscriber equipment questions (the GN group). Mr G. Olausson from the Swedish Telecommunications Administration provided some information about the methods adopted to market and introduce multi-line telephone sets. This was followed by a paper from L M Ericsson dealing with the analysis of fault statistics for DIALOG telephone sets and a shorter contribution about operation and maintenance of PABX equipment with the intention of encouraging a discussion and obtaining views regarding centralized maintenance. The resultant discussions indicated that the administrations wanted some form of alarm transmission to a central point but that this information should be of a limited character.

- The problems of maintenance and fault finding in electronic exchanges of the future were also touched upon very briefly.

The maintenance conference 1974 with delegates from English-speaking telecommunications administrations

Hans Thorelli In Memoriam

Hans Thorelli, L M Ericsson's former Vice Managing Director, died on the 4th August.

Hans Thorelli was born in Stockholm in 1893 and was thus 81 when he died. In 1914 he obtained a degree in electrical engineering at the Royal Institute of Technology. He then attended ASEA:s two-year training course, after which he worked for one year as a planning engineer with Söderbloms Gjuteri AB, a foundry at Eskilstuna in Central Sweden. During the years 1917—1923 the worked for firms in Germany and the USA.

In 1923 he joined L M Ericsson. At that time L M Ericsson's first automatic exchange in Sweden with 500-line selectors was being installed at Norra Vasa exchange in Stockholm, and it was here that he first came into contact with the type of work that was to be his sole interest for many years to come.

During the ten years that followed, Hans Thorelli travelled widely as inspector and chief of L M Ericsson's installation activities. The new 500-line selector system found a good market in several countries. Many were the installation foremen, installers and young engineers who, with Hans Thorelli as chief, were abroad putting 500-line selector exchanges into operation in, for example, the Netherlands, Spain, Russia, Poland and Italy. During his frequent visits to the installation sites he won great respect for his immense capacity for work and his great knowledge.

In 1931 Hans Thorelli was appointed chief of the Exchange Division and in connection with the reorganization of 1933 he became Works Manager for L M Ericsson's Stockholm factory. He held the latter post until 1935, when he was appointed Assistant Manager. As direct assistant to the managing director he was then responsible for questions concerning foreign manufacturing companies within the Ericsson Group.

In 1938 Hans Thorelli was given the assignment of directing the technical planning of L M Ericsson's new factory. He also served as Works Manager until the transfer to the new factory took place in 1940. He was then appointed Chief Engineer with the task of coordinating the LME factories both in Sweden and abroad from the technical and manufacturing technical points of view. In 1949 he was appointed Vice Managing Director. He resigned on reaching retiring age in 1958 but for several years after this he was at the disposal of the Managing Director for special assignments.

Hans Thorelli applied himself energetically to all tasks that he undertook. Numerous memoranda, notes and tables bear testimony today to the thoroughness with which he analyzed all problems. His efforts towards a rational production and administration were indefatigable, but at the same time he always showed a deep interest and warmhearted feeling for the people in the organization.

Despite the fact that it is now many years since Hans Thorelli retired from active service, his achievements and his name are still fresh in the memory of many employees both in Sweden and abroad.

Malte Patricks

Ericsson do Brasil, the Quinquagenarian that is getting threefold capacity

Some of the inauguration guests by the side of a commemorative plaque, which was unveiled in connection with the inauguration in June of two new factories in Eugenio de Melo, São José dos Campos, where Ericsson do Brasil are building on a site of 613,000 m². From the left, the mayor of the town Sérgio Sobral de Oliviera and Dr. Salvador Julianelli, chairman of São Paolo's legislative assembly. To the right of the plaque, the Minister for Communications in the federal state São Paolo Dr. José Meiches and the Federal Communications Minister Euclides Quant de Oliviera.

Ericsson do Brasil, the Ericsson Group's subsidiary company in Brazil, is to almost treble its present capacity during the next few years.

The vast expansion program, which is in the process of being carried out in this now fifty-year-old company, comprises the building of a number of new factories, a reinforcement of the administrative and technical staffs and an increase in the resources for the company's training activities. The program reflects the economic growth of Brazil, which has been very substantial during the last ten years, especially during the latter half of this period, when the gross national income increased by on average 10 per cent per annum.

The importance of good telecommunications was appreciated at an early stage by the Brazilian authorities. At the present time the telecommunications administrations are in the middle of an extensive expansion program which entails the installation of almost ten million public lines by 1982. This should be considered in relation to the fact that today the total number of telephone sets in the country is less than three million.

L M Ericsson's activities in Brazil date back as far as the last century — the first order was received in 1891. For over thirty years marketing was in the hands of agents, before L M Ericsson in 1924 established its own sales company, the present Ericsson do Brasil, which nowadays has a comprehensive manufacturing program, over 6,000 employees and an invoicing which last year amounted to 384 million Swedish crowns (about US $85 million).

News from Finland:

• On July 1st, Finland's Minister of Transport, Pekka Tarjanne, inaugurated the automatic telephone traffic from Finland to the other Nordic countries and the Federal Republic of Germany. The traffic is routed by L M Ericsson's crossbar switch exchanges, type ARM, in Helsinki.

• The stored-program controlled telephone exchange technique made its official debut in Finland on May 24th this year, when an L M Ericsson AKE 13 local transit exchange was inaugurated in Abo, for the town's Telephone Company. The exchange, which has an initial capacity of 5,600 multiple positions, was put into service about two months before the inauguration.

At about the same time a small number of lines were connected in to the AKE 13 exchange in Helsinki, which was ordered by the Post and Telegraph Administration, for national and international traffic. The initial capacity of the exchange is 5,400 multiple positions and extensions for a further 9,600 have been ordered.

• Apart from this centre, the Post and Telegraph Administration have ordered another AKE 13 for Helsinki, for national and international traffic. The exchange is to be put into service starting in 1978 and the initial capacity will be 11,400 multiple positions.

• Helsinki Telephone Association have ordered an AKE 13 local transit exchange with an initial capacity of 4,000 multiple positions for the local traffic within its network zone. It is to be taken into service in 1976.

The inauguration of automatic long distance traffic from Finland on July 1st 1974. Minister of Transport Pekka Tarjanne calls his colleague, Cabinet Minister Bengt Norling in Stockholm. To the right: V. A. Johansson, Director General of the Post and Telegraph Administration

Railway signalling equipment for 80 million SKr for Taiwan

As a part of its comprehensive electrification program, the Taiwan Railway Administration has ordered railway signalling equipment for approximately 80 million Swedish crowns (approximately US $18 million) from L M Ericsson. The order is the largest that the company has ever received for this type of product. The equipment is to be delivered over a period of four years and will be manufactured mainly in Sweden.

Competitors for the signalling part of the project were the American General Electric and the British GEC. L M Ericsson received a Letter of Intent in January this year and negotiations were completed in April.

The total project, in which the signalling equipment forms a part, comprises the electrification of the 1,000 kilometer long main line Keelung-Kaohsiung, including the purchase of electric locomotives and electric motor coach trains.

During the last ten years L M Ericsson have delivered railway signalling equipment to Taiwan on a large scale. The current order consists mainly of signalling safety equipment, line blocking system, Centralized Traffic Control (CTC) of the new electronic type JZA 700, equipment for automatic train control (ATC), line cable, VF telegraph equipment and certain modifications to plant delivered earlier.

When the whole of the Taiwan Railways modernization project for the main line in question along the west coast of the island is completed in 1978, the travelling time between the two towns Keelung and Kaohsiung will be reduced from six to four hours.

30 000 new PABX lines in Australia

L M Ericsson Pty Ltd have received one of the largest PABX orders ever to be placed by the Australian Post Office.

Within a year 160 PABXs with crossbar switches are to be installed in Australia. This corresponds to about 30,000 new lines. The significance of this figure is best appreciated when it is realized that the total number of PABX lines installed in Australia during the last year was about 60,000.

L M Ericsson have manufactured PABX equipment in Australia since 1961.

Orders for 160 million SKr from Indonesia

L M Ericsson have received orders from the Indonesian oil company Pertamina Indonesien to a value of 106 million Swedish crowns (approximately US $33 million). The orders comprise telephone exchange equipment, PABX equipment, telephone sets and telex equipment.

New factory in England for Thorn-Ericsson Ltd

Thorn-Ericsson Telecommunications Ltd, a company owned jointly by Thorn Electrical Industries and Telefonaktiebolaget L M Ericsson, are to build a new factory at Scunthorpe in north-east England. The production will consist primarily of PABX equipment. The flow of orders on the English market for private branch exchanges of L M Ericsson design is expanding substantially, and during the last twelve months the value of orders received has exceeded 70 million Skr (approx. US $15.5 million).

The Netherlands:

New Head Office and a new factory

In the Netherlands, the Minister of Transport and Communications T. E. Westerterp has inaugurated a new Head Office and factory building, each covering an area of 3,000 square metres, for L M Ericsson's wholly-owned subsidiary company in the Netherlands, Ericsson Telefoonmaatschappij, situated at Rijen in the southern part of the country.

During the opening ceremony a special telephone connection was established. The Dutch Minister spoke from the rostrum via a push-button telephone set to the PABX computer, which is installed in L M Ericsson's office buildings at Bollmora, outside Stockholm. The computer, which gives a spoken answer, was provided with a special inaugural program in Dutch for the opening ceremony at Rijen.

The Ericsson Group

With associated companies and representatives

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2. L M Ericsson Telemateriel AB
1. AB Rifa
1. Sieverts Kabelverk AB
1. Svenska Radio AB
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1. Sales company with manufacturing
2. Sales and installation company
3. Associated sales company with manufacturing
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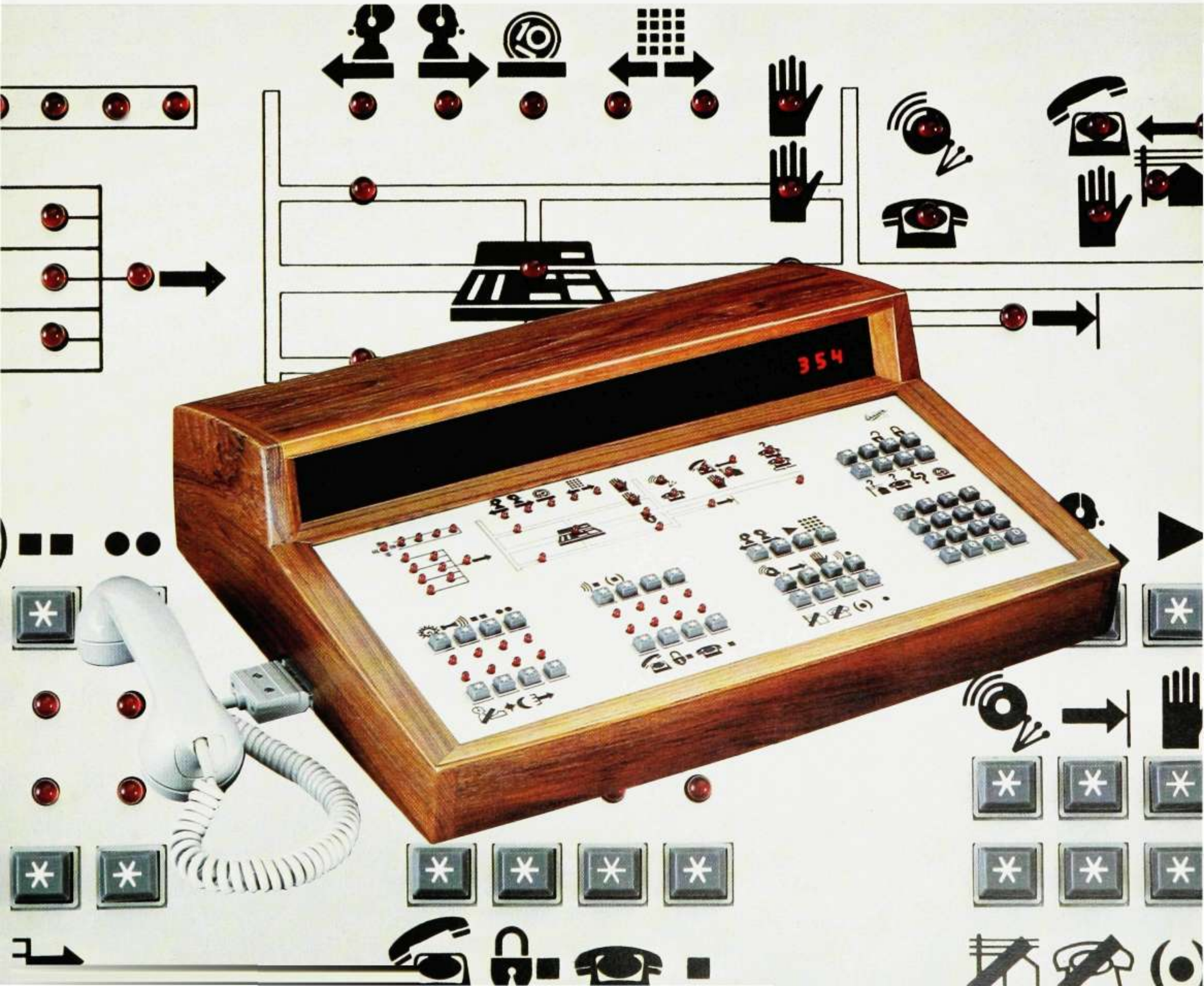
5. Other company
6. Other associated company
7. Technical office

TELEFONAKTIEBOLAGET LM ERICSSON

ERICSSON REVIEW

DEVELOPMENT OF THE TELEPHONE NETWORK IN EGYPT
ELECTRONIC PRIVATE BRANCH EXCHANGE
POWER SUPPLIES FOR ELECTRONIC TELEPHONE EXCHANGES
NEW FIELD TELEPHONE SET
WORLDWIDE NEWS

4 1974



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Contents

COVER

Operator console for electronic private branch exchange. The panel is provided with symbols instead of text making the same version at the console suitable for use in all countries.

Development of the Telephone Network in Egypt

Mokbel El Badrawy

Arab Republic of Egypt Telecommunications Organization, ARETO, is responsible for all public telecommunication services in Egypt. This article will deal with the development of the telephone network in the country, how L M Ericsson's local and trunk transit crossbar exchanges offering toll ticketing were introduced, and how a domestic factory manufacturing L M Ericsson's crossbar exchanges on a licence basis is gradually growing up into a large-scale interprise.

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First automatization

The first automatic telephone exchange of type Rotary 7 A was put into service in Cairo in 1929. Several exchanges of the same type have since been installed in Cairo and Alexandria, which today have about 102 000 and 40 000 Rotary lines respectively.

Automatic exchanges of other types were also gradually installed in some other towns. Six of them are still in service, one being an L M Ericsson 500-line selector exchange with a capacity of 2 000 lines, which was installed in Suez in 1951.

Introduction of LM Ericsson crossbar systems

Up to the end of the 1950's the telephone network was not greatly developed. There were only a small number of local automatic telephone exchanges and the trunk traffic was handled entirely manually.

After the revolution in 1952, however, the industrialization of Egypt increased rapidly, and with it the standard of living. This created demands for a faster increase in the number of automatic telephone lines offering modern facilities and for automatization of the trunk traffic.

ARETO therefore studied all modern telephone systems available on the world market and prepared the technical specifications for an international invitation for tenders. This comprised seven local exchanges totalling 44 000 lines and seven trunk transit exchanges for fully automatic handling of trunk traffic and using toll ticketing for charging of trunk calls. The invita-

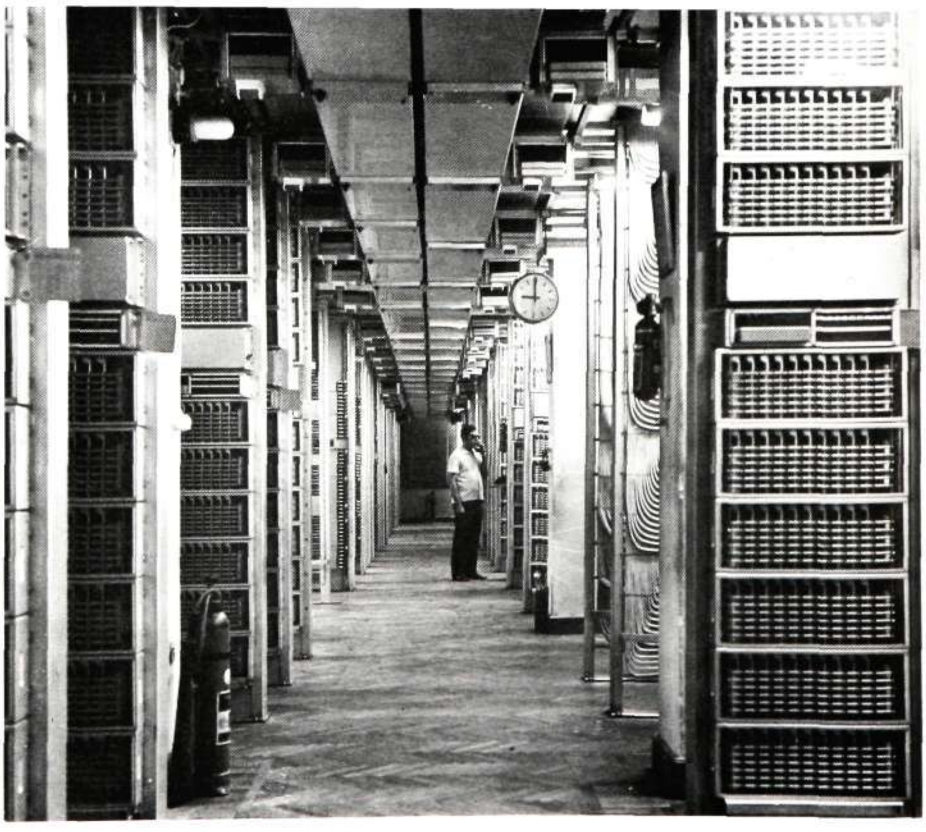

Fig. 1
Automatic crossbar exchange system ARF 102 in Abbassia

MOKBEL EL BADRAWY
Director General, Egyptian
Telecommunications Organization

tion for tenders also prescribed that the successful tenderer should grant a licence to an Egyptian Governmental Factory for domestic manufacture of the offered telephone system.

After extensive technical and financial investigations the contract, which contained exchanges of crossbar type, ARF 102, fig. 1, for local traffic and ARM 20 and ARM 50 for trunk traffic, was awarded to L M Ericsson in 1959.

Among the reasons for ARETO's decision were that this crossbar system is flexible and offers all modern features, that it has proved to require a minimum of maintenance, that it interworks smoothly with other systems, that it is suited for toll ticketing and that it is especially suited for local manufacture.

This initial contract with L M Ericsson was then followed by another order covering 21 new exchanges, to be installed in important towns all over Egypt, and the extension of two exchanges in Cairo. Since then much equipment has been ordered, mainly from the domestic factory.

Toll ticketing and MFC signalling systems

Egypt has played a prominent role in the field of toll ticketing and was one of the first countries outside the USA to introduce this system. In fact the toll ticketing equipment designed and supplied by L M Ericsson to ARETO was the first of its kind to be delivered by this company.

Originally toll ticketing was used for all automatic trunk traffic. However, in order not to load the equipment unnecessarily, ARETO has decided to use multimetering for all zone traffic as soon as this traffic is converted to automatic operation. This will probably be carried out first in the Cairo zone. Toll ticketing will then only serve trunk traffic between zones.

Originally punch-card machines of type IBM 526 and 523 were used for the recording of the TT information, but it was then necessary to insert new cards every few hours. There was also the problem of transporting the cards from the different exchanges to the computer centre at Cairo, and this

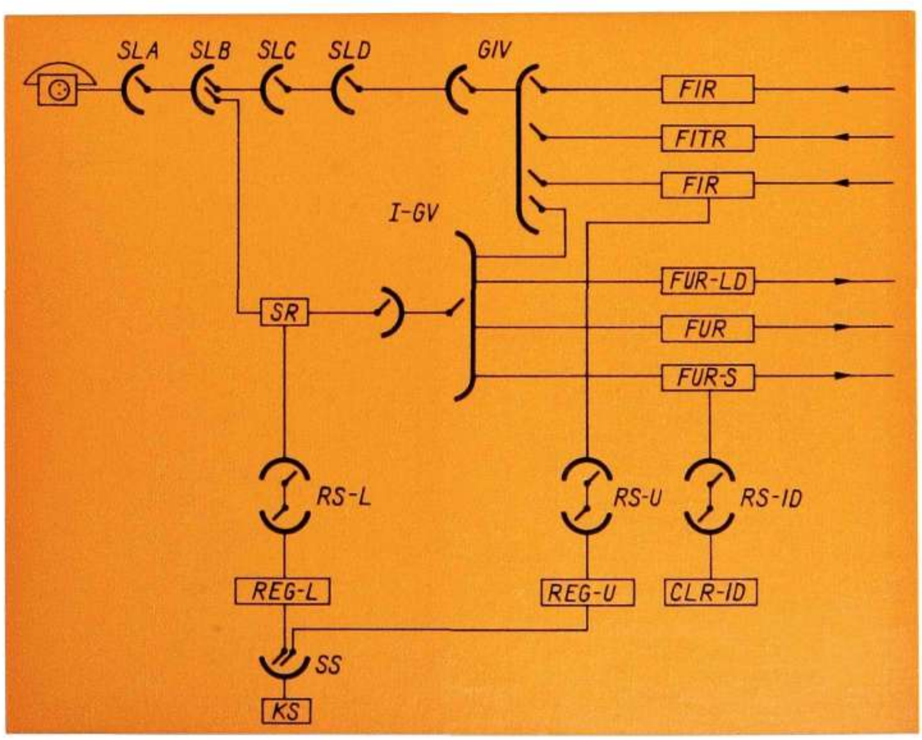

Fig. 2
Simplified trunking diagram of Abbassia crossbar exchange system ARF 102

REG-L	**Local register for MFC and DC signalling**
REG-U	**Register with translation of DC to MFC signalling**
CLR-ID	**Circuit for identification and transfer of A-number**
FUR	**Outgoing junction circuit**
FUR-LD	**Outgoing junction circuit to LDD-network**
FUR-S	**Outgoing circuit to Rotary special Service Group Selector**
FIR	**Incoming junction circuit**
FITR	**Incoming junction circuit from LDD-network**
SR	**Cord circuit**
SPLR	**Outgoing circuit to local special service**
KS	**Code sender**
SS	**Sender finder**
RS	**Register finder**
GV	**Group selector stage**
SL	**Subscriber's stage**

would increase concurrently with the growth of the trunk traffic. ARETO has therefore decided to use magnetic tape units for this purpose and the necessary equipment is now being installed. The question is also being studied as to whether the data on the tapes should be transmitted from the different exchanges over data channels to the computer centre at Cairo at nighttime.

Egypt was the first country in the world to use the same compelled multifrequency signalling system (MFC), of L M Ericsson design, in both local and trunk transit crossbar exchanges. It is, of course, very advantageous to use the same system for local and trunk traffic as this avoids unnecessary signalling translation.

The MFC system is also very suitable for signalling in large areas such as Cairo and Alexandria, where the range of operation is significant. Thanks to its rapidity and the great number of signalling possibilities in both directions, it is well adapted to toll-ticketing signalling and has also many other advantages.

When the Rotary exchanges in Cairo and Alexandria, with their operating range of only 1 200 ohms, are in due course replaced by ARF 120, one single signalling system will be used throughout Egypt, which will simplify the equipment and improve the service quality even further.

Local exchanges ARF 102

The local exchanges of type ARF 102 are well adapted to the conditions in Egypt, both in the provinces and in the multi-exchange areas of Cairo and Alexandria. They include identification of the A-subscriber's number and transfer of this number to the transit register for use in connection with toll ticketing, as well as other facilities that may be required in the foreseeable future.

In the early days, when the number of ARF 102 lines was small compared with the number of Rotary lines, the local registers REG-L in the ARF 102 exchanges were as a rule able to operate the selectors in the Rotary exchange. For traffic from Rotary to ARF

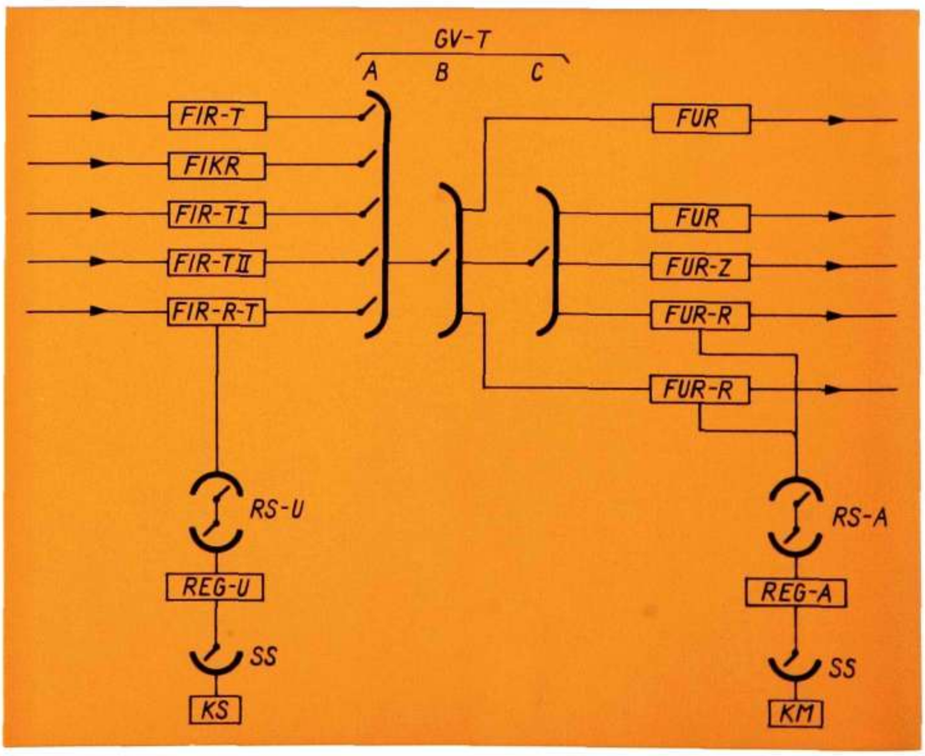

Fig. 3

Simplified trunking diagram of a tandem exchange with crossbar selectors in Cairo area

REG-A	Register with translation of MFC to DC signalling
REG-U	Register with translation of DC to MFC signalling
FIR-T	Circuit for incoming transit traffic from crossbar exchanges
FIR-R-T	Circuit for incoming transit traffic from Rotary exchanges
FIKR	Circuit for incoming transit traffic from crossbar exchanges with trunk offering facility
FUR	Outgoing junction circuit to crossbar exchanges
FUR-R	Outgoing junction circuit to Rotary exchanges
FUR-Z	Outgoing junction circuit with zone metering facility
KS	Code sender
KM	Code receiver
GVA/B/C	Group selector stage
RS	Register finder
SS	Sender finder

102 the latter exchanges were usually provided with translating registers REG-U for signal translation between the two systems, fig. 2.

Later on, when the ratio of ARF 102 to Rotary lines changes (especially as Rotary lines are gradually being replaced by ARF 102), another solution will be applied, at least for new ARF 102 exchanges. Their local registers will be simplified and they will not contain either interworking equipment for traffic to Rotary or translating registers for traffic from Rotary. In the Cairo area the translating equipment for traffic in both directions will be concentrated to two tandem exchanges that are now being installed.

Comprehensive computations carried out on a computer showed that an optimum solution would be obtained by introducing two tandem exchanges in the Cairo exchange area. One of these exchanges is shown in the trunking diagram, fig. 3. The alternative routing principle would be applied through these tandem exchanges. Figure 4 shows the main (low congestion) traffic routes in the Cairo area after the introduction of these two tandem exchanges.

It was also decided to utilize the new tandem exchanges as additional selector stages for distributing the traffic from Rotary to crossbar exchanges, thus avoiding the necessity of introducing auxiliary selector stages in old Rotary exchanges, which would not have been justified from other points of view as the Rotary exchanges are to be replaced gradually.

Transit exchanges ARM 20 and ARM 50

It is planned to use the ARM system throughout the long distance (LD) networks, including international and intercontinental exchanges. Registers and repeaters are the same in ARM 20 and ARM 50. The basic equipment is also the same for telex exchanges, and telephone and telex exchanges can thus be combined if and when required. Standardizing the equipment in this way facilitates manufacture, planning, training and maintenance.

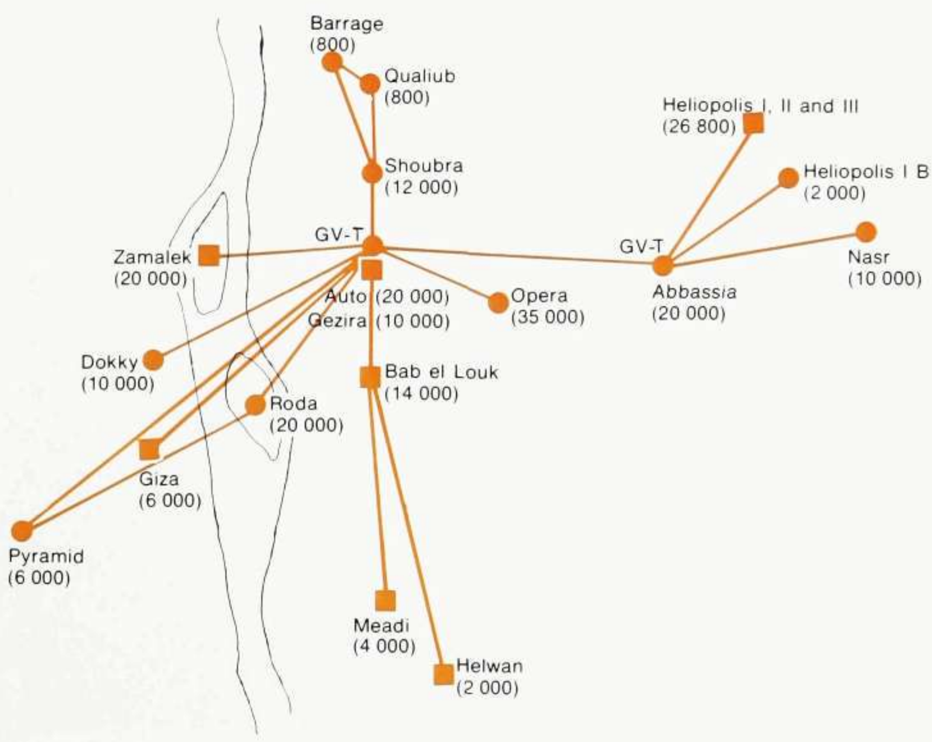

Fig. 4

Main low congestion routes in Cairo local exchange area with two tandem exchanges

● **ARF exchanges**

■ **Rotary exchanges**

For a transit exchange, with its long and expensive lines, the most important requirements are good transmission characteristics and good line utilization. The ARM system has switchable pads and echo suppressors and offers full availability and alternative routing in order to meet these requirements.

It is planned to divide Egypt into at least 19 zones, 12 in Lower Egypt and 7 in Upper Egypt. Each zone will in its turn be divided into an appropriate number of groups. It is also the intention to bring the zones together to form a number of regions at a later stage. At present the LD network contains four ARM 20 and three ARM 50 exchanges, which constitute the zone centres for the seven most densely populated zones of Lower Egypt, fig. 5. In this way the biggest towns of Egypt are linked into a fully automatic LD network including toll ticketing!

Coaxial cables are now being used and it is also planned to use them in the future between zone centres. Direct routes are to be provided between the majority of these centres with alternative routing to a great extent.

The ARM exchanges at the zone centres are provided with complete toll-ticketing equipment and their trunk registers can receive and store the A-number from the local exchange registers.

A simplified trunking diagram of the Cairo trunk exchange ARM 201/4 is shown in fig. 6. A special GV distribution stage of type ARF is introduced for distributing the incoming trunk traffic to the different crossbar exchanges in the Cairo area, thereby reducing the number of outlets required in the ARM exchange. In order to improve the transmission features this selector stage is 4-wire, thus allowing individual balancing of the lines after transformation in hybrids to 2-wire. High congestion routes from large zone centres that carry terminal traffic to Cairo will also be connected directly to this distribution stage, thus freeing the corresponding capacity in the ARM 20 exchange. For the time being the international traffic, which is shortly to be automatized, is being handled from manual switchboards with 4-wire through connections.

A combined national and international ARM telex exchange has been installed in Cairo and a national ARM telex exchange in Alexandria. They are both adapted to interwork with teletypewriters with the Arabic as well as with the Latin alphabet.

Numbering

A closed numbering scheme will be applied in each zone with a number length in the future of 5 to 7 digits. Each zone has an area code of 2—3 digits starting with 0. The 2-digit codes

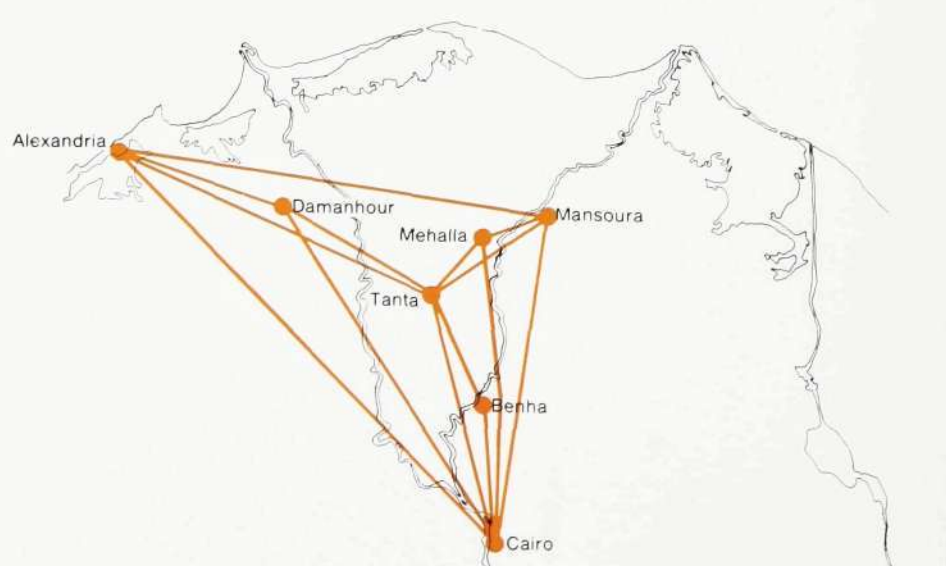

Fig. 5
Present trunk telephone network in Egypt with seven zone centres

are used for the Cairo and Alexandria zones with the greatest number of subscribers. Thus according to present plans the total length of a number for national traffic, code number plus subscriber number, will not exceed 9 digits.

Training and installation

ARETO's staff have been fully trained in the installation and maintenace of the equipment. Originally the training courses were held at L M Ericsson's headquarters in Stockholm, but for several years the training has been undertaken by the Technical Training and Research Institute, TTRI, in Cairo, with satisfactory results. This training has also given valuable knowledge useful for the maintenance of the exchanges.

The installation of the crossbar exchanges was gradually taken over by ARETO and after a few years all ex-

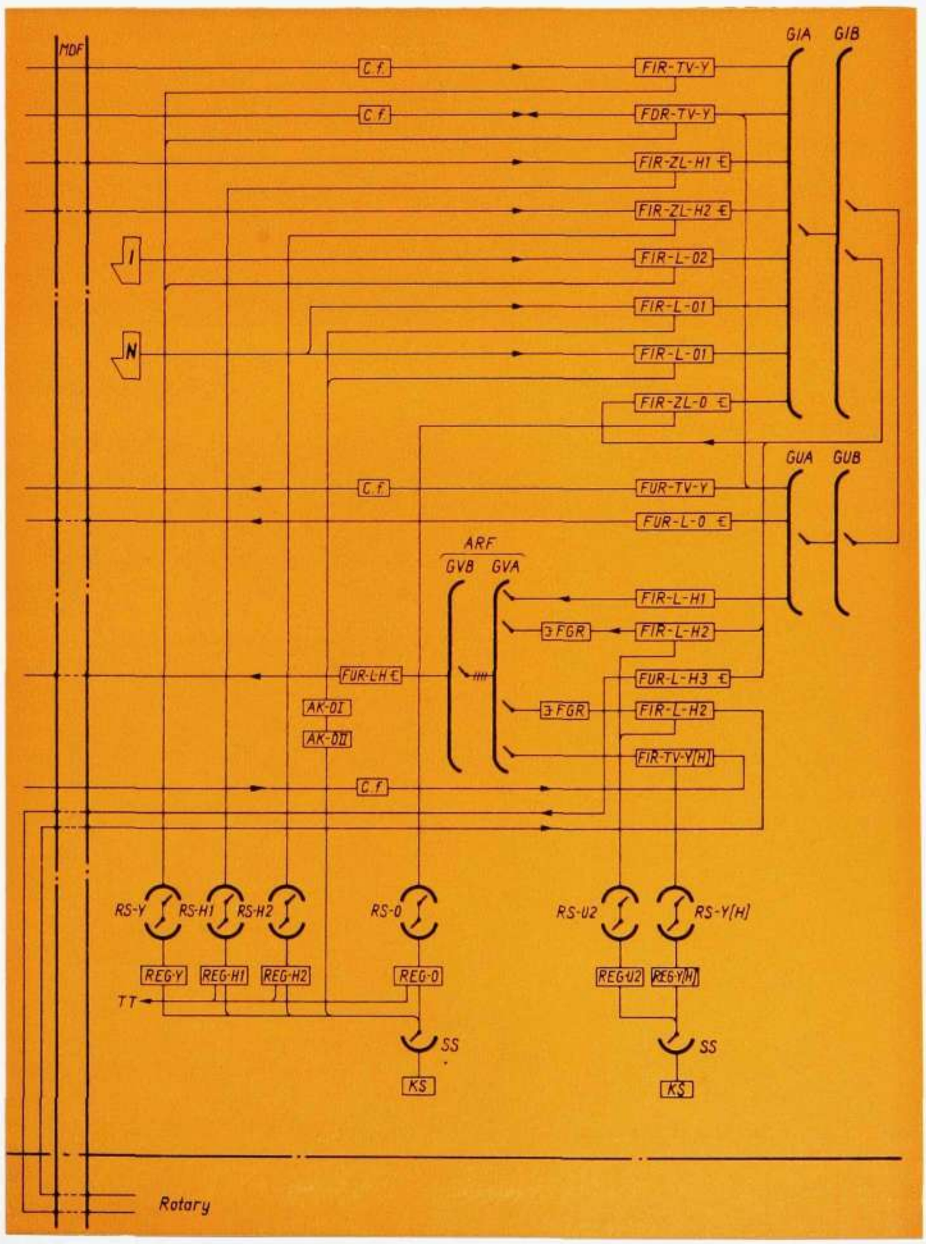

Fig. 6

Simplified trunking diagram of the Cairo trunk exchange system ARM 201/4

FIR-ZL-H1	Incoming junction circuit from ARF with tariff impulse sending and DC signalling (loop-code)
FIR-ZL-H2	D:o from Rotary
FIR-ZL-O	D:o from operator's position
FUR-L-O	Outgoing junction circuit to operator's position with DC signalling (loop-code)
FIR-TV-Y (H1)	Incoming junction circuit to ARF-distribution stage from other automatic trunk exchange with MFC signalling
FUR-L H3	Outgoing junction circuit to Rotary with DC signalling
FIR-TV-Y	Incoming junction circuit from other automatic trunk exchanges with MFC signalling
FUR-TV-Y	Outgoing junction circuit to other automatic trunk exchanges with MFC signalling
FDR-TV-Y	Bothway junction circuit for other automatic trunk exchanges with MFC signalling
FIR-L-H1	Incoming junction circuit to ARF distribution stage from international operator's position or other automatic trunk exchanges via ARM
FIR-L-H2	Incoming junction circuit to ARF distribution stage from Rotary or from operator's position via ARM
FUR-L-H	Outgoing junction circuit, from ARF distribution stage to Cairo local ARF exchanges
FIR-L-O1	Incoming junction circuit from trunk operator's position to automatic trunk network and ARF distribution stage
FIR-L-O2	D:o from international operator's position
REG-H1	Register for outgoing traffic from ARF local exchanges with TT tariff metering
REG-H2	D:o from Rotary
REG-Y	Register for transit and terminating traffic
REG-O	Register for outgoing operator's traffic with TT tariff metering
REG-U2	Translation register
REG-Y(H)	*Register for terminating traffic*
KS	Code sender
GIA/B	ARM incoming group selector
GUA/B	ARM outgoing group selector
RS	Register finder
SS	Sender finder
ARF GVA/B	ARF distribution stage group selector
N	Trunk operator's position
I	International operator's position

changes were being installed by the administration. This has also provided valuable training for the maintenance of the exchanges.

Domestic factory

A licence agreement with L M Ericsson was signed in 1959 for the domestic manufacture of local crossbar exchanges ARF 102, private crossbar exchanges, telephone instruments etc. This agreement has later been extended to include ARM exchanges. The production capacity of the factory is now the equivalent of 25 000 lines and 50 000 telephone instruments per year. The grade of integration, i.e. the local share of manufacture, is high and at present there is a staff of 750.

Expansion plans

A rough estimate of the average annual expansion of exchanges in Egypt during the next five-year period is 30 000 lines for local exchanges and 1 000 multiple positions for transit exchanges. After the completion of this period the network in Cairo will be as shown in fig. 7.

Summary

The ARF and ARM crossbar systems have proved to be very flexible in application, fulfilling the requirements for efficient use in Egypt. They are well suited for local manufacture and meet the expectations placed on them when ARETO decided to introduce them in Egypt.

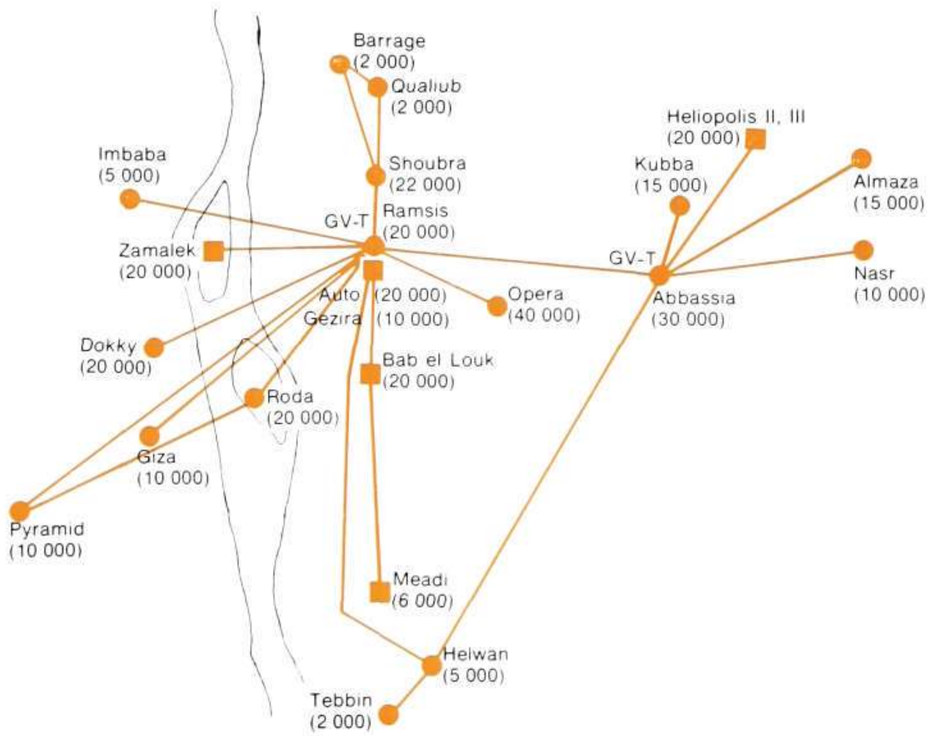

Fig. 7
Five year expansion plan for the Cairo local network

● **ARF exchanges**

■ **Rotary exchanges**

Electronic Private Branch Exchange ASD 551

Helmut Kegl and Gösta Neovius

A new generation of private branch exchanges, based on modern electronic components, is being developed within the Ericsson Group. This article presents one of the exchanges, ASD 551, which was developed by ELLEMTEL. The development work was commissioned jointly by the Swedish Telecommunications Administration and L M Ericsson.
ASD 551 is compactly constructed and takes up very little space. Every effort has been made to achieve an exchange with short installation and testing times. The new technique has resulted in an exchange with great flexibility.
Consequently it is very easy to enlarge the exchange or to incorporate new facilities. The operator console has a new design and apart from the normal handling of calls the operators have been provided with facilities for controlling and supervising the function of the exchange.

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ASD 551 is a stored program controlled private branch exchange system in which the program is stored in an permanent semiconductor memory (PROM) and the data is stored in an electrically changeable semiconductor memory (RAM). The switching network is designed as a three stage link system and is built up of reed relay matrices with 8×4 crosspoints and 3-wire through connections.

With a relatively high average traffic 592 extensions can be connected to an ASD 551 exchange. With moderate or low average traffic this number can be increased to as many as 832 extensions.

The exchange is built up with reed relays, miniature relays, thick film circuits, integrated circuits etc. which are mounted on printed circuit boards. These boards are plugged into shelves, and the shelves are connected to the racks via plugs and jacks. The printed circuit boards, shelves and racks are delivered from the factory already connected and tested. The racks are connected together by cables, which are pre-manufactured in the factory, and which are plugged into jacks at the tops of the racks. The extensions and the exchange lines are also connected to the racks via plugs and jacks.

In its basic design the exchange is equipped with the facilities that are normally included in a modern private branch exchange. In addition the exchange can be equipped for a large number of optional facilities by including the appropriate printed circuit boards, without having to increase the number of racks or having to make changes to the rack and shelf connections.

Telephone sets with conventional rotary dials or with key sets may be connected to the exchange. Push-button telephone sets, which apart from the ten digit buttons have buttons with the star and square symbols, allow signals between extensions and the exchange. These additional signals are used for programming such services as

- call diversion
- follow-me
- bypassing of call diversion and follow-me
- internal abbreviated dialling
- individual night service
- reminder signalling

The push-button telephone sets also have a service button for calling in a register, for instance when making an inquiry call. The exchange lines and registers have receivers for the service signal, which can be sent as a disconnection for a specified length of time, an increase in loop resistance or earthing one of the branches of the speech wires.

When designing the exchange particular attention was paid to both extension procedures and operator procedures. CEPT recommendations have been followed as far as possible. How man/machine considerations have influenced the design of the operator console and how symbols have been used to replace text, thereby making the same version of the console suitable for use in all countries, will be dealt with in more detail below.

System design

Trunking diagram and principle of operation

The trunking diagram for the system is shown in fig. 1. The switching network is used not only for the established connections but also during the setting up of calls.

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Thus when setting up a local call the calling extension is first connected via the switching network to a free register. After dialling this connection is released and instead the extension is connected to a free connecting circuit, the other side of which is connected to the called extension.

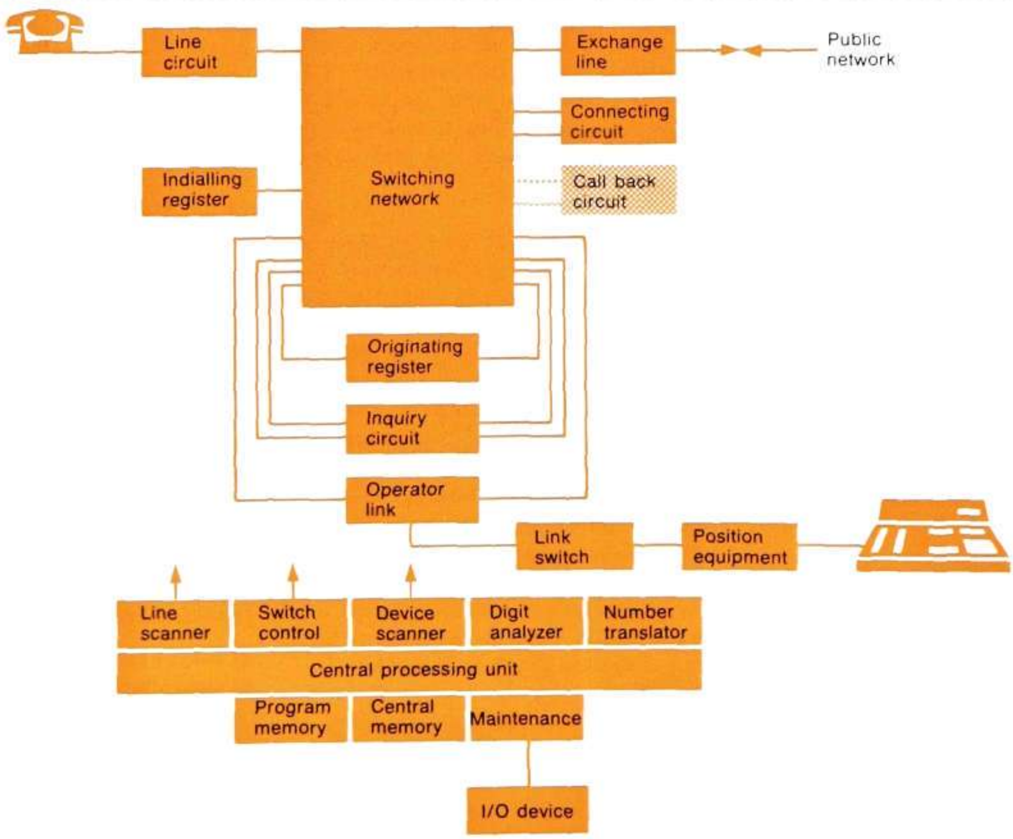
In the case of an outgoing external call, connection is also first made to a register but when the first digit has indicated that it is an external call, another connection is initiated from the other side of the register to a free exchange line via the switching network. The register then repeats the continued dialling and is able to both receive and send the VF push-button code or dial impulses. Thus the exchange can be equipped with both rotary dial and push button telephone sets in any combination and is connected to the parent exchange for one or other of the two methods of digit transfer. After all the digits have been transmitted, the register is released and the two earlier connections are replaced by a direct connection through the switching network from the extension to the exchange line.

For incoming external calls dealt with by an operator, a connection is made from the exchange line to an idle operator link that can be reached by a free operator. The operator keys the wanted extension number on the keyset, whereupon another connection is set up from the other side of the operator link to the wanted extension. Ringing takes place from the operator link, which is released upon answer. The two earlier connections are then replaced by a direct connection from the exchange line to the extension.

Since during the setting-up the exchange lines for outgoing traffic are connected to registers and for incoming traffic to operator links, it has been possible to solve certain functions during this stage with circuits in the registers and operator links, which has resulted in some simplification of the exchange line equipment.

Fig. 1

Block diagram of the ASD 551 exchange



Racks	3	4	5	6	7	8	9
Multiple positions in the A stage	128	256	384	512	640	768	896
Extensions	112	232	352	472	592	712	832
Device connections in the A stage	16	24	32	40	48	48	48
Inlets in the C stage	64	96	128	160	192	192	192
Connecting circuits SNR	10	14	18	22	26	26	26
Exchange lines FDR	24	40	56	72	88	88	88
Registers REG-L	4	6	8	10	12	12	12
Call-back equipment RRD	2	2	2	2	2	2	2
Operator links AUX-O	6	10	14	18	22	22	22
Inquiry links AUX-Q	3	4	5	6	7	7	7
Operators	2	3	4	5	6	6	6

Table 1

Capacity of the system at different extension stages

The switching procedures described briefly above are controlled by a central processing unit (CPU), which operates in two different cycles. During the *scanning cycle* CPU starts the line scanners and device scanners. During this cycle any changes in the states of the extensions and devices are recorded. The cycle is repeated until one or more changes have occurred that require action. The *connection cycle* is then started. In this cycle the traffic program is called that corresponds to the changes that have the highest priority level in the priority list built into the exchange. Any other changes must be rediscovered during later cycles. The traffic programs that will be called in this way on different occasions in connection with for example an outgoing call are:

- connection of extension to register
- connection of register to exchange line
- disconnection of register and connection of extension to exchange line
- disconnection of exchange line

The traffic programs on their part utilize various subprograms, which are common for several traffic programs and which can also be called several times from the same traffic program. Examples of subprograms that are called by the traffic program, "connection of extension to register", are:

- selection of device
- setting up of switching path
- operation of relays in a device.

The system data store is divided up into different parts for the following purposes:

Extension store for, among others:

- classes of service
- line lock-out indication
- call diversion indication
- follow-me indication
- call back indication.

Device store for, among others:

- state information
- connected extension's multiple position
- dialled digits
- supervision times.

Optional facilities store for, among others:

- call back
- call diversion
- follow-me
- abbreviated dialling
- reminder service.

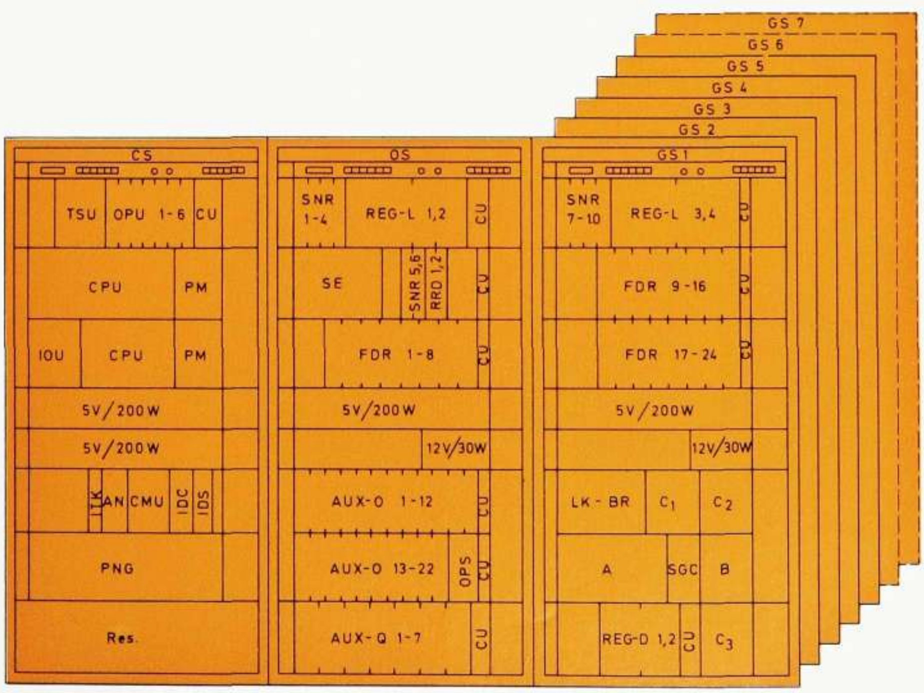


Fig. 2

The placing of the units in the racks

CS (Central processor rack)

TSU	Equipment for supervision and measurement of the traffic
OPU	Operator's equipment
CPU	Central processing unit
PM	Program store
IOU	Maintenance panel
ITK	Exchange line traffic control
AN	Number analyzer
CMU	Data store
IDC	Device scanner
IDS	Equipment for selection of switching paths
PNG	Programmable number group. Includes line scanners and the majority of the additional services
CU	Connecting unit

OS (Devices rack)

SNR	Connecting circuits
REG-L	Registers for internal and outgoing traffic
SE	Signalling unit
FDR	Exchange line
AUX-O	Operator's link
AUX-Q	Inquiry link
OPS	Operator's link switch
RRD	Call-back equipment

GS (Group rack)

LK-BR	Line circuit
A, B, C	Switching network
SGC	Switch control unit
REG-D	Direct in-dialling register

Disposition of the racks

The disposition of the racks is shown in fig. 2 and the capacity of the system at different extension stages is given in table 1.

The central processor rack (CS) contains the control equipment for the exchange, the supervision and maintenance equipment and space for the equipment that is required for the optional facilities.

The devices rack (OS) contains six connecting circuits, eight exchange lines and two registers. The rack has space for all the operator links, inquiry links and call-back equipment required for a fully equipped exchange. This rack also contains the common signalling and ringing equipment.

The group racks (GS) each contain switching equipment for a maximum of 128 A-multiple positions and 192 C-multiple positions, line equipment for 120 extensions and four connecting circuits, 16 exchange lines and two registers.

For tie-line traffic individual exchange line equipments are replaced by tie-line equipments, and for direct in-dialling two direct dialling registers are included in the bottom switch shelf.

The distribution of the connecting circuits, exchange lines and registers between the devices rack and the group racks has been chosen to provide the best possible adaptation to the traffic requirements with various degrees of extension capacities.

Grouping and disposition of the devices

The switching network is built up in groups of 128. Fig. 3 shows the switch grouping for such a 128-group with the C stage built out to 64 inlets. By the addition of further switch matrices the C stage can be increased in steps of 32 inlets to a total of 192 inlets. In the figure each switch matrix, with the dimensions 8×4, has its four inlets enclosed in a rectangle and the symbols point towards the eight points in the next stage that can be reached via the matrix.

Between the A and the B stages the traffic is concentrated in the ratio of 2:1, the inlets of the A matrices being connected in pairs to the outlets of the B matrices. In order to distribute the traffic if the traffic load is uneven in the A stage, this interconnection is carried out in a cyclically permutated pattern (link transposition).

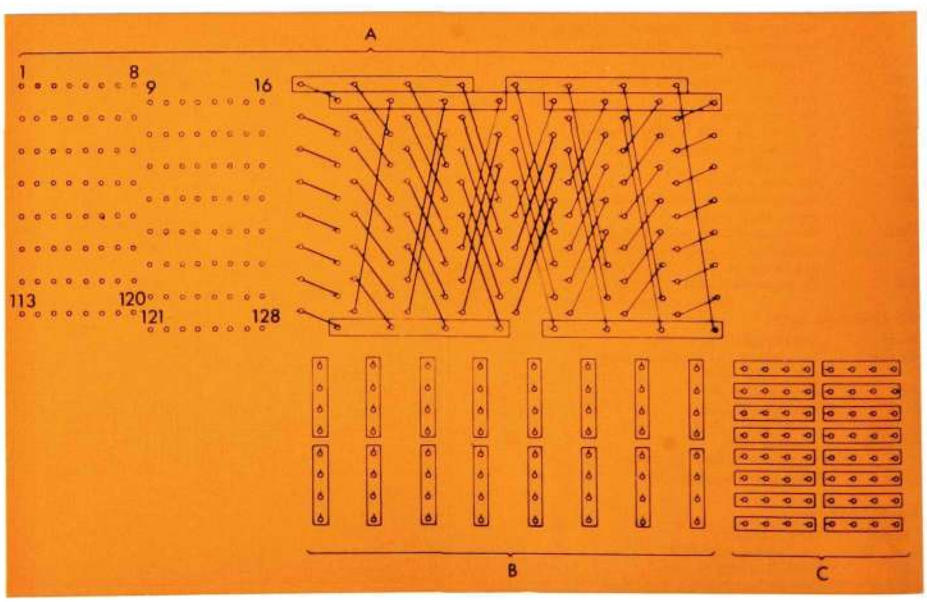


Fig. 3
Switch grouping for a 128-group

When there are several 128-groups the C inlets are multiplied over all groups so that from an inlet it is possible to reach an arbitrary A-multiple position. The C multiple is connected to plug units at the top of each group rack. Factory manufactured cables are used for interconnecting the multiple. This interconnection also extends to the top of the devices rack.

The operator links and inquiry links in the devices rack are permanently connected to predetermined inputs in the different 32-groups of the C stage, whereas the remaining devices in the rack are permanently connected to the C-multiple positions in the first 32-group.

In each group rack the four connecting circuits and 16 exchange lines in the rack are connected to 24 C inputs in the first 32-group in the rack. By carrying out the interconnection between the tops of the racks with a displacement of one 32-group, the devices for the first group rack will be in the second 32-group, seen from the devices rack, the devices for the second rack in the third 32-group and so on.

By using the above disposition procedure it has been possible to standardize the wiring of the group racks and to avoid an intermediate distribution frame for placing the devices in the C multiple.

Traffic capacity

When designing ASD 551 the aim has been to limit the planning work required for each separate installation by building up the system on a modular basis, with a suitably chosen number of devices of each type within each module (rack). The system is used most efficiently with 0.17 erlangs per extension and with the internal traffic accounting for 30 per cent of the total traffic at a grade of service of 0.01.

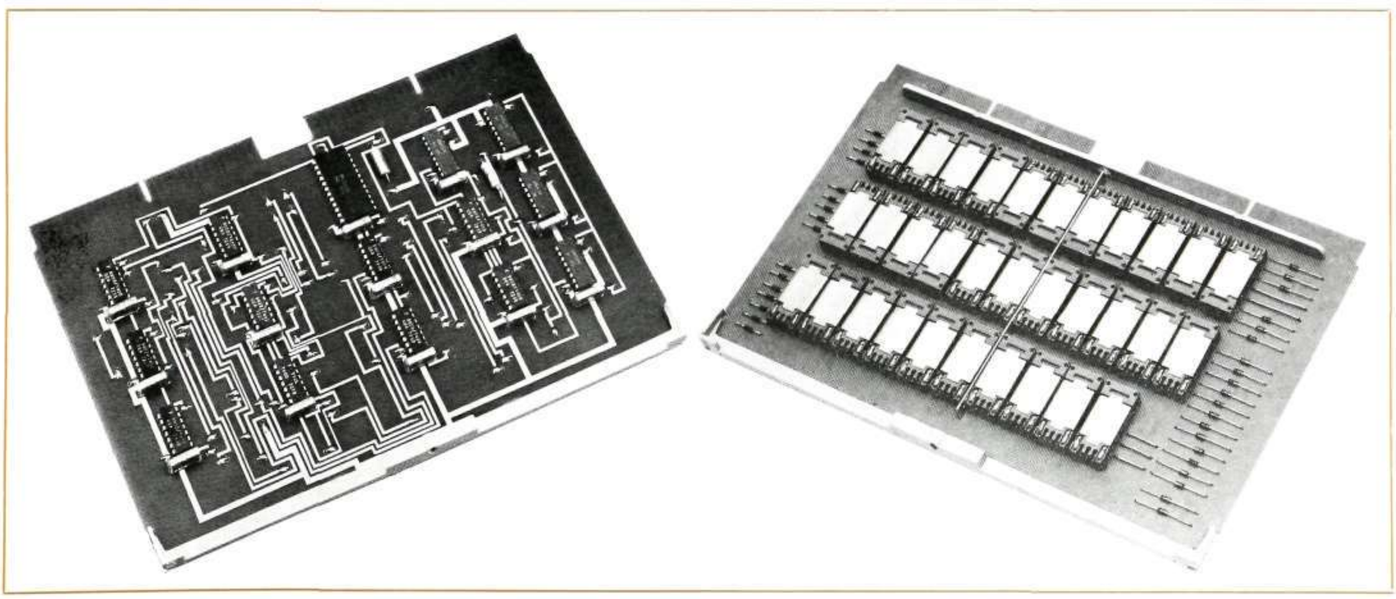
For any other ratio between the internal and total traffic and for other values of traffic per extension, the number of connecting circuits, the number of exchange lines or the number of extensions will be decisive for the traffic capacity.

Mechanical design

Printed circuit board assemblies shelves and racks

All components are mounted on printed circuit boards with single or double-sided foiling. Boards of two different heights are used: a single board corresponding to one board storey and a double board corresponding to two board storeys, see fig. 4. The boards

Fig. 4
Double circuit boards (right: switch matrix)



are plugged into shelves for one, two or four board storeys, with different combination possibilities of single and double boards, see fig. 5. Depending on the height of the components a printed board assembly will take up a space in the shelf of two (13.3 mm), three (20 mm) or more modules. A shelf has a length of 112 modules and thus can accommodate a maximum of 56 printed board assemblies.

The shelves are specially designed to provide good heat dissipation. Each shelf has an air input in the front and an air outlet along the top rear edge. Hence the complete shelf gets effectively aired since the whole of the board surface is passed by the current of air. The shelves are connected to jack units placed to the right in the rack, see fig. 6.

The racks are built up of tubes with a square profile. The tubes are joined together quite easily on the installation site, and thus the racks require very little space when being transported. The rack dimensions are as follows: height 2200 mm, width 1042 mm, depth 261 mm..

The racks are wired and tested in the factory before delivery. Two different types of plug-ended cables are used for the wiring between racks, each having a standard length. The simple procedure for installing the racks and the ingenious method of interconnecting them result in a short installation time. L M Ericsson's miniaturized Main Distribution Frame BAB 320[1] is recommended for the exchange, since with its small space requirement it harmonises well with the exchange.

Components

The switching element in the ASD 551 switching network is a reed relay with three contacts. Since the switching network is built up of electromechanic contacts it has been considered appropriate to also use such contacts for switching the speech branches in the traffic carrying devices. Both monostable and bistable miniature relays are used for this purpose.

Specially designed thick film circuits are used for sensing signals from an extension in the line equipment and the

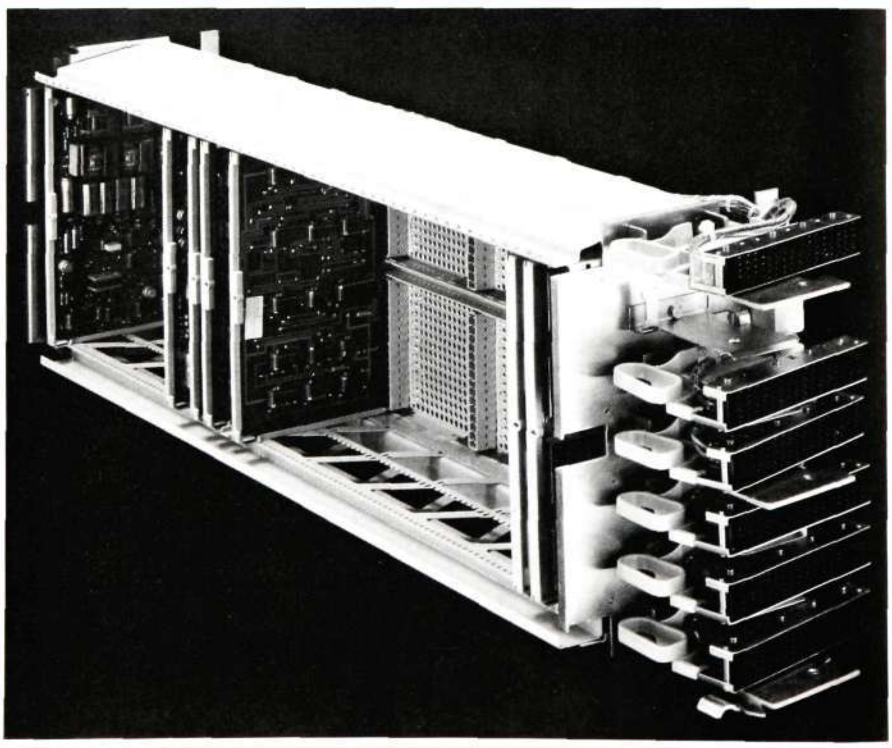


Fig. 5
Shelf for two-storey printed circuit board assemblies

devices carrying traffic. Likewise, all current feeding of extensions takes place via what are known as fuse resistors, designed using thick film technique, which serve to protect the equipment against excess current. The traffic carrying devices also contain discrete circuits and TTL circuits. Mostly TTL circuits are used in the control equipment, from simple gates to complex stores. Newly designed holders for light emitting diodes, push-buttons and jacks permit mounting on the fronts of printed boards as well as on maintenance panels and the like.

Operator console and operator functions

The operators are responsible for a large part of the service that is provided for the telephone users. Consequently during the design work great importance was attached to the problem of providing a functionally correct design for the operator console. Every effort was made to attain the best possible relationship between man and machine, see fig. 8.

Lamps (light emitting diodes) and push-buttons are assembled in separate functional fields, and the push-buttons that are often used are placed near each other in an easily accessible position, which facilitates the work of the operator. Symbols are used throughout instead of text.

The simple symbol language facilitates the training of operators. Those operators who have had the opportunity of assessing the new operator console have been favourably impressed by the possibility of following the setting up of a call and of being able to read out in different fields the origin of the call, the type of call and the state of the called extension.

The operator's normal routine when handling a call does not differ substantially from what is customary in other exchanges. Facilities are provided for camp-on, holding, announcing, serial calls and so on.

The operator can accept a call with the answering button, and after dialling depress the connect button to complete the connection. In order to simplify the work of the operator and reduce the handling time, the operator can set the equipment for automatic call reception and automatic transfer of incoming calls.

Apart from the normal handling of calls the operator can also control and supervise the function of the exchange in various ways.

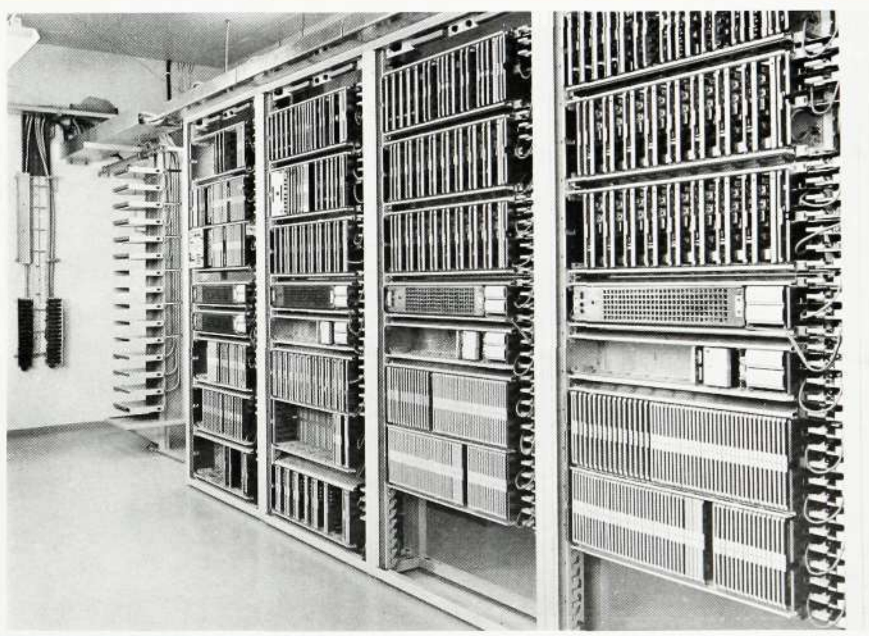
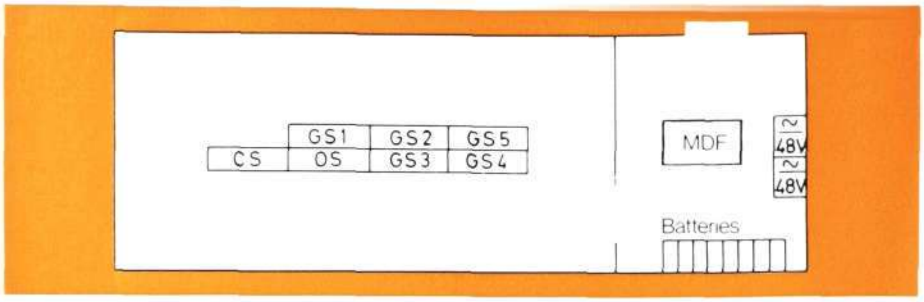


Fig. 6
Exchange room with central processor rack, devices rack and group racks

Fig. 7
Layout of the ASD 551 exchange



The operator can change the classes of service and directory numbers of the extensions, and also program the external abbreviated numbers, the diversion address for an extension and follow-me.

The operator can start and supervise traffic recording, which is handled automatically by equipment in the exchange.

Traffic disturbance in the form of overloading of a certain group of devices is indicated on the operator console, and by using a special procedure the operator can determine which group is being overloaded and also the traffic load.

The operator console contains lamps for indicating alarm condition. The lamps show the class of alarm, and thus the degree of urgency, when functional disturbances occur.

The following optional facilities are provided for the operators:

- call metering
- call-recording
- machine answer
- busy lamps field
- call waiting indicator.

Power equipment and tone and ringing set

ASD 551 is supplied with power in the usual way from the —48 V generated by the main power equipment in the exchange. Batteries are used for standby power supply. Voltages of +5 V and +12 V are used for driving electronic circuits and relays. These voltages are generated by stabilized d.c. voltage converters that are fed from —48 V. The converters are mounted in shelves which are placed in the racks as shown in fig. 2. The ringing and tone signals are generated by a tone and ringing set, which is common for the exchange and which is mounted in the devices rack.

Installation and testing

Owing to its compact construction, ASD 551 requires a relatively small space. The racks, with the exception of the central processor rack, are most suitably mounted back to back, see fig. 7. Each rack requires a total floor space of about 2 m^2 incl. free space. The height of the racks has been chosen so that the exchange can be installed in premises in which the height of the ceiling is 2.4 m or more.

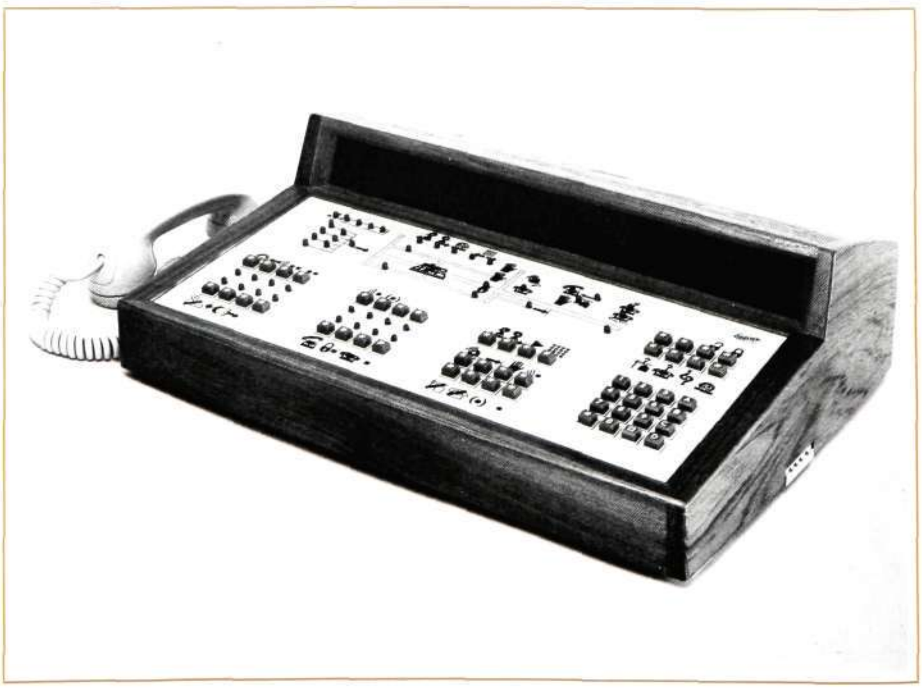


Fig. 8
Operator console. The panel is provided with symbols instead of text

The units included in the exchange control system functionally are tested together in the factory. Other units are tested automatically at the installation site by means of special test programs. Thus the installation testing is simple and takes only a short time.

Operation and maintenance

The maintenance of ASD 551 is based on L M Ericsson's maintenance method CCM (Controlled Corrective Maintenance). The method is summarized as follows:

— the function of the private branch exchange is supervised continuously as regards technical faults and the traffic handled

— no action is taken before the supervisory equipment indicates that action is necessary

— all manual and even automatic routine testing is avoided while the exchange is in service. However, measures (automatic) are taken to limit the number of traffic disturbances caused by the occurrence of a technical fault.

Service supervision

During normal operation the function of the exchange is supervised continuously. An alarm is given when the number of unsuccessful attempts to establish a connection because of a technical fault and/or congestion exceeds a predetermined, adjustable fraction of the total number of attempts. Unsuccessful attempts to establish a connection include failure to set up the switches, cutting in on an established connection, malfunction of a device, time release etc. Data concerning unsuccessful attempts to establish a connection are recorded in the fault recording unit, which is dimensioned for storing data for up to 16 malfunction occasions and which operates according to the principle first in — first out.

The alarm is sent via the exchange alarm system to the operators' room where it is indicated in three different levels in the operator console. Apart from the supervision of technical faults, the exchange can provide facilities for supervising (measuring) the traffic handled by the different groups of devices. An alarm is then given if the traffic exceeds a predetermined value and indicates that the group of devices in question should be increased. The results of the measurements during the busy hour can be read off and presented in erlangs. In this way the work of the supervision and maintenance staff has been simplified considerably.

In order to limit as much as possible the number of traffic disturbances caused by a technical fault, the exchange has been provided with the following functions:

— the current feeding of lines to the public exchange and to interworking exchanges is supervised in those cases where current feeding takes place when the lines are unoccupied. If the line is disconnected or short-circuited, the device (FDR-C or FDR-X) is automatically blocked. At the same time the exchange operator is called and the reason for the call and the line number are given.

— a faulty device (for example a device that cannot be operated, or a device with an incorrect state) gets a disturbance marking in the data store. Such a device will then not be selected until all devices without faults are engaged. If then the attempt to establish a call is successful the disturbance marking is annulled.

— when a printed circuit board assembly, which forms part of a device that carries traffic, is removed from its place in the shelf, the device gets an absence marking in the data store. The same applies for devices that lose their power supply, for example because a fuse blows.

Maintenance panel

In order to be able to check how the programs are executed and what information is transported on the buses between different units while tracing a fault in the program controlled electronic exchange, the exchange is provided with a maintenance panel, see

Fig. 9
Maintenance panel, which is mounted in the central processor rack

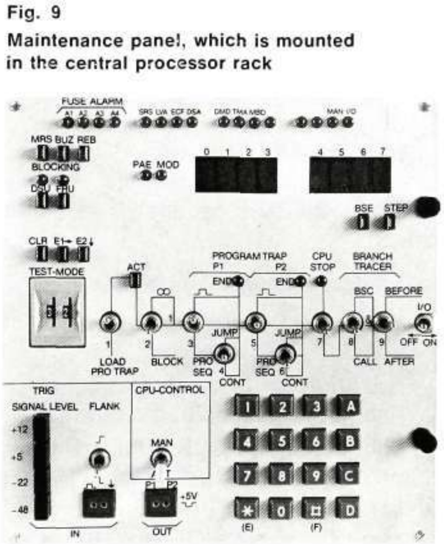


fig. 9. The panel is placed in the central processor rack at a suitable working height. By operating switches and depressing buttons on this panel the supervision and maintenance staff can check the execution of the program and the bus information at the desired time and for the desired connection. By analyzing this information a picture is created of the function of the exchange, and any malfunction or irregularity can be traced.

Service functions

Changing the service functions in conventional exchange systems is often time consuming as changes then have to be made in the hardware. In ASD 551 this work has been facilitated considerably, it being possible to change the extension data (opening, closing and moving of extension numbers, changing of the extension class) and also certain exchange data (programming of external abbreviated numbers, diversion addresses etc.) from the operator console or from the maintenance panel.

Changes of data of a more individual character, such as follow-me and programming of internal abbreviated numbers, can be carried out by the extension users.

Calling facilities

BASIC EQUIPMENT

The basic equipment for ASD 551 permits the following functions:

- internal calls
- outgoing calls, direct or via the operator
- incoming calls via the operator
- inquiries
- transfer
- three-party conference
- diversion to a common attended position. The function may be ordered and cancelled from a push-button telephone set
- classification, restricted, unrestricted
- night service connection to a predetermined extension.

ADDITIONAL EQUIPMENT

The exchange can be supplemented with additional equipment, for which space is available in the racks.

Facilities that make it easier to reach a particular person:

- automatic call back
- call waiting or priority
- paging
- call diversion to an individual attended position. The function is programmed by the operator and is ordered and cancelled by the extension with a push-button telephone set
- call diversion to an individual attended position when no answer is received
- follow-me
- individual night service connection on a short term basis, programmed by the extension
- individual night service connection on a long term basis, programmed by the operator.

Facilities that make communication more effective:

- direct in-dialling
- tie-line traffic
- external abbreviated dialling
- internal abbreviated dialling
- group-hunting
- centralized multi-line telephone function (call pick-up)
- transfer of extension number to attended position in connection with call diversion
- direct connection when calling a loudspeaker telephone.

Facilities that are requested in some cases:

- control of long distance dialling
- individual call metering
- specified call metering
- selection of individual exchange line for, for example, data traffic
- connection without dialling to a predetermined extension (alarm telephone)
- reminder service

Technical Data

Capacity	592 (832) extensions 0.17 (0.12) erlangs with a grade of service of 0.01 and 30 % internal traffic 88 exchange lines 26 connecting circuits 12 registers 6 operators
Telephone sets	with rotary dials for 10 or 16 Hz and pulse ratio 30/70—50/50 with push-button sets for tone frequency key sending in accordance with CCITT recommendations
Loop resistance	1800 Ω max. for an extension, including the telephone set 2000 Ω max. for an exchange line
Leakage	40 kΩ
Transmission loss	0.6 dB at 800 Hz
Crosstalk	80 dB min.
Numbering	extension numbers of three or four digits Numbers of one or two digits to exchange line routes, operator etc.
Power supply	— 48 V d.c., for electronic circuits converted to + 5 V and + 12 V max. power consumption 1.7 kW

ADDITIONAL FACILITIES

Some of the additional facilities that are of special interest are described below.

Automatic call back

This facility implies that an extension calling an internal number and getting the engaged tone may request automatic supervision of the wanted extension. The function is initiated with an after-dialling digit. When both the wanted extension and the orderer of this facility are free, the orderer is recalled by means of the call-back equipment. When the orderer answers, a normal internal connection is established towards the wanted extension, which is rung up. The orderer is still able to use the telephone set in the usual manner during the supervision period.

The exchange is able to provide this supervisory function for up to 16 ordering extensions at the same time. Moreover several calling extensions can order supervision of the same extension. Only two devices, RRD, are required for the actual calling back. An established supervision may also be cancelled with a cancelling code.

Call-waiting

This facility implies that a call to an engaged extension is signalled with one tone signal to the wanted extension only while the call is in progress. The facility is available for internal as well as external calls. The wanted extension can accept the new call by terminating the call in progress or by holding the call in progress and setting up a connection with the caller. When this new call is finished, the original connection is re-established.

Abbreviated dialling

Abbreviated dialling can be external or internal.

The external abbreviated dialling permits the extensions to reach predetermined subscribers within the national and international network by dialling a number consisting of three or four digits. Even nationally and internationally restricted extensions may use the external abbreviated dialling. The subscriber numbers that the extensions are to reach when dialling external abbreviated numbers are programmed from the operator console. The equipment capacity is 192 subscriber numbers.

The internal abbreviated dialling equipment enables an extension, after dialling a special character followed by a digit, to reach the addressee who corresponds to one of ten different internal directory numbers that have been programmed in by the calling extension. A directory number may be an internal extension or an external abbreviated number. Up to 138 extensions, can be given access to this facility.

Control of long distance dialling

This equipment permits control of automatically connected outgoing calls. The class of the calling extension determines how the dialled digits are to be analyzed. If the analysis indicates that the dialled number is unallowed, a congestion tone is sent to the extension. Alternatively the call may be redirected to the operator. The equipment permits control of 32 arbitrary numbers of six digits. This facility in combination with external abbreviated dialling provides effective control of the external traffic.

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Power Supplies for Electronic Telephone Exchanges

Anders Örevik

Electronic telephone exchanges make new demands on the quality of the distribution voltages, mainly because of their sensitivity to transients. The design of the d.c. distribution network is therefore extremely important. For this reason a new distribution system has been developed within L M Ericsson for telephone exchanges, with radically changed principles for both current distribution and earthing. The most serious risk of operational disturbances arises in connection with the transients developed when a short circuit occurs and a fuse blows in consequence. The article describes what happens during the transient time, both in a conventional distribution system and in the new system. The author also describes the practical design of the new distribution system and gives an account of the results of the measurements carried out on a completed installation.

UDC 621.311.4:
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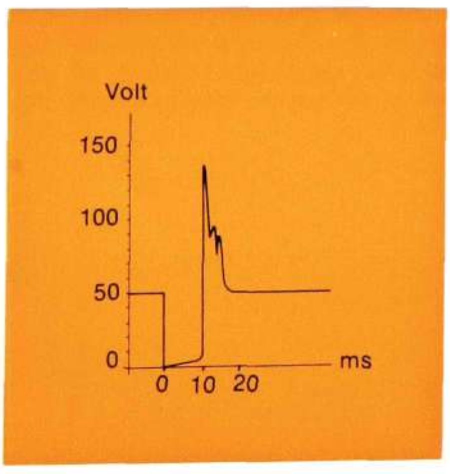
LME 781
8088

Fig. 1
Example of a transient voltage caused by a short circuit and the resultant breaking of a fuse



In a telephone exchange direct current is distributed from the central power plant to the switching equipment via positive and negative conductors arranged in relation to each other in such a way that the inductance is kept to a minimum. Inductances in a distribution system can cause troublesome speech and signalling crosstalk. They also give rise to voltage transients when the current in the conductors changes rapidly. Fig. 1 shows how the feeding voltage for a switching device can vary when a short circuit occurs that causes a fuse to blow. Conventional electromagnetic switching devices are usually far too slow to react to such short-term voltage changes as are shown in fig. 1. Neither is there any risk that they will be damaged. Electronic circuits react quite differently. They are fast and often work with low voltages. Voltage variations of short duration can therefore quite easily cause malfunction of such circuits. Moreover, unexpected transient voltage peaks can destroy transistors and other semiconductor components.

New requirements for the distribution systems

The new distribution system has been developed in conjunction with the design of the L M Ericsson processor-controlled AKE 13 telephone exchanges, fig. 2. In the main, two requirements have been decisive for the design of the system.

1. The feeding voltage for the electronic racks of the processors, *including transient voltage deviations,* must lie between 44 V and 60 V.

2. Any voltage differences, static as well as transient, must not exceed 0.6 V between arbitrary points within the zero plane, which constitutes the signal earth conductor and which is available over the entire exchange.

These requirements must be satisfied not only with normal operation but also with all forms of disturbances in the distribution system, for example with *short circuit between negative and* positive conductors, between a negative conductor and the zero plane (signal earth conductor) and between a negative conductor and the racks. It has been possible to meet these requirements by using a suitable design for the distribution system and suitable division of the central power plant.

The stringency of the new requirements can best be judged by comparing with a conventional distribution system.

Transients in a conventional distribution system

Fig. 3 shows a number of suites of racks, which obtain their power supply from the distribution rack via common, very low resistance conductors. The power plant is symbolized by the battery. A short circuit is assumed to have occurred at point I, which is located in the first rack in the lower suite, immediately after the suite fuse. The types of fuses used as suite fuses have a release time of 5—20 ms at the currents in question here. This is sufficient time for the short-circuit current to reach its steady state value, which is limited occurred at point I, which is located in only by the resistances in the short circuit loop. Typical values are given in fig. 3. The resistance of the fuses is so low that it can be neglected.

The electromotive force (emf) of the power plant is distributed in the circuit

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formed by the short circuit, in relation to the resistances included in the circuit. The resistance at the short circuit itself is assumed to be zero. Thus at this point and in all suites of racks that are further away from the power plant, and which are fed from the same distribution fuse, for example point II, the voltage will be zero. The voltage at point III, the common distribution point for the entire telephone exchange, will be equal to half the emf of the power plant, since the resistance of the power plant is equal to the sum of the resistances in the positive and negative conductors up to the short-circuit point. This means that until the fuse has had time to blow, no part of the exchange has a voltage higher than half the normal working voltage. When the suite fuse then breaks the short-circuit current, which in this case is in the order of 6,000 A, the inductances in the short circuit loop cause the distribution voltage to exceed the normal value (see fig. 1). How high the voltage will rise at a given point depends on the sum of the inductances in that part of the short circuit loop which comprises the power plant and the conductors up to the point in question and also on the strength of the short-circuit current at the instant that the fuse blows. The highest peak value is thus obtained at the point where all the inductances in the short circuit loop contribute, i.e. immediately before the fuse. In practical cases the peak value at this point, and hence also at point II, can rise to about 200 V. At point III on the other

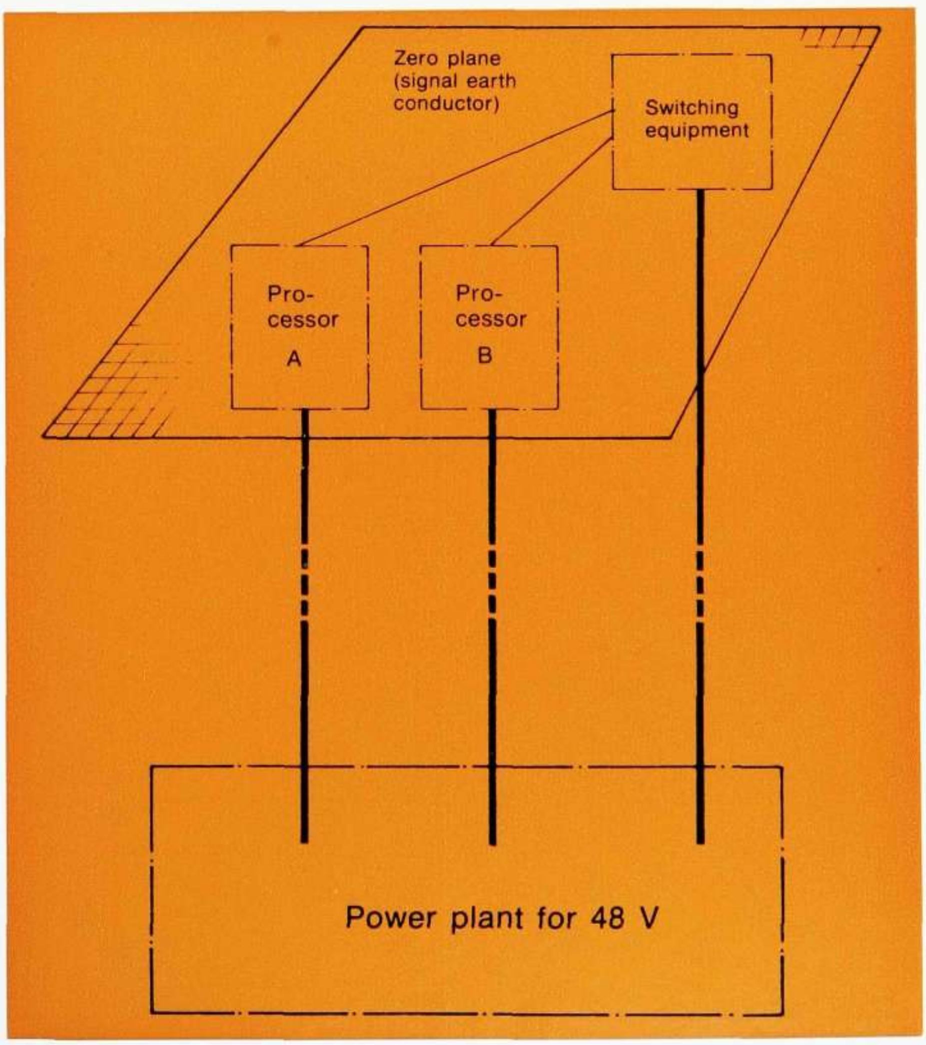


Fig. 2
Main parts of an AKE exchange

hand only the inductance of the power plant will have any effect and the voltage increase will be considerably less.

Hence, in a telephone exchange with a conventional distribution system a short circuit in the switchroom can cause a reduction in voltage, which although of short duration can be very large, and the subsequent voltage peak can rise to values in the region of 200 V.

The new distribution system

In the new distribution system each functional unit, consisting of separate electronic racks or groups of switching racks, is fed with current individually.

Fig. 4 shows the basic design of the system. Characteristic features of the system are:

— No negative conductor has a lower resistance than 45 mΩ

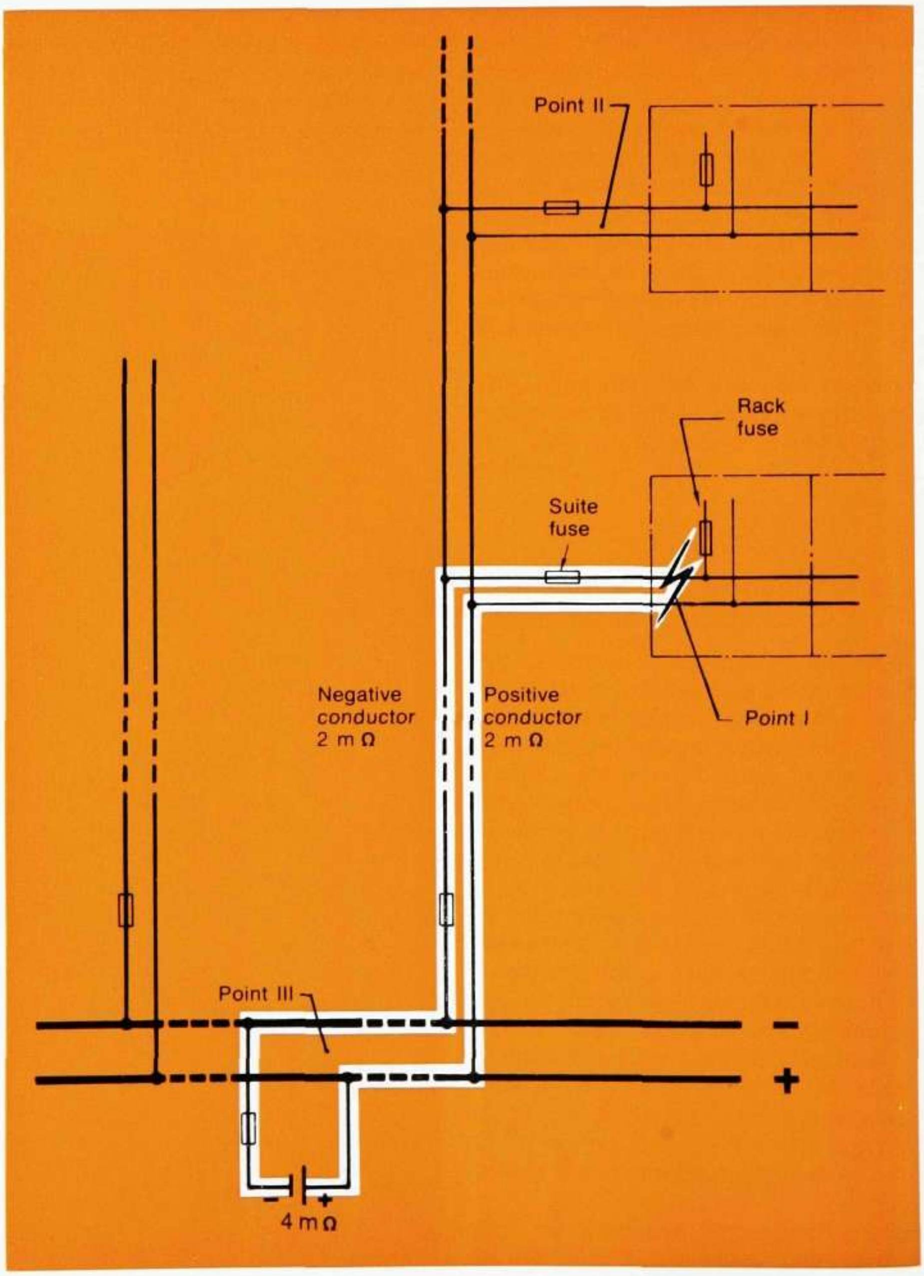


Fig. 3
Short circuit in a conventional distribution system

- The internal resistance of the power plant is not greater than 4 mΩ
- Each negative conductor is accompanied by a positive conductor
- All positive conductors are connected to each other via a low resistance network that functions as a zero plane. The resultant resistance of the parallel-connected positive conductors is in the region of 0.1 mΩ.

With the selected resistance values of 45, 0.1 and 4 mΩ, the voltage at the common distribution point, when a short circuit occurs in a functional unit, will fall in the relation

$$\frac{45 + 0.1}{45 + 0.1 + 4} = 0.92$$

Hence the voltage reduction is limited to 8 %.

The requirement of a minimum voltage of 44 V at the feeding point in an electronic rack implies that the distribution voltage is never allowed to fall below

$$\frac{44 + 1.5}{0.92} = 49.5 \text{ V}$$

where 1.5 corresponds to the maximum voltage drop in a negative conductor to an electronic rack.

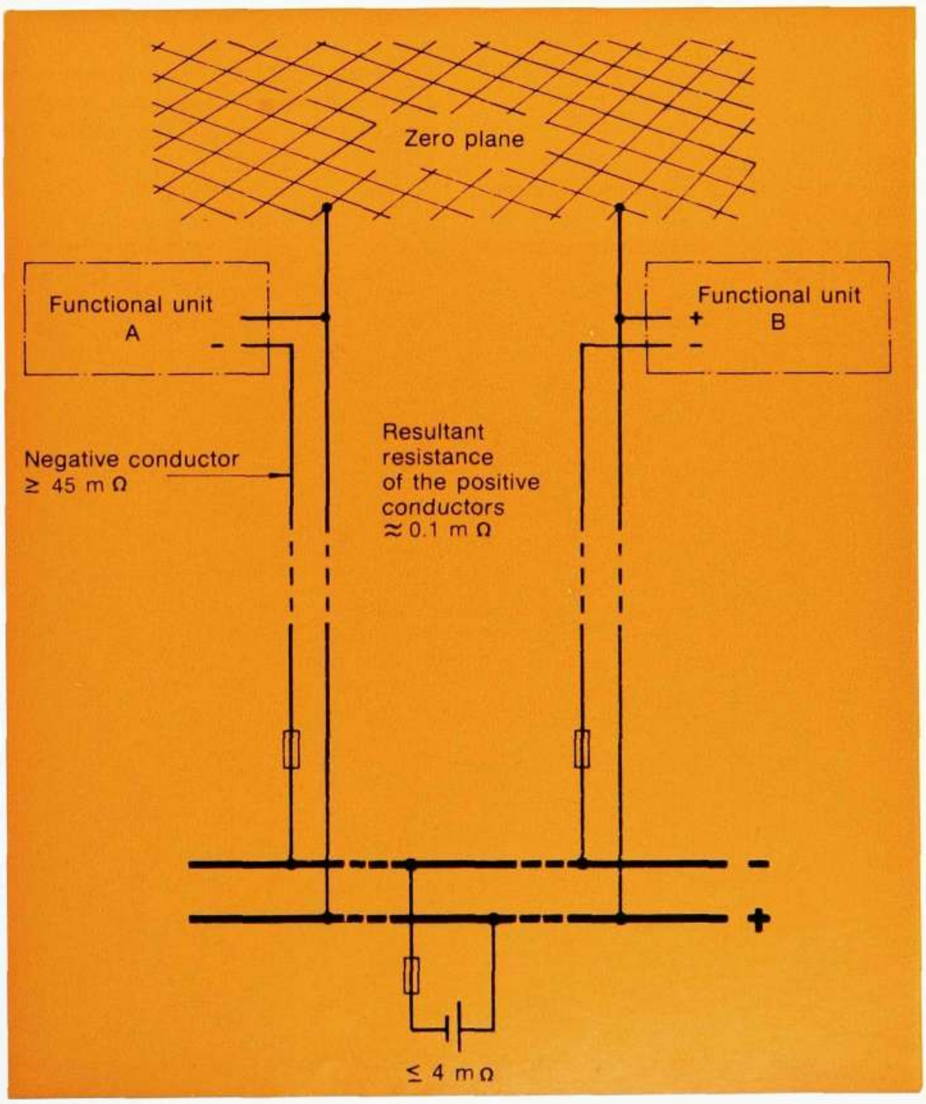


Fig. 4
The principles of the new distribution system

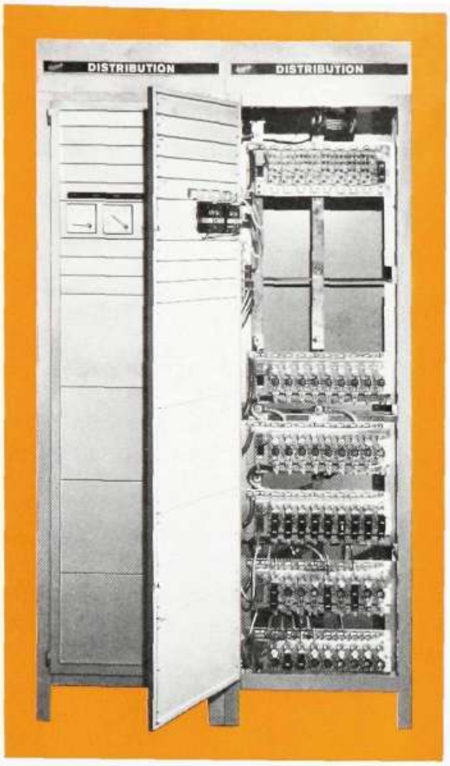


Fig. 5
Distribution racks in an electronic telephone exchange

The resistance of 45 mΩ in the negative conductor limits the short-circuit current to about 1,000 A. Since the current can be defined as regards its magnitude, it is possible to dimension the zero plane so that the requirement of a maximum voltage difference of 0.6 V can be met.

The limitation of the short-circuit current also helps to limit the voltage peak that is obtained when the fuse breaks the short circuit current. This voltage peak could constitute a risk for the semiconductors in the connected units. Owing to the limited short-circuit current and the relatively low inductance of the power plant, the voltage peak is limited to about 1.2 times the normal distribution voltage. Consequently no special transient protection is required.

Since the three-dimensional network, which consists of the positive conductors and the network that forms the zero plane, has such a low resistance that it is able to carry the current if a direct short circuit occurs between a positive and a negative conductor, without the voltage difference exceeding 0.6 V, the network is particularly suitable for earthing the racks. This permits a simplification of the racks as it is then unnecessary to make a distinction between load-bearing and screening construction elements.

The object of the rack earthing is to give the racks a potential that does not deviate appreciably from the earth potential of the exchange. Among other things this reduces the stresses on the insulation between the live parts and the rack.

The practical design of the distribution system

The practical design of the new distribution system varies depending on the

Fig. 6
The practical design of the distribution in an AKE exchange

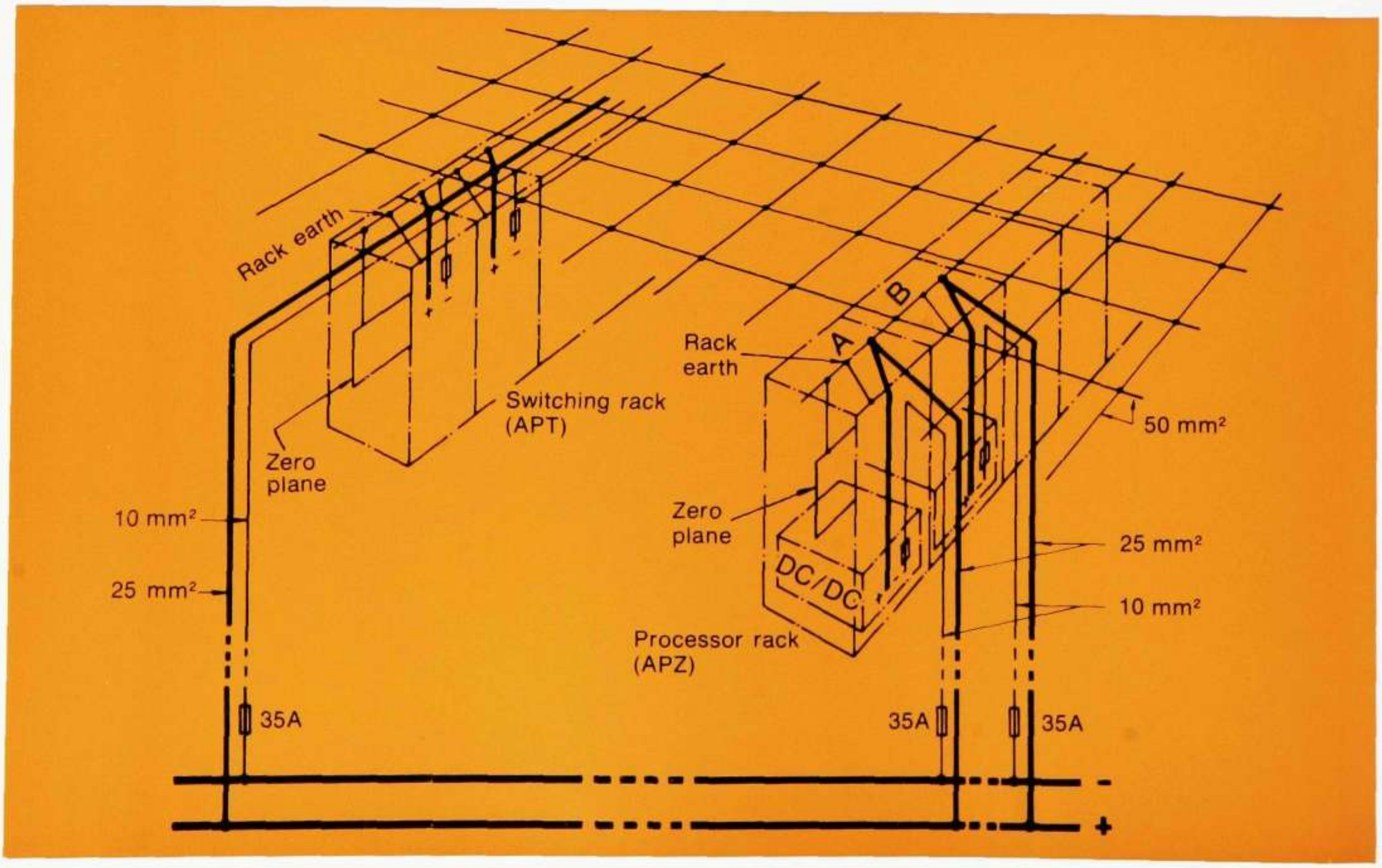
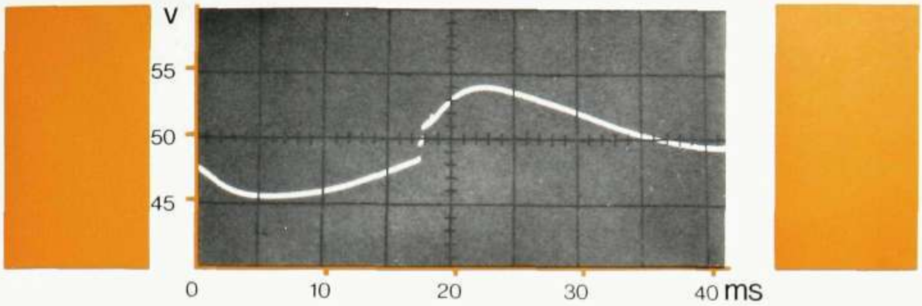


Fig. 7

Transient variations in the feeding voltage to an electronic rack, caused by a short circuit in an adjoining rack



type of exchange. The design described below has been standardized for the AKE 13 type of exchange that was mentioned earlier. Fig. 6 shows in detail how the distribution system feeds the various racks.

All negative conductors have an area of 10 mm^2 and are fused with 35 A fuses. All positive conductors have an area of 25 mm^2 and are placed close up to their associated negative conductors.

As a rule, each DC/DC converter (rack power unit) in the processor equipment is fed over its own negative conductor. The DC/DC converters contain automatic circuit protectors which release for faults in the converters and for certain external faults. The protector is also used if it is necessary to switch off a rack for any reason. The 35 A fuse in the distribution rack is intended only as a pure line protection. In the switching equipment, where the current consumption per rack is lower and where any transients do not have serious consequences, a common negative conductor is used for several racks. These racks are equipped with fuses.

The earthing network consists of 50 mm^2 bare stranded copper wire. The copper wires are run along the top irons in each suite of racks and also along the interconnecting irons. At all crossing points the stranded wires are connected to each other by crimping.

Fig. 6 shows how the positive conductor to a processor rack is connected to the stranded wire in the earthing network which is placed in the top iron of the rack. The positive conductor for the rack, the internal zero plane for the rack (signal earth conductor) and the rack framework are all connected to this wire.

The areas of 10 mm^2 for the negative conductor and 25 mm^2 for the positive conductor have been selected as standard for the system for the following reasons.

In view of the current surge that occurs when switching on the electronic racks, the conductor area chosen for the negative conductor is the smallest that permits the use of a 35 A fuse. The positive conductor forms part of the low-resistance zero plane, and consequently the conductor area has been determined in relation to the total cost for this. Since the positive and negative conductors are placed close up to each other in large bundles of wires in cable runways and troughs, increasing the area of the positive conductor will also increase the thermal load that the conductor pair is able to withstand. With a negative conductor of 10 mm^2 and a positive conductor of 25 mm^2, the maximum thermal load for PVC insulated conductors is, on average, 17 A per pair.

The areas of 10 and 25 mm^2 are suitable for distribution distances of between 25 and 70 metres. If any rack is placed nearer than 25 metres from the distribution rack, a resistance strip of 30 mΩ is connected in series with the negative conductor. If the average distance exceeds 60 m it may be necessary to increase the areas of the conductors.

The distribution from the central power plant

The new distribution system provides an effective protection against disturbances that occur in the exchange room. If on the other hand short circuits occur in the power plant, the current is not limited by high-ohmic negative conductors. Such short circuits result in unacceptable voltage reductions. However, it is possible to prevent serious operational disturbances by designing the power plant in a suitable way. As an example fig. 8 shows the design that was developed as standard for AKE exchanges. In this example power is supplied from three separate parts of the plant, A, B and C. Parts A and B each feeds a processor, and are connected via diodes to part C, which feeds the switching equipment. Using this design for the power plant means that

— the feeding voltages to the two processors cannot be affected at the same time by a short circuit in the power plant

— if a fault occurs in the A or B part, *the processors are fed from the C* part

— only the C part need be equipped with spare units.

Test results

The new distribution system was first installed in Fredhäll automatic exchange in Stockholm. Comprehensive measurements that were carried out at the exchange verified the design calculations and assumptions. The test program included a large number of short-circuit tests. Transient voltages were investigated in the racks that were judged to be most unfavourably placed, and the voltage differences were measured between the worst placed points in the zero plane. A special short-circuiting device was used in order to achieve well defined short circuits.

The measurements showed that

— no rack (apart from the one with the fault) received a voltage lower than

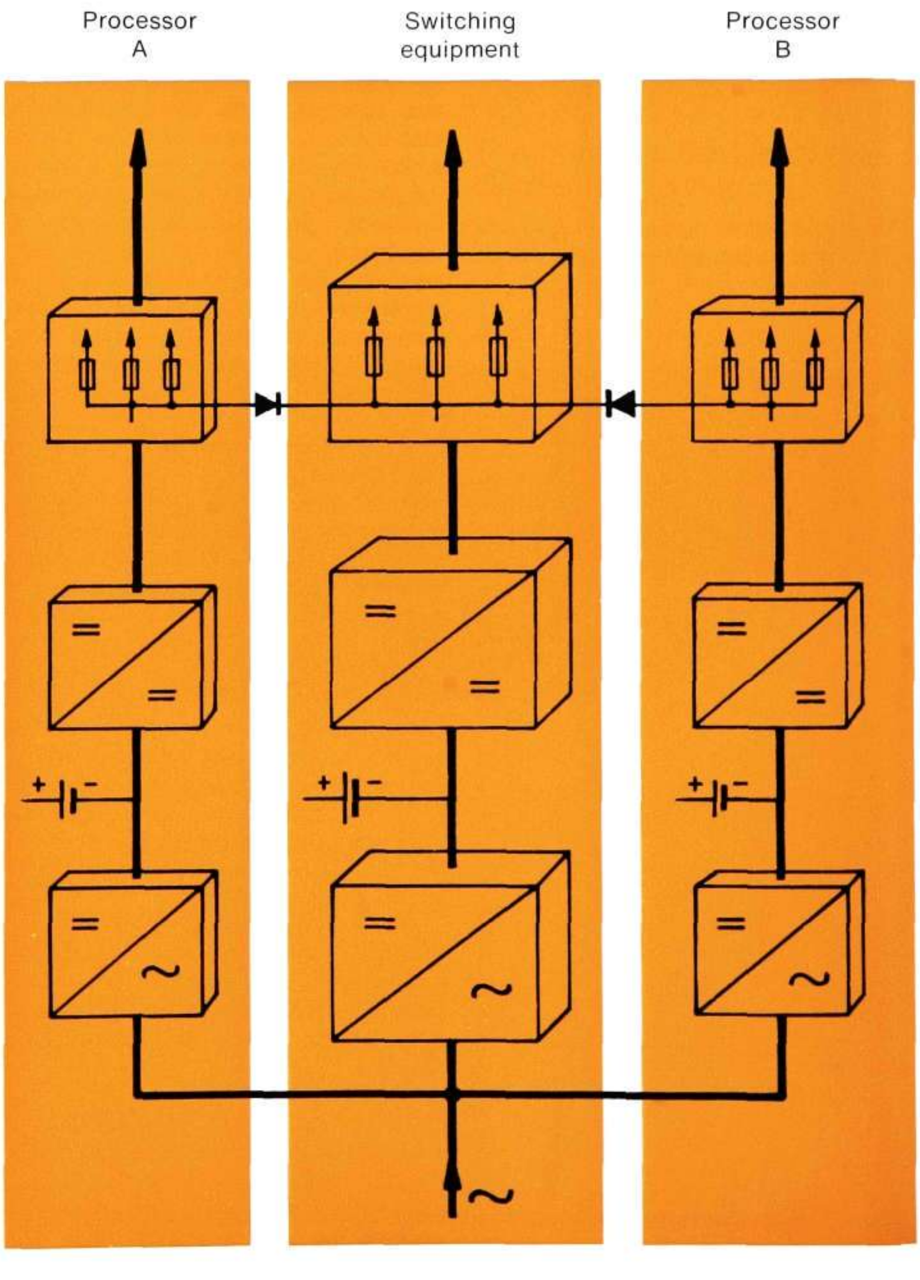


Fig. 8
Power plant for an AKE exchange

45.5 V or higher than 54 V. (Permitted range 44—60 V.) See fig. 7

— the voltage differences in the zero plane did not exceed 0.2 V. (Permitted value 0.6 V.)

Summary

In the L M Ericsson distribution system for electronic telephone exchanges the following principles have been followed:

— individual current feeding is used from the central power plant to the separate functional units.

— the positive conductors in the rack room are connected to each other via a low resistance earth network. This network functions as a common positive conductor for the exchange, serves as a zero plane for the signals and provides an earth potential for the rack frameworks

— the negative conductors have high resistance compared with the internal resistance of the power plant and limit the current if a short circuit occurs in the rack room.

This design means that

— the amplitudes of transients have been limited to values that are not disturbing

— transient potential differences between different points in the zero plane of the exchange have been reduced to extremely small values (< 0.6 V).

These properties of the distribution system together with a special design of the central power plant give a power supply without disturbing transients. By this means the prerequisites have been created for the highest possible reliability in electronic telephone exchanges.

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New Field Telephone Set DPAR 00103

Arne Huse

The Material Administration of the Norwegian Army and A/S Elektrisk Bureau in collaboration have developed and put into production a new Norwegian field telephone set. A dial attachment for the set is being developed. The mechanical design is based on an extruded aluminium tube as the basic element. The telephone set makes extensive use of electronic components, inasmuch as it has an electronic ringing generator, tone ringer and an electromagnetic microphone with amplifier. The new telephone set has better transmission characteristics and weighs less than older sets with carbon microphones.

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LME 822

Development of the field telephone

A/S Elektrisk Bureau, Oslo, in collaboration with the Material Administration of the Norwegian Army have developed a field telephone set in accordance with a development contract placed by the Norwegian Armed Forces. A trial series of 2 000 such sets was delivered to the Army by the end of 1973.

The telephone set is the result of work in a value analysis group, with representatives from the Army Material Administration and A/S Elektrisk Bureau, which was given the task of finding a simplified solution based on experience gained from an earlier field telephone model.[1] This model was evaluated using value analysis methods, and during this work the group found a number of unnecessary or less important functional uses that could be left out.

The original model was based on the requirements of the Norwegian Armed Forces and military specifications. Additional requirements were put forward as a result of subsequent operational tests. A critical evaluation of the requirements showed that some of them were unnecessarily stringent and costly, out of date or formulated in such a way that they were directed towards a particular solution and prevented a free flow of ideas. The extensive use

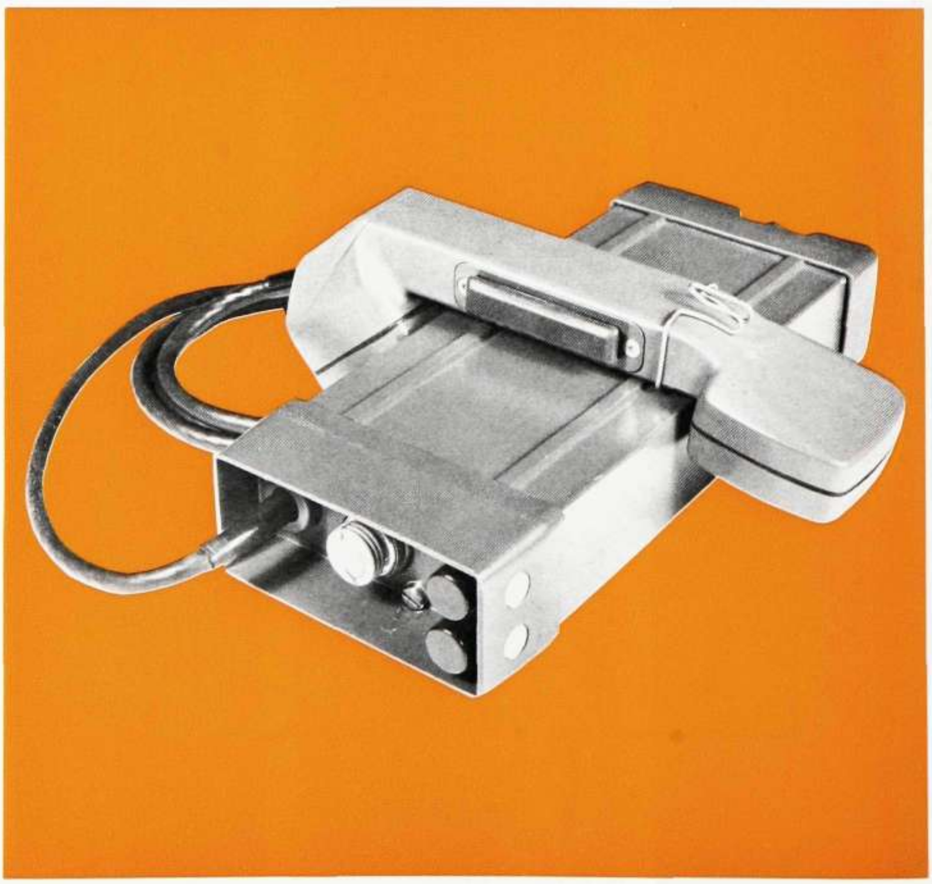

Fig. 1
Telephone set 1/DPAR 00103 as a desk telephone.
In 1973 A/S Elektrisk Bureau were awarded the Norwegian Design Prize for this new field telephone set

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a subsidiary of the Ericsson Group

of value analysis in connection with the re-evaluation of the requirements, functional limits and specifications simplified the work of arriving at the simple design of the telephone set shown in fig. 1.

The dial attachment for the telephone set is being developed. The final design is expected to be as shown in fig. 2.

As a result of collaboration between the customer and the manufacturer a telephone set has been produced that

— is built in accordance with an established mechanical design using modern and reliable materials and components[2]

— is light, watertight and so robust that it can be used in the field

— complies with British Specification DEF-133, Table L3 — Ground Equipment, Exposed and Immersible

— is easy to operate and simple to service

— may be used as a desk telephone or as a field telephone in a carrying case

— has such weight and size that it can be placed in the pocket of a service jacket and operated there

— has excellent transmission quality.

Mechanical design

The field telephone set, which the Norwegian Armed Forces have designated TP-6N, is shown in fig. 4.

The basic mechanical idea: An extruded aluminium tube with a cover at each end.

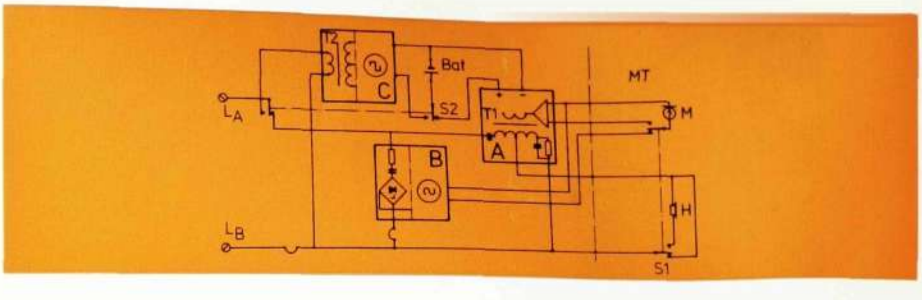
Fig. 2

The field telephone connected up as a CB automatic telephone, the rear cover being replaced by a dial attachment. The microtelephone is secured in the cradle. The cradle switch is hidden under the microtelephone. The attachment is rainproof

Fig. 3

Block diagram of the local battery telephone set

A	Transmission circuit with balanced coupling and microphone amplifier
B	Tone ringer, approximately 2000 Hz
C	Ringing generator 1.3 W, 25 Hz nominal
Bat.	3 batteries, 1.5 V dry cells BA 030
L_A, L_B	Line terminals
MT	Microtelephone with a 5-wire microtelephone cord
M	*Microphone, 350 Ω, electromagnetic*
H	Receiver, the same NATO-coded type as the microphone
S1	Push-button switch in the microtelephone, for speech
S2	Push-button switch on the front panel, for ringing



When extruding, even wall thickness is obtained along the entire length of the tube. The cross-section can be made relatively complicated, and production of the tube itself is simple.

The shape enables the telephone set to be carried without undue discomfort under outer clothing in order to keep the batteries warm in cold weather. The batteries are connected together in the simplest possible way by being placed one after the other in the tube.

The microtelephone H-67N is moulded in a matt olive-green plastic. It has electromagnetic insets as receiver and microphone, a push-button switch for speech connection in the middle of the hand grip and a clip for hanging it up. The microtelephone is designed in such a way that it is possible to use it while wearing a helmet, and it is a design condition that it shall not be possible to open the microtelephone without tools. It is watertight.

The telephone set is shown dismantled in fig. 8. All joints have rubber gaskets in order to make the telephone set waterproof.

The rear cover and front panel are cast in silumin. The fixing screws for the rear cover have milled heads and coin slots. The battery spring and the connector for the printed board assembly are mounted on the inside of the cover. The line is connected to the line terminals via insulated wires passed through the side of the front panel. The line terminals and the push-button switch are placed so that they are protected mechanically. The contact for the positive pole of the battery contact holder is such that the batteries are able to make contact only when they are inserted correctly.

As was mentioned earlier, the case is an extruded tube of aluminium alloy. On the outside it has four longitudinal ribs which prevent the rubber gaskets

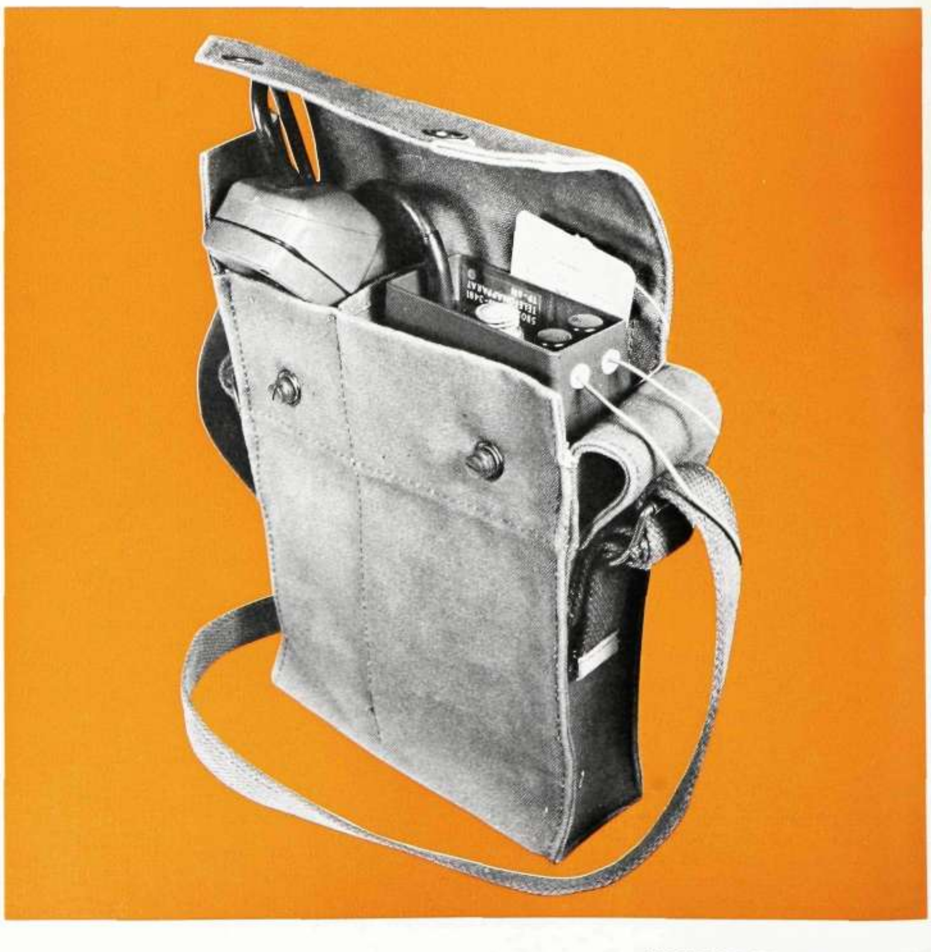


Fig. 4

Telephone set DPAR 00103 in a carrying case, which also contains brief operating instructions with a phonetic alphabet

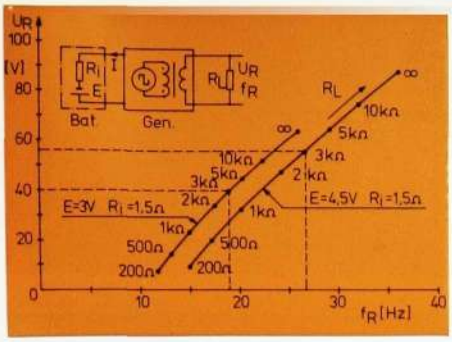


Fig. 5

Ringing generator. The relationship between ringing voltage and frequency with varying load

E = 4.5 V	**New batteries**
E = 3 V	**Discharged batteries**
U	**Ringing voltage, rounded-off square wave**
f	**Ringing frequency**
R_L	**Load resistance**
I	**Battery current**

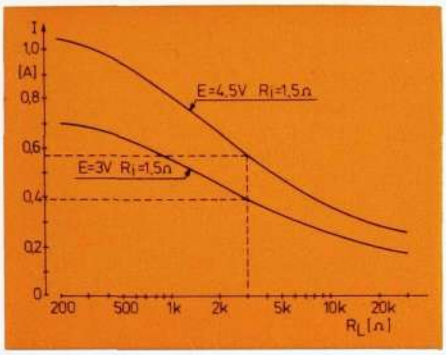


Fig. 6

Ringing generator. Battery current as a function of load

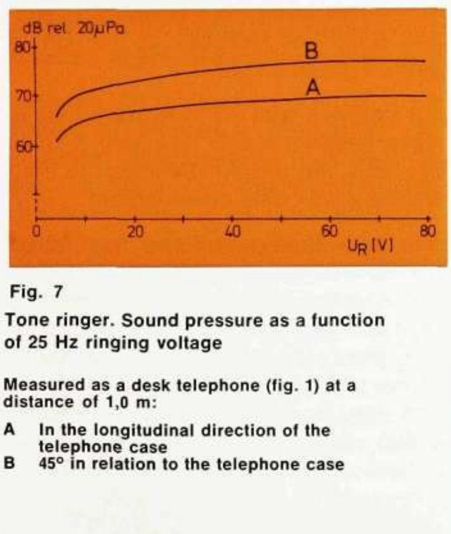


Fig. 7

Tone ringer. Sound pressure as a function of 25 Hz ringing voltage

Measured as a desk telephone (fig. 1) at a distance of 1,0 m:

A **In the longitudinal direction of the telephone case**
B **45° in relation to the telephone case**

from being pressed together too much. Inside the case longitudinal guide slots are provided for the printed board assembly. A wall separates the batteries from the printed board assembly.

All the electrical components in the telephone set are mounted on the printed board assembly. The ringing generator is mounted nearest to the gold-plated, double-sided edge contacts. Then comes the tone ringer and the transmission circuits with the microphone amplifier. The printed board assembly is fastened flexibly to the front panel, which is connected via ten gold-plated contact pins.

Block diagram

A simplified block diagram of the field telephone set is shown in fig. 3.

The line terminals are connected to the tone ringer and the speech circuit. These are disconnected by means of the push-button switch S2 on the front panel. The ringing generator is then connected to the line and to the battery and delivers almost the normal ringing voltage to the line. When S2 is in the unoperated condition the tone ringer receives the low frequency ringing signal and sends it out as a tone from the microphone as in Norwegian civilian telephones since 1967.[3] Speech can be transmitted and received when S1 in the microtelephone is depressed. The telephone set is protected against overhearing and does not draw battery current when S1 is not depressed.

Ringing generator

The ringing generator is a transformer-coupled blocking oscillator with two transistors. The waveform of the ringing voltage is almost a square wave. The ringing generator starts immediately the battery is connected, but a delay circuit causes the ringing voltage to build up gradually to its full value. Figs. 5 and 6 show the characteristic measured results with new and old batteries. Ranges of 30—35 km to a field exchange have been achieved over light field cable WD-1/TT (140 Ω/km looped, 1 dB/km attenuation at 800 Hz).

Tone ringer

In the tone ringer the incoming ringing signal is rectified and drives an LC oscillator. The ringing tone consists of an almost sinusoidal voltage at about 2 000 Hz, which is amplitude modulated by twice the ringing frequency. Fig. 7 shows the results of measurements of the sound pressure with the telephone set placed on a desk. As may be seen, the sound pressure is somewhat dependent on direction. When the telephone set is used in a carrying case as shown in fig. 4, the sound pressure is about the same as curve A.

Transmission

The transmission circuit includes the microtelephone and the balanced telephone set coupling with the microphone amplifier. The telephone set has local feeding from a 4.5 V battery. The

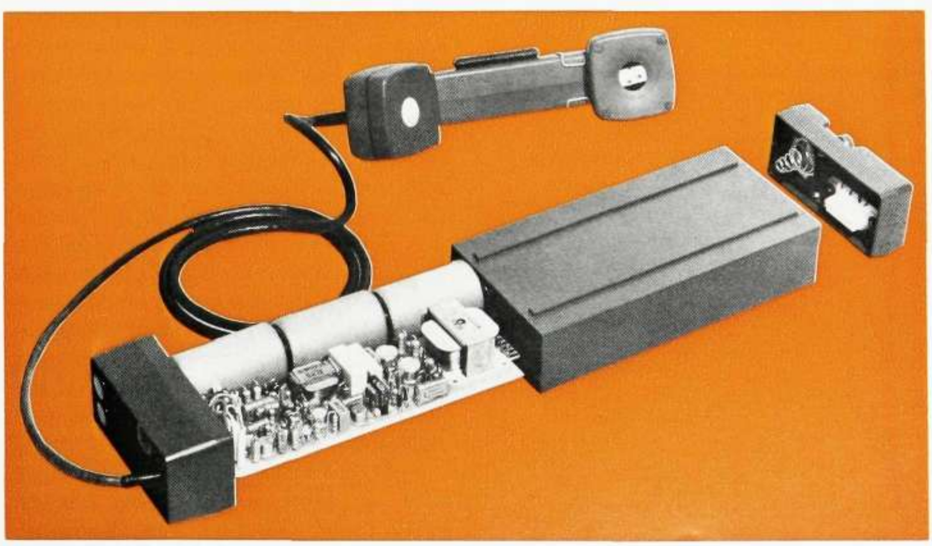


Fig. 8

The telephone set dismantled consists of a rear cover, case, printed board assembly, batteries, front panel and microtelephone

Fig. 9

Frequency curve when sending.

Sound pressure level 94 dB linear with the microphone (OREM C. AEN). Load 600 Ω

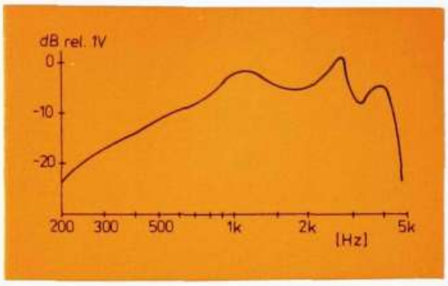
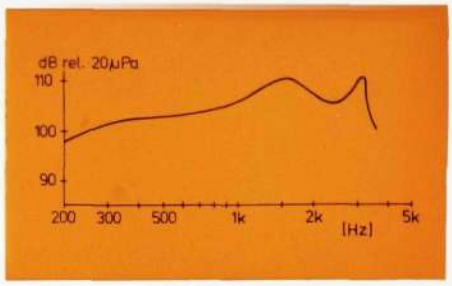


Fig. 10

Frequency curve when receiving.

IEC artificial ear, 0.5 V, 600 Ω generator



Technical Data

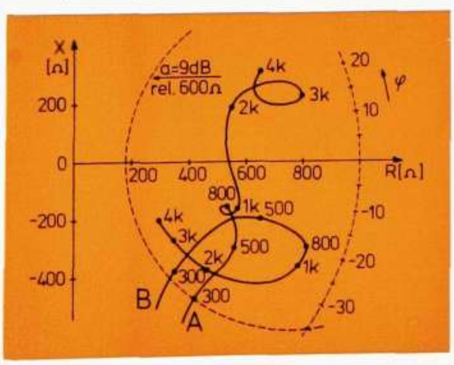
	Height mm	Width mm	Length mm	Weight kg
Micro-telephone	55	70	210	0.33
Micro-telephone cord			1250	
Telephone set	47	100	233	0.95
Carrying case	65	185	260	0.35
Telephone set complete with batteries and carrying case				1.9

Fig. 11

Telephone set impedance as a function of frequency with new and discharged batteries

A Push-button switch for speech depressed (speech condition)

B Push-button switch for speech not depressed (idle condition)



microphone amplifier, which is directly coupled over two stages and utilizes one transistor for stabilizing the working point, draws a nominal current of 8 mA when S1 is operated. A number of operational instructions have been laid down in order to avoid unintentional high frequency detection from powerful transmitters in the vicinity of the telephone set and the line. As it must also be possible to use the telephone set towards the network of the Telecommunications Administration, the transmission data has to the greatest possible extent been made the same as for the Norwegian civilian telephone sets.

Fig. 9 shows the frequency curve when sending from the telephone set. The battery voltage has very little effect on this. The distortion factor at 800 Hz and with an output of 1 mW into 600 ohms has a characteristic value of 3—5 per cent, irrespective of the battery voltage. The low distortion factor and the linearity of the transmission circuit make the telephone set usable down to whispering level, which is of importance when the set is used in the field. Fig. 10 shows the frequency curve when receiving, and fig. 11 the impedance curves for the speech and idle conditions.

Operational tests, both in quiet and noisy surroundings, indicate that this telephone set is far superior to the carbon granule telephone set both as regards quality and range.

Battery consumption

As the ringing generator is a current consuming device that is not used in conventional field telephones, considerable importance has been attached to the question of minimizing the battery consumption. The life of the batteries is dependent on how often the telephone set is used. If it is assumed that in a time of crisis there are six calls an hour for eight hours each day, that every other call is an outgoing one with a calling signal of three seconds, that the clearing signal time is one second for each call and that the mean call time is two and a half minutes, then at a temperature of 20° C a total of 13 dry cells BA 030 will be used up each year. (Battery change every three months.) The discharge time for equivalent NiCd cells (3.5 Ah) is three and a half months.

For comparison it may be mentioned that it is not unusual for field telephones with carbon granule insets to draw between 40 and 50 mA from two dry cells BA 030. With the traffic mentioned above this would also mean a consumption of 13 dry cells per year, and a discharge time of only about one and a half months for NiCd cells. Hence the inclusion of the ringing generator does not result in an increase in battery consumption in relation to carbon granule telephone sets if care is taken to ensure that the ringing signal is not longer than necessary.

Summary

The 2 000 telephone sets in the first delivery have been in service in the Armed Forces since the beginning of 1974, and hitherto the reaction has been positive.

The electronic ringing generator draws a fair amount of current, but if used with moderation the battery consumption does not increase in relation to carbon granule sets.

For soldiers who hitherto have had to carry telephone sets weighing 5 kg in the field, the weight reduction to 2 kg will be a welcome development.

The new field telephone has better transmission characteristics and thus the communication network can be planned and dimensioned accordingly. Higher power and less distortion increases the intelligibility and range and thereby enables calls to be made under more pleasant conditions than before.

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WORLDWIDE NEWS

New exchange system presented at international symposium

Developments within electronic switching technology during recent years were reviewed at the 1974 International Switching Symposium, arranged by the German section of IEEE and held at Munich during September 9th—13th. At the symposium the new LM Ericsson exchange system AXE was presented for the first time in public.

Almost 1000 delegates from a large number of companies, institutions and telephone administrations had met to hear and discuss over 100 reports dealing with development of international traffic, reliability of switching systems, comparisons between analog and digital switching techniques, the use of the telephone network for data traffic, automation of maintenance and administrative functions, recent experience of processor controlled systems etc.

The delegation representing the Ericsson Group consisted of representatives from the product divisions of the parent company, from ELLEMTEL, which is owned jointly with the Swedish Telecommunications Administration, and from a number of the associated companies in various countries. Kjell Sörme, ELLEMTEL, presented the new L M Ericsson exchange system AXE and Lars-Olof Norén, L M Ericsson, gave some points of view regarding the software reliability. Björn Svedberg, L M Ericsson, was responsible as rapporteur for a session devoted to recent experience of stored-program-controlled systems.

Facts about system AXE

- **AXE is an electronic SPC exchange system based on functional modules.**
- **The system is designed throughout with printed board assemblies and is built up using a new mechanical construction practice in which the board magazine constitutes the largest mechanical and functional unit.**
- **In its present design the system uses reed relays, but it is prepared for alternative equipment, primarily digital group switches.**
- **The control system is a data processing system with logic which is partly decentralized. There is a central, synchronously duplicated processor and a number of small regional duplicated processors, the number depending on the size of the system. Through this decentralization a system structure has been created that gives good economy even for small exchanges, at the same time that the demand for a high maximum capacity is met.**
- **The AXE system satisfies the high demands made on modularity in many respects. The basic system offers normal facilities in the form of subscriber services and maintenance functions. By equipping the exchanges with the appropriate functional modules, a large number of additional facilities can be provided.**

Computer-controlled telex developed

The Swedish Telecommunications Administration has ordered a fully electronic computer-controlled exchange for telex traffic. The exchange, which is to be installed in Malmö, South Sweden, is to be taken into service during 1977 and will handle both national and international telex traffic.

The ordered exchange is the first of a new generation of transit exchanges for telex and data traffic. It has been developed by ELLEMTEL, the development company owned jointly by the Telecommunications Administration and L M Ericsson. The exchange is controlled by a computer developed for use also in the L M Ericsson computer-controlled telephone exchanges.

The new exchange has no mechanical switches and a time division system is used instead for the switching procedure. It has been possible to reduce both the space and power requirements considerably and at the same time obtain a high traffic handling capacity. The computer and all common parts of the system have been duplicated in order to achieve high reliability. At the same time most of the operational and maintenance functions have been automatized.

The system offers subscribers a number of new, advanced services among which may be mentioned:

- *automatic group message*, which permits a subscriber to send a message to several addressees at the same time, thereby saving time and effort.
- *abbreviated dialling*, which means that a subscriber need only dial two digits instead of the present 10 or 12 in order to connect up to certain subscribers.
- *keysending*, which means that a dial is no longer necessary as the teleprinter keyboard is used for sending selection information. This gives, for example, shorter setting-up times.
- *closed networks*, which means that exclusive networks can be formed within the telex network for groups of subscribers.
- *information regarding call duration*, whereby a subscriber can obtain information regarding the duration of a call immediately after its completion.

Field trials show:
Picture telephony justified for internal communication

The results of field trials with picture telephones, which have been going on in certain design and production departments at LM Ericsson's main plant in Stockholm since the beginning of 1973, were presented for interested delegates at the 7th International Symposium of Human Factors, held in Montreal recently.

Time saving of up to 120 man hours per year and picture telephone was reported, and a preliminary economic rule of thumb for short distance applications can now be formulated: the cost of an internal picture telephone system can be defrayed in three years with a traffic of three calls per day and picture telephone. This only takes into account the man hours saved due to more efficient communication between certain departments. To this must be added the economic advantages achieved through shorter times for handling various questions.

At the request of the users, the question of extending the company picture telephone network is now being discussed at LM Ericsson.

With normal settings the screen covers a document surface equivalent to size A5. A larger or smaller document surface can be obtained with a zoom lens. During the course of the call, picture transmission takes place in both directions simultaneously and if necessary the subscriber can switch over to his own picture in order to check it

The picture telephone network that was built up at L M Ericsson after careful pilot studies contains, apart from switching equipment, ten picture telephones placed in departments for ordering, design, manufacture and testing. The picture telephones are placed so that each extension in each department can be used by several persons. The highest picture quality is used in the system (5 MHz bandwidth).

About 80 users of picture telephones were interviewed in order to obtain reactions and attitudes regarding the introduction and use of picture telephones. The results show that 96 per cent of the users consider the picture telephone a new effective communication aid. It was most appreciated in departments where the work consists of numerous questions that are handled quickly, and where it was possible to save a considerable amount of time.

One of the more striking examples of time saving that can be achieved by the introduction of picture telephony was reported from a department responsible for manufacturing prototype relay sets. Before picture telephones were introduced, the designers, who were consulted regularly, had to go to the prototype department. Each such discussion occasion usually took 30 minutes plus a walking time of five minutes in each direction. With picture telephony corresponding questions now take only ten minutes to clear up.

Another advantage in this case is that through picture telephony the designers are now immediately available when the production office needs help, for instance to make a decision or provide information.

The field trials reported here constitute the second phase in a series of trials that began in November 1971.

In the workshop specially trained workshop staff carry out programming of punched tape for the numerical control of, for example, wire spark machines, using electronic calculators

New manufacturing methods for prototypes

New manufacturing methods introduced in the mechanical prototype workshop at the main plant of L M Ericsson in Stockholm have eliminated the bottleneck which conventional manufacture of prototypes and blanking tools for mass production previously constituted.

In the prototype workshop in Stockholm the previous working procedure — manual manufacture of experimental tools, manufacture of mass production tools usually with long delivery times, and improvised medium size production while waiting for the finished tools — has been replaced by new methods which have resulted in a considerable reduction in manufacturing costs and delivery times.

The machine tools and control systems for the prototype workshop have been selected so that the workshop staff are able to carry out both programming and punching of the required punched tapes at the place where they usually work.

The same operator takes care of all functions that occur in connection with the tool manufacture, i.e. tool design, programming, obtaining material, operating the machines, stocking tools and ordering tool maintenance. The staff consists of internally trained toolmakers, precision tool makers, milling machine workers and turners. Of the roughly 70 persons employed in the prototype workshop, ten are directly employed on the development of new methods and tools.

The new manufacturing methods are now being introduced in the larger factories of the Ericsson Group in, among other countries, Australia, Brazil, Spain and Norway.

New type of CTC system in operation

The first L M Ericsson CTC (Centralized Traffic Control) system of type JZA 700 was put into service in October 1974 for the Administration of the state-owned Spanish railways, RENFE. The system is based on integrated circuit techniques and is the third generation of CTC systems in a development chain based on twenty years of operational experience.

The system recently put into operation remotely controls the train traffic on the line Zaragoza—Lerida—San Vicente in the north-eastern part of the country from a centre at Lerida. The length of the route is 350 km and it comprises 30 substations.

Up to 2500 indications from the line can be accepted on the 18 m long indication panel in the centre at Lerida, and 1100 orders can be sent out to the substations from the keysets of the two train despatchers.

The railway signal project which is now complete is the largest hitherto carried out by L M Ericsson in Spain. The Spanish subsidiary company L M Ericsson S. A. has been responsible for all installation work.

The introduction of CTC is one stage in the modernization program being carried out by the Spanish Railway Administration.

A symposium devoted to power supply questions, at which 60 representatives of the Brazilian telecommunications administrations and Ericsson do Brazil took part, was held in Guarajá, Brazil, on September 23—26. The symposium dealt with technical problems and views on the power supply of telecommunication plant now and in the future. Four lecturers from L M Ericsson's power supply department in Stockholm took part

The prototype of the L M Ericsson mobile search radar PS-70/R which was developed for the new anti-aircraft robot system of the Swedish army, has been delivered to the Material Administration of the Swedish Armed Forces. PS-70/R is a pulse-Doppler radar that distinguishes between echoes from fixed and moving objects and which can track approaching enemy aircraft even at treetop level. The picture shows the equipment mounted on a cross-country lorry

DIALOG becomes DIATRONIC

A new generation of telephone sets with fully electronic speech circuit and linear electromagnetic microphone is now being introduced by L M Ericsson. The telephone set is called DIATRONIC and is a further development "under the cover" of the well known light-weight telephone DIALOG, of which over five million have been manufactured since its introduction in 1963.

In the new telephone the old carbon microphone is replaced by a linear electromagnetic microphone, which gives optimum transmission level and lower maintenance costs.

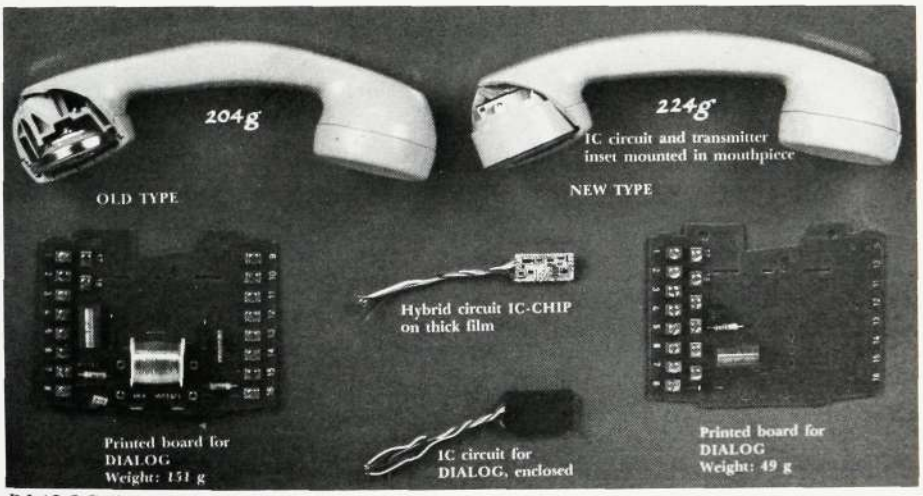
I the DIATRONIC the speech circuit consists of an integrated microcircuit which is mounted in the same space as the microphone. An advantage of this compact design is that the entire unit can easily be screened against electromagnetic radiation, which can otherwise constitute a problem when an amplifier element is included in the telephone set. The electronic speech circuit in DIATRONIC has made it possible to leave out the speech transformer. An impulsing unit with pushbuttons can be used as a direct replacement for the dial, without having to modify the telephone.

Electronic traffic route testers for Holland

L M Ericsson have received a large order from the Dutch PTT for their new program-controlled traffic route tester, TRT m 70. The order comprises 113 master and 738 satellite equipments and constitutes one step towards the general introduction, in accordance with a decision previously made by the PTT, of the maintenance method CCM developed by L M Ericsson.

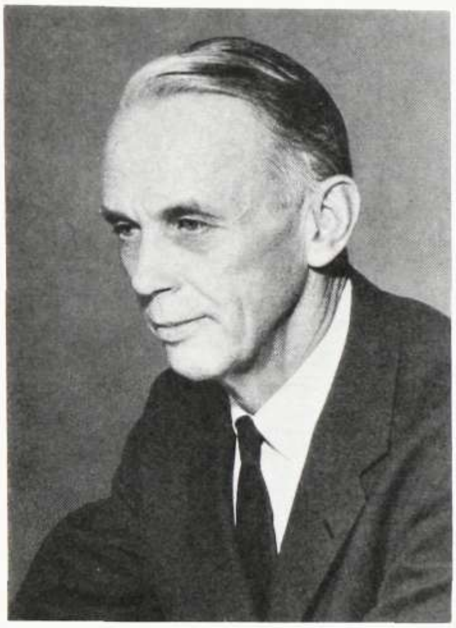
The L M Ericsson traffic route tester has proved to be a useful aid for the maintenance of automatic telephone exchanges. It is connected to the exchange equipment in the same way as normal subscribers, and by means of generated test connections it checks statistically the operational quality of the telephone network from the point of view of the subscribers.

For several years the Dutch PTT have used traffic route testers with great success for supervision of the traffic quality. Ericsson Review No. 3/1972 includes a report of the results of six years in use in Rotterdam.



DIALOG (left) and DIATRONIC (right)

Sven Ture Åberg
In memoriam



Sven Ture Åberg, President of Telefonaktiebolaget L M Ericsson during the years 1953 to 1964, died on October 10, 1974. He was born in Skellefteå in Northern Sweden on October 16, 1903, and was thus almost 71 when he died.

After taking his engineering degree in 1927 Sven Ture Åberg joined L M Ericsson and served for long periods abroad both in Europe and South America.

In 1936 he was appointed assistant export manager at the main office in Stockholm. From 1937 he was the company representative in the USA and during the years 1940—1945 President of the Ericsson Telephone Sales Corporation. On his return to Sweden in 1946 he was appointed Vice President for Sales and in 1953 President of L M Ericsson. He was a member of the Board of L M Ericsson until 1973 and thereafter honorary member.

Apart from Board assignments in a number of L M Ericsson Swedish and foreign subsidiary companies Sven Ture Åberg held several posts in branch and trade organizations such as the Federation of Swedish Industries and the Association of Swedish Exporters.

Dr. Marcus Wallenberg, Chairman of the Board of L M Ericsson:

"What then were the qualities that brought this remarkable man upwards towards continuously more responsible tasks? Was it favourable circumstances or was it his inherent qualifications? Assuredly the circumstances often play a part because they clamour for a decision. But in the case of Sven Ture Åberg it was his competence that was decisive. What then characterized his competence?

Firstly: a sterling character. He was true, had pure intentions, put the interests of the company first, incorruptibly just, human, helpful and loyal with an admirable devotion to L M Ericsson, its staff and its goals.

Secondly: his technical knowledge, a necessary prerequisite for a successful sales career.

Thirdly: a born salesman, with a true and charming argumentation ability, inventiveness and creative imagination and a wealth of experience from many years of sales work in large and small questions in different fields with the whole world as his operational area.

Fourthly: an able negotiator with a good knowledge of languages as a technical and essential aid, a good understanding of peoples' mentality, infinite patience, fantastic perseverence with a magnificient fighting spirit tempered by an appreciation of what is possible.

[illegible]d personal judgement, inspiring for colleagues, stimulating to deeds, forceful and charming personality characterized by humour and an understanding humanness. In other words an outstanding leader.

Let us now point out: During the period when Sven Ture Åberg was President, and thanks to L M Ericsson's excellent staff at all levels and of all categories, LME consolidated their independent position among the world's leading telecommunication companies and broke through to the world-leading stratum of international telecommunication companies, an acknowledged fact reluctantly accepted by competitors — perhaps the most reliable sign that a widespread acceptance has been achieved."

At their annual meeting the Swedish Academy of Engineering Sciences rewarded Sigurd Nordblad, Chief Engineer of L M Ericsson's telephone cable division in Stockholm, for technical pioneer achievements in the field of telephone cable manufacture. In the picture Sigurd Nordblad receives from the King of Sweden the Academy's gold medal for the conception and development of the cross-stranding technique, which gives the cables better transmission data and permits more economic production

A delegation consisting of leading personalities in the Italian telecommunication service and representatives of the Italian subsidiary company of L M Ericsson visited L M Ericsson in Stockholm for the period September 25—27 to study the latest developments in the telecommunication field. In the picture Carlo Cerutti, Board member and President of STET, a state-owned Italian holding company for telecommunications, is welcomed by the President of L M Ericsson Björn Lundvall and Vice President Fred Sundquist (far right)

The Ericsson Group

With associated companies and representatives

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1. Telefonaktiebolaget LM Ericsson
2. L M Ericsson Telemateriel AB
1. AB Rifa
1. Sieverts Kabelverk AB
1. Svenska Radio AB
5. ELLEMTEL Utvecklings AB
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3. GNT AUTOMATIC A/S

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Representatives in:
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1. Sales company with manufacturing
2. Sales and installation company
3. Associated sales company with manufacturing
4. Associated company with sales and installation
5. Other company
6. Other associated company
7. Technical office

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